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Path of Integrated Development of Rural Ecological Agriculture and Leisure Agriculture in the Process of Rural Revitalization

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SUMMARY: *The effective integration of rural eco-agriculture and leisure agriculture is an important realization form of rural revitalization strategy. This paper determines the development of ecological agriculture and leisure agriculture coupling measurement dimensions, in which the ecological agriculture level contains two dimensions of agricultural performance and agricultural input, and the leisure agriculture level has five dimensions of infrastructure, economic benefits, tourism performance, tourism input and social benefits, and the joint entropy and gray correlation methods are used for the calculation of the weight of their indicators. Based on the development content and characteristics of rural ecological agriculture and leisure agriculture, we build a framework for determining the coupling degree of the two with reference to the capacity coupling model and calculation method of physics. Under this framework, the comprehensive development level of the ecological agriculture system of the research sample in ten years is 0.253~0.859, and the comprehensive development level of the leisure agriculture system is 0.214~0.892, and the coupling degree of the two is 0.154~0.707, which reaches an intermediate level of coordination after ten years of development. Accordingly, this paper suggests that at the level of leisure agriculture, based on modern technological tools to strengthen publicity, attract tourists, and promote the growth of economic scale; and at the level of ecological agriculture in the form of economic support for the innovation of its mode of production and the maintenance of the production structure. The integration of leisure agriculture and ecological agriculture forms a high-quality sustainable development path to help rural revitalization.*

KEYWORDS: *rural revitalization; coupled development; ecological agriculture; leisure agriculture*

1 Introduction

With the proposal of China's rural revitalization, the transformation and upgrading of agricultural development has been accelerated. Rural revitalization refers to the development strategy of promoting the sustained and healthy development of rural economy and improving the living standard and happiness of farmers through rural industrial restructuring, rural infrastructure construction and rural environment improvement on the basis of comprehensive utilization of urban and rural resources [1-4]. Rural revitalization is not only growing village collective income and improving infrastructure, but also the process of letting the fields return to nature and letting the land grow new vitality. In this process, the integrated development of rural ecological agriculture and leisure agriculture assumes a key role.

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Eco-agriculture emphasizes ecological function as the bottom line, and improves soil health, reduces chemical inputs, and optimizes input-output ratios through integrated management such as crop rotation, intercropping, cover crops, biological prevention and control, and ecological fertilization [5-7]. The core lies in combining the self-repairing ability of natural ecology with the production skills of farmers, resulting in durable land, improved crop resistance, and steadily increasing economic income [8, 9]. This concept requires the government, enterprises, and farmers to form a consensus: ecology and economy go hand in hand, and short-term gains go hand in hand with long-term sustainability. Leisure agriculture is the use of idyllic landscapes, natural ecological planning and development, play the leisure function of the countryside, to meet the visitors to eat, live, the situation, combined with agricultural products, food and living conditions, after the scientific line, travel, shopping, entertainment and other needs, both to benefit the farmers, but also to meet the urban residents of the rural experience of a new form of agricultural industry [10-13]. Through the integration of ecological agriculture and leisure agriculture such as Nongjiale, agricultural gardens, agricultural picking, ancient villages, lodging and other development paths to become a new form of tourism, can play a role in promoting the development of the rural economy, but also pull the new situation of urban tourism [14-16].

With full reference to the existing research and actual situation, this paper selects two evaluation levels of eco-agriculture and five evaluation levels of leisure agriculture, and jointly establishes a development coupling measurement system containing 31 secondary indicators. Comprehensive entropy value method and gray correlation method are used as the weighting method of evaluation indexes to establish the coupling measurement framework. Select research samples and collect research data to determine the development evaluation index weights, and summarize and analyze the coupling and coordination degree of eco-agriculture and leisure agriculture based on the sample data. Combined with the sample coupling and coordination development, the integration development path of rural ecological agriculture and leisure agriculture is proposed.

2 Coupled measurement system of rural ecological agriculture and leisure agriculture

Based on the qualitative research and analysis of the eco-agriculture system, this paper has screened out the indicators of the main influencing factors of eco-agriculture with high frequency, and identified 2 first-level indicator levels of agricultural performance and agricultural inputs, with a total of 11 second-level indicators. On the indicators of the main influencing factors of leisure agriculture, 5 levels of primary indicators were identified, including infrastructure, economic benefits, tourism performance, tourism inputs and social benefits, with a total of 20 secondary indicators. The specific coupled measurement indicators of ecological and leisure agriculture systems are shown in Table 1.

