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Article

The Application Mode and Implementation Path of Smart Housing in Rural Tourism Resource Integration

Jianfei Xing[1], Xiao Li[1,*] and Li Sun[1]

[1] Business & Tourism Institute, Hangzhou Vocational & Technical College, Hangzhou, Zhejiang, 310018, China
* Correspondence author: lisa7982@163.com

Abstract: Since the reform and opening up, China's rural tourism has developed rapidly, and now it has become a new driving force for the growth of the tertiary industry and even the national economy, especially the integration and development of rural tourism and smart housing resources, which further promotes the development of rural tourism and other related industries. In this paper, the coupling role of rural tourism and smart housing is summarized from the four aspects of resources, products, enterprises and markets, and the coupling model is constructed. Using the gray correlation method, the behavioral characteristics of the smart housing-rural tourism system in the study area are reflected, and the final results are calculated through gray correlation to map the size of the degree of association between the data. The coupling coordination degree model was introduced to assess the degree of coordinated development of rural tourism and smart housing with a comprehensive assessment. The more stable indicators of the correlation between smart housing and rural tourism in the study area are the number of domestic tourists and international tourism revenue, with the correlation coefficients of 0.793 and 0.811, respectively. The coupling coordination degree of Haikou and Sanya in the study area in 2023 is 0.609 and 0.582, which are in the state of primary coordination and near-coordination, respectively, and the level of coupling coordination degree of the coastal area is higher than that of other areas. The level of coupling coordination in coastal areas is higher than that in other areas, and relevant countermeasures for the sustainable development of rural tourism are proposed for the dysfunctional situation existing in the study area.

Keywords: Rural tourism; smart housing; coupling role; gray correlation method

1. Introduction

With the rapid development of tourism in recent years, rural tourism has become the preferred place for people to travel, which brings opportunities for rural tourism. And in the development of rural tourism, tourism resource integration is a crucial link, which involves integrating and optimizing various tourism resources to provide better tourism experience and services. With the development of information technology and artificial intelligence, the application of smart tourism in resource integration brings opportunities for the sustainable development of rural tourism [1-2].

The concept of smart tourism is extended under the construction of smart city, in essence, smart tourism belongs to the combination of tourism, digital development products, the use of cloud computing, big data, Internet release resources, so that tourists can conveniently grasp the tourism information, according to which to adjust the tourism plan, so that tourists' tourism has become more convenient and faster [3-5]. The application of smart tourism can enable tourists to understand the condition of scenic spots, promote the deep integration between transportation, hotels and the Internet, integrate all kinds of resources, build a core database of tourism resources, and provide convenient management conditions for tourists' tourism. And smart housing, as an important component of smart tourism, plays an important role in enhancing tourist sports [6-8]. Housing is the basic needs of tourists,

to ensure good housing conditions for tourists has always been the focus of rural tourism, in order to improve the housing experience of tourists, smart housing has become is a new type of solution, smart housing personalization, intelligence and interactivity and other aspects of the advantages for tourists to bring an unprecedented tourism experience, for the sustainable development of rural tourism is of great significance [9-12].

Papagiannidis, S and Davlembayeva, D. examined the perceived functional and emotional value of smart housing and the factors contributing to this value, revealing through their investigation that the functional value of smart housing is related to perceptions of value for money, usefulness of smart devices, and that smart housing improves recreational experiences, aesthetics, and enjoyment of using technology [13]. Coghlan, A. et al. explored how lodging managers used smart technologies during the crisis and the process of using digital data outputs to drive tourism sustainability actions, and developed a discussion of the results by analyzing different case studies [14]. Çeltek, E. introduced smart hotels and described hotels that use smart technologies, revealing that smart hotels provide a personalized experience and are able to respond quickly to the needs of travelers and provide them with personalized services [15]. Dalgic, A. and Birdir, K. emphasized that smart hotels provide travelers with a different and advanced technology oriented experience by utilizing advanced technology to reduce service failures and save costs and described the application of IoT to provide travelers with a more comfortable travel experience [16]. The above study examined the application of smart housing in tourism accommodation, which not only improves travelers' accommodation experience, but also contributes to cost saving and sustainable development, however, the application of smart housing in rural tourism was not mentioned.LIN,M.L. et al. examined how digital transformation can contribute to the integration of resources in rural tourism, and found that in digital technology offers the possibility of integrating agro-tourism resources, which can help to improve the quality of tourism and improve the quality of tourism through the composition of a new type of tourist attractions, enriching tourism and leisure options [17]. Zhu,W and Shang,F. built a rural wisdom tourism system under the background of Internet+, combined with the current situation of rural tourism, improved the traditional rural tourism model, and examined the application of Internet+ technology in the architecture of the wisdom tourism system, which verified that the system has a certain effect [18]. It can be seen that rural tourism is having a traditional tourism model to the intelligent model, including intelligent infrastructure, intelligent housing, etc., but the application of intelligent housing in the integration of rural tourism resources has not been paid attention to by academics at present.

This study is a combination of physics theory, sociology's questionnaire method, anthropology's survey interview method and political science's related theories, focusing on the use of governance theory to conduct an integrated study, so this study has innovations in terms of theoretical methods. This study chooses Hainan Province as the study area, and first analyzes the current situation of smart housing in the integration of rural resources in the study area. The coupling model of smart housing and rural resources is constructed to sort out the relationship between them. By establishing the statistical mathematical modeling method of gray correlation, we explore the posting progress between the two indicators and analyze the correlation of each factor. According to the role mechanism of the development and change of the coupling coordination degree of smart housing and rural tourism, the coupling coordination index system between smart housing-rural tourism is established, and the coupling coordination degree of the two is calculated. From the two directions of spatio-temporal change and trend change, the change pattern of the coupling coordination degree of smart housing in rural tourism resource integration between 2013 and 2023 is sorted out.

2. Status of rural tourism development

2.1. Overview of the study area

This paper takes Hainan Province as an example to study the integration of rural tourism resources in the region. Hainan Province has a land area of 35,200,000km², a sea area of 2,000,000km², and a resident population of 9,447,200 people. This study selects the whole of Hainan Province and 18 directly governed cities and counties on the island (excluding Sansha City) as the research object, including three prefecture-level cities (Haikou, Sanya and Danzhou), five county-level cities (Wuzhishan, Wenchang, Qionghai, Wanning and Dongfang), four counties (Ding'an, Tunchang, Chengmai and Lingao), as well as six national self-governing counties (Ledong, Lingshui, Baisa, Changjiang, Qiongzhong and Baoting). In terms of spatial characteristics, six cities and counties - Wuzhishan, Ding'an, Tunchang, Baisha, Qiongzhong and Baoting - are inland19, while the remaining 12 cities and counties are coastal. Rural tourism and smart housing are the leading industries in Hainan Province. Figure 1 shows the resource integration status of smart housing and rural tourism in Hainan

Province. Since the construction of the International Tourism Island, rural tourism in Hainan Province has continued to develop, and the proportion of resources has increased from 13.03% in 2013 to 19.82% in 2023. The resources of smart housing show the trend of change firstly improving and then decreasing, the proportion of which reaches the highest of 38.16% in 2021, and then begins to decline, the proportion of which is 26.74% in 2023. Influenced by the change of resources of smart housing, the combined development level of the two also shows the change trend of increasing and then decreasing, with the highest share reaching 56.76% in 2021 and then decreasing to 46.56% in 2023.

