Increasing the Use of Community Open Spaces: An Analysis of Site Area, Accessibility, and Attractiveness

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***Abstract*—Open space activities are influenced by various factors. This research explores the influence of accessibility, site area and attractiveness on the use of community open space. The Shenzhen Overseas Chinese Town community was chosen as the case study area. Here, four-day activities in each open space were observed, and the unit area, serviced resident population, and employed population were calculated. In addition, the relative magnitude of the field attractiveness of each open space was calculated, thus allowing for the establishment of single and multiple factor models that affect the use of open space. This research finds that, for community open spaces, site area and attractiveness are more important influential factors than accessibility on community outdoor activity. The open space area is the most important factor affecting open space activities. When the unit area of a community open space is 500 m^2 to 2000 m^2, its efficiency is higher. For community open spaces having similar unit areas, increasing their attractiveness is more important than enhancing their accessibility. Thus, to increase the use of community open spaces, thoughtful design (and redesign) of spaces is required that creates moderate size, attractive open spaces with various facilities and friendly environment that encourage active use, rather than focus on excessive accessibility and magnificent decorations.**

***Keywords*—community open space, attractiveness, accessibility, site area**

I. Introduction

Public open spaces are key built environment elements within neighborhoods intended to encourage various physical activities, provide a number of significant benefits, and serve various important functions that improve the quality of life in cities [1-3]. In urban and landscape planning studies, the quantity and quality of open spaces in a community have been eliciting increasing attention. Open spaces can promote residents' outdoor activities, which in turn help reduce stress and provide opportunities that promote relaxation [4-7]. Many dynamic factors and their complex interactions affect the influence of open spaces on human health in urban areas [8]. Based on studies on outdoor activities, many countries have formulated a number of policies and guidelines that guide the planning and design of public open spaces with the aim of promoting the use of open spaces by residents. Landscape design of public open spaces, which usually cover large areas with complex components and functions, have become a challenging task in the field of urban landscape design [9].

Many studies had found significant variations in open space utilization among different groups [10-12]. The spatial configuration of parks, the number of parks and their accessibility, represents the basic park access potential for their residential populations[13, 14]. The distance of the open space from the user is assumed as the most important factor influencing the use of open space[15, 16]. A distance of 300 m to 400 m is considered as an important threshold [17]. When the distance of a user to the open space is more than 400 m, the use frequency decreases rapidly [18]. Some studies have found that different attributes of open spaces, such as area, facilities and environment, affect the frequency of use [19-22]. A study from Australia reported that 70% of the respondents choose to visit those open spaces they find attractive among open spaces with similar scale and accessibility [18].

Meanwhile, previous study found that the actual or perceived dimensions of open space size did not directly influence user preferences. Adherence to the venue design itself and its opportunities for activities and landscape appear to be more important [19]. Previous studies had also emphasized that, in terms of daily leisure activities in the urban open space, the importance of the quality of the "microenvironment" (local environment) surpassed that of the overall environment [23]. However, do people actually prefer a larger, more accessible open space with better environment-friendly facilities? Under the same conditions, how do we comprehensively consider urban planning work considering the number and improvements of the urban community open space, accessibility, attractiveness, site area, and other factors? How do these factors work together to affect community open space activities?

The goals of the current study are to analyze the specific factors influencing the use of urban community open spaces in a typical community and to explore strategies through which community open space utilization can be strengthened. The study uses a typical Chinese community as the study case. Under the background of rapid urbanization for the past 30 years, China's urban residential areas have accumulated high population density; however, few urban public open spaces are being provided. Community open spaces are usually extensive used and play an important role in providing space for public life.

II. Data Acquisition

This empirical study analyzes a specific open space of

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Shenzhen Overseas Chinese Town (OCT) community. The OCT community is located in Nanshan District, Shenzhen City. This community was developed and constructed in 1985. At present, it is built and administrated by the state-owned enterprise, the OCT Group, with excellent internal facilities and exquisite environment. Over the years, the OCT community has become a modernized seashore city integrating tourism, housing, commercial offices, creative cultural industries, and other functions. According to the Master Plan of the OCT (2015–2025), the community resident population is 37,700 and the total employed population is approximately 21,800. This study selected the north area of Shennan Avenue, which mainly contains residential and office groups in a total land area of 306.2 hm^2.