Table 1: Evaluation system for ecological agriculture and leisure agriculture indicators

Target layer	Criterion layer	Indicator layer
(EA) Ecological Agriculture	(EA1) Agricultural Performance	(EA11) Value Added of Primary Industry
		(EA12) Proportion of Primary Industry in GDP
		(EA13) Grain Production
		(EA14) Gross output value of agriculture,forestry,animal husbandry and fishery
		(EA15) Disposable Income of Rural Residents
	(EA2) Agricultural Investment	(EA21) Agricultural Intermediate Consumption
		(EA22) Arable Land Area
		(EA23) Total Power of Agricultural Machinery
		(EA24) Agricultural Fertilizer Application Rate
		(EA25) Agricultural Fixed Asset Investment Amount
		(EA26) Number of Employees in Primary Industry
(LA) Leisure Agriculture	(LA1) Infrastructure Construction	(LA11) Farmhouse Leisure Tourism Characteristic Village
		(LA12) Provincial Modern Agricultural Park
		(LA13) National Demonstration County
		(LA14) Beautiful Leisure Village
	(LA2) Economic Benefits	(LA21) Operating Revenue
		(LA22) Total Profit
		(LA23) Leisure Agriculture Labor Productivity
		(LA24) Proportion of Net Income from Third Industry by Rural Residents
	(LA3) Tourism Performance	(LA31) Domestic Tourism Revenue
		(LA32) International Tourism Foreign Exchange Income
		(LA33) Tourism Contribution Rate to GDP
		(LA34) Total Tourism Revenue from Grade A Scenic Areas
	(LA4) Tourism Investment	(LA41) Number of Star-rated Hotels
		(LA42) Number of Employees in Star-rated Hotels
		(LA43) Total number of travel agencies
		(LA44) Number of Travel Agency Staff
		(LA45) Total Number of Grade A Tourist Attraction Areas
	(LA5) Social Benefits	(LA51) Number of business entities
		(LA52) Number of Employees
		(LA53) Number of farmers employed

3 Methods for analyzing the coupled development of ecological agriculture and leisure agriculture

3.1 Empowerment of development evaluation indicators

3.1.1 Entropy method

In order to deeply explore the coupling research, this study draws on relevant previous studies to construct a coupling model of ecological agriculture and leisure agriculture. The entropy value method is used to calculate the weights of the evaluation indicators, and in order to have an interactive effect between the standardized scale and the different measurement levels of

the indicators, the indicator system should be disaggregated into positive and negative indicators before the dimensionless processing. The efficacy function of each indicator of ecological agriculture and leisure agriculture on the system can then be expressed as equation (1):

$$u_{ij}=\begin{cases}\dfrac{X_{ij}-X_{\min}}{X_{\max}-X_{\min}} & \text{Positive indicators}\\ \dfrac{X_{\max}-X_{ij}}{X_{\max}-X_{\min}} & \text{Negative indicators}\end{cases} \quad \text{Which } u_{ij}\in(0,1) \tag{1}$$

In equation (1), X_{ij} is the value of the j th indicator of its sample i, where the maximum and minimum values are represented by $X_{\max}$ and $X_{\min}$, respectively. The value of u_{ij} is the function of each indicator on the system, and its value is between 0 and 1. When u_{ij} is closer to 0, it means the more dissatisfied, and when u_{ij} is closer to 1, it means the more satisfied.

The weights of the indicators are calculated using the entropy assignment method to obtain relatively objective data. Firstly, let X_{ij} denote the value of the sample, i denotes the sample $(i=1,2,3,\cdots,n)$; j denotes the indicator $(j=1,2,3,\cdots,n)$.

(1) Indicator "positive value + non-negative" processing as formula (2):

$$u'_{ij}=\frac{X_{ij}-X_{\min}}{X_{\max}-X_{\min}}+0.01 \tag{2}$$

(2) Specific gravity conversion is done for the indicator as in equation (3):

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

(3) Calculate the entropy value of j indicators as in equation (4):

$$e_j=-\frac{1}{\ln n}\sum_{i=1}^{n}p_{ij}\times\ln(p_{ij}) \tag{4}$$

where, $0\le e_j\le 1$

(4) Calculate the degree of variation of j indicators as in equation (5):

$$g_j=1-e_j \tag{5}$$

where e_j indicates the entropy value of the j th indicator, p_{ij} indicates the proportion of the j th indicator of the i th sample to the overall proportion of the indicator, n is the number of samples, and g_j indicates the coefficient of variation of the j th indicator.

(5) Calculate the weight of the indicator as in equation (6):

$$W_j = \frac{g_j}{\sum_{j=1}^{n} g_j},\ j = 1, 2, \cdots, n \tag{6}$$

In the above equation (6), W_j is the weight of the indicator, and the weight of each indicator is obtained by using the entropy value assignment method.

(6) Calculate the comprehensive evaluation value

Based on the weights of the indicators obtained from the calculation and the standardized value, the comprehensive evaluation value of the evaluated object is obtained. Since ecological agriculture and leisure agriculture are in two independent and different systems, interacting with each other and influencing the sub-systems, the contribution of the indicators to the respective sub-systems can be realized through the integration method, and the indicators are calculated using the linear weighting method. Therefore, the comprehensive evaluation function of ecological agriculture and leisure agriculture can be expressed as equation (7):

$$U_{i=1,2} = \sum_{j=1}^{n} W_j u_{ij},\ \sum_{j=1}^{n} W_j = 1 \tag{7}$$

In equation (7), the comprehensive evaluation function U_1 and U_2 denote ecological agriculture and leisure agriculture respectively, where W_j denotes the weight and u_{ij} denotes the standardized value, and the higher the value, the higher the comprehensive index of ecological agriculture and leisure agriculture, which means that its development status is also better, and vice versa, the worse.

