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Study on the impact of rural land development and utilisation on the coordinated development of regional ecological environment

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Abstract: In order to effectively resolve the conflict between land use and ecological security, this paper studies the impact of rural land development and utilisation on the coordinated development of regional ecological environment. After selecting the index, the data are dimensionless, the index data weight is calculated, and the comprehensive evaluation function of ecological environment is established. According to the comprehensive evaluation function of land use and ecological environment, the rural land use evaluation index and ecological environment comprehensive index are obtained. Combined with the coupling coordination degree, the impact of rural land development and utilisation on the coordinated development of regional ecological environment is clarified. The results show that when the benefit of rural land development and utilisation is 0.5923, it can promote the coordinated development of regional ecological environment. When it exceeds 0.5923, it is not conducive to the coordinated development of ecological environment.

Keywords: rural land; development and utilisation; ecological environment; coordinated development; evaluation index.

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1 Introduction

The agglomeration of the population promotes the rapid development of society and at the same time causes the loss of food security, and the contradiction between man and land continues to intensify (Cai et al., 2021; Zameer et al., 2020; Liu et al., 2020). In addition, in the past, urban spatial layout planning mainly focused on the 'supply and demand balance' model and traditional inertial driving and guidance. The ecological vulnerability and sensitivity were not considered sufficiently, that is, when people use land to pursue economic benefits, they ignore their own factors. Ecological carrying capacity, this single-objective planning method makes the ecosystem and the rapidly expanding land use system not achieve a good run-in and adaptation (Wang et al., 2019, 2020). The rapid progress of industrialisation and urbanisation has increased the development and utilisation of land, resulting in an imbalance between the scarcity of land economic supply and the expansion of social demand (Xie et al., 2021). At the same time, the ecological and environmental problems caused by unreasonable land use methods have become more and more serious (Yang and Hu, 2019). In the face of the increasingly obvious contradiction between land use and ecological environment, how to achieve the balance of the relationship between the two and achieve the goal of sustainable development requires us to indirectly improve the comprehensive social benefits by improving the ecological environment and provide support for the stable development of land resources (Cui et al., 2019).

Study the relationship between the exploitation and utilisation of rural land and ecological environment, reveals the variation characteristics of the coordination degree between, on the one hand, to science, effectively resolve the conflict between land use and ecological safety, and optimisation of regional land use structure, coordinating the land economic output and ecological benefits to provide theoretical support and decision-making basis; On the other hand, it has a more sober understanding of the social and economic level and ecological environment quality, and has a grasp of its future development situation, and targeted to seek for resources and environmental protection countermeasures, in order to ensure the stability of regional environment and ecological system. Different scholars have conducted research on related issues; Liu et al. (2021) proposed a coordination degree calculation model and applied it to the field of land ecology, which has become an important method to measure the degree of coordination between regional systems. Zhao et al. (2019) used the mean square error decision-making method and the coordination degree model to measure the comprehensive benefits of land use from the three levels of economy, ecology and society, and conducted a quantitative analysis of the coupling and coordination level between subsystems. Gao et al. (2021) incorporated CO_2 emissions into the indicator system, and explored the temporal and spatial characteristics of the coordination between land use and ecological security in the province. Zhu et al. (2021) evaluated the synergy between sustainable land use and ecological environment based on the coordination degree model.

In order to further the effectiveness of the research on the impact of rural land development and utilisation on the coordinated development of regional ecological environment, this paper starts from the two aspects of land use and ecological environment, and uses the model to effectively analyse the utilisation rate of rural land resources through the numerical analysis environmental impact model of coupling coordination degree. The technical route of the overall research is as follows:

1 According to the actual development status of rural land and the ecological environment of the region, according to the selection principle of indicators, the research index data are selected and processed dimensionless. Based on the dimensionless evaluation index data, the comprehensive evaluation function of ecological environment is constructed.

2 Based on the above evaluation function, the rural land use evaluation index and ecological environment comprehensive index are obtained. Combined with the coupling coordination degree, the impact of rural land development and utilisation on the coordinated development of regional ecological environment is clarified, so as to effectively resolve the conflict between land use and ecological security.

3 Based on the data of rural land development and utilisation from 2015 to 2020, the data of regional environmental impact are studied.