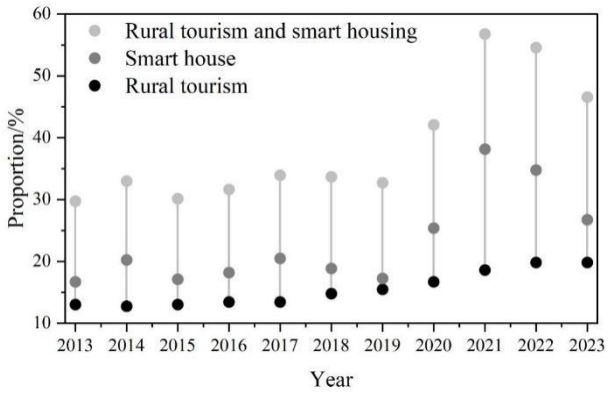

Figure 1. Resource integration of intelligent housing and rural tourism in Hainan province

2.2. Mechanism of resource coupling between rural tourism and smart housing

2.2.1. Description of the coupling mechanism

Coupling originates from the category of physics, which originally refers to the phenomenon of close cooperation and mutual influence between the inputs and outputs of two or more circuit elements or networks. Nowadays, coupling is widely used in social science research, and industrial coupling refers to the mutual influence between two industries, the exchange and circulation of resources, human resources and information and other elements, and the competition and linkage in the field of production, circulation and sales, forming a benign resonance development relationship.

The internal foundation of rural tourism and smart housing determines that there are excellent coupling conditions between the two. For one thing, rural tourism has a positive pull effect on smart housing, enhancing its industrial connotation and extension. Developers make full use of tourism resources to attract tourists for sightseeing, leisure and vacation, residence and other consumer behavior, which can provide opportunities for the development of smart housing projects. Emerging rural tourism elements continue to penetrate into the smart housing, giving the smart housing products unique tourism connotation and prompting developers to carry out product innovation, which can meet the diversified needs of tourism consumers and enhance tourism satisfaction. Secondly, the development of rural tourism can provide a publicity platform for smart housing development projects, which can help expand the scale of the smart housing market. Third, under the background of rural tourism, the coupling of the two projects will certainly stimulate the related fringe enterprises, sprout a series of new products and services, and realize the optimization and upgrading of industrial structure.

2.2.2. Coupling Modeling

The coupling role of rural tourism and smart housing is mainly reflected in four aspects: resources, products, enterprises and markets, as shown in Figure 2. In terms of resources, scarce shared resources such as local scenic spots and ethnic traditional culture as production factors are the material basis for promoting the coupling of rural tourism and smart housing. In terms of products, cultural tourism towns, resorts and other products with dual attributes of tourism and smart housing can meet the common needs of consumers, thus realizing cross-industry linkage development. In terms of enterprises, enterprises related to rural tourism and smart housing seek cross-border cooperation with each other, reorganize the internal organization structure of enterprises, and promote the emergence of new cross-industry enterprises to realize the diversified extension of the value chain. In terms of market, rural tourism market and smart housing market penetrate into each other, breaking the constraints between industries and entering into a deeper state of integration and development.

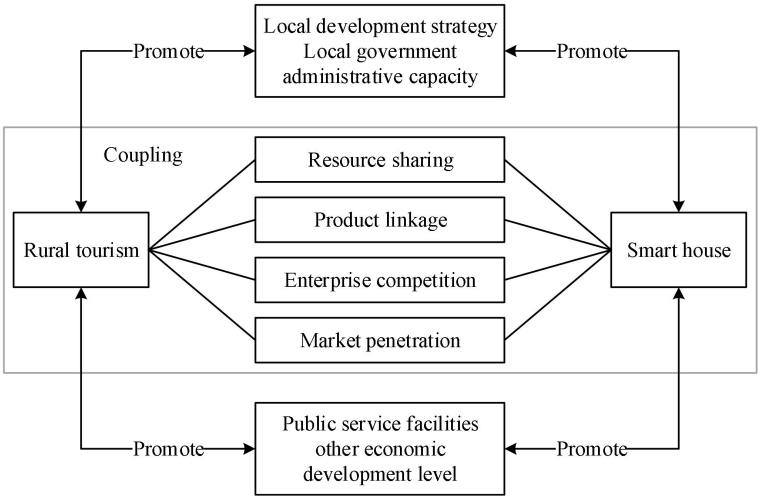

Figure 2. The coupling of rural tourism and intelligent housing

3. Empirical study on the impact of smart housing on rural tourism

3.1. Gray correlation analysis of smart housing and rural tourism

3.1.1. Calculation of gray correlation analysis

Gray correlation method to smart housing and rural tourism between the indicators found in the actual data as a prerequisite, through the establishment of statistical mathematical modeling methods to explore the geometric form of the relationship between the indicators of the closeness to determine the size of the correlation between the different factors, the closer the geometric style of the sequence curve and therefore the higher the grey correlation between the factors, and vice versa, the lower the degree of correlation [19].

Firstly, the reference and comparison sequences that can reflect the behavioral characteristics of the smart housing-rural tourism system are identified, where the change in smart housing is selected as a trade-off factor for the gross value of smart housing, which has the symbol X_0 [20]. The gross value of smart housing product is the reference sequence of the system: $X_0(k) = (x_0(1), x_0(2), \ldots, x_0(n))$, $k = 1, 2, ..., n$, where n indicates that it is the unit time of each sequence.

Let the comparison sequence of rural tourism: $X_i(k) = (x_i(1), x_i(2), \ldots, x_i(n)), i = 1, 2, \ldots, m$, where i indicates that it is the i rd indicator of rural tourism, while n indicates that it is the unit time of each sequence, and m indicates the number of indicators of the evaluated object. The final result of the gray correlation can reflect the size of the degree of correlation between the data, so the gray correlation coefficient $\gamma(x_0(k), x_1(k))$ of X_i is:

$$\gamma(x_0(k), x_i(k)) = \frac{\min_i \min_k \min_k n \mid x_0(k) - x_i(k) \mid + \delta \max_i \max_k \max_k n \mid x_0(k) - x_i(k) \mid}{\mid x_0(k) - x_i(k) \mid + \delta \max_i \max_k \max_k n \mid x_0(k) - x_i(k) \mid} \tag{1}$$

Where δ is the resolution coefficient, is to reduce the distortion caused by the difference interval is too large, $\delta \in (0,1)$, and δ generally take 0.5, δ the smaller the resolution is larger.