3.1.2 Gray correlation method

If the changes of two factors in the development process of ecological agriculture and leisure agriculture system show trend consistency, the higher the degree of correlation between the two factors is considered to be; on the contrary, it is lower. The coupling of ecological agriculture and leisure agriculture is a joint effect of multiple factors, in the study of the coupling process to select the factors that have a valuable part, and then in the data processing, to produce results with regularity. In this paper, we use the formula of gray coefficient $\xi_{ik}(t)$ and correlation degree R_{ik} to calculate the gray correlation between ecological agriculture and leisure agriculture indicators. The steps are as follows:

(1) In this paper, we set the sequence $X_i =$ ecological agriculture, and the sequence $Y_k =$ leisure agriculture, and select the ecological agriculture sequence as the reference series, and take the leisure agriculture sequence as the comparison series.

(2) Due to the different magnitudes and orders of magnitude of the original data, the data need to be dimensionless, and the calculation uses the initialization method to deal with the data.

(3) Gray correlation coefficient calculation is carried out using formula (8):

$$\xi_{ik}(t) = \frac{\min\limits_{i}\min\limits_{k}\left|\bar{X}_i(t) - \bar{Y}_k(t)\right| + \rho\max\limits_{i}\max\limits_{k}\left|\bar{X}_i(t) - \bar{Y}_k(t)\right|}{\left|\bar{X}_i(t) - \bar{Y}_k(t)\right| + \rho\max\limits_{i}\max\limits_{k}\left|\bar{X}_i(t) - \bar{Y}_k(t)\right|} \tag{8}$$

The discriminant coefficient ρ reflects the significance of the difference between the correlation coefficients, which generally takes the value of 0-1, and in general takes the value of 0.5. $\xi_{ik}(t)$ is the correlation coefficient between the i th indicator of eco-agriculture and the k th indicator of leisure agriculture at the k th point of time; $\overline{X}_i$ and $\overline{Y}_k$ are the normalized values of each indicator of eco-agriculture and leisure agriculture at the t th moment, respectively; $\min\limits_{i}\min\limits_{k}\left|\overline{X}_i(t)-\overline{Y}_k(t)\right|$ is the minimum absolute difference; $\max\limits_{i}\max\limits_{k}\left|\overline{X}_i(t)-\overline{Y}_k(t)\right|$ is the maximum absolute difference.

(4) Correlation calculation using equation (9):

$$R_{ik}=\frac{1}{n}\sum_{i,k=1}^{n}\xi_{ik}(t) \tag{9}$$

where $n=1,2,3,\cdots,n$. The value of R_{ik} is taken within $(0,1)$. The larger the value, the higher the correlation and the stronger the coupling.

3.2 Establishment of the coupling determination framework

Coupling degree is to reflect the system from disorder to order, the degree of influence between the elements within the system. The determination of the coupling degree of ecological agriculture and leisure agriculture studied in this paper is not a simple measurement of the elements of the two systems, but to find out the factors affecting the coupling relationship between the two in the process of determination, on the one hand, ecological agriculture provides the required resources for leisure agriculture, on the other hand, leisure agriculture expands the space for the development of ecological agriculture, and there is a relationship between the two in the process of development that is mutually reinforcing and mutually constraining.

3.2.1 Coupling determination function

In this paper, on the basis of previous research, we construct the coupling evaluation framework of the two, and measure and analyze the coupling relationship between the two, and judge the degree of mutual influence between the two and the degree of their coordinated development. In this paper, through the understanding of the meaning of capacity coupling and the capacity coupling degree model in physics, and extending and expanding it, the coupling degree model of the interaction between multiple systems can be established as equation (10):

$$C_n=\left[\frac{U_1\times U_2\times\cdots\times U_n}{\prod\left(U_i+U_j\right)}\right]^{\frac{1}{n}} \tag{10}$$

where $U_i\left(i=1,2,3,\cdots,m\right)$; $U_j\left(j=1,2,3,\cdots,n\right)$, denotes the system.

