

# Evaluation and Optimization of Production-Living-Ecological Space in Urban Fringe Against the Background of Rural Revitalization Strategy

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## ABSTRACT

This project takes Taihe Town, which is located at the edge of Guangzhou City, as the research object, and classifies the production-living-ecological space land in Taihe Town. It uses the method of combining objective and subjective to establish the comprehensive evaluation system of production-living-ecological space in Taihe Town, and according to the evaluation results, comprehensively analyzes the advantages and disadvantages of production-living-ecological space distribution in Taihe Town. Based on this, it provides enlightenment for the economic growth, the improvement of residents' living standard and the optimization of ecological environment of other towns in the urban fringe areas, and puts forward reasonable suggestions for the further development of Taihe Town.

**Keywords:** Production-living-ecological space evaluation system, Urban fringe area, Analytic Hierarchy Process (AHP), Expert scoring method.

## 1. INTRODUCTION

Since President Xi Jinping put forward the rural revitalization strategy in the report of the 19th CPC National Congress, and China's rural development has officially entered a new stage, with a clearer direction for the development path, plan and driving force of rural development. Different from rural areas in exurbs or remote areas, rural areas in urban fringe have great advantages in transportation, capital, information exchange, land price and other aspects due to their unique location. It is an important front to narrow the development gap between urban and rural areas, realize integrated development between urban and rural areas, and solve the problem of "imbalance and insufficiency" in China's development. Therefore, if villages in urban fringe can make full use of urban resources, grasp development opportunities, tap rural functions, give play to industrial and economic advantages, and develop rural traditional culture, they can become an important model for rural revitalization.

The study of "production-living-ecological space" was first carried out by scholars in Taiwan,

who explored the achievements of Taiwan after the development of "production-living-ecological agriculture" in the 1980s. In the research of scholars in mainland China, Hu Wantai et al. discussed the object content of production-living-ecological space from different spatial regional perspectives [1]. Zhou Nana, Yang Hui et al. studied the spatial evolution characteristics and optimization of regional production-living-ecological space [2]; Wang Kun evaluated the spatial adaptability of land from the perspective of multi-function of land [3]. On the whole, some achievements have been made on the connotation, classification system and pattern optimization of production-living-ecological space. However, limited by the availability of land data, most of the research areas are focused on the county level and above, and there are few researches on the micro townships and villages. Although there is no concept definition of production-living-ecological space in foreign countries, it is not difficult to see its concept of harmonious development in its urban planning, which requires the coordination of production, life and ecology. In 1882, Arturo Soria Y Mata connected the town with a road, making it easier for

people to move between production and living, while maintaining a close relationship with nature. This planning concept has been embodied in the application of the concept of production-living-ecological space. In 1898, British scholar Howard put forward the theory of garden city, emphasizing that the garden and agricultural land around the city should be preserved to build a good ecological space. In the middle of the 20th century, the blind expansion of urban land led to the increasingly significant problem of urban suburbanization. Western scholars began to look for a new model of urban development. In 1928, the American government delimited the scale boundary of Oregon in view of the urban sprawling phenomenon, so as to avoid the disorderly expansion of production space. In recent years, foreign scholars have focused on the evaluation of land use suitability. For example, Rodriguez-Gallego et al. used GIS modeling to discuss the conflicts and contradictions between production-living-ecological space. To sum up, foreign scholars have not clearly defined the concept of production-living-ecological space, and researches on rural spatial optimization mainly focused on land functions, economic benefits and spatial layout optimization. The exploration of the optimization and control of production, living and ecological land space by scholars from various countries can provide reference for this project to optimize the layout of eco-ecological space in Taihe Town.

So as the research object, this article selects Guangzhou Baiyun district tai town to big cities typical urban fringe area as an object from the micro level to explore its influence in big cities grow and space layout of the main problems and aims to put forward more specific and targeted strategy, policy and planning to promote the development of regional economy, culture, and ecology.

## **2. DATA SOURCES AND RESEARCH METHOD**

### **2.1 Overview of the Study Area**

Taihe Town is located in the central part of Baiyun District, Guangzhou City, with an area of 155.33km<sup>2</sup>. It is adjacent to Renhe Town in the west, Zhongluotan Town in the north, Huangpu District in the east, Tonghe Street and Yongping Street in the south and southeast, which are located in the center of Guangzhou City. It is between

urban and rural areas, and belongs to the urban-rural junction of a big city.