To establish the research framework of the use of open space, this research collected four sets of data. First, it identified all the public spaces and divided them into 112 independent units; second, an environmental scan was carried out to obtain the environmental characteristics of every open space unit; third, the accessibility of each unit was calculated using service population as an indicator; and finally, a systematic four-day observation was carried out to count the number of users in each space unit.

A. Open space recognition and unit division

Firstly, the research comprehensively surveyed all open spaces of the OCT, particularly those in which people can enter and stay to a certain extent. The open space located in the high-end residential community and the villas were not included in this research because they were closed to the public. In addition, streets, water surfaces, inaccessible mountains, and open spaces inside the construction were excluded. In order to explore the environmental elements affecting the use of open spaces, all open spaces were divided into a number of several space units on the basis of spatial configuration and environmental characteristics. These space units are relatively homogenous and independent units that shared similar internal physical attributes (i.e., pavage, vegetation, and facilities) and spatial structures yet differed from their neighboring units. Those spaces enclosed by trees, fences, walls, steps, or other clear boundaries were allocated to different space units, while successive spaces are not allocated into different space units. This process was carried out in order to maintain basic conformity or continuity of landscape elements inside the space units, and to simultaneously achieve a larger difference or obvious space separation between adjacent space units. Moreover, to guarantee the size comparability of the basic spatial units, we ensured that the area of each space unit was not less than 100 m^2.

Based on the above principles, all open spaces in the research area were divided into 112 open space units, with an average area of approximately 2,130 m^2. The composition and functions of each space unit are somewhat different. Their accessibility also significantly differs: some are easy to reach, while some are of poor accessibility. The use of the space units also differ: some space units are crowded, whereas many space units are seldom visited.

B. Environmental scanning and attractiveness analysis of open space

The researchers conducted a full investigation and documentation of the environmental characteristics of all the open space units. Refer to previous studies [9, 18, 24], this audit content mainly included three aspects (space composition, facilities, and landscape features) with 17 characteristics variables. For the space composition, the total site area, accessible lawn area, forest space area (the tree covered area), footpath length and hard floor area, were measured. The site facilities comprised eight types: outdoor fitness facilities, commercial facilities, seats, auxiliary seats, rain and sun-shading devices, non-motor vehicle facilities, sanitation facilities, and lighting facilities. Finally, the landscape environment surveys included the number of waterscape (waterscape in OCT mainly include lakes, pools, fountains, and streams), (mammal and bird) biological habitat types, sculptures, and motor vehicle parking volume.

In order to study the factors affecting the attractiveness of community open space, another research parallel with this one focused on the influence of multidimensional characteristics of the open space itself on its attractiveness[25]. In that research, the 17 features scanned in the open space units were used to establish the single factor and integrated regression models. Their results showed that lawn area, number of waterscapes, footpath length, number of benches, commercial facilities, and outdoor fitness facilities comprised six significant variables affecting the attractiveness of an open space.

In contrast to general understanding on urban open spaces, our findings indicated that in community open spaces, forest space is not significantly attractive to residents. By contrast, the model reveals its weak exclusion effect on open space users. The investigation showed that the forest occupies a lot of spaces and most open spaces under forest spaces lack an exquisite design. The dense forestry woods also made the space feel unsafe. The wide animal was supposed to be a factor that enhances site attraction, but our regression model revealed great exclusion between animal and crowd activities. In field observation, the term “animals” refers to wild animals rather than pets; these animals are mainly birds and mammals that live in their private habitats, far away from noisy human activities. The presence or absence of outdoor fitness facilities in a community open space is very essential. Our regression model showed that, the presence of fitness facility in an open space unit could attract 38 and 91 users to stay on weekdays and weekends, respectively. This result reflected the extreme scarcity and importance of outdoor fitness facilities in communities in China.