The gray correlation $\gamma(x_0, x_1)$ of the comparison sequence X_i for the reference sequence X_0 is calculated as follows:

$$\gamma(X_0, X_i) = \frac{1}{n} \sum_{k=1}^{n} \gamma(x_0(k), x_i(k)) \tag{2}$$

$\gamma(X_0, X_i)$ is the correlation value of the comparison sequence X_i of the two evaluation systems with respect to the reference sequence X_0 . The larger the value of $\gamma(X_0, X_i)$, the closer the

comparison sequence is to the reference sequence. The two systems are then sorted according to the magnitude of the value of $\gamma(x_0, x_i)$ to obtain the order of superiority of the two systems.

3.1.2. Selection of Gray Correlation Model Indicators

The main representative industries of rural tourism include travel agency industry, star-rated hotel industry, and tourist attraction industry. Meanwhile, the total number of tourists, the total income of tourism and the number of rural tourism employees are the important metrics of rural tourism. In addition, the number of tourism colleges and the number of students in tourism colleges provide backup talents and technical services for rural tourism in Hainan Province, which play an important role in the development of rural tourism in Hainan Province. Therefore, the indicators for rural tourism are domestic tourism revenue of X_1 (billion yuan), international tourism revenue of X_2 (billion yuan), the number of domestic tourists of X_3 (million), the number of inbound tourists of X_4 (million), the total number of tourism employees of X_5 (people), the number of travel agencies of X_6 (number), the number of star-rated hotels of X_7 (number), the number of tourism scenic spots of X_8 (number), the number of tourism colleges and universities of X_9 (number), the number of tourism college students of X_{10} (people). Tourism employment is measured by the total number of employees in travel agencies, star-rated hotels, and tourist attractions, and tourism colleges and universities include higher education institutions and secondary vocational schools.

Setting the above indicators of rural tourism as a systematic comparison sequence $X_i = (x_i(1), x_i(2), ..., x_i(n))$, i denotes the i rd indicator of rural tourism, and n denotes the unit time of each sequence.

In this paper, we choose the data from 2013 to 2023, which are mainly from the statistical yearbook of Hainan Province, China Tourism Statistical Yearbook and Social Development Statistical Bulletin of Hainan Province from 2014 to 2024, and Table 1 shows the data related to the value-added of smart housing and rural tourism from 2013 to 2023.

During the period of 2013~2023, the value added of smart housing in Hainan Province ranges from 7,745.2 million yuan to 45,098.5 million yuan, with an average annual growth rate of 19.474%. During the period, rural tourism in Hainan Province has developed rapidly, with domestic tourism revenue growing from 16.0685 billion yuan to 110.5942 billion yuan, with an average annual growth rate of 21.858%, and the number of domestic tourists has also changed considerably, with an increase of 3.105 times. Investment in manpower and hardware institutions corresponding to the development of rural tourism has also risen markedly, with the total number of tourism employees increasing by 0.43 times, the number of travel agencies by 1.186 times, and the number of tourist attractions the fastest-growing, by 5.577 times.

Table 1. 2013~ 2023 intelligent housing added value and rural tourism data

Year	X_0	X_1	X_2	X_3	X_4	
2013	**77.452**	160.685	24.469	4136.615	80.685	
2014	83.932	153.645	12.948	3645.485	54.369	
2015	95.942	197.865	24.625	4468.325	76.685	
2016	108.368	224.652	30.265	4984.435	88.648	
2017	125.953	264.865	35.252	5541.358	100.365	/
2018	154.385	324.485	40.422	6249.325	118.688	
2019	194.358	379.648	30.823	6618.482	89.639	
2020	238.985	456.685	35.321	8165.685	103.458	
2021	313.486	620.685	45.102	10264.428	132.885	
2022	398.375	846.482	50.632	13648.855	167.685	
2023	**450.985**	1105.942	63.423	16978.978	196.765	
Year	X_5	X_6	X_7	X_8	X_9	X_{10}
2013	38463	280	189	26	18	10966
2014	33458	306	226	27	17	8220
2015	44465	345	242	30	19	9725
2016	45315	372	253	32	19	10868
2017	54352	415	295	42	20	11826
2018	54132	486	300	53	23	12322
2019	48982	509	335	60	24	12322

2020	53085	530	340	68	21	12869
2021	55312	598	265	95	23	13854
2022	57068	608	300	153	35	14875
2023	54985	612	284	171	30	15675

Due to the inconsistency of the sample raw data, it is necessary to de-scalarize the data in order to facilitate the cross-comparison of the results. The initial values of the two industries are obtained X_i. The correlation coefficient matrix is then calculated to obtain the correlation degree. The formula of X_i is shown in (3) and (4):

$$X_i = \frac{x_i}{x_i(1)}, i = 0,1,2,...,m \tag{3}$$

$$X_i = (x_i(1), x_i(2), ..., x_i(n)) \tag{4}$$

From the formula (3), (4) we can see that the value of X_i for the two industries behind the n units of time indicators (including the first unit of time) and the first unit of time indicator ratio, according to the law, the results are also each industry after n units of time (including the first unit of time) and the first unit of time indicators of the ratio of the value of the indicators as shown in Table 2, indicators in the growth of the year until 2023, the average annual indicator value rose to 3.375.

Table 2. The average value of intelligent housing and the mean of country tourism

X_i'	**2013**	**2014**	**2015**	**2016**	**2017**	
X_0'	1	1.085	1.245	1.452	1.625	
X_1'	1	0.985	1.236	1.452	1.644	
X_2'	1	0.545	1.125	1.325	1.532	
X_3'	1	0.895	1.086	1.186	1.328	
X_4'	1	0.675	0.988	1.123	1.238	/
X_5'	1	0.893	1.175	1.187	1.412	
X_6'	1	1.068	1.269	1.352	1.536	
X_7'	1	1.293	1.298	1.398	1.578	
X_8'	1	1.042	1.126	1.242	1.632	
X_9'	1	1.135	1.132	1.132	1.132	
X_{10}'	1	0.795	0.896	0.965	1.098	
X_i'	2018	2019	2020	2021	2022	2023
X_0'	1.958	2.425	3.035	4.038	5.132	5.863
X_1'	2	2.365	2.863	3.828	5.285	6.815
X_2'	1.758	1.285	1.385	1.985	2.226	2.685
X_3'	1.536	1.632	1.935	2.532	3.284	4.068
X_4'	1.425	1.089	1.248	1.632	2.052	2.485
X_5'	1.432	1.236	1.435	1.425	1.568	1.598
X_6'	1.785	1.826	1.835	2.158	2.132	2.236
X_7'	1.706	1.815	1.948	1.536	1.785	1.515
X_8'	1.706	2.465	2.625	3.785	5.869	6.848
X_9'	2	1.436	1.408	1	2	1.585
X_{10}'	1.423	1.135	1.169	1.265	1.358	1.425

