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The Social Equity of Urban Parks in High-Density Urban Areas: A Case Study in the Core Area of Beijing

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Abstract: Urban parks beautify the environment and promote urban public health, and their spatial allocation is significant in maintaining environmental justice. However, the current allocation of urban parks focuses on quantity fairness and pays insufficient attention to accessibility and quality fairness. This study investigated the core area of Beijing and analyzed the fairness of urban park allocation based on park accessibility, area, and quality. We used big data crawling, the two-step floating catchment area method, comprehensive equity evaluation of parks, spatial autocorrelation, and non-parametric tests. The results showed inequality in terms of accessibility, area, and quality, with high spatial distribution in the north and low spatial distribution in the south. The accessibility, shortest distance, and total area of urban parks in high-income residential areas were 3.0, 2.1, and 1.8 times higher, respectively, than those of the low-income residential areas. This indicates that high-income groups have better accessibility, live closer to, and have access to larger urban parks. Middle-income and above groups had access to green space, whereas medium-to-low-income residential areas had poor access to parks, particularly high-quality parks. These findings provide decision-making and planning references for the optimal allocation and rational planning of urban parks.

Keywords: green space equity; urban parks; accessibility; green space quality assessment; high-density city; Beijing core area

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1. Introduction

The positive role of urban parks in urban development, such as providing habitats for flora and fauna, improving air quality, reducing urban noise, providing exercise and fitness spaces for residents, and improving the urban public health environment, has been widely recognized [1–3]. These benefits have made urban green spaces an important measure of a livable city [4]. Therefore, the provision of equitable urban green spaces is of great significance to the sustainable development of the city and public health [5,6]. Walking is positive for human health and is one of the most common physical activities among adults [7,8]. Since other types of travel modes such as bicycles, public transportation, and driving require certain preconditions—such as transportation purchase or payment of a certain fee, which are not available to everyone from the point of view of fairness—and walking is a mode of travel that is directly available to the vast majority of the population, this paper will only consider walking as a mode of travel.

The environmental justice theory holds that all people of different ethnicities, incomes, classes, or social statuses in the same space and time should have the right to equally enjoy

the wellbeing of environmental optimization and avoid the harm caused by environmental pollution [9]. In Europe, the large-scale construction of parks began in the 18th century with the parks movement, which was created to improve the living conditions of human settlements, and the public and non-governmental organizations have played a huge role in promoting the construction of parks [10–12]. The academic community's understanding of the fairness of parks and green spaces ranges from quantitative and spatial fairness to social fairness and from the enhancement in quantity and quality to the inclination of disadvantaged groups and people of color [13,14]. China's park system is different; it is more like a top-down movement, and the construction of Chinese parks is still dominated by a top-down model [15,16]. In recent years, through learning from the construction of parks and green spaces in foreign countries, the Chinese government hopes to solve the problem of uneven spatial distribution at the planning level and, at the same time, organically integrate and renew parks to carry out other functions [17,18]. Therefore, the problem of park layout is the result of the government's macro-level (planning level) regulation coupled with micro-level updating.

Studies have found that urban park quality and accessibility are distributed significantly unequally across socioeconomic groups of different ethnicities [19], incomes [20,21], ages [22], and religions [23]. Vulnerable groups tend to have less access to urban parks and poorer environments in which to use them [24]. This suggests the presence of environmental injustice in the distribution of urban parks, which can exacerbate urban socioeconomic class differentiation and worsen the health of socially disadvantaged groups. Urban parks are public products with important social, economic, and ecological environmental benefits. Therefore, the fairness of their spatial allocation is a hotspot for research in the field of environmental justice, and the scientific construction of fairness evaluation parameters is an important prerequisite for fairness research. In addition to measuring the service level of urban parks, such as park area, number of parks, and other material attribute parameters, park accessibility, park quality, and other non-material attribute parameters have received extensive attention [25]. Research on accessibility as the evaluation parameter of allocation fairness has been relatively in-depth [26,27]. Accessibility measurement methods include buffer analysis [28], network analysis [29], gravity model [30], and the two-step floating catchment area method [31,32]. The latter two are widely used to calculate the accessibility of urban parks. The two-step floating catchment area (2SFCA) method has been extended in terms of transportation cost, search radius, distance decay function, and transportation travel mode [33,34]. It has been applied in various public service facility accessibility evaluations by integrating the competition between supply and demand and spatial resistance. The Gaussian function is often used as a distance decay function, as it fits the change in distance sensitivity of people visiting urban parks [35]. Studies on green space equity are limited and often neglect the distributional equity of park quality [23,36]. Studies on park accessibility that use the 2SFCA method often assume that parks have the same quality; however, the quality of parks largely determines their level of service and service capacity and affects their attractiveness [37]. Attractiveness is a key factor in the evaluation of urban green space accessibility. The allocation of public service resources is fair only when urban green spaces meet residents' needs in terms of both accessibility and quality.

In addition, existing research on the equity of urban park layouts in high-density cities mostly focuses on the urban cluster area or city scale [38–40], whereas fine-tuned research on urban areas at the subdistrict scale is scarce. In studies on the relationship between the supply and demand of urban parks, census data are mainly used to indicate the demand, with rough data precision and assuming that the population is uniformly distributed in space [27,41]. This does not reflect the actual distribution of the city population. Existing studies have analyzed the inherent causes of inequity in green spaces in high-density cities; however, most studies have not proposed a strategy to improve the fairness of green space [38,39]. A few studies have proposed increasing the number of parks to improve the fairness of green spaces without considering the situation in the core area of the dense city, where land resources are limited [42]. Therefore, the research scale of many existing studies

does not match the scale of urban planning practice, and the applicability and practicality of the research results are not sufficiently strong to effectively guide urban green space renewal or management practice.

Beijing, as the capital of China, is an international metropolis, and its core area is the core carrying area of the national political center, cultural center, and international communication center, and an important window area to display the image of the national capital. The threshold standard for a high-density city in the world is 15,000 people/km^2 [43], and according to the data provided by the Beijing Bureau of Statistics, the population density of the core area of Beijing reached 20,700 people/km^2 in 2021 [44], which is considered to be a typical high-density urban area [45]. In view of this, this study, based on the perspective of environmental justice, takes 27 high-density subdistricts in the core area of Beijing as the study area and analyzes the urban parks in the study area in terms of three aspects—park area, park accessibility, and park quality—using the comprehensive evaluation of park quality based on field research; the evaluation of accessibility based on big data crawling on the Internet and the Gaussian two-step mobile search method; spatial autocorrelation analysis; and a non-parametric test. The equity pattern of spatial allocation is analyzed, and measures to improve the equity of urban park allocation in cities are proposed with reference to the actual situation of high-density cities.

2. Materials and Methods

2.1. Study Area

The core area of Beijing, including Dongcheng and Xicheng Districts (Figure 1), contains 32 subdistricts with a total area of about 92.5 km^2 [46,47]. The current research results on a large number of urban parks in the core areas of Beijing still indicate the existence of green inequality [48,49]. Due to the specificity of historical development, some subdistricts in the core area of Beijing are dominated by institutional units, cultural protection units, and commercial complexes, and have a population density below 15,000 people/km^2, failing to meet the previously mentioned threshold criterion of 15,000 people/km^2 for the world's high-density cities; the five subdistricts that did not meet the conditions were excluded from the scope of this study. Therefore, 27 subdistricts with a total area of 74.01 km^2 and a population density of more than 15,000 people/km^2 were selected as a typical research sample of high-density urban areas. We considered the edge effect of residents' exposure to green space [50]—that is, administrative boundaries at the subdistrict level cannot limit the range of activities available to residents and that parks within a certain range of the administrative boundaries of the 27 streets in the study area are potential accessible areas for residents. A distance of 1.5 km is the acceptable limit for residents to walk [51]. Therefore, a buffer zone with a radius of 1.5 km was established, and urban parks within the buffer zone were included in this study to ensure the research was sound.

2.2. Data Sources and Processing

2.2.1. Urban Park Data

Based on the Beijing Municipal Parks Classification and Grading Management Measures (2022 edition) [52], Urban Green Space Classification Standards (CJJT 85-2017) [53], and Urban Green Space Planning Standards (GB/T 51346-2019) [54], urban parks were classified into five categories: comprehensive, community, street garden, historical, and theme. According to the statistics of Beijing Municipal Forestry and Parks Bureau for the year 2022 [55], the free-accessible green spaces in the abovementioned categories were chosen. The study area and buffer zones contained 166 parks (Figure 1c, Table 1).

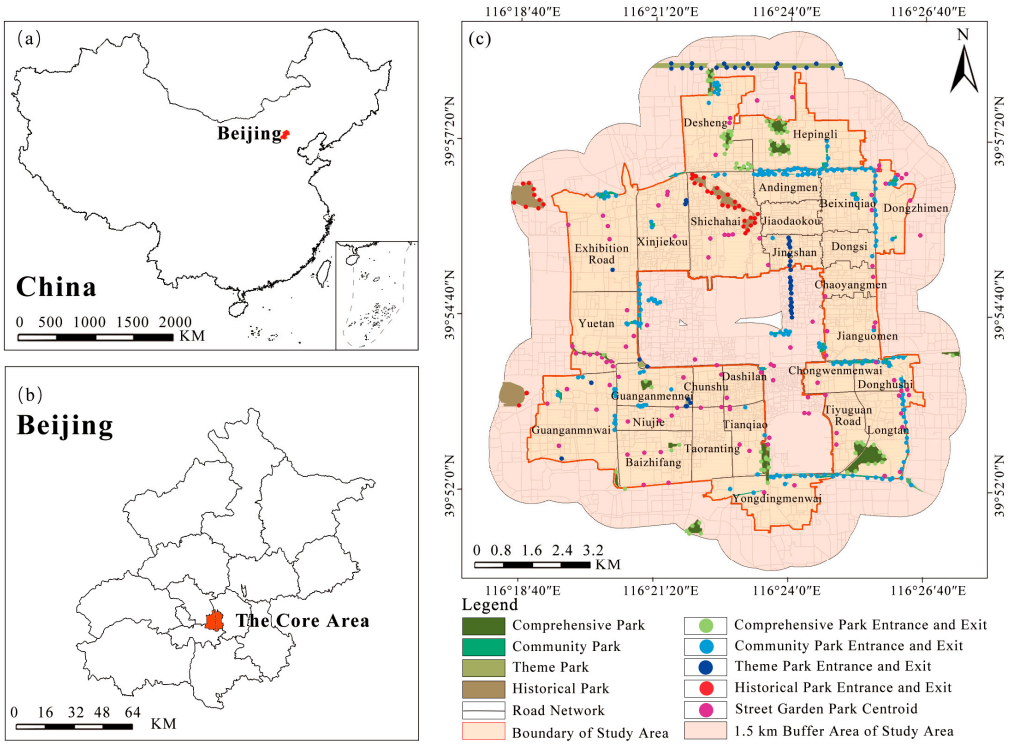


Figure 1. (**a**) Location of Beijing in China; (**b**) Location of the core area in Beijing; (**c**) Study area and distribution of subdistricts and city parks at all levels.

