Supply-demand analysis of park services for different age groups in Community life Circle: a central district in Shanghai as a case

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Abstract: Parks prominently contribute to the healthy lives of urban residents at all ages in their community life circle(CLC), however, it is rarely discussed what distinction in different age groups' personas exist and furthermore whether the supply and the demand of park services for them are matched. This results in socio-spatial injustice of urban parks and inefficiency of park services in terms of healthy city planning, design and governance. propose an enhanced method that takes both sides of supply and demand into account to reflect the authentic budget of park services in the CLC. At the same time, age plays a weighting factor in the evaluation progress so that the outcome could be more adaptive to specific groups of residents and thus support a targeted decision making in constructing CLC. A central district in Shanghai was taken as a case and the result suggests that in 177 out of 304 community units of this area, the elder and children's demand for park services could be basically or even better, while the young face a better situation. The service budgets also depict different spatial agglomeration. Some improvement strategies are thus proposed to assure a better healthy-oriented built environment.

Keywords: park services; demand-supply analysis; community life circle; two-step floating catchment area

Introduction

The master plan of Shanghai 2035 proposes the notion of the 15-minute Community Life Circle(CLC) as the basic unit for organizing community, which ensures basic service facilities and open space within the residents' walking accessible range so as to create a comfortable community space(Li, 2017). As a result of that, the number of researches focusing on improving service of open space in the CLC increase rapidly in recent years(Huang et al., 2019, Sun and Chai, 2017).

Urban parks, as a pivotal component of urban open space, serve residents in recreation, sightseeing and some other ecological regulating services like air purification, rainwater absorption and so on. To optimize parks' spatial pattern and to improve their service quality therefore necessarily contribute to the construction of the CLC. Nowadays the most common approach is to ameliorate the accessibility of parks, with multifarious methods in hand, for instance, provider-to-population ratios, travel impedance to nearest provider, average travel impedance to provider and gravity model(Guagliardo, 2004). The principle of them inherently bases on the assumption that

park services could be consumed only when residents could reach them. That is to say, it emphasizes parks' role as supplier of the services and services are distributed to each life circle.

Meanwhile people demand various park services according to their features. David Crawford found out the public open spaces in high socio-economic neighborhoods posses more more features relating with physical activities amongst children(Crawford et al., 2008). The investigation of Jiang Haiyan suggests the more localized resident are, the more park services they would consume(Haiyan et al., 2010). Also park services are mainly consumed by children and the elderly and the young and middle-aged people only carry out community activities after work and on weekends, of which visiting a park is not inclined to be their preferred one(Li, 2017, Wang and Wang, 2016, Huang and Zhu, 2018). In that case, with personas of consumers of park services we should segment some specific needs of groups of various features in ages, income occupation and so on, furthermore judge whether or not service supply accordingly meet those demand. However, pertinent researches are still relatively rare.

Two-step Floating Catchment Area(2SFCA) method is a reasonable approach to integrate supply and demand of services. It considers population-to-provider ratio twice in turn in terms of supplier and demander: firstly, for each service supplier, all populations which falls within a threshold distance should be determined and then, for each service demander, the objective is to determine all available services that fall within a threshold distance. In the end a final outcome of population-to-provider ratio would be calculated out(Luo and Wang, 2003). This method has been applied mainly in spatial accessibility evaluation of health care facilities(Delamater, 2013, McGrail and Humphreys, 2009) (Nakamura et al., 2017)and also recently more inclined to other services like urban green space(Dony et al., 2015, Wu et al., 2018). However, the 2SFCA method manifests as a reflection of service supply in the end, since the population-to-provider ratio could be considered as a ratio of supply which is filtered twice by threshold distance. When it comes to demand, it's only possible to know how much services have been provided, rather than how much needs have been met.

Based on 2SFCA method, this paper aims to propose an enhanced method that takes both sides of supply and demand into account to reflect the authentic budget of park services in the CLC. At the same time, age plays a weighting factor in the evaluation progress so that the outcome could be more adaptive to specific groups of residents and thus support a targeted decision making in constructing CLC.

