Research Article

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Suitability evaluation method of urban and rural spatial planning based on artificial intelligence

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Abstract: In order to realize the sustainable development of urban overall space, aiming at the increasingly serious environmental problems in the process of contemporary rapid urbanization, based on the relationship between urban and rural space and environmental capacity, a suitability evaluation method of urban and rural spatial planning based on artificial intelligence is proposed. This paper constructs the theoretical system of sustainable development evaluation of urban and rural spatial resources and uses artificial intelligence technology to reasonably select evaluation factors and standardize the evaluation indicators so as to achieve the research goal of accurately evaluating the suitability of urban and rural spatial planning. It analyzes the influencing factors of urban–rural spatial standard regional division, develops the design of the spatial planning suitability analysis system, and establishes the urban-rural spatial suitability evaluation. The scope of sustainability evaluation was extended to the level of urban and rural spatial planning and design, and the preliminary work was done to solve the problems of urban spatial structure and decision-making. The experimental results show that the planning method has high environmental adaptability and rationality.

Keywords: artificial intelligence, urban and rural spaces, suitability evaluation

1 Introduction

With the rapid increase of urbanization and the excessive expansion of space construction, natural ecological damage, urban environmental pollution, and adverse impact on residents' physical and mental health are observed [1]. In such a crisis, scholars have conducted extensive targeted research on the urban spatial environment, put forward the concepts of an ecologically benign city, livable environment, and urban sustainable development, and established many effective test standards and evaluation systems on this basis. Skrzypczak and coworkers [2] have proposed landslide hazard assessment map as an element to support urban and rural spatial planning. Landslide and rockfall are one of the many phenomena affecting the sustainable construction of urban and rural spatial planning and the safety of infrastructure. The purpose of this study was to use statistical methods to draw a detailed landslide hazard map for selected areas of the Carpathians in Poland. This method seems to be particularly useful in assessing sensitivity and landslide hazards on a local scale in relatively small areas. Han et al. [3] have determined the urban–rural heterogeneity of air pollution in 35 major cities in China. Urbanization and air pollution have the main human impact on the Earth's environment, weather, and climate. Each has been extensively studied, but their interaction has not been confirmed. Using four different long-term observation data sets of ground and

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space observations from 2001 to 2015, the spatial variation or heterogeneity of urban and rural air quality in 35 major metropolitan areas in China was investigated. The air pollution in urban areas in summer was more serious than in rural areas. However, rural pollution was more uniform, and the pollution in winter was more serious than in summer.

Urbanization leads to great changes in the spatial distribution of air pollution by changing the surface properties and boundary layer micro meteorology, but it was not clear, especially between the center and suburbs of metropolitan areas. Therefore, a suitability evaluation method of urban and rural spatial planning based on artificial intelligence is proposed. Urban and rural spatial planning is a new field that has emerged in recent years. It belongs to a new discipline of urban planning and design and urban and rural space. So far, the research on urban and rural spatial planning has made some achievements, mainly focusing on the summary and reference of urban and rural spatial development models at home and abroad, as well as the exploration of different urban and rural spatial development models and planning control systems, which has laid a solid foundation for the construction of sustainable development evaluation system in the future. The innovation in our research content is that it establishes a scientific, systematic, and standardized urban–rural spatial sustainability evaluation system by using artificial intelligence means to quantitatively evaluate the impact of urban–rural space on the overall natural environment and sustainable development trends in cities.

2 Suitability evaluation method of urban and rural spatial planning

2.1 Influencing factors of regional division of urban and rural spatial standards

Environmental assessment of the urban–rural space ecological coupling conditions can help determine the current conditions of the urban–rural space and the symbiotic evolution of the urban–rural space and ecological environment, as well as understand the evolution process of self-organization of the urban–rural space under different conditions so as to create the conditions of urban–rural space self-organization [4,5]. The environmental assessment of the urban–rural spatial ecological coupling conditions consists of the urbanization and ecological environment relationship assessment, ecological carrying capacity assessment, and urban–rural coupling degree assessment. The evaluation of the coupling relationship between urbanization and ecological environment seeks to study the coupling mechanism and time sequence law of urbanization and ecological environment so as to clarify the construction focus and direction of planning areas [6]. Ecological carrying capacity is the premise to ensure the steady development of urban and rural space, and the evaluation of urban and rural ecological carrying capacity is the most important work to determine the orderly and self-organized development of urban and rural space and ecological environment [7]. The evaluation of urban–rural coupling degree seeks to evaluate the coupling relationship between urban and rural areas. Through the establishment of the urban–rural index system, weight, and reference standard including social, economic, environmental, and other aspects, the comprehensive evaluation can guide the direction and focus of urban–rural planning policy-making [8]. The main contents of urban and rural space overall planning include urban and rural land layout planning, urban and rural transportation system planning, urban and rural infrastructure planning, rural settlement layout planning, and urban and rural environmental protection planning (as shown in Figure 1).

The connection of all levels of spatial planning is an important part of the spatial planning system, and it is also an unavoidable problem in the process of delimiting urban space and urban development boundary. In practical work, we must first determine the delimitation object of each level of the main body [9]. In the survey, government departments at all levels were generally concerned about the division of powers of different levels of government in the delimitation and control of urban space and urban development boundaries. If the provincial spatial planning specifies all the urban space and urban development boundaries of all the towns within its jurisdiction, the flexibility of spatial planning as a control tool

