Rationality analysis of urban spatial distribution and development direction based on environmental impact assessment——On to the Jianghua Yao nationality autonomous county

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Abstract. The rational planning of urban spatial distribution and development direction could benefit the urban economy, social environment and other aspects, as an essential part of urban planning. Since the *Law of EIA* promulgated in 2003, the scope of environmental impact assessment has been upgraded to a higher level of overall urban planning whereas the influence is not significant. In 2018, urban and rural planning function was merged into the Ministry of Natural Resources, from leading urban construction to serving the protection of urban natural resources. It is also a new and significant approach to analyse the rationality of urban spatial distribution and development direction from the perspective of environmental impact assessment. The purpose of Jianghua Yao autonomous county is to build an eco-tourism civilized city, which is representative in the selection of cities for environmental impact assessment. On the space structure of functional areas and the development direction to the indicator elements of Yao nationality autonomous county class was divided into 4 categories, 5 layers,15 index factors were selected to construct the environmental impact assessment index system. Using analytic hierarchy process (AHP) to select the indexes weights assignment, then according to the evaluation criterion to evaluate it, we draws the analysis conclusion in the environment aspect. The planned urban spatial distribution and development direction of Jianghua Yao autonomous county from 2014 to 2020 are reasonable, have little negative impact on the environment, and are suitable for the green development of the city.

1 Introduction

Since the *Law of EIA* promulgated in 2003, the scope of environmental impact assessment has been upgraded to a higher level of overall urban planning whereas the influence is not significant. In 2018, urban and rural planning function was merged into the Ministry of Natural Resources, from leading urban construction to serving the protection of urban natural resources. The traditional method to determine the spatial distribution and development direction of the city is to delimit the four districts, evaluate the suitability of construction land and determine the function, nature and development direction of the city based on the analysis of urban development conditions. Some scholars put forward the urban development preference model and farmland loss model based on the smart growth of urban spatial development direction to identify the "smart" spatial expansion direction of the urban [1] or use land suitability evaluation to carry out land use planning for urban sustainable development [2]. GIS also contains analytical tools to help with urban problems, providing the user with extra useful functionality [3]. But they all lack of consideration of the perspective of environment. Therefore, this paper will evaluate the overall planning of Jianghua from the perspective of environmental impact and draw a conclusion.

2 Construction of environmental evaluation index system

2.1 Overview of Jianghua county

Jianghua Yao autonomous county is located in the south of YongZhou city, Hunan province. According to *the general urban planning of Jianghua Yao autonomous county (2014-2020)*, the urban space is divided into industrial zone group, living zone group and tourist zone group, etc., and the development direction of land is determined to be east-west and northward extension.

The new urban construction and functional layout may cause various ecological damage to the city, including the fragmentation of the ecological environment, the decline of its stability, the change of biodiversity, the decline of environmental function, and the damage of water, soil and atmosphere [4]. This study mainly discusses the spatial distribution and development direction of the city. Therefore, the construction of roads, bridges, water supply and drainage, the construction of various functional areas and other projects will have different degrees of impact on the local water environment, air environment, acoustic environment, society and ecological environment [5]. This study mainly takes the above several environmental index levels in each partition as an example to conduct research.

2.2 Determination of environmental assessment index factors

According to the requirements of the overall plan for Jianghua county, from the space distribution and the development direction into consideration, the county environmental evaluation index system is divided into four major categories. The factors index layer is divided into 5 layers. Tab.1 is obtained according to the impact analysis between different element layers.

Table 1. Influence Analysis of Element Layer.

	Road Traffic	Industrial Area	Living Area	Tourist Area
The Water Environment	★	★★★	★★★	★★
Air Quality	★★★	★★★	★★	★
Acoustic Environment	★★	★	★★	★
Solid Waste	★	★★	★★★	★★★
Landscape	★	★★	★★	★★