Determine the difference series, i.e., the series of indicators obtained by calculating the mean like of each of the relevant indicators of smart housing and rural tourism. That is: $\Delta_i(k), \Delta_i = (\Delta_i(1), \Delta_i(2), ..., \Delta_i(n))$. The formula is calculated as follows:

$$\Delta_i(k) = |\, x_i(k) - x_n(k) \,|, k = 0,1,2,...,n; i = 0,1,2,...,m \tag{5}$$

Determine the maximum value M and minimum value m in these differential sequence elements obtained with smart housing and rural tourism i.e.: $M = \max_{1<i<m} \max_{1<k<n} \Delta_i(k)$ & $m = \min_{1<i<m} \min_{1<k<n} \Delta_i(k)$, then calculate the correlation coefficient, see equation (6) and finally calculate to determine the degree of correlation, see equation (7):

$$\gamma_{0i}(k) = \frac{m + \delta M}{\Delta_i(k) + \delta M}, \delta \in (0,1), \delta = 0.5 \tag{6}$$

$$\gamma_{0i} = \frac{1}{n} \sum_{k=1}^{n} \gamma_{0i}(k) \tag{7}$$

The gray correlation between smart housing and rural tourism can be finally obtained by Equation (7) γ_{oi}.

3.2. Analysis of the correlation between smart housing and rural tourism

This chapter empirically analyzes the correlation between smart housing and rural tourism in Hainan Province, with data from the 2013~2023 Hainan Provincial Statistical Yearbook, China Tourism Statistical Yearbook, and Hainan Provincial Social Development Statistical Bulletin.

Table 3 shows the gray correlation coefficients of smart housing to each indicator of rural tourism from 2013 to 2023, and the correlation coefficients between rural tourism indicators and the value added of smart housing are more stable, while the correlation coefficients between some indicators and the value added of rural tourism fluctuate more. The more stable indicators are the number of domestic tourists (0.793) and international tourism income (0.811), and the correlation between other indicators and the value added of smart housing are unstable, especially the number of tourist attractions and domestic tourism income.

Table 3. Gray correlation coefficient

Year	**2013**	**2014**	**2015**	**2016**	**2017**	
X_1	1	0.945	0.995	0.994	0.983	
X_2	1	0.934	0.953	0.935	0.925	
X_3	1	0.895	0.909	0.912	0.893	
X_4	1	0.945	0.972	0.935	0.915	
X_5	1	0.996	0.991	0.983	0.982	/
X_6	1	0.935	0.983	0.992	0.962	
X_7	1	0.982	0.968	0.956	0.953	
X_8	1	0.998	0.963	0.915	0.962	
X_9	1	0.905	0.989	0.906	0.853	
X_{10}	1	0.892	0.895	0.896	0.831	
Year	2018	2019	2020	2021	2022	2023
X_1	0.996	0.925	0.926	0.946	0.765	0.536
X_2	0.862	0.765	0.615	0.623	0.625	0.685
X_3	0.851	0.626	0.635	0.648	0.669	0.687
X_4	0.863	0.615	0.542	0.435	0.413	0.376
X_5	0.924	0.713	0.616	0.532	0.465	0.485
X_6	0.913	0.735	0.598	0.496	0.765	0.385
X_7	0.983	0.863	0.852	0.806	0.426	0.425
X_8	0.994	0.615	0.498	0.482	0.406	0.386
X_9	0.853	0.623	0.536	0.492	0.385	0.364
X_{10}	0.789	0.589	0.489	0.386	0.359	0.356

In order to facilitate the statistical results from an overall perspective, the distribution of each value

needs to be considered. The representative points in the statistical situation are grouped into one value, i.e., its average value is sought, to carry out the gray correlation analysis.

Table 4 shows the degree of correlation and ranking, the gray correlation between smart housing in Hainan Province and its domestic tourism revenue is the highest, followed by the number of star-rated hotels. The lowest correlation is with the number of students in tourism colleges and universities. The high correlation between smart housing and domestic tourism income is related to the large value of domestic rural tourism income in Hainan Province and the large number of domestic tourists, as a strong correlation and high value-added rural tourism, no matter what type of tourists come to the countryside, they need to reside, catering, shopping, hospitality, and other services, which are also dependent on the smart housing to carry out.

According to the data, the following results can be drawn:

First, the correlation between each indicator and the value added of smart housing is greater than 0.5, which is at a high level, while the correlations in the table are all above 0.6, indicating that the selected rural tourism indicators can reflect the degree of correlation between rural tourism and smart housing, and all of them have a significant impact on smart housing.

Secondly, the range of gray correlation is 0.68~0.91, among which, there are three indicators above 0.8, and the gray correlation between domestic tourism revenue and the value added of smart housing is 0.91, which is in the first place, and the economic benefits of smart housing and rural tourism converge. The gray correlation between the number of star-rated hotels and the value added of smart housing is 0.838, ranking in the second place, which shows that the influence of rural tourism resources on the development of smart housing cannot be underestimated.There are 6 indicators of rural tourism between 0.7 and 0.8, and the correlation values of the number of inbound tourists, the number of tourist attractions, and the number of tourism colleges and universities are comparable with about 0.7.1 of the indicators below 0.7 is the number of students of tourism colleges and universities, and the correlation degree is 0.68.

Thirdly, the correlation rank of the 10 indicators of rural tourism to smart housing is specifically: domestic tourism revenue $\geqslant$ number of star-rated hotels $\geqslant$ international tourism revenue $\geqslant$ number of travel agencies $\geqslant$ number of domestic tourists $\geqslant$ total number of tourism employees $\geqslant$ number of tourism scenic spots $\geqslant$ number of inbound tourists $\geqslant$ number of tourism colleges and universities $\geqslant$ number of students in tourism colleges and universities. Overall the gray correlation level is obvious and can reflect the degree of correlation between each indicator of rural tourism and smart housing.

