Evaluation of spatial form of rural ecological landscape and vulnerability of water ecological environment based on analytic hierarchy process

Abstract: The spatial form of the rural ecological landscape and the vulnerability of the water ecological environment are evaluated to understand the status of the rural ecological system and provide a scientific basis for improving and protecting the rural ecological environment. With the acceleration of the urbanization process, rural areas in urban fringe areas have become an important carrier of urban space expansion and function allocation due to their advantages in transportation and resources, and have been included in the urban production and consumption system. The fast change in country capabilities and the consistent change in land use structure show a differentiated and enthusiastic improvement pattern. According to the point of view of provincial rejuvenation and new urbanization, this study discussed about the time-space qualities of provincial change and land use change, examined the coupling connection between rustic change and land use change, and set forward commonsense country improvement procedures and land guideline measures, which can not only stimulate the vitality of rural development but also consolidate the foundation of rural revitalization. Through the investigation and analysis of rural ecological land, it was found that the rural ecological land decreased from 95.14 to 89.84% from 2015 to 2019, then rose to 92.94%, and finally fell back to 91.74%, which is relatively stable on the whole. It can be seen that the spatial form, coupling, and coordination of the water ecological environment in rural ecological landscape presents a stable trend.

Keywords: rural ecological landscape, analytic hierarchy process, security and communication networks, coupling coordination

1 Introduction

Assessing the vulnerability of water ecological environment can help us find the key problems and bottlenecks in the ecological environment, to take targeted measures to improve. Ecological benefit is a system that can not only consider economy and environment but also seek the best balance point of economy and ecology based on the ecological balance and the virtuous and efficient cycle of the ecological system; during the time spent on monetary and social exercise and financial worth, various methods should be adopted to minimize the consumption of resources and the impact on the environment. Through the in-depth interpretation and disclosure of the ecological environment problems, people can better understand the sustainable development of human society, while taking into account the protection and development of the ecological environment and integrating them.

From the perspective of rural ecological economy, and combining the theory of rural ecological economy and the theory of institutional coupling, this study establishes the interaction model of rural ecological economy, theoretically analyzes the interaction and influence of rural ecological economy, reveals the material basis and dynamic
mechanism of ecological economy, and according to the current situation and problems of ecological economy, formulates rural development strategies and clarifies rural development goals. The ecological benefit is a quantitative evaluation index, which corresponds to the ratio of products and the impact on the environment, thus making the ecological benefit measurable and operable. It can convert the goal of sustainable development into an operable measurement method, expanding the research methods and methods of sustainable development.

This article talks about the coupling of rustic land use and climate according to the natural viewpoint. The development of rural ecological benefits is considered from the perspective of rural ecology and rural residents' activities. Based on giving full thought to country environmental insurance and provincial turn of events, taking the rustic coupling issue under the “natural” viewpoint as the exploration item, and taking the “provincial biological advantages” as the advanced point, the “rustic coupling” research structure in light of the “environmental advantages” was creatively settled. Rural ecology is a complex ecosystem, which includes land use, vegetation cover, water resources, and soil quality.

2 Related work

In the last 10 years, although urbanization has had a great impact on the rural ecological pattern, its ecological environment is still in a stable state. Feng and Jinggui elaborated on the connotation of water ecological environment in rural ecological landscape and analyzed the structure, function, and value of rural landscape ecology according to the rural revitalization strategy proposed in the report of the 19th National Congress of the Communist Party of China and the No. 1 Document of the CPC Central Committee in 2018, combined with the current situation of rural environmental pollution in China [1]. Chen explored suitable waterfront space design methods in combination with the morphological characteristics, composition principles, and spatial forms of the Jiangnan region and the design concept of modern architecture [2]. Yang and Yong mainly evaluated the overall health of the wetland park, ignoring the spatial differences in the internal health of the wetland park [3]. These works' methodologies lacked theoretical concepts or other forms of novelty.

