

# MEASURING THE WALKABILITY AROUND THE URBAN PARKS: A CASE STUDY OF NANJING

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## Introduction

Urban parks provide considerable health benefits for citizens including support physical activity. The surrounding environments of urban parks especially relevant to walking are critical whether people visit the parks. With case study in Nanjing, the aim of this paper is to assess the walkability around the urban parks, and provide insights of promoting active environment.

## Method & Indicator

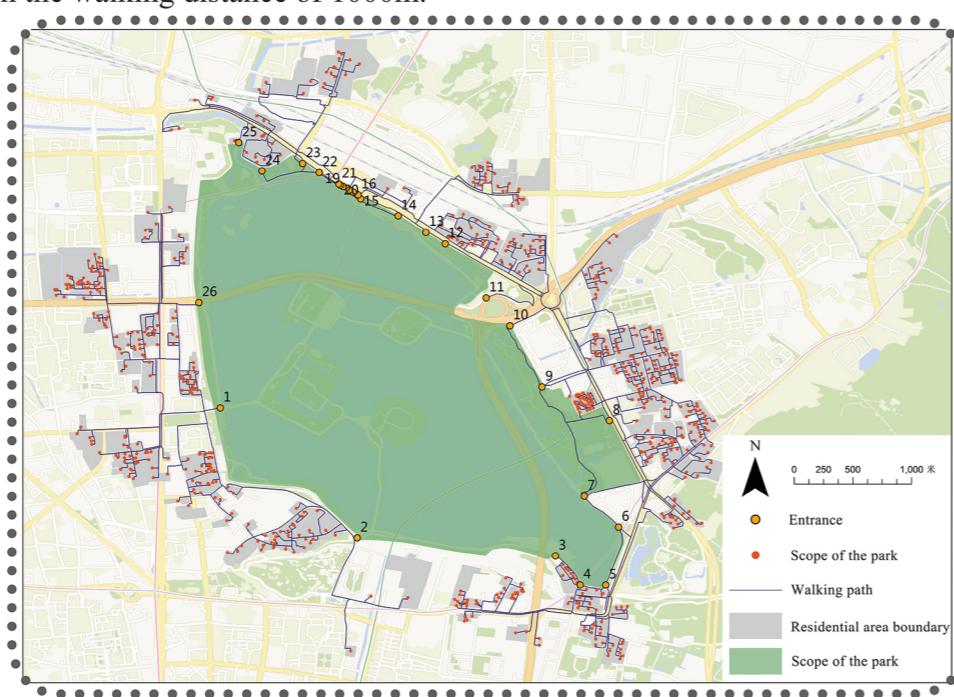
### Object of study :

The object of this study is Xuanwu park in Nanjing, which is an important place for recreation in Nanjing over the years. With a total area of 502.08 hectares, there are 26 entrances.

### Method and data:

Authors use Python in August 2019, crawled the residential buildings, residential boundaries and walking paths within 1000m around the park. After data cleaning, 664 POI residential buildings, 100 residential boundaries and 1554 walking paths were selected within the walking distance of 1000m.

In addition, the study data also include : (1) the distance, time, turn, number of road crossings, starting point, end point and other information of each walking path; (2) population density data of Nanjing (100\*100m grid data); (3) street view photo data (15,528 pieces, collected in October 2019), are obtained by capturing the street view photos of Baidu Map through the waypoints of the path and 4 viewpoints of one point, POI data of various types in Nanjing (collected in August 2019, subject to the classification of Baidu Map); (4) high-definition image of Baidu Map.



### Indicators :

1. Service POI, service residential boundary area and service population: (1) Xuanwu park within reach of the residential building POI in 1000m walking distance. (2) If one or more POI points are considered to be within the residential boundary, it is considered to be serving the community and as the service area of the park. (3) Population data is the superposition of population density data and the residential boundary, which represents the population served.

2. Baidu Map recommended walking path, distance and time: This path comes from the travel simulation data and it's the recommended path in the walking algorithm of Baidu Map.

3. PDR: The ratio of path distance to Euclidean distance (greater than or equal to 1) between the park entrance and residential points reflects the degree of path directness ratio (PDR). When the block size is pleasant and the permeability of the road network is high, the PDR is relatively low.

4. The number of turns: to reflect the smoothness of the walk or the number of times you need to stop to turn or cross a road in response to new road conditions.