Table 4. Correlation and sort

Profession	Gray correlation	Gray correlation classification	Gray correlation range
Domestic travel income	0.91	1	0.8~0.9
International tourism revenue	0.811	3	0.7~0.8
Number of domestic tourists	0.793	5	0.7~0.8
Inbound number	0.728	8	0.6~0.7
Total number of tourist practitioners	0.79	6	0.7~0.8
Number of travel agents	0.797	4	0.7~0.8
Star hotel number	0.838	2	0.7~0.8
Number of tourist attractions	0.747	7	0.8~0.9
Number of tourist schools	0.719	9	0.7~0.8
Number of student students	0.68	10	0.6~0.7

4. Empirical research on coupled coordination of smart housing and rural resource integration

4.1. Selection of indicators

Article indicators should be determined in accordance with the guidelines of controllability, dominance, data accessibility and focus, based on the consultation of several experts in the field of smart housing, according to the role of the mechanism of development and change of the degree of

coordination of the coupling of smart housing-rural tourism, to establish the coupling and coordination indicator system between smart housing-rural tourism.

As the two industrial systems in general present a more complex industrial system, combined with the principle of scientific rationality to establish its indicator system to explore the integration degree of the two industries, so as to ensure that the results of the study have a certain degree of scientific significance. In order to ensure the accuracy of the data, a real and effective index system should be constructed.

This study takes the 18 directly governed cities and counties in Hainan Province as the target of analysis, and collects and collates the data related to smart housing and rural tourism in Hainan Province and the 18 directly governed cities and counties from 2013 to 2023, and implements standardized treatment for them. When exploring the coupling coordination of different systems of smart housing and rural tourism, it is necessary to know the evaluation index of the comprehensive development level of each sub-system, and the formulas are shown in (8) and (9):

$$u = \sum_{j=1}^{n} \omega_j x_{ij}, \omega_j \geq 0, \sum_{j=1}^{n} \omega_j = 1 \tag{8}$$

$$v = \sum_{k=1}^{t} \omega_k y_{ik}, \omega_k \geq 0, \sum_{k=1}^{t} \omega_k = 1 \tag{9}$$

Where: u represents the comprehensive development level of smart housing, v represents the comprehensive development level of rural tourism, ω_j represents the indicator weights of smart housing, and ω_k represents the indicator weights of rural tourism. $x_{ij}^{'}$ represents the j th characteristic indicator of the i th year of smart housing, y_{ik} represents the k th characteristic indicator of the i th year of rural tourism, and they are all dimensionless standardized values, that is, the known raw data are preprocessed in accordance with the method of standardization of the polarity, i represents the order of the year, $i = 1, 2, ..., m$, j represents the number of indicators of smart housing, $j = 1, 2, ..., n$, and k represents the number of indicators of rural tourism, $k = 1, 2, ..., t$.

Table 5 shows the system of smart housing and rural tourism integrated development indicators, based on the spatial similarities and differences in the financial growth status of smart housing to determine the corresponding indicators. The factors of the comprehensive development status of rural tourism can be analyzed by the rural tourism indicators with high correlation obtained in the previous section, in order to facilitate a systematic, accurate and reasonable analysis of the coordination between the two industries.

Table 5. Intelligent housing and rural tourism comprehensive development index system

Target layer	Standard layer	Index level	Index attribute
Intelligent housing comprehensive development level index system	Smart housing development investment construction	U1 Smart housing development investment (100 million yuan)	Forward direction
		U2 Building construction area (10,000 square meters)	Forward direction
		U3 Completed area (10,000 square meters)	Forward direction
	Smart housing sales	U4 Smart housing sales area (10,000 square meters)	Forward direction
	Smart housing operation	U5 Number of smart housing development enterprises (PCS)	Forward direction
Target layer	Standard layer	Index level	Index attribute
National tourism comprehensive development level index system	Rural tourism economy development	V1 Gross tourism income	Forward direction
	Rural tourism market to develop tourism economic income	V2 Number of overnight visitors received	Forward direction
		V3 Number of foreign tourists	Forward direction
		V4 Number of domestic tourists	Forward direction
	Development of	V5 Number of scenic spots	Forward direction

	rural tourism services	V6 Number of hotels	Forward direction
		V7 Number of bed	Forward direction

4.2. Construction of the indicator system for the comprehensive development level of Hainan rural tourism

4.2.1. Construction of the indicator system for the development level of rural tourism resources

The evaluation index system constructed includes three guideline layers related to rural tourism, tourism economic development, tourism service development, tourism market development, and related index items, which are subjective and objective, and closely related to rural tourism development, to get the final system of related indexes about the optimization of rural tourism structure, as shown in Table 6.

First, the quality indicators of tourism economic development. The main purpose of developing rural tourism is to bring economic income, and the total tourism income can best reflect the overall development level of rural tourism. Second, tourism market development quality indicators. The number of tourists directly reflects the popularity of local tourism, including the number of overnight tourists, the number of foreign tourists and the number of domestic tourists. The number of overnight tourists can reflect the number of people who are willing to stay in the local area, and accommodation can generate more tourism income. The number of foreign tourists shows the popularity in the international arena, and Hainan's low level of this indicator shows a low degree of internationalization. Third, tourism service quality indicators. Tourist satisfaction and tourism service quality is closely related to the quality of tourism services, including food, clothing, housing, transportation and service personnel service level and other aspects of tourism. This paper chooses the number of scenic spots, the number of hotels and the number of beds as a quantitative measure of service quality indicators, Hainan Province in 2023 the development of rural tourism indicators quantitative results were 4, 56.611, 14627.444.

Table 6. Rural tourism in rural Hainan province

Cities and counties	**Economic development of rural tourism conditions**	**Rural tourism market development**			**Rural tourism development situation**		
	Total tourism revenue (billion Yuan)	**Number of overnight visitors received**	**Travel abroad Number of guests**	**Domestic tourist numbers**	**Scenic number**	**Hotel number**	**Number of bed**
Haikou	321.569	17186086	289854	6687565	15	186	66485
Sanya	593.348	22655325	898752	896545	13	265	94852
Danzhou	24.956	2697852	41536	2648563	6	43	8066
Wuzhishan	38.688	3503452	33485	3469585	10	51	12548
Wenchang	54.364	5136448	52153	5084632	4	75	18265
Qionghai	39.599	2935542	71866	2924985	2	85	10359
Wanning	54.345	5136587	52489	5086525	3	78	18566
Dongfang	12.835	142936	16987	1412985	5	21	5242
Dingan	4.498	700352	432	700356	0	7	1032
Dunchang	20.269	2759036	7169	2750985	2	40	6485
Chengmai	8.215	1132185	1315	1098652	0	18	3085
Lingao	8.598	1078563	1132	1079855	2	15	2653
Ledong	2.987	463253	374	465252	3	14	1248
Lingshui	6.336	1023639	1168	1007856	1	18	2685
Baisha	9.436	1078652	12985	1063522	0	50	3868
Changjiang	6.198	872652	2346	868485	3	24	3645
Qiongzhong	6.269	753625	1468	751365	2	13	1252
Baoting	3.935	483265	416	482985	1	16	2958

4.2.2. Measurement of the level of resource integration

The entropy method is applied to select the weights, and the formula is calculated as (10) and (11):

$$\omega_j = \frac{1-R_j}{\sum_{j=1}^{n}(1-R_j)} \tag{10}$$

$$\omega_k = \frac{1-S_k}{\sum_{k=1}^{t}(1-S_k)} \tag{11}$$

Where ω_j represents the weight of the j nd indicator of smart housing and ω_k represents the weight of the k th indicator of rural tourism. The weights of their indicators are calculated through equations (10) and (11).