2 Construction of evaluation function for coordinated development

Before studying the coordination relationship between land intensive use and ecological environment, it is necessary to quantify the coordination degree of rural land environment. At the same time, considering the application scope of different methods and the content of this paper, the multi factor comprehensive evaluation method is selected. Through the establishment of environmental assessment data set, the development index system is constructed by using weighted algorithm. The technical roadmap is shown in Figure 1.

2.1 Index selection principle

The index system is a collection of elements that reflect the structural characteristics of the evaluation object. In view of the intricate mechanism between land use and ecological environment systems, in order to better reflect the coordinated development of the system and improve objectivity, the following principles should be followed when setting indicators:

1 Both scientific and practical

Scientificity is the primary criterion that the evaluation system should have. The selected indicators must be able to truly, accurately and reasonably represent all aspects of the coupling and coordination between the systems, and at the same time be concise and clear. The number of indicators must be appropriate, so that they can be coarse and prominent under the premise of being available. Essentially, carefully and using feasible standards.

2 Systematic and hierarchical consideration

The collaborative evaluation of urban land use and ecological environment covers two sub-systems, and the system has multi-level attributes. Therefore, the establishment of the index system must coordinate the functions of each system, and highlight the links between the systems while reflecting the structure of the sub-systems. The selection of indicators is comprehensive and not to repeat, in addition, the weights should be determined according to the degree of contribution of different index elements to the evaluation, reflecting the characteristics of each level, that is, the overall grasp and the clear combination of levels.

3 Both dynamic and static

Since the evaluation of regional land use and ecological environment synergy is based on a certain time and space scale, the selection of indicators should take into account the dynamic change characteristics of each element and reflect the development trend of the system in different periods to facilitate prediction and decision-making. Coordinated development as a process is also a goal. Therefore, the index system should also have corresponding stability in a certain stage, revealing the current development status of the system.

4 Both universality and regionality

There are differences in natural conditions and economic and social development levels between regions, which result in slightly different factors that affect the degree of synergy between land use and ecological environment. Therefore, when constructing the index system, it is necessary to combine the characteristics and actual conditions of each region. At the same time, it should be universally applicable and have the conditions for conducting horizontal comparative analysis with other regions.

5 Both comprehensiveness and dominance

The coordinated progress of land use and ecological environment pursues unification of benefits and comprehensive evaluation content. Therefore, the coverage of the index system should be wide, so that the various elements that affect the degree of coupling and coordination can be fully displayed, but the selected indicators are not The more the better, it must have a certain degree of representativeness, that is, select factors that can reflect the most important aspects of the coordination level of the system, highlight the dominant factors, avoid similar factors, and improve the reliability of the evaluation results.