5. The number of road crossings: to reflect the smoothness of walking or the perceived safety and traffic risk of pedestrians.

6. The number of POI along the street: In the walking path, the more POI along the street, the higher the street safety, the more vibrant the street is, and the more suitable for pedestrians to walk. The number of POI along the street in this paper is based on the POI data of Baidu Map around Xuanwu park and the 100m line buffer of the walking path.

7. Green vision rate: Refers to the proportion of green plants seen by people's eyes, which emphasizes the three-dimensional visual effect and represents the higher level of urban greening. In this paper, the green vision rate is obtained by analyzing the hue of street view photos in HSV mode through Python's OpenCV library.

8. Street view photo image elements: When people walk, they can see the landscape, which can improve their walking perception. At the same time, railings, seats, street lamps and other facilities can also improve their walking experience. In this paper, the image elements of street view photos are identified through the API interface of Baidu AI open platform.

## Results

### Park service area analysis :

Distance	Euclidean distance			Path distance		
	POI	Service area( $\text{km}^2$ )	Service population	POI	Service area( $\text{km}^2$ )	Service population
500m	276	0.54	8960	153	0.24	4029
1000m	1148	3.8	87505	664	2.07	44540

Based on the Euclidean distance and path distance, the overall service scope of Xuanwu park was analyzed within 500m and 1,000m. As can be seen from the above table, the number of POI based on path distance (664) is significantly less than the number of POI in the Euclidean distance(1148). Path itself can reach the location and area is significantly smaller than the Euclidean distance, which is still used in some scope of planning and research. The percentage of the area covered by the 500m and 1,000m service area based on path distance in the Euclidean distance was 44.12% ( $0.24\text{km}^2$ ) and 54.50% ( $2.07\text{km}^2$ ), respectively.

Within the 1000m walking path, the average walking path is 727m, the average walking time is 620 seconds, the average number of turns is 4.63, and the average PDR is 1.42. Hess thinks that the PDR is generally 1.2-1.5, and a value greater than 1.8 that the road network is too tortuous. Therefore, it can be seen that within the 1000m walking circle of Xuanwu park, the PDR tends to be normal.

### Performance analysis of park entrance service :

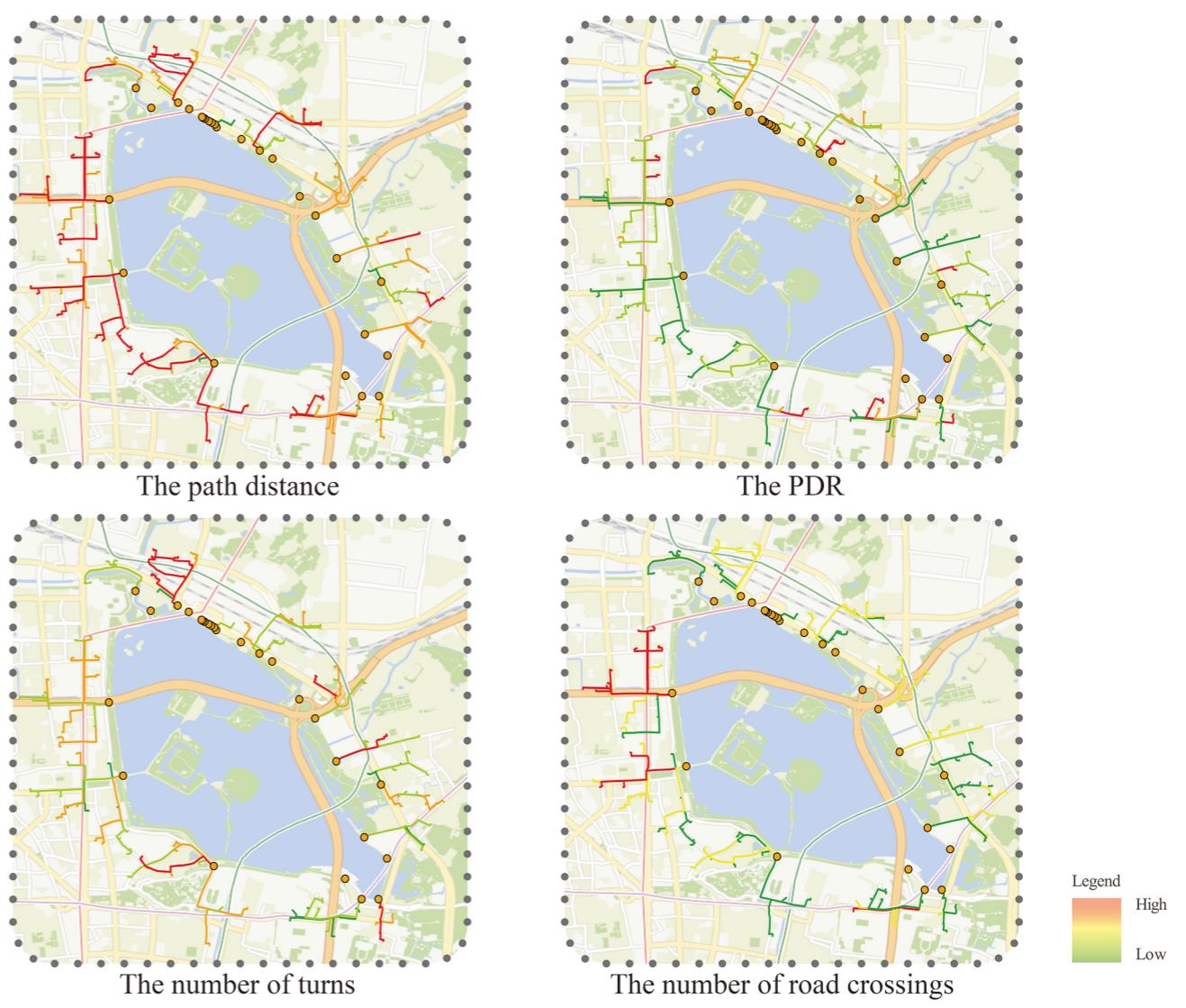
Xuanwu has a very long interface with the city, the POI between different entrances, the service residential area and the service population is very difference.