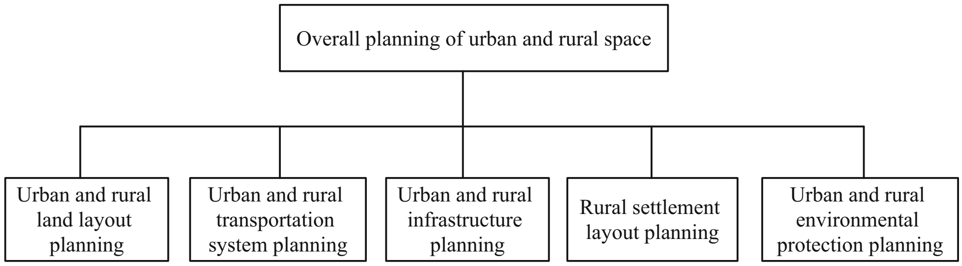

Figure 1: Main contents of urban and rural space overall planning.

will be greatly limited. It is difficult for the lower level government to make reasonable amendments to the zoning and planning control line according to the actual situation of its jurisdiction. The government at different levels will often face the pressure of spatial planning adjustment [10]. At the same time, the higher level government's spatial planning task is too heavy, and the lower level government cannot play its role, which will cause a certain waste of planning resources. In contrast, if the scope of the upper level is too small or the control scale is too coarse, it cannot play the role of the upper level spatial planning in the overall management of urban development and construction within the jurisdiction [11]. After analysis and discussion, the following rules were determined in the spatial planning pilot of Fujian Province: Provincial spatial planning evaluates the suitability of urban and rural space in the whole province; the delimitation object of urban space was limited to the central city, county, and township of each city; the delimitation object of urban development boundary was limited to the central city and county seat of each city; and the urban and rural space was empty. The planning structure is shown in Figure 2.

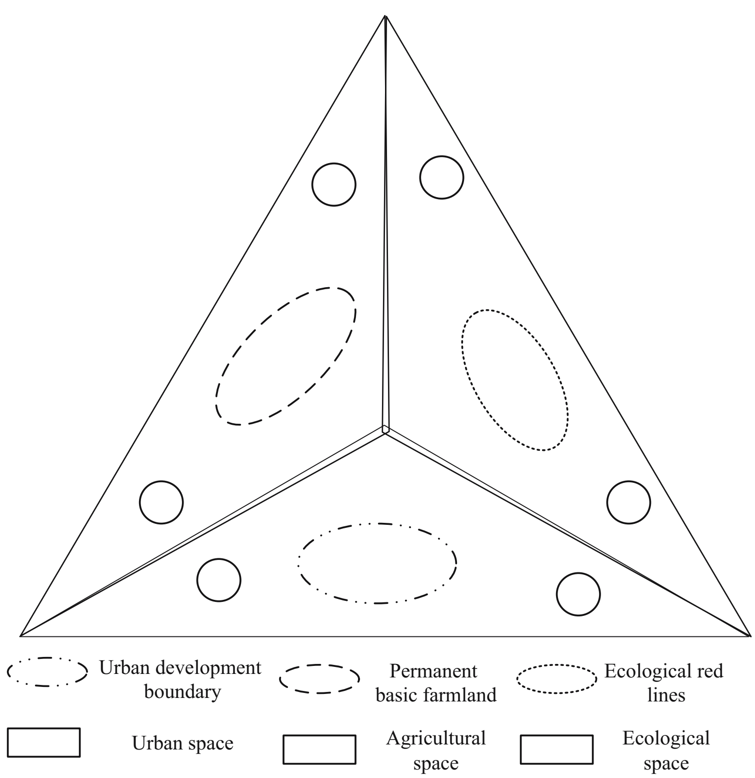

Figure 2: Related factors of urban and rural spatial planning.

The spatial precision of urban and rural spatial planning will affect the results of urban suitability assessment and the delimitation of urban space and urban development boundary. Therefore, what precision should be adopted in different levels of planning and how to link the results have become a problem [12]. As a spatial base map, it should be implemented to every land patch, so the demarcation of urban space and urban development boundary was the natural boundary with a grid as the unit. On the one hand, the determination of grid size should consider the characteristics of urban land division and the requirements of fine land use management; on the other hand, it should consider the management efficiency, which should not be too large or too small [13]. For this reason, a number of different types of regions were selected as samples for analysis throughout the country. The specific steps are shown in Figure 3.

