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Coordinated development paths for rural ecological environment protection and housing construction: a comprehensive analysis from the perspective of rural governance

Jia Hao[1] and Hefang Chen[2,*]
[1] School of Sociology, Sanya University, Sanya, Hainan, 572000, China
[2] College of Foreign Languages, Zhongkai University of Agriculture and Engineering, Guangzhou, Guangdong, 510550, China
Corresponding authors: (e-mail: chenhefang@zhku.edu.cn).

Abstract Currently, China's rural development faces a major challenge of coordinated development of ecological environmental protection and housing construction. Under the traditional development mode, housing construction often ignores ecological constraints, leading to resource waste and environmental degradation. During the implementation of rural revitalization strategy, how to realize the benign interaction between ecological protection and housing construction has become a key issue. Based on the perspective of rural governance, this study analyzes the coordinated development path of rural ecological environmental protection and housing construction by using the entropy value method and the coupled coordination degree model. An evaluation system containing 6 specific indicators in 2 dimensions of housing safety and ecological environmental protection is constructed, and spatial correlation analysis is carried out using Global Moran's I and Local Moran's I methods. Taking the countryside of Zhengzhou City as an example, the development level and coupling and coordination relationship between the two systems are calculated from 2014 to 2023. The results show that: the rural ecological environmental protection index grows from 0.224 in 2014 to 0.841 in 2023; the index of high-quality development of housing construction improves from 0.195 to 0.776; the degree of coupling coordination rises from 0.513 to 0.898, with an evolutionary path of on the verge of dysfunction-barely coordinated-primary coordinated-intermediate coordinated-well coordinated; Global Moran' s I are all greater than 0 and pass the significance test, indicating that the spatial positive correlation is significant. The study proposes differentiated development paths to promote agricultural modernization and improve the construction of rural cultural system in mildly dysfunctional areas, and optimize rural governance and strengthen rural ecological construction in areas on the verge of coordination, which provide theoretical guidance and practical reference for the coordinated development of rural ecological environment protection and housing construction.

Index Terms Rural governance, ecological environmental protection, housing construction, coupling coordination degree, spatial relevance, development paths

I. Introduction

In the journey of rural revitalization, ecological governance is a key link that cannot be ignored [1]. Effective rural governance is able to achieve rural ecological protection, thus accelerating the pace of rural revitalization [2]. However, in the process of rural governance, there are many areas where rural ecological environmental protection and housing construction are not coordinated, and in today's society, ecological environmental protection and housing construction have become an important topic of our common concern [3]-[5]. How to achieve the coordinated development of the two is the key to the sustainable development of rural areas, the improvement of farmers' quality of life and the successful implementation of the rural revitalization strategy [6]-[8].

Ecological environment is the foundation of a beautiful countryside, fresh air, clean water, fertile land and rich biodiversity, which are all unique natural resources of the countryside and valuable assets for rural development [9]-[11]. However, for some time in the past, due to the excessive pursuit of economic development, some rural areas have neglected ecological environmental protection, especially housing construction has occupied a large amount of land [12]-[14]. These have invariably caused land erosion, soil pollution and water quality deterioration, irrational mining and logging have destroyed the vegetation of mountains and forests, and the random discharge of industrial wastewater and garbage has made the rural environment dirty and unkempt [15]-[17]. These problems not only affect the ecological balance of the countryside, but also bring a lot of trouble to the production and life of

farmers [18]. Rural housing construction is an important foundation for rural development, but it not only pursues the economic development of the countryside, but also promotes the comprehensive and coordinated development of rural economy, society and environment, so the coordinated development of rural ecological environment protection and housing construction is of great significance for the sustainable development of the countryside [19]-[22].

In the context of the new era, China's rural development has entered a key stage of transformation and upgrading, and the development concept of ecological civilization construction and livelihood improvement is deeply rooted in people's hearts. As an important carrier of ecological environment and the main space for farmers' life, the quality of ecological environment in rural areas is directly related to the quality of life and health of rural residents. At the same time, as the most basic living needs of farmers, the level and quality of housing construction is also an important indicator of the results of rural development. However, in the actual development process, there are often contradictions and conflicts between ecological environmental protection and housing construction, and how to improve the living conditions of farmers under the premise of protecting the ecological environment has become an important issue facing rural development. From the perspective of rural governance, an effective governance mechanism can coordinate the interests of all parties, balance the development needs and environmental constraints, and realize the goal of sustainable development. In recent years, academics have conducted in-depth studies on rural ecological environmental protection and housing construction respectively, but the systematic analysis of the coordinated development mechanism of the two is still insufficient. Especially under the perspective of rural governance, it is of great theoretical value and practical significance to construct a scientific evaluation system to accurately measure the level of coordinated development of the two, identify the spatial distribution characteristics and evolution laws, and propose targeted development paths.

