

Research on the Impact Assessment of Public Service Facilities on Land Use Intensity: the Case of Regulatory Planning of Shangmaying of Baoji

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Abstract: To further study the effects of public service facilities on the land use intensity at regulatory planning level and enhance the scientific determination of land use intensity, this paper expounds the influence mechanism and factors of the public service facilities on land use intensity in regulatory planning, and conducts quantitative evaluation of the influence factors through theoretical analysis, mathematical analysis and analytic hierarchy process etc. The results show that the influence mechanism of public service facilities on the land use intensity goes throughout all three levels of regulatory planning. Different characteristics of public service facilities on each level determine their different influence factors and take effect on the land use intensity index of the corresponding level, thus affecting the determination of the block floor area ratio. Based on this, this paper proposes a method to determine the land use intensity in regulatory planning under the restriction of public service facilities and completes the test in practice, which may provide a reference for determining the land use intensity in regulatory planning.

Keywords: Impact assessment, land use intensity, public service facilities, regulatory planning.

1. INTRODUCTION

Regulatory planning has gone through nearly 30 years process so far in China. The research on land use intensity in regulatory planning stage has always been the focus on the academia [1], while as the carrier of urban public interests, public service facilities has been paid more and more attention to related research. Both in the aspects of researches on land use intensity and public service facilities: Xian Baoning, etc. (2008) defined the concept of floor area ratio and put forward the comprehensive model determined by the floor area ratio [2]. Huang Minghua, etc. (2010) launched a "Range" research on land use intensity of regulatory planning [3]. Different types of researches enriched the connotation of land use intensity, while the factors that affected land use intensity in regulatory planning were also elaborated. In terms of the total amount of regulatory planning researches, Sun Feng etc. (2009) believed that the inheritance of the total amount of urban master planning should be fully taken into account in the determination of land use intensity in regulatory planning so as to avoid the fallacy of composition [4]. Lu Qin etc. (2009) carried out a research on the bearing capacity of regulatory planning, and put forward five restricting factors and each bearing capacity quantitative analysis method [5]. In the determination of hierarchical control aspects: under the background of The Urban And Rural Planning Law acted, Wei Dong etc. (2009) proposed the preparation methods of hierarchical regulatory planning, and emphasized the hierarchical control on land use Intensity [6]. Liu Huijun etc. (2013) believed that the floor area ratio

should be determined by the classification of public welfare facilities land and commercial land, and proposed a method to determine the floor area ratio hierarchically [7]. Researches from the perspective of public service facilities are the following: Yang Xiao (2007) put forward that the property of public service facilities, and presented a scientific facility layout model [8]. Fei Yan etc. (2012) proposed the total amount control method of public service facilities in residential area [9]. Chen Xiuwen (2007) proposed evaluation system for public service facilities service [10]. The study above could make sure the following 3 points: Firstly, the hierarchical control of regulatory planning adapts to the current urban planning system in our country. Secondly the determination of land development intensity is restrained by the total amount of the urban boundary. Thirdly, the public service facility is an important influence factor to determine land use intensity. It can be seen that the fact public service facilities affect the determination of land use intensity in regulatory planning has been accepted in all kinds of researches. But how public service facilities affect the land use intensity determining of regulatory planning has not yet been clearly explained, and further researches are needed.

Therefore, in order to clarify the influence mechanism of public service facilities on the land use intensity of regulatory planning, and find a method to quantify the impact assessment, in the current hierarchical regulatory planning formulation system, taking the regulatory planning of Shangmaying area of Baoji as an example, this paper explores the impact assessment of public service facilities on the land use intensity of regulatory planning.

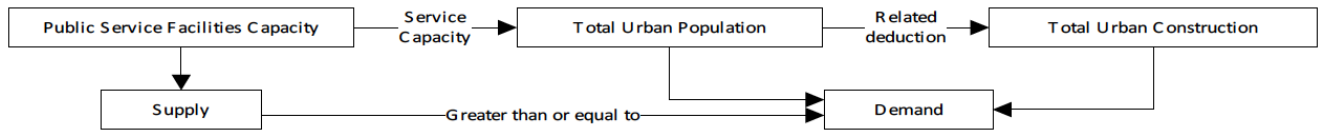


Fig. (1). Supply and demand relations between public service facilities and total urban construction amount.