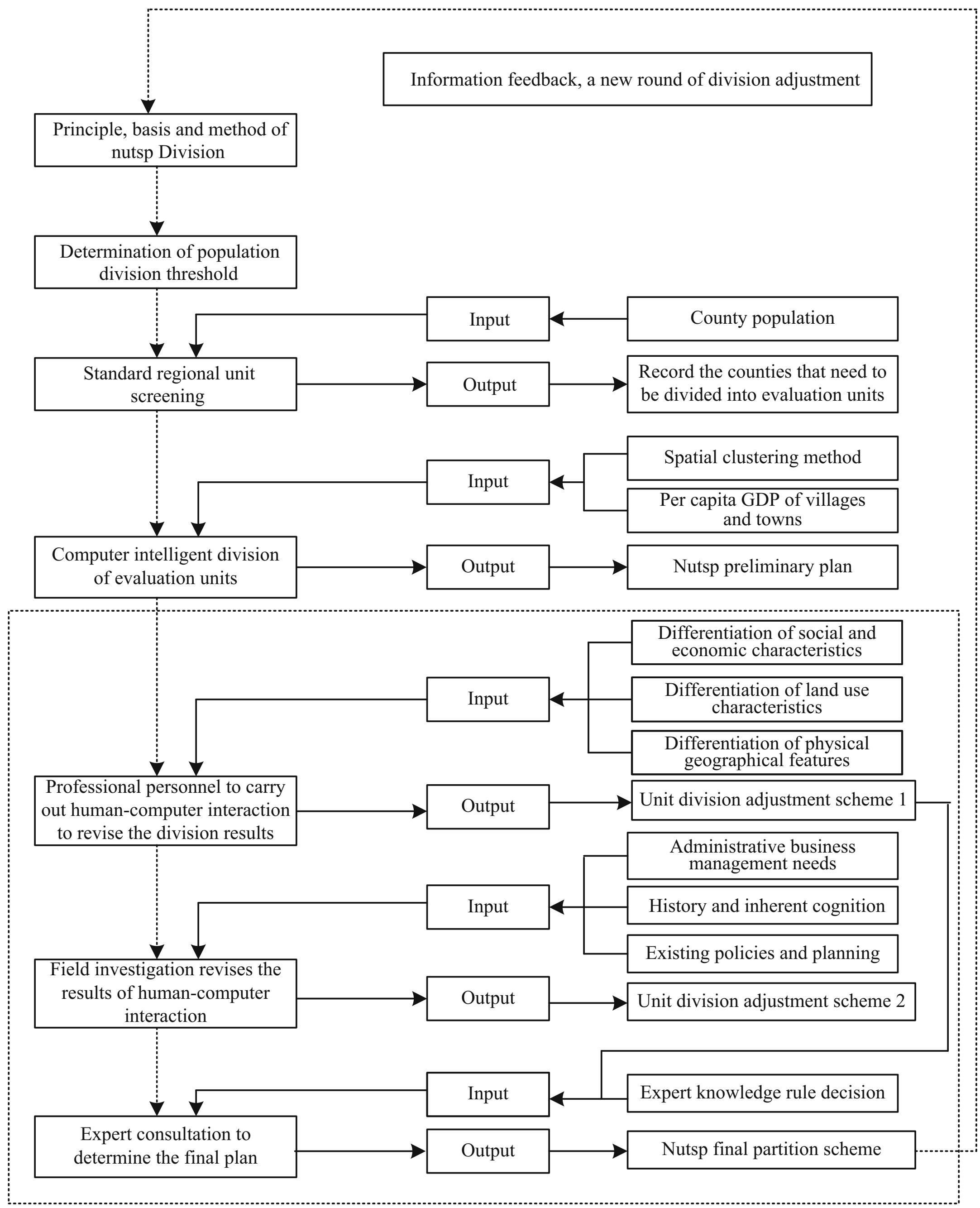

Figure 3: Regional evaluation of urban and rural spatial standards.

Urban and rural spatial planning often has a certain service time, so the division of evaluation units should at least reflect the state of urban and rural spatial development in time and space. If the granularity of spatial evaluation unit was too large, it can hardly reflect the evolution of urban and rural space horizontally, such as urban industrial construction. If the granularity was too coarse, the urban and rural spatial patterns might be the same. At present, China is in a period of rapid development of urbanization and industrialization [14]. Therefore, it is necessary to distinguish the relationship between urban and rural areas in urban and rural spatial planning. According to the standard regional unit division of urban and rural space in Hunan province, the relationship between urban and rural areas is mainly combined with the overall planning layout of the city where the prefecture-level city is located, and the towns in the direction of the development strategic axis of the prefecture-level city are grouped to construct the basic evaluation unit of urban industrialization [15]. The development and protection of urban and rural space mainly starts from the construction of comprehensive regional bodies such as urban industrialization, agricultural modernization, and ecological protection barriers. Therefore, when constructing the strategic pattern of urban and rural spatial function development, it was necessary to construct appropriate regional space for each type of function. From the perspective of management, the competent departments of each function can find their own core space positioning from the urban and rural space.

2.2 Spatial planning suitability analysis system

The construction of sustainable development evaluation of urban and rural spatial planning needs to adopt a two-level evaluation system of qualitative and semiquantitative methods from a macro perspective, and use different evaluation methods according to different evaluation contents. As the evaluation system must reflect the green development level of urban natural habitat and ecological environment, urban and rural space construction toward green development efforts should be encouraged, and create conditions for the sustainable development of the whole city's society and economy, the sustainability evaluation system of urban and rural space planning should not only reflect the current situation of urban and rural space development but also combine with the reality of the city. It provides a scientific basis for the design, construction, and management of urban and rural spaces [16]. Therefore, the construction of the evaluation system should consider the following principles: it needs to be quantitative and operational; it needs to have planning guidance function: it guides the way of urban and rural spatial development through indicators; it not only pays attention to effectiveness but also encourages all kinds of attempts and efforts; and it shows fairness and competitiveness [17]. The evaluation method of urban and rural spatial environmental sustainability is a technology and method that expects to integrate and analyze the environmental data and indicators in urban and rural spaces through mathematical algorithms, models, and other comprehensive analysis means, and then makes a comprehensive evaluation of the expected sustainable development of planning and design [18]. The construction of sustainable development evaluation of urban and rural spatial planning needs a clear technical route and should be based on the discipline characteristics of urban planning and design. The route framework of suitability analysis for major spatial planning is shown in Figure 4.

This paper uses situation analysis, also known as strengths and weaknesses analysis, to determine the strengths, weaknesses, opportunities, and threats of the project itself, and it lists four related factors through investigation, which are arranged in the form of a matrix. Using the idea of system analysis, all kinds of factors are matched and analyzed, from which a series of corresponding conclusions are obtained, and the conclusions usually have a certain decision-making nature. Sustainable development factors include external factors and internal factors. External environmental factors include opportunity factors and threat factors, which are favorable and unfavorable factors that have a direct impact on urban and rural spatial development. The internal factors include advantages and disadvantages, which are the positive and negative factors in the development of urban and rural spaces. When analyzing these factors, we