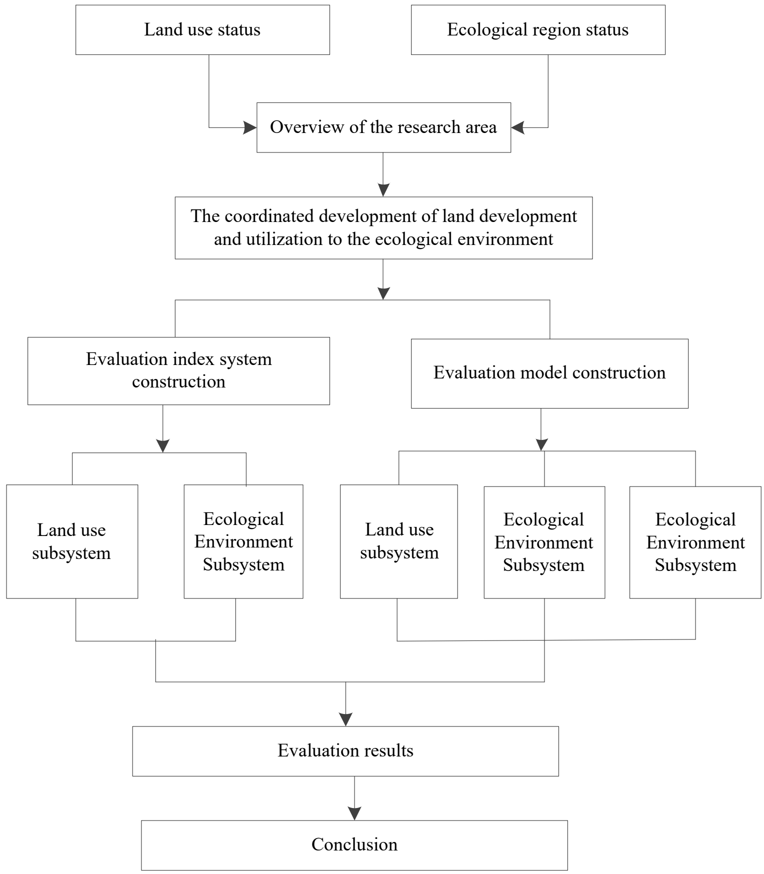
2.2 Dimensionless index value

If want to compare and calculate between different data, you need to perform non-quantification processing on the index value, and use the range standardisation method to process the value:

$$X_{ij}{}' = \begin{cases} \dfrac{\left(X_{ij} - X_{imin}\right)}{\left(X_{imax} - X_{imin}\right)} \; Positive \\ \dfrac{\left(X_{imax} - X_{ij}\right)}{\left(X_{imax} - X_{imin}\right)} \; Negative \end{cases} \tag{1}$$

In the formula, X_{ij}' is the standardised value of j index in year i; X_{ij} is the actual value; X_{imin} is the minimum value; X_{imax} is the maximum value.

Figure 1 Technology roadmap



When applying the range standardisation method, there are two points to pay attention to: one is that the indicators are different, and the corresponding formulas should be used to calculate; second, if new data is added, the standardisation operation needs to be repeated, because the newly added value may be possible The maximum and minimum values in the original data are changed, which affects the standardisation result.

2.3 Calculate the weight of indicator data

After realising that the index data unit of land intensive use and ecological environment evaluation is not quantified, the index is assigned, and the specific weight value of each index can be used to reflect the difference in the importance of each index (Yang et al., 2020). In order to reduce the influence of human subjective factors, data assignment through entropy method:

1 Conversion processing to eliminate negative and extreme values. After some index values are standardised, there may be small or negative or extreme values. In order to enable them to participate in the calculation, the translation is standardised to eliminate negative and extreme values.

$$X''_{ij} = H + X'_{ij}, i = 1, 2, ..., m; \; j = 1, 2, ..., n \tag{2}$$

In formula (2), X''_{ij} is the index value after translation; H is the amplitude, and the value is 1.

2 Calculate the proportion of the i-th sample value under the j-th index.

$$P_{ij} = \frac{X''_{ij}}{\sum_{i=1}^{m} X''_{ij}} \tag{3}$$

3 Calculate the entropy value of the j-th index.

$$e_j = -k \sum_{i=1}^{m} P_{ij} \ln(P_{ij}) \tag{4}$$

In formula (4), $e_j > 0$ and P_{ij} is the standardised value of the year j index. If X''_{ij} is all equal to j, then:

$$P_{ij} = \frac{X''_{ij}}{\sum_{i=1}^{m} X''_{ij}} = \frac{1}{m}, i = 1, 2, ..., m; \; j = 1, 2, ..., n \tag{5}$$

At this time, e_j can take the maximum value, namely:

$$e_j = -k \sum_{i=1}^{m} \frac{1}{m} \ln\left(\frac{1}{m}\right) = klnm, \; j = 1, 2, ..., n \tag{6}$$

If $k = \frac{1}{lnm}$, $e_j = 1$, so $0 \le e_j \le 1$.

4 Calculate the difference coefficient g_j of the j-th index

$$g_j = 1 - e_j, \; j = 1, 2, ..., n \tag{7}$$

For the specified column j, the smaller the entropy value, the greater the difference between the indicators, and the more important the representative indicators.

5 Calculate the weight of the j-th index.

$$w_j = g_j \Big/ \sum_{i=1}^{m} g_j, \; j = 1, 2, ..., n \tag{8}$$

2.4 The establishment of comprehensive evaluation function

This article assumes that $x_1, x_2, \ldots, x_n$ is m indicators describing land use, and $y_1, y_2, \ldots, y_n$ is n indicators describing ecological environment, then:

1 Comprehensive evaluation function of land use

$$u(x) = \sum_{i=1}^{m} a_i x_i, i = 1, 2, ..., m \tag{9}$$

Among them, a_i is the weight value of the land use index, and x_i is the standardised value of the i-th index of land intensive use.