The earth's biological life inside this territory has been somewhat impacted by the overall expansion of the economy and society. Based on the research of landscape theory and related theories, Han et al. analyzed three types of cave dwellings and compared their advantages and disadvantages. In view of the existing problems, suggestions for improving the spatial layout of modern cave dwellings are put forward [4]. According to the plant information of Puxing Village, a typical village in Chengdu Plain, Shu et al. drew a positioning map using FRAGSTATS software to analyze the landscape ecological pattern [5]. Lin et al. took the Xiamen coastal zone as an example, and based on the theory of physical coupling degree, established a comprehensive evaluation system for the coupling degree of space intensity and ecological security. Quantitative analysis and determination of the coupling and coordination degree of each bank section are divided into four categories: good coordination, high coupling; medium coordination, moderate coupling; medium coordination, micro coupling; and primary coordination, micro coupling [6]. There are many research contents and achievements on space, but there are few studies on the water ecological environment in rural ecological landscapes.

3 Evaluation method of water ecological environment in rural ecological landscape

3.1 Analytic hierarchy process

With the in-depth integration of landscape ecology and rural planning technology, supported by positioning technology, using remote sensing, image recognition, continuous positioning observation, and other means, the spatial characteristics of landscape units such as landscape morphology index, corridor connectivity index, matrix diversity, and evenness index can be quantitatively described [7,8]. Through the study of rural ecological land use patterns, people can study the characteristics and protection laws of rural ecological land use patterns and comprehensively evaluate them. To some extent, it reflects the changes in rural land use under the ecological environment. The analytic hierarchy process is a decision-making method that breaks down the elements always related to decision-making into levels such as goals, criteria, and schemes, and carries out qualitative and quantitative analysis on this basis [9].

Ecological benefits refer to the various services and benefits created by the natural ecological environment, including the hydrological cycle, soil conservation, climate regulation, carbon dioxide adsorption, biodiversity maintenance, and other ecological services and welfare [10]. Ecological benefits mainly include rural economic and ecological
Ecological benefits, social and ecological benefits, and ecological and environmental benefits [11,12]. According to different residential environment composition systems, various ecological benefits can be divided into urban ecological benefits and rural ecological benefits, as shown in Figure 1.

For example, in rural areas, changes in population size and structure will directly affect the economic development and social and cultural transformation of the area. At the same time, the development of the rural economy will also have an impact on the local population structure and social culture, and then affect the ecological environment and resource utilization of the region. The structured analysis elements of urban landscape are often referred to as the surface topography of natural land, which also shows the variability of urban landscape. Ecological land is the main component of the urban and rural ecological environment. The spatial structure characteristics of ecological land can be described by ecological patterns. It is the spatial distribution and combination of a series of ecological lands of different sizes, shapes, and types [13]. Landscape pattern indicators can provide a clear quantitative method for the previous abstract landscape patterns, and landscape pattern analysis software can provide a large number of landscape pattern indicators. On this basis, landscape form indicators are divided into two types: dynamic characteristics of landscape individuals and composite spatial forms, as shown in Table 1.

The survival of rural residents depends on nature. Their settlements are relatively small and closed, without any planning. They are developed in a natural way. Compared with cities, they have a more perfect natural system [14,15]. The “society economy environment” subsystem in the rural system is coupled with each other, showing an obvious overall and hierarchical relationship, as shown in Figure 2.

On this basis, the meanings of various indicators and their dependence on the ecological perspective are shown in the overall scale of a region measured by the number of patches, which reflects the landscape diversity of the region and is the basic value of various evaluation indicators [16,17]. From the perspective of the number of patches, the patch density is the degree of fragmentation of the landscape, and its calculation formula is as follows:

$$PG = \frac{m}{X}(10,000)(100),$$

where PG is the density of patches and m is the total number of patches; X refers to the area of the whole

