Chin. Geogra. Sci. 2015 Vol. 25 No. 5 pp. 644–656
doi: 10.1007/s11769-015-0781-y

Springer Science Press
www.springerlink.com/content/1002-0063

Urban Green Space, Uneven Development and Accessibility: A Case of Dalian′s Xigang District

YANG Jun[1], LI Chuang[1], LI Yuechen[1], XI Jianhao[2], GE Quansheng[2], LI Xueming[1]

(1. *Liaoning Key Laboratory of Physical Geography and Geomatics*, *Liaoning Normal University*, *Dalian* 116029, *China*; 2. *Institute of Geographic Sciences and Natural Resources Research*, *Chinese Academy of Sciences*, *Beijing* 100101, *China*)

Abstract: This study examines the socio-spatial context of uneven development and the residential accessibility of green space in Dalian of Liaoning Province, China. The social fairness was analyzed with a community scale as the basis. We combined social scientific methods with a GIS method using a behavior accessibility model from the perspectives of fairness of urban green space allocation based on social geography, geographic information science, management science and many other related discipline theories. The results show that: 1) Most of the urban green space distribution presents an unbalanced phenomenon, and it does not match with the population distribution; 2) We found some differences in the accessibility of the population with different attributes and opportunities to use and enjoy the urban green spaces, mainly due to: the dual social and spatial attributes of the residents and the serious stratum differentiation generated were the internal causes; the residential space differentiation and the pursuit of economic and real estate development were the direct causes; and unreasonable planning, in regard to the fact that government policies did not give consideration to efficiency and fairness, was also an important factor.

Keywords: behavior accessibility; fairness of green space; behavior accessibility model; Xigang District of Dalian; GIS

Citation: Yang Jun, Li Chuang, Li Yuechen, Xi Jianhao, Ge Quansheng, Li Xueming, 2015. Urban green space, uneven development and accessibility: a case of Dalian′s Xigang District. *Chinese Geographical Science*, 25(5): 644–656. doi: 10.1007/s11769-015-0781-y

1 Introduction

As an important part of public service facilities, urban green space play a key role in the regulation and improvement of urban ecology. In addition, they also have the important responsibility of overseeing green space construction with social fairness in mind. Social fairness refers to the opportunity of residents for enjoying urban green space at the same level. In other words, people with different social and economic backgrounds should have equal opportunities to enjoy the resources of urban green space. However, the imbalance of economic development in our current time has led to a serious problem of socioeconomic stratum differentiation. Furthermore, residential space differentiation is becoming more severe, and the green space can not be enjoyed by everyone; the supply of urban green space can not meet the growing demand of city residents; and the problem of the unfairness of urban green space allocation is progressively becoming a prominent issue.

The studies on the fairness of urban green space allocation by western countries were performed in three stages: a regional equalization stage, with a per capita green space quantity as the standard; a space fairness stage, based on an accessibility model; and then a transition to a social fairness stage, with people as the main focus. Prior to the 1970s, western countries believed that justice meant that everyone should enjoy equally, and the equal distribution of urban green spaces was regarded as a fair core target (Rich, 1979). This empha-

Received date: 2014-08-26; accepted date: 2014-11-21
Foundation item: Under the auspices of National Natural Science Foundation of China (No. 41471140)
Corresponding author: YANG Jun. E-mail: yangjun@lnnu.edu.cn

sizes the fact that the per capita public service of providing green space should be equal in the geographical spatial unit (Lineberry, 1977). Post 1970s, western countries put into effect a new public management reform policy emphasizing economics and the efficiency of supply (Wang, 2007). Five sub-concepts put forward by Lucy (1981) and three criteria proposed by Wicks and Crompton (1986) are representatives of the theories for the evaluation of fairness, but the essences are still the continuation of equality reform. The largest distribution efficiency of the urban green space was explored from the perspectives of geographic equity and space allotment fairness. Accessibility is the main means for fairness measurement of urban green spaces, combined with the spatial analysis of GIS, in order to weigh the distances and costs (Talen and Anselin, 1998). During the period from the end of the 20th century to the early 21st century, the research of urban green space fairness in western countries was transformed from fairness of land to fairness of people. Urban parks and green open spaces serve important environmental functions (Cohen *et al*., 2014), thus the problem of the fairness of urban green space should be to consider the demand and the application model of different social populations (Beler, 1997), and must also ensure different populations share equal accessibility to green space (Talen, 1998). Racial, social and economic factors (Dai, 2011), and the aspects of people′s preferences and concepts for green space (Wright *et al*., 2012) will also affect equitable distribution of green space among residents (Kabisch and Haase, 2014).

Although the research on the fairness of urban green space allotment in China has begun recently through economic development, consciousness of green space has been growing rapidly and attracting great attention among scholars. Chinese studies of the fairness of urban green space allotment have became important issues, and it can be seen that in 1993 China introduced the Regulations of City Planning and Construction Index, in which the per capita urban green space areas and coverage rates were used as the evaluation index. This embodied the fairness of the distribution quantity. In 1995, the academician of Lu Dadao introduced the concept of accessibility in the field of domestic city geography for the first time (Gu and Yin, 2010). Since then, Chinese studies of green space allotment have mainly focused on the analysis of accessibility (Yu *et al*., 1999; Hu *et al*., 2005; Ma and Cao, 2006; Yin and Kong, 2006; Li *et al*., 2008; Sang *et al*., 2013). These studies only focused on the rationality of spatial distribution, while the fairness of the green space allotment still requires more research. Yin *et al.* (2008) introduced an index of accessibility and equity into the evaluation of urban green space. This was based on the GIS technology developed by Shanghai and Qingdao as examples for the concepts of people-orientation and social fairness in a city′s construction of green spaces. Jiang *et al.* (2010) explored the spatial differences of the Guangzhou Park green space at the Sub-district scale and the difficulties related to social fairness, by using the GIS network analysis and cushion analysis method, then combined with the social economic status of the population (Jiang *et al*., 2010). Zhou *et al.* (2013) explored the fairness of the urban green space pattern oriented behavior scale by using the neighborhood analysis method in ArcGIS, based on the basic concept and theory of landscape ecology, and taking the city of Shenzhen as an example.

Rapid economic development has caused the acceleration of differentiation of urban social stratum and significant differentiations of the residential space. As a result, the problems of green space that could not be enjoyed by everyone become more prominent. There is a conflict between the growth demand for green spaces by the population and the insufficient supply of basic green space. This imbalanced scenario restricts the effective supply of the resources of urban green space. Therefore, the present study conducted an in-depth analysis on the allocation and supply of urban green space on availability and quantity to explore the mechanism of the produced unfairness and point out effective countermeasures, and residents′ behavior scale is also an important factor of accessible green space. On the basis of previous studies, we taked Xigang District of Dalian City as an example, based on the network analysis, combined with the behavior scale of residents, built behavior accessibility model, in-depth analysis the configuration of urban green space in number and on the space with a community scale base and behavior scale features. The results of this study have very strong practical significance.

