

# Study on the Optimization of Spatial Layout of Public Sports Facilities in Urban Communities—A Case Study of Xiangshan Street Community in Shenzhen

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**Abstract:** Community is the last stage in the three-level allocation of public facilities. Public sports facilities are the basic carrier of a city. The rational layout and healthy development of community public sports facilities are of great significance to meet people's needs, improve their comprehensive quality and build a strong sports nation. From the perspectives of planning influencing factors and post-use evaluation, using literature method and hierarchical analysis (AHP), this paper constructs a multi-level evaluation model for the spatial rationality of public sports facilities in urban communities, analyzes the shortcomings and development directions of the spatial layout of public sports facilities in Xiangshan Street Community, and finally proposes four optimization strategies: Sports and Tourism Integration, Green Sports, Demand Orientation and National Fitness, thus trying to promote the community-level spatial layout planning of public sports facilities, and provide reference for the same kind of case.

**Keywords:** Public Sports Facilities; Spatial Layout; AHP; Optimization Strategies

## 1. Introduction

A reasonable spatial layout of public sports facilities is conducive to balancing the relationship between construction space and facility space, promoting healthy urban development while providing a good fitness environment for residents. Domestic research on the optimization of the spatial layout of public sports facilities is mainly carried out in terms of layout theory, planning layout and satisfaction. Hongtao Xu<sup>[1]</sup> applied the theory of smart urban growth and proposed several principles to promote the synergistic development of public sports facilities and urban space<sup>[1]</sup>; Hongzhi Wang<sup>[2]</sup> and others used spatial data processing tools to analyse the layout and number of public sports facilities in the region and proposed optimization strategies; Zihao Zhao<sup>[3]</sup> constructed an evaluation system of Changchun Nanhu Park elderly activity area landscape, and provided advice for the construction of senior citizens' activity areas in urban parks.

Communities are the last stage in the three-level configuration of public facilities at the municipal, district and community levels, but researches on the spatial layout of public sports facilities that focuses on public needs and implements community-level planning are insufficient. As urban communities are well located, densely populated and well organized, this paper takes a typical urban community, the Xiangshan Street Community in Shenzhen, as a case to study the spatial layout rationality of public sports facilities in urban communities and discusses the according strategies for optimization.

## 2. Research method

The case is analyzed and investigated mainly by literature reading and hierarchical analysis. Firstly, by reviewing related documents and public policies, the basic status quo of the spatial layout of community public sports facilities is known to provide theoretical support for the study; the current situation and development of planning factors such as location, economy, green space and population within the community are also analyzed to provide direction and policy basis for subsequent optimization. Secondly, through field research, information on the surroundings, the current situation of use and user evaluation of public sports facilities are obtained; using the hierarchical analysis method, theoretical and field research information are integrated to construct Xiangshan Street Community public sports

facilities space layout rationality evaluation index system, based on which qualitative and quantitative analysis of questionnaire and interview data are carried out. Finally, based on the comprehensive analysis results of subjective and objective analysis, the planning core and optimization strategies is determined. The technical route of this paper is shown in Figure 1.