Based on the above background, this study adopts the method of combining quantitative analysis and qualitative analysis, firstly, the entropy value method is used to construct a comprehensive evaluation model of the development level of rural ecological environmental protection and housing construction, and a multi-dimensional index system is established which includes economic cost, housing safety, housing environment, environmental quality, ecological protection, ecological governance, etc. Secondly, the coupling degree model is used to construct a scientific evaluation system to accurately measure the coordinated development level of both. Second, the coupling degree model and the coupling coordination degree model are used to analyze the interaction relationship between the two systems and the level of coordinated development. Again, global and local spatial autocorrelation analysis methods are used to reveal the spatial distribution characteristics and clustering law of the coupled coordination degree. Finally, based on different types of coordinated development, differentiated coordinated development paths are proposed from the perspective of rural governance to provide theoretical support and policy recommendations for promoting the coordinated development of rural ecological environmental protection and housing construction.

II. Model for measuring the level of development of rural ecological environment protection and housing construction

II. A.Evaluation of research methodology

II. A. 1) Principles for the selection of indicators

The selection of the indicator system should be related on a set of quantifiable systems, consisting of factors that are independent of each other in terms of indicators, and the system should basically reflect the state of ecological and economic development. The design of the system should be scientific and objective, and the selection of indicators should be accurate and comprehensive. In general, the selection of the indicator system follows the following principles:

(1) Principle of scientificity. Each indicator chosen should reflect one aspect of land ecology or economic development as much as possible. Scientificity is reflected in the fact that the indicators have clear connotations and the scope and calculation methods are clear. Secondly, the design and determination of the indicators cover all aspects of change as far as possible, i.e., they can systematically and comprehensively portray the situation of ecological security and economic development in the countryside.

(2) Principle of operability. The construction of the indicator system should transform the conceptual or degree level into measurable, calculable and comparable indicators, and quantify them into numerical values that can intuitively understand the current level of rural economic development and land ecology.

(3) Principle of representativeness. Under the circumstance of ensuring that the content of the evaluation system is complete and the objectives are reachable, the selected indicators should be informative. Both can respond to the actual situation of the evaluation object, but also strive to simplify, with corresponding representativeness.

(4) The principle of system comprehensiveness. The selection of any evaluation index system is to guarantee that economic development and land ecological security are compatible and development is sustainable.

II. A. 2) Entropy method evaluation model

Principle of entropy method: the concept of entropy originates from thermodynamics and is a measure of uncertainty of the system condition. Information system is a measure of the level of order, while entropy is a measure of the degree of disorder, the absolute value of the two are equal, but indicate the opposite [23]. Based on this feature, the entropy value method is used to find the message entropy of different data, the smaller the message entropy is, the smaller the degree of disorder of the information system is, the larger the actual utility value of its information is, and the higher the weight of the indicator is. The entropy value method has the advantages of authenticity, rationality and scientificity, and the entropy value method model can be utilized to make an evaluation of rural ecological environmental protection and housing construction development. There are m indicators in n years, p_i is the standardized value of the i nd indicator in the j rd criterion layer; A_{ij} is the percentage of the i th indicator in the j th indicator; e_j is the entropy value of the j th indicator; w_j is the j th weight. The calculations are as follows:

In the first step, the raw data are polarized to avoid the effect of the scale; the values are shifted to avoid logarithmic meaninglessness when solving for entropy.