2 Materials and Methods

2.1 Study area

The Xigang District is located in the downtown area of

Dalian City, Liaoning Province, China (Fig. 1). To the east is the Zhongshan District, and to the west is the Shahekou District. The geographical position of the Xigang District is advantageous, as the north of the Xigang District is adjacent to the famous Dalian Port and a strategic entrance location to Bohai Bay and it is also adjacent to the main international routes. The Xigang District is the administrative center of Dalian City, and its total area is 26.18 km^2. It has seven sub-districts (or *jiedao* in chinese): Bayilu Sub-district, Baiyun Sub-district, Renmin Square Sub-district, Beijing Sub-district, Rixin Sub-district, Zhanbei Sub-district, and Xianglujiao Sub-district. It governs a total of 41 communities.

2.2 Data sources

The demographic and survey data, remote sensing data, and the land use data of the Xigang District of Dalian City in 2009 are shown in Table 1. The land use and green space data were fused, spliced and overlaid, and the unified geographic coordinates were determined by using ArcGIS. In accordance with the classification standard of urban green space of the People′s Republic of China (CJJ/T 85-2002), combined with the green space features of the Xigang District of Dalian City, the current green space was reclassified into four types. These four types are: theme parks, street parks, attached green space, and scenic forest lands, as shown in Table 2. The social demographic statistical data of the Xigang District were from Xigang Statistical Yearbook of 2009.

2.3 Methods

2.3.1 Selection of green space accessibility model

Public accessibility is an important standard to measure the fairness of the spatial layout of urban green spaces. Accessibility refers to the degree of difficulty that is needed to be overcome by the residents in order to reach a service or place of activity (Van and Wiedemann, 2003). Ways to study accessibility are divided into two

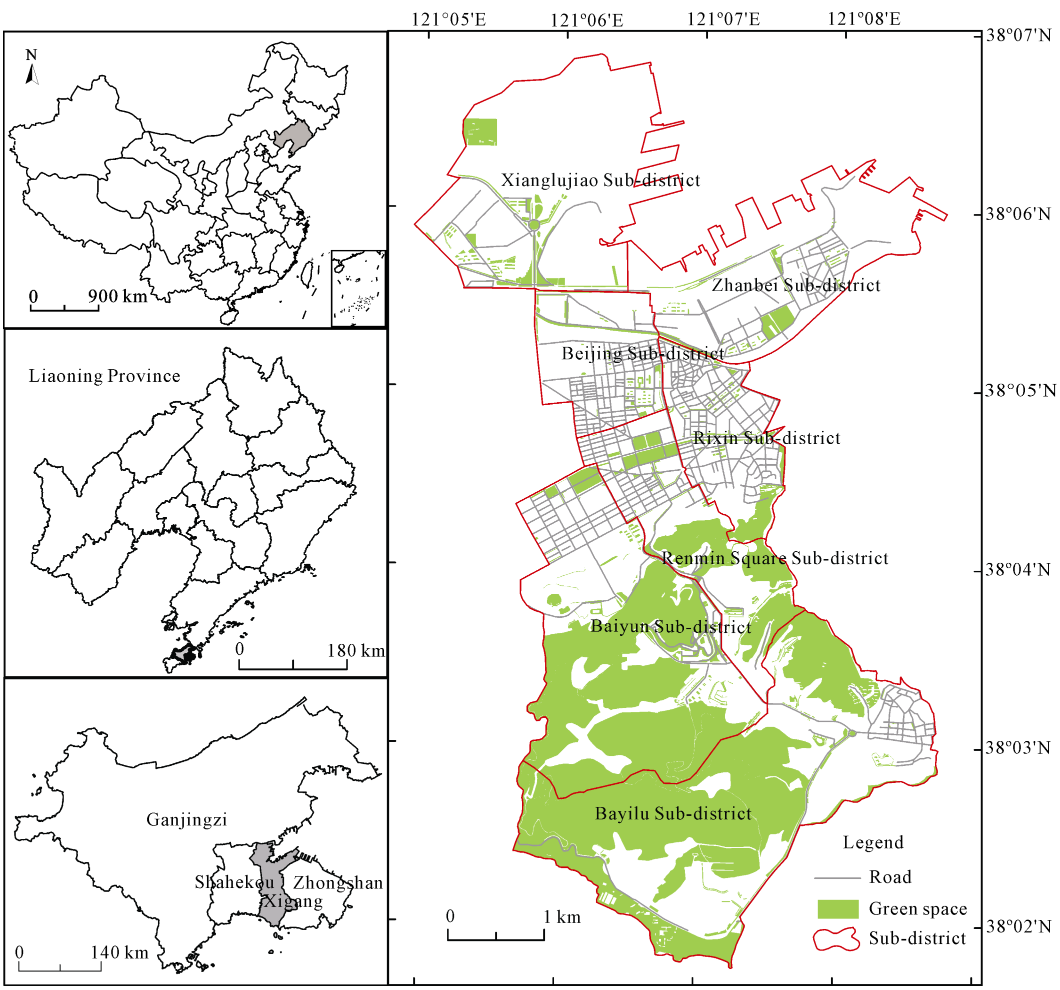

Fig. 1 Location map of study area

Table 1 Data sources and description

Year	Data	Attribute	Source
2009	Remote sensing data	Xigang 0.5 m air digital orthophoto map, 2.5 m SPOT 5 satellite images	Dalian Land Resources and Housing Bureau
	Land use data	Xigang 1 : 10 000 and use data including roads, settlements, cities and other elements of the data	Dalian Land Resources and Housing Bureau
	Green space distribution in Xigang	Xiggang 1 : 10 000 green space maps	Dalian Land Resources and Housing Bureau
	Statistical yearbook in Xigang	Demographic data, survey data	Dalian Statistical Bureau