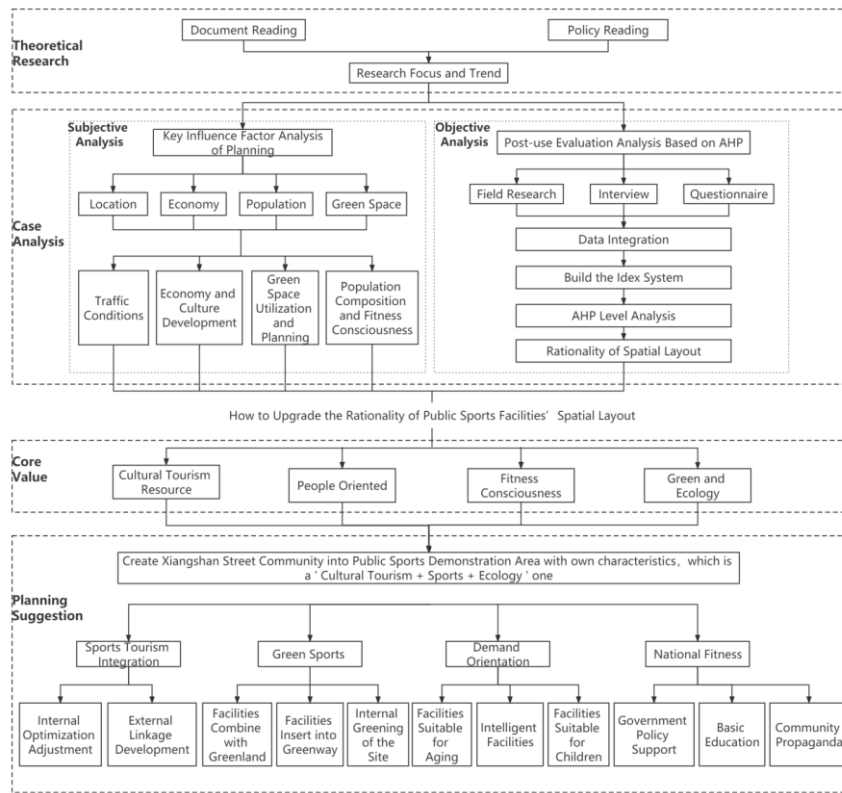


Figure 1: Technical Route

### 3. Case empirical analysis

#### 3.1 Construction of evaluation index system

##### 3.1.1 Selection of evaluation indexes

Table 1: Xiangshan Street Community Public Sports Facilities Space Layout Rationality Evaluation Index [4-9]

Target Level	Criterion Level	Index Level	Index Origin
Xiangshan Street Community Public Sports Facilities Space Layout Rationality	Accessibility (B1)	C11: Reachability Distance ( m )	Tianye Zhuge (2020)
		C12: Traffic Convenience	Meitong Shen (2021)
		C13: Time Taken To Reach ( min )	Ying Hu (2021)
		C14: Density of Facility Site (site / residence)	Field Researchu
	Fairness (B2)	C21: Number of Facilities (number / site)	Field Researchu
		C22: Facility Location	Chunlin Ma (2015)
		C23: Convenience of Elders and Children	Jun Pang (2020)
		C24: Convenience of Low-income Groups	Jun Pang (2020)
		C25: Convenience of Disability Group	Hongtao Xu (2021)
	Vitality (B3)	C26: Facility Types Completeness (species / site)	Meitong Shen (2021)
		C31: Duration of Facility Use (min / time)	Tianhao Xue (2015)
		C32: Facility Usage Frequency (times / week)	Tianhao Xue (2015)
		C33: Openness of Facility Site	Field Researchu
Management Service (B4)	C34: Congestion of Facility Site	Field Researchu	
	C41: Integrity of Related Service Facilities	Field Researchu	
	C42: Facilities Related Management	Deping Wei (2012)	

At present, there is no unified standard for the evaluation index system of the spatial layout of

public sports facilities. This paper combines information from relevant studies and field research on the spatial layout of public sports facilities and establishes a hierarchical evaluation index system as shown in Table 1.

**3.1.2 Determination of weights**

(1) Weight assignment method

The weighting of the indexes can be determined by fuzzy methods, and this paper specifically uses expert scoring questionnaires. Respondents compare the importance of two indexes based on their own expertise and finally calculate the weight of each index by means of a scale value.

(2) Judgement matrix

The formula for constructing the judgment matrix is as follows.

$$A = (A_{ij})_{n \times n} \tag{1}$$

$A_{ij}$  represents the scoring value of the importance of element  $i$  and element  $j$  relative to the upper level index, and  $n$  represents the number of elements. In addition, the matrix is required to satisfy three conditions:  $A_{ij} > 0$ ;  $A_{ij} = \frac{1}{A_{ji}}$ ;  $A_{ii} = 1$ .

(3) Hierarchical single ranking and consistency test

The maximum eigenvalue  $\lambda_{max}$  of the eigenvector  $W$  can be found using the sum method as follows.