NOTE: ★ Small impact; ★★ Moderate impact; ★★★ Greater impact

2.3 Construction of environmental impact assessment index system

Generally, the concept of sustainable development in urban development planning is taken into account and economic, environmental and social objectives are harmonized [6]. According to the overall plan of Jianghua county, its urban spatial distribution and development direction will affect the water, atmosphere, acoustic environment and ecological environment, and generate solid waste. According to the factor impact table, the water environment is mainly affected by industrial areas and living areas. Therefore, the main index factors are the quality compliance rate (%) of the centralized drinking water source, the water quality compliance rate (%) of the water function area, and the regional domestic sewage treatment rate (%). Atmospheric environment is mainly affected by road traffic and industrial zone, so the main index factors are environmental air quality (API) excellent rate (%), pollutant emission intensity (sulfur dioxide, ammonia nitrogen). The acoustic environment is mainly affected by the traffic and living environment. Therefore, the average sound level on both sides of urban trunk lines [dB(A)] and the compliance rate of urban noise environmental quality (%) were 2. Solid waste is mainly affected by industrial areas and living areas, so the index factors are industrial solid waste disposal utilization rate (%) and household waste harmless treatment rate (%) [7]. All functional areas of ecological landscape environment have influences, so the evaluation index factors are vegetation coverage rate, biological abundance index, county ecological environment status index (EI), water network density index [8]. The index system is shown in the following table.

Table 2. Element Layer Analysis.

Index Element Layer	Evaluation Objective	Evaluation Index
The water environment	Water environment related elements are selected for planning and evaluation	Water quality standard rate of centralized drinking water source（%） Water function area water quality standard rate（%） Regional sewage treatment rate（%）
Air quality	Selected elements related to atmospheric environment for planning and evaluation	Ambient air quality (API) good rate（%） Pollutant emission intensity (sulfur dioxide, ammonia nitrogen)
Acoustic environment	The relevant elements of noise environment are selected for planning and evaluation	Diurnal mean sound level on both sides of city main line [dB(A)] Urban noise environment quality standard rate（%）
Solid waste	Solid waste environmental factors were selected for planning and evaluation	Utilization rate of industrial solid waste disposal（%） Household garbage harmless disposal rate（%）
Ecological landscape	Selected ecological landscape environment related elements for planning and evaluation	Vegetation coverage（%） Biological abundance index（%） County ecological environment index（EI） Water network density index

Table 3. Index System of Environmental Impact Assessment.

Evaluation Index Element Layer	Index Factor	Evaluation Index Unit
Road traffic impact layer B1	Diurnal mean sound level on both sides of city main line c1 Traffic accessibility c2 Industrial sewage treatment rate c3	dB(A) Excellent/good/poor % %
Industrial area affected layer B2	Utilization rate of industrial solid waste disposalc4 Pollutant emission intensity (sulfur dioxide, ammonia nitrogen) compliance ratec5	% %
Living area influence layer B3	Ambient air quality (API) good ratec6 Urban noise environment quality standard ratec7 Household garbage harmless disposal ratec8 Regional sewage treatment ratec9 Water quality standard rate of centralized drinking water sourcec10 Water function area water quality standard ratec11	% % % % % %
Tourist area influence layer B4	Vegetation coveragec12 Biological abundance indexc13 Water network density indexc14 County ecological environment index（EI）c15	% / / /

3 Environment evaluation index system of weight assignment

AHP is a more appropriate research method for urban development problems generally considered as social problems [9]. For the complex system of planned regional economic environment, the contributions of various levels of elements are different, that is, the whole system has different response degrees to the changes of different elements. Therefore, as an expression of the environmental impact characteristics of the planning area, the importance and weight of the indicators should be distinguished in the planning environmental impact assessment index system, that is, different indicators should be given different weights. Evaluation for urban sustainable development is significant to improve the future development of urban [10]. This paper adopts "Analytic Hierarchy Process" by assigning weights at different levels, which can avoid the confusion and mistakes of subjectiveness and a large number of indicators simultaneously, which is conducive to improving the simplicity and accuracy of prediction and evaluation. The index system contains quantitative and qualitative data indexes. Therefore, in the process of data analysis, this paper adopts both qualitative analysis method and semi-quantitative analysis method.

3.1 Analytic hierarchy process (AHP)

The rationality of urban spatial distribution and development direction is taken as the target layer of AHP and the environmental impact assessment of rail transit, living area, industrial area and tourist area is taken as the evaluation factor layer. The lowest layer is the detailed and specific indicators determined by screening [11].

Hierarchy reflects the relationship between factors, but the proportion of each criterion in the criterion layer is different in different decision makers. When it comes to certain issues, some elements may have different ideas for each person, so for such elements, it is not easy to get accurate evaluation results, or even contradictory [12]. Hence the AHP presents the novel idea on the issues that will promote further development. Firstly, there is Tab.4 of Importance Level and Its Apportionment [13].

Table 4. Importance Level and Its Assignment.

Scale	Meaning
1	C_i and C_j is the same
3	C_i is slightly stronger than C_j
5	C_i is stronger than that of C_j
7	C_i is obvious stronger than that of C_j
9	C_i is absolutely stronger than that of C_j
2,4,6,8	C_i element to C_j element is between the two adjacent levels mentioned above.
1,1/2, …,1/9	C_i element to C_j element is the reciprocal number of All above.