Table 2 Urban green space classification of Xigang District in Dalian

Primary classification	Secondary classification	Implication
A. Park green space	A_1. Theme parks	A_1: These have specific content or form, and include green recreational facilities such as: children's parks; zoos; botanical gardens; historic parks; scenic parks; amusement parks, *etc*.
	A_2. Street parks	A_2: These are located outside of urban road space, in a piece of green space relatively independent and include: small gardens and street plaza green space
B. Attached green space	B_1. Attached green space	B_1: Including street trees and other green belt, green residential area in addition to other residential parks, institutions, organizations, military units, enterprises, institutions owned green space
C. Other green space	C_1. Scenic forest lands	C_1: These landscapes with a certain scenic value play a role in urban environments throughout the woodland landscape

types, namely qualitative research (Dawson, 1995; Mullick, 1993) and quantitative research. Quantitative research methods mainly include statistical analysis and GIS analysis. GIS analysis is simpler and relatively more accurate than statistical analysis (Giles-Corti *et al*., 2005; Jim and Chen, 2006; Sonmez Turel *et al*., 2007). Additionally, the spatial analysis and evaluation method of GIS also provide a possibility for evaluating the spatial distribution of urban green space on a regional scale. The commonly used GIS accessibility analysis methods include the minimum neighborhood distance model, the cost resistance model and the gravitational potential energy model. However, these different model methods are based on different theories. For example, the minimum distance mode only considers the Euclidean distance, and does not reflect the actual road network accessibility factor, although the costs resistance model represents a true reflection of transportation costs, but it did does fully take into account the level of green space, the method of travel and other factors. Unlike other GIS analysis methods, the network analysis model through road network to calculate the range of urban green space can be accessed by certain methods of transportation and accurately reflect the process of residents using the green space, and the vector data can overcome the effects of the granularity of generated raster data. On this basis, we consider the interactive relationship among the three aspects of: human living patches, traffic patches and green space patches, by different distances as residents′ appropriate and maximum activity scales, then construct the behavior accessibility model, under the different behavior scales, and perform a comparison of per capita green area.

2.3.2 Constructing behavior accessibility model

(1) Spatial relationship between human living patches and green patches

The previous research models of accessibility of urban green space have been mainly based on cost, traffic, chance, and other objective factors, and often overlook the main role of the resident population. From a sociological perspective, it was believed that the residents cognized the urban green space allocation by defining the scope of space activities for themselves, which is influenced by the behavior scale. The residents have dual attributes: a space attribute and a social attribute. These two attributes together influence the accessibility of urban green spaces. As illustrated in Fig. 2, according to Yin′s result of accessibility and equity assessment on urban green space , less than the 500 m range is defined as the accessibility is very good, less than 1000 m range is defined as the accessibility is well, more than the 1000 m range is defined as the accessibility is poor, based on the relevant research results (Yin *et al*., 2008), in consideration of Dalian Xigang District being mostly in the mountain and hilly terrain, and combined with residents travel mode and traffic and other factors, 300 m and 1000 m were used as the appropriate and maximum activity scales of the cognitive green space behavior of the residents. These results reveal that the residents from different scales enjoyed different amounts of

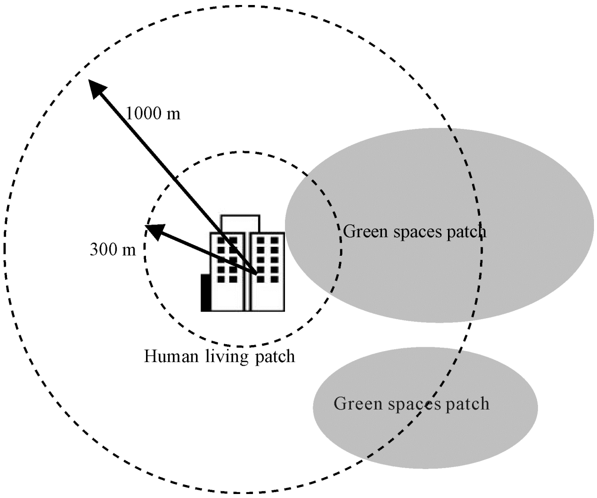

Fig. 2 Schematic of patches spatial relationships

green space. The spatial location of green space patches directly affected the enjoyment levels of the residents from the different scales, which also directly reflected the problems connected with the urban green space allocation. Therefore, the behavior scale is also an important aspect for the exploration of the difficulties of the urban green space accessibility.

(2) Constitution of traffic network model

In the actual research, the green space patches and the residential patches are connected by a transportation network. The different behavior scales of the residents are all embodied by the actual traffic network. The network analysis model must be used to obtain the actual process in order to reflect the residents entering into the green spaces. As shown in Fig. 3, the constructing elements of the network analysis model mainly included: the ***Center***, which is the position of urban green space; the ***Link***, which is the abstracted road traffic network obtained using the GIS platform; the ***Node***, which is the intersection point between the roads; and the ***Impediment***, which is the road traffic capacity and time or cost in overcoming any obstacles from one position to another position within the model. The urban road network must be used as support if the residents wish to reach the central position, thus the different behavior scales of the residents must be considered by traffic road network model.

(3) Coupling of three relationships: green space, traffic and residence

The behavior accessibility model, as shown in Fig. 4, considers the interactive relationship between the three aspects of: human living patches, traffic patches and

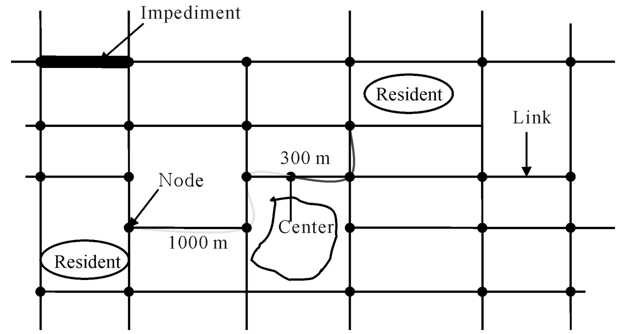

Fig. 3 Schematic of network model

green space patches. However, it is also based on the road network that is placed in order to simulate the process of the residents' use of the green spaces. Based on the above conditions, the behavior scales of the residents were introduced to comprehensively analyze the amount and types of green spaces which are enjoyed by the residents, in order to determine the most suitable and the maximum activity ranges required. As demonstrated in Table 2, the various green space accessibility models of GIS were investigated and analyzed. The network analysis model was found to be more suitable than the other models. This network analysis model used the vector data and overcame the granularity effects produced by the raster data, and is able to accurately reflect the actual process of the residents using the green spaces.

This study was based on the road network, while blocks and green space entrances were used to build the topology network data. In regards to the enjoyment methods of the urban green spaces, the main purposes of the surrounding green spaces for the urban residents are to walk or exercise. Therefore, this study only considered the resistance model of the walking modes with a walking speed of 1 m/s. The time costs of the 300 m and 1000 m behavior scales were approximately 5 min and 15 min for required times to reach the green spaces, respectively. The waiting resistance value at the road node was set as 30 s. According to the length of each road segment, the corresponding resistance value of each segment was calculated. Then, the accessibility graph of the network analysis was produced by the Network Analysis in ArcGIS. The effective service area and population's statistical area were overlapped in order to calculate the per capita sharing of green space quantity, and the accessibility amount from the different scales was used for the contrast analysis.