Entrance	POI	Service area( $\text{km}^2$ )	Service people
No. 8	217	0.45	6965
No. 9	141	0.37	6277
No. 26	123	0.38	11704
No. 1	118	0.36	12485
No. 6	100	0.32	4523
No. 4	89	0.19	2530
No. 7	73	0.26	3421
No. 10	70	0.38	6418
No. 5	67	0.20	2573
No. 13	66	0.21	4067
No. 14	55	0.27	4960
No. 3	55	0.14	1874
No. 12	48	0.16	2850
No. 2	40	0.21	4848
No. 23	32	0.26	4148
No. 16	32	0.15	2571
No. 18	30	0.16	2751
No. 15	30	0.15	2571
No. 17	30	0.15	2571
No. 21	28	0.27	4485
No. 19	28	0.16	2751
No. 20	28	0.16	2751
No. 22	24	0.28	4474
No. 25	15	0.08	1470
No. 24	9	0.08	1256
No. 11	6	0.03	491
Average	60	0.22	4145

The service efficiency of different entrances within 1000m is shown in the table. Among them, each entrance serves 60 POI on average, No. 8 and No. 9 in the east of Xuanwu park and No. 26 and No. 1 in the west of Xuanwu park (217, 141, 123 and 118) serve the most POI. No. 25, No. 24 and No. 11 in the north of Xuanwu park serve the least POI, which are 24, 15 and 9. No. 11 serves the fewest POI (6). The residential service area is similar to the ranking of service POI, with an area of  $0.22\text{km}^2$  for each entrance. No. 26 and No. 1 in the west of Xuanwu park and No. 8 and No. 9 in the east serve a large population of 12485, 11704, 6964 and 6418, respectively. The results were ranked contrary to the service POI, indicating that the population density in the west of Xuanwu park was greater than that in the east. No. 14, No. 25, No. 24 and No. 11 serve a small population of 1874, 1470, 1256 and 491, respectively, with an average of 4145 people serving each entrance.

### Analysis of walking path and walking environment:

Taking the residential boundary as the analysis object, among the 1554 recommended walking paths within the walking range of 1000m, the shortest one in each residential boundary was selected as the walking path of the community, and 100 walking paths were selected for the analysis of walking path and environment.

