Research on accessibility analysis of park green space based on big data: Taking Xiongan New Area in China as an example

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ABSTRACT

Park green spaces are an important part of urban ecosystems, promoting urban livability and improving residents' well-being. The rational spatial distribution of park green spaces promote equitable and healthy urban development. Accessibility studies of park green space are essential for measuring its spatial distribution and evaluating the effectiveness of its ecological services. Based on open source network big data such as POI and vector road network data, this study uses ArcGIS network analysis to analyse the accessibility of park green spaces in Xiongan New Area under three modes of transportation: walking, cycling and driving. It shows that the park green space resources in Xiongan New Area are lacking at this stage, and there are blind spots for park green space services in individual areas. The accessibility ratio is less than 20% under walking and cycling modes, while the accessibility ratio is better under driving mode, reaching 92.46% within 15 min. The optimization strategy is further proposed with the data analysis to provide a theoretical basis for the green space planning and design of Xiongan New Area.

Keywords: Big data, GIS, park green space, accessibility analysis

1. INTRODUCTION

In late 2019, a sudden outbreak of Corona Virus Disease 2019 (COVID-19) swept the world[1], dramatically changing people's daily lives and having a significant negative impact on society. Several studies have shown that the persistence of the epidemic has exacerbated negative emotions such as anxiety, fear, and stress among urban residents[2]. With the normalization of the epidemic, people pay more attention to their physical and mental health[3], and the desire for outdoor green recreational spaces gradually increases. As an important leisure and recreation place, park green space is an important way for residents to get in touch with nature, and also provides a space for exercise and relaxation, which plays an important function in improving people's physical and mental health[4-6]. As a pilot city construction with high starting point planning and high standard construction, the Xiongan New Area is a sustainability program and a national event, which highlights the higher demand for sustainable urban development and the new expectation of residents' healthy life. Studying the layout and accessibility of parks in Xiongan New Area is important to measure whether residents can easily enjoy the services provided by park green spaces and to further evaluate the social service functions of park green spaces in Xiongan New Area.

This study analyzes the accessibility of the existing park green spaces in Xiongan New Area, obtains the service areas of the existing park green spaces, and judges whether the layout of the existing park green spaces is reasonable in the light of the specific conditions of different areas, so as to provide data support and reference for the design of the spatial location of the park green spaces and the configuration of public service facilities in Xiongan New Area in the future.

2. RESEARCH SUBJECTS AND RESEARCH METHODS

2.1 Overview of the study area

Xiongan New Area is a national-level new area under the jurisdiction of Hebei Province, located in the hinterland of Beijing, Tianjin and Baoding, including Xiong County, Rongcheng County, Anxin County and some surrounding areas (Figure 1).

The specific area and population distribution of Xiongan New Area are shown in Table 1.

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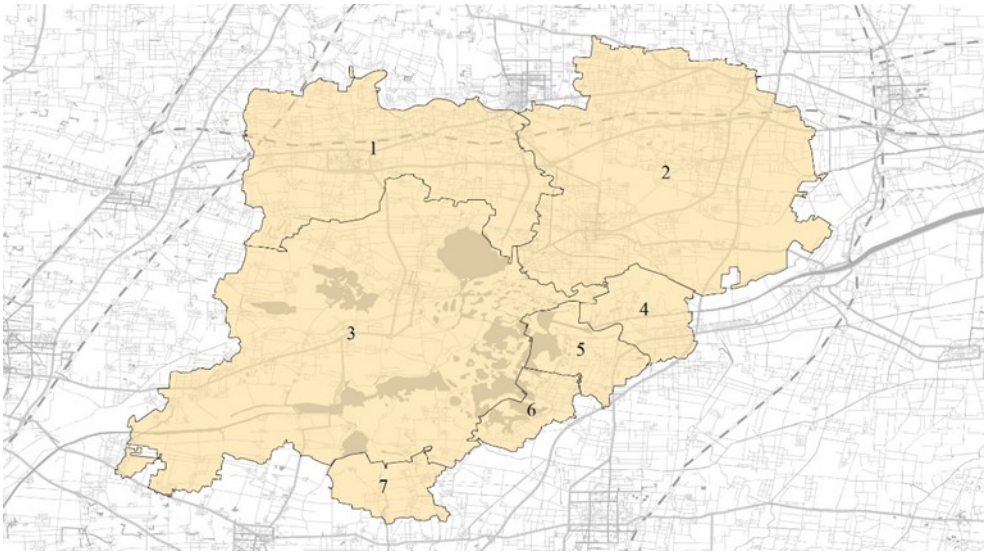

Figure 1. Location map of the study site in Xiongan New Area.