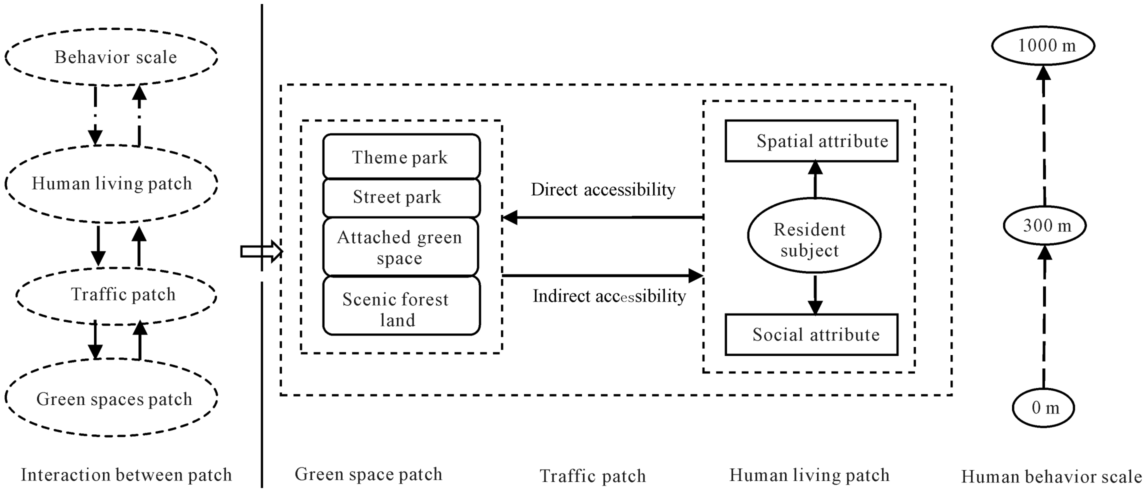

Fig. 4 Building process of behavior accessibility model

3 Results and Analysis

3.1 Analysis of accessibility of various sub-districts

As shown in Fig. 5, the overall distribution of green space in the Xigang District was uneven, showing that the allotment in the south is greater than in the north, and there are more allotments in the south than in the north. The quantity of the occupied green spaces of Bayi Sub-district and Baiyun Sub-district are higher, where the large areas are mostly specialty parks and scenic forests. Figure 6 shows the accessibility time distribution map of the overall green spaces of the Xigang District. It can be seen from Fig. 6 that the accessibility time of the main specialty parks in the Xigang District was relatively long; most of areas is greater than 60 min.

In ArcGIS, overlay analysis the layer of green accessibility time distribution and the layer of sub-district, then, in each sub-district, statistics various types of green space area under the different time level, as shown in Table 3, there are having large differences of the accessibility quantity and types of green spaces in the different time ranges of the various sub-districts. According to the comparison of the different behavior scales, and within the behavior scale of 300 m: the accessibility amount of green spaces were as follows: 1) That of Renmin Square Sub-district was the highest with the value of 60.09 ha; the accessibility amount of green space of the street park is 10.57 ha; the accessibility amount of green space of the attached green space is 5.76 ha; and the accessibility amount of green space of the scenic woodland is 43.76 ha. 2) The accessibility amount of green space of Beijing Sub-district was the least with the value of 5.78 ha; and where the type of all of the accessibility green spaces was scenic forest. Within the behavior scale of 1000 m, the accessibility amount of green spaces were as follows: 1) The accessibility amount of green space of Baiyun Sub-district was the highest with the amount of 78.01 ha; in which the specialty public type green spaces had 55.08 ha; the street park type had 9.74 ha; and the attached green space had 13.18 ha. 2) The accessibility amount of green space of Beijing Sub-district was the least, at 6.92 ha, and the types of the accessibility green spaces are all the scenic forests. When comparing the two different scales, the accessibility green space of Beijing Sub-district is the lowest.

3.2 Analysis of accessibility of various communities under different behavior scales

In each community, using statistics green space areas that could be accessed in 5 min and 15 min, and the total area of green space, according to community population, we calculated the per capita green area within 300 m and 1000 m range and the per capita green area of each community. In ArcGIS, we used the polygon layer of the community convert to the centroid point, then interpolated the analysis and normalized the results of the interpolation. Figure 7a and Fig. 7b are the results of the interpolation based on the per capita green area that could be accessed within the 300 m to 1000 m range. Figure 7c shows the contour maps of the per capita green space areas of the various communities. It can be seen

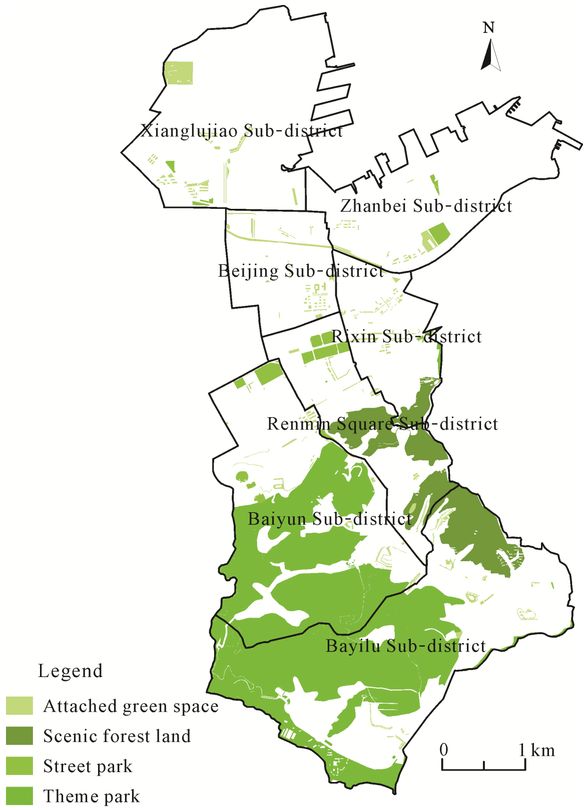

Fig. 5 Urban green space classification map

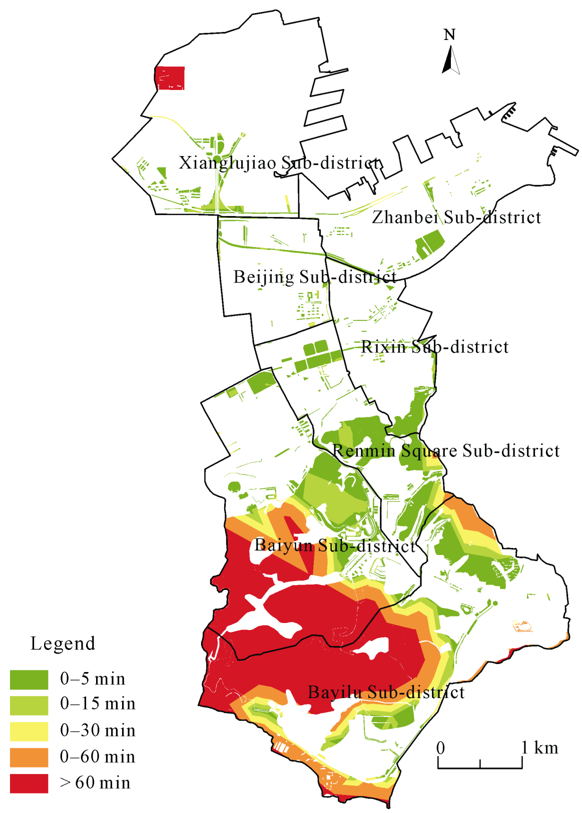

Fig. 6 Green accessibility time distribution in Xigang

from Fig. 7c that the per capita green space in the southern communities of the Xigang District is more prominent than that of the northern communities. Table 4 illustrates that the per capita green space of the various communities in the 1000 m scale is greater than that of the 300 m scale, which is particularly apparent in the Xiangchuan community. So it becomes clear that the unevenness of the allocation of green space is the main cause of the different accessibility amounts, as well as the per capita green space amounts, in the various communities.