Table 1. Overview of different classes of urban parks in the study area.

Type	Appropriate Scale/km^2	Service Radius/m	Number	Park Description
Comprehensive park	10, 50	1500	16	Green spaces with rich contents, suitable for various outdoor activities and with comprehensive recreational and service facilities
Community park	1, 10	800	44	Green spaces with independent land use and basic recreational and service facilities, providing services for the daily activities of surrounding residents
Street garden park	0.1, 1, Width $\geq$ 12 m	300	94	Green spaces that are independent, small in scale, or diverse in shape, convenient for residents to access in the vicinity and with certain recreational functions
Historical park	—	1500	3	Green spaces that embody the representative gardening art of a certain historical period and require special protection
Theme park	—	800	9	Green spaces with specific content and form, as well as corresponding recreational and service facilities
Total	—	—	166	—

Note: The data are based on Urban Green Space Classification Standard (CJJT 85-2017), Urban Green Space Planning Standard (GB/T 51346-2019), and Beijing Park Classification and Grading Management Measures (2022 Edition).

The area of interest (AOI) data and the point of interest (POI) data of park green space entrances and exits in Beijing were obtained from the Gaode map in batch using Python. The above data were checked using the statistics of the "List of Parks in Beijing" published by the Beijing Municipal Forestry and Parks Bureau in 2022, and the missing data were supplemented with visual interpretation using BigMap18 satellite images (Figure 1c). The urban park entrance point acquisition was divided into three cases: (1) if the park area was less than 1 km^2, the park geometric center of mass coordinates was used to replace the park entrance and exit coordinates; (2) if the park area was greater than 1 km^2, and the park had a fence, the coordinates of the park entrance points were directly acquired; (3) if the park did not have a fence, the coordinates of multiple entrance points were acquired, with the distance of the interval of each entrance point not exceeding 50 m [56].

To characterize the quality of green spaces, urban park quality data were obtained through field research, and vegetation Normalized Difference Vegetation Index (NDVI) was calculated using Landsat 8 satellite images. The field research was conducted from June to August 2022, the source of the Landsat 8 satellite image data was the Geospatial Data Cloud Landsat 8 OLI-TIRS Satellite Digital Product (https://www.gscloud.cn/search (accessed on 30 October 2022)) [57], and the full names of OLI and TIRS are Operational Land Imager and Thermal Infrared Sensor, respectively. Images had a spatial resolution of 30 m × 30 m and cloud content of less than 5%. As the most vigorous plant growth in Beijing occurs from June to September, the satellite image was taken on 10 August 2020.

2.2.2. Road Network Data

The road network data of the study area in the Open Street Map (OSM) were transformed using ArcGIS Editor for OSM 10.6 plug-in, and the data were organized to obtain the road vector data supporting walking. The origin–destination(OD) cost matrix in the ArcGIS network analysis tool was used to calculate the shortest distance from the residential area to the green space patches. Based on previous studies, a topological relationship network composed of urban park entrances and exits, roads, and traffic rules was constructed to set a walking speed of 1.42 m/s [58] and an average waiting time at intersections of 30 s.

2.2.3. Demographic and Economic Data

Population size represents the potential demand for urban parks and is closely related to green space equity [59]. This study considered the residential area as the research object. We built a web-based Python crawler tool to crawl from the Lianjia website (https://hhht.lianjia.com (accessed on 30 October 2022)) to obtain data fields such as the name of the residential area, latitude and longitude, number of households, and transaction price. As of October 2022, the number of residential areas located in the study area was 1338. Based on the results of the seventh population census, the average household population in downtown Beijing was 2.31 [60], and the population of each residential area was estimated (Figure 2a). This method of measuring the spatial distribution of the population and the number of people using residential areas as a unit improves the accuracy of the population data, increasing the precision of the study results.

Urban residential price is a marketized expression of the unbalanced allocation of residential space resources, mapping the socioeconomic characteristics of different classes of social groups [61]. Therefore, this study used different house prices to characterize the spatial distribution of the economic characteristics of social groups. House prices in the study area were divided into five grades (I, II, III, IV, and V) according to the natural breakpoint method, which corresponded to the population's income level (low, medium–low, medium, medium–high, and high income, respectively), and the spatial distribution pattern of the different socioeconomic groups was calculated (Figure 2b). The principle of the natural breakpoint method is to find a set of subgroups where the differences between each subgroup are the largest but the differences within each subgroup are the smallest [62,63]. Categorizing the residential areas within the study area in this way allows for the definition of social groups at different economic levels, but it is worth noting that

what is referred to in this paper as high-income or low-income residential groups is only a relative situation within the study area, and is not relative to the Beijing or national level.

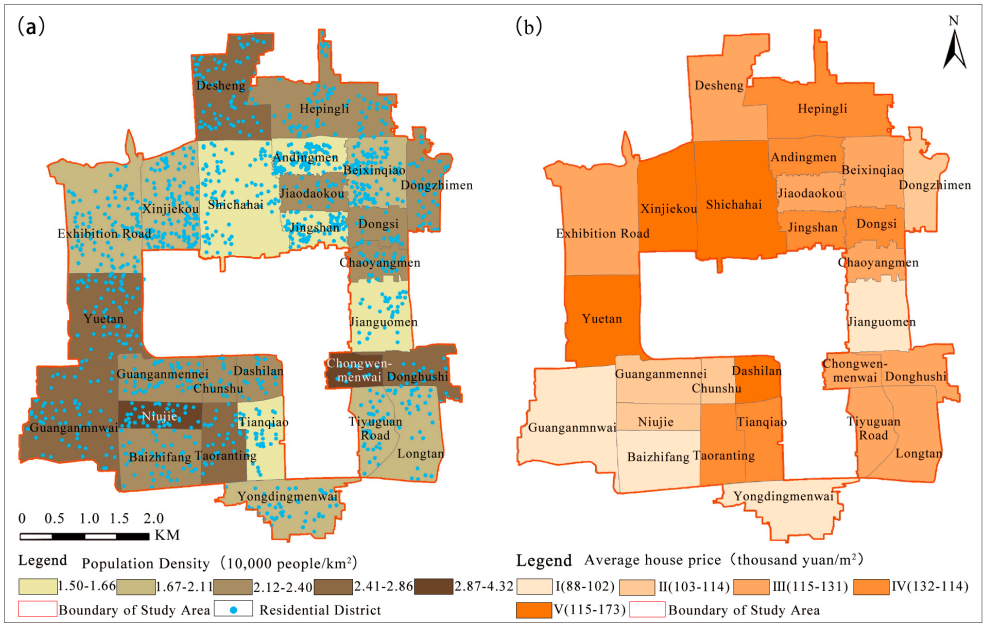


Figure 2. (**a**) Distribution of residential areas and subdistrict population density; (**b**) Average price of houses in each subdistrict.

2.3. Methods

2.3.1. Equity of the Spatial Configuration by Park Accessibility

Urban park accessibility is an important geographic parameter that measures the time or cost urban residents require to reach urban parks [64]. Considering the supply and demand factors and the decay of accessibility with distance [65], the 2SFCA method based on the Gaussian function (G) was used to calculate the accessibility of residential areas to various urban parks. To improve calculation accuracy, the travel distance from the residential area to urban parks along the road network was used instead of the straight-line distance radius of the search area.

First, the search threshold for supply point j was determined with a radius of distance d_0 centered on the supply point j. The set of demand points k falling within the search threshold was sought, and the supply–demand ratio R_j for supply point j was calculated as follows [66]:

$$R_j = \frac{S_j}{\sum j \in \left\{ d_{kj} \le d_0 \right\} G\left(d_{kj}, d_0 \right) P_k} \tag{1}$$

$$G\left(d_{kj}, d_0 \right) = \begin{cases} \frac{e^{-\frac{1}{2}\left(\frac{d_{kj}}{d_0}\right)^2} - e^{-\frac{1}{2}}}{1 - e^{-\frac{1}{2}}}, d_{kj} \le d_0 \\ 0, \; d_{kj} > d_0 \end{cases} \tag{2}$$

where S_j represents the total supply capacity of point j, the area of the park; R_j is the supply–demand ratio of point j, which represents the service capacity of the park; d_{kj} is the distance between the demand point k and the supply point j, which is expressed in terms of the length of the path; P_k is the scale of the demand point k, which is expressed in terms of the number of population in the residential area within the distance threshold $(d_{kj} \le d_0)$; and $G\left(d_{kj}, d_0 \right)$ is the distance attenuation function that takes into account spatial friction factors.

Second, each demand point i was established to search for the supply point j within the radius d_0. The decay of the Gaussian function was performed, and the supply–demand ratio R_j of all parks and green spaces city parks j was summed as the accessibility [67]:

$$A_i = \sum_{j \in \{d_{ij} \le d_0\}} G(d_{ij}, d_0) R_j \quad (3)$$

where A_i is the demand point i of the park green space urban park accessibility and represents the per capita occupancy of urban parks within the service radius, with larger values indicating better accessibility; the meaning of other indicators is the same as in Equation (1). Using the natural breakpoint method, the accessibility values were divided into five levels. Using the natural breakpoint method, it is possible to find a set of reachability groupings where the difference in reachability between each grouping is the largest, but the difference within each grouping is the smallest [62,63].