Table 1. Area and population distribution of different areas in Xiongan New Area[a].

Data Category	Rongcheng County	Xiong County	Anxin County	Gougezhuang Town	Maozhou Town	Qijianfang Township	Longhua Township
Area (km^{2})	314	677.55	738.6	62.08	58.2	52.20	107
Population (million)	27.32	47.86	45.37	2.90	2.63	2.69	5.28

[a] The source of area data is the official government website, and the source of population data is the seventh census data.

2.2 Data source

In this study, the POI (Point of Interest) data of park green spaces are obtained by Python after crawling from the application programming interface of Amap API (Application Programming Interface) interface and filtered by various methods such as data cleaning, coordinate correction and geospatial matching, etc. Each POI data includes name, category, coordinates, classification and other information. Vector road network data is obtained by OpenStreetMap.

2.3 Research method

In this study, the accessibility analysis is based on statistical analysis and GIS-based spatial accessibility analysis, and the service coverage of park green spaces under walking, cycling and motorized traffic is calculated based on road network. Firstly, the basic network is constructed in ArcGIS software, which mainly includes center, connection, node and impedance[7]. The center represents the spatial location point of the park green space (large parks take the main entrance as the spatial location point), the connection is the network structure used to simulate different levels of roads, the node is the road intersection, and the resistance is the capacity of the traffic road (Figure 2).

And the serviceable area ratio of the park green space under different-time costs of 5, 10 and 15 minutes in the three modes are obtained respectively, which are:

$$Park\ Walking\ Accessible\ Area\ Ratio = \frac{Park\ Walking\ Accessible\ Area}{Total\ Study\ Area} \times 100\% \quad (1)$$

$$Park\ Cycling\ Accessible\ Area\ Ratio = \frac{Park\ Cycling\ Accessible\ Area}{Total\ Study\ Area} \times 100\% \quad (2)$$

$$Park\ Driving\ Accessible\ Area\ Ratio = \frac{Park\ Driving\ Accessible\ Area}{Total\ Study\ Area} \times 100\% \quad (3)$$

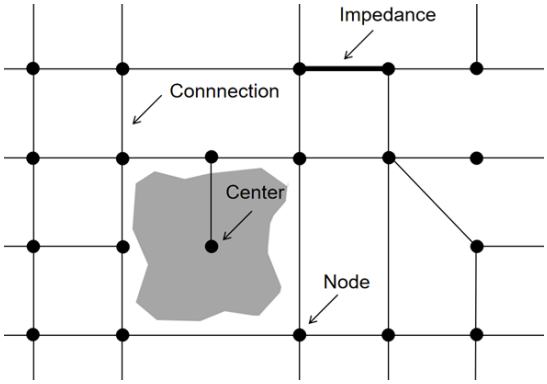

Figure 2. Basic network diagram.

3. RESULT

This study establishes traffic accessibility network through ArcGIS, combines road data, park green space data, population data and other basic big data, uses data statistical analysis method and GIS-based spatial accessibility analysis method to calculate the accessibility area of park green space within the scope of Xiongan New Area for walking, cycling and driving mode, and uses software to visualize the results as follows.

3.1 Walking accessibility analysis

The average walking speed was set at 80m/min in the walking accessibility analysis. The results show that the reachable area of park green space in Xiongan New Area shows a dotted layout, and the overall park green space service coverage is poor (Figure 3). In terms of the reachable area, the park green space service coverage is better in Rongcheng and Anxin counties, followed by Xiong County. The three counties in Renqiu City and Longhua Township in Gaoyang County severely lack park green space, and the surrounding parks are poorly accessible under walking conditions.

Further analysis of park green space resources in Anxin and Rongcheng counties, including Xiongan Country Park in Rongcheng County and Baiyangdian Scenic Area Park in Anxin County, which are larger in scale, set the main entrance spatial location point as the “center” of the park green space to reduce the error in accessibility analysis. It can be seen that even though it has rich park green spaces, but due to the limitation of traffic network, there are many blind spots of parkland services under walking conditions.