### Table 1: Landscape pattern index

<table>
<thead>
<tr>
<th>Classification based on</th>
<th>The index type</th>
<th>Landscape index/abbreviation</th>
</tr>
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<tbody>
<tr>
<td>Landscape individual unit</td>
<td>The number of</td>
<td>Number of patches</td>
</tr>
<tr>
<td></td>
<td>Degree of landscape dominance</td>
<td>Patch density</td>
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<td></td>
<td>The shape of</td>
<td>Boundary density</td>
</tr>
<tr>
<td>Landscape spatial structure</td>
<td>Landscape structure</td>
<td>Mean plaque area index</td>
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<td></td>
<td></td>
<td>Landscape shape index</td>
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<td>Index of aggregation</td>
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</table>
terrain; and \(a\) refers to the event that has the greatest impact between large cities and interprovincial combinations determined by judging the number of ecological restoration events in various scenic spots in large cities. The so-called “boundary density” refers to the ratio of the total side length to the total area of the landscape or type, which reflects the scope of boundary division.

\[
SG = \frac{P}{X},
\]

where \(P\) is the perimeter of the whole landscape. This index can better reflect the impact of human activities on the landscape system in the process of rural coupling. The topographical index KEA is as follows:

\[
KEA = \frac{\sum_{i=1}^{m} a_{i}^{2} \left( \ln p_{xy}^{2} - \ln i_{ab}^{2} \right)}{\left( \sum_{j=1}^{n} p_{xy}^{2} \right) \left( \sum_{j=1}^{n} \ln p_{xy}^{2} \right)},
\]

where \(i_{ab}\) is the area of \(ab\), \(p_{xy}\) is the circumference of \(ab\), and \(m_{ab}\) is the number of patches.

KEA reflects the complexity of morphology in different spatial ranges. The fractal dimension ranges from 1 to 2. When the fractal dimension is closer to 1, the more regular and concise the patch shape is, and the more vulnerable it is to human interference. On the contrary, the larger the fractal dimension value is, i.e., the closer it is to 2, the more complex its shape is, and the less it would be interfered by human beings. This indicator can better reflect the impact of human factors on the urban landscape system in the process of urban and rural integration. The degree of plaque aggregation \(XA\) is as follows:

\[
XA = \left[ \frac{d_{aa}}{\max - d_{aa}} \right]
\]

where \(d_{aa}\) represents the number of corresponding landscape types similar to adjacent plates, and \(XA\) is based on the common boundary between land units of the same type. When there is no common boundary between pixels, the aggregation degree of this kind of land is the lowest; on the contrary, the aggregation index is the largest.

The progressions of provincial natural land use primarily include the structure and development of environmental land use, the scale and structure of ecological land use, the transformation process of ecological land use, the increase and decrease in ecosystem service value, and the change in landscape pattern index. The value of ecosystem services is based on the area of ecological land, rather than the landscape form of ecological land, which cannot reflect the horizontal ecological process of land. The ecological land-use efficiency of different regions is an important factor affecting the local ecological basic conditions, and the impact of rural construction on the ecological environment of the region. Ecological land use efficiency is an important indicator to measure the ecological environment in rural areas. Using the analytic hierarchy process, from the perspective of ecological land structure, ecological service value, and ecological land spatial form, 3
Benchmark layers and 20 indicator layers are, respectively, established to build the ecological land efficiency indicator system, as shown in Table 2.

The analytic hierarchy process has the advantages of systematization, comparability, flexibility, visualization, and comprehensiveness, which can better solve complex decision-making problems and improve decision-making efficiency and quality. Hierarchical analysis is to decompose the elements in decision-making into targets, criteria, schemes, and other levels, and decompose the factors of the level into several levels according to the different attributes of the level, and make qualitative and quantitative decisions on the elements of the same level, and the interaction and influence of each level. The research on the spatial relationship of villages from the ecological perspective combs and comments on the current ecological environment problems from three aspects of spatial relationship, ecological benefits, and system coupling analysis, and clarifies the problems faced by the current ecological environment research and the future development trend. The rural coupling and the rural coupling of ecological benefits from the ecological perspective are shown in Figures 3 and 4.