After completing the above two steps, the bivariate Moran's I spatial autocorrelation method was used to analyze the spatial autocorrelation relationship between different socio-economic groups and urban park parameters, and the geographic spatial correlation pattern between urban park parameters and housing prices was obtained. The global bivariate Moran's I measures whether there is a spatial correlation between urban park accessibility and population income level in the study area and the magnitude of the correlation. The bivariate global spatial correlation index was calculated as [68]

$$I = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} (Y_i - \overline{Y}) (Y_j - \overline{Y})}{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} \sum_{i=1}^{n} (Y_i - \overline{Y})^2} \quad (4)$$

where I is the bivariate global spatial correlation index; n is the total number of spatial units (in this case, the total number of subdistricts); w_{ij} is the spatial weight matrix; Y_i and Y_j are the values of the study variables for the ith and the jth spatial units in the study area, respectively; and Y is the average value of the study variables for all the spatial units in the core area.

The value of global Moran's I ranges $[-1, 1]$. Moran's I values greater than 0 indicate that urban park accessibility and income level are positively spatially correlated; that is, spatial units with high (low) observations are surrounded by spatial units with high (low) observations. Larger values indicate clearer clustering. Values greater than or equal to 0.2 indicate high clustering, values less than 0 indicate a negative correlation, suggesting that units with high (low) observations are clustered with those with low (high) observations clustered together, and values of 0 indicate no correlation and no spatial autocorrelation. The local bivariate Moran's I reflects the local spatial correlation within geographic units and can be used to explore the spatial heterogeneity within the study area through Local Indicators of Spatial Association (LISA) plots. At a certain level of significance, LISA plots illustrate four types of relationships between the urban park accessibility values of a given location and income levels of the population in neighboring locations. This includes two types of positive intercorrelation clusters—high–high (HH) and low–low (LL)—and two types of negative spatial correlation clusters—low–high (LH) and high–low (HL) [56].

2.3.2. Equity of Spatial Allocation by Park Area

The size of the park area is an important parameter for measuring the service level of parks. Based on the results of the accessibility analysis, the total park area available within 1.5 km of each residential area was calculated separately. Using the total park area available within 1.5 km of the residential area as the main variable, the spatial autocorrelation analysis method was used to examine the geospatial matching pattern between the total park area and different socioeconomic groups, to analyze the spatial correlation between the two, and calculate the difference in the total park area available to residential areas with different

economic levels. We used the non-parametric test method to characterize the fairness of the social spatial allocation of the park area [69,70].

2.3.3. Equity Evaluation of Quality of Spatial Configuration of Urban Parks

Based on the National Garden City Series Standards [71] and the Beijing Gardening and Greening Special Plan (2018–2035) [72], this study evaluated the quality of urban parks in three dimensions: landscape ecology (LE), recreation and entertainment (RE), and cultural education (CE). We quantified the indicators to facilitate the comparison between individual green spaces (Table 2).

Table 2. Urban park quality rating form.

Evaluation Dimension	Evaluation Elements	Standard	Scoring Methodology
Landscape Ecology (LE)	Vegetation	Scored using NDVI	Derived from NDVI
	Animal	Small mammals, birds, fish, reptiles, amphibians, insects	Category Count
	Ecological Facility	Water-harvesting and drainage facilities, such as permeable paving, and stormwater treatment devices	Presence score
	Water Feature Elements	Rivers, lakes, fountains, pools, etc.	Presence score
Recreation and Entertainment (RE)	Sports and Fitness Facilities	Fitness plaza, fitness equipment, jogging track, ballfields, children's facilities	Category Count
	Rest and Leisure Facilities	Rest seats, pavilions, chess tables, tea rooms, cafeterias	Category Count
	Amenity	Restrooms, newsstands, convenience stores, vending machines	Category Count
	Security Facility	Lighting, cameras, first aid access, barrier-free facilities	Category Count
	Access Facility	Parking lots	Presence score
Cultural Education (CE)	Cultural Educational Facilities	Cultural heritage sites; memorials; exhibition halls; science and technology museums; cultural, educational, and popular science exhibition plaques	Category Count
	Landmark	Sculptures; murals; monuments; or landmarks of historical, artistic, or educational significance in line with the cultural atmosphere of Beijing	Presence score
	Radio and Television Broadcasting Communication Coverage Facilities	Multimedia screens, broadcast sound	Category Count
	Ancient and Famous Tree	/	Presence score

Scoring methods were categorized into three types: element, category count, and presence [41]. Vegetation was scored using the NDVI, reflecting vegetation growth, and vegetation cover [73]. The NDVI ranges from −1 to 1. Negative values indicate clouds, water, and snow, which are highly reflective of visible light; 0 indicates rocky and bare soil; and positive values indicate vegetation cover, which increases with more cover. The summer NDVI values were calculated for each park area (after removing the water areas),

and the NDVI range was divided into five scoring intervals corresponding to 0, 1, 2, 3, and 4 points from smallest to largest. The water feature elements were scored individually in the landscape ecology dimensions to avoid canceling out the scores of the green spaces in the NDVI [74]. For certain amenity elements, scores were given based on the number of categories; for instance, parks with restrooms, newsstands, and convenience stores were given a score of 3 for the amenity element. For elements other than those mentioned above, presence (1) or absence (0) was used as a judgment criterion. Finally, the element scores were combined to obtain the total score for the three dimensions of park quality. The scores were further normalized to obtain the normalized LE (NLE), normalized RE (NRE), and normalized CE (NCE) values, which enhanced the comparability of the calculation results.

Total score (TS) was the sum of the NLE, NRE, and NCE values and represented the overall quality of the urban parks. The comprehensive quality score of each park was divided into five categories according to the score value. Based on the results of the accessibility analysis, the number of high-quality parks available within 1.5 km of each residential area and the average quality of the parks within 1.5 km of walking distance were calculated. We used the mean value of park quality within a 1.5 km walking distance as the main measurement variable of fairness. We utilized spatial autocorrelation analysis to examine the geospatial matching pattern and spatial correlation between the mean value of park quality and different socioeconomic groups. Non-parametric tests were used to analyze the comparative differences in park quality levels of the residential subdistricts with different economic levels.

3. Results

3.1. Equity of Urban Park Accessibility Space Allocation

As shown in Table 3, the proportions of residential areas within a distance of 0.5, 1, and 1.5 km from urban parks were 41.40%, 82.73%, and 94.54%, respectively, indicating that the accessibility of residential areas in the study area to the city park was better in general. However, there were significant differences in spatial configurations (Figure 3a,b), and the spatial distribution of accessibility to the city park of residential areas in each subdistrict was relatively similar to the distribution pattern of residential neighborhoods. The spatial distribution of residential accessibility to urban parks in each subdistrict was similar to that of residential neighborhood house prices. The spatial autocorrelation analysis of the bivariate spatial autocorrelation between residential housing prices and urban park accessibility yielded a Moran's I value of 0.38, indicating a significant spatial clustering relationship. HH clusters were mainly located in Desheng Subdistrict, Shichahai Subdistrict, Andingmen Subdistrict, Xinjiekou Subdistrict, and the surrounding subdistricts, whereas LL clusters were mainly located in Guang'anmenwai Subdistrict, Jianguomen Subdistrict, Dongzhimen Subdistrict, and their surrounding subdistricts.

Table 3. Distance of residential areas from parks and the economic level of neighborhoods.

Distance–Cost (km)	Time–Cost (min)	Number of Residential Areas					Total/Percentage
		Low Income	Low–Middle Income	Middle Income	Middle–High Income	High Income	
≤0.5	≤6	51	81	209	145	68	554/41.40%
0.5–1.0	6–12	127	102	159	128	37	553/41.33%
1.0–1.5	12–18	46	28	50	34	0	158/11.81%
>1.5	>18	39	34	0	0	0	73/5.46%
Total		263	245	418	307	105	1338/100%