Normalize the judgement matrix  $A$  by column

$$A_j = \frac{a_{ij}}{\sum_{i=1}^n a_{ij}} \quad (j = 1, 2, \dots, n) \tag{2}$$

Calculate the sum of the data in each row of the judgment matrix  $\bar{A}_i$

$$\bar{A}_i = \sum_{j=1}^n a_{ij} \quad (i = 1, 2, \dots, n) \tag{3}$$

Normalize the vector  $\bar{A}$

$$W = \frac{\bar{A}_i}{\sum_{j=1}^n \bar{A}_j} \tag{4}$$

Calculation of judgment matrix maximum eigenvalue  $\lambda_{max}$

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^n \frac{(AW)_i}{W_i} \tag{5}$$

Define the consistency index as  $CI$ :

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad n \text{ represents the order of judgement matrix} \tag{6}$$

Define the stochastic consistency index as  $RI$ , the  $RI$  Values are shown in Table 2 below.

Table 2: RI Value Comparison Table

Demension	1	2	3	4	5	6	7	8
$RI$	0.00	0.00	0.52	0.89	1.12	1.26	1.36	1.41

When  $CR = \frac{CI}{RI} < 0.1$  is satisfied, then the consistency test of the judgment matrix passes, otherwise it fails.

**3.1.3 Evaluation system construction**

The hierarchical analysis method was used to calculate the judgment matrix of each level and obtain the results of the weight of each index to the target level, and finally establish the evaluation system of

indexes for the spatial rationality of the layout of public sports facilities in Xiangshan Street Community, as shown in Table 3 below.

Table 3: Evaluation Index System of Xiangshan Street Community Public Sports Facilities Space Layout Rationality

Target Level	Criterion Level	Weights of Criterion Level	Index Level	Weights of Index Level	Weights of Target Level
Xiangshan Street Community Public Sports Facilities Space Layout Rationality	Accessibility (B1)	0.320	C11: Reachability Distance ( m )	0.318	0.102
			C12: Traffic Convenience	0.121	0.038
			C13: Time Taken To Reach ( min )	0.390	0.125
			C14: Density of Facility Site ( site / residence )	0.171	0.055
	Fairness (B2)	0.220	C21: Number of Facilities ( number / site )	0.064	0.014
			C22: Facility Location	0.263	0.058
			C23: Convenience of Elders and Children	0.239	0.053
			C24: Convenience of Low-income Groups	0.087	0.019
			C25: Convenience of Disability Group	0.148	0.033
			C26: Facility Types Completeness ( species / site )	0.199	0.044
	Vitality (B3)	0.289	C31: Duration of Facility Use ( min / time )	0.109	0.032
			C32: Facility Usage Frequency ( times / week )	0.297	0.086
			C33: Openness of Facility Site	0.390	0.113
			C34: Congestion of Facility Site	0.204	0.059
Management Service (B4)	0.171	C41: Integrity of Related Service Facilities	0.250	0.043	
		C42: Facilities Related Management	0.750	0.128	

### 3.2 Assessment results

#### 3.2.1 Data analysis

Table 4: Evaluation Results of Xiangshan Street Community Public Sports Facilities Space Layout Rationality

Target Level	Criterion Level	Index Level	Weights	Grade Average	Weighted Score	
Xiangshan Street Community Public Sports Facilities Space Layout Rationality	Accessibility (B1)	C11: Reachability Distance ( m )	0.318	3.609	1.148	
		C12: Traffic Convenience	0.121	4.609	0.558	
		C13: Time Taken To Reach ( min )	0.390	4.391	1.712	
		C14: Density of Facility Site ( site / residence )	0.171	3.478	0.595	
	Fairness (B2)		C21: Number of Facilities ( number / site )	0.064	3.935	0.252
			C22: Facility Location	0.263	4.13	1.09
			C23: Convenience of Elders and Children	0.239	3.783	0.904
			C24: Convenience of Low-income Groups	0.087	4.37	0.380
			C25: Convenience of Disability Group	0.148	3.783	0.560
			C26: Facility Types Completeness ( species / site )	0.199	4.848	0.965
	Vitality (B3)		C31: Duration of Facility Use ( min / time )	0.109	3.609	0.393
			C32: Facility Usage Frequency ( times / week )	0.297	3.5	1.040
			C33: Openness of Facility Site	0.390	4.152	1.620
			C34: Congestion of Facility Site	0.204	3.174	0.647
Management Service (B4)		C41: Integrity of Related Service Facilities	0.250	3.522	0.880	
		C42: Facilities Related Management	0.750	3.761	2.820	