Materials and methods

Study area

The study area is located in a central city of Shanghai, with a total area of 54.76 km^2. There are a household-registered population of about 920,000 in the area, among which children(under 12 years old) account for 6.31%, young and middle-aged(13-59 years od) for 73.62%, and the elderly(over 60 years old) for 20.06%.

In contrast to other central districts of Shanghai, the study area own an insufficient total green space and its park area per capita in the study area is relatively low, which drives it urgent to improve the budget of parks service. As Figure 1 shows, the parks in the study area are classified into 4 levels according to *Shanghai Park Classification and Classification Management Standards and Assessment Methods* and *Shanghai Controlled Detailed Planning Technical Guidelin*es, namely district park, community park, street park and pocket park. Parks have a specific service radius which corresponds to the class(details in Table 1). The Shanghai Botanical Garden is excluded since it is not an ordinary residential park.

The research involves four types of data: (1) road network, which is extracted and topologically corrected from the road center line in the landuse map 2011. (2) parks data, including information of name, location, area, entrance location and so on, which are derived from the land use map and complemented with google earth and other related materials. (3) population, which refers to the 6th National Population Census of China. (4) results of

questionnaire survey which was conducted on the working days and weekends in the summer of 2017. 13 parks, from district parks to pocket parks, were surveyed and the respondents were residents around the parks. Except for the basic profile information, the questionnaire mainly focused on the frequency of visiting parks.

All the data were loaded into ArcGIS 10.3 and edited in the Gauss Kruger Xian 1980 120E projection coordinate system. The neighborhood committee is chosen to be the spatial statistical unit, with the number of 304 in total.

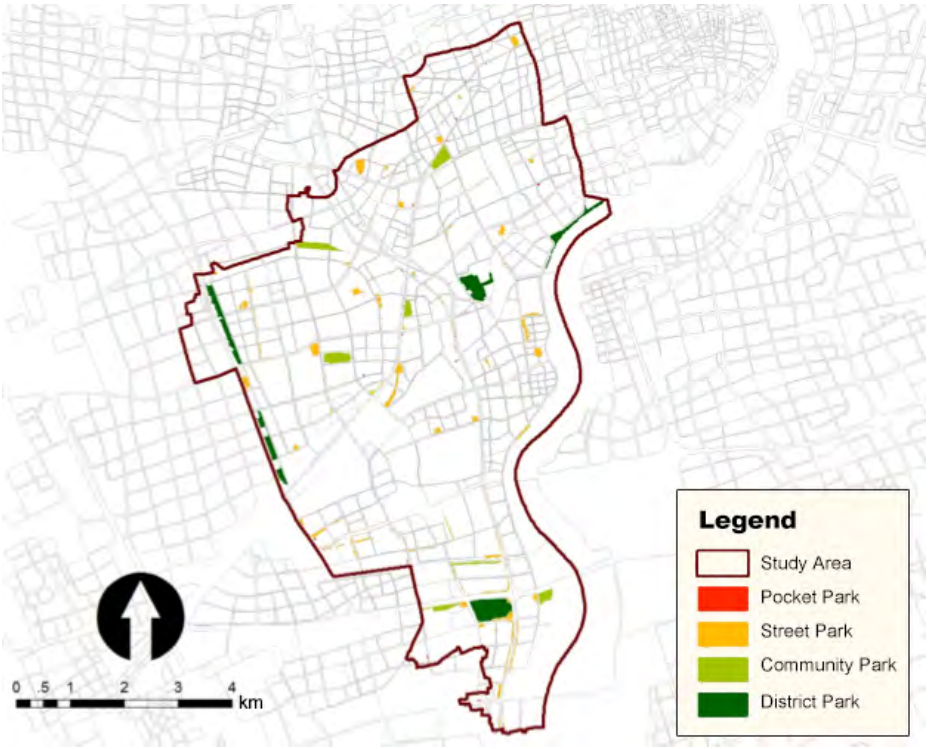

Figure 1. *Parks in the study area*

Table 1. *Statistic information of the parks in the Study Area*

Class	Threshold (hm^2)	Service Radius(m)	Number	Area in total (hm^2)	Percentage of Study area
District park	≥10	2,000	5	85.88	1.57%
Community park	≥4	1,000	6	45.77	0.84%
Street park	≥0.3	500	97	89.53	1.64%
Pocket Park	<0.3	250	82	9.91	0.18%
			Total:	227.49	4.23%