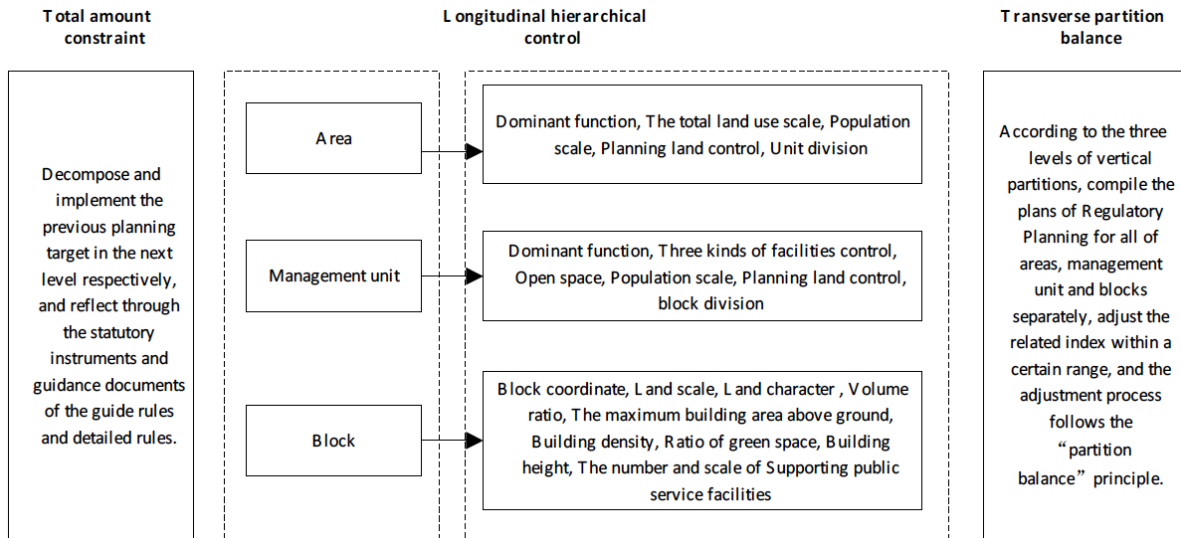


Fig. (2). Hierarchical regulatory planning technology system.

Table 1. Volume ratio index of three levels in regulatory planning.

Regulatory Planning level	Type of land use intensity index		Index connotation
Area	Regulatory planning volume ratio	Area average volume ratio	Description of the average land use intensity of areas
Management unit		Units base volume ratio	Description of the average land use intensity of management units
Block		Block volume ratio	Description of the average land use intensity of blocks

2. INFLUENCE MECHANISM OF PUBLIC SERVICE FACILITIES OF LAND DEVELOPMENT INTENSITY

2.1. Relations between Public Service Facilities Capacity and Total Amount of Urban Construction

(1) The relationship between supply and demand

The floor area ratio is the core index of land use intensity. The impact of public service facilities on land use intensity is manifested by the impact on the determination of floor area ratio, and the influence runs through the whole process of regulatory planning. The following are the ways to mitigate the influence of public service facilities on the floor area ratio. First, the relationship between the total amount and the capacity of urban construction need to be clarified. The total amount of the urban construction is the construction amount required in planning, including four categories of residential, commercial, industrial, logistics and warehouse type. These are the construction demand. The urban capacity is the capacity of all kinds of facilities carrying urban construction, mainly including road infrastructure, public service facilities, municipal infrastructure, and urban green space among

which the capacity of public service facilities is the ultimate bearing capacity of all kinds of public service facilities, namely the so-called supply quantity in microeconomics. The quantitative link between these two parts is the population. To ensure the urban residents a certain living quality level, the public service facilities capacity must be sufficient to bear the total urban construction needs (Fig. 1).

