Article

Examining the Relationship between Environmentally Friendly Land Use and Rural Revitalization Using a Coupling Analysis: A Case Study of Hainan Province, China

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Abstract: This paper explores the coupling relationship between land use and rural development to improve the environmentally friendly level of land use and attain accelerated rural revitalization. On the basis of the coupling framework, the quantitative study included the dimensionless method, the entropy method, and the coupling measure model with an empirical study in the Hainan province of China. Specifically, we evaluated levels of environmental friendliness and rural revitalization, and further calculated the coupling degree, coupling coordination degree, and the relative development degree between the two. Results demonstrated that (1) both the levels of environmentally friendly land use and rural revitalization showed an upward trend; (2) the coupling degree between environmentally friendly land use and rural revitalization was always at a high level; (3) the coupling coordination degree was improved from reluctant coordination to a quality coordination level; and (4) the relative development degree has changed since 2014, and environmentally friendly land use began to lag behind rural revitalization. This study contributes to the literature by integrating the coupling model into the relationship between land use and rural development, and the results of the article can provide a reference for China and other developing countries to coordinate land use and rural development.

Keywords: environmentally friendly land use; rural revitalization; coupling measure model; Hainan Province

1. Introduction

Rural development has drawn worldwide attention in recent years [1–3], especially in China since the rural revitalization strategy was proposed in the report at the 19th National Congress of China. As the space carrier for human social and economic activities, land plays an important role in rural revitalization. On the one hand, the flow of production factors and the response of actors in the process of rural revitalization will inevitably bring about changes in regional production, life, ecological spatial structure, and land use patterns. On the other hand, the transformation of land use patterns will directly or indirectly affect the implementation of rural revitalization. This shows that land use and rural development interact with and restrict each other. Exploring the coupling relationship between environmentally friendly land use and rural revitalization is important to promote

the coordinated development of the two and promote sustainable rural development. At the same time, both rural development and land use are important for developing countries that urgently need a good development model to coordinate the relationship between the two. This paper takes the Hainan province of China as an example to study the coupling relationship between environmentally friendly land use and rural revitalization, which can provide a reference for other developing countries where a similar development model may be applied.

The current research on environmentally friendly land use mainly focuses on the definition of concepts, the establishment of evaluation index systems, and the analysis of typical environmentally friendly land use patterns. Aside from this, the research objectives in the existing literature focus mostly on urban land rather than rural land. Research on environmentally friendly land use in rural areas mainly includes the following two aspects: innovation of environmentally friendly agricultural production technology [4–6] and research on the attitudes, willingness, and influencing factors of environmentally friendly agricultural production methods from the perspective of farmers [7–10]. Most of the research on rural revitalization from the perspective of land is centered on land remediation and rural land policy reform. Liu [11] explained the importance of rural revitalization in China and the challenges of land use sustainability. Hamilton [12] also believed that rural land resources should be used as the basis for rural economic development in America. Pašakarnis et al. [13] pointed out that land consolidation is an essential tool in the creation of sustainable rural areas. Long et al. [14] explained the connotation of rural revitalization and land remediation and their mutual feeding relationship and proposed the regional implementation path of land remediation in the context of rural revitalization. Zhao [15] believed that promoting the reform of rural land policy laid a good foundation for the implementation of a rural revitalization strategy. Chen et al. [16] and Du et al. [17] demonstrated, theoretically, that improving the land policy system is the key to promoting rural revitalization, providing suggestions for rural land policy reform. Zhang [18] proposed the institutional innovation of rural revitalization in three ways: deepening rural system reform, perfecting modern agricultural management systems, and steadily promoting the reform of the rural collective property rights system. Some studies have analyzed the relationship between rural development and land use. Chang [19] proposed that environmentally friendly land use and new rural construction are mutually reinforcing and consistent. Long et al. [20] analyzed the relationship between land use transformation and rural revitalization and proposed that the land use transformation path in rural revitalization mainly includes reconstructing rural production space to achieve industrial revitalization, reconstructing rural ecological space to achieve ecological revitalization, and reconstructing rural living space to achieve organizational and cultural revitalization. Park [21] studied environmentally friendly land use planning with greenbelt policy reform in South Korea as an example. Jansen et al. [22] applied a quantitative livelihood approach to analyze the relationship between rural development policies and sustainable land use by taking the hillside areas of Honduras as an example. Zhang et al. [23] studied the coordinated evaluation of rural transformation development and land use transformation and quantitatively evaluated coordination degree between rural transformation development and land use transformation using data for Anhui Province.