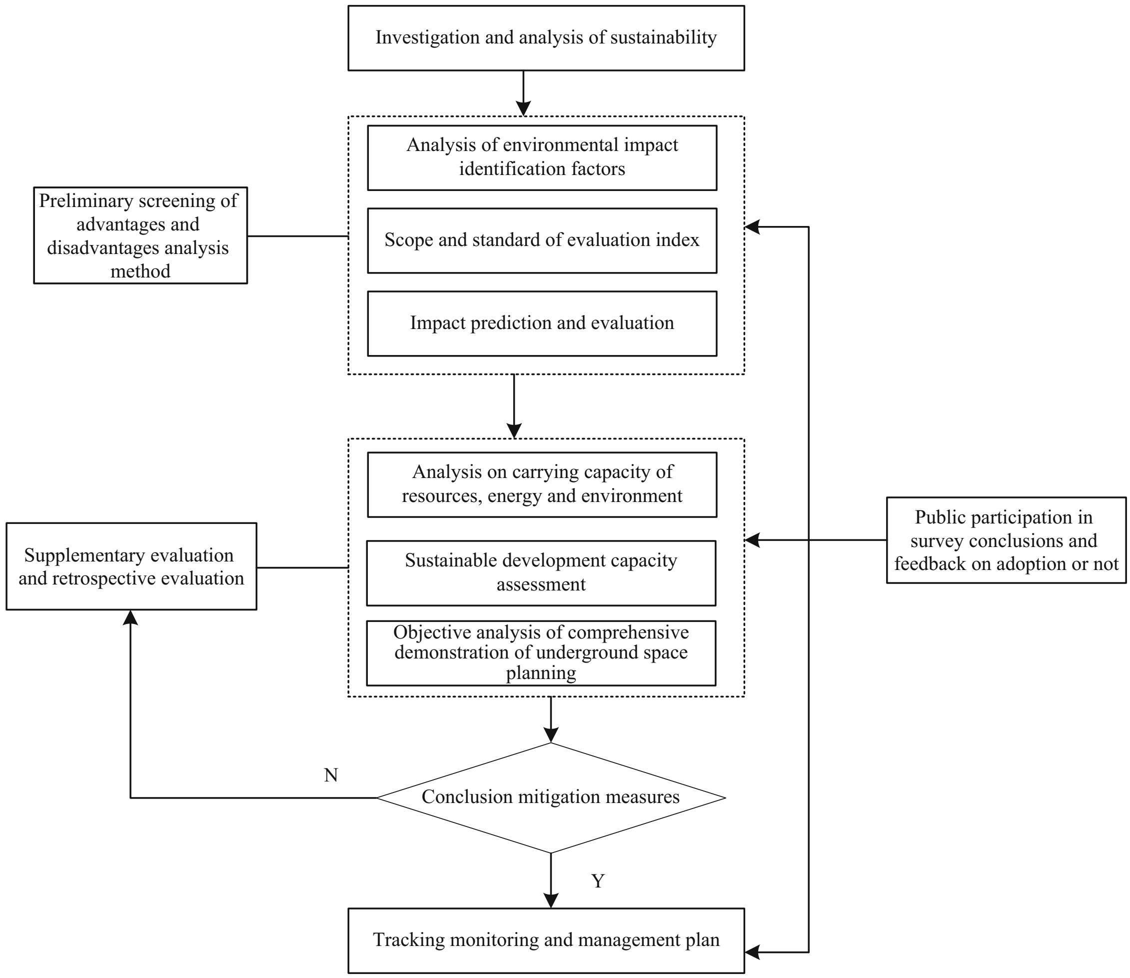

Figure 4: Route framework of spatial planning suitability analysis.

should not only consider the history and current situation but also measure them from the perspective of future development as shown in Figure 5.

The purpose of introducing strengths, weaknesses, opportunities, and threats (SWOT) analysis into the construction of sustainability evaluation system of urban and rural spatial planning is to ascertain the advantages and disadvantages through the evaluation of internal factors of SWOT. The evaluation of OT external factors finds out opportunities and threats, and uses systematic thinking to match these seemingly independent factors for comprehensive analysis, so as to give full play to the advantages, curb the disadvantages, seize the opportunities, eliminate the threats, and obtain alternative future development countermeasures [19] as shown in Tables 1 and 2.

In order to realize the integrity and stability of the ecosystem within the scope of sustainability evaluation of urban and rural spatial planning, and reasonably develop, utilize, and protect land resources, according to the regional environmental characteristics, resource conditions, and constraints of urban and rural spatial planning projects, through SWOT analysis and environmental coordination analysis, and according to relevant environmental protection policies, regulations, and standards, the qualitative evaluation method and price were determined. The indicators mainly include 32 indicators in eight aspects, including water environment, ecological environment, atmospheric environment, acoustic environment and solid, waste, water and soil resources, cultural relics protection, and social economy while including 10 restrictive indicators, 6 guiding indicators, and 16 expected indicators [20] as shown in Table 3.

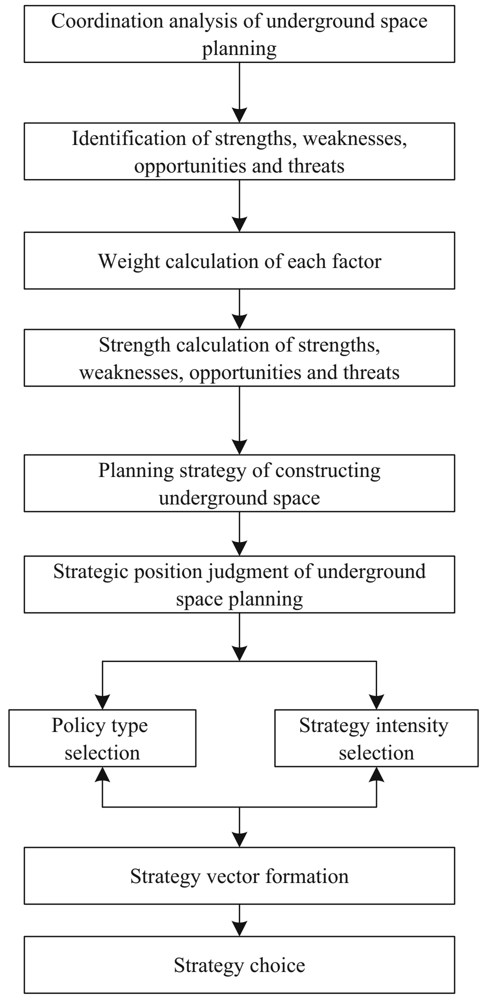

Figure 5: SWOT work flow chart.