2 Comprehensive evaluation function of ecological environment

$$e(y) = \sum_{j=1}^{n} b_j y_j,\ j = 1, 2, ..., n \tag{10}$$

Among them, b_j is the weight value of the ecological environment index, and y_j is the standardised value of the j-th index of the ecological environment.

3 Study on the impact of land use on the coordinated development of ecological environment

3.1 Land use and ecological environment assessment

According to the comprehensive evaluation function of land use and ecological environment, the rural land use evaluation index and comprehensive ecological environment index are obtained:

$$F(x) = \sum_{i=1}^{m} a_i x_i \tag{11}$$

$$G(y) = \sum_{j=1}^{n} b_j y_j \tag{12}$$

Among them, m and n are the number of land indicators and the number of ecological environment indicators.

3.2 Coordinated development of land use and ecological environment

According to the environmental assessment index coefficient, the calculated deviation coefficient is:

$$C_r = \frac{s}{\frac{1}{2}[F(x) + G(y)]} = \sqrt{2\left|1 - \frac{F(x) \times G(y)}{\left[\frac{F(x) \times G(y)}{2}\right]^2}\right|} \tag{13}$$

In formula (13), s is the dispersion factor of land use and ecological environment. When the value of C_r is smaller, the degree of environmental coordination is higher. Therefore, the ecological environment impact model is constructed according to the dispersion coefficient:

$$G = \left\{\frac{F(x) \times G(y)}{\left[\frac{F(x) + G(y)}{2}\right]^2}\right\}^k \tag{14}$$

In formula (14), G is the degree of influence and k is the land utilisation rate. In the text, the value of k is 2 and $C > 0$. When the value of C is larger, it proves that the degree of coordination is better.

3.3 Coupling model construction

A coupling model is constructed to calculate the coupling coordination degree between the rural land intensive use level and the ecological environment level of a city from 2015 to 2020 to obtain the coupling development degree. The coupling coordination degree and development degree between the land intensive use level and the ecological environment level are realised through the coupling coordination degree.

The coupling coordination degree can reflect the coordination between land intensive use and ecological environment, but it can not further explain the level of this coordination relationship (Su and Jiang, 2021). If the comprehensive score of land intensive use and ecological environment is low and very close in a certain period of time, it can be determined that there is a high coupling co scheduling. Therefore, in order to further comprehensively analyse the coordination between intensive land use and ecological environment, the development degree and benefit indicators will be calculated, and the calculation formula is as follows:

$$D = \sqrt{C \times T} \tag{15}$$

$$T = \alpha u(x) + \beta e(y) \tag{16}$$

Among them, C is the coupling coordination parameter, T is the utilisation benefit, D is the coordinated development degree, α and β are the weights that have not yet been determined. In this article, $\alpha = \beta = 0.5$.

In order to clarify the development stages of each district, combining the results of the coordination degree measurement and referring to related documents (Guo et al., 2021), the land coordination degree is divided into 9 levels, as shown in Table 1.

Table 1 Land coordination degree division table

Coordination	*Coordinated development type*	*Coordination*	*Coordinated development type*
$0 <\leq D < 0.2$	Severe imbalance	$0.6 \leq D < 0.7$	Primary coordination
$0.2 \leq D < 0.3$	Moderate Disorder	$0.7 \leq D < 0.8$	Intermediate coordination
$0.3 \leq D < 0.4$	Mild disorder	$0.8 \leq D < 0.9$	Well coordinated
$0.4 \leq D < 0.5$	Proximity disorder	$0.9 \leq D < 1$	Quality coordination
$0.5 \leq D < 0.6$	Barely coordinated		

3.4 Calculation of evaluation index weight

According to the constructed environmental development impact model, the evaluation index weights of the land and ecological environment structure are calculated, and the specific weight values are shown in Table 2.