### Table 2: Efficiency index of ecological land

<table>
<thead>
<tr>
<th>Rule layer</th>
<th>Index layer</th>
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<tbody>
<tr>
<td>Landscape pattern index</td>
<td>Number of patches</td>
</tr>
<tr>
<td></td>
<td>Patch density</td>
</tr>
<tr>
<td></td>
<td>Edge density</td>
</tr>
<tr>
<td></td>
<td>Mean plaque size</td>
</tr>
<tr>
<td></td>
<td>Landscape shape index</td>
</tr>
<tr>
<td></td>
<td>Index of aggregation</td>
</tr>
<tr>
<td>Ecological land use structure</td>
<td>Proportion of ecological land in total land use</td>
</tr>
<tr>
<td></td>
<td>Water system occupies a proportion of ecological land</td>
</tr>
<tr>
<td></td>
<td>Forest land occupies a proportion of ecological land</td>
</tr>
<tr>
<td></td>
<td>Proportion of cultivated land to ecological land</td>
</tr>
<tr>
<td></td>
<td>Grassland occupies a proportion of ecological land</td>
</tr>
<tr>
<td>Ecological service value</td>
<td>Ground average gas regulation function</td>
</tr>
<tr>
<td></td>
<td>Land average climate regulation function</td>
</tr>
<tr>
<td></td>
<td>Land water conservation function</td>
</tr>
<tr>
<td></td>
<td>Land average soil formation and protection function</td>
</tr>
<tr>
<td></td>
<td>Land per capita waste treatment function</td>
</tr>
<tr>
<td></td>
<td>Land average biodiversity conservation</td>
</tr>
<tr>
<td></td>
<td>Land average food production</td>
</tr>
<tr>
<td></td>
<td>Ground average raw material</td>
</tr>
<tr>
<td></td>
<td>Land average entertainment culture</td>
</tr>
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![Figure 3: Rural coupling research from the ecological perspective.](image)
First, a hierarchy model is constructed, and then a set of pairwise comparison matrices are constructed. Finally, each scheme is sorted according to its weight. From the perspective of ecology, rural coupling refers to the close interaction between the rural ecosystems, human society, and economic systems. It is a kind of dynamic and complex ecological process, that involves many problems such as resource utilization, environmental capacity, ecological security, and so on [18].

3.2 Coupling evaluation

All indicators can be divided into positive and negative categories. The larger the positive indicators, the more beneficial they are to the system, while the negative indicators are the opposite. For example, the greater the patch density and edge density, the more fragmented the landscape, and the more adverse the system development. Through data standardization, the data are mapped in the range of 0–1. The formulas are as follows:

\[
A_a = \frac{a_x - a_{min}}{a_{max} - a_{min}},
\]

\[
A_a = \frac{a_{max} - a_x}{a_{max} - a_{min}},
\]

where \(a_x\) represents the value before and after data normalization, and \(a_{min}\) and \(a_{max}\) represent the minimum and maximum of the sampled data, respectively. The entropy weight value is determined by the amount of information transmitted from the index to the decision-maker, which can better reflect the utility of the index entropy. This study uses this method to determine the weight of each index in the spatial variation of the village landscape. The calculation is carried out according as follows:

\[
p_{ab} = \frac{t_{ab}}{\sum_{a=1}^{m} t_{ab}},
\]

\[
H_b = -1/\ln n \sum_{x=1}^{m} p_{ab} \ln p_{ab},
\]

\[
F_b = 1 - H_b,
\]

\[
\phi_b = F_b/\sum_{b=1}^{m} F_b,
\]

\[
V_a = \sum_{b=1}^{m} \phi_b t_{ab},
\]

where \(H_b\) is the entropy value of indicator \(b\), representing the total contribution of all evaluation objects to indicator \(b\); \(F_b\) is the difference coefficient, representing the degree of inconsistency of the contribution of each evaluation object under indicator \(b\); \(\phi_b\) is the weight of indicator \(b\) and \(V_a\) is...
the comprehensive evaluation index of the system in a year \( a \).