When there are only two systems, the capacity coupling degree function can be obtained as equation (11):

$$C_2 = \left[\frac{U_1 \times U_2}{\prod (U_1 + U_2)} \right]^{\frac{1}{2}} \tag{11}$$

Since this paper considers ecological agriculture and leisure agriculture as two systems and denotes ecological agriculture system and leisure agriculture system by EA and LA, respectively, the physical capacity coupling degree model was extended to establish the ecological agriculture and leisure agriculture coupling capacity model as equation (12):

$$C = \left[\frac{EA^0 \times LA^0}{\prod \left(EA^0 + LA^0 \right)} \right]^{\frac{1}{2}} \tag{12}$$

where EA^0 represents the comprehensive development level evaluation value of the ecological agricultural system, and LA^0 represents the comprehensive development level evaluation value of the leisure agricultural system, then the comprehensive evaluation functions of the ecological agricultural evaluation system and the leisure agricultural evaluation system are established respectively, i.e., there are Eqs. (13)-(14):

$$EA^0 = \sum_{i=1}^{m} a_i \times w_{ti} \tag{13}$$

$$LA^0 = \sum_{j=1}^{n} b_j \times q_{tj} \tag{14}$$

Here, $\sum a_i = 1, \sum b_j = 1$. a_i represents the weight of the ith indicator in the ecological agriculture system, and b_j represents the weight of the jth indicator in the leisure agriculture system. w_{ti} represents the dimensionless value of the ith indicator in the tth year of the ecological agriculture system, and q_{tj} represents the dimensionless value of the jth indicator in the tth year of the leisure agriculture system. m is the number of indicators in the ecological agriculture system, and n is the number of indicators in the leisure agriculture system.

From equation (12), C indicates the coupling degree between ecological agriculture and leisure agriculture, and the coupling degree $C \in [0,1]$. The larger the value of C, the better the coupling between ecological agriculture and leisure agriculture, and vice versa, the worse the coupling. When $C = 0$, there is no coupling between the two systems, indicating that there is no influence and no role between the two; when $C = 1$, the coupling level is the highest, and the two systems are fully coupled, indicating that the two interact with each other, and the two coupling degree stage division standards are as follows:

(1) When the coupling degree is located in the interval of 0.00, it is in the stage of "irrelevant" coupling, and the system shows disordered development.

(2) The coupling degree is located in the (0.00,0.30) interval, in the "low level" coupling stage, the system began to appear between the lower level of the coupling phenomenon.

(3) When the coupling degree is in the range of (0.30,0.50), it is in the stage of "antagonistic" coupling, and the systems start to influence each other and realize the exchange between elements.

(4) The coupling degree is located in the interval of (0.50,0.80), in the coupling stage of "friction", the system is in the stable coupling, benign coupling state.

(5) The coupling degree is located in the (0.80,1.00] interval, in the "high level" of the coupling stage, complete coupling between the system, coordinated and orderly development.

3.2.2 Coupling coordination determination function

Coupling degree, as a kind of quantitative index to measure the coupling relationship between systems, it can well measure the coupling relationship between ecological agriculture and leisure agriculture. However, due to the inherent limitations of the coupling degree measurement itself, it cannot reflect the relationship between the coupling coordination degree. Eco-agriculture and leisure agriculture belong to different systems, and their respective development levels differ greatly, and relying solely on the coupling degree function model to analyze and judge the degree of coordinated development between the two may make the results inconsistent with the actual situation.

In the actual measurement, there may be ecological agriculture system comprehensive development level and leisure agriculture system comprehensive development level are low or high phenomenon, there may be coupling degree are higher or lower than the phenomenon of the two comprehensive development level. In order to avoid this inconsistency, so as to more truly reflect the coupled and coordinated development of the relationship between the two, this paper draws on the results of others based on the construction of eco-agriculture and leisure agriculture coupled and coordinated development model as equation (15):

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

which has the formula (16):

$$R = \delta_1 \times EA^0 + \delta_2 \times LA^0 \tag{16}$$

In equation (16), D represents the coupling coordination degree of the two, R is the comprehensive evaluation index of the two, reflecting the contribution of the overall development level of the two systems to the coupling coordination degree, δ_1, δ_2 are the contribution coefficients of the two systems, and $\delta_1 + \delta_2 = 1$. Given that this paper regards the two as sibling systems, ecological agriculture and leisure agriculture have the same status and importance in regional economic development, so this paper assigns δ_1, δ_2 to 0.5 respectively.

It can be seen that $D \in [0,1]$, D value is higher, indicating that the two coupled coordination is better, the higher the level of development of the two, the more harmonious coupled development relationship. When $D = 0$, it indicates that the coupling coordination between the two systems has the lowest level of development, and the two are in an extremely dysfunctional state; when $D = 1$, it indicates that the coupling coordination between the two has reached the highest level, and the two systems are in an optimal coordination state. Therefore, the closer the value of D is to 1, the better the coupling coordination between the two, the higher the coupling development level; the closer the value of D is to 0, the worse the coupling coordination between the two, the lower the coupling development level. In order to more intuitively reflect the coupling coordination between the two systems, this paper sets the coupling coordination degree division standard as follows:

(1) Dissonance level: [0.00,0.50). When the coordination degree is in the interval of [0.00,0.10), it belongs to the extreme disorder level; when the coordination degree is in the

interval of [0.10,0.20), it belongs to the severe disorder level; when the coordination degree is in the interval of [0.20,0.30), it belongs to the moderate disorder level; when the coordination degree is in the interval of [0.30,0.40), it belongs to the mild disorder level; when the coordination degree is in the [0.40,0.50) interval, it is on the verge of dissonance grade.