(2) Hierarchical control system

With the development of regulatory planning technology system and the carrying out of the comprehensive coverage of regulatory planning, the regulatory planning system in large and medium-sized cities in China tend to use the hierarchical model. The hierarchical control is to add the “management unit” level to the two-level system of “area-block” of the traditional regulatory planning to form the “area-management unit-block” three-level system. Under the control of “the total constraints, hierarchical control and partition balance” (Fig. 2). There exist different index connotation and delivery feedback relation in the three-level system of regulatory planning to determine the floor area ratio (Table 1). In the case of the total amount identified, decompose and implement the floor area ratio by layers and then

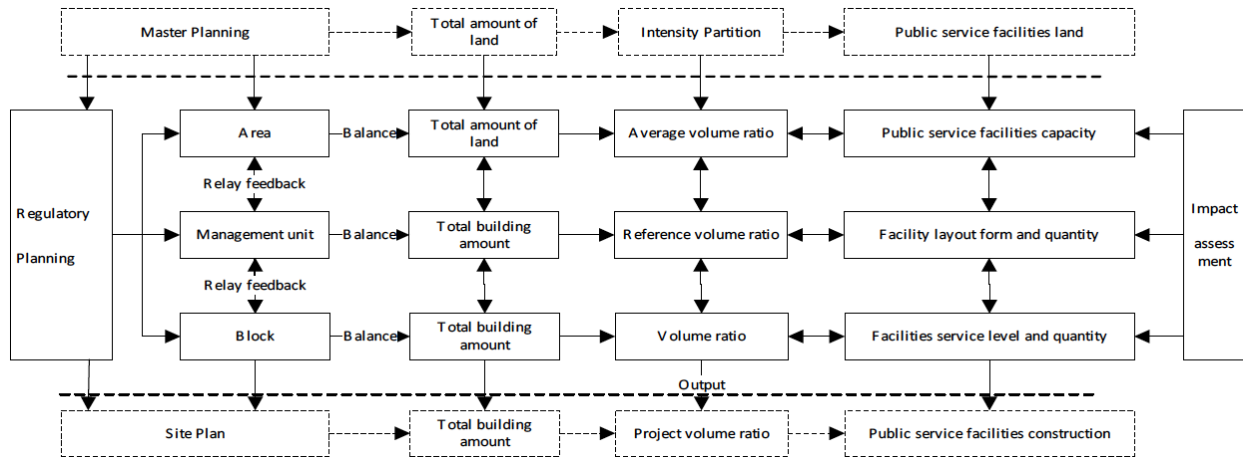


Fig. (3). Influence mechanism of public service facilities and land use intensity.

feedback and correct it, and ultimately determine the block floor area ratio. The influence of public service facilities also goes throughout these three levels.

2.2. Influencing Mechanism Framework of the Regulatory Planning Three Levels

The influence of public service facilities on land use intensity exists in the whole process of land use planning. In regulatory planning stage, the impact mechanism mainly acts as the mutual feedback influence mechanism in the vertical and hierarchical transfer and the influence mechanism and factor in the horizontal regional balance. Under the vertical and horizontal bidirectional influence mechanism, the land use intensity could be determined layer by layer. The influence mechanism framework of both public service facilities and land use intensity could also be determined (Fig. 3).

2.3. The Mutual Feedback Influence Mechanism in the Vertical and Hierarchical Transfer

In the influence mechanism, vertical influence mechanism includes transfer mechanism and feedback mechanism. Transfer mechanism is mainly embodied as the total transmission and distribution layer by layer, in which the conversion process is from top to bottom. Feedback mechanism is the feedback behavior in the process of total amount allocation, of which the adjustment process is from bottom to top.