Framework of evaluation

This research takes consumption count of park services as the measurement for service supply and demand. On the one hand, for service supply evaluation, determine the ratio of park services that each park provides to the spatial units in its service catchment and then calculates available consumption count, which could interpret the level of park service supply. On the other, service demand could be measured in the way that required consumption count is calculated with the frequency of different age groups' visiting parks per week. At last, both separate evaluations are integrated to reflect the budget of the supply-demand. Compared with 2SFCA, this method

supplements the evaluation with the consideration of the demand side, which is independent of the evaluation of the supply side, so it can realize an integrated analysis. At the same time, the features of service consuming of different age groups are taken into account in terms of range of CLC and service-consumption frequency. Details of each step are as follows.

Firstly, determine the ratio of service supply. Each park is reclassed and has a service radius d. The service catchments of each park are generated with the network analysis tool in ArcGIS. Each catchment covers a plurality of spatial statistical units and then with the equation(1) we can calculate out the supply ratio of each park for each spatial statistical unit. The ratio correspond to the size of the park(larger parks have a larger service catchment and thus cover more spatial units) and the principle of equitable geographical distribution(larger spatial units should obtain more services from the parks). The equation of calculating the ratio is below:

$$W_j = \frac{S_{k_i}}{\sum S_{k_i}} \tag{1}$$

where W_j means the ratio for park j, S_{ki} is the area of the i_{th} spatial statistical unit k located in the service catchment and S_{k_i} is the sum of all S_{k_i}.

Secondly, determine the level of supply with available consumption count. The CLC of each age group has different range, thus take 15-minute walking distance as its radius(Li, 2017). In this study, according to the walking speed, the radius for the elderly and children is 1.2km and 2km for the young and middle-aged population. Usually children are accompanied by guardians (mostly the elders in China) to the park, so the study has included children and the elderly into the same group to simplify the discussion. With the network analysis tool can ArcGIS generate CLC catchments for each age group. After that calculate the ratio of effective service supply by each park in the CLC catchment and then available consumption count for each age group with the equation as below:

$$X_{k_p} = \sum(W_{k_j} \times M_{k_p}) \tag{2}$$

where X_{kp} is available consumption count for age group p, which reflects how many people could ideally speaking be served by a park. W_{kj} is the ratio of effective service supply by park j in the CLC for the spatial unit k and M_{kp} is the population of age group p in unit k.

Thirdly, determine the level of demand with required consumption count as the equation below:

$$Y_{k_p} = \sum(\alpha \times M_p) \tag{3}$$

where Y_{kp} means required consumption count, which reflects how many people would like to consume services of a park, M_{kp} is the population of age group p in unit k, and α is the frequency of visiting parks of different age groups, which is determined by a questionnaire survey.

Finally, determine the budget Q of demand and supply for each spatial unit with the equation below:

$$Q_{k_p} = X_{k_p} - Y_{k_p} \tag{4}$$

When Q_{kp} is greater than or equal to 0, that indicates the budget for park services of age group p manifests moderate or good in the spatial unite k. On the contrary, when Q_{kp} is less than 0, that indicates the budget not satisfactory and a larger absolute value suggests a worse situation. We could furthermore propose adaptive strategies and carry out targeted approaches for each park and spatial unit.

Results

Supply level

As shown in Figure 2 the spatial distribution of the services supply for the young and middle-aged people and the children and the elderly is roughly the same. Abundant supply area is concentrated in the central part of the study area and the riverside area, while scarce supply are in the north and west. Overall speaking, the level of service supply for children and the elderly differentiate amongst each spatial units is more than for middle-aged people and apart from that in most spatial units is in the upper-middle class.