Thus, the current research adopted those six variables and used the method of double arithmetic progression to calculate the relative attractive value of all open space units. The calculation formula is given by

$$A_i = \sum_{j=1}^{n} S_{i,j} * \frac{j}{n} \quad (1)$$

where A_i is the total value of attraction of open space unit i; i is the serial number of a sample, and its values range from 1–112; n is the number of variables (n=6); j is the serial number

of a variable, and the values of j range from 1–6; and S_{ij} is the score of variable j in open space unit i, with its values ranging from 1–5. Here, a higher score represents the better condition of variable j in open space unit i. The results show that the average attractiveness score of all 112 open space units is 1.36, while the maximum and minimum values are 2.53 and 0.7, respectively. The open space unit with the highest attractiveness value is located at the lakeside area of the southern part of the Portofino Pure Water Shore business street. This waterfront site has more than 10 benches and various steps that can be used as auxiliary seats, and more than 10 stores and restaurants are situated in the area. The site also has several fitness equipment and a pleasant walking environment. Meanwhile, the open space unit that has the lowest attractiveness value is located on a hard-paved empty space in front of the *Shahe* sub-district office building. This site does not have any landscaped facilities and is often occupied by motor vehicles, making it a virtual parking lot.

C. Accessibility analysis of open space units

Accessibility is an important factor that affects the utilization of an open space. Walking is usually the most convenient and most preferred method of reaching the community open spaces. In the research area, the walking environment is better because it is rarely affected by the motor vehicle traffic. Hence, this research used the population of a certain distance from the open space (i.e., service population) to measure the accessibility of the open space.

The survey of the service population in the open space had two parts: one for the resident population, and the other is for the employed population (service population= resident population + employed population). In implementing the OCT Master Plan Research, the researchers visited the property management departments in all communities to obtain the resident population data at the end of 2013 in all residential groups. The data included the number of people living in rented and owned houses, which more accurately reflected the resident population of 2013 than that of the population census (2010) data. Statistical data showed that the resident population of the residential groups at the end of 2013 reached 29,293.

The size of the employed population in the same community is also large, comprising employees belonging to the subordinate enterprises of the OCT Group, employees of the Creative Industrial Park, and those of the surrounding commercial establishments in the area. The subordinate enterprises have detailed personnel statistics, while the creative industrial park management is familiar with the situation of their employees in the park. Given that information on the business-employed population in every region is incomplete, the employed population was calculated by the experience value of the commercial business area. The employed population of the research area, as calculated, is 16,917.

After calculating the overall distribution of resident and employed population, the service population within a certain distance away from the open space was then identified. Determining the appropriate distance threshold is the key to accessibility calculation. A higher distance value means that more people will suffer from low accessibility, whereas a lower distance value means that fewer people will benefit from high accessibility. Previous studies have shown that 300 m to 400 m is an important threshold for people to visit public space. Specifically, when the distance is more than 400 m from the open space, the frequency of use decreases rapidly[18]. In the research area, the populations living within 100, 200, and 300 m of a community open space account for 55.8%, 17.5% and 15.1%, respectively, for a total of 88.4%. Meanwhile, 57.1%, 21.2%, and 15.6% of the employed population work within 100, 200 and 300 m from a nearest open space for a total of 94.0%. Therefore, this study adopted the maximum distance of 300 m from the open space as its service area to calculate for the resident and employed populations and measure the accessibility of the open space. A high service population indicates that the open space has better accessibility.

Furthermore, from in-situ investigations we found that almost all the resident buildings and most of the office building are evenly distributed inside each resident and working group, thus this research assumed that the resident and employed populations are evenly distributed inside each residential and working group. The density of the population in every group was calculated and then multiplied with the service area of a certain open space unit, to obtain the service population of the group belonging to the open space unit. Then, the service population of every group in the service area of an open space unit was summarized to estimate the living and employment population of every open space unit. The calculation shows that, within the service area of each open space unit, the average resident population is 3,403 and that for the employed population is 592.