Table 2 Calculation results of evaluation index weights

Criterion layer	*Index layer*	*Weights*
Land use structure	Proportion of cultivated land	0.7804
	Proportion of land used for traffic water	0.0815
	Proportion of unused land	0.1464
	Land economic density	0.0395
Economic benefits of land use	Fixed asset investment per land	0.0251
	GDP per area of primary industry	0.0081
	Per capita GDP of the secondary industry	0.0123
	Tertiary industry GDP per area	0.0138
	The population density	0.0562
	Urbanisation rate	0.0267
Social benefits of land use	Engel coefficient of rural residents	0.0385
	Natural population growth rate	0.0254
	Annual per capita net income of rural households	0.0318
	Per capita resident savings deposit balance	0.0215
	Number of employees per unit area	0.0368
Resource utilisation	Water resources per capita	0.0988
	Effective irrigation area per capita	0.2965
Environmental quality	Industrial wastewater discharge	0.0321
	Industrial waste gas emissions	0.0509
	Solid waste production	0804
Ecological environment	Forest cover rate	0.0259
	Afforestation area	0.0485
	Fertiliser use intensity	0.0862
Pollution control	Industrial wastewater discharge rate	0.0358
	Comprehensive utilisation rate of industrial solid waste	0.0563
	Urban sewage treatment rate	0.0359
	Harmless treatment rate of domestic garbage	0.0663

4 Analysis on the impact of land use on the coordinated development of ecological environment

4.1 Evolution of dispatching development degree

The dimensionless value and index coefficient of rural land use and ecological environment index of a city calculated, and the specific evaluation function of coordinated development degree are shown in Table 3.

Table 3 2015–2020 comprehensive evaluation function of rural land use and comprehensive evaluation function of ecological environment

	2015	*2016*	*2017*	*2018*	*2019*	*2020*
$F(x)$	0.1107	0.2713	0.3256	0.4625	0.5164	0.6328
$G(y)$	0.4562	0.3958	0.6912	0.5426	0.6125	0.6923

According to Table 3, the evaluation index $F(x)$ of rural land use and the comprehensive index $G(y)$ of ecological environment from 2015 to 2020 can be obtained to obtain the coordination degree C of rural land use and ecological environment. By determining the weight values α and β of the two in the comprehensive benefit, the comprehensive evaluation index T can be obtained. The coordination degree and the comprehensive evaluation index are both 0.5. When the value is higher than 0.5, the coordination degree is better. The specific results obtained for C and T.

Table 4 Coordination degree of rural land use and ecological environment from 2015 to 2020

	2015	*2016*	*2017*	*2018*	*2019*	*2020*
C	0.3961	0.9326	0.9826	0.9958	0.9954	0.9914
T	0.2861	0.33296	0.4235	0.5923	0.6559	0.7264

According to the above C and T results and formulas, the coordinated development degree D of rural land use and ecological environment from 2015 to 2020 is finally obtained. The results are shown in Table 5.

Table 5 The coordinated development degree of rural land use and ecological environment from 2015 to 2020

	2015	*2016*	*2017*	*2018*	*2019*	*2020*
D	0.3349	0.5576	0.6508	0.7653	0.7725	0.8499

4.2 Analysis of evaluation results of coordinated development

According to the evolution result of the dispatching development degree, the rural land use evaluation index $F(x)$, the ecological environment comprehensive index $G(y)$ and the coordinated development degree D are calculated using the land and ecological environment evaluation model.

Table 6 2015–2020 assessment results of the impact of land use on the ecological environment

	F(x)	*G(y)*	*D*	*Type*
2015	0.1107	0.4562	0.3349	Moderately unbalanced land use lagging type
2016	0.2713	0.3958	0.5576	Barely coordinated decline state type
2017	0.3256	0.6912	0.6508	Moderately coordinated ecological environment lagging type
2018	0.4625	0.5426	0.7653	Moderately coordinated ecological environment lagging type
2019	0.5164	0.6125	0.7725	Moderately coordinated land use lagging type
2020	0.6328	0.6923	0.8499	Well coordinated development

As shown in Table 6, Figure 2, and Figure 3, the degree of coordinated development of land use and ecological environment from 2015 to 2020 is only out of balance in 2015, while the degree of coordination in other years has increased year by year. The evaluation of rural land use and ecological environment in 2020 is the highest value in five years.