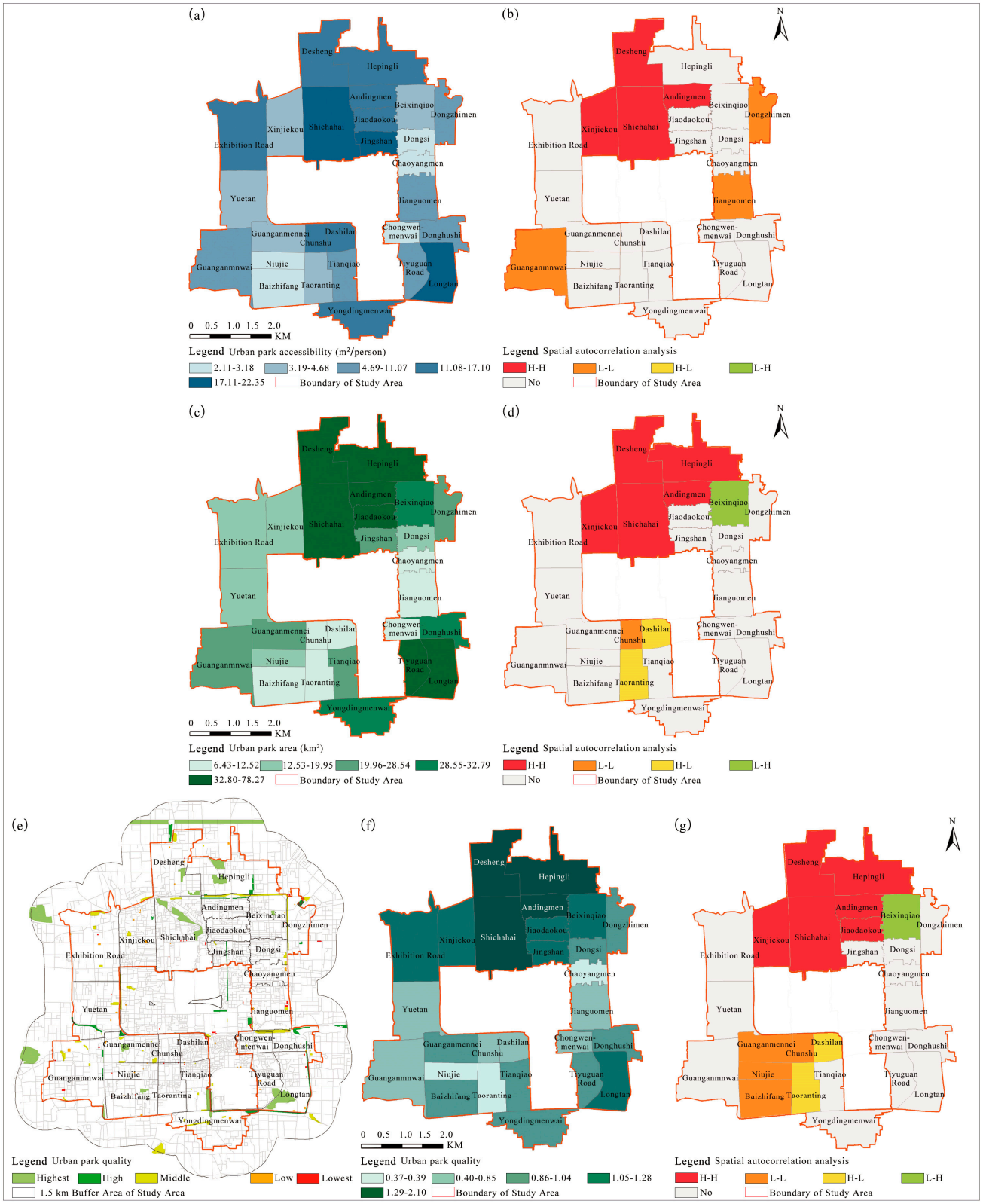


Figure 3. (**a**) Distribution of average accessibility of residential areas to urban parks by subdistrict; (**b**) Spatial autocorrelation analysis of socioeconomic level and accessibility of urban parks; (**c**) Total park area available within 1.5 km of residential areas; (**d**) Spatial autocorrelation analysis between socioeconomic levels and urban park area available within 1.5 km of residential areas; (**e**) Grading of urban park quality; (**f**) Mean value of park quality within 1.5 km of residential neighborhoods in each subdistrict; (**g**) Spatial autocorrelation analysis of socioeconomic level and park quality distribution.

Based on previous studies, 1.5 km is an acceptable walking distance, and 0.79 km is an optimal walking distance [51]. As shown in Figure 4, the average distances to urban parks for medium-, medium–high-, and high-income neighborhoods were less than 0.79 km (0.55, 0.57, and 0.39 km, respectively), whereas low- and medium–low-income neighborhoods were further from the nearest park (0.80 and 0.83 km, respectively). Conversely, medium-, medium–high-, and high-income residential areas had higher urban park accessibility scores and higher mean and median values than those of low- and medium–low-income residential areas. This revealed a significant difference in the distance to urban parks and accessibility scores between residential areas with different incomes. Medium-, medium–high-, and high-income residential areas had better accessibility to urban parks, whereas low- and medium–low-income groups had worse accessibility. Therefore, the spatial configuration of accessibility to urban parks in the study area exhibited significant environmental injustices.

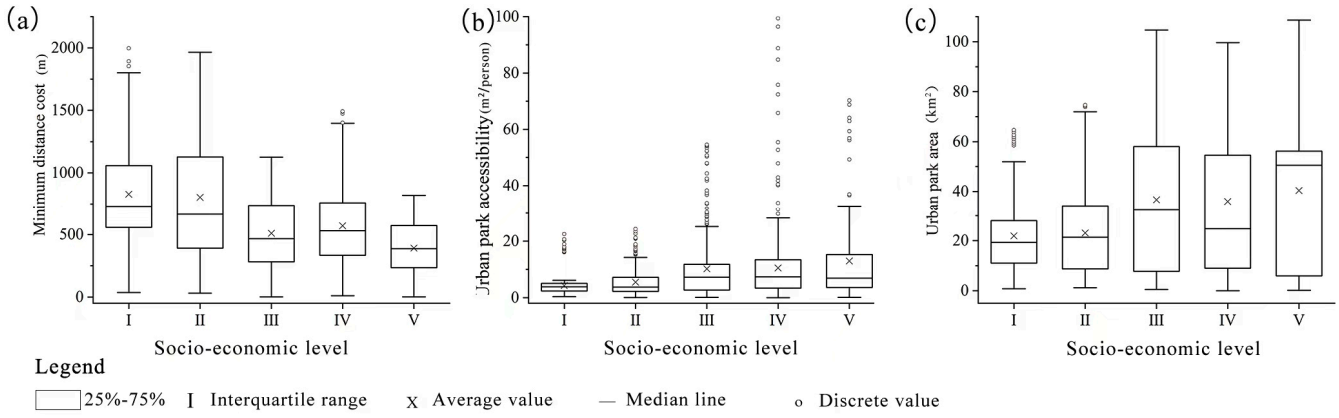


Figure 4. Residential areas with different economic levels. (**a**) Minimum distance to reach parks; (**b**) Urban park accessibility; (**c**) Total area of accessible parks within 1.5 km.

3.2. Equity of Spatial Allocation by Park Area

As shown in Figure 3c,d, the subdistricts with larger total urban park areas within 1.5 km of the residential areas in the study area (with an area of more than 28.55 km^2) were mainly in the Shichahai, Desheng, Hepingli, Andingmen, and Jiaodaokou Subdistricts. Large-scale green parks were mainly located in these subdistricts or adjacent districts, and the distribution pattern was similar to that of the high-income residential areas. Conversely, the residential areas with smaller total urban park areas were mainly located in the Chunshu Subdistrict and its west side subdistricts, which were concentrated in low-income residential areas. The Moran's I value obtained from the bivariate spatial autocorrelation analysis of residential area house price and access to the total area of urban parks within 1.5 km of the residential neighborhoods was 0.29. This revealed a spatial distribution pattern of high park area supply in high-income residential neighborhoods and low park area supply in low-income residential neighborhoods in the study area. HH-clustered residential neighborhoods were mainly located around Shichahai Park, Qing Nian Hu Park, Beibinhe Park, and other large green parks. LL-cluster residential areas were mainly located in areas lacking large free parks. HL-cluster residential areas were located in the Taoranting Subdistrict and Dashilan Subdistrict. LH-cluster residential areas were located in the Beixinqiao Subdistrict.

There were large supply differences in the distribution of accessible urban parks within 1.5 km by income residential areas, with high-income residential areas having an average of 40.44 km^2 of total accessible urban parks and 1.8 times that of low-income residential areas (21.94 km^2; Figure 4). Medium-income residential neighborhoods had the most accessible urban park area (40.90 km^2), 1.9 times more than that in low-income neighborhoods. This indicated that the spatial allocation of accessible urban parks within 1.5 km was

inequitable among residential areas with different incomes, revealing a significant pattern of environmental injustice.

3.3. Equity of Park Quality

The 166 urban parks were scored on LE, RE, and CE, and the scores were normalized to 0–1 for comparison (Table 4). The total score and mean value of RE were the highest, LE was the second highest, and CE was the lowest. The standard deviation and variance of the dimensions indicated differences in the quality of the urban parks. In addition, there were significant positive correlations between the scores for LE, RE, and CE. To further elaborate on these relationships, the data were analyzed in relation to other attributes of urban parks. The results demonstrated a significant positive correlation between all the three-dimensional scores and the park area (Table 5), indicating that the quality of large parks was better than that of medium-sized parks and that the quality of medium-sized parks was better than that of small-sized parks.

Table 4. Urban park quality scores and correlation statistics.

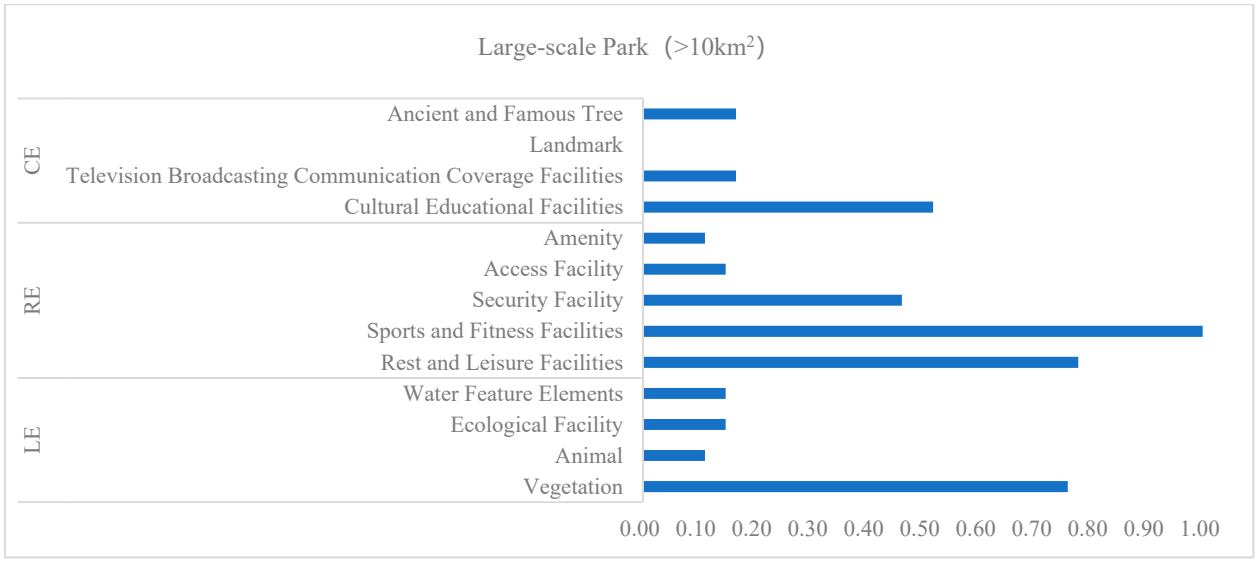
	N	Minimum Value	Maximum Value	Total	Average Value	SD	Variance	Relevance to Landscape Ecological	Relevance to Park Area
Landscape Ecology (LE)	166	0	1.00	60.61	0.37	0.27	0.07	1.000 **	0.546 **
Recreation and Entertainment (RE)	166	0	1.00	65.33	0.39	0.26	0.07	0.659 **	0.630 **
Cultural education (CE)	166	0	1.00	42.36	0.26	0.32	0.11	0.635 **	0.575 **