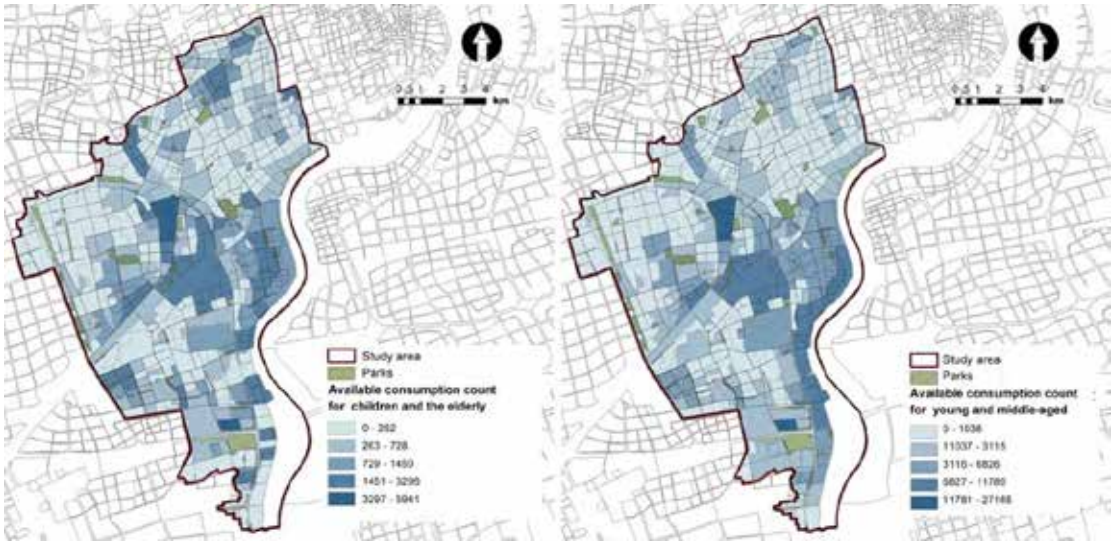

Figure 2. *Supply level of park services in each spatial unit for two age groups*

Demand level

In the end, a total of 280 valid questionnaires were collected, among which 171 were young and middle-aged respondents, 90 the elderly and 19 children. If the respondents visit a park every day, it is counted as 1. Then 3-4 times a week as 0.75, 2-3 times a month as 0.5, 2-3 times a season as 0.25, other lower frequency as 0. The average frequency of each age group is calculated out afterwards and the result suggests that the frequency of young and middle-aged people's visiting a park is 0.59, while children and elderly is 0.85.

As shown in Figure 3, the middle-aged and young people who demand for more park services concentrate in the in the middle of the study area. In contrast to that, the group of the elderly and children own much stronger demand for park services. The number of spatial units with higher demand is more amongst them than amongst young and middle-aged people and distribute wilder in the spatial dimension. On the whole, each age group's high demand areas have less spatial overlap. For example, the demand for children and the elderly in the northern part of the study area is moderately high, but the demand for young and middle-aged is on the contrary low. This indicates that parks in different parts of the study area have different target visitors.