(2) Coordination grade: [0.50,1.00]. When the coordination degree is in the interval of [0.50,0.60), it belongs to the barely coordination grade; when the coordination degree is in the interval of [0.60,0.70), it belongs to the primary coordination grade; when the coordination degree is in the interval of [0.70,0.80), it belongs to the intermediate coordination grade; when the coordination degree is in the interval of [0.80,0.90), it belongs to the good coordination grade; when the coordination degree is in the interval of [0.90,1.00] range, it belongs to high quality coordination grade.

4 Integrated development of ecology and leisure agriculture based on coupled coordination

4.1 Selection and description of the research sample

Province H, which occupies a key position in food production, was selected as the sample for the study of this paper, which has a large scale and abundant production of agricultural products such as grain crops, paddy, cotton, tea, oilseeds and sugarcane. The sown area and production of major crops in Province H from 2013 to 2022 are summarized in Table 2.By 2022, the sown area of grain crops in Province H reached 4.84 million hectares, and the sown area of paddy reached 4.1 million hectares with a production of 27.718 million tons. And the output of major crops in Province H has shown a fluctuating upward trend over the past ten years, and the overall development trend is stable and improving, with a high level of eco-agriculture development.

Table 2: The production situation of major crops in Province H from 2013 to 2022

Year	Output (10,000 tons)					Sown area (1000 hectares)		
	Rice	Cotton	Tea	Oilseeds	Sugarcane	Grain	Rice	Cotton
2013	2712.1	24.8	19.38	183.65	95.62	4925.9	4203.1	158.2
2014	2649.6	26.3	20.67	209.91	91.25	4946.5	4204.9	180.6
2015	2732	27.2	22.18	229.95	86.88	5030.9	4260.5	198
2016	2802.1	28.66	22.43	222.45	88.48	5074	4309.3	178.3
2017	2743.1	23.4	23.5	239.09	88.33	5108.7	4318.2	165.2
2018	2830.5	16.5	25.08	248.42	80.51	5164.3	4374.7	135.7
2019	2854.6	15.9	26.47	257.54	80.61	5152.4	4387.5	109.2
2020	2822.4	16.2	27.5	257.52	80.85	5109.4	4377.3	112.1
2021	2838.2	14.6	28.61	240.73	47.88	5077.6	4338.4	101.3
2022	2771.8	12.2	30.36	249.1	48.46	4846.6	4108.7	69.5

Statistics on the changes in the number of leisure agriculture business entities and the growth of revenue from 2013 to 2022 in Province H are shown in Figure 1. The number of leisure agriculture business entities grows from 640 in 2013 to 1,507 in 2022, with a growth rate of more than 100.00%. The revenue grows from 1.377 billion yuan in 2013 to 2.485 billion yuan in 2022, which is a large and impressive revenue despite the relatively flat growth trend.

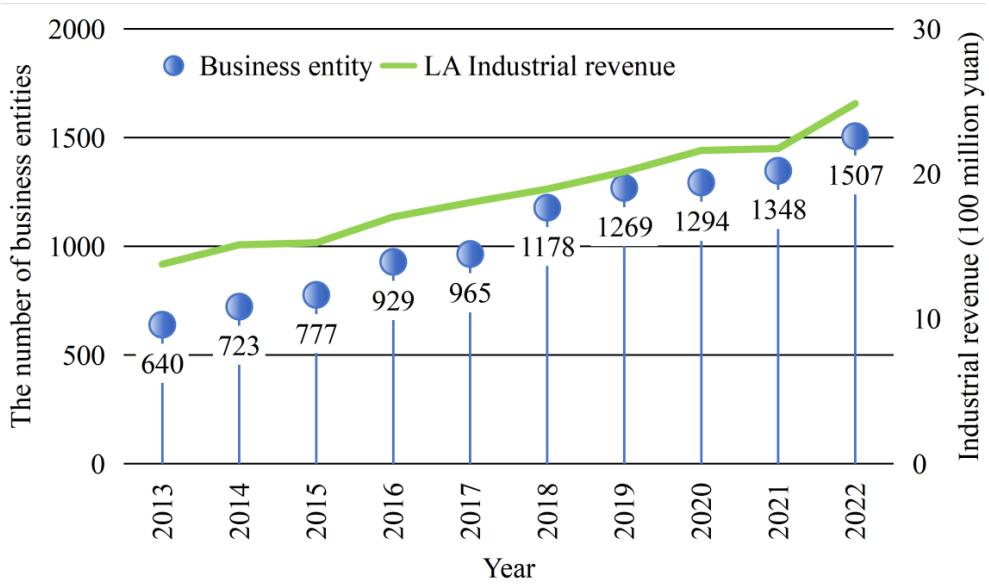

Figure 1: Business entities and revenues of leisure Agriculture from 2013 to 2022