Table 3 Comparison of different times of sub-districts' access to amount of green space and green type (ha)

Sub-district	Time	Green space classification				Total
		Theme parks	Street parks	Attached green space	Scenic forest lands	
Bayilu	0–5 min	10.17	0.04	6.07	26.38	42.66
	0–15 min	31.06	0.11	6.86	33.75	71.79
	0–30 min	64.66	0.11	7.75	43.54	116.06
	0–60 min	137.52	0.11	8.09	55.31	201.03
	＞60 min	169.75	0.00	0.00	0.02	169.77
Baiyun	0–5 min	24.61	8.47	11.36	0.00	44.45
	0–15 min	55.08	9.74	13.18	0.00	78.01
	0–30 min	72.16	9.75	13.38	0.00	95.29
	0–60 min	116.85	9.75	13.40	0.00	140.00
	＞60 min	145.76	0.00	0.00	0.00	145.76
Beijing	0–5 min	0.00	0.00	0.00	5.78	5.78
	0–15 min	0.00	0.00	0.00	6.92	6.92
	0–30 min	0.00	0.00	0.00	7.11	7.11
	0–60 min	0.00	0.00	0.00	7.11	7.11
	＞60 min	0.00	0.00	0.00	0.00	0.00
Renmin Square	0–5 min	0.00	10.57	5.76	43.76	60.09
	0–15 min	0.00	10.95	5.93	52.91	69.79
	0–30 min	0.00	10.95	5.96	57.42	74.33
	0–60 min	0.00	10.95	5.96	58.69	75.60
	＞60 min	0.00	0.00	0.00	0.00	0.00
Rixin	0–5 min	0.76	0.68	4.01	11.81	17.26
	0–15 min	1.54	0.68	4.31	12.16	18.69
	0–30 min	1.54	0.68	4.31	12.16	18.69
	0–60 min	1.54	0.68	4.31	12.16	18.69
	＞60 min	0.00	0.00	0.00	0.00	0.00
Xianglujiao	0–5 min	0.00	1.10	10.38	0.00	11.47
	0–15 min	0.00	1.82	13.63	0.00	15.46
	0–30 min	0.00	1.82	14.46	0.00	16.28
	0–60 min	0.00	1.82	14.49	0.00	16.32
	＞60 min	0.00	0.00	0.00	0.00	0.00
Zhanbei	0–5 min	0.00	4.61	6.08	0.00	10.69
	0–15 min	0.00	4.75	7.11	0.00	11.86
	0–30 min	0.00	4.75	7.42	0.00	12.17
	0–60 min	0.00	4.75	7.42	0.00	12.17
	＞60 min	0.00	0.00	0.00	0.00	0.00

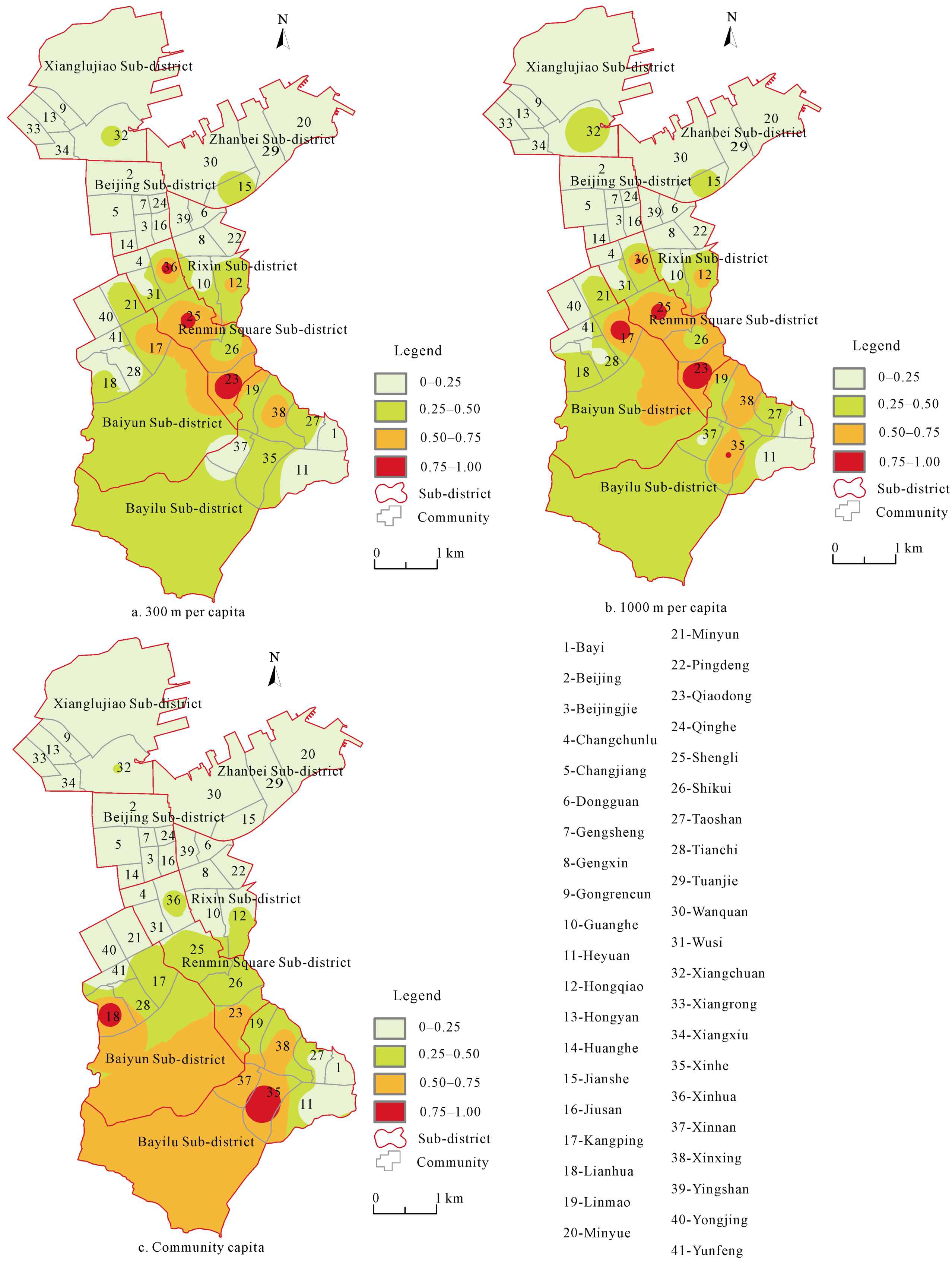

Fig. 7 Different scales access to green space areas and average per capita green space area in Xingang