Positive indicators are standardized:

$$P_{ij} = \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})} + 0.01 \tag{1}$$

Negative indicators are standardized:

$$P_{ij} = \frac{\max(X_{ij}) - X_{ij}}{\max(X_{ij}) - \min(X_{ij})} + 0.01 \tag{2}$$

In the second step, the entropy value is calculated;

$$\begin{aligned} e_j &= -\frac{1}{\ln m} * \sum_{i=1}^{m} A_{ij} \ln A_{ij}, Ej \in (0,1) \\ A_{ij} &= P_{ij} / \sum_{i=1}^{n} P_{ij} \end{aligned} \tag{3}$$

Step 3, weighting calculation;

$$W_j = \frac{1 - e_j}{\sum_{i=1}^{m} (1 - e_j)} \tag{4}$$

The fourth step is the calculation of the level of land ecological security and economic development;

$$U_1 = \sum_{i=1}^{m} W_j P_{ij} \tag{5}$$

$$U_2 = \sum_{i=1}^{m} W_j P_{ij} \tag{6}$$

where: U_1 is the assessed value of ecological protection of the countryside, and U_2 is the level of development of housing construction.

II. B.Indicator system construction and data sources

Based on the input-output linkage of housing construction and PSR framework, referring to the construction of housing construction and ecological protection indicator system by existing scholars, combining with the special characteristics of housing construction development and outstanding ecological environment problems, and based on the principles of scientific, systematic and data availability of the indicator selection, we will construct the evaluation index system of ecological protection and housing construction development, which contains 6 specific

indicators, respectively from the dimensions of housing safety and ecological environmental protection. The evaluation index system of ecological protection and housing construction development is shown in Table 1.

Table 1: Coupling coordination development evaluation index system

Target layer	Criterion layer	Index layer
Housing construction	Economic cost	Land cost
		Material cost
		Planning fee
		infrastructure
	Housing safety	Structural safety
		Fire safety
		Site safety
	Housing environment	Green distribution
		House lighting
Ecological protection	Environmental quality	Water quality
		Air quality
		Soil quality
	Ecological protection	Forest resource protection
		Soil and water conservation
		Biodiversity protection
	Ecological governance	Agricultural pollution management
		Environmental improvement of rural habitat

II. C.Modeling

II. C. 1) Coupling model

The original coupling degree model is given by:

$$C_n = n\left[\frac{u_1 u_2 ... u_n}{\Pi(u_i + u_j)}\right]^{\frac{1}{n}} \tag{7}$$

where C_n denotes the degree of coupling, n denotes the number of subsystems, and u denotes the integrated development index, and when n=2, the coupling degree model is calculated as:

$$C_2 = 2\left[\frac{U_1 U_2}{(U_1 + U_2)^2}\right]^{\frac{1}{2}} \tag{8}$$

Referring to the existing studies, this paper grades the coupling degree with nodes of 0.3, 0.5 and 0.8, and divides it into the stage of unrelated and disordered development of rural ecosystems and ecological environment systems, the stage of low-level coupling, the stage of fly-down, the stage of friction, and the stage of high-level coupling.

II. C. 2) Coupling harmonization model

On the basis of the coupling degree model [24], in order to more accurately analyze the interaction and coordinated change relationship between the two systems and the elements within the system, this paper introduces the coupling coordination degree model, which is calculated by the formula:

$$D = \sqrt{C * T}, T = \alpha U_1 + \beta U_2 \tag{9}$$

where D indicates the degree of coupling coordination, C indicates the degree of coupling, and T indicates the comprehensive evaluation index, which is used to respond to the overall situation of the two systems, where U_1 and U_2 are distributed to indicate the comprehensive development index of sub-system 1 and sub-system 2, and in this paper, it refers to the comprehensive development index of the rural ecological environment system and the comprehensive development index of the housing construction α, β is a coefficient to be determined, which is used to measure the importance of the rural ecological environment and the eco-environmental degree, in general $\alpha + \beta = 1$, this paper considers that the two systems of rural ecological environment and ecological development

have equally important roles in the economic and social development of the countryside, and therefore set $\alpha = \beta = 0.5$, i.e:

$$D = \sqrt{C * T}, T = 0.5U_1 + 0.5U_2 \tag{10}$$

In general, the coupling coordination degree $D \in (0,1)$.

II. C. 3) Relative development models

In order to compare the rural ecological environment and housing construction in Zhengzhou City more intuitively, this paper introduces a relative development model that can respond to the relative degree of development between the rural ecological environment and housing construction in Zhengzhou City from 2014 to 2023, and the calculation formula is as follows:

$$\theta = \frac{U_1}{U_2} \tag{11}$$

Among them, θ represents the relative development degree, U_1 and U_2 distributions represent the comprehensive development index of subsystem 1 and subsystem 2, and in this paper, it refers to the comprehensive development index of rural ecological environment system and the comprehensive development index of housing construction. In this paper, the relative development type of rural ecological environment and ecological environment is divided into three types: when the relative development degree is less than 0.9, it belongs to the lagging type of rural ecological environment; when the relative development degree is between [0.9, 1.1], it belongs to the synchronous development type of the two: when the relative development degree is more than 1. 1, it belongs to the lagging type of ecological environment.