4.2 Empirical analysis of the coupled development of ecological agriculture and leisure agriculture

4.2.1 Determination of indicator weights

The indicators of the coupled determination system of rural ecological agriculture and leisure agriculture were sequentially subjected to entropy value and gray correlation calculation, and the final weight value of each evaluation indicator was comprehensively obtained as shown in Table 3.In (EA) ecological agriculture system, (EA1) agricultural performance indicator and (EA2) agricultural input indicator obtained a weight value of 0.58 and 0.42, respectively, reflecting the development of ecological agriculture which is dominated by its production. In (LA) leisure agriculture, (LA1) infrastructure, (LA2) economic benefits, (LA3) tourism performance, (LA4) tourism inputs and (LA5) social benefits, a total of five indicators, received weight values of 0.16, 0.29, 0.27, 0.15, 0.13, respectively, which not only indicates that the economic benefits of leisure agriculture are outstanding in terms of their outputs, but also reflects its tourism-oriented Characteristics.

Table 3: The weight values of each indicator

Target layer	Criterion layer	Weight	Indicator layer	Weight
(EA) Ecological Agriculture	(EA1) Agricultural Performance	0.58	EA11	0.0940
			EA12	0.0649
			EA13	0.0901
			EA14	0.0755
			EA15	0.1028
	(EA2) Agricultural Investment	0.42	EA21	0.1166
			EA22	0.0771
			EA23	0.1029
			EA24	0.0925
			EA25	0.0899
			EA26	0.0937
(LA) Leisure Agriculture	(LA1) Infrastructure Construction	0.16	LA11	0.0522
			LA12	0.0477
			LA13	0.0631
			LA14	0.0311
	(LA2) Economic Benefits	0.29	LA21	0.0259
			LA22	0.0653
			LA23	0.0531
			LA24	0.0406
	(LA3) Tourism Performance	0.27	LA31	0.0443
			LA32	0.0371
			LA33	0.0270
			LA34	0.0448
	(LA4) Tourism Investment	0.15	LA41	0.0659
			LA42	0.0528
			LA43	0.0644
			LA44	0.0595
			LA45	0.0743
	(LA5) Social Benefits	0.13	LA51	0.0548
			LA52	0.0607
			LA53	0.0354

4.2.2 Calculation and analysis of the degree of coupling coordination

Using linear weighting method and coupling model to calculate the comprehensive development level, coupling degree and coordination degree of eco-agriculture and leisure agriculture in Province H during 2013-2022, the output results are shown in Table 4, and accordingly, the comparison of the comprehensive development level of eco-agriculture and leisure agriculture among them is shown in Fig. 2, and the degree of coupling and the degree of coordination degree of coupling is shown in Fig. 3.

Table 4: The coupling coordination degree of the H province region from 2013 to 2022

Year	Comprehensive Development Index		Com-parison	Coupling degree	Coupling coordination degree	Coordination level
	EA	LA				
2013	0.253	0.214	EA>LA	0.004	0.154	Severe Imbalance
2014	0.408	0.363	EA<LA	0.064	0.178	Severe Imbalance
2015	0.582	0.516	EA>LA	0.327	0.386	Mild Disruption
2016	0.631	0.623	EA>LA	0.393	0.402	Near Imbalance
2017	0.711	0.697	EA>LA	0.451	0.406	Near Imbalance
2018	0.782	0.741	EA>LA	0.526	0.562	Reluctantly coordinated
2019	0.794	0.816	EA<LA	0.603	0.597	Reluctantly coordinated
2020	0.839	0.847	EA<LA	0.641	0.601	Primary Coordination
2021	0.853	0.864	EA<LA	0.678	0.665	Primary Coordination
2022	0.859	0.892	EA<LA	0.723	0.707	Intermediate Coordination