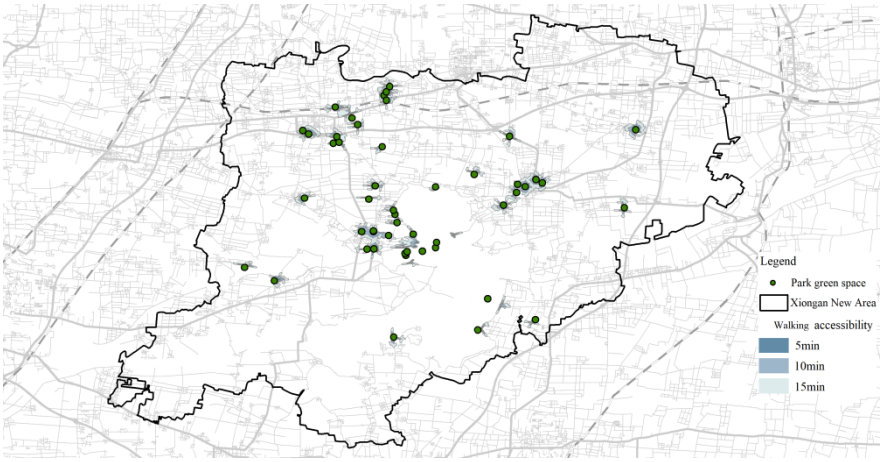

Figure 3. Walking accessibility analysis diagram.

3.2 Cycling accessibility analysis

The cycling accessibility analysis set the average bicycle travel speed to 15 km/h and set the dwell time at the traffic light at the road intersection to 30 seconds. The results show that the cycling accessibility area of the park green space shows a layout characteristic that is highly correlated with the agglomeration of residential areas, while being strongly influenced by the road layout (Figure 4), similar to the results of previous studies[8]. Among them, the accessible area of park green space in Rongcheng County shows a scattered shape under cycling mode, with smooth roads in the west and east, but lacking park green space resources. The accessible area of park green space in Xiong County shows a cluster shape, with obvious grading under different time classes, but there are blind areas of park green space services in the north. The accessible area of park green space in Anxin County shows a cluster shape, with park green space resources mainly concentrated in the north, while the central part such as Baiyangdian area is not connected by some roads, even though there are green space resources, the accessibility is poor and there are blind areas for park green space services. The remaining four areas are lack of park green space resources.

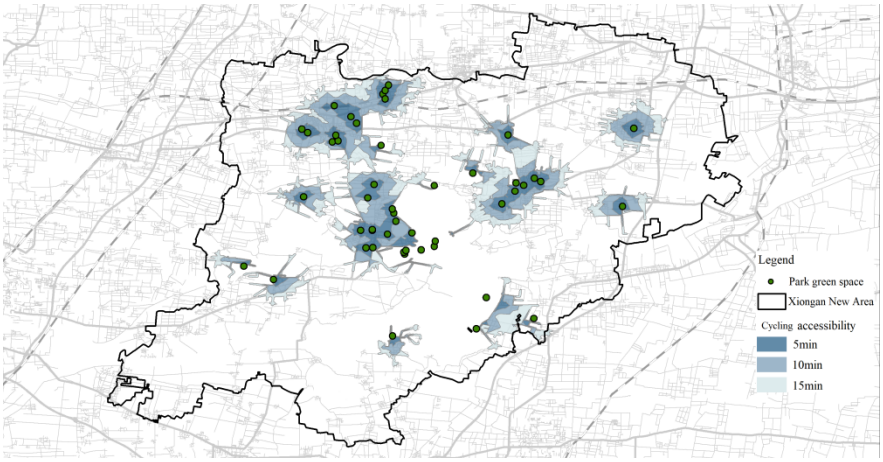

Figure 4. Cycling accessibility analysis diagram.

3.3 Driving accessibility analysis

The average speed of motor vehicles is 100 km/h for highways, 90 km/h for expressways, 70 km/h for national roads, 50 km/h for provincial roads and 40 km/h for county roads, and the stopping time at the traffic lights at road intersections is set to 30 seconds. The results show that the accessibility of park green areas in Xiongan New Area shows a dispersion from the center to the surrounding area (Figure 5). Under driving conditions, the overall park green space accessibility is good, and the park green space accessibility in Rongcheng County is optimal. In addition, the accessibility of the eastern part of Xiongxian County is poor due to the inaccessibility of some roads, and the accessibility of the southwestern part of Anxin County is poor due to the lack of parkland resources. Overall accessibility by motorized transport has been significantly improved compared to walking and cycling.