3.2 Evaluation index synthesis

According to the index system, by the above scale method and through the questionnaire survey of expert consultation, 8 experts in this field were selected to grade the importance of the index and the scoring results were discussed and summarized internally, while the parewise discriminant matrix was obtained as follows[14]:

Table 5. Discriminant Matrix.

	B1	B2	B3	B4
B1	1	1/2	1/4	1/3
B2	2	1	1/3	1/2
B3	4	3	1	2
B4	3	2	1/2	1

MATLAB was used to calculate the maximum characteristic root of the judgment matrix $\lambda_{max} = 4.0310$. Consistency test of judgment matrix is carried out to calculate the consistency index:

$$CI = \frac{\lambda_{max} - n}{n-1} = \frac{4.0310-4}{4-1} = 0.0103 \quad (1)$$

Mean random consistency index. Random consistency ratio:

$$CR = \frac{CI}{RI} = \frac{0.0103}{0.9} = 0.0115 < 0.10 \quad (2)$$

Therefore, the results of AHP have satisfactory consistency, that is, the distribution of weight coefficient is very reasonable. MATLAB is used to calculate the weight of indicators.

Table 6. Weight of Indicators.

Index layer	Weight
B1	0.0954
B2	0.1601
B3	0.4673
B4	0.2772

We use the AHP to calculate the index weight. Construct judgment matrix $S = (u_{ij})_{p \times p}$

Table 7. Discriminant Matrix.

	C1	C2
C1	1	1/2
C2	2	1

MATLAB was used to calculate the maximum characteristic root of the judgment matrix $\lambda_{max} = 2$. MATLAB is used to calculate the weight of indicators.

Table 8. Weight of Indicators.

Index layer	Weight
C1	0.3333
C2	0.6667

Construct judgment matrix $S = (u_{ij})_{p \times p}$

Table 9. Discriminant Matrix.

	C3	C4	C5
C3	1	1/2	2
C4	2	1	3
C5	1/2	1/3	1

MATLAB was used to calculate the maximum characteristic root of the judgment matrix $\lambda_{max} = 3.0092$. The consistency index should be calculated as follows:

$$CI = \frac{\lambda_{max} - n}{n-1} = \frac{3.0092-3}{3-1} = 0.0046 \quad (3)$$

Mean random consistency index $RI = 0.58$. Random consistency ratio:

$$CR = \frac{CI}{RI} = \frac{0.0046}{0.58} = 0.0079 < 0.10 \quad (4)$$

Therefore, the results of AHP have satisfactory consistency, that is, the distribution of weight coefficient is reasonable. MATLAB is used to calculate the weight of indicators.

Table 10. Weight of Indicators.

Index layer	Weight
C3	0.2970
C4	0.5396
C5	0.1634

We use MATLAB to calculate the weight of indicators with the same method of calculation. In this study, the single weight value of the evaluation index determined by AHP above is as follows:

Table 11. Single Weight Value of Evaluation Index.

Index		Weight	Index		Weight
B1	C1	0.031797		C8	0.020468
	C2	0.063603		C9	0.030748
B2	C3	0.047550		C10	0.151218
	C4	0.086390		C11	0.081497
	C5	0.026160	B4	C12	0.133860
B3	C6	0.048506		C13	0.075398
				C14	0.043520
	C7	0.134816		C15	0.024447

3.3 Index data acquisition and weight assignment

This research according to “ Jianghua county government information disclosure annual report”; “ Jianghua county economic and social development statistical bulletin”; “Annual report on environmental air quality of Jianghua yao autonomous county” ; “Assessment of ecological environment quality in Jianghua yao autonomous county from 2013 to 2017 ”. And relevant research materials, the actual value of each index data acquisition, data fixed number of year of 2013 to 2017. According to the relevant national standards “national forest city evaluation standard”, “environmental impact evaluation standard” and the average level of similar cities, the standard reference value is determined. According to the evaluation standard of technical specification for evaluation of ecological environment condition (trial) (HJ/t192-2015), the evaluation of ecological environment quality of Jianghua Yao autonomous county was conducted by Hunan Environmental Monitoring Center Station.

Table 12. Index Data and Index Evaluation.