The concept of coupling originates from physics, which refers to the transmission of energy between media. Coupling is a phenomenon caused by the interaction between two or more systems. The coupling model is used to study the relationship between the landscape spaces in each period of the evaluation village and quantify the landscape spaces in each period, thus making up for the shortcomings of spatial analysis. This coupling formula is as follows:

\[
Z = \left[ V_{a} \right] \prod_{i=1}^{m} (V_{x} + V_{y})^{i},
\]

where \( Z \) is the coupling degree between \( m \) systems and \( V_{x}(x = 1, 2, ..., m) \), \( V_{y}(x = 1, 2, ..., m) \) are the comprehensive evaluation indices. However, this mode cannot evaluate the advantages and disadvantages of coupling, that is, higher coupling can still be achieved in the case of low integration of multiple systems. In order to overcome the above shortcomings, this study proposes a coupled cooperative scheduling model that can objectively reflect the cooperative development of multiple systems. The model is expressed as follows:

\[
G = \sqrt{Z \times R}, \quad R = \sum_{a=1}^{m} \phi_{a} V_{a},\]

where \( G \) is the cooperative scheduling among \( m \) systems, and \( R \) is an overall coordination index. \( \phi_{a} \) is an uncertain factor, representing the contribution of the \( a \)-th system to the integrated system.

Spatial analysis is the quantitative study of geospatial phenomena, and its conventional ability is to manipulate spatial data into different forms and extract its underlying information. This article studies the different kinds of land use in rural Wuhan relying on remotely sensed satellite visual data, and derives a meaningful land use index. Through spatial analysis, superposition analysis, and other methods, the evolution of ecological land in rural areas of Wuhan is analyzed, which gives a premise to the exploration on the spatial coupling qualities of metropolitan and provincial space in Wuhan, as displayed in Figure 5.

3.3 Water ecological environment in rural ecological landscape

Evaluating the spatial form of the rural ecological landscape can help us understand the pattern and distribution of the rural ecological environment, to formulate reasonable land use planning and landscape design schemes [19]. The water ecological environment in rural ecological landscapes is an important component of agricultural production and the natural environment. The quality of the water ecological environment directly affects many key indicators such as soil fertility, crop quality and quantity, water supply, and protection capacity. Therefore, it is important to consider the factors of the water ecological environment in the assessment of the spatial morphology of rural ecological landscapes and the vulnerability of the water ecological environment. Ecosystems in rural areas tend to have much greater water demands than those in cities. Therefore, protecting the water ecological environment and maintaining the supply of water resources can provide necessary irrigation and breeding for agricultural production. In order to protect the aquatic ecological environment, a series of measures can be taken as follows.

Reduce the use of agricultural chemicals, replace chemical fertilizers with organic fertilizers, adopt green agriculture, and protect water sources and agricultural ecosystems. Increase the area of water conservation areas, protect water sources, strengthen soil and water conservation measures, and prevent soil erosion and water pollution. Build water ecological landscapes, utilize water resources such as wetlands and rivers, build ecological corridors, and improve the stability and resilience of the water ecosystem. Strengthen rural sewage and garbage treatment, formulate strict pollution discharge and recycling policies, and achieve environmentally friendly agricultural production. In short, protecting the water ecological environment in rural ecological landscapes is crucial for maintaining the balanced development of agricultural production and the natural environment. The vulnerability assessment of the water ecological environment is an assessment of the stability and sustainable development of water ecosystems. It includes various factors such as the essential characteristics of water resources, economic and social development, and human activities, and is used to address the challenges and problems faced by the water ecological environment in different regions and periods.

The core of rural ecological benefits is the unity of ecological protection and development, that is, while promoting rural economic development, we should fully consider the carrying capacity of rural resources and ecological environment, effectively protect and improve the rural ecological environment, and improve the stability and sustainability of the rural ecosystem.

The assessment of water ecological environment vulnerability usually includes the following steps. Establish an evaluation index system. According to the essential characteristics of the water ecological environment and economic and social development, determine evaluation indicators, such as water resource utilization, water pollution control, and water ecosystem stability.
Data collection and processing. Collect data related to evaluation indicators and process them to conform to the format and specifications required for evaluation and analysis.