(1) Transfer mechanism

The total amount inherits from master planning to regulatory planning areas. By judging the public service facilities capacity, the area total amount could be adjusted, and the land use intensity (i.e. the average volume ratio) could be guaranteed. The area total amount then is transmitted to the management unit level for the primary distribution, and that of land is converted to the total building amount to determine the land use intensity of management unit (i.e., the reference volume ratio). The total construction volume of each management unit passes further to the block level to be assigned again and finally to determine the volume ratio.

(2) Feedback mechanism

The total amount of each level is the foundation to determine the land use intensity, thus it requires constant feedback and quantity adjustment. For instance, the determina-

tion of the management unit reference floor area ratio would response to the adjustment of the land layout of public service facilities on the area level and then would pass again to the optimization of the reference volume ratio on the management unit level. Such feedback process also exists in block level. In the constant mutual feedback optimizing process of “feedback-adjustment-feedback again”, the block floor area ratio will be finally determined, and the floor area ratio of the specific block project will output to guide the site plan implementation.

2.4. The Influence Mechanism and Factor in the Horizontal Regional Balance

2.4.1. Area Level

(1) Influence Mechanism

The total amount of area principle is the inheritance of the total amount determined by master planning. However, the total amount of master planning, which is based on the amount of the land level, cannot be equal to the total construction of areas. Therefore, in the area level, the total construction amount needs to be re-determined based on master planning. Public service facilities scale and per capita indexes have certain rigidity character, especially the educational and medical facilities index. The capacity of public service facilities directly affects the determination of the total amount of area, thereby affecting the average area floor area ratio.

(2) Influence Factor

Public service facilities capacity is the main influence condition affecting land use intensity determination at the area level, and the specific influence factors should include all the factors that determine the level of public service facilities capacity, mainly includes: ①The category of facilities. Different categories of facilities have different influence degree on public service facilities capacity. By sorting out the literature, public service facilities can be divided into administrative management and community service facilities, cultural facilities, educational facilities, sports facilities, medical facilities, social welfare facilities and commercial service facilities. ②The level of facilities. An important reference index for computing facilities capacity is the grade

and scale of public service facilities. Combining with the urban administrative classification, public service facilities can be divided into municipal, district and community.

2.4.2. Management Unit Level

(1) Influence mechanism

Based on the confirmed total amount of area, in regulatory planning management unit level, the total amount needs to be assigned. The assignment is not uniform for each management unit, so that the impact of public service facilities to volume ratio could be extended to the management unit level. The unbalance of public service facilities distribution causes the horizontal difference of public service facilities capacity between different management units. While the total construction allocation condition of each management unit needs to consider the public service facilities capacity of the management unit. So the distributive total construction of each management unit determines directly the reference volume ratio of this management unit.

(2) Influence factor

The distribution of public service facilities is the main reason of the difference in the bearing capacity of different management units, specifically embodied in the following two aspects: The perfection level of public service facilities. The perfection level of public service facilities inside the management unit is the main factor to decide capacity of public service facilities of the unit. Commercial aggregation degree. Because of the particularity of commercial service facilities, the perfection level is needed to be represented by the aggregation degree.

2.4.3. Block level

(1) Influence Mechanism

Under the background of the urban construction marketization, residents' demand for public services are no longer limited to exist or not, but rose to the quality requirements. In the block level, the determination of the block volume ratio is also influenced by public service facilities. On the basis of facilities service radius, the specific service level of public service facilities related to the block determines the land use intensity of the block.

(2) Influence Factor

Based on Maslow's "Demand Level Theory", public service facilities service level depends mainly on the security, convenience and applicability of the facilities. Considering the supply type of partial public service facilities is

profit-oriented, the manageable convenience would be added as evaluation factor.

3. QUANTITATIVE EVALUATION OF INFLUENCE FACTOR

Throughout the study, the influence mechanism and factors on various levels are defined, based on which, the article quantitatively evaluates the influence of land-use intensity from factors of all levels through the method of mathematical statistics and analytic hierarchy process (AHP).