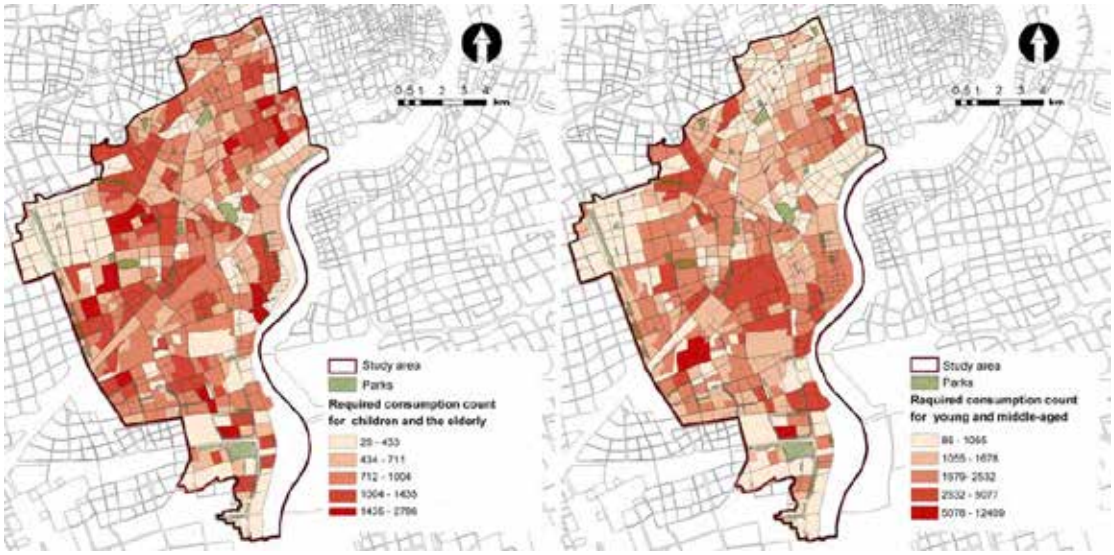

Figure 3. *Demand level of park services in each spatial unit for two age groups*

Budget level

The result of overlapping the demand and supply level suggests that as far as the elderly and children are concerned, as shown in Table 2, 177 out of 304 spatial units have a moderate or even ideal budget, but for the other 127 units the supply could not meet the demand. In contrast, the group of young and middle-aged enjoy a better service budget. In over two thirds of the spatial units, the supply could meet the demand or even oversupply. However, Figure 4 all in all indicates that the spatial distribution of budget for different age groups is somehow consistent with each other. The oversupply area is all concentrated in the middle and the supply shortage area is all in the northern part.

Table 2. *Budget of park services for two age groups in all neighborhood committee units*

	Young and Middle-aged		Children and the elderly	
	Number of Units	Percentage	Number of Units	Percentage
shortage	17	6%	21	7%
moderate shortage	86	28%	106	35%
matched	115	38%	120	39%
moderate oversupply	38	13%	25	8%
oversupply	48	16%	32	11%
Total	304	100%	304	100%

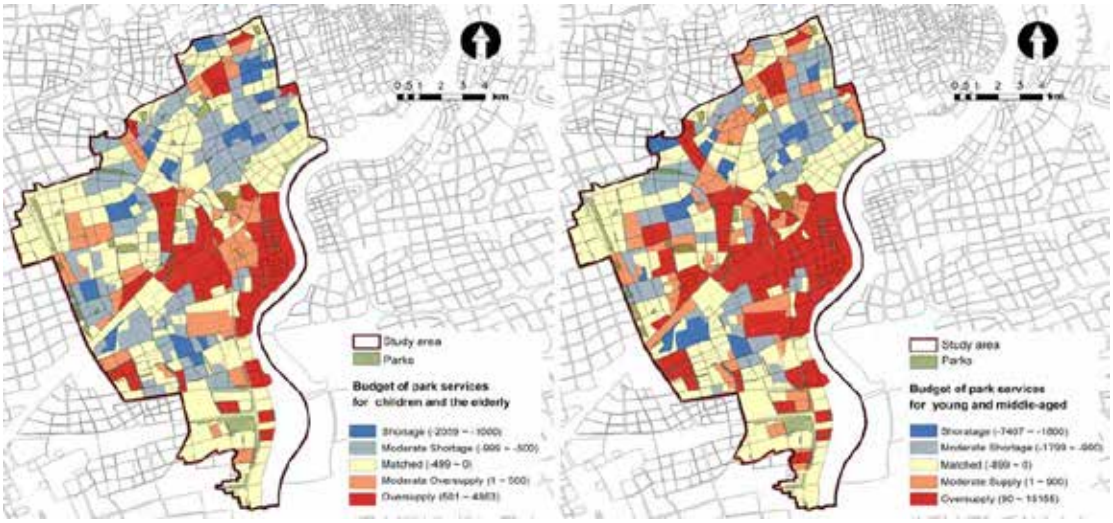

Figure 4. *Budget level of park services in each spatial unit for two age groups*

Discussion

As the spatial correlation analysis of park service budget in CLC for different age groups illustrates the Moran I index implies positive spatial correlation between supply and demand for all the age groups, which is significant at the level of α=0.01. That is to say, there is spatial agglomeration of service budget and we could identify the areas which are oversupplied or in huge shortage on the basis of Hot Spot Analysis (Figure 5) and afterwards propose the improvement strategies.