Index weight assignment. Assign weights to various indicators, taking into account the importance of different indicators in the overall evaluation of the water ecological environment, and the interrelationship between different indicators. Weight is a relative concept, which is analyzed based on a certain indicator. The weight of an indicator refers to the relative importance of the indicator in the overall evaluation.

Model establishment. According to the evaluation index system and weight, a mathematical model is established to assess the vulnerability of the water ecological environment.
Analysis of evaluation results. Based on the results of the evaluation model, the vulnerability of the regional water ecological environment is diagnosed and analyzed, and improvement measures are proposed.

The vulnerability assessment of the water ecological environment is crucial for promoting the sustainable use of water resources and the protection of water ecosystems. The evaluation results can guide the government and relevant departments to formulate reasonable policies and plans and promote the rational use, protection, and management of water resources. At the same time, the evaluation results can also provide a scientific basis for decision-makers to effectively predict and respond to possible problems and risks. In short, the vulnerability assessment of the water ecological environment is one of the important means to protect water resources and water ecosystems. Through scientific assessment and analysis of the vulnerability of the water ecological environment, the sustainable development of human society and ecosystems can be better guaranteed.

4 Evaluation of water ecological environment in rural ecological landscape space

4.1 Evaluation of area and data sources

This study takes Wuhan as the research object. As the capital city of Hubei Province, Wuhan is located in the middle of China, at the intersection of the Yangtze River and the Han River. It is an important transportation hub and megacity in inland China and an important industrial, and the Han River. It is an important transportation hub and megacity in inland China and an important industrial, and the Han River. It is an important transportation hub and megacity in inland China and an important industrial, educational, and scientific research base. Wuhan governs 9 urban areas, 4 suburbs, 108 sub-district offices, 21 towns, 15 townships, 1,107 communities, and 2,033 administrative villages. This study takes the spatial form of the water ecological environment in the rural ecological landscape in Wuhan as the research object.

The rural ecological environment is the most fundamental element of the ecological landscape. The rapid development of urbanization has greatly affected the rural ecological space structure and posed a large threat to the rural ecological environment. Hence, the parameters of the regional ecological have changed as a consequence of modernization, which is crucial for the safeguarding of rural ecology and environmental conservation. According to some relevant scholars, Wuhan has experienced the most rapid urban growth and urban–rural interactions in the past years. Its economic and social development is rapid, the urban population is rapidly increasing, urban construction is rapid, and infrastructure is constantly improving. However, at the same time, the rural space is rapidly shrinking, and the ecological environment is seriously damaged.

4.2 Rural spatial coupling characteristics of ecological land

As indicated by the spatial coupling attributes of land use, land is separated into four classifications: timberland, prairie, developed land, and water region. The scale, structure, area conversion, ecological service value, and landscape pattern of ecological land were compared and analyzed. This study starts with the service value, landscape pattern, and structure of ecological land, and establishes the evaluation index system of ecological land benefits. In Figure 6, the weight and comprehensive score of rural economic benefit indicators can be seen.

Figure 6 shows the absolute score and its difference in the standard level in the assessment record arrangement of the country's monetary and natural advantages. From the perspective of rural economy, energy consumption, and environmental pollution in Wuhan, the weights and comprehensive scores of the evaluation indicators of rural economic and ecological environment quality in Wuhan are analyzed as shown in Figure 6(a) and (b). After 2015, agricultural efficiency continued to decline significantly, but rebounded after 2018; however, with the reduction in agricultural efficiency, the impact of agriculture on the environment would be greater and greater after 2015, and the pollution of agriculture on the environment would continue to increase after 2017. This shows that in China's industrial development, agricultural production has a serious dependence on and causes damage to the natural ecological environment, and there is a trend of further deterioration.