3.1. Area Level

The influence factors in area level include grading and classification of facilities. In the area level, computing capacity of public service facilities with different grades and different categories has different standards. Therefore, the influence weight of grades and categories of public service facilities needs to be determined, thus to judge the reference coefficient which is calculated by various types of capacity. Based on the determined coefficient, comprehensively counting of facility capacity on different grades and different categories could help to get the capacity of public service facilities in the area.

The main method of computing the weight of facilities is Analytic Hierarchy Process. Firstly, divides the levels of influencing factors (Fig. 4), then compares different types of facilities and generates the weight judgment matrix based on the relative importance of the ratio (Table 2). Based on the judgment matrix, calculates the feature vector value and root value, and tests consistence, thus eventually gets the influence factor weight of the area level (Table 3). Given space limitations, the calculation will not be repeated.

From the results of Table 3, it can be seen that the municipal public service facilities are the main reference of the capacity determination of public service facilities on each level of facilities. Education facilities, medical facilities and commercial service facilities are the main facility categories, which influence calculating capacity.

Once the weights of facilities of different grades and different categories on the area level are defined, there are two steps to determining land use intensity contains: first, to quantify the service level of the total amount of public service facilities which can determine the capacity of public service facilities in the present situation area. By comparing with the present situation of the population, it can be judged whether there is an allowance of service for all kinds of

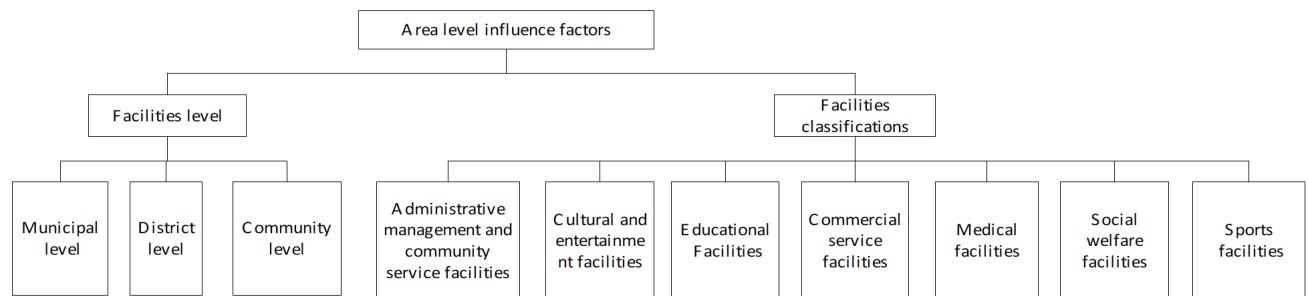


Fig. (4). Influencing factors in the area hierarchy.

Table 2. Judgment matrix of weighs at facilities classified.

Facility Name	Educational facilities	Medical facilities	Commercial service facilities	sports facilities	Cultural facilities	Administrative services and community facilities	welfare facilities
Educational facilities	1	2	3	4	4	5	6
Medical facilities	1/2	1	2	3	3	4	5
Commercial service facilities	1/3	1/2	1	2	2	3	4
Sports facilities	1/4	1/3	1/2	1	2	3	4
Cultural facilities	1/4	1/3	1/2	1/2	1	2	3
Administrative services and community facilities	1/5	1/4	1/3	1/3	1/2	1	2
welfare facilities	1/6	1/5	1/4	1/4	1/3	1/2	1

Table 3. The weight factors of facilities in the area level.

Influencing factors		Weight
The type of facilities	Educational facilities	0.35
	Medical facilities	0.23
	Commercial service facilities	0.15
	Sports facilities	0.11
	Cultural facilities	0.08
	Administrative services and community facilities	0.05
	Welfare facilities	0.03
Facility level	Municipal	0.16
	District	0.30
	Community-level	0.54

facilities, which is used to increase the serviced population. Second, make sure whether additional facilities can bring the increase in total population to estimate whether the newly added facilities could bring the increase of the population gross. The above two can increase the floor level of service ability which is the capacity of public services. In order to determine the average floor area ratio, the capacity of Public services is used to infer the total construction.