D. Observations of Public Open Space Users

The site investigation of the utilization of all community open space units was conducted. The 112 open space units were divided into nine groups according to proximity for observation. A total of 18 undergraduate students from Shenzhen University, divided into nine groups, were trained as observers and were tasked to observe and collect data from each of the nine groups of open space units. The observers went on a walk through all the space units in each group every hour, and recorded the instantaneous number of users in each space unit. The weather conditions, including temperature, wind and sunshine, in each observation period were recorded beforehand. The observation time in each day lasted from 9 am to 10 pm, and documentation was performed every hour. After the first and second hours of observation, the observers were assembled to unify the recording standard and to solve the problems they encountered during observation. To avoid observation bias, the data of the first two hours were dismissed. Extensive data were obtained on two weekdays and two weekends in November 2014 under fair weather conditions for outdoor activity.

A total of 35,090 people participating in various outdoor activities were observed; the average activity population number in every open space unit was 313 people. During the day (9 a.m. to 6 p.m.), 27,854 people were observed, while 7,235 people were observed in the evening (7 p.m. to 10 p.m.). During the two weekdays, 14,854 people were observed, while 20,236 people were observed during the weekends. The population used in the subsequent text analysis comprised the summary of population observed at each hour of the four-day

site investigation.

The data confirm that the highest daily stream of people was present in the open space from 3 p.m. to 5 p.m., whereas the lowest stream was recorded during lunch time and dinner time. At other time periods within a day, the stream of people was relatively stable, and then after 9 p.m., a rapid decrease in the number of people was observed.

III. Model Building and Result Analysis

A. Single factor model of open space activity

A single factor model was established first to explore the main factors affecting the use of open spaces. The dependent variables of the model are total activity and activity density, and the independent variables are resident population, employed population, site area, and attractiveness. The basic information of every variable is shown in Table 1. The regression results are shown in Table 2.

TABLE 1 BASIC INFORMATION OF ALL VARIABLES

Type	*Variables*	*Dimension*	*Symbol*	*Mean*	*SD*	*Min*	*Max*
Dependent variable	Total activity	Person	P	313	379	3	2101
	Activity density	Person/Hectare	D	1888	2117	21	9386
Independent variable	Living population	Person	R	3403	1642	183	6384
	Employment population	Person	E	592	279	38	1207
	Site area	Square meters	S	2129	2635	104	18188
	Attractiveness	-	A	1.36	0.43	0.70	2.53

The analysis results of the single factor model show that open space activity has a significant positive correlation (significance level: 0.05) with the accessibility of the resident population, and a weak positive correlation with the accessibility of the employed population. These findings suggest that in the research area, open space activity is mainly related to its accessibility to the resident population and slightly related to its accessibility to the employed population. The research area primarily contains residential communities, with the southern and eastern parts have business establishments, offices, cultural centers, and so on. The results confirm that the open space utilization rate of the employed population is low.

TABLE 2 CORRELATION COEFFICIENTS OF THE DEPENDENT AND INDEPENDENT VARIABLES BASED ON THE SINGLE-FACTOR MODEL

Correlation Coefficient	*Total Activity*	*Activity Density*
Accessibility (resident population)	0.1857**	0.0791
	(0.0499)	(0.4068)
Accessibility (employed population)	0.0710	0.0670
	(0.4567)	(0.4825)
Site area	0.5197***	-0.1615*
	(0.0000)	(0.0889)
Attractiveness	0.3529***	0.0278
	(0.0001)	(0.7711)

Note: *p* values are shown in brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The total open space activity is significantly positive correlated (significance level: 0.01) with the site area and site attractiveness; among the two factors, site area has the highest correlation coefficient and significance level of 0.5197 and 0.001, respectively. These findings indicate that the larger the open space area, the higher the number of total internal activity it can host. However, considering the utilization efficiency of the unit area, that is, using activity density and site area for correlation analysis, the result shows a significant negative correlation (significance level: 0.1). This finding indicates that the larger the area, the lower the activity density and space utilization efficiency.

Furthermore, the activity density of the open space has a small correlation coefficient with several other independent variables, and the significance level is low. In short, the single-factor model shows that open space activity is significantly positive correlated with the resident population, site area, and attractiveness. However, the interaction and the mutual relationship between the independent variables remain unclear, thus we built multi-factor models.