** $p < 0.01$.

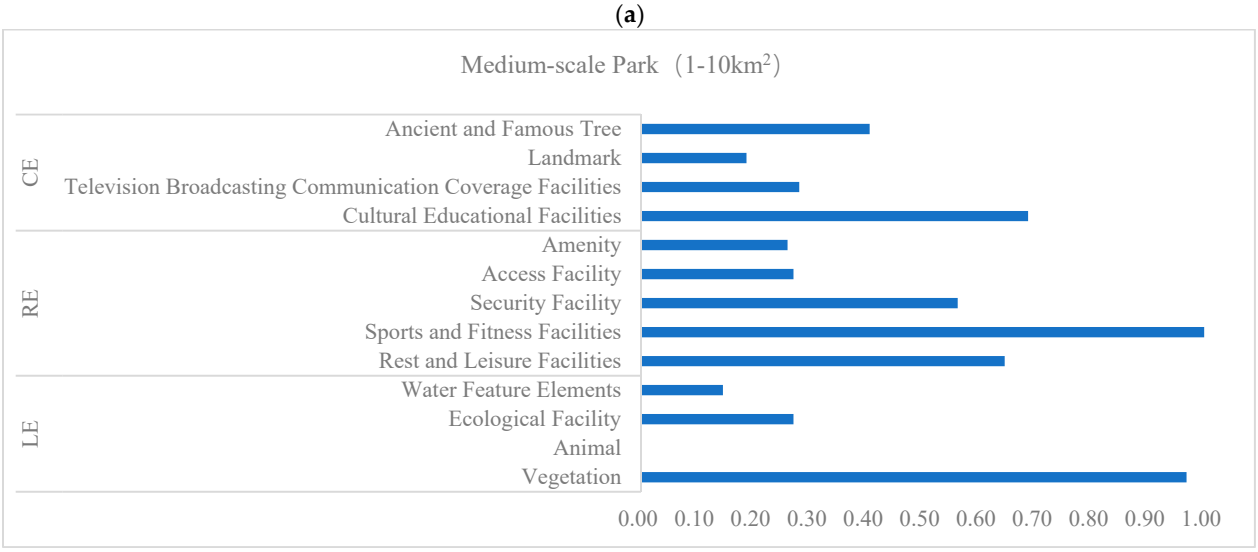
Table 5. Statistics on the quality score of urban parks of different sizes.

	Mean for LE	Mean for RE	Mean for CE
Small-scale parks (<1 km^2)	0.18	0.27	0.21
Medium-scale parks (1–10 km^2)	0.41	0.51	0.55
Large-scale parks (>10 km^2)	0.67	0.77	0.65

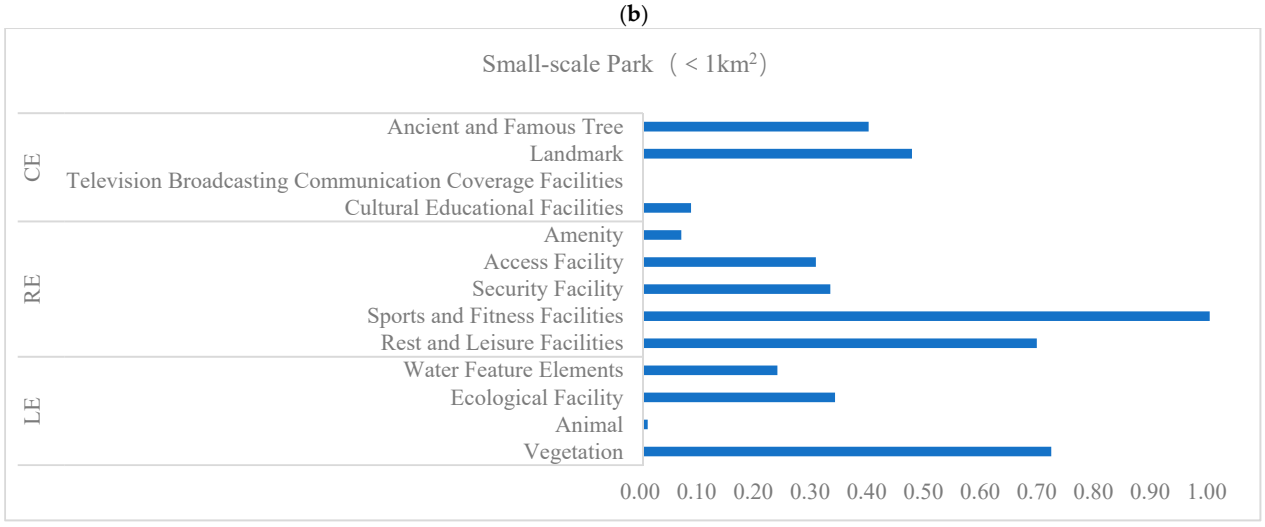
The statistical results are shown in Figure 5, with higher scores in the RE of urban parks of all sizes for sports and fitness facilities, rest and leisure facilities, and security facilities; lower scores for access facilities and amenities in large parks; and lower scores for amenities in small parks. Vegetation scored the highest in the LE dimension for all three park sizes, and animal elements were the least abundant in medium and small parks. In the CE dimension, large- and medium-sized parks had the highest scores for cultural and educational facilities, lowest scores for landmarks, highest scores for landmarks in small parks, and lowest scores for radio and television broadcasting communication coverage facilities.



(**a**)



(**b**)



(**c**)

Figure 5. (**a**) Normalized values of the total scores of various quality evaluation factors for large-scale urban parks; (**b**) Normalized values of the total scores of various quality evaluation factors for medium-scale urban parks; (**c**) Normalized values of the total scores of various quality evaluation factors for small-scale urban parks.

The quality grades of the parks are shown in Table 6 and Figure 3e; 166 were high- and very-high-quality urban parks, mainly distributed in the Shichahai Subdistrict, Desheng Subdistrict, Andingmen Subdistrict, Hepingli Subdistrict, and Longtan Subdistrict. The spatial distribution of urban parks in the study area was significantly inequitable (Figure 3f,g), and the mean value of urban parks within 1.5 km of the residential area showed a pattern of high values in the north and low in the south. The spatial autocorrelation analysis yielded a value of 0.41 for Moran's I, which indicated a significant distribution of agglomerations (HH clusters were distributed in the vicinity of high-quality parks in the form of clusters, whereas LL clusters were distributed in the areas lacking large parks). Medium and low agglomerations were distributed in areas lacking large parks, and neighborhoods with medium income and above had higher-quality urban parks. Low-income neighborhoods had lower quality urban parks, indicating an inequitable distribution of urban park quality in the study area.

Table 6. Classification of park quality level ratings.

Urban Park Quality Grade	Number	Representative Urban Park
Highest (top 10%)	17	Youth Lake Park, Liuyin Park
High (top 20%)	17	North Second Ring Road City Park, Ditanyuanwaiyuan Park
Middle (top 50%)	50	Yijun Park, Taoyuan Park
Low (top 75%)	41	Tongxin Park, Baiguanglu Park
Lowest (bottom 25%)	41	Niujie Park, Jinyuchi Park
Total	166	-

As shown in Figure 6, the quality of green space in high-income residential areas able to reach neighboring parks was significantly better than that in low-income residential areas, with the quartiles of the former being significantly larger than those of the latter. The mean value (1.45) was 1.5 times that of the latter (0.99). Medium–high- and high-income residential areas had access to an average of 1.39 and 1.45 high-quality parks, and the mean values of the distances to high-quality parks were 0.98 and 0.87 km, respectively. The average number of high-quality parks accessed by low- and medium–low-income neighborhoods were 0.99 and 1.06, respectively, and the average distance to high-quality parks was 1.26 and 1.08 km, respectively. This indicated that higher-income neighborhoods were near more parks that were closer and of higher quality, whereas lower-income neighborhoods had fewer parks that were farther and of lower quality, which shows a significant pattern of environmental injustice in the study area.

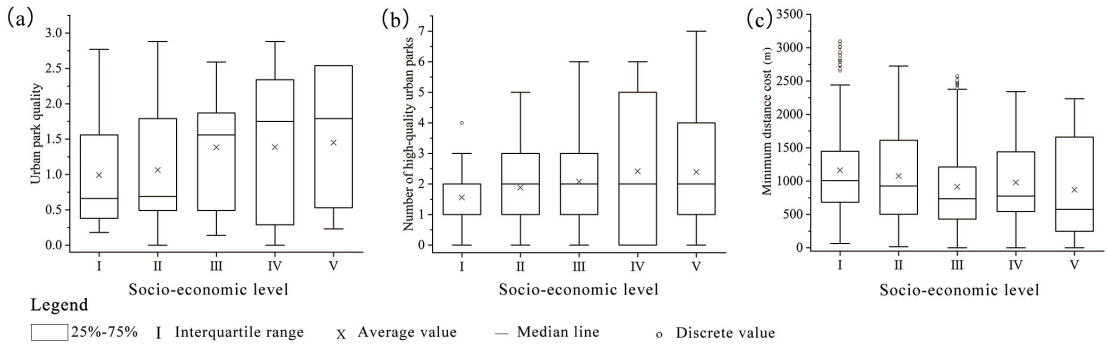


Figure 6. Parks within 1.5 km of residential areas with different economic levels. (**a**) The quality of accessible urban parks; (**b**) Number of high-quality parks; (**c**) Minimum distance to high-quality parks.

3.4. Comprehensive Evaluation of Spatial Allocation Fairness

As shown in Table 7, residential areas with moderate and high incomes have better accessibility, larger areas, and higher-quality urban parks, indicating a pattern of environmental injustice in evaluating the fairness of the allocation of urban parks in terms of accessibility, area, and quality. Moreover, there were significant differences in the spatial allocation of fairness in each parameter. The accessibility value of parks around high-income residential areas and shortest distance scores were 3.0 and 2.1 times higher, respectively, than those of low-income residential areas. The difference in the area of parks within 1.5 km of residential areas was the second highest (this parameter was 1.8 times higher in high-income compared to low-income areas). The difference in the minimum distance to reach high-quality urban parks in residential areas of different incomes was relatively small; however, few parks were within 0.79 km of low- and medium–low-income residential areas. High-quality parks were unavailable within 1.00 km, restricting access to ecosystem services provided by parks within a suitable distance.