3.2. Management Unit Level

The affecting factor of the hierarchy is perfection of public service facilities and commercial aggregation. At the same time, calculation of the Analytic Hierarchy Process (AHP) can help to divide the level of the management unit affecting factor (Fig. 5), confirming its weight distribution and evaluation of value (Table 4).

From the results of Table 4, perfection of public service is an important reference factor determining the division of the strength in a management unit. In fact, the capacity of public service of area is decomposed in a management unit to quantify capacity of the facility.

Based on the determined land use planning, analyse the difference of the bearing capacity of the facilities in different management unit, generally evaluate the condition of the facilities within each unit, and finally obtain the total score of the same management unit of service capability. On the basis of its service capability, the total amount construction for ensuring reference floor area ratio in the management unit is initially divided. The key determining the intensity of land use is to evaluate public services generally rather than to quantify the specific facilities.

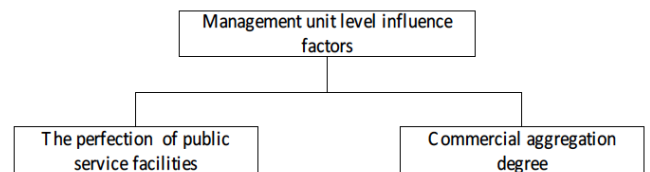


Fig. (5). Influencing factors in the Management unit level

Table 4. The weight distribution of influencing factor in the snap of public service facilities.

Influencing factors	The hierarchical property	Value	Weight
Perfection degree of public service facilities	Municipal public facilities	3	0.67
	District public facilities	2	
	Community-level public facilities	1	
Commercial aggregation degree	Municipal Commercial-scale	3	0.33
	District Commercial-scale	2	
	Community-level commercial-scale	1	

Table 5. The weight distribution of distribution of influencing factor in block level.

First target A		Secondary target B		Guidelines layer C		Weights of the layer C to A
Weight	Classification of factors	Weight	Facilities performance	Weight		
Facilities classified	0.5	Educational facilities	0.343	Security	0.637	0.109
				Convenience	0.258	0.044
				Applicability	0.105	0.018
		Medical facilities	0.231	Security	0.54	0.063
				Convenience	0.297	0.035
				Applicability	0.163	0.019
		Commercial service facilities	0.148	Security	0.472	0.035
				Convenience	0.285	0.021
				Applicability	0.170	0.013
				Convenient operation and management	0.073	0.006
		Sports facilities	0.11	Security	0.546	0.030
				Convenience	0.233	0.013
				Applicability	0.137	0.008
				Convenient operation and management	0.083	0.005
		Cultural facilities	0.082	Security	0.467	0.019
				Convenience	0.278	0.012
				Applicability	0.160	0.007
				Convenient operation and management	0.095	0.004
		Administrative services and community facilities	0.052	Security	0.54	0.014
				Convenience	0.297	0.008
				Applicability	0.163	0.004
		Welfare facilities	0.034	Security	0.54	0.009
				Convenience	0.297	0.005
				Applicability	0.163	0.003
Supply classified	0.5	Public Welfare	0.54		0.27	
		Quasi: Public Welfare	0.297		0.149	
		Profitability	0.163		0.081	