The literature review results show that, in terms of research content, systematic research on the relationship between land use and rural development is relatively rare. In terms of research perspectives, studies on environmentally friendly society and land use mostly take cities as research areas rather than rural areas, and the research on rural development mostly uses micro-studies at the village level, which cannot reflect the overall level of the region. In terms of research method, the research on land use and rural development is mostly theoretical research, which needs to be verified by quantitative analysis. This paper studies the coupling relationship between environmentally friendly land use and rural revitalization, which fills the academic gap to some extent. Compared with the existing research, this article takes Hainan Province as the research unit, and the research scope extends from a village-level unit to a provincial unit to reflect the overall regional situation. On the basis of a theoretical framework, the relevant index system was constructed to quantitatively analyze

the level of environmentally friendly land use in rural areas, the level of rural revitalization, and the change of the coupling relationship between the two using data from 2010–2017 in Hainan Province, China. This study provides a theoretical basis and data support for the development of a coordinated development strategy for environmentally friendly land use and rural revitalization and provides an experience for other developing countries to achieve sustainable rural development.

2. Theoretical Framework

2.1. Definitions

Environmentally friendly land use refers to land use patterns that aim at environmental–economic–social coordinated development [24], save and intensively utilize land resources, improve land use efficiency, promote the transformation of traditional production technologies into environmentally friendly technology, protect and improve the ecological environment [25], and achieve regional sustainable development.

Rural revitalization is a macro, systematic, and comprehensive development strategy [26]. The goals include adhering to the priority development of agriculture and rural areas, accelerating the modernization of agriculture and rural areas [27], and establishing and improving the policy system for the integration of urban and rural development in accordance with the requirements of industrial prosperity, ecological livability, rural civilization, effective governance, and affluent life.

Coupling was originally a physics concept and describes the phenomenon that occurs when two or more things or movement forms interact with each other with a certain regularity. This phenomenon is also called a coupling relationship [28]. The coupling framework is used to study the relationships between different systems in many fields, especially in research on the relationship between urbanization and the environment [29–31]. On this basis, this paper defines the relationship between environmentally friendly land use and rural revitalization (the two systems) through their respective elements (subsystems) to interact with each other as the coupling relationship of environmentally friendly land use and rural revitalization.

2.2. Theoretical Framework

As stated before, a mutual interaction relationship exists between the two systems of environmentally friendly land use and rural revitalization. As detailed below, to further theoretically demonstrate the relationship between the two systems, this article refers to a previous research framework [32] to include three dimensions: connotation of the two systems [26,33–35], modes of implementing the two systems [36,37], and goals of having environmentally friendly land use and rural revitalization [27,38,39], then constructing the theoretical framework of the coupling relationship between environmentally friendly land use and rural revitalization.

Through an in-depth analysis of the connotation, mode, and goals of environmentally friendly land use and rural revitalization, it is found that the two systems of environmentally friendly land use and rural revitalization are mainly represented by the relationship between means and goal. Environmentally friendly land use is a means, and rural revitalization is a goal. Their essences are complementary and mutually reinforcing. Environmentally friendly land use is conducive to optimizing rural land layout; the intensive use of land; and realizing the unification of the ecological, economic, and social benefits of land, then promoting the implementation of rural revitalization. At the same time, rural revitalization has guided and promoted the realization of environmentally friendly land use and has provided economic, technical, and management foundations in the process of environmentally friendly land use. On the basis of system theory, synergy theory, and sustainable development theory, we can demonstrate the coupling relationship between the two in terms of connotation coupling, mode coupling, and goals coupling. The theoretical framework of the coupling relationship between environmentally friendly land use and rural revitalization is as follows (Figure 1).