Table 1: SWOT analysis of urban and rural spatial planning

Internal strengths	Internal weakness
S1: Intensive development, saving urban construction land	W1: Space development may cause land subsidence
S2: Potential economic and environmental benefits	W2: The construction is difficult
S3: The existing underground space planning theory has some basic research	W3: Great impact on the environment
S4: The geotechnical characteristics of underground space have their own advantages	W4: Small regional environmental capacity
S5: Huge urban traffic pressure, demand extends underground	W5: Uncertainty of planning forecast

Further analysis of the environmental impact factors under the spatial planning is as shown in Table 4 [21].

From the positive relationship, the more developed the city's scientific and technological civilization, the more resources it can obtain from nature, and the more problems it will produce, including the environment; on the other hand, from the negative correlation, the more environmental problems it has, on the contrary, the greater the impact and constraints it will have on the sustainable and healthy development of society. However, if the economic system, the social system, and the natural environment are

Table 2: Urban and rural spatial planning indicators

External opportunities	External threats
O1: Policy opportunities for regional development	T1: Insufficient understanding of spatial planning
O2: Environmental policy opportunities, such as total amount control of environmental governance	T2: Research blank of spatial evaluation system
O3: Developing space opportunities	T3: Public support

Table 3: Qualitative analysis system of spatial planning sustainability evaluation

Environmental elements	Environmental objectives	Evaluation criterion	Attribute
Water environment	Control water pollution, protect water quality, meet the requirements of functional areas, protect groundwater quality	(1) Water environmental capacity of main pollutants within the planning scope (T/a)	Binding
		(2) Total sewage discharge of underground construction projects within the planning scope (10,000 tons/a)	Anticipation
		(3) Discharge of COD, petroleum, ammonia nitrogen and total phosphorus (T/a)	Anticipation
		(4) Sewage treatment scale, efficiency and compliance rate (%)	Anticipation
		(5) Change of groundwater level in planning area (m)	Anticipation
Ecological environment	Maintaining the stability, integrity, and ecological service function of regional ecosystem	(1) Biodiversity index after implementation of planning scope	Guidance
		(2) Vegetation coverage rate after implementation of the planning area (%)	Guidance
		(3) Water and soil loss rate (%)	Guidance
		(4) Proximity between planning area and ecologically sensitive area (m)	Binding
		(5) The degree of regional ecological fragmentation that may be caused by the construction of the planning scope	Binding
		(6) Ecological sensitive area occupied by the planning area (MU)	Binding
Air environment	Reduce the emission of air pollutants and meet the standard of air environmental function zone	(1) Air environmental capacity of underground space (10,000 tons/a)	Binding
		(2) Annual emission of greenhouse gas and waste gas (10,000 m^3/year)	Anticipation
		(3) Control of main air pollutants such as SO_2/NO_x, smoke and dust (m^3/a)	Anticipation
		(4) Proportion of air quality standard area of underground space in total area	Anticipation

mutually promoting and harmonious, and the pollutants discharged to the environment are compatible with the resources, the regeneration ability of the environment, and the reinvestment of the economic system and the social system into the natural system, then the overall urban system will be coordinated and sustainable. This is also the ultimate goal of urban planning and design. Up to now, there have been many structural conflicts and contradictions in urban and rural spaces of big cities in China due to planning mistakes, which have caused great pressure on urban environment and resources. The objective of the sustainable development evaluation system of urban and rural spatial planning was to ensure the efficient use of land resources after the implementation of the overall construction of urban and rural spatial

Table 4: Environmental impact factors under spatial planning

Acoustic environment	Control the environmental noise to meet the requirements of response function area	(1) Average value of regional environmental noise (DB (a))	Anticipation
		(2) Guidance compliance rate of construction noise and highway traffic noise (%)	Guidance
		(3) Proportion of area with environmental noise up to the standards in underground space (%)	Anticipation
Solid waste	Solid waste to achieve harmless, reduction and resource treatment and disposal	(1) Annual output of garbage, general solid waste, and hazardous solid waste (10,000 tons/a)	Anticipation
		(2) Harmless treatment rate of garbage, general solid waste, and hazardous solid waste (%)	Anticipation
		(3) Comprehensive utilization rate of solid waste (%)	Anticipation
Utilization of natural resources and energy	Ensure the rational allocation of land resources and the optimal use of natural resources	(1) Water consumption per 10,000 yuan of planned output value (T/10,000 yuan)	Anticipation
		(2) Consumption of fossil energy per 10,000 yuan output value (T/10,000 yuan)	Binding
		(3) Comprehensive utilization rate of energy	Binding
		(4) Reasonable utilization of geothermal, wind, solar, and other renewable energy within the planning scope	Binding
		(5) Planning scope and energy structure	Guidance
Comprehensive environment of social economy	Ensure social stability, economic development, and natural harmony	(1) Overall space transportation within the planning scope	Anticipation
		(2) Safety and public satisfaction	Guidance
		(3) Total planned economic output value (10,000 yuan/a)	Anticipation
Cultural heritage and natural landscape	Protection of cultural relics and landscapes with cultural and environmental values	(1) Intact rate of cultural heritage protection, animal and plant protection habitat (%)	Binding
		(2) Impact of planning scope on cultural relics protection units and protected habitats of animals and plants	Binding
		(3) Added tourism resources after planning	Anticipation

planning, realize the rational use and optimal allocation of water resources, and ensure that the atmospheric environment, surface water environment, groundwater environment, and ecological environment meet the functional requirements of the corresponding functional areas. Therefore, through the construction of the evaluation system to test and determine the rationality of urban and rural spatial planning scheme, it is conducive to improve the efficiency of urban land use and create conditions for the protection of the aboveground natural environment. At the level of urban overall space, it also provides vast space resources for the realization of ecological city, greatly improves the quantity and quality of urban public green space, creates a functional and structural urban green space and ecological environment system, and comprehensively improves the quality of urban space environment so as to gradually build a livable city with beautiful environment, natural harmony, and sustainable economic and social development.