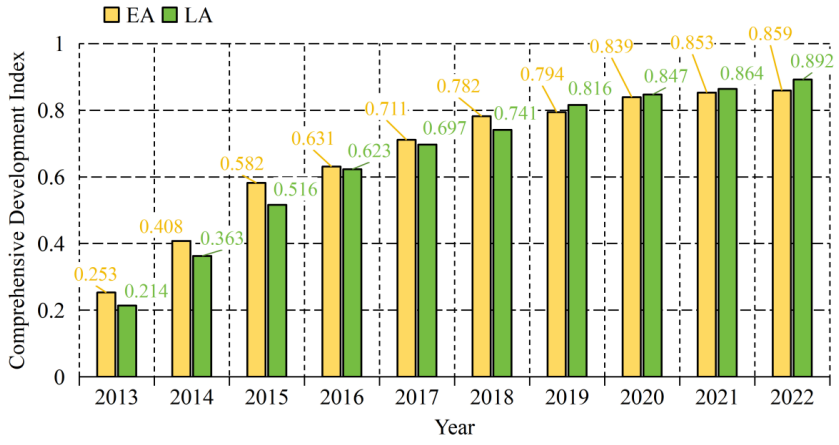

Figure 2: The comprehensive development level of EA system and LA system

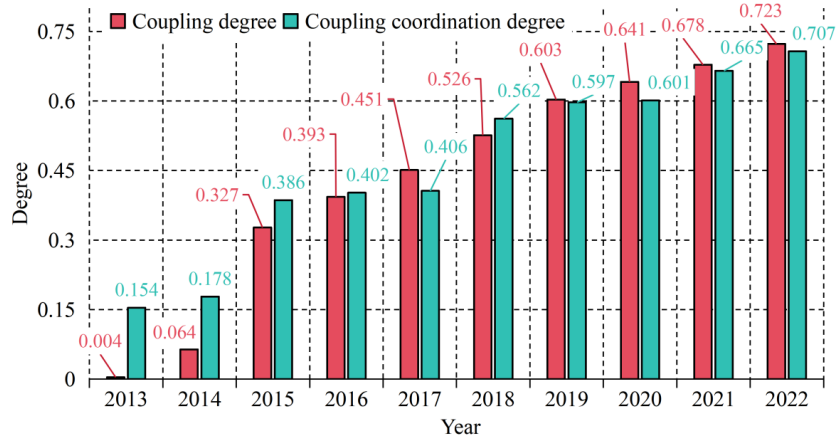

Figure 3: The coupling and coordination level of EA system and LA system

By analyzing Table 2 and Figures 2 and 3 comprehensively, it can be observed that the overall development level of the ecological agriculture (EA) system in Province H increased from 0.253 to 0.859 during the period from 2013 to 2022, while the development level of the leisure agriculture system (LA) rose from 0.214 to 0.892. Moreover, before 2019, the development level of the ecological agriculture (EA) system was consistently higher than that of the leisure agriculture system (LA), but after 2019, the development level of the ecological

agriculture (EA) system was surpassed. In terms of growth rates, ecological agriculture (EA) systems have seen less change over the 10-year period, with slower, more stable growth rates. Leisure agriculture (LA) systems, on the other hand, started to gain momentum from 2015 onwards and the growth rate became larger. In 2018, it began to converge (0.741) to the comprehensive development level of the ecological agriculture (EA) system (0.782), narrowing the development gap between the two and realizing the surpassing of the comprehensive development index from 2019. Correspondingly, the level of coordination between the ecological agriculture (EA) system and the leisure agriculture system (LA) in Province H has also been gradually improved over the past 10 years, with the degree of coordination of the coupling rising from 0.154 to 0.707, and from the original "extremely dysfunctional" level to the "intermediate coordination" level. The degree of coupling coordination increases from 0.154 to 0.707, from the original "extremely dysfunctional" level to "intermediate coordination" level. This indicates that the pace of development of leisure agriculture in Province H has accelerated, and it is gradually moving towards an economic industry based on tourism, and the development of the industry will enter a new stage.

4.2.3 Simulation of coordinated development of ecological and leisure agriculture

Combined with the above analysis, it can be seen that in the early stage of coupling development, the development of ecological agricultural system has become a system, leisure agriculture system is still in its infancy, during this period, mainly by the ecological agriculture for leisure agriculture to provide resources and financial support; and in the coupling development of the recent past, the leisure agriculture relying on the support of ecological agriculture to complete the construction of the structure of the construction of the system perfect and has achieved significant results, although the leisure Although the economic benefits generated by the leisure agriculture system have completely surpassed the ecological agriculture system and begun to feed the ecological agriculture system, its development still relies heavily on the agricultural resources provided by the ecological agriculture system. Accordingly, based on the development data of ecological agricultural system and leisure agricultural system in Province H from 2013 to 2022, this subsection takes the resource input degree of ecological agricultural system as 5.00%, 15.00%, 30.00% and 50.00% respectively, and explores the influence of the resource input degree of ecological agricultural system on the leisure agricultural system as shown in Figure 4.