Table 4 show the quantitatively analyzed relationship among the different accessibility amounts of the green spaces in the various communities within the different scales, as well as the per capita green space amount of the communities. It can be determined that the per capita green space amounts of the communities of Pingdeng, Huanghe and Minyun, located in the north of the Xigang District, are lower, with the respective values of 0.47 m^2, 0.10 m^2 and 0.33 m^2 in the 300 m scale. These data reveal the fact that the community green space and space allocation are severely insufficient. For example, the per capita green space quantities of the Lianhua, Xinhe and Xinqu are higher, at 41.32 m^2, 44.06 m^2 and 28.99 m^2, respectively. However, the accessibility to the green space quantities of these communities are lower, at 5.50 m^2, 8.24 m^2 and 12.69 m^2 in the 300 m scale, and also show 9.24 m^2, 18.02 m^2 and 16.36 m^2 in the 1000 m scale, which all are lower than those of the per capita amount of the community green space. These data indicated that the green space of this type of community is more abundant, but the space allocation is not suitable. For example, the per capita green space quantities of the Hongyan and Xiangchuan communities are 13.36 m^2 and 11.48 m^2, which are similar to the accessibility green space quantity of the 1000 m scale. These results indicate that the supply of the green space of this type of community is balanced and the allocation of space is suitable. Also, in the Kangping and Shengli communities, which are located in the southern part of the Xigang District, the per capita amounts of the community green space are 21.83 m^2 and 19.47 m^2. The accessibility green space quantities in the 1000 m scale are 22.17 m^2 and 20.47 m^2, which are greater than that of the per capita amount of green space for the community. This suggested that the supply of green space in this type of community is saturated, and the allocation of the green space is excessively high.

3.3 Fairness analysis based on behavior scale

In this study, the overall distribution of green space in the Xigang District was found to be uneven, and exhibited higher allocations in the south and lower in the north. The occupied green space of Bayi Sub-district and Baiyun Sub-district are very high, and the main

Table 4 Different scales and average per capita green community green comparison

Community	Population	300 m per capita (m^2)	1000 m per capita (m^2)	Community capita (m^2)	Community	Population	300 m per capita (m^2)	1000 m per capita (m^2)	Community capita (m^2)
Bayi	5634	0.09	0.30	0.30	Pingdeng	9386	0.47	0.47	0.47
Beigang	9200	1.66	5.18	5.18	Qiaodong	6700	19.94	23.68	28.35
Beijingjie	8806	0.45	0.45	0.46	Qianghe	5197	0.01	0.01	0.01
Changchunlu	2666	0.42	1.47	1.47	Shengli	15100	16.30	20.47	19.47
Changjiang	4847	0.17	0.23	0.23	Shikui	12448	8.44	10.49	12.62
Dongguan	8122	0.89	0.91	0.91	Taoshan	8963	7.19	9.02	10.22
Gengshen	5013	0.17	0.17	0.17	Tianchi	4478	2.07	4.62	20.96
Gengxin	10160	1.18	1.19	1.19	Tuanjie	14672	0.43	0.62	0.62
Gongrencun	8447	0.01	0.01	0.01	Wanquan	6582	3.48	5.11	5.57
Guanghe	9120	2.82	3.39	3.39	Wusi	5197	4.00	4.00	4.00
Heyuan	9473	0.80	0.80	4.91	Xiangchuan	5857	6.02	10.97	11.48
Hongyan	9500	10.78	13.36	13.36	Xiangrong	10668	1.02	1.19	1.30
Hongqiao	9800	0.88	0.88	0.88	Xiangxiu	11681	1.52	2.00	2.00
Huanghe	3449	0.10	0.10	0.10	Xinhe	5490	8.24	18.02	44.06
Jianshe	7869	8.94	8.94	8.94	Xinhua	4900	17.23	18.35	18.42
Jiusan	7868	1.29	1.94	2.17	Xinnan	5926	0.65	5.26	32.14
Kangping	5895	13.93	22.17	21.83	Xinxing	12360	12.69	16.36	28.99
Lianhua	4672	5.50	9.24	41.32	Yingshan	6288	0.71	0.81	0.81
Linmao	8560	6.63	8.04	13.76	Yongjing	9910	0.63	1.35	1.48
Minle	14380	0.33	0.39	0.39	Yunfeng	6518	0.06	0.09	0.09
Minyun	6984	7.93	8.19	8.19					

types of green spaces are large areas of theme parks and scenic forest lands. Figure 6 shows the accessibility time distribution map of the overall green space of the Xigang District. However, it was found that the accessibility time was relatively long, with most of the accessibility times being more than 60 min. There are large differences in the accessibility of the quantity and types of green spaces for the various sub-districts in the different time ranges. When comparing the different behavior scales within 300 m, the amount of green space of Renmin Square Sub-district was found to be the highest with the value, at 60.09 ha. Most of the amount of green space was the street parks type, at 10.57 ha; the amount of the attached green space was 5.76 ha; and the amount of the scenic forest lands was 43.76 ha. The accessibility amount of the green space of Beijingjie Sub-district was found to be the least, at 5.78 ha, in which the types of all accessible green spaces are scenic forest lands. In regard to the behavior scale of within 1000 m, the accessibility amount of the green space of Baiyun Sub-district was found to be the highest, at 78.01 ha, in which theme parks are 55.08 ha; street parks are 9.74 ha; and attached green space is 13.18 ha. The accessibility amount of the green space of Beijing Sub-district was the least, the amount being only 6.92 ha, of which all of the accessibility green space types are scenic forest land. In comparing the two scales, the accessibility amount of the green space of Beijing Sub-district, within the different scales, was considered to be very insufficient.

Based on the comparison of the per capita green quantity in the different scales and the average green space quantity, this research divided the relationship of green spaces within the various communities into four categories.