2.3 The realization of urban and rural space suitability evaluation

Through the collection of urban linear space planning and design results in recent years, the project types were mainly urban linear park, green belt, waterfront space, and street space, and the expression of design results was mainly to shape and enhance the image of landscape and ecological space along the line. It is true that the shaping of linear space landscape and the beautification of ecological image can quickly attract urban public activities and give the most direct sensory stimulation. But because of this, the public's cognition of linear space as landscape is also limited, which is quite different from the actual characteristics of urban linear space planning and design, which is comprehensive and complex. Under the background of rapid urbanization, the problems of urban linear space are becoming more and more complex, and the contradiction is also gradually obvious. Therefore, through the construction of a comprehensive evaluation system, it is necessary not only to evaluate the construction of urban space, function, and ecological landscape along the line but also to bring the planning, design, and planning research results into the horizontal comparison category so as to realize the interactive evaluation and clarify the internal relationship between the main contradictions and demands faced by the planning, design, and research. The planning strategies and measures suit the case. Therefore, it is necessary to optimize the interactive evaluation system of urban and rural spatial planning indicators as shown in Figure 6.

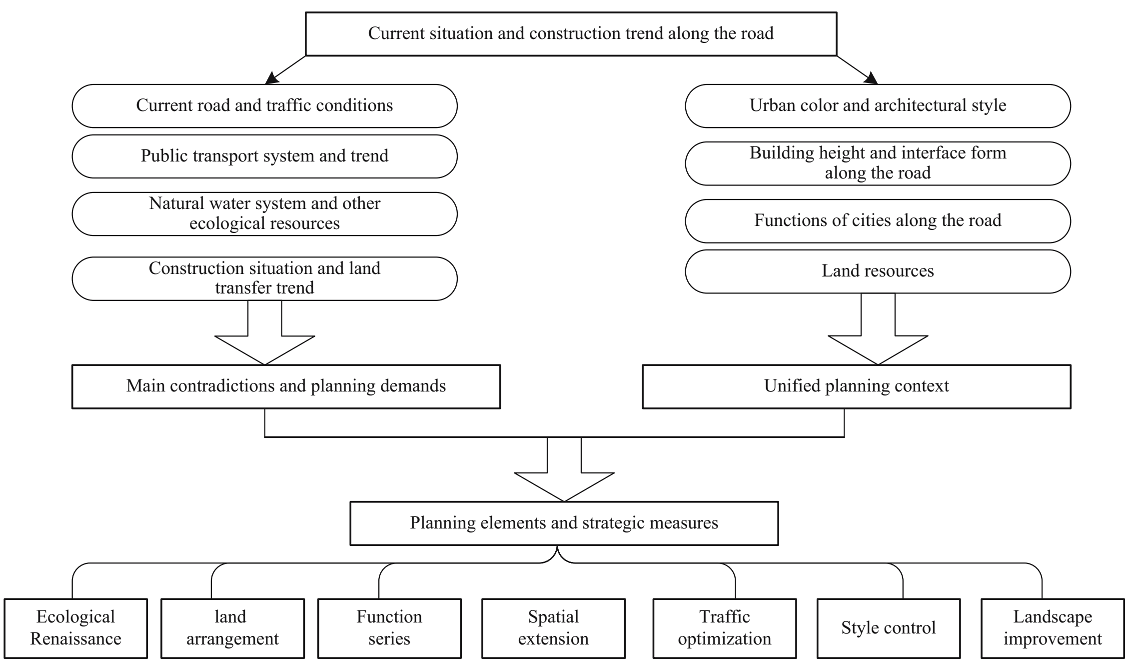

Figure 6: Interactive evaluation system of urban and rural spatial planning indicators.

Through the qualitative evaluation system scheme, enter the selection. The main evaluation indicators are the assessment of resources, environmental carrying capacity, and sustainable development capacity, which are not investigated in the initial evaluation. Ecological suitability evaluation grades each single factor on the basis of ecological investigation, evaluates each factor one by one, and draws up a single ecological factor map. Then, the importance scale 1–9 assignment method is used to assign the weight of each key single factor.

$$E = \sum_{i=1}^{n}(P_i \times E_i). \tag{1}$$

In the formula, n is the total number of evaluation indexes of urban ecological degree; E is the comprehensive index of ecological degree; E_i is the ecological degree index of an ecological technical index; and P_i is the weight value of an ecological technical index. In the process of evaluation, the EKC curve reveals that with the development of economy and the improvement of per capita income, the environmental quality index of urban ecological environment quality gradually rises along the left side of the inverted U-shaped curve (the environmental quality becomes worse), and then falls into the right side after passing through the top critical area (the environmental quality becomes better). This transfer process occurs during modernization, and the quality of urban ecological environment gets worse. Another major feature is reversing the deterioration trend and entering a virtuous circle. It shows the progress of civilization and the improvement of life quality (represented by the overall change of ecological environment quality) brought by modernization, which is an important embodiment of urban "development quality" in the process of modernization.