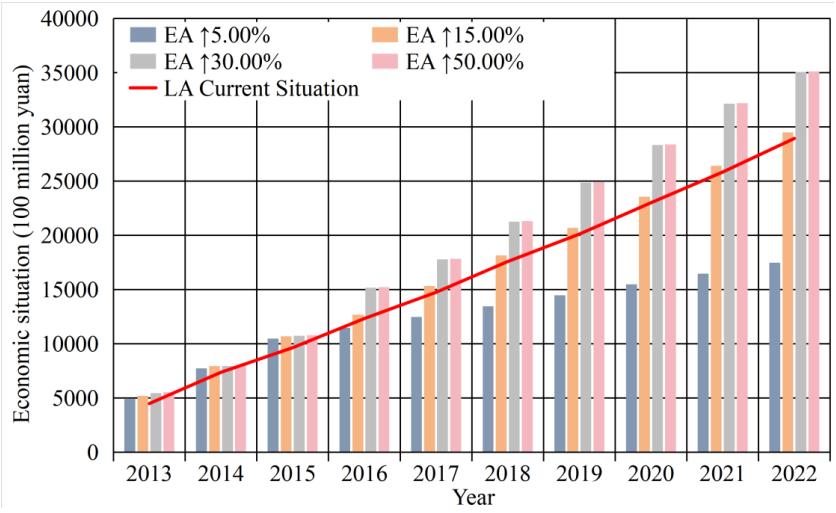

Figure 4: The degree of influence of the resource input of the EA on the LA

Overall, the economic benefits of recreational agricultural systems increase with the level of resource inputs to the ecological agricultural systems. before 2017, the economic benefits of ecological agricultural systems with different levels of resource inputs did not show significant differences and were consistent with the reality that they were still in the stage of system construction. after 2017, the level of 10.00% of resource inputs nearly coincided with the reality, and the economic benefits of recreational agricultural systems with 30.00% and 50.00% of the ecological agricultural system resource input of the economic benefits of leisure agriculture system began to show a high rate of growth, and in this situation there are 30.00% and 50.00% of the degree of resource input to produce economic benefits are more similar to the resource efficiency overlap, indicating that the degree of 30.00% of the degree of resource input tends to be close to the saturated state. Indicates that the ecological agriculture to supply leisure agriculture development industry is not desirable, the two should be combined with the actual situation to set a balance point, in order to carry out effective integration and development, to maximize economic benefits.

4.3 Path of integrated development of rural eco-agriculture and leisure agriculture

Comprehensive analysis of the above content can be seen, thanks to the ecological agriculture in the early capital and agricultural resources to help, leisure agriculture development so far has formed a systematic industrial supply system and economic operation structure. Both in the overall development of interdependence, mutual support, ecological agriculture can provide sufficient content construction and development resources for leisure agriculture, leisure agriculture can support the modernization and scale of ecological agriculture in the economic form. This paper takes the high-quality coupling and coordination between rural ecological agriculture system and leisure agriculture system as the goal, and puts forward the following integration development path:

(1) Create characteristic cultural content and strengthen publicity and promotion efforts

Starting from the local characteristic crop production process, farmers' labor life and rural native humanities, actively explore and innovate agricultural products and leisure agriculture activities to form the local unique leisure agriculture cultural connotation. On this basis, combined with the market characteristics of packaging its agricultural cultural connotation, make full use of a variety of media forms of publicity, social network platforms as the main position, focusing on its leisure agriculture publicity and promotion activities. By creating a unique, memorable tourism image, expanding the visibility and influence of the local leisure agriculture industry. In addition, in the process of publicizing its leisure agriculture, it can also widely collect the leisure agriculture experience needs of tourists and develop corresponding leisure agriculture products. With the rich and characteristic agricultural cultural connotation as the cornerstone, borrowing the Internet marketing and other new age tools to widely attract tourists from all over the world, transforming the resource advantages into economic power, and promoting the process of rural revitalization.

(2) Maintaining ecological agricultural construction and realizing sustainable development

Ecological agricultural resources are the foundation of leisure agriculture development. Therefore, while relying on ecological agricultural resources to promote the economic development of leisure agriculture, attention should be paid to the maintenance and construction of ecological agricultural resources in this process. In addition to firmly retain the original ecological agricultural origin, structure, but also need to follow the development process of the times, to ecological conservation and development of agriculture as the goal of accelerating the revision and improvement of the ecological agriculture of the overall planning and maintenance of the program, standardize the development and use of ecological

agriculture. Under the guidance of the green development concept, the introduction of modern science and technology to innovate ecological agricultural production mode, improve the production level and quality of agricultural production, and ultimately realize the sustainable development of ecological agriculture and leisure agriculture complement each other.

5 Conclusion

In the coupled determination of rural ecological agriculture and leisure agriculture, this paper proposes a coupled determination index system containing a total of 31 secondary indicators from a total of seven perspectives, including agricultural performance, agricultural inputs, infrastructure, economic benefits, tourism performance, tourism inputs and social benefits. Among them, the eco-agriculture system is dominated by agricultural performance (yield) (0.58), and the leisure agriculture system is dominated by economic efficiency (0.29) and tourism performance (0.27).

Within the framework of the constructed ecological agriculture and leisure agriculture coupling degree determination, based on the analysis of the research sample data to obtain its ecological agriculture in the 10-year comprehensive development level in the range of 0.253 to 0.859, leisure agriculture in the range of 0.214 to 0.892, 10 years of ecological agriculture and leisure agriculture coupling and coordinated development to the intermediate level of coordination (0.707).

Combined with the simulation analysis results that the economic efficiency of eco-agriculture when the degree of resource input of eco-agriculture is 30.00% and leisure agriculture tends to be optimal, this paper, based on the goal of the rural revitalization strategy, puts forward the following suggested paths to the integrated development of the two: (1) to create distinctive cultural content and strengthen the publicity and promotion efforts; and (2) to maintain the construction of eco-agriculture to achieve sustainable development.

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