Now the town has jurisdiction over 21 villagers' committees (266 economic cooperatives) and 12 community residents' committees, with a total population of 375,940. According to the relevant spirit of the city and district on the construction of the central town, Taihe Town, as the second batch of key construction of the central town in Guangzhou, will take "today's central town, tomorrow's satellite city" and the future of the city of Guangzhou as the development goal.

### **2.2 Classification of Production-Living-Ecological Space Land Use**

The life, ecology and production of "Production-Living-Ecological Space" are mutually unified and interactive. They influence each other, are inseparable, and are closely related to human activities. Living space mainly meets people's living and living needs, and is related to people's life well-being and cultural development. Ecological space can improve the quality and comfort of people's life and reflect the harmonious relationship between human development and natural environment. Production space provides material materials for people, is an important place for social development, and is the direct driving force of economic development.

Based on this study and combined with the actual situation of Taihe Town as well as the feasibility of the classification, Taihe Town land space into production space, living space and ecological space of the three primary index and seven secondary indexes, and the corresponding land use types are summarized. Production space corresponds to the land, such as cultivated land, land for industrial and logistics warehousing, business, etc. The space level can be divided into three secondary indexes. This topic respectively is industrial production space, agricultural production space and service space. Living space corresponds to living land, such as urban residential land, public facilities land, administrative and office land. In spatial level, it includes two indexes: urban living space and rural living space. Ecological space corresponds to ecological land, such as woodland, grassland, water area, etc., and can be divided into adjusting ecological space and accommodating ecological space at spatial level.

### 2.3 Data Source and Processing of Evaluation System

According to the characteristics of the three factors, the actual situation of Taihe Town and the availability of data, this study constructed an evaluation system of production-production space in Taihe Town, which included 20 evaluation

indexes from three dimensions. The data are obtained from ArcGIS analysis of remote sensing images of Taihe Town, statistical yearbook of Taihe Town, field survey of local residents and questionnaires (a total of 250 valid questionnaires were collected). The index classification and detailed explanation of each index are shown in the "Table 1".

Table 1. Production-living-ecological space evaluation system

First Indicators	Second Indicators	Third Indicators	Units	Relevance
living space	living environment	per capita residential floor space	m <sup>2</sup> /person	+
		housing-price-to-income ratio		-
		satisfaction with public service facilities		+
	traffic condition	average commuting time	min	-
		density of road network	m <sup>2</sup>	+
	spatial attribute	average patch area of living space	m <sup>2</sup>	+
dispersion of living space patch		%	-	
ecological space	ecological maintain	vegetation coverage	%	+
		water coverage	%	+
		ecological land coverage rate	%	+
	ecological service	the proportion of days with good air quality	%	+
		ecological environment satisfaction		+
	spatial attribute	maximum ecological space patch index		+
		patch dispersion of ecological space		-
production space	spatial attribute	production land coverage rate	%	+
		average patch area of production space	m <sup>2</sup>	+
		patch dispersion of production space	%	-
	economic factor	land average investment in fixed assets	¥ / m <sup>2</sup>	+
		growth rate of secondary industry	%	+
		growth Rate of Tertiary Industry	%	+

### 2.4 Construction of Processing of Evaluation Systems

#### 2.4.1 Weight Determination Based on Analytic Hierarchy Process

Analytic Hierarchy Process (AHP) is a multi-objective decision analysis method that combines qualitative and quantitative analysis methods. The main idea of this method is to decompose the complex problem into several levels and several factors, make comparative judgment on the importance of two indicators, and establish a judgment matrix. By calculating the maximum eigenvalue and the corresponding eigenvector of the judgment matrix, the weight of the importance degree of different schemes can be obtained, which provides the basis for the choice of the best scheme. The method of Analytic Hierarchy Process (AHP) is used to calculate the weight coefficient of

indexes. In fact, on the basis of the establishment of an orderly hierarchical index system, each index in the system is judged by pairwise comparison, and the weight coefficient of each index is calculated comprehensively by using the evaluation results.