III. Results and analysis

III. A. Measurement of rural ecological environment protection and housing construction development

III. A. 1) Measurement of ecological protection in the countryside

Calculated to obtain a rural ecological environmental protection index in Zhengzhou City, while measuring the housing construction and environmental governance index as shown in Table 2. From the table, it can be seen that the overall trend of the rural ecological environmental protection index in 2014-2023 is increasing, from 0.224 in 2014 to 0.841 in 2023.In terms of sub-dimensions, the housing construction index and the environmental governance index are both on an upward trend. The housing construction index reflects the economic cost of housing construction and development, and the indicators in this system are all negative, and the larger the index, the greater the economic pressure on housing construction and development. The environmental governance index reflects the effectiveness of ecological environmental protection, the index is lower in 2014, 2015, 2016, the three years of industrial emissions, wastewater emissions, good air quality days are fewer. After 2015, the environmental governance index shows a growing trend. It shows that the countryside in the economic development, put the construction of ecological civilization in a prominent position, environmental governance has greater effectiveness, the comparison is: housing construction index > environmental governance index, and the environmental governance index is low, which shows that the future of ecological governance in the countryside of Zhengzhou City still has a long way to go.

Table 2: Annual environmental index

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Housing construction	0.124	0.213	0.138	0.233	0.295	0.334	0.414	0.482	0.532	0.557
Environmental governance index	0.103	0.061	0,067	0.341	0.163	0.163	0.196	0.263	0.315	0.336
Environmental protection index	0.224	0.268	0.202	0.472	0.455	0.496	0.605	0.739	0.852	0.841

III. A. 2) Measurement of housing construction development

The index of high-quality development of rural ecological environment and housing construction in Zhengzhou City (H1) was calculated, while the economic cost index (A1), housing safety index (B1), housing environment index (C1), environmental quality index (S1), and ecological resource protection index (S2) were measured, and the results are shown in Table 3.

From the table, it can be seen that the high quality development index of rural ecological environment and housing construction in Zhengzhou City shows an upward trend from 2014 to 2023, from 0.195 in 2014 to 0.776 in 2023, an increase of 0.581. The high quality development index grows rapidly. Comparison of the sub-dimension

development index is: ecological resources protection index (0.155) > housing safety index (0.147) > economic cost index (0.124) > environmental quality index (0.106) > housing environment index (0.059).The economic cost index shows a fluctuating upward trend from 2014 to 2023.

Table 3: Annual high quality development index

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Average
A1	0.023	0.027	0.038	0.049	0.055	0.128	0.147	0.147	0.235	0.287	0.124
B1	0.022	0.025	0.045	0.085	0.107	0.141	0.176	0.238	0.251	0.257	0.147
C1	0.043	0.051	0.068	0.073	0.083	0.079	0.049	0.061	0.047	0.022	0.059
S1	0.055	0.063	0.055	0.096	0.075	0.056	0.015	0.461	0.067	0.063	0.106
S2	0.067	0.093	0.148	0.135	0.152	0.107	0.212	0.213	0.175	0.157	0.155
H1	0.195	0.251	0.342	0.426	0.473	0.499	0.592	0.683	0.762	0.776	0.534