4.2.3. Determination of the weights of the indicators

Through the entropy weight method, the above steps were used to calculate the weights of the data related to smart housing and rural tourism in Hainan Province in 2023, as shown in Table 7, the weight coefficients of U5 and V7 were the largest among the smart housing and rural tourism indicators, which were 22.951% and 20.396%, respectively.

Table 7. Relevant data weight

/	**Information entropy (e)**	**Information utility value(d)**	**Weight coefficient(w)**
U1 Smart housing development investment (100 million yuan)	0.765	0.235	18.345%
U2 Building construction area (10,000 square meters)	0.806	0.194	15.144%
U3 Completed area (10,000 square meters)	0.726	0.274	21.390%
U4 Smart housing sales area (10,000 square meters)	0.716	0.284	22.170%
U5 Number of smart housing development enterprises (PCS)	0.706	0.294	22.951%
V1 Gross tourism income	0.796	0.204	10.642%
V2 Number of overnight visitors received	0.806	0.194	10.120%
V3 Number of foreign tourists	0.762	0.238	12.415%
V4 Number of domestic tourists	0.716	0.284	14.815%
V5 Number of scenic spots	0.706	0.294	15.336%
V6 Number of hotels	0.688	0.312	16.275%
V7 Number of bed	0.609	0.391	20.396%

4.2.4. Measurement of the level of integrated development

Figure 3 shows the comprehensive development level of smart housing and rural tourism resources in Hainan Province 2023, Haikou and Sanya are both much higher than other cities and counties, and the two smart housing and rural tourism are 0.948, 0.648, 0.495, 0.853, respectively. It should play its leading role in driving the development of neighboring cities and counties at the north and south ends. Qionghai and Wanning's rural tourism development level in the province is in the second echelon, one is that it has rich tourism resources, and the second is that it is the traditional strong counties in the cities and counties of Hainan Province, and should further play to its advantage. Danzhou City, as the western city of Hainan, its rural tourism and smart housing comprehensive development level are much higher than other cities and counties in the west, should be further developed into a western development of the highland, driving the development of other cities and counties in the west.

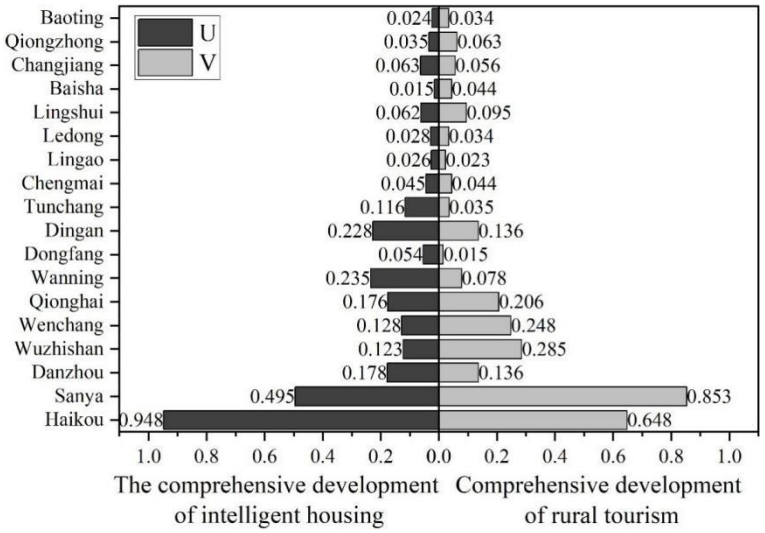

Figure 3. The comprehensive development level of rural tourism resources in Hainan province

4.3. Calculation of the coupled coordination degree of resource integration

4.3.1. Coupled Coordination Degree Models

Table 8 shows the coupling coordination level, this paper regards rural tourism and smart housing as two subsystems that interact and influence each other, and applies the coupling theory to construct the coupling degree model between rural tourism and smart housing:

$$C = \sqrt{4U_1U_2 / (U_1 + U_2)^2} \tag{12}$$

Where: C for the degree of coupling, U_1, U_2 for rural tourism, smart housing system development level comprehensive evaluation index. The value of C ranges from 0 to 1, and the larger the value of C, the higher the degree of mutual influence between the two.

However, the coupling degree model can not fully reflect the real coupling level between the two systems, that is, when the development level of rural tourism and smart housing in a region is low, it will also show a high degree of coupling. Therefore, this paper introduces the coupling coordination degree model to comprehensively assess the degree of coordinated development of rural tourism and smart housing [21]. The coupling coordination degree model is as follows:

$$D = \sqrt{C \times T}, T = \alpha U_1 + \beta U_2 \tag{13}$$

Where: D is the degree of coupling coordination, T is the comprehensive evaluation index of rural tourism and smart housing, α and β are parameters to be determined, $\alpha + \beta = 1$. According to the literature study, α and β take the value of 0.5.

Table 8. Coupling coordination level

Serial number	Coupling coordination degree(D)	Rank division	
1	0~0.09		Extreme dissonance
2	0.1~0.19		Severe disorder
3	0.2~0.29	Maladjustment	Moderate disorder
4	0.3~0.39		Mild disorder
5	0.4~0.49		On the brink
6	0.5~0.59		Grudging
7	0.6~0.69		Primary coordination
8	0.7~0.79	Coordination	Intermediate coordination
9	0.8~0.89		Good coordination
10	0.9~1		Quality coordination

4.3.2. Calculation of the degree of coupling coordination

According to the previous comprehensive evaluation results of smart housing and rural tourism in

Hainan Province, combined with the relevant formulas, the calculation can be obtained to coordinate the competitiveness coupling of tourism development in cities and counties in Hainan Province. Figure 4 shows the results of the coupling coordination degree calculation, the integrated coupling coordination degree of cities and counties and the comprehensive development level of smart housing rural tourism has a high degree of consistency, Sanya and Haikou have the highest degree of coupling coordination, respectively, 0.935 and 0.835, respectively, to achieve a high quality of coordination and good coordination, Wenchang, Lingshui, Chenggmai, Wanning, and Qionghai are in the second tier, while other cities and counties have poorer levels of coordination, and the degree of Ledong coordination only is 0.121, and the level of rural tourism development is far behind the level of smart housing development.