(1) Shortages of green space allocation. The communities with serious shortages of green space allocation included: Bayi, Beigang, Beijingjie, Changchunlu; Changjiang, Dongguan, Gengsheng, Gengxin, Gongrencun, Guanghe, River Park, Hongqiao, Huanghe, Yingshan, Yongjing, Yunfeng, Tuanjie, Wanquan, Wusi, Xiangrong, Xiangxiu, Minyue, Jiusan, Qinghe, and Pingdeng. The supplies of the per capita green space quantities of these 25 communities were found to be very unacceptable. These populous communities possess inadequate green space area allotments. To clarify, the populations living in the Gongrencun, Hongqiao and Minyue communities mainly belong to the lower income groups. The findings led to the conclusion that the accessibility of green space quantity within the different scales was very low, and reflects serious regional unfairness. These regions should increase the green space quantity in order to optimize the allocation.

(2) Unbalanced space allocations. The space allocations were found to be unbalanced in the following communities: Tianchi, Xinnan, Linmao, Lianhua, Shikui, Taoshan, Xinhe, Xinxing, and Qiaodong. The per capita green quantities of these nine communities are higher, but the accessibility of the green space quantity in the different behavior scales is lower. In particular, the accessibility of the green space quantity in the 300 m scale is low, which causes the unbalanced allocation of the green spaces, and leads to relative unfairness in these regions. These areas should focus on optimizing the distribution of the green spaces, and in particular should increase the allocation of the accessibility of green space in the 300 m scale. This will ensure that the residents can enjoy sufficient green space within different scales.

(3) Balanced allocation of green space. The allocation of green space was more balanced in the following communities: Minyun, Jianshe, Xiangchuan, Hongyan and Xinhua. The per capita quantity and the accessibility of green space quantity of these five communities were relatively balanced. Especially in the 1000 m scale, the accessibility of green space quantity and the average green space quantity were found the same, leading to fairness in allocation in these areas.

(4) The oversaturated allocation of green spaces. The allocation of the green space was found to be too saturated in the following communities: Kangping and Shengli, as the accessibility of green space quantity was greater than that of the per capita green space quantity. In the 1000 m scale, the accessibility of green space quantity was especially high. The allocation of green space was found to be too high, which caused unfair high allocation for these regions in regard to green space distribution.

4 Discussion and Conclusions

According to the above analysis, it can be seen that the current unfair urban green space is equipped with the following: 1) Uneven spatial distribution: the overall urban green space is not balanced; 2) urban green space allotment not matching with the distribution of the population: there are fewer green space allotments in the areas with larger population, and there are more areas of green space allotments in the areas with lower population; 3) differences in the green space accessibility and user opportunities in populations with different attributes: high-income people enjoy a high degree of green space, with high accessibility and use of the opportunity; the low-income population of green space has a low accessibility and use opportunities.

The reason for the unfairness of urban green space was generated and explained by some scholars in economic terms (Beler, 1997; Dai, 2011). There are aspects of the impact of urban resident's preferences (Wright *et al*., 2012) and behavior scale (Zhou *et al*., 2013) and government planning policies (Jiang *et al*., 2010). However, the in-depth analysis of the underlying causes of these three features (known urban green space unfairness) is not a unilateral factor, and a variety of factors led to a synergistic effect, such as 'residential', 'economical' and 'political'. Figure 8 illustrates the factors that can affect the unfair city green space allocations as determined in this study.

(1) **Resident factors**: The residential population is the possessors of the service function of the urban green spaces. The benefit differences determine the fairness of urban green space allotments. The determining factors lie in the spatial attributes of green spaces for the residents, such as location and traffic conditions. At the same time, the users are also the selectors of urban green spaces. The decision factors lie in the social attributes of the resident population, such as the social economic status of population and the behavior scale, which together decide the acceptable service types of green space. However, according to the different scales and type restrictions of urban green spaces, there are two ways of selecting the accessibility of the green spaces, i.e., the indirect method and the direct method, as in the example of some specialty parks. The indirect accessibility reason could be that the park charges user fees. For some low consumer groups, there was found to be some unfairness in accessibility to these parks. However, it was noted that for some free of charge and direct accessibility green spaces, the accessibility in the different behavior scales varied. This also explains that the location of the inner residential green space for the

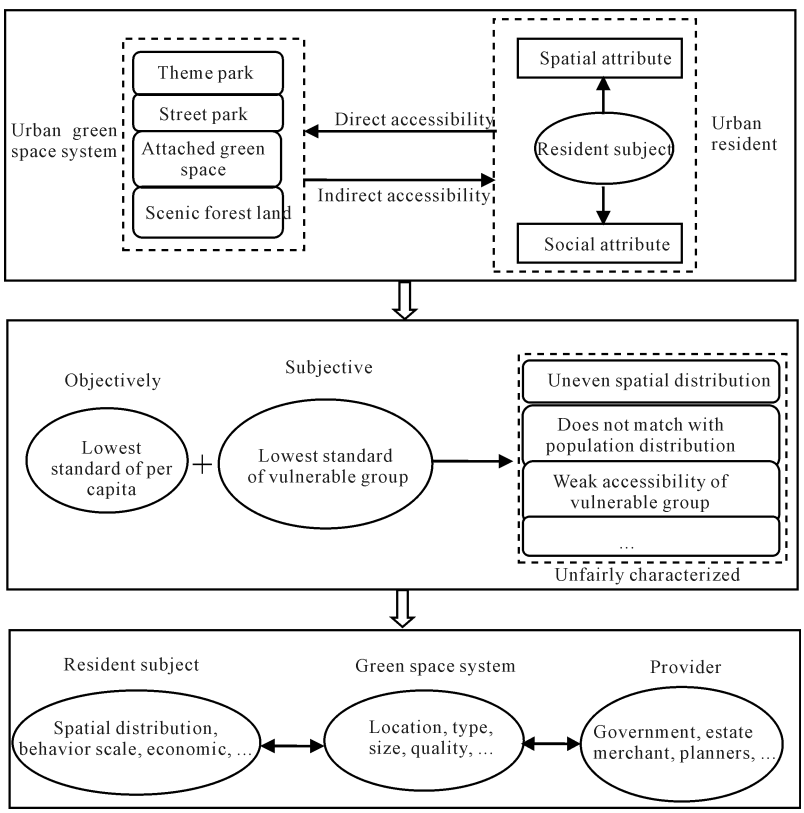

Fig. 8 Mechanism figure of urban green space unfairness characteristics

low income population groups is unsatisfactory. Therefore, the residents′ income level and living space position may lead to the serious class differentiation. These factors may be the intrinsic reasons which reflect the unfair allocation of city green spaces to a certain extent.

(2) **Economic factors**: The requirements of housing for the areas′ population are not only limited to the living function at this stage due to the increase in material and spiritual levels, there is also a demand for the better living environments which are healthy and natural. Real estate market investors should keep this in mind if they wish to successfully attract more interested customers and stimulate demand. The commercial housing market attracts high-end consumers, and the commercial housing customer demands a high allocation of green space. Not only is the amount of green space allocation inside residential areas generally higher than that of the ordinary residential allocation, but high income groups demand higher external green scale in these types of the residential districts. Therefore, the real estate market invests in selecting places with convenient traffic flow, as well as large scale green space availability and quality. This produced residential space differentiation is a direct leading cause of the unfair distribution of green space for residential enjoyment.