Table 7. Characteristics of the spatial distribution of green space in residential areas of different socioeconomic levels.

Socioeconomic Level	Minimum Distance to Park (km)	Accessibility (m^2/Person)	Total Park Area (km^2)	Number of High-Quality Parks	Park Quality	Minimum Distance to High-Quality Park (m)
Low	0.83	4.31	21.94	1.56	0.99	1.26
Low–middle	0.80	5.50	23.08	1.89	1.06	1.08
Middle	0.55	14.45	40.90	2.32	1.46	0.92
Middle–high	0.57	10.54	35.99	2.41	1.39	0.98
High	0.39	13.00	40.44	2.39	1.45	0.87
p value	0.00	0.00	0.00	0.00	0.00	0.00

4. Discussion

4.1. Spatial Heterogeneity of Urban Park Accessibility, Accessible Area, and Quality

Due to the special characteristics of the historical development of Beijing's core area, some large parks are concentrated, such as Shichahai Park, Youth Lake Park, Beibinhe Park, and Longtan Park. These large parks tend to have a more complete quality of service, and at the same time, the subdistricts in which these parks are located have a medium or low population density, which is the reason why areas with high accessibility, obtainable park area, and high-quality parks are clustered in the Shichahai Subdistrict, Hepingli Subdistrict, Longtan Subdistrict, and its neighboring subdistricts (Figure 3c,d). Other areas, such as Niujie Subdistrict and its neighboring subdistricts, have higher population density and less green space and small areas, while the quality of small parks is worse than that of large parks. Therefore, these subdistricts have lower accessibility to parks, smaller access to urban park areas, and fewer chances to access high-quality parks.

In terms of quality concerns, medium- and large-scale parks have better planted landscapes and richer facilities and are of better quality than spatially compact small-scale urban parks. The total scores for the different dimensions of park quality were, in descending order, RE > LE > CE (Table 4). RE is the most important park quality evaluation dimension. Sports and fitness facilities, rest and leisure facilities, and security facilities are present in most parks. This indicates that the RE function of parks is an important factor for planners to consider and is better managed in urban parks in the core area of Beijing. However, some large parks have insufficient parking and lack newsstands, convenience stores, and other facilities, and some small parks lack restrooms, vending machines, and other facilities. In the LE dimension, vegetation is the main focus of park construction; animal landscapes are less common in small and medium-sized urban parks, likely due

to funding, maintenance, and habitat environment limitations. In the CE dimension, the core area, which is a concentrated area of cultural heritage in Beijing, has many parks with ancient and famous trees. Some parks in the core area are outdated; therefore, not all parks, especially small ones, had radio and television broadcasting and communication coverage facilities.

4.2. Socioeconomic Differentiation and Equity

Urban park services in Beijing's core area are clustered towards high-income areas, with middle-income and higher groups enjoying the most prominent green space advantages, access to higher green space accessibility, shorter distance to parks, and higher park quality. Low-income groups have lower levels of urban park services, similar to the situation in many Western cities [22,75]. This may be because housing and land prices are easily influenced by the surrounding urban parks [76,77], and the ability and willingness of high-income groups to pursue high levels of service green space is stronger than that of low-income groups, which further exacerbates the phenomenon of social differentiation in green space use.

However, unlike the results of other studies, the middle-income group rather than the high-income group has the best accessibility, the largest area of parks accessible within 1.5 km, and a high park quality score in this study. This may be because some higher-income subdistricts in the study area, such as the Dashilan Subdistrict, Taoranting Subdistrict, Yuetan Subdistrict, and Xinjiekou Subdistrict, are located in the heart of the core area. They are near state organizations and units, cultural relics, and monument protection zones, as well as commercial districts, such as Financial Street and Xidan, and thus had high house prices. These subdistricts did not have large free urban parks and had a weak park supply capacity, thus decreasing the average level of park services available to the high-income group.

4.3. Improvement in Green Space Equity in High-Density Urban Areas

This study examined a high-density urban area characterized by early development, a high degree of construction, high population density, and limited land resources in the urban area. This does not provide space for the construction of large green areas. The Beijing "14th Five-Year Plan" for Major Infrastructure Development states that the coverage rate of urban parks within a 500 m service radius should reach 90% [78]. However, only 41.40% of the residential areas met this goal. This study identified future planning directions for governments and planners to improve the equity of green spaces.

Based on the above research, we believe the equity-enhancement strategy for urban parks in high-density urban areas should start from two aspects. First, the accessibility and area equity of urban parks should be improved by adding new gardens. Street gardens have the characteristics of small scale, flexible shape, and certain ecological recreational functions [79,80]. New playgrounds can allow residents to reach urban parks faster, which improves the accessibility of urban parks and increases their total area. Considering the land scarcity in high-density urban areas, park-greening methods cannot be limited to ground greening. In areas where parks are extremely scarce, roof greening, wall greening, and greening under viaducts can be used to build three-dimensional parks and improve residents' access to greenery. The second direction is to optimize the stock—improving the quality and equity of urban parks by upgrading the quality of existing parks. Improvement in park quality can increase the attractiveness of the park itself to residents and help meet their needs. The quality evaluation system of urban parks proposed in this study can be used to determine the deficiencies of urban parks in terms of recreational, ecological, and cultural facilities, helping improve quality.

This study identified the nine subdistricts in the study area that had the worst urban park accessibility and area equity: Dongsi, Chaoyangmen, Jianguomen, Chongwenmenwai, Niujie, Baishifang, Chunshu, Taoranting, and Dazhalan. According to the land status of these subdistricts, the form of a small green space can be flexibly determined according

to the type and size of the space, and the design of small gardens can be conducted in a variety of ways, such as climbing vegetation on the wall, hanging vegetation in the air, embellishing vegetation on the window sill, and planting vegetation on the ground. The three-dimensional greening of the window and balcony can take the form of attaching wall-type, overhanging-type, rattan trellis-type, trellis-type, planter-type, and other types of greenery. Roof greening can be conducted in accordance with the roof condition to increase the rate of green vision.

The distribution pattern of park quality in the study area was inequitable. This study identified the nine subdistricts with the worst quality in the study area: Chaoyangmen, Niujie, Taoranting, Yuetan, Guang'anmenwai, Chunshu, Dashilar, Chongwenmenwai, and Jianguomen. According to the park quality evaluation results and combined with the park situation, the LE dimension quality scores of large-, medium-, and small-sized parks were relatively similar. Planners should continue to strengthen investment in the maintenance of vegetation, water features, and ecological facilities; optimize the vegetation structure; create habitat conditions that increase complexity and diversity; and avoid the invasion of exotic species [81] to create conditions for the protection of animal diversity. For large- and medium-sized parks in the subdistricts, development should focus on convenience facilities, access facilities, and landmark structures. Planners should improve the quality of the RE dimension by adding convenience facilities, such as newsstands and convenience stores, and planning three-dimensional parking buildings. Planners should improve the quality of the CE dimension by adding new sculptures, murals, monuments, and other landmark structures in line with the cultural atmosphere of the study area. For small parks, the quality of the RE dimension can be improved by adding convenience facilities, such as restrooms and vending machines. The quality of the cultural and educational dimensions can be improved by adding radio and television broadcasting and communication coverage facilities, such as multimedia screens, radio, and sound broadcasting, and cultural and educational facilities, such as cultural, educational, and popular science exhibits.

4.4. Innovations, Limitations, and Future Research

The innovations of this paper are: (1) in terms of research scale, the subdistrict is used as a unit to carry out refined research; (2) in terms of exploring dimensions, the accessibility, area, and quality of parks and green spaces are explored from three aspects, so that the evaluation dimensions are more comprehensive; (3) in terms of data precision, the population is estimated using the number of households in the residential area and the average number of people per household in Beijing, and the distribution of the population in the space is determined using the data of residential areas from the Lianjia website, which that can more realistically reflect the population size throughout its distribution in space, which is better than the census data used in previous studies; (4) in terms of calculation methods, this study used the actual travel distance from the residential area to the city park along the road network, instead of the radius of the straight line distance of the search area, which is more in line with the travel trajectory of the residents; (5) in terms of conclusions, we analyzed the accessibility of the park green space in the study area and the area and the quality of the worst subdistricts, combined with the evaluation results of park green space quality, government policy orientation, related literature and professional experience, etc., to propose a strategy to improve the equity of high-density urban park green space, which is of some reference significance for improving the equity of high-density urban park green spaces in other countries with similar situations.

This study had some limitations. Due to the difficulty of obtaining data on residents' income, this study only used the average house price of the residential area to characterize the socioeconomic differences of the residential area and the social characteristics of the population. Thus, we were unable to consider the gap between rich and poor residents in the same residential area, which may have an impact on the study results. In addition, factors such as age, gender, and occupation are closely related to the income of urban residents. Future research should consider these characteristics to more accurately measure

the socioeconomic level of the population. Moreover, this study assumed that the residents preferentially use the nearest urban parks and walk the shortest paths to their residential neighborhoods, and the personalized choices of the parks and paths of arrival by the residents were not considered. Furthermore, some incompleteness may have occurred in the selection of the green space quality evaluation indicators, and different indicators could affect the assessment of the quality of the green space. Future research should use a questionnaire survey to clarify user data and urban park use by different social groups. Future studies should build a subjective and objective combination of park quality evaluation systems and aim to optimize and improve the quality of green spaces, promote social equity, and enhance public health.

5. Conclusions

Urban parks are becoming increasingly important in cities for the health and wellbeing of residents, and green space inequity is a pressing issue in high-density cities. This study used 27 subdistricts in Beijing's core area with a population density of more than 15,000 people/km^2 as an example and explored the inequality of the urban green space environments from three dimensions: urban park accessibility, area, and quality. We used multi-source big data. We found that urban park accessibility, area, and quality had a spatial pattern of high in the north and low in the south, and underserved areas were mainly located in Chunshu, Niujie, Baipiefang, Taoranting, and Chaoyangmen Subdistricts. In addition, we observed a spatial mismatch in accessibility, area, and quality of parks available for social groups at different economic levels. The average value of public park services available to subdistricts with medium and high economic levels was higher than those with low economic levels. Moreover, this study constructed a set of replicable evaluation systems for urban park accessibility, area, and quality; used quantitative indicators to measure the service level of parks; and proposed targeted suggestions for improving the equity of urban parks. These findings could provide powerful support for the renewal of urban parks in other high-density cities.