As far as those oversupply areas are concerned, it would better emphasize shaping characteristics of parks and provoke their differentiated development. Supplying surplus only means the delectable number of park services rather than the quality. The next step to construct CLC, we could identify the recreational preferences in each CLC through some robust and comprehensive surveys. Then it's possible to initiate a bottom-up differentiation of park system and improve the quality of park services.

To improve insufficient supply areas, one simple but effective way is to raise the budget level of those parks surrounding the weak budget areas. Since China steps into the urban development stage of stock renewal now, it is difficult to meet the intensive demand for park services by constructing new large parks in the central urban area. That highlights therefore the importance of the existing parks. In that case, to expand recreational space and to supply more recreational facilities in parks come first when we try to take the opportunity of urban renewal to alleviate the mismatch between supply and demand of park services.

One another way to ameliorate weak budget areas is to excavate idle space and construct pocket parks. Pocket parks can be scattered in urban areas to serve residents and feature in superior accessibility and highly frequently visited. Though small scale for each, the total performance is impressive when there are numerous pocket parks. To build a sharing recreational parks in residential area, open attached green space and other kinds of pocket parks, could it benefit not only in raising the efficiency of space, but also in promoting park service budget by forwarding with breakthrough points.

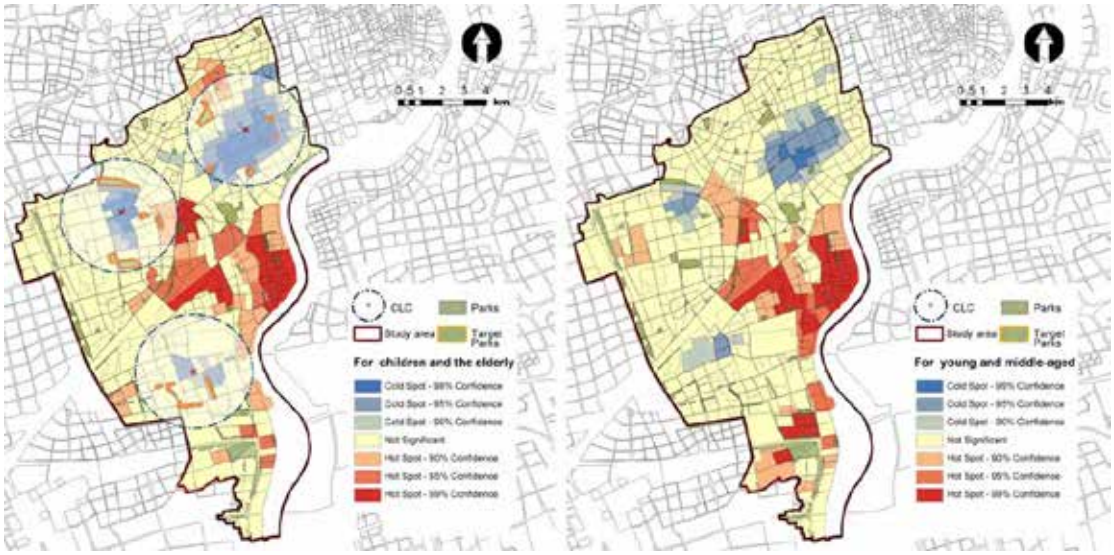

Figure 5. *Identification of hot and cold spot of service budget within CLC*

Conclusion

This paper proposes an method to evaluate and analyze the budget of park services in constructing CLC. In the case of a central district in Shanghai, where the method has been applied and practiced, the results indicate that the method has advantages in simple operation, especially comprehensively depicting the supply, demand of park services in term of different age groups. This method promises to promote the efficiency of urban green space in the context of urban renewal. However, the study assumes that the possibility of enjoying park services within the CLC is equal, which leads to a distorted cognition, since residents who live closer to parks are more likely to consume park services. Otherwise, it's not sufficient enough to support the improvement decision-making when evaluating park services without other criteria apart from accessibility. These shortcomings ought to be corrected in the future.

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