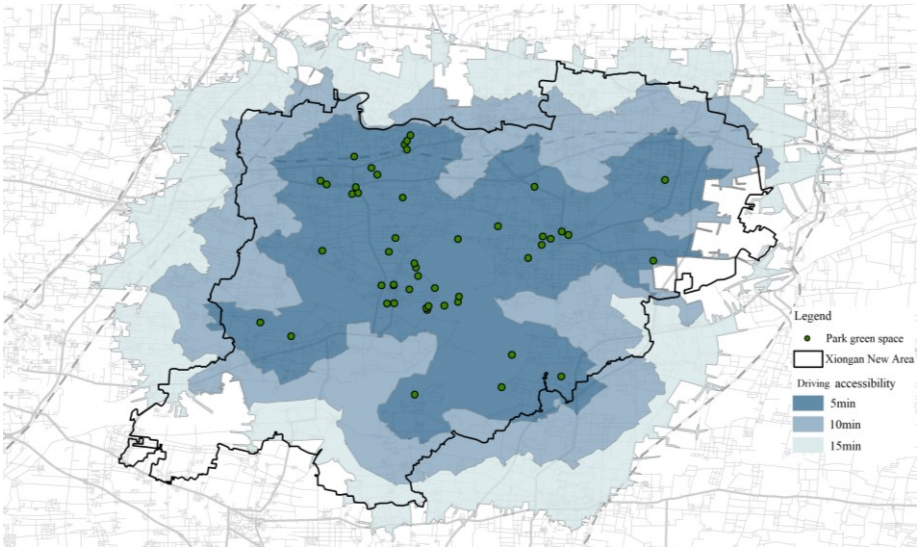

Figure 5. Driving accessibility analysis diagram.

3.4 Comparison of the service area of park green space under different modes of transportation

Statistical analysis of the overall accessibility area under three different modes of travel shows that the accessibility effect under different time classes is ranked as driving, cycling and walking. The highest accessibility area of the three travel modes is 92.46% (Table 2).

Under walking mode, the service area ratio within 5min and 10min is only 0.21% and 0.88%, and the service area within 15 min is 2.52%. Under cycling mode, the service area ratio is 3.41% within 5 min, 9.56% within 10 min, and 16.10% within 15 min. Under driving mode, the service area within 5min accounted for 53.10%, 84.70% within 10 min and 92.46% within 15 min. Compared with the cycling and walking mode, the accessibility of driving mode has been significantly improved, and the ratio of reachable area can account for more than 20%, and the service area is lower under the walking mode.

Table 2. Service area ratio of park green space under three modes of transportation.

Reachable time classes	Service area ratio of park green space for different ways of travel (%)		
	Walking	Cycling	Driving
0-5 min	0.21	3.41	53.10
0-10 min	0.88	9.56	84.70
0-15 min	2.52	16.10	92.46

4. OPTIMIZATION SUGGESTIONS

At present, the distribution of park green space in Xiongan New Area is uneven, and the park green space resources are mainly concentrated in the central and northern parts of the area, while the park green space resources in Rongcheng County are relatively abundant, followed by Xiong County and Anxin County. The accessibility of park green space is mainly influenced by the parkland resources and road layout. The poor accessibility of park green space under walking mode is not conducive to the sustainable development of Xiongan New Area, resulting in low service efficiency of park green spaces and wasted resources[9], and the number of park green spaces should be increased around the main residential areas, especially in the east and west of Rongcheng County, the south of Anxin County and the north of Xiong County.

The abandoned land as well as forest land should be fully utilized and developed to build as park green areas to provide leisure and recreational places for citizens[10].

In addition, the regional slow-moving transportation system should be improved. During the field research, it was found that the Xiongan New Area lacks slow traffic network at this stage. In the Hebei Xiongan New Area Planning Outline, it is stated that Xiongan New Area will develop an independent greenway network. By strengthening the construction of regional greenways, it is possible to isolate the greenways from motorized spaces and also effectively connect residential areas with park green spaces, breaking the single form of park green spaces and facilitating residents to quickly and safely reach the surrounding park green spaces for healthy activities[11]. At the same time, the greenway system carries the fitness, leisure and entertainment functions of the public, and also effectively improves the accessibility of the park green space, enhancing the residents' sense of access, happiness and security for the ecological recreation space[12-14].

5. CONCLUSION

This study analyzed the distribution and spatial accessibility of park green spaces in Xiongan New Area by using GIS and big data, and showed that there is a lack of park green space resources and poor accessibility under walking and cycling conditions. By increasing the number of park green spaces and improving the regional slow transportation system, thus enhancing the efficiency of using park green space resources, making the park green spaces better perform its ecological service functions, and providing a theoretical basis for the green space planning and design of Xiongan New Area.

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