Urban coupling and ecological benefits are inseparable. Only by comprehensively promoting the coordinated development of rural coupling and ecological protection can we maximize rural ecological benefits and play a more positive role in promoting rural revitalization and sustainable development [20]. In order to understand the features of existing urban coupling, it is necessary to analyze and compare the inner city policies, pursuing symbiosis, urban-rural ecotone, and rural area bonding, and current urban general coupling. The aspects of urban-rural...
spatial connection were investigated numerically and qualitatively from the viewpoint of ecological benefits. The analytic hierarchy process technique was used to create the assessment index system regarding biological land use efficiency in urban and rural areas. The coupling degree of various urban and rural mechanisms and environments was analyzed by using useable function assessment methods, bonding degree prototypes, and coupling cooperation graduate model. The changes in urban and rural natural attributes are statistically analyzed and tested by the following methods, and the results are as shown in Figure 7. The statistical analysis method was used for extensive statistics and comparative analysis, as shown in Figure 7.

According to the model, the correlation and collaborative transmission correlation between the economic benefits of Wuhan’s urban and rural market economies and pollutants from 2015 to 2019 were analyzed, and the results are shown in Figure 7(a). Urban and rural economies are plainly distinct, as demonstrated in Figure 7(b). This outcome from the divergence between work production of metropolitan and rustic regions enlarges the distance...
Figure 7: Efficiency and coupling degree of rural economy. (a) Rural economic efficiency and (b) rural coupling.
**Figure 8:** Comparison of three types of land area and three regions’ ecological land. (a) The proportion of three types of land area and (b) comparison of ecological land use in the three regions.
between both economy and interest in nature. The improvement of the rustic economy requires a lot of interest in regular habitat. Cooperative dispatch additionally mirrors the connection between economy and biological systems in a metropolitan and rustic turn of events. From the difference in coupling and composed booking, the coupling connection among urban communities and towns and the environment in Wuhan kept on improving from 2015 to 2019, while the coupling circumstance before 2018 deteriorated, and after 2018, there was a critical improvement. The impact of metropolitan country coordination on working on the nature of provincial farming advancement has been accomplished.

4.3 Comparison of ecological land

The change pattern of the country’s environmental land is displayed in Figure 8. The change range of land resources increases first and then decreases, while the change range of cultivated land decreases. It can be seen from Figure 8(a) that from 2015 to 2017, the ecological land use in rural areas of Wuhan was decreasing year by year, and the development momentum in 2017–2018 was enhanced; in 2015–2017, construction land increased, while in 2017–2019, it decreased; the undeveloped land increased slightly from 2015 to 2016, continued to decline from 2016 to 2018, and began to increase from 2018 to 2019.

The crossover across urban and rural areas has diminished, while the rural towns have essentially continued to exist. This is the correlation between biological land use and land usage in the three villages. The proportion of ecological land in the Wuhan urban area in the total land area of each region is shown in Figure 8(b). The extent of natural land in metropolitan and provincial regions has diminished by 72.64% in 2015 and 42.64% in 2019; the proportion of rural-urban ecotone decreased from 90.64% in 2015 to 76.04% in 2019; the change range of rural ecological land is relatively small. From 2015 to 2019, it decreased from 95.14 to 89.84%, then rose to 92.94%, and finally fell back to 91.74%, but remained basically stable.

5 Conclusion

Assessing the vulnerability of the water ecological environment can identify the problems of water resources management in rural areas, find timely solutions, and ensure the effective use of local water resources and the sustainable stability of the rural ecological environment. In recent decades, due to the global population density and socio-economic activities, the process of rural urbanization has expanded rapidly, and the rural landscape pattern has undergone significant changes. The development of rural urbanization is often accompanied by the fragmentation of urban landscape patches and the continuous reduction and fracture of ecological space. With the development of various disciplines and the demand for research, the application scope of coupling technology is expanding and has gradually penetrated into all aspects of various disciplines. This study introduced the concept of ecological benefits into the rural landscape ecosystem and analyzed its ecological benefits. Rural ecological benefit is an extensive investigation of the ecological impacts of various economic and social activities, and efficiency of rural residents from the perspective of ecology and activities of rural residents. Provincial environmental space is a significant component that influences the economic improvement of rustic culture and the existence of country occupants. It is an invisible “natural polymer” in the provincial environmental framework. Increasing the proportion of rural ecological space is an important way and means to achieve rural ecological security and institutional integrity, enhance rural functions and characteristics, and ensure the sustainable and healthy development of the rural economy.

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