The scores for each index under the four criterion level were calculated according to the hierarchical analysis method. The most heavily weighted of the 4 third grade indexes under Accessibility (B1) is the Time taken to reach (C13), with an average satisfaction score of 4.391, ranking second among the Accessibility indexes. All 6 third grade indexes under the Fairness (B2) have an average satisfaction score of medium to high, among which the Facility Location (C22) gets the greatest weight, with an average satisfaction score of 4.13 and the Number of Facilities (C21) gets the least weight. The most weighted of the 4 third grade indexes under the Vitality(B3) is the Openness of Facility Site (C33), and its average satisfaction score is high, while the weight for Congestion of Facility Site (C34), at 0.204, ranking third among the Vitality indexes, but its weighting is at the top of the overall evaluation indexes. The greatest weighting one between the two third grade indexes under the Management Services (B4) is Facilities Related Management (C42), which is at the top of the overall indexes, but its average satisfaction score is only 3.761. The specific results are shown in Table 4.

### 3.2.2 Integrated analysis

Combining the results of data analysis, field research and regional background information, a comprehensive analysis of the spatial layout of public sports facilities in the Xiangshan Street Community was conducted, with the following conclusions.

#### 1) Community traffic is convenient and the accessibility of facilities is high

The community is surrounded by third-grade roads, with the main road Qiaoxiang Street in the north side; and the internal traffic is complete, with the fourth-grade roads densely distributed. (The community road system is shown in Figure 2) The existing 7 public sports facilities are close to the third-grade road, close to the entrance and exit. Combined with the rationality evaluation and analysis results, the accessibility of the facilities is high, but it can be further strengthened.

#### 2) Community land use types are rich, and most facilities are in residential land

The land use types within the community is rich, mainly including cultural and educational land such as OCT primary school, public leisure land such as ecological square and industrial land such as OCT creative industrial park. (The type of community land is shown in Figure 3) In general, the existing public sports facilities in the community are mostly distributed in residential land, and the distribution of the facilities in different land resources is unbalanced, which affects the fairness and accessibility of the spatial layout of facilities.

#### 3) Community location is superior, and the facilities layout does not cooperate with the current situation and future trend of the community economic industries

The community is located in Shahe Block, Nanshan District, Shenzhen City. There are three economic development areas around the community: Qiaoxiang Road Headquarters Business Industrial Belt, OCT Group and Shenzhen Bay Super Headquarters. (The community location is shown in Figure 4)

4) The industry within the community is also rich, concentrated in the west side of the ecological square, the North District of the OCT Creative Culture Park. The spatial layout of facilities lacks coordination with the development of community economy and industry, and lacks integrity and cooperation.

#### 4) Community population composition is diverse, the convenience of facilities for the elderly and children is not high, and the overall supply level is insufficient

In the past 5-8 years, more migrants have migrated to the community, and the population will continue to rise in the future. The number of middle-aged and elderly groups in the community is big, and the number of children also has a growth trend, but the evaluation results show that the convenience of facilities for the elderly and the disabled and the friendliness of the disabled are not high. According to the survey, the number of friendly facilities for special groups in each site is seriously insufficient, and the supply is not enough to meet the large proportion.

#### 5) Community ecological environment is good, the combination of facilities and green resources is poor, and the internal environment of the site affects the use experience

The community has an excellent ecological environment, with a complete greenway system outside and two greenway network 'public destinations' inside. (The community's green space resources are shown in Figure 5) On the whole, more than half of the facilities are located in the residential area, which are close to the green areas attached to the roads, but little located in the green space. However, the poor configuration of plants inside has led to an overabundance of mosquitoes and insects, which has had an impact on the residents' using experience.