The basic steps are as follows: analyze the relationship among various factors in the system and establish the hierarchical structure of the system; make pairwise comparison of each element in the same level on the importance of a criterion in the upper level to construct a judgment matrix; calculate the relative weight of the elements to be compared for the criterion by the judgment matrix; calculate the composite weight of each layer element to the system target and sort it.

The specific methods to complete this topic are as follows:

2.4.1.1 Constructing the Evaluation Index Judgment Matrix of Production-Living-Ecological Space

In this topic, the method of "1-5 scale" was used to allow experts to rate the pair importance of the

Table 2. The 1-5 scale and its meaning

A index than B index	extremely important	very important	important	a little important	same
A index evaluation	5	4	3	2	1

constructed judgment matrix, and make it pass the consistency test of "average random consistency index RI standard value". ("Table 2")

2.4.1.2 Determining the Composite Weight of Production-Living-Ecological Space Evaluation Index System

The composite weight of each of the 20 indexes in the hierarchical system is the key factor to calculate the overall weight of Production-Living-

Table 3. The synthetic weight of production-living-ecological space evaluation index system

First Indicators	Second Indicators	Third Indicators
A1 living space (0.200)	B1 living environment (0.033)	C1 per capita residential floor space (0.007)
		C2 housing-price-to-income ratio (0.011)
		C3 satisfaction with public service facilities (0.015)
	B2 traffic condition (0.066)	C4 average commuting time (0.025)
		C5 density of road network (0.041)
	B3 spatial attribute (0.101)	C6 average patch area of living space (0.036)
		C7 dispersion of living space patch (0.065)
A2 ecological space (0.387)	B4 ecological maintain (0.082)	C8 vegetation coverage (0.017)
		C9 water coverage (0.035)
		C10 ecological land coverage rate (0.030)
	B5 ecological service (0.156)	C11 the proportion of days with good air quality (0.047)
		C12 ecological environment satisfaction (0.109)
	B6 spatial attribute (0.149)	C13 maximum ecological space patch index (0.046)
C14 patch dispersion of ecological space (0.103)		
A3 production space (0.413)	B7 spatial attribute (0.180)	C15 production land coverage rate (0.037)
		C16 average patch area of production space (0.063)
		C17 patch dispersion of production space (0.079)
	B8 economic factor (0.233)	C18 land average investment in fixed assets (0.048)
		C19 growth rate of secondary industry (0.068)
C20 growth Rate of Tertiary Industry (0.117)		

Ecological Space. The specific calculation method is: the weight of each index of each matrix multiplies the weight of the above layer. For example, B1 living environment =0.165×0.2=0.033. Like this, get the composite weight of Production-Living-Ecological Space evaluation index. The results are shown in "Table 3".

2.4.2 Weight Determination Based on Expert Scoring Method

Expert scoring method is a quantitative method to determine the weight of indicators based on expert opinions. In this study, a total of seven experts in this field were invited to score. The procedure of this method is as follows:

- Select experts;
- Determine the indicators of the ecological space evaluation system of Taihe Town;
- Provide experts with background information about Taihe Town, and ask for expert opinions by scoring the questionnaire from 0 to 9 (where 9

- represents very important and 0 represents very unimportant);
- Analyze and summarize expert opinions and feedback statistical results to experts;
- Experts revise their opinions according to the feedback results;
- After several rounds of consultation and feedback, the final analysis conclusion was formed. After several rounds of revision of the scoring results, the weight results that meet the standard deviation range requirements are shown in the "Table 4".

Table 4. Weight table of expert scoring method

	Standard Deviation	Average Value	Weight Conversion
per capita residential floor space	0.69	6.86	0.054
housing-price-to-income ratio	0.76	6.71	0.053
satisfaction with public service facilities	0.98	7.57	0.060
average commuting time	0.53	7.57	0.060
density of road network	0.76	6.29	0.050
average patch area of living space	0.53	5.57	0.044
dispersion of living space patch	0.58	5.00	0.040
vegetation coverage	0.49	6.71	0.053
water coverage	0.58	6.00	0.047
ecological land coverage rate	0.90	6.14	0.049
the proportion of days with good air quality	0.79	7.43	0.059
ecological environment satisfaction	0.79	7.57	0.060
maximum ecological space patch index	0.76	5.71	0.045
patch dispersion of ecological space	0.76	5.29	0.042
production land coverage rate	0.53	5.43	0.043
average patch area of production space	1.35	5.14	0.041
patch dispersion of production space	0.98	4.43	0.035
land average investment in fixed assets	0.82	7.00	0.055
growth rate of secondary industry	0.76	6.71	0.053
growth Rate of Tertiary Industry	0.49	7.29	0.058