Figure 2 Changes in the comprehensive evaluation function of rural land use and the comprehensive evaluation function of ecological environment from 2015 to 2020

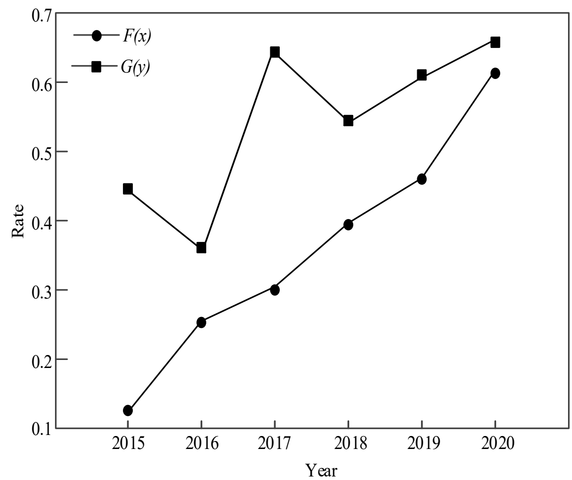
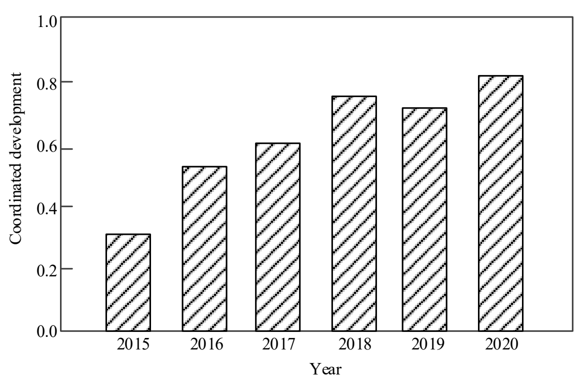


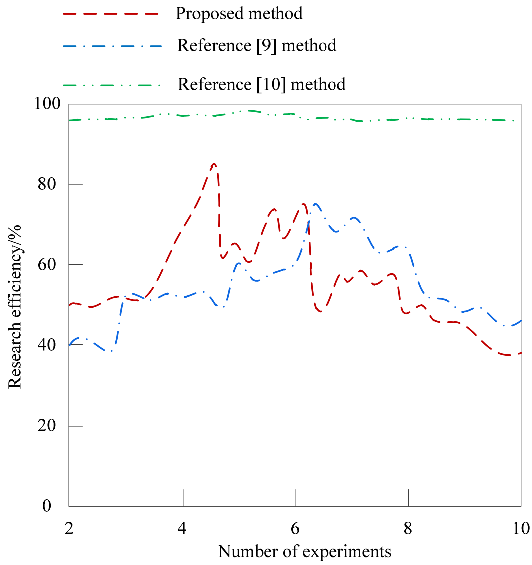
Figure 3 Changes in the coordinated development degree of rural land use and ecological environment from 2015 to 2020



After completing the relationship between the coordinated development of rural land use and ecological environment, it is necessary to compare and verify the efficiency of different methods, and compare this method with Liu et al. (2021) and Zhao et al. (2019). The comparison results of the research efficiency of the three methods are shown in Figure 4.

From the comparison results of research efficiency shown in Figure 4, it can be seen that the research efficiency of this method is always at a high level, even reaching more than 95%; In contrast, the research efficiency results of the two literature comparison methods show significant fluctuations, and the minimum research efficiency is difficult to reach the required level. Therefore, it shows that this method can improve the research efficiency under the condition of obtaining effective research results, which proves that this method has strong practical application ability.

Figure 4 Comparison results of research efficiency (see online version for colours)



5 Conclusions

Based on the land use data of a city from 2015 to 2020, this paper studies and analyses the coordinated development of rural land development and utilisation and regional ecological environment. Based on the relevant coordination degree identification standards, the overall situation of rural land utilisation rate and land use is calculated by using the environmental impact model. The results show that the coordination degree of regional ecological environment reaches the maximum in 2018, which is 0.9958, and the benefit of land development and utilisation is 0.5923. In 2019, the benefit of land development and utilisation will reach 0.6559, while the lack of coordination of regional environmental development will decrease to 0.9954. Therefore, it shows that the benefit of land development and utilisation cannot exceed 0.5923; otherwise it will have a negative impact on the coordinated development of regional environment. According to the impact research results, it can help rural areas formulate sustainable land development and utilisation strategies.