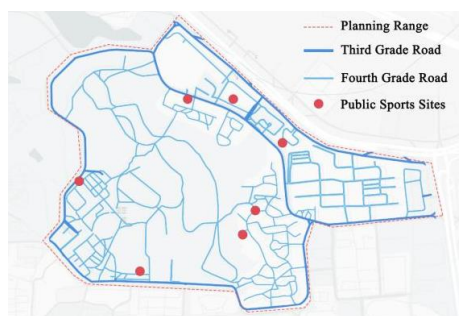


Figure 2: Community Road System

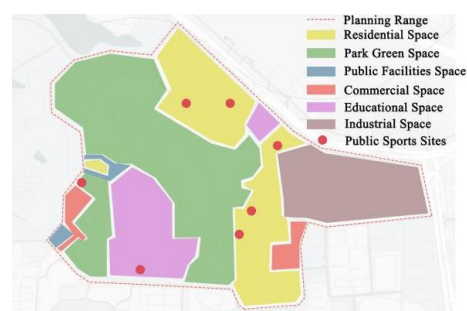


Figure 3: Community Land Use

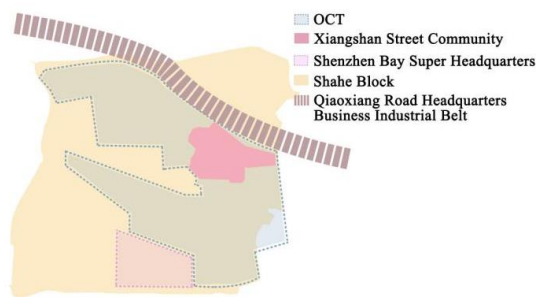


Figure 4: Community Geographical Location



Figure 5: Community Green Space Resources

### 3.3 Planning recommendations and optimization strategies

Based on the analysis results above, this paper proposes four core optimization values: "Cultural Tourism Resources", "People Oriented", "Fitness Consciousness" and "Green and Ecology", and further set the planning goal: "Turning Xiangshan Street Community into a 'sports + cultural tourism + ecology' integrated, people-oriented public sports demonstration area with its own characteristics". According to the principles of equity, coordination, moderate advancement and operability, four optimization strategies are proposed to achieve the planning goal.

#### (1) Sports and Tourism Integration

Located within the OCT Tourism Resort, the community has the potential to integrate sports and tourism. By combining cultural tourism with community sports, a "sports + cultural tourism" theme community can be created. (The concept is shown in Figure 6) The optimization of the layout of public sports facilities in the community should make use of the existing sports resources and festivals or events such as the OCT Cultural Tourism Festival, the National Fitness Month and other cultural tourism resources to guide the development of "culture + sports" and "sports + tourism" in the community.

#### (2) Green Sports

With its superior ecology and abundant green space resources, the Xiangshan Street Community has the best conditions to development green sports. (The concept is shown in Figure 7) The optimization of the public sports facilities layout in the community should promote the organic integration of facilities and green space resources; enhance the accessibility of facility sites and increase the length of use of facilities; motivate the combination of community public sports facility with green spaces such as parks; treat facility sites as small "public destinations", combined it with slow walking systems to insert into greenways; select suitable plant species and design the plant configurations within the sites to achieve a harmonious adaptation of ecology and beauty.

#### (3) Demand Orientation

The planning of community public sports facilities should distinguish service groups and design the public sports facilities according to their different features. ( The concept is shown in Figure 8 ) According to the demographic characteristics and people's actual demand, the facilities should be ageing, child-friendly and intelligent to provide residents with sports facilities that meet their expectations and needs. From the three aspects of fitness needs, social needs and management services, the configuration and design of community public sports facilities should meet the needs of the elderly; the needs and characteristics of children are also fully considered to create child-friendly community; modern information technology, such as cloud computing, is integrated into the construction of the public service system for national fitness.