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References

1. Jennings, V.; Larson, L.; Yun, J. Advancing sustainability through urban green space: Cultural ecosystem services, equity, and social determinants of health. *Int. J. Environ. Res. Public Health* **2016**, *13*, 196. [CrossRef] [PubMed]
2. Maas, J.; Verheij, R.A.; de Vries, S.; Spreeuwenberg, P.; Groenewegen, P.P. Green space, urbanity, and health: How strong is the relation? *J. Epidemiol. Community Health* **2006**, *60*, 587–592. [CrossRef] [PubMed]
3. Van den Berg, A.E.; Maas, J.; Verheij, R.A.; Groenewegen, P.P. Green space as a buffer between stressful life events and health. *Soc. Sci. Med.* **2010**, *70*, 1203–1210. [CrossRef] [PubMed]
4. Chiesura, A. The role of urban parks for the sustainable city. *Landsc. Urban Plan.* **2004**, *68*, 129–138. [CrossRef]

5. Richardson, E.A.; Pearce, J.; Mitchell, R.; Kingham, S. Role of physical activity in the relationship between urban green space and health. *Public Health* **2013**, *127*, 318–324. [CrossRef] [PubMed]
6. Zheng, Z.; Shen, W.; Li, Y.; Qin, Y.; Wang, L. Spatial equity of park green space using KD2SFCA and web map API: A case study of Zhengzhou, China. *Appl. Geogr.* **2020**, *123*, 102310. [CrossRef]
7. Brownson, R.C.; Jones, D.A.; Pratt, M.; Blanton, C.; Heath, G.W. Measuring physical activity with the behavioral risk factor surveillance system. *Med. Sci. Sports Exerc.* **2000**, *32*, 1913–1918. [CrossRef]
8. Lachapelle, U.; Pinto, D.G. Longer or more frequent walks: Examining the relationship between transit use and active transportation in Canada. *J. Transp. Health* **2016**, *3*, 173–180. [CrossRef]
9. Wende, H.E.W.; Zarger, R.K.; Mihelcic, J.R. Accessibility and usability: Green space preferences, perceptions, and barriers in a rapidly urbanizing city in Latin America. *Landsc. Urban Plan.* **2012**, *107*, 272–282.
10. Plieninger, T.; Kizos, T.; Bieling, C.; Le Dû-Blayo, L.; Budniok, M.-A.; Bürgi, M.; Crumley, C.L.; Girod, G.; Howard, P.; Kolen, J.; et al. Exploring ecosystem-change and society through a landscape lens: Recent progress in European landscape research. *Ecol. Soc.* **2015**, *20*, 5. [CrossRef]
11. Conrad, E.; Cassar, L.; Jones, M.; Eiter, S.; Izaovičová, Z.; Barankova, Z.; Christie, M.; Fazey, I. Rhetoric and Reporting of Public Participation in Landscape Policy. *J. Environ. Policy Plan.* **2011**, *13*, 23–47. [CrossRef]
12. Conrad, E.; Christie, M.; Fazey, I. Is research keeping up with changes in landscape policy? A review of the literature. *J. Environ. Manag.* **2011**, *92*, 2097–2108. [CrossRef] [PubMed]
13. Oscilowicz, E.; Anguelovski, I.; Garcia-Lamarca, M.; Cole, H.V.S.; Shokry, G.; Perez-del-Pulgar, C.; Arguelles, L.; Connolly, J.J.T. Grassroots mobilization for a just, green urban future: Building community infrastructure against green gentrification and displacement. *J. Urban Aff.* **2023**. [CrossRef]
14. Haase, A.; Koprowska, K.; Borgstrom, S. Green regeneration for more justice? An analysis of the purpose, implementation, and impacts of greening policies from a justice perspective in Lodz Stare Polesie (Poland) and Leipzig?s inner east (Germany). *Environ. Sci. Policy* **2022**, *136*, 726–737. [CrossRef]
15. Zhou, Q.Q.; van den Bosch, C.C.K.; Chen, Z.G.; Wang, X.Y.; Zhu, L.Y.; Chen, J.R.; Lin, Y.B.; Dong, J.W. China's Green space system planning: Development, experiences, and characteristics. *Urban For. Urban Green.* **2021**, *60*, 127017. [CrossRef]
16. Zhou, Q.Q.; Chen, J.R.; van den Bosch, C.C.K.; Zhang, W.B.; Zhu, L.Y.; Vera, Y.M.R.; Dong, J.W. Constructing an Aims-Indicators-Methods framework for Green Space System Planning in China. *Urban For. Urban Green.* **2022**, *67*, 127437. [CrossRef]
17. Li, Z.; Liang, Z.; Feng, L.; Fan, Z. Beyond Accessibility: A Multidimensional Evaluation of Urban Park Equity in Yangzhou, China. *ISPRS Int. J. Geo-Inf.* **2022**, *11*, 429. [CrossRef]
18. Guo, R.; Song, X.Y.; Li, P.R.; Wu, G.M.; Guo, Z.L. Large-Scale and Refined Green Space Identification-Based Sustainable Urban Renewal Mode Assessment. *Math. Probl. Eng.* **2020**, *2020*, 2043019. [CrossRef]
19. Dai, D. Racial/ethnic and socioeconomic disparities in urban green space accessibility: Where to intervene? *Landsc. Urban Plan.* **2011**, *102*, 234–244. [CrossRef]
20. Wolch, J.R.; Byrne, J.; Newell, J.P. Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. *Landsc. Urban Plan.* **2014**, *125*, 234–244. [CrossRef]
21. Chen, Y.; Yue, W.Z.; La Rosa, D. Which communities have better accessibility to green space? An investigation into environmental inequality using big data. *Landsc. Urban Plan.* **2020**, *204*, 103919. [CrossRef]
22. Rigolon, A. Parks and young people: An environmental justice study of park proximity, acreage, and quality in Denver, Colorado. *Landsc. Urban Plan.* **2017**, *165*, 73–83. [CrossRef]
23. Rigolon, A. A complex landscape of inequity in access to urban parks: A literature review. *Landsc. Urban Plan.* **2016**, *153*, 160–169. [CrossRef]
24. Hoffimann, E.; Barros, H.; Ribeiro, A.I. Socioeconomic inequalities in green space quality and accessibility-evidence from a southern european city. *Int. J. Environ. Res. Public Health* **2017**, *14*, 916. [CrossRef] [PubMed]
25. Wang, D.; Brown, G.; Liu, Y. The physical and non-physical factors that influence perceived access to urban parks. *Landsc. Urban Plan.* **2015**, *133*, 53–66. [CrossRef]
26. Zhu, Z.P.; Li, J.Y.; Chen, Z.R. Green space equity: Spatial distribution of urban green spaces and correlation with urbanization in Xiamen, China. *Environ. Dev. Sustain.* **2023**, *25*, 423–443. [CrossRef]
27. Li, Z.M.; Fan, Z.X.; Song, Y.; Chai, Y.B. Assessing equity in park accessibility using a travel behavior-based G2SFCA method in Nanjing, China. *J. Transp. Geogr.* **2021**, *96*, 103179. [CrossRef]
28. Liao, H.W. Mapping, evaluation and improvement of open accessible green spaces in central urban districts of Beijing. *Mod. Urban Res.* **2019**, *9*, 104–111.
29. Oh, K.; Jeong, S. Assessing the spatial distribution of urban parks using GIS. *Landsc. Urban Plan.* **2007**, *82*, 25–32. [CrossRef]
30. Cai, Y.W.; Cheng, J.; Wei, J. Spatial pattern and accessibility of urban park greenland in center of Guangzhou City. *Ecol. Environ. Sci.* **2011**, *11*, 1647–1652.
31. Luo, W.; Whippo, T. Variable catchment sizes for the two-step floating catchment area (2SFCA) method. *Health Place* **2012**, *18*, 789–795. [CrossRef]
32. Radke, J.; Mu, L. Spatial decompositions, modeling and mapping service regions to predict access to social programs. *Geogr. Inf. Sci.* **2000**, *6*, 105–112. [CrossRef]