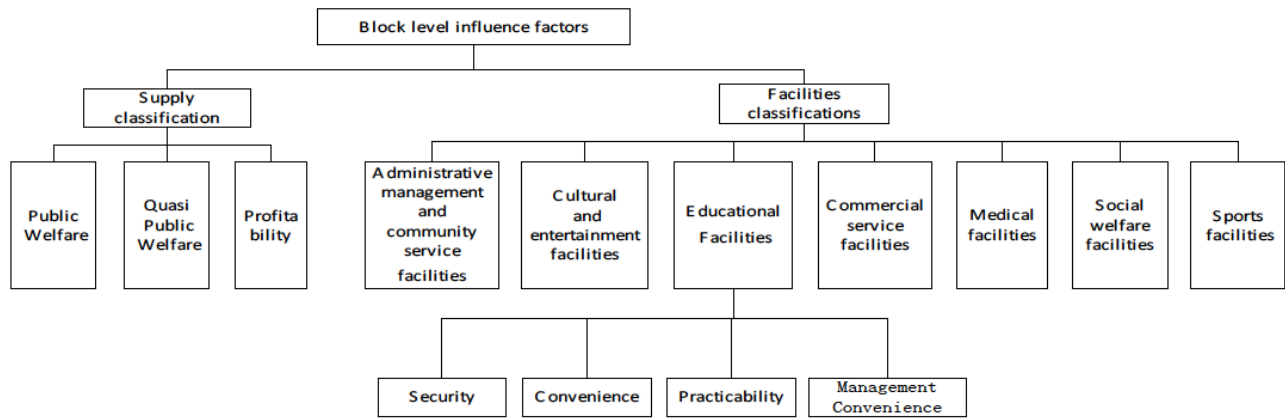


Fig. (6). Influencing factors in the block level.

3.3. Block Level

The level of public service facilities is mainly determined by the services and economic attributes of specific facilities. Evaluate the services and economic attributes of different types of facilities. Also, the influencing factors is refined and layered by the analytic hierarchy process to quantify the impact of weight (Fig. 6 and Table 5).

On the basis of determining reference volume ratio in a unit, ensure the addition and reduction coefficients of land use intensity according to the service quality and then determine the land development intensity.

4. THE EMPIRICAL RESEARCH

4.1. The Survey of Shangmaying Area

Shangmaying area is located in the center of Jintai district, Baoji city, which is one of the most important built-up areas of central urban area. The master planning of Baoji (2008-2020) has determined the designated function of Shangmaying area as the sub-centre of commerce and trade in Baoji. In this paper, the scope we study is that the south is to Wei River, the north by the Panlong tableland, east to the Jin Ling River, and west to the administration center, with the land area of 1168.82 hectares. Up to 2012, the population of Shangmaying area is about 18 million in which about 2.6 million is the population of shantytowns. With the process of urbanization in Baoji, urban renewal problems need to be solved quickly. As an important residential area in the center of Baoji, the renewal of shantytowns of Shangmaying must keep up with the pace of the urban development. How to determine the land use intensity of the area reasonably and ensure the quality of residents' life becomes the focus problem of this planning.

4.2. Influence of Public Service Facilities on Land Use Intensity

The regulatory plan of Shangmaying uses the capacity as the starting point. In order to determine the total area construction, it studies on the bearing capacity of the Shangmaying area from the aspects of urban traffic, public service facilities, municipal infrastructure, space environmental capacity, etc. Based on the regulatory planning technology system of "total constraints, hierarchical control, partitioning balance", resolve the total amount layer-by-layer and ultimately

determines the land use intensity of the block. Here focuses on the process of determining the bearing capacity of the volume ratio of each level based on public service facilities.

(1) The area level

In the area level, the total amount construction of Shangmaying area needs to be forecast satisfying the requirement of the total population of the present situation through remedying the lack amount of present and the amount of population growth that new facilities bring out, thus it can draw the total planning population of Shangmaying area about 220 thousand. Based on the determined 220 thousand of the population and the estimated standard household [11] (i.e. the average household population is 3.1, with the residential construction area of 140 square meters), combining 9935000 of the total construction of the residential land with 596000 of public service facilities determined above, that define the total construction of Shangmaying area is about 10531000 . In the case of the total amount construction in area being determined, the average floor area ratio of this area is about 0.9.

(2) The management unit level

Shangmaying area is divided into 9 management units. In the case that total area construction is determined, based on the influential factors weight of management unit level and the public service facilities layout of Shangmaying described above (Fig. 7), through assigning valuations on each management unit and combining the previously determined weight, the grade point of land use intensity for public service facilities can be calculated in each management unit, as shown in Table 6.