### 3. RESULTS AND ANALYSIS

The theory of ecological function of national land space provides the basic paradigm of national land cognition at the macro scale, which is significantly different from the production-living-ecological space at the micro scale. The production-living-ecological function comes from the production-living-ecological space, but is higher than the limitation of production-living-ecological space [4]. In order to be able to evaluate the function of production-living-ecological space from many aspects, this paper, based on the perspective of production-living-ecological function, constructs an evaluation system of production-living-ecological space, which mainly includes three first-level indicators and ten second-level indicators. Analytic Hierarchy Process (AHP) and Delphi Method were respectively used to calculate the weights of the two rounds of expert scores. Finally, the least square method was used to comprehensively calculate the weights of the two

rounds to reach the optimal solution, and the corresponding scores of each index were calculated ("Table 5").

**Table 5. Score results of production-living-ecological function evaluation system**

First Indicators	Second Indicators	Third Indicators	Conversion score	Weight	Points	Total points	Average
living space (0.200)	living environment	per capita residential floor space	61.64	0.031	1.9108	17.9332	2.5619
		housing-price-to-income ratio	45	0.032	1.4400		
		satisfaction with public service facilities	64	0.038	2.4320		
	traffic condition	average commuting time	40	0.043	1.7200		
		density of road network	98.8	0.045	4.4460		
	spatial attribute	average patch area of living space	20	0.04	0.8000		
		dispersion of living space patch	99.7	0.052	5.1844		
ecological space (0.387)	ecological maintain	vegetation coverage	59.83	0.035	2.0941	24.9789	3.5684
		water coverage	24.5	0.041	1.0045		
		ecological land coverage rate	83.04	0.04	3.3216		
	ecological service	the proportion of days with good air quality	84.9	0.053	4.4997		
		ecological environment satisfaction	61	0.084	5.1240		
	spatial attribute	maximum ecological space patch index	38	0.046	1.7480		
		patch dispersion of ecological space	99.82	0.072	7.1870		
production space (0.413)	spatial attribute	production land coverage rate	87.83	0.04	3.5132	22.6681	3.7780
		average patch area of production space	20	0.052	1.0400		
		patch dispersion of production space	99.84	0.057	5.6909		
	economic factor	land average investment in fixed assets	61.91	0.052	3.2193		
		growth rate of secondary industry	25	0.06	1.5000		
		growth Rate of Tertiary Industry	88.56	0.087	7.7047		

### 3.1 Life Function Evaluation

From the perspective of living space, the evaluation of living function is the lowest, the residents' living environment is still to be improved, the per capita living area is small, the housing price is high relative to the residents' income, and the residents' satisfaction with the surrounding public service facilities is only at a medium level. All these factors will reduce the quality of residents' living. At the same time, the survey found that it takes a long time for residents in this town to go to work and school, which will lead to the decline of residents' life happiness due to the long daily commuting time, indicating that the traffic accessibility between the town and the urban area still needs to be improved in the future planning. Although the place of Taihe Town south linked to Tonghe has been formed with a range of supporting facilities of these areas concentrated in real estate development, the current residential land consolidation is still incomplete. In the future development, residential areas should be further

rationally planned, and residential areas should be concentrated and connected to achieve the scale benefits of infrastructure sharing and supporting industries.

### 3.2 Ecological Function Evaluation

As can be seen from "Table 5", the importance of ecological function ranks the second in the production-living-ecological function. Ecological space is an important place to regulate the living environment of human beings. However, according to the previous land use classification, there is a lack of attention to ecological land. Therefore, the ecological function dimension in the production-living-ecological function enhances the importance of ecological factors in the living environment of human beings. The secondary industry in Taihe Town is relatively developed, but the environmental pollution is also serious. In the three-level indicators, the vegetation coverage rate, water coverage rate and ecological environment satisfaction score are low. Although the ecological

land occupies a large proportion within the territory, the ecological function still needs to be integrated and improved.