(3) **Policy factors**: The government policies should combine both efficiency and fairness in regional control, and economic development should be synchronized with social equity. Policies should not be allowed for promoting regional economic development while blindly pursuing economic benefits at the cost of the destroying social fairness. Allowing the development of real estate by investors in some areas is bound to lead to the phenomenon of living space differentiation of the city residents, thereby causing the unfair allotments of green spaces by affecting the enjoying of city residents. Government planning and regulation should be active throughout the entire process. Appropriate improvement of traffic should be used to increase the accessibility to park green space. Therefore, government policies are important to the fairness or unfairness of the enjoyment of green space by urban residents.

References

Beler E F, 1997. The distribution of urban public services: the case of parks and recreational services in Ankara. *Cities*, 14(6): 353–361. doi: 10.1016/S0264-2751(97)00026-7

Cohen P, Potchter O, Schnell I, 2014. A methodological approach to the environmental quantitative assessment of urban parks. *Applied Geography*, 48: 87–101. doi: 10.1016/j.apgeog.2014.01.006

Dai D, 2011. Racial/ethnic and socioeconomic disparities in urban green space accessibility: where to intervene? *Landscape and Urban Planning*, 102(4): 234–244.

Dawson K J, 1995. A comprehensive conservation strategy for Georgia′s greenways. *Landscape and Urban Planning*, 33(1): 27–43. doi: 10.1016/0169-2046(94)02012-5

Giles-Corti B, Broomhall M H, Knuiman M *et al.*, 2005. Increasing walking: how important is distance to, attractiveness, and size of public open space? *American journal of preventive medicine*, 28(2): 169–176. doi: 10.1016/j.amepre.2004.10.018

Gu Mingdong, Yin Haiwei, 2010. Review on spatial accessibility and equity of public facilities. *Urban Problems*, (5): 25–29. (in Chinese)

Hu Zhibin, He Xingyuan, Lu Qingxuan *et al.*, 2005. Green space accessibility research based on GIS: taking Shenyang as an example. *Journal of Shenyang Jianzhu University* (*Natural Science*), 21(6): 671–675. (in Chinese)

Jiang Haiyan, Zhou Chunshan, Xiao Rongbo, 2010. Spatial differentiation and social equity of public parks in Guanzhou. *City Planning Review*, (4): 43–48. (in Chinese)

Jim C Y, Chen W Y, 2006. Recreation–amenity use and contingent valuation of urban greenspaces in Guangzhou, China. *Landscape and Urban Planning*, 75(1): 81–96. doi:10.1016/j.landurbplan.2004.08.008

Kabisch N, Haase D, 2014. Green justice or just green? Provision of urban green spaces in Berlin, Germany. *Landscape and Urban Planning*, 122: 129–139. doi: 10.1016/j.landurbplan.2013.11.016

Li Bo, Song Yun, Yu Kongjian, 2008. Evaluation Method for Measurement of Accessibility in Urban Public Green Space Planning. *Acta Scientiarum Naturalium Universitatis Pekinensis*, 44(4): 618–624. (in Chinese)

Lineberry R L, 1977. *Equality and Urban Policy*: *The Distribution of Municipal Public Services*. Sage Publications.

Lucy W, 1981. Equity and planning for local services. *Journal of the American Planning Association*, 47(4): 447–457. doi: 10.1080/01944368108976526

Ma Linbing, Cao Xiaoshu, 2006. A GIS-based evalutation method for accessibility of urban public green landscape. *Acta Scientiarum Naturalium Universitatis Sunyatseni*, 45(6): 111–115. (in Chinese)

Mullick A, 1993. Accessibility issues in park design: the National Parks. *Landscape and Urban Planning*, 26(1): 25–33. doi: 10.1016/0169-2046(93)90005-X

Rich R C, 1979. Neglected issues in the study of urban service distributions: a research agenda. *Urban Studies*, 16(2): 143–156. doi: 10.1080/00420987920080221

Sang Lijie, Shu Yonggang, Zhu Weiping *et al.*, 2013. Accessibility of urban green spaces in Hangzhou City. *Progress in Geography*, 32(6): 950–957. (in Chinese)

Sonmez T H, Malkoc Y E, Altug I, 2007. Evaluation of elderly people′s requirements in public open spaces: a case study in Bornova District (Izmir, Turkey). *Building and Environment*, 42(5): 2035–2045. doi: 10.1016/j.buildenv.2006.03.004

Talen E, 1998. Visualizing fairness: equity maps for planners. *Journal of the American Planning Association*, 64(1): 22–38. doi: 10.1080/01944369808975954

Talen E, Anselin L, 1998. Assessing spatial equity: an evaluation of measures of accessibility to public playgrounds. *Environment and Planning A*, 30(4): 595–613. doi: 10.1068/a300595

Van H A, Wiedemann T, 2003. A monitoring tool for the provision of accessible and attractive urban green spaces. *Landscape and Urban Planning*, 63(2): 109–126. doi: 10.1016/S0169-2046(02)00192-5

Wang Laijie, 2007. Changes in public services in Western countries: orbits and characteristics. *Socialism Studies*, (6): 89–92. (in Chinese)

Wicks B E, Crompton J L, 1986. Citizen and administrator perspectives of equity in the delivery of park services. *Leisure Sciences*, 8(4): 341–365. doi: 10.1080/01490408609513080

Wright W H E, Zarger R K, Mihelcic J R, 2012. Accessibility and usability: green space preferences, perceptions, and barriers in a rapidly urbanizing city in Latin America. *Landscape and Urban Planning*, 107(3): 272–282. doi: 10.1016/j.landurbplan.2012.06.003

Yin Haiwei, Kong Fanhua, Zong Yueguang, 2008. Accessibility and equity assessment on urban green space. *Acta Ecologica Sinica*, 28(7): 3375–3383. (in Chinese)

Yin Haiwei, Kong Fanhua, 2006. Accessibility analysis of urban green space in Jinan. *Chinese Journal of Plant Ecology*, 30(1): 17–24. (in Chinese)

Yu Kongjian, Duan Tiewu, Li Dihua *et al*., 1999. Landscape accessibility as a measurement of the function of urban green system. *City Planning Review*, 23(8): 8–11. (in Chinese)

Zhou Xiang, Zhang Xiaogang, He Longbin *et al*., 2013. Equity assessment on urban green space pattern based on human behavior scale and its optimization strategy: a case study in Shenzhen. *Acta Scientiarum Naturalium Universitatis Pekinensis*, 49(5): 892–898. (in Chinese)