A. Multi-factor model of open space activity

By using the single-factor model, we were able to roughly determine the correlation and direction of the dependent and independent variables. However, many independent variables have a common effect on the dependent variable. By using the single-factor model, the effect of other variables cannot be controlled. Therefore, the multi-factor model was developed, followed by an analysis of how the independent variables work together. Under the precondition of controlling the effect of other variables, the effect of an independent variable is similarly described. Based on this, two multi-factor models are created, which are given by.

$$P_i = C + \alpha R_i + \beta E_i + \chi S_i + \delta A_i + \varepsilon_i \quad (2)$$

$$D_i = C + \alpha R_i + \beta E_i + \chi S_i + \delta A_i + \varepsilon_i \quad (3)$$

Where C is a constant term, ε_i is the disturbance, and R_i, E_i, S_i, and A_i represent the accessibility of the resident population, accessibility of the employed population, site area and the attractiveness of open space units, respectively. These two models illustrate the influencing factors of total activity

(P_i) and activity density (D_i) of open space unit i. The regression results are presented in Table 3.

TABLE 3 REGRESSION RESULTS OF THE MULTI-FACTOR MODEL

Item	*Total activity*	*Activity density*
Accessibility (living population)	0.03*	0.13
	(1.69)	(0.85)
Accessibility (employment population)	-0.04	-0.00
	(-0.38)	(-0.00)
Site area	0.06***	-0.19***
	(3.44)	(-3.52)
Attractiveness	125.83*	931.85**
	(1.87)	(2.11)
_cons	-74.95	993.76
	(-0.73)	(1.47)
N	112	112
R^2	0.300	0.049
adj. R^2	0.274	0.014
F	6.86***	3.13**

Note: *t* values are shown in brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The regression results of the multi-factor model show that, while controlling the effect of other variables, the site area remains as the most significant factor influencing open space activity (significance level: 0.01). Site area also has a positive effect on total activity and a negative effect on the activity density. Specifically, when site area is increased by 100 m^2, the average population in the site increases by 6 people, whereas the activity density decreases by 19 people/ha.

However, the open space site area is neither the larger the better, nor the smaller the better. The statistical data show that the activity density in the site area of 500 m^2 to 2000 m^2 surpasses the average level, accounting for 66.7% of the total activities. The average activity density varies for sites with different area sizes. When the site covers an area of 500 m^2 to 2000 m^2, the average activity density is high. However, when the open space unit area is considerably large, the site is usually relatively empty and has difficultly gaining high popularity among users. Meanwhile, when the open space unit is considerably small, the facilities and spaces provision are limited; hence, fewer people can gather in that area. For these reasons, the site area should not be exceedingly large or small. Hence, the suggested unit area of an urban community open space unit that can gather higher number of users should range from 500 m^2 to 2000 m^2.

The site area is the primary factor influencing the total open space activity. After controlling the site area variables, the attractiveness variable of open spaces is entered into the multi-factor model instead of the accessibility variable. This means that for open spaces with the same area sizes, those with better environment and facilities attract more people than others, rather than those spaces with better accessibility. The attractiveness variable has significant positive correlations with the influence on both the total activity and activity density in the open space. When the relative attractiveness increases by 1, the number of participants in the site activity increases by approximately 126 people (significance level: 0.1) and the activity density correspondingly increases by 932 persons/ ha (significance level: 0.05). The attractiveness of the open space can be improved by increasing the lawn area, creating waterscapes, increasing the footpath, installing seats, as well as integrating commercial and fitness facility designs and methods.

Following the site area and attractiveness variables, the accessibility of the resident population becomes the last variable entered into the multi-factor model. The reasons are further discussed in the subsequent section. Under the precondition of controlling other variables, when the resident population around the open space increases by 100 people, the number of participants of the site activity increases roughly by 3 people (significance level: 0.1), and the activity density increases by 13 people (not significant). In the multi-factor regression model, the accessibility of the employed population still has an extremely low correlation with total activity and activity density, suggesting that the employed population has extremely low influence on the community open space activity. Moreover, this finding reveals that the degree of open space utilization among the employed population in this community is considerably limited. In the research area, the employed population is usually exceedingly busy to engage in public activities, except during lunch break. Moreover, when they are not working, the employed population rarely stays in open spaces near their work places. Hence, the number and locations of various open spaces provided in the business and official areas should be considered at this point; in addition, the employed population should be provided with open spaces that satisfy their specific needs.