### **3.3 Production Function Evaluation**

In the evaluation system of production function of Taihe Town, the importance of production function is in the first place. However, it can be seen from "Table 5" that the average patch area of the production space in Taihe Town is not large, but the patch dispersion of the production space is relatively high and the production space is relatively concentrated. In addition, the growth rate of its secondary industry is low, which is due to the large size of the secondary industry in Taihe Town and the slow growth rate. The high growth rate of the tertiary industry indicates that Taihe Town has a good development trend of the tertiary industry.

The core content of land planning is to analyze the cooperative and competitive relationship between ecology and production space, and to plan the development and protection pattern of land space while considering efficiency and life balance. As a typical small town in the fringe area of Guangzhou, Taihe Town has obvious geographical advantages. Industrial economic construction, infrastructure construction and environmental construction undertake the development and expansion of big cities, so it develops rapidly [5]. However, according to the overall score of production function in "Table 5", there is still a certain distance between the production function in Taihe Town and "intensive and efficient".

## **4. CONCLUSION**

From the perspective of development level, the overall level of production-living-ecological space in Taihe Town is relatively high. Based on the analysis of production-living-ecological function evaluation system, this paper provides some suggestions for the development and management of Taihe Town in the future.

In the evaluation system of the production-living-ecological function of Taihe Town, the importance of production function ranks first, and the average score of the evaluation is the highest. The development of the secondary and tertiary industries is good, and the economy develops rapidly. Therefore, we should focus on promoting

the development of Guangzhou International Logistics Port, Lin'an Logistics Park and other key industrial projects, so as to enhance the industrial development level of Taihe Town, form characteristic competitiveness, inject new vitality for sustainable economic development, and promote rural revitalization.

Ecological function is the second most important. Although there are forest parks, reservoirs and other important ecological function lands in Taihe Town, their ecological functions still need to be integrated, and residents' satisfaction with the ecological environment also needs to be improved. So, we should pay more attention to the ecological land, expand the green area, strengthen the control of environmental pollution through the introduction and improvement of relevant policies, and commit ourselves to building a characteristic town surrounded by mountains and rivers, pleasant scenery and ecological harmony, so as to create a new model of green development.

The living function is the lowest part of the production-living-ecological space evaluation score in Taihe Town, which reflects the urgent need to improve the living environment in the town, public facilities and services, traffic accessibility and so on. Therefore, it should increase the residential land, planning the layout of residential land and production land as a whole. At the same time, it should further improve the traffic network, build the urban modern public transport system, and realize the separation of passenger and freight transport, so as to optimize the internal and external traffic system, effectively dredge the urban traffic and give full play to the superior traffic location advantage of Taihe Town.

## **AUTHORS' CONTRIBUTIONS**

Shengwei Zou was responsible for keeping track of research progress and determining the weight of expert scoring method, Jiahe Chen analysed the weight of Analytic Hierarchy Process, Huizhu Yang completed the data analysis and wrote the conclusion, Yanqiu Ma contributed to production-living-ecological space evaluation system, and Yangfan Yu collected the data and edited.

## **REFERENCES**

- [1] Hu Wantai, Wang Ligu, Shu Muhui, Reflections on delimiting the three basic spaces in the compilation of urban and rural

- plans [J], *City Planning Review*, 2016,40(05):21-26+53.
- [2] Zhou Nana, Evolution Characteristics and Optimization of "Production-Living-Ecology" Space in Wudi County [D], Shandong Agricultural University, 2019.
- [3] Wang Kun, Lin Yuan. Analysis of the Collaborative Preparation in Urban-Rural Planning and Land Use Planning [J]. *Guangdong Land Science*, 2017,16(01):45-48.
- [4] Liu Jilai, Liu Yansui, Li Yurui, Classification evaluation and spatial-temporal analysis of "production-living-ecological" spaces in China [J], *Acta Geographica Sinica*, 2017,72(07):1290-1304.
- [5] Lin Shanquan, Development Strategy of Small Towns Near Metropolis: Taihe Town, Baiyun District, Guangzhou [J], *Planners*, 2019,35(13):54-61.
- [6] Rodriguez-Gallego L, Achkar M, Conde D. Land Suitability Assessment in the Catchment Area of Four Southwestern Atlantic Coastal Lagoons: Multicriteria and Optimization Modeling [J]. *Environmental Management*, 2012, 50(1):140-152.