III. B. Coupling harmonization

The coupling degree, coupling coordination degree and relative development degree of rural ecological protection development and housing construction in Zhengzhou City are calculated, and the results are shown in Table 4. From the table, it can be seen that from 2014 to 2023, the coupling degree of rural ecological protection and housing construction development in Zhengzhou City is in the range of 0.929 to 0.998, which is in the stage of high coupling, indicating that there is a high degree of interaction and constraints between rural ecological protection and housing construction development in Zhengzhou City, and there is a good interactive relationship between the 2 systems. The coupling coordination degree shows a steady upward trend, from 0.513 in 2014 to 0.898 in 2024, with an evolutionary path of on the verge of dysfunction-barely coordinated-primary coordination-intermediate coordination-good coordination. Specifically, 2014 belongs to the development on the verge of dislocation, with a relative development degree of 1.801, and the development is characterized by lagging high-quality development, indicating that the level of high-quality development is low, and the ecological environment does not play a positive role in high-quality development. The coupled coordination degree in 2014-2016 is at [0.513, 0.543], which belongs to the development of barely coordinated development, with a relative development degree is less than 0.8, the development is characterized by ecological environment lagging behind, indicating that the rigid constraints of ecological environment and housing construction development are significant. The coupling coordination degree in 2017-2023 is at [0.679, 0.898], the evolution path of the coupling coordination degree is primary coordination-intermediate coordination-good coordination, the relative development degree is at [0.8, 1.2], and the development is characterized by the development of ecological environment and housing construction is almost synchronized, and the system is in an optimized state. Zhengzhou City, as the capital city of Henan Province, has superior geographic advantages and human resource advantages, fully seizes the strategic opportunity of the national central city, actively implements the new development concept, and comprehensively promotes the high-quality development of the economy, taking ecological environmental protection as the starting point.

Table 4: Coupling result

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Coupling degree	0.997	0.991	0.929	0.996	0.998	0.998	0.997	0.997	0.998	0.998
Coupling coordination	0.513	0.545	0.543	0.679	0.683	0.701	0.667	0.843	0.889	0.898
Relative development	1.801	0.786	0.473	1.006	0.911	0.974	1.031	1.067	1.112	1.091

III. C. Analysis of the spatial correlation of the coupling coordination degree

III. C. 1) Global autocorrelation analysis

The results of Global Moran's I by the degree of coordination of the coupling of rural ecological conservation development and housing construction high quality development in Zhengzhou City are shown in Table 5. During the study period, Global Moran's I is greater than 0, P-value is less than 0.005, and Z-value is greater than 1.97, which all pass the significance test. It indicates that the spatial positive correlation of the coupling coordination degree of rural ecological protection development and high-quality development of housing construction in Zhengzhou City is significant, and the coupling coordination degree shows a clustered distribution.

Global Moran's I of coupled coordination degree of rural ecological protection and development and housing construction high-quality development in Zhengzhou City from 2014 to 2023 shows an overall trend of first rise and

then fall; the spatial aggregation state in 2019 reaches a 10-year peak, indicating that the cities and municipalities with similar levels of coupled coordination degree are in a centralized spatial distribution state; the global Moran's I index after 2016 overall shows a decreasing trend, indicating that the coupling coordination degree of the same type of regional aggregation weakened.

Table 5: Coupling coordination degree global Moran's I index and test

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Moran's I	0.471	0.475	0.499	0.491	0.511	0.525	0.517	0.501	0.483	0.483
Z	5.651	5.675	5.957	5.822	6.121	6.301	6.203	4.002	5.751	5.638
P	0.001	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.001	0.000

III. C. 2) Local spatial autocorrelation analysis

Global Moran's I indicates the existence of agglomeration or outlier phenomenon in the study area, which cannot reflect the local spatial aggregation characteristics, and Local Moran's I can reflect the aggregation status of the local area through its distribution scatterplot and LISA plot, and Moran's scatterplot is shown in Fig. 1.

As can be seen from the figure, the local Moran's I index of the coupling and coordination of rural ecological protection and development and high-quality development of housing construction in 2014 is distributed in four quadrants, with more distribution in the first and third quadrants, which belongs to the “high-high” and “low-low” types, with a strong local spatial positive correlation. The first and third quadrants have more distributions, which belong to the same type of distribution “high-high” and “low-low”, with strong local spatial positive correlation; the distribution in the second and fourth quadrants, i.e., “low-high” and “high-low” types of regions, is less, which indicates that the development of neighboring regions is more synchronized, and the influence on each other is larger. The local spatial autocorrelation indices of the coupling coordination degree in 2019 and 2023 are distributed in quadrants 1 and 3 more than in quadrants 2 and 4, and there is not much difference in the distribution of scatters, and the number of scatters in the high-value agglomeration area and the low-value agglomeration area is more or less the same, which is a relatively stable spatial autocorrelation.