Figure 1. Theoretical framework diagram of the coupling relationship between environmentally friendly land use and rural revitalization.

2.2.1. Connotation Coupling

The connotation of environmentally friendly land use includes optimizing the structure and layout of land use, intensive use of land, adopting modern science and technology to realize land sustainable development, and achieving a coordinated development of environment–economy–society.

The connotation of rural revitalization includes promoting agricultural modernization; constructing a modern agricultural industrial system, production system, and management system; cultivating new agricultural management entities; improving the agricultural socialized service system; and realizing the connection between small farmers and modern agricultural development. It also includes implementing the new development concept of “innovation, coordination, green, openness, sharing”, thereby improving the rural governance system by combining self-management, the rule of law and rule of virtue, and helping rural culture prosper.

Through the comparative analysis of the connotation of environmentally friendly land use and rural revitalization, it is found there is a connotational coupling between environmentally friendly land use and rural revitalization. Environmentally friendly land use can help promote agricultural modernization, and rural modernization can help achieve environmentally friendly land use. Optimizing the structure and layout of rural land and adopting modern science and technology will help to build a modern agricultural industrial system, production system, and management system. Thus, promoting modern science and technology and the idea of intensive land use is conducive to cultivating new agricultural management entities and realizing the connection between small farmers and modern agricultural development. Furthermore, modern science and technology, land sustainable development, and the ecological benefits of land use have implemented the new development concept of “innovation, coordination, green, openness, and sharing”. Finally, the improvement of the rural governance system and the prosperity of rural culture contribute to the coordinated development of the environment–economy–society.

2.2.2. Mode Coupling

This section demonstrates the mode coupling of environmentally friendly land use and rural revitalization from financing, implementation, public participation, management, and technology.

- Financing model coupling. The financing models of environmentally friendly land use and rural revitalization generally include government investment, enterprise investment, and farmer investment. The capital benefits of their investments are finally reflected in rural revitalization.
- Implementation mode coupling. The implementer of environmentally friendly land use and rural revitalization is consistent, generally including districts, towns, villages, enterprises, and individuals. It can facilitate the coordinated development of the two.
- Public participation model coupling. Public participation is required in the process of both environmentally friendly land use and rural revitalization. It can be divided into partial participation and whole process participation. The effect of the whole process is better than that of partial participation.
- Management mode coupling. Scientific planning management is necessary for both environmentally friendly land use and rural revitalization. There are certain similarities in these procedures, including preparation management, approval management, and implementation management. Judging from the principle requirements of the two, we must follow the requirements of “government guidance, mass voluntary, encourage participation, guarantee democracy, scientific planning, overall coordination; respect the law, adapt to local conditions; highlight key points and implement step by step”. Further, both environmentally friendly land use planning and rural revitalization planning must be carried out under the overall local planning of economic and social development.
- Technology mode coupling. Environmentally friendly land use can be achieved through land use planning, land suitability evaluation, land use control, and other technologies. The realization of rural revitalization relies on agricultural production technology, village construction technology, infrastructure construction, and ecological environment optimization. Furthermore, land use planning, land suitability evaluation, land use control, and land use structure adjustment can support village construction technology and infrastructure construction. Strengthening land control and protecting ecological land and ecological agriculture is conducive to optimizing the ecological environment. Therefore, environmentally friendly land use and rural revitalization are closely linked and highly coupled in the technology model.

2.2.3. Goals Coupling

Environmentally friendly land use has the goals of ecological, economic, and social benefits. Rural revitalization has the requirements and goals of industrial prosperity, ecological livability,

rural civilization, effective governance, and affluent life. Therefore, the goals coupling is expressed as the coupling of ecological benefits and ecological livability, the coupling of economic benefits with industrial prosperity and affluent life, and the coupling of social benefits with rural civilization and effective governance.

- The coupling of ecological benefits and ecological livability. In terms of the natural environment, both must be environmentally oriented in the land use process; strengthen the prevention and control of land pollution; and achieve the green development of industry, the sustainable use of land