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References

Cai, J., Li, X., Liu, L., Chen, Y., Wang, X. and Lu, S. (2021) 'Coupling and coordinated development of new urbanization and agro-ecological environment in China', *Science of The Total Environment*, Vol. 77, No. 6, pp.148–153.

Cui, X., Fang, C., Liu, H. and Liu, X. (2019) 'Assessing sustainability of urbanization by a coordinated development index for an urbanization-resources-environment complex system: a case study of Jing-Jin-Ji region, China', *Ecological Indicators*, Vol. 96, No. 25, pp.383–391.

Gao, X., Wang, K., Lo, K., Wen, R., Mi, X., Liu, K. and Huang, X. (2021) 'An evaluation of coupling coordination between rural development and water environment in Northwestern China', *Land*, Vol. 10, No. 4, pp.405–409.

Guo, D., Wang, D., Zhong, X., Yang, Y. and Jiang, L. (2021) 'Spatiotemporal changes of land ecological security and its obstacle indicators diagnosis in the Beijing-Tianjin-Hebei Region', *Land*, Vol. 10, No. 7, pp.706–711.

Liu, J., Jin, X., Xu, W., Gu, Z., Yang, X., Ren, J. and Zhou, Y. (2020) 'A new framework of land use efficiency for the coordination among food, economy and ecology in regional development', *Science of The Total Environment*, Vol. 71, No. 15, pp.135–141.

Liu, J., Tian, Y., Huang, K. and Yi, T. (2021) 'Spatial-temporal differentiation of the coupling coordinated development of regional energy-economy-ecology system: a case study of the Yangtze River Economic Belt', *Ecological Indicators*, Vol. 12, No. 4, pp.107–114.

Su, Q. and Jiang, X. (2021) 'Evaluate the economic and environmental efficiency of land use from the perspective of decision-makers' subjective preferences', *Ecological Indicators*, Vol. 12, No. 9, pp.109–116.

Wang, K., Tang, Y., Chen, Y., Shang, L., Ji, X., Yao, M. and Wang, P. (2020) 'The coupling and coordinated development from urban land using benefits and urbanization level: case study from Fujian Province (China)', *International Journal of Environmental Research and Public Health*, Vol. 17, No. 6, pp.564–569.

Wang, X., Dong, Z., Xu, W., Luo, Y., Zhou, T. and Wang, W. (2019) 'Study on spatial and temporal distribution characteristics of coordinated development degree among regional water resources, social economy, and ecological environment systems', *International Journal of Environmental Research and Public Health*, Vol. 16, No. 2, pp.421–428.

Xie, X., Fang, B., Xu, H., He, S. and Li, X. (2021) 'Study on the coordinated relationship between urban land use efficiency and ecosystem health in China', *Land Use Policy*, Vol. 10, No. 2, pp.105–109.

Yang, C., Zeng, W. and Yang, X. (2020) 'Coupling coordination evaluation and sustainable development pattern of geo-ecological environment and urbanization in Chongqing municipality, China', *Sustainable Cities and Society*, Vol. 61, No. 32, pp.102–107.

Yang, Y. and Hu, N. (2019) 'The spatial and temporal evolution of coordinated ecological and socioeconomic development in the provinces along the Silk Road Economic Belt in China', *Sustainable Cities and Society*, Vol. 47, No. 8, pp.104–109.

Zameer, H., Yasmeen, H., Wang, R., Tao, J. and Malik, M.N. (2020) 'An empirical investigation of the coordinated development of natural resources, financial development and ecological efficiency in China', *Resources Policy*, Vol. 65, No. 22, pp.101–108.

Zhao, X., Li, S., Pu, J., Miao, P., Wang, Q. and Tan, K. (2019) 'Optimization of the national land space based on the coordination of urban-agricultural-ecological functions in the Karst areas of Southwest China', *Sustainability*, Vol. 11, No. 3, pp.675–679.

Zhu, C., Lin, Y., Zhang, J., Gan, M., Xu, H., Li, W. and Wang, K. (2021) 'Exploring the relationship between rural transition and agricultural eco-environment using a coupling analysis: a case study of Zhejiang Province, China', *Ecological Indicators*, Vol. 12, No. 7, pp.107–116.