IV. Development path analysis from the perspective of rural governance

IV. A. Coordinated paths for rural development in mildly dislocated areas

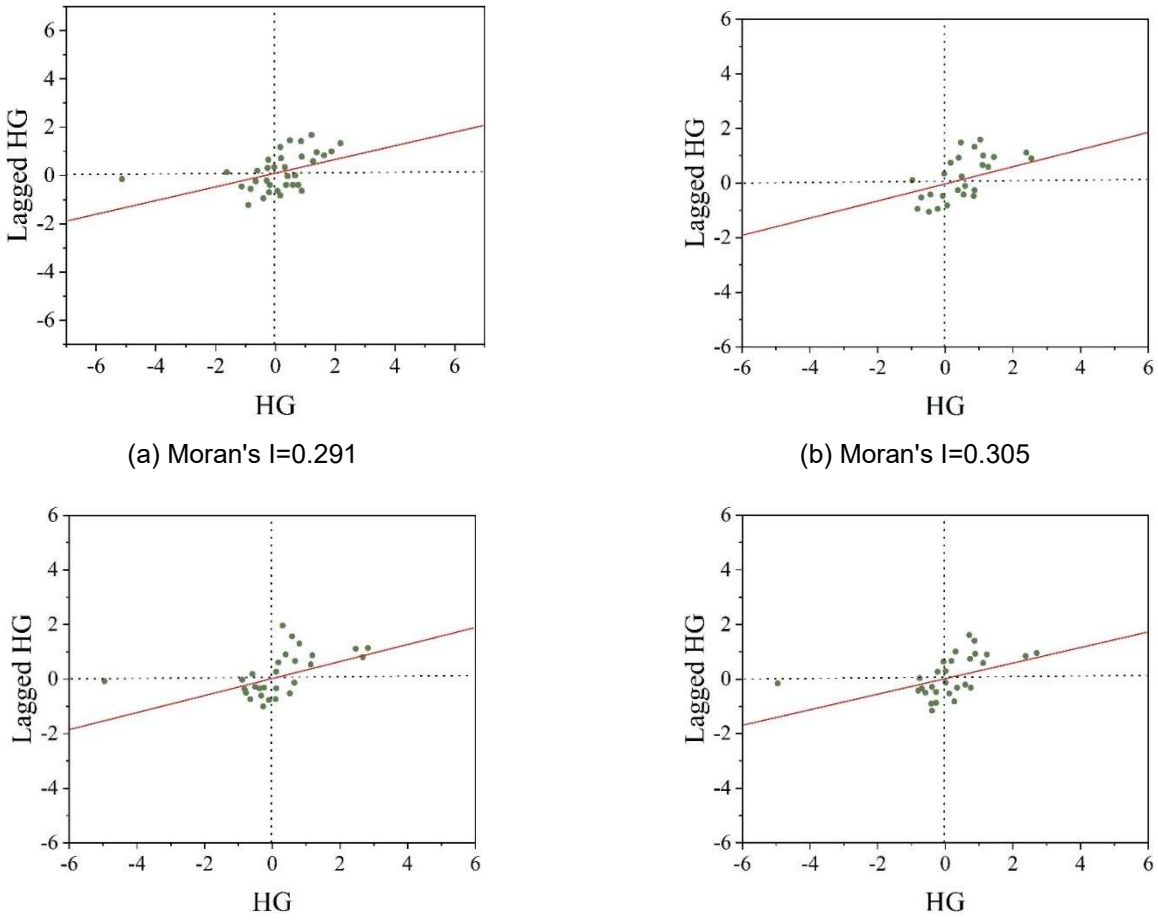
IV. A. 1) Promoting the modernization of agriculture

At present, the countryside in most areas of Henan Province is still in a state of mild dislocation, and the task of rural development is still relatively burdensome. It is particularly important and urgent to promote the modernization of rural agriculture in the cities and villages of Henan Province, especially Hebi, Jiyuan, Jiaozuo, Pingdingshan, Luohe, Puyang, Xinyang, Zhoukou and other cities, which are greatly affected by the economic subsystem. To promote industrial prosperity in rural areas, to promote the rural areas of dislocation to the coordinated state of development, to promote the development of agricultural modernization will be a good breakthrough. On the one hand, scientific and technological innovation, the introduction of advanced technology, as the core driving force to promote the process of agricultural modernization. Henan Province, as a large agricultural province, China's breadbasket, has rich experience in planting, but the lack of scientific and technological inputs, resulting in an imbalance between the quality and quantity of agriculture, so it is necessary to carry out scientific and technological innovation, accelerate the promotion of scientific and technological research around the use of farmland, disease prevention and control, agricultural product safety and other aspects. On the other hand, it is necessary to establish brand awareness of agricultural products and carry out brand building.