The mathematical expression of the EKC curve is as follows:

$$z = m - n(x - p)^2 - E. \tag{2}$$

In the formula, z is the degree of deterioration of the ecological environment; x is the per capita GDP; and m is the environmental threshold. Using the derivation method of mathematical formula, we can deduce the mathematical formula of the coupling of urbanization and ecological environment from the mathematical formula of the inverted U-shaped EKC curve and logarithmic curve

$$z' = m - a\left[10^{\frac{y+b}{a}} - p\right]^2 - z. \tag{3}$$

In the formula, z is the degree of deterioration of ecological environment; y is the level of urbanization; m is the threshold of ecological environment; and a, b, p are non-negative parameters. Taking the urban population as the population base, its growth rate is expressed as the function of urban population $r(x)$ and $r(x)$ is the decreasing function of X. The simplest assumption is that $r(x)$ is a linear function of x, $(x) = r - sx$, r, $s > 0$, where R is equivalent to the growth rate when $x = 0$, which is called the inherent growth rate. The meaning of introducing a coefficient is to introduce the maximum population X that can be accommodated by natural resources and environmental conditions, which is called the maximum population capacity. When $x = x$, the growth rate is zero, that is, $R(x\text{–}) = 0$, s is determined. The comprehensive evaluation method based on fuzzy mathematics is a very effective multifactor decision-making method. According to the "membership theory" of fuzzy mathematics, the comprehensive evaluation method transforms qualitative evaluation into quantitative evaluation, that is to say, fuzzy mathematics is used to make an overall evaluation of things or objects restricted by many factors. Fuzzy comprehensive evaluation method has the characteristics of clear results and strong systematic nature, which can better solve the fuzzy and difficult-to-quantify problems. It is very suitable for urban and rural spatial planning, which has many non-deterministic problems. The evaluation of sustainable development ability of urban and rural spatial planning seeks to determine the evaluation index through the identification and screening of environmental, social, and economic factors. The fuzzy comprehensive evaluation method of index plus weight is used to evaluate the regional sustainable development ability under the influence of planning scheme quantitatively or semiquantitatively.

$$r(x) = z \times r\left(1 - \frac{x}{z'x_n}\right). \tag{4}$$

In the formula, r and x_n are constants determined according to urban demographic data or experience factor $\left(1 - \frac{x}{x_m}\right)$. It reflects the blocking effect on urban population growth. Then the growth rate of urban population is

$$\begin{cases} \dfrac{\mathrm{d}x}{\mathrm{d}t} = r\left(1 - \dfrac{x}{x_w}\right)x, \\ x(0) = x_0. \end{cases} \tag{5}$$

The above nonlinear differential equation is solved by the method of separating the variables:

$$x(t) = \frac{x_m}{1 + \left(\frac{x_m}{x_0} - 1\right)e^{-rt}}. \tag{6}$$

Based on the coordination theory of complexity science, the coupling degree model of urbanization and ecological environment is constructed.

$$C = 2x(t)\{(u_1 \cdot u_2)/[(u_1 + u_2)(u_1 + u_2)]\}^{1/2}. \tag{7}$$

According to the relative and absolute limitations of the influencing factors, and whether there is a relationship of mutual compensation and substitution between the indicators, the evaluation of natural suitability of human settlements needs to select the appropriate integration methods in different links according to the internal scientific logic of the influencing factors, such as the minimum factor method (short board effect), multifactor weighted sum method, "minimum factor + multi factor sum." The influence of terrain on urban and rural construction and traffic convenience is the result of elevation and slope, which has a certain compensation and substitution effect. The multifactor weighted sum method can be used for index integration. In geography, topographic relief is generally used to comprehensively characterize regional altitude and surface cutting degree. The index is mainly used to divide the geomorphic types, and to carry out regional resource and environmental assessment of soil erosion sensitivity, freeze-thaw erosion sensitivity, soil erosion, and urban and rural construction. Although this index is different from the common weighted sum method, its essence is still the sum of the effects of elevation and slope, which indicates that there is a complementary relationship between the two factors. The calculation formula is as follows:

$$R_{\mathrm{DLS}} = \frac{A_{\mathrm{LT}}}{1{,}000} + [\max(H) - \min(H)] \times \frac{P(A)}{A_z}. \tag{8}$$

In the formula, R_{DLS} is the topographic relief, A_{LT} is the average altitude of a certain area with a grid unit as the center; $\max(H)$ is the highest altitude in the area; $\min(H)$ is the lowest altitude in the area; $P(A)$ is the flat area in the area; and A_z is the total area of the area. The overall goal of urban–rural coupling degree evaluation is the high integration and coordinated development of urban and rural areas. According to the theory of urban composite ecosystem, this overall goal is comprehensively reflected in the social, economic, and environmental aspects, so the overall goal is divided into three subgoals: urban–rural economic integration, urban–rural social integration, and urban–rural environmental integration. The criterion level of urban–rural economic integration subgoal is the economic coupling degree; the criterion level of urban–rural social integration subgoal is composed of population coupling degree, life coupling degree, and service guarantee coupling degree; the criterion level of urban–rural environmental integration subgoal is composed of natural environment coupling degree and artificial environment coupling degree. Under the criterion layer, there are 20 single indicators to form a complete hierarchical structure of urban–rural coupling degree evaluation index system

Sustainable development capacity includes many aspects, such as resource conditions, energy supply, natural environment, social environment, land, ecology, infrastructure, emergency response capacity, management, and so on. According to the qualitative evaluation of urban and rural spatial planning, combined with the characteristics of urban and rural spaces, the quantitative index system is established. The category and grade of the quantitative evaluation index of urban and rural spatial planning are determined according to the planning and sustainability objectives and the target values given. The numerical value category is scored by interpolation method.

In the development and utilization of urban and rural space, the influence of elevation and slope also has a certain degree of independence. For example, the areas with larger slope are prone to geological disasters, but the correlation with elevation is small; the altitude response of human beings in high altitude areas is mainly affected by elevation but almost not related to slope. Therefore, the minimum factor method should be used to identify the impact of terrain on human physiological function and the risk of geological disasters, rather than the common weighted sum method.