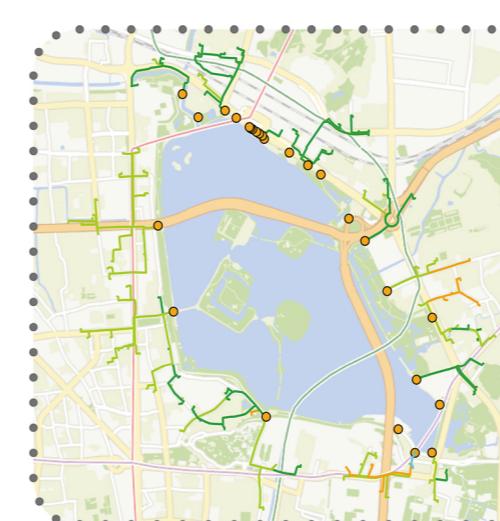


The path distance: 8 paths are less than or equal to 250m, 26 paths are less than or equal to 500m, and 64 paths are less than or equal to 750m. The walking paths over 750m account for 36% of the total. The long distance is distributed in the west and south of Xuanwu park, especially No.1, No.2, No.26. The shorter distance is distributed in the east of xuanwu lake, especially No.10, No.7 and No.5.

The PDR: The median PDR of 100 walking paths was 1.38, among which 34 were less than 1.3, mostly distributed in the southeast and southwest of Xuanwu park, and 19 were higher than 1.6. There are 12 items higher than 1.8, accounting for 12%. Among them, the highest value of PDR is 3.1 from Xinzuang 53 community to No.13. The path located in the southeast of Xuanwu park has a relatively low PDR and a good road permeability.

The number of turns: The median and average number of turns in 100 paths are 4 times and 5.7 times respectively, among which 20 communities need to turn more than 6 times and 2 communities need to turn more than 8 times. The communities connected to No.3 generally have too many turns, with an average of 6.2, and a relatively high PDR.

The number of road crossings: The median and average number of crossings times of 100 paths are 2 and 1.6 respectively, among which 6 communities need not cross the road to reach Xuanwu park, 43 communities need to cross the road once, and 38 communities need to cross the road twice. The 13 communities need to cross the road three times to reach Xuanwu park, mainly distributed in No.26. The main reason may be that the out of the entrance is the Ximofan road, and most of the communities have to go through this road to reach No.26, so they increase the number of times to cross the road in the surrounding communities.



The number of POI along the street: The coefficient along the street of road POI is the ratio of the number of POI to the path distance. The mean and median of POI coefficient along the street of 100 paths are 0.11 and 0.09. The paths are divided into 4 categories by the natural break method. Among them, there are 36 communities less than or equal to 0.082, 86 communities less than or equal to 0.15, and 2 communities greater than 0.33. The POI coefficient of Jinlingyu community was the largest, 0.60, connected with No.4. The POI coefficient of Xiaoshi 100 street is the smallest, 0.01, connected with No.23. The POI coefficient of northeast Xuanwu park and southwest Xuanwu park is lower. The POI of the path connected with No.9, No.8 and No.4 has a higher coefficient along the street.

Green vision rate: The mean and median green vision rate of 100 paths were 29% and 30%, respectively. It can be seen that the green vision rate of the path around Xuanwu park is better. There are 88 paths with green vision rate greater than or equal to 15%, and 60 paths with green vision rate greater than or equal to 25%. Among them, the path with the highest green vision rate was Jinlingyu community -- No.4, which was 74%. The path with the lowest green vision rate is Luxiying community -- No.26, which is 9%. The overall green vision rate of the path around Xuanwu park is good, and the green vision rate of the connection between No.23 and No.26 is poor.



Street view photo image elements: The mean and median of the 100 image elements are 2.0, that is, there are 2 image elements in the average street view photo of each path that can improve the pedestrian walking experience. According to the natural break method, paths are divided into four categories. 10 paths have image elements less than 1.7, 34 paths have image elements less than 1.9, and 24 paths have image elements greater than 2.1. Among them, the path with the most image elements is Suojin 4 community -- No.7, 2.4. The path with the lowest image elements is Jinlingyu community, which is 1.25. The image elements of the path connected to No.2, No.23, No.13, No.8 and No.7 were high, while the image elements of the path connected to No.26 were low.

## Discussion

Proximity to urban parks not necessarily lead to more visiting and physical activity. Beside the attractiveness within the park, the last kilometre to the parks are crucial. Objective measures are integral to diagnosis the pedestrian environment, and prescribe constructive tactics. Positive interventions on environment are suggested to prompting walking around parks and environmental justice. The tactics consist of universal design, enhance permeability visually and physically.