IV. A. 2) Improvement of the rural cultural system

Most of the rural areas in Henan Province are affected by the social system in addition to the economic system when moving towards a coordinated state, therefore, in addition to promoting the development of agricultural modernization and broadening the path of farmers' income channels, we should also improve the construction of the rural cultural system. Rural culture in the countryside has a long history and a wide audience, the development of the countryside also has an important role, improve the rural cultural system can be carried out from the following two aspects: first, improve the construction of the rural cultural system, the rural culture of living protection. Excellent folk culture is an important part of rural culture, excellent folk culture can not only show the cultural characteristics of the countryside and villagers can produce incentives, it should be true to show in front of the masses, while not forgetting the excellent folk culture in the inheritance of development, in the development of inheritance, to achieve the living state of protection. Secondly, build the rural public culture system. Rural public culture in Henan is yet to be enriched in terms of both content and form. To realize the comprehensive revitalization of the countryside, it is

very important to construct a rural public culture with a strong sense of cultural identity, and at the same time improve the cultural system with a high degree of cultural confidence.



(a) Moran's I=0.291

(b) Moran's I=0.305

(c) Moran's I=0.308

(d) Moran's I=0.290

Figure 1: The local Moran's I index scatter point distribution in 2014-2023

IV. B. Coordinated Paths for Rural Development in Areas on the Verge of Harmonization

IV. B. 1) Optimizing rural governance

As the Luoyang, Nanyang, Zhengzhou and Shangqiu regions of Henan Province make progress towards a state of coordination, they should optimize rural governance in addition to promoting path choices for the integrated development of primary, secondary and tertiary industries in the countryside. The revitalization of the countryside should focus not only on agriculture and farmers, but also on the countryside itself and on rural construction and governance. In the process of rural development, there are urgent problems in governance, should improve the level of rural organization, strengthen rural governance.

IV. B. 2) Strengthening rural ecology

The development of rural areas on the verge of harmonization in Henan Province is not only affected by economic and social systems, but also by environmental systems. For the development path of the rural environment in the four cities of Luoyang, Nanyang, Zhengzhou and Shangqiu, the rural environment should be built around the governance of ecological problems. First, it is necessary to improve the level of rural ecological governance, realize the neatness of the rural environment, improve the ability to deal with ecological garbage by establishing rural garbage transfer stations, and at the same time, deal with sewage in the townships to create a livable environment in the countryside. Secondly, for the ecological environment has been damaged in the countryside, funds should be invested to repair the rural ecology, improve the rural environmental protection system, and at the same time, a

number of ecological demonstration villages can be established to form a good demonstration effect on other rural areas. Thirdly, the rural environment needs not only a relevant system but also the ability of self-monitoring, improving the relevant laws and regulations, and implementing the implementation of policies in the construction of the environment, so as to put the tasks into practice.

V. Conclusion

Through the construction of the evaluation model of coordinated development of rural ecological environmental protection and housing construction, it is found that the development level of the two systems continues to improve and the role of mutual promotion is becoming more and more significant. Comparison of the development indexes by dimension shows that the ecological resource protection index reaches 0.155, the housing safety index is 0.147, the economic cost index is 0.124, the environmental quality index is 0.106, and the housing environment index is 0.059, indicating that ecological resource protection and housing safety are the main driving forces for coordinated development. The coupling analysis showed that the coupling degree was maintained at a high level of 0.929 to 0.998 during the study period, reflecting a strong interaction relationship between the two systems. The results of spatial analysis show that Global Moran's I index reached a peak of 0.525 in 2019, and then showed a decreasing trend, indicating that the spatial agglomeration of the same type of region has weakened. The relative development degree analysis reveals that the relative development degree stabilizes in the range of 0.8 to 1.2 after 2017, and the development characteristics shift to a state of almost simultaneous development of ecological environment and housing construction. Based on the characteristics of different coordination states, mildly dysfunctional areas need to achieve a breakthrough by promoting the development of agricultural modernization and improving the construction of the rural cultural system, while areas on the verge of coordination should focus on optimizing the rural governance mechanism and strengthening the investment in ecological construction. This study provides a scientific basis for the choice of paths for rural areas at different stages of development, and helps to realize the benign interaction and sustainable development of rural ecological environment protection and housing construction.

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