Based on the calculations above, we can designate SMY06, SMY07 is at the first level, SMY04 SMY 05 and SMY 09 is at the second level, SMY 02 SMY 03 SMY 08 is at the third level, SMY01 is at the last level. The total amount allocation for each management unit can be determined according to the comprehensive value of the public service facilities capacity and then the unit reference floor area ratio can be determined (Table 7 and Fig. 8).

(3) Block Level

On the block level, determining the land development intensity of each block needs to combine with the specific circumstances surrounding. It regards facility service radius as

Table 6. Level of land use intensity of each unit of in Shangmaying area.

Number of management unit	The public service facilities carrying capacity comprehensive value
SMY01	1.00
SMY02	1.67
SMY03	1.67
SMY04	2.34
SMY05	2.67
SMY06	3.00
SMY07	3.00
SMY08	1.67
SMY09	2.00



Fig. (7). Public service facilities of Shangmaying area.

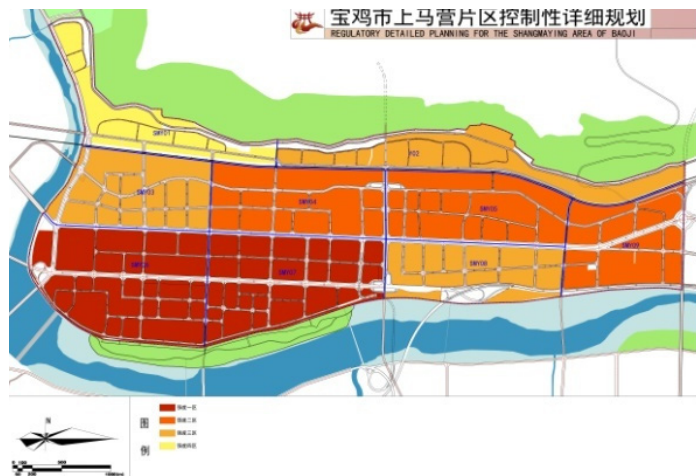


Fig. (8). Intensity zoning in the management unit.

the major reference conditions, and for a certain block, any service facility, which can radiate this block, needs to be assigned and evaluated. The comprehensive value of service ability of public service facilities of this block can be obtained by accumulating the value of different facilities. In

each unit, judging the coefficient of increase and decrease of land use intensity with actual situation around the block and combining reference floor area ratio of the intensity partition, finally the land development intensity of this block can be determined.

Table 7. Reference volume rate of Shangmaying area management unit level intensity.

Type of indicator	Land type	Intensity of the first area	Intensity of the second area	Intensity of the third area	Intensity of the forth area
The reference floor area ratio	Residential land	3.0	2.5	2.2	1.8
	The land for business service facilities	4.0	3.5	3.0	2.5
	The land for public service facilities	2.0	1.6	1.2	0.8
Management unit		SMY06 SMY07	SMY04 SMY05 SMY09	SMY02 SMY03 SMY08	SMY01

CONCLUSION

In the regulatory planning, how to determine scientifically the land use intensity has always been a scholar focusing on topics, and public service facilities is an important influence factor to determine the land use intensity. In order to find a method of determining scientifically land use intensity in regulatory planning, this paper does a research on the influencing mechanism of public service facilities for the land use intensity in regulatory planning. First of all, through the collation of relevant literature and theoretical study, influence mechanism of three levels of regulatory planning is proposed and explained from the vertical and horizontal directions. Second, from the evaluation of public service facilities, the study has filtrated and divided all aspects of the influence factor, determined the weights, quantified the influence evaluation and put forward the method to determine the land use intensity under the constraint of public service facilities of each level. Finally, it is tested empirically in regulatory planning in Shangmaying area of Baoji. The determining method of land use intensity with constraints of public service facilities mentioned above has some certain reference significance for scientifically determining land use intensity in regulatory planning. But this paper just puts forward the preliminary research thinking. It requires a lot of practice test and in-depth studies for the interactive relationship between the bearing capacity factors of public service facilities and other facilities in the urban and the range covered with the method.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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