3 Experimental results

Using the above model, the paper studies the coupling degree of urbanization and ecological environment in different regions on the national scale and concludes that the coupling degree C of urbanization and ecological environment is between 0 and 1. When $C = 0$, Fengyu degree is very small, urbanization and ecological environment are in a state of indifference, urbanization and ecological environment are in disordered development, and urbanization and ecological environment are in a low level of coupling stage. At this time, the level of urbanization is low, the ecological environment carrying capacity is strong, and it can fully bear and digest the consequences of urbanization. When $0.3 < C < 0.5$, urbanization and ecological environment were in the antagonistic stage, and urbanization is developing rapidly. Its development needs plenty of funds and population transfer as support, and the ecological environment has begun to be unable to fully bear and digest its impact. When $0.5 < C < 0.8$, urbanization and ecological environment enter the running-in stage, urbanization has crossed another inflection point, population urbanization level is more than 50, urban development has been restricted by the early ecological environment damage, and a considerable amount of development funds have been injected into ecological restoration, and urbanization and ecological environment begin to show benign coupling; thus, urbanization and ecological environment have entered a new stage. At $0.8 < C < 1$, urbanization has crossed another turning point. Ecological urbanization and urban ecology have become the basic goal of people's lives, and urbanization and ecological environment have entered a high-level coupling stage. This model is used to analyze the coupling degree of spatial planning and ecological environment (Figure 7).

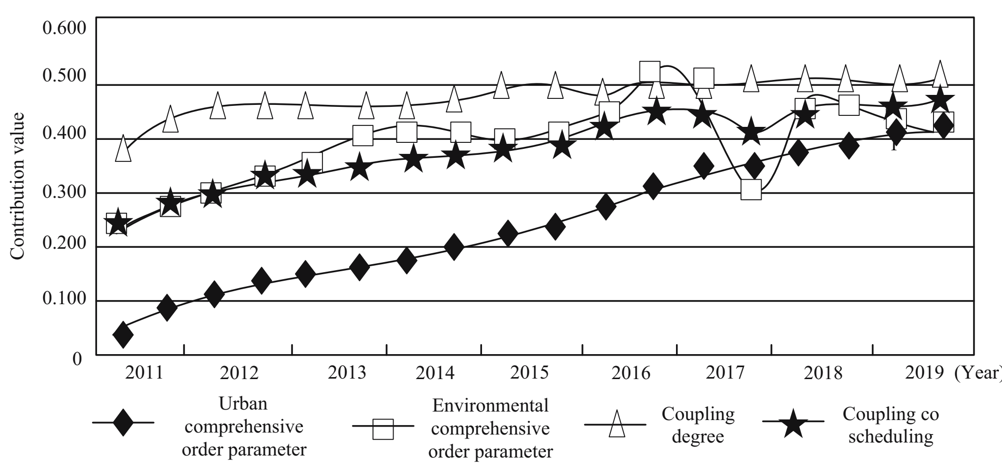

Figure 7: Change of coupling degree between urban and rural spatial planning and ecological environment.

After the main evaluation procedure of sustainability evaluation is completed, the planning evaluator needs to take the urban and rural spatial planning objectives and regional socioeconomic development objectives as the basis, through system coordination, the regional resources and environment carrying capacity and design of other relevant urban planning (such as surface urban planning, comprehensive transportation planning, municipal facilities planning, etc.) at the overall level of the city, and the environmental suitability and rationality of the plan are comprehensively analyzed, and the adoption opinions of the plan that is in line with the planning objectives and sustainable development objectives are given. The plan which is basically in line with the planning objectives but still has some problems is given. The suggestions of optimization adjustment or modification are put forward, and the basis of relevant adjustment and modification is provided. The plan that is destructive to the environment and ecology is strongly denied.

4 Discussion

On the basis of the evaluation results, the undertaker of urban and rural spatial planning aims at protecting the regional environment, further adjusts and revises the urban and rural spatial planning scheme from the perspective of improving the economic and environmental benefits of urban and rural spatial development, and complements and improves the urban and rural spatial planning scheme by combining the comprehensive evaluation opinions. In the process of optimization and adjustment, measures for sustainable development should also be earnestly implemented. The development and construction of urban and rural spaces should be environmentally, socially, and economically viable with enhanced management and supervision. At the same time, combining with the evaluation, the reasonable control of urban and rural space development and total scale and land on the basis of the legitimate use, making full use of the opportunity of space in urban and rural areas, from the angle of system integrating the city ground space and the surrounding area, under the condition of coordination with all kinds of ground plans, reasonable suggestions based on the urban and rural spaces to achieve the goal of building an intensive society and a livable city are put forward.

5 Conclusion

Through the above research, the following conclusions are drawn:
(1) Urban and rural spatial planning and design can effectively improve the efficiency of urban land use, create conditions for protecting the aboveground natural environment, and provide broad spatial resources for the realization of ecological city.
(2) Extending the scope of sustainability evaluation to the level of urban and rural spatial planning and design is of great significance to solve the problems of urban spatial structure and decision-making.
(3) Sustainability evaluation is a developing process. Its guiding ideology and evaluation methods can meet the requirements of coordinated development of society, economy, and environment only when they are constantly improved with the changes of urban development. Therefore, the establishment of a scientific and reasonable urban and rural spatial planning evaluation system can truly improve the quality of urban human settlements, promote the harmony between man and nature, and realize the all-round and sustainable development of the economy and society.

However, the imbalance of urban and rural spatial environment caused by blind urban and rural spatial construction decision-making in modern cities can be further studied in the future to solve the problems in urban and rural spatial planning.

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