In general, except for Haikou and Sanya, other cities and counties in Hainan Province have a lower level of comprehensive development and coupling coordination of smart housing and rural tourism, indicating that the vast majority of cities and counties in Hainan Province have a low level of smart housing development and rural tourism development, and the two influence each other and constrain each other, which affects the coordinated development of smart housing and rural tourism.

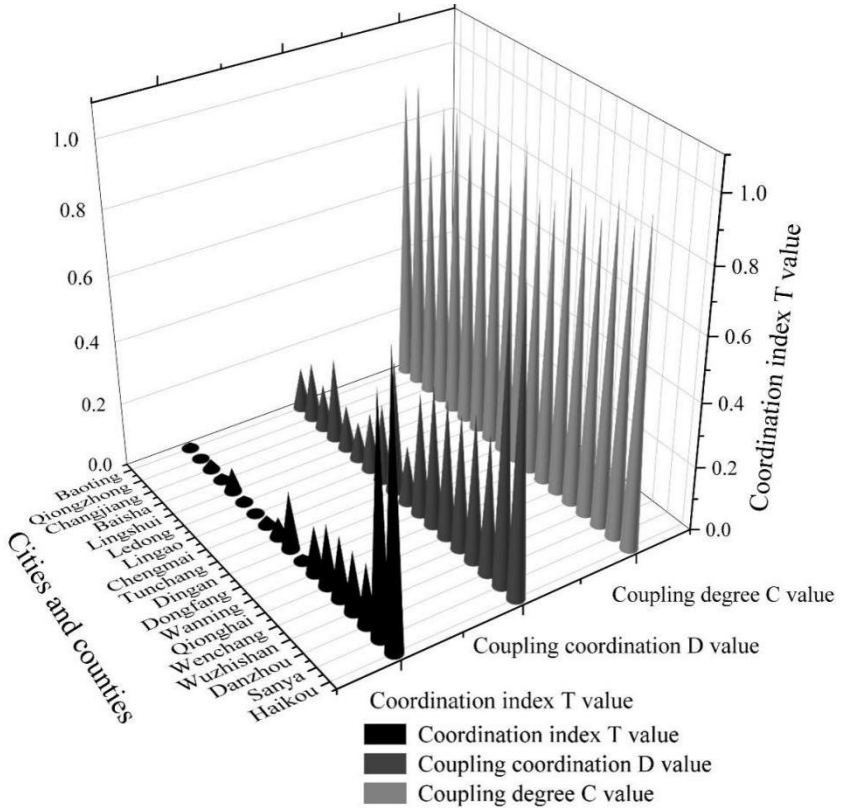

Figure 4. Coupling coordination results

4.4. Patterns and trends in spatial and temporal changes in coupling

4.4.1. Spatial and temporal changes

Figure 5 shows the spatio-temporal transformation of rural tourism and smart housing, during the period of 2013-2023, the distribution of the coupling degree of rural tourism and smart housing in each region of Hainan Province is relatively stable, and the average value of each region is in the antagonistic stage between 0.401 and 0.499.

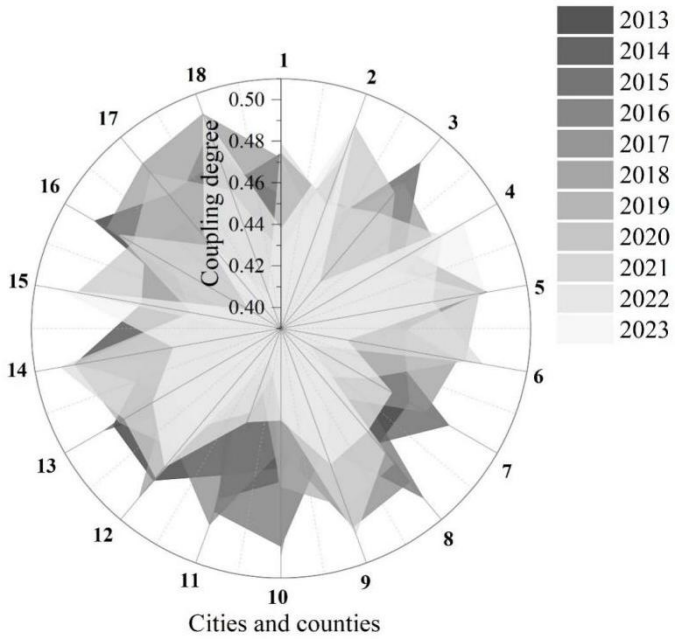

Figure 5. The spatial and temporal transformation of rural tourism and intelligent housing

4.4.2. Trends

Three years, 2013, 2018 and 2023, were selected to explore the spatial pattern and changing trend of the coupling coordination degree of rural tourism and smart housing in Hainan Province, and Figure 6 shows the changing trend of the coupling coordination degree of rural tourism and smart housing.In 2013, the coordination degree of smart housing in rural tourism resource integration (CCD) in Haikou City and Sanya City were 0.605 and 0.684, respectively, which were both were in primary coordination, Qionghai City and Wanning City were in mild dysfunction, Lingshui County and Wenchang City were in moderate dysfunction, Baisha County and Qiongzhong County were in extreme dysfunction, and the rest of the areas were in severe dysfunction. Among them, the level of coupling coordination in the eastern coastal areas of Hainan Province is higher than that of other areas.In 2018, the CCDs of Haikou and Sanya were 0.598 and 0.67, respectively, which were in the near-coordination and primary-coordination states; Qionghai and Wanning cities were in the mildly dysfunctional state; Lingshui County, Wenchang City, Danzhou City, and Chenggmai County were in the moderately dysfunctional state; Baisa County was in the extremely dysfunctional state; and the rest of the areas were in the severely The remaining areas are in a state of severe dislocation. The level of coupling coordination in the eastern and northern coastal areas of Hainan Province is higher than that of other areas, and in 2023, the coupling coordination degrees of Haikou City and Sanya City are 0.609 and 0.582 respectively, which are in the state of primary coordination and near-coordination, while the coupling coordination degrees of Qionghai City, Wanning City, Lingshui County, Wenchang City, Danzhou City, and Chenggmai County are in the state of moderate dysfunctions, the coupling coordination degree of Qiongzhong County is in the state of extreme dysfunction, and the rest of the areas are in the state of severe dysfunctions. The remaining areas are in a state of severe dislocation. The level of coupling coordination is higher in the eastern and northern coastal areas of Hainan Province than in other areas.