Evaluation Index Element Layer	Index Factor	2013	2014	2015	2016	2017
B1	C1	62	60	69.3	69.5	—
	C2	Good	Good	Good	Excellent	Excellent
	C3	57%	—	60%	57%	—
B2	C4	80%	80%	90%	80%	—
	C5	100%	100%	100%	100%	100%
B3	C7	95.83%	—	98%	95.13%	90.90%
	C8	52.3	52	53.8	54	—
	C9	78.93%	88.88%	86%	90%	100%
	C10	79.31%	82.61%	—	—	83.8%
	C11	100%	100%	100%	100%	100%
		97.22%	100%	100%	100%	100%
B4	C12	76.85%	76.80%	77.66%	78.50%	78.80%
	C13	84.92	—	80.90	—	—
	C14	44.04	—	40.05	—	—
	Cs15	80.50	—	83.38	—	—

4 Analysis on the rationality of urban

4.1 Single evaluation index analysis

The data of 2014-2017 after the implementation of the plan is compared with the data of 2013 before the implementation of the plan. Evaluation impact factors were used to calculate the evaluation index method. The positive data was higher than that listed as 1 before the planning and lower than the ratio of the calculated annual data before the planning 2013. Negative data is lower than that listed in column 1 of 2013, and higher than that of 2013. The evaluation indexes are listed below.

Table 13. Evaluation Index.

Index Factor	2014	2015	2016	2017
C1	1	0.89	0.89	—
C2	—	—	1	1
C3	—	1	1	—
C4	1	1	1	—
C5	1	1	1	1
C6	—	1	0.99	0.94
C7	1	0.97	0.96	—
C8	1	1	1	1
C9	1	—	—	1
C10	1	1	1	1
C11	1	1	1	1
C12	0.99	1	1	1
C13	—	0.95	—	—
C14	—	0.9	—	—
C15	—	1	—	—

4.2 AHP score results

With reference to the classification methods commonly used in the comprehensive index in relevant studies, the classification standards in this study were set as four levels, as shown in the following table [15].

Table 14. Comprehensive Evaluation Index Classification.

C	>90	89-80	79-70	<70
The Evaluation Results	Mostly	Partly	Rarely	Unreasonable

Table 15. The score table

	Weight	Score		Weight	Score
C1	0.031797	92	C8	0.020468	100
C2	0.063603	100	C9	0.030748	100
C3	0.047550	100	C10	0.151218	100
C4	0.086390	100	C11	0.081497	100
C5	0.026160	100	C12	0.133860	99
C6	0.048506	97	C13	0.075398	95
			C14	0.043520	90
C7	0.134816	97	C15	0.024447	100

By analytic hierarchy process, the environmental impact of urban master plan can be evaluated. The evaluation model composed of the final weight of this standard is very useful for assessing the environmental impact of urban planning plans.

After calculation, the B1 score of Jianghua Yao autonomous county is 9.28. The score of B2 was 16; B3 scored 46.2. The score of B4 is 26.9. Therefore, the rationality of urban spatial distribution and development direction in Jianghua County can be scored 98.38.

4.3 Conclusion of rationality analysis

According to the index system factors in this paper, the main traffic lines in Jianghua are Luo Zhanjiang railway, Eight Horizontal" road network planning and construction of the main and secondary roads just to solve the problem. Among them, the external contact is convenient, the communication between the internal functional areas is convenient, and the accessibility is high. Moreover, the traffic noise generated by vehicle transportation on the main traffic trunk roads that have been built is also up to the standard and has little impact on the surrounding environment. The green belt coverage rate of main traffic lines is relatively high.

Living areas is divided into five groups, planning area of 6.98 km^2, accounting for more than 27.86%, hazard-free treatment rate of living garbage and centralized drinking water quality success rate is high, the water quality standard of 100%, planning and implementation of living garbage classification first, recycle and reuse, and cannot be recovered by the sanitation department to non-hazardous waste plant concentrate processing, including sewage after treatment also recycle, housing construction area of 57.9 m^2 per capita is at a higher level. Moreover, the per capita public green space area also reaches 10 m^2 per person, reaching the level of national garden city, and the total scoring rate reaches 100%, G207 national road and S322 provincial road, which score low in terms of traffic convenience. The "Six Vertical and which is in line with the strategic positioning of green ecological development. The negative impact on ecological environment and social and humanistic environment of Jianghua Yao autonomous county is small.

Through research and analysis of this article, from the aspects of overall planning environmental impact assessment on the urban spatial distribution and spatial development direction of the Yao nationality autonomous county has carried on the macroscopic analysis, with qualitative and quantitative methods, the index data is analysed, and in the environmental aspects of the analysis conclusion: on the Yao autonomous county in 2014-2020, planning the urban spatial distribution and reasonable development direction, is suitable for the development of the city.

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