IV. DISCUSSION

Many factors influence the use of open spaces by urban residents. The influencing factors and mechanisms of action are still being explored. In general, more activities are observed in open spaces with high resident populations, large area sizes and pleasant environment, such as those located in the urban center area of most cities.

Many earlier studies have reported the significant influence [4, 26] of accessibility on open space utilization. In Australia, a research that controlled the size of the park and environment variables found that residents with better accessibility to large attractive public open spaces were 50% more likely to achieve high level of walking [18]. Natural England argued that people should have an area of not less than 2 ha of green open space within 300 m from their homes [27]. In recent years, with the continuous improvements in residential environments and the construction of many large open spaces, the accessibility of residents to open spaces has considerably improved as well. In the present study, 55.8% and 88.4% of the population live within 100 m and 300 m from the open space, respectively. Residents who live beyond 300 m from the open space usually live in the partly high-end residential community and villas with exclusive open spaces for their internal residents. In the community selected in this study, the accessibility of open space is at a high level, whereas the enhancement of open space accessibility did not increase the resident's use of open spaces significantly. Therefore, accessibility is not a factor limiting the residents' use of open space.

Similarly, a study on Danish residents used the multi-logistic regression model and examined the relative importance of different variables affecting the extent to which residents use

specific open spaces. The results showed that the most used open space by residents is not the nearest one and that the factors influencing the extent of use include site size, distance, age, and health condition, among others [26]. Another study pointed out that for most Danish people, the distance to the nearest green space is not a factor restricting their extent of use. Thus, the addition of more green spaces near residents cannot promote the extent of usage[27]. The regression results of the present study similarly show that in the developed OCT community, accessibility is not the primary factor influencing open space utilization. Following this finding, it should be attractiveness and size of the site area that should be prioritized.

The regression results of this study also show that open spaces with larger-sized areas attract more activities, but correspond to low activity density. As early as 1986, some scholars have pondered on one question on open spaces: Are areas with large sizes always good? That study found that user preferences are not affected by the actual or perceived dimensions of open spaces [19]. In fact, with more facilities, the space with a larger area provides better and more diverse environments, thus creating more experiences for the people and further encouraging them to participate in public activities [18]. In this research, the attractiveness scores and site area have a correlation coefficient of 0.466 and significance level of 0.001. However, from the perspective of utilization efficiency of the open space unit, the larger area is not definitely better. When the community open space unit covers an area of 500 m^2 to 2000 m^2, its activity density is high, indicating high utilization efficiency. Particularly, the average activity density in those open space units with moderate size is 150% higher than other open space units with a larger or smaller size. Therefore, blindly pursuing large open spaces is not a feasible option. Instead, a design featuring appropriate open space area sizes and provision of pleasant facilities and high-quality environment can promote higher utilization efficiency.

V. Conclusion

This research finds that, for community open spaces, site area and attractiveness are more important influential factors than accessibility on community outdoor activity. For the supply of urban community open spaces, several factors should be prioritized to promote the utilization efficiency of open spaces. These are explained in detail below.

The site area is the most important factor influencing open space activities. Site area has a significant positive effect on total activity and a significant negative effect on activity density. When the unit area of a community open space ranges from 500 m^2 to 2000 m^2, its utilization efficiency is higher. Given that exceedingly large or small venues are not conducive to gaining popularity, open spaces should thus feature a moderate area size and balanced layout.

In community open space units with similar area sizes, increasing their attractiveness is more important than enhancing their accessibility. The attractiveness of open spaces can be improved through such methods as increasing the lawn area, creating waterscapes, increasing the walkways, installing more seats, as well as incorporating commercial and fitness facilities. The resident population has a significantly positive effect on open space activity, whereas the employed population has almost no effect on open space activity. Hence, To increase the use of community open spaces, thoughtful design (and redesign) of spaces is required that creates moderate size, attractive open spaces with various facilities and friendly environment that encourage active use, rather than focus on excessive accessibility and magnificent decorations.

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Biography

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