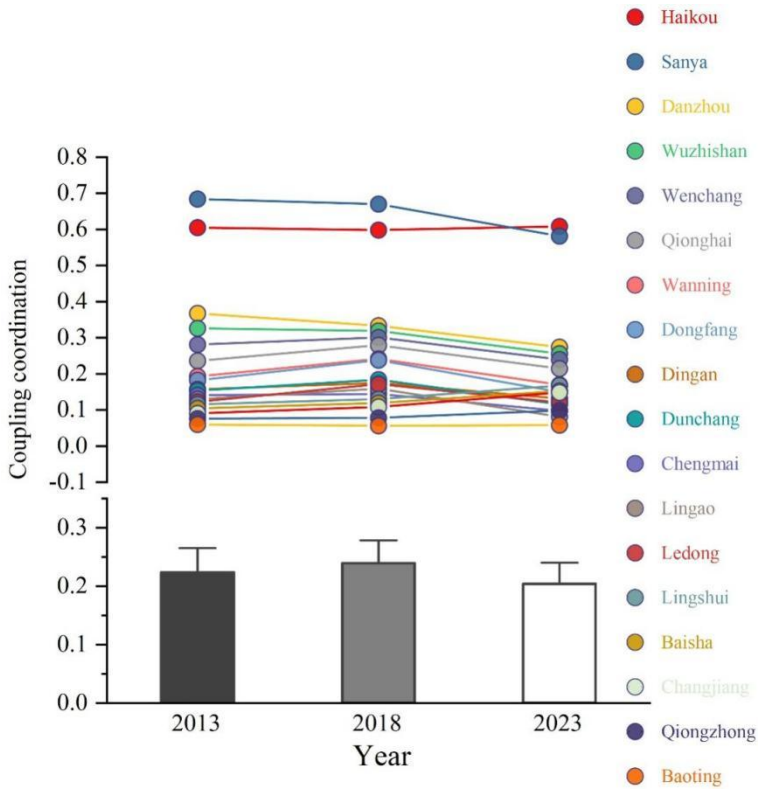

Figure 6. The trend of coupling coordination of rural tourism and intelligent housing

5. Countermeasures Suggestions for Sustainable Development of Rural Tourism Resources

5.1. Precise identification to capture key drivers

The coupling relationship between rural tourism and smart housing is a combination of multiple influencing factors, and its core driving factors must be grasped in order to realize the resource integration of the two. This paper suggests starting from the analysis of the interaction mechanism between the two industries, and puts forward policy recommendations to enhance the level of coupling between the two. First, strengthening the public service facilities of the two industries has strengthened the foundation of industrial development. In the new pattern of regional tourism development, the development of rural tourism requires high-quality public services to ensure that public transportation, education and medical care, etc., and tourism distribution and consulting can be provided for tourists, which is a prerequisite for the mutual coupling development of rural tourism and smart housing. Therefore, we should increase the investment in infrastructure and improve the function of transportation supporting services to enhance the comprehensive carrying capacity of the city, attract more users to participate in rural tourism and then drive the rapid development of smart housing. The second is to accelerate the construction of transportation, especially in the construction of railroads between different regions and the construction of highways in the region, tourism activities show significant heterogeneity, tourists must use transportation when conducting tourism activities, and the development of urban transportation helps to enhance the value of the surrounding properties. The booming development of transportation industry promotes both rural tourism and smart housing to drive the interpenetration of related industries to achieve multiple coupling. Therefore, transportation should be regarded as one of the basic conditions for the development of tourism smart housing, improve the infrastructure construction, strengthen the connection with other industries, build a diversified investment and financing system, and improve the investment efficiency. Thirdly, we should promote the integration of resources of the two industries to realize the synergistic development of the two industries and realize the synergistic development of the two industries. Fourthly, it is necessary to strengthen the operation of tourism real estate and increase the value-added rate of its products thereby improving its competitiveness in the international arena. The attraction of rural tourism projects to consumers is mainly reflected in the development of tourism resources. Integrate all aspects of local tourism resources so that they can realize deep-level integration, thus forming the core competitiveness

of the project.

5.2. Government-enterprise cooperation to create a win-win situation

Strengthening cooperation between the Government and developers to achieve mutual benefits and promote the healthy development of industries in both places. Both rural tourism projects and smart housing projects are aimed at obtaining a return on the developer's investment, contributing to the development of local rural tourism and the economy, and driving the catering, transportation, accommodation and other industries, which can not only enhance the local industry, but also alleviate the pressure on the employment of local residents, which is beneficial to both the government and the developer.

For smart housing developers, it is important to grasp the policy guidance of the central government on rural tourism and smart housing, which should be compatible with the development direction of the country from a macro perspective. At the same time, developers need to actively respond to market competition, improve their management level and professional and technical capabilities, and establish brand awareness. In addition, developers also need to have an in-depth understanding of local regional planning and industry development policies, should focus on the social benefits of the project in the initial planning, and strive to establish a good relationship with the enterprise, and strive for strong government support for the project.

For government agencies, it is important to play a pioneering role. On this basis, the relevant government departments should further strengthen their macro-management function to create a favorable environment for the linkage development of rural tourism and smart housing. On the one hand, the state should introduce corresponding policies to promote the development of rural tourism and smart housing, and provide strong policy guarantee and support for the development of rural tourism and smart housing. On the other hand, the government should give full play to its role in guiding and supervising at the macro level, coordinating and guiding the combination of tourism and smart housing, and dynamically monitoring the coupling status of the two industries and making timely interventions and adjustments, so as to better promote the coupling and coordinated development of the two.

6. Conclusion

In this paper, an empirical investigation is carried out on the status quo of rural tourism resources integration in the study area, the coupling mechanism between smart housing and rural tourism is proposed, and the corresponding coupling model is established. Sequentially using the gray correlation model and the coupling coordination model, respectively, to calculate the degree of correlation and coordination between the two.

(1) The current situation of resource integration for the sustainable development of rural tourism in Hainan Province can be seen that the proportion of resources increases from 13.03% in 2013 to 19.82% in 2023. The integrated development level of smart housing and rural tourism shows a trend of change that first increases and then decreases, with the highest proportion reaching 56.76% in 2021 and decreasing to 46.56% in 2023.

(2) The gray correlation between smart housing and rural tourism resources ranges from 0.68 to 0.91, in which the gray correlation between domestic tourism income and the value added of smart housing is 0.91, ranking first, and the economic benefits of smart housing and rural tourism converge.

(3) Comprehensive assessment of the development of rural tourism in the cities and counties of the study area, after the coupling degree of coordination calculation, we know that Sanya and Haikou cities have the highest degree of coupling and coordination, respectively, 0.935 and 0.835. In general, the vast majority of cities and counties in Hainan Province, the level of development of smart housing and the level of development of rural tourism are not high.

Therefore, for the problems of smart housing in the integration of rural tourism resources, two directions of sustainable development countermeasures are proposed.

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