#### (4) National Fitness

From the state to the local, all policies are committed to promoting the national fitness strategy. Community, schools and government form a joint force to create a national fitness environment, enhance residents' enthusiasm of using public sports facilities, and stimulate the health awareness of the whole community and even a wider range of people. Community carries out sports fitness related publicity and regular activities; schools ensure the teaching effect and teaching quality of physical education in class, add basic courses related to physical education, extracurricular fun sports activities,

and stimulate students' interest in sports; on the government side, continue to follow up the implementation of relevant policies, and increase support for fitness paths and national fitness projects in the policy system. (The concept is shown in Figure 9)

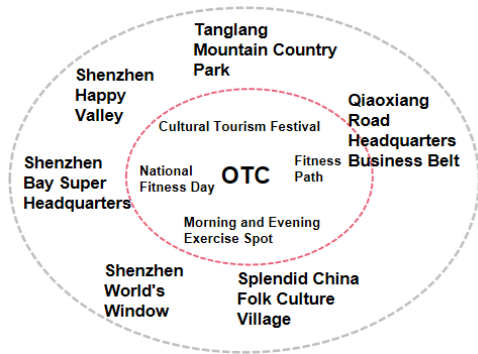


Figure 6: Strategy of Sports and Tourism Integration

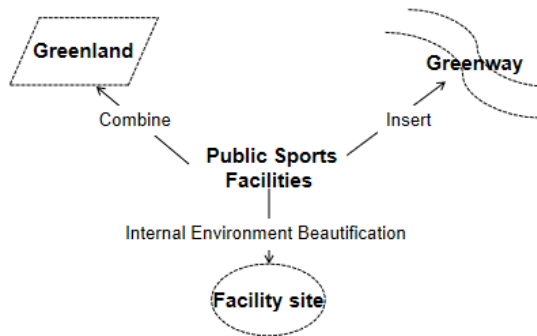


Figure 7: Strategy of Green Sports

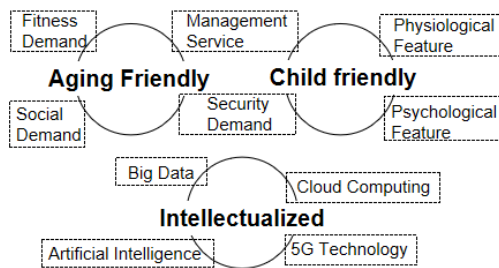


Figure 8: Strategy of Demand Orientation

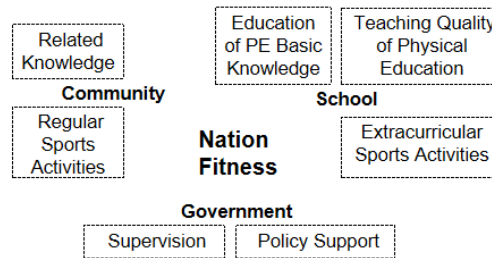


Figure 9: Strategy of National Fitness

#### 4. Conclusions

Community sports are a solid foundation for national fitness. The planning of public sports facilities in urban communities aims to balance the spatially coordinated development of sports and urban construction, so as to establish a public sports facilities system that fits the development of urban communities, meets people's fitness needs, has high rationality of spatial layout and high satisfaction of people's use.

This paper selects the Xiangshan Street Community located in Shahe Block, Nanshan District, Shenzhen City, analyzes the problems existing in the spatial layout of public sports facilities, and initially proposes corresponding optimization strategies. This paper mainly uses the methods of literature, field investigation and analytic hierarchy process to analyze the planning influencing factors of its location, economy, population and green space, as well as the rationality evaluation factors of the spatial layout of public sports facilities in the community, including accessibility, fairness, vitality and management services. According to the results of data analysis and document analysis, the existing problems of public sports facilities in the community are summarized, and the four core values of planning are put forward. The optimization design focuses on the planning goal of "building the Xiangshan Street Community into a 'sports + cultural tourism + ecology' integrated, people-oriented, public sports demonstration area with its own characteristics" and has formulated four planning strategies of 'Sports and Tourism Integration', 'Green Sports', 'Demand Orientation' and 'National Fitness'.

Through the evaluation of the rationality and the relevant background data, this paper makes a detailed analysis of the current situation and planning influencing factors of public sports facilities in Xiangshan Street Community, and puts forward the optimization strategies. However, there are still some deficiencies, such as the lack of research data on issues related to public sports facilities management services, which is also where this article needs to be further improved.

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