33. Wu, W.; Zheng, T. Establishing a "dynamic two-step floating catchment area method" to assess the accessibility of urban green space in Shenyang based on dynamic population data and multiple modes of transportation. *Urban For. Urban Green.* **2023**, *82*, 127893. [CrossRef]
34. Tao, Z.L.; Yao, Z.X.; Kong, H.; Duan, F.; Li, G.C. Spatial accessibility to healthcare services in Shenzhen, China: Improving the multi-modal two-step floating catchment area method by estimating travel time via online map APIs. *BMC Health Serv. Res.* **2018**, *18*, 345. [CrossRef] [PubMed]
35. Dai, D. Black residential segregation, disparities in spatial access to health care facilities, and late-stage breast cancer diagnosis in metropolitan Detroit. *Health Place* **2010**, *16*, 1038–1052. [CrossRef]
36. He, P.; Chen, W.Z.; Cheng, Q.; Zhao, L. Research progress on urban green space justice at home and abroad. *Chin. Gard.* **2019**, *5*, 28–33. [CrossRef]
37. Yang, L.J. Research on the Evaluation Method and Application of Fair Performance of Urban Parks from the Perspective of Spatial Justice. Ph.D. Thesis, Chongqing University, Chongqing, China, 2022.
38. Zhang, J.; Cheng, Y.; Zhao, B. Assessing the inequities in access to peri-urban parks at the regional level: A case study in China's largest urban agglomeration. *Urban For. Urban Green.* **2021**, *65*, 127334. [CrossRef]
39. Wu, J.; Peng, Y.; Liu, P.; Weng, Y.; Lin, J. Is the green inequality overestimated? Quality reevaluation of green space accessibility. *Cities* **2022**, *130*, 103871. [CrossRef]
40. Zhang, R.; Zhang, C.-Q.; Cheng, W.; Lai, P.C.; Schüz, B. The neighborhood socioeconomic inequalities in urban parks in a High-density City: An environmental justice perspective. *Landsc. Urban Plan.* **2021**, *211*, 104099. [CrossRef]
41. Zhang, R.; Peng, S.; Sun, F.; Deng, L.; Che, Y. Assessing the social equity of urban parks: An improved index integrating multiple quality dimensions and service accessibility. *Cities* **2022**, *129*, 103839. [CrossRef]
42. Cao, Y.L.; Guo, Y.H.; Zhang, M.J. Research on the Equity of Urban Green Park Space Layout Based on Ga2SFCA Optimization Method-Taking the Core Area of Beijing as an Example. *Land* **2022**, *11*, 1323. [CrossRef]
43. Li, M.; Ye, C.D. Threshold standards and global distribution characteristics of high density cities. *World Reg. Stud.* **2015**, *1*, 38–45.
44. Beijing Municipal Bureau Statistics Survey Office of the National Bureau of Statistics in Beijing. Beijing Statistical Yearbook 2021—Population and Employment. Available online: https://nj.tjj.beijing.gov.cn/nj/main/2021-tjnj/zk/indexch.htm (accessed on 30 October 2022).
45. Zheng, S.W.; Ma, M.H. Definition and evaluation of ecological space in high density urban core areas: A case study of Beijing. *Planner* **2021**, *3*, 64–71.
46. The People's Government of Beijing Municipality. Government Term: Capital Functional Core Area. Available online: https://www.beijing.gov.cn/zhengce/zwmc/202203/t20220315_2630693.html (accessed on 6 September 2023).
47. The People's Government of Beijing Municipality. Regulatory Detailed Plan for the Capital Functional Core Area (Block Level) (2018–2035). Available online: https://www.beijing.gov.cn/zhengce/zhengcefagui/202008/W020200902354838202786.pdf (accessed on 30 October 2022).
48. Feng, S.; Chen, L.; Sun, R.; Feng, Z.; Li, J.; Khan, M.S.; Jing, Y. The Distribution and Accessibility of Urban Parks in Beijing, China: Implications of Social Equity. *Int. J. Environ. Res. Public Health* **2019**, *16*, 4894. [CrossRef] [PubMed]
49. Wu, J.; He, Q.; Chen, Y.; Lin, J.; Wang, S. Dismantling the fence for social justice? Evidence based on the inequity of urban green space accessibility in the central urban area of Beijing. *Environ. Plan. B Urban Anal. City Sci.* **2020**, *47*, 626–644. [CrossRef]
50. Dong, P.; Yang, C.; Rui, X.; Zhang, L.; Cheng, Q. An effective buffer generation method in GIS. *Int. Geosci. Remote Sens. Symp.* **2003**, *6*, 3706–3708.
51. Du, Y. Research on the threshold of suitable walking distance for community residents. *Transp. Res.* **2015**, *2*, 20–24+30.
52. Beijing Municipal Forestry and Parks Bureau. Beijing Municipal Measures for the Classification and Grading Management of Parks. Available online: http://yllhj.beijing.gov.cn/zwgk/fgwj/gfxwj/202206/t20220621_2747422.shtml (accessed on 30 October 2022).
53. Beijing Beilin Landscape Architecture Planning and Design Institute Co., Ltd. Classification Standard for Urban Green Space (CJJT 85-2017). Available online: http://www.doc88.com/p-0911729504887.html (accessed on 30 October 2022).
54. *GB/T 51346-2019*; Urban Green Space Planning Standards. Ministry of Housing and Urban Rural Development of the People's Republic of China: Beijing, China, 2019. Available online: http://www.doc88.com/p-9572968496447.html (accessed on 30 October 2022).
55. Beijing Municipal Forestry and Parks Bureau. List of Parks in Beijing. Available online: http://yllhj.beijing.gov.cn/ggfw/bjsggml/ (accessed on 16 April 2023).
56. Guo, P.; Sun, Y. Reachability of parks and green spaces in Tianjin central urban area based on internet map service and Ga2SFCA. *J. Tianjin Norm. Univ. Nat. Sci. Ed.* **2020**, *5*, 63–69.
57. Astronomical Science Data Center; Space Science and Application Research Center; Chinese Academy of Sciences. Geospatial Data Cloud. Available online: https://www.gscloud.cn/search (accessed on 30 October 2022).
58. Browning, R.C.; Baker, E.A.; Herron, J.A.; Kram, R. Effects of obesity and sex on the energetic cost and preferred speed of walking. *J. Appl. Physiol.* **2006**, *100*, 390–398. [CrossRef]
59. Qin, H.; Zhu, J.; Xu, H.; Cao, H. Research on equity evaluation and optimal layout of urban park green space supply. *Land* **2022**, *10*, 95–103.

60. The Standing Committee of the Beijing People's Congress. Announcement of Main Data of the Seventh National Population Census in Beijing. Available online: http://www.bjrd.gov.cn/xwzx/bjyw/202105/t20210520_2393731.html (accessed on 30 October 2022).
61. Jin, H.; He, G.; Huang, Q. Research on reachability of urban park green space in Hangzhou from the perspective of social equity. *J. Northwest For. Univ.* **2022**, *3*, 261–267.
62. Li, S. Research on Optimizing the Spatial Pattern of Ecological Construction in Dalian City Based on GIS/RS Technology. *Liaoning Norm. Univ.* **2022**, *7*, 15. [CrossRef]
63. Liu, T.; Xu, L.; Yuan, K. A Capacity Determination Method for Shared Bicycle Parking Areas Based on Natural Breakpoint Method. Available online: http://kns.cnki.net/kcms/detail/42.1824.U.20220923.1358.046.html (accessed on 6 September 2023).
64. Yu, K.; Duan, T.; Li, D. Evaluation methods and cases of landscape reachability as a functional indicator of urban green space system. *Urban Plan.* **1999**, *8*, 7–10+42+63.
65. Yang, D.H.; Goerge, R.; Mullner, R. Comparing GIS-based methods of measuring spatial accessibility to health services. *J. Med. Syst.* **2006**, *30*, 23–32. [CrossRef] [PubMed]
66. Ren, J.; Wang, Y. Analysis on reachability of park green space in Huangpu District of Shanghai based on improved two-step mobile search method. *Prog. Geogr. Sci.* **2021**, *5*, 774–783. [CrossRef]
67. De, T.; Sun, Y.; Xie, M. Evaluation of reachability of park green space in Shenzhen based on improved Gauss two-step mobile search method. *Prog. Geogr. Sci.* **2021**, *7*, 1113–1126.
68. Moran, P.A. Notes on continuous stochastic phenomena. *Biometrika* **1950**, *37*, 17–23. [CrossRef]
69. Alhakim, A.; Hooper, W. A non-parametric test for several independent samples. *J. Nonparametric Stat.* **2008**, *20*, 253–261. [CrossRef]
70. Derrick, B.; White, P.; Toher, D. Parametric and Non-Parametric Tests for the Comparison of Two Samples Which Both Include Paired and Unpaired Observations. *J. Mod. Appl. Stat. Methods* **2019**, *18*, eP2847. [CrossRef]
71. *2022-00025*; National Garden City Selection Standards. Ministry of Housing and Urban Rural Development of the People's Republic of China: Beijing, China, 2022. Available online: https://www.mohurd.gov.cn/gongkai/zhengce/zhengcefilelib/202201/20220114_764128.html (accessed on 30 January 2023).
72. Beijing Municipal Forestry and Parks Bureau. Beijing Landscape Greening Special Plan (2018–2035). Available online: http://yllhj.beijing.gov.cn/zwgk/ghxx/gh/202109/P020211028350583088823.pdf (accessed on 30 January 2023).
73. Wang, R.; Yang, B.; Yao, Y.; Bloom, M.S.; Feng, Z.; Yuan, Y.; Zhang, J.; Liu, P.; Wu, W.; Lu, Y.; et al. Residential greenness, air pollution and psychological well-being among urban residents in Guangzhou, China. *Sci. Total Environ.* **2020**, *711*, 134843. [CrossRef]
74. Markevych, I.; Schoierer, J.; Hartig, T.; Chudnovsky, A.; Hystad, P.; Dzhambov, A.M.; de Vries, S.; Triguero-Mas, M.; Brauer, M.; Nieuwenhuijsen, M.J.; et al. Exploring pathways linking greenspace to health: Theoretical and methodological guidance. *Environ. Res.* **2017**, *158*, 301–317. [CrossRef] [PubMed]
75. Kabisch, N.; Haase, D. Green justice or just green? Provision of urban green spaces in Berlin, Germany. *Landsc. Urban Plan.* **2014**, *122*, 129–139. [CrossRef]
76. Lutzenhiser, M.; Netusil, N.R. The effect of open spaces on a home's sale price. *Contemp. Econ. Policy* **2001**, *19*, 291–298. [CrossRef]
77. Wu, W.; Chen, W.Y.; Yun, Y.; Wang, F.; Gong, Z. Urban greenness, mixed land-use, and life satisfaction: Evidence from residential locations and workplace settings in Beijing. *Landsc. Urban Plan.* **2022**, *224*, 104428. [CrossRef]
78. The People's Government of Beijing Municipality. Major Infrastructure Development Plan for the 14th Five Year Plan Period in Beijing. Available online: https://www.beijing.gov.cn/gongkai/guihua/wngh/sjzdzxgh/202203/t20220303_2621094.html (accessed on 30 October 2022).
79. Xue, F.; Gou, Z.; Lau, S.S.Y. Green open space in high-dense Asian cities: Site configurations, microclimates and users' perceptions. Sustain. *Cities Soc.* **2017**, *34*, 114–125. [CrossRef]
80. Delgado-Capel, M.; Cariñanos, P. Towards a standard framework to identify green infrastructure key elements in dense Mediterranean cities. *Forests* **2020**, *11*, 1246. [CrossRef]
81. Wang, H.Y.; Wang, H.Q.; Chen, X.Y. Review of research on evaluation and enhancement of urban biodiversity at home and abroad. *J. Ecol.* **2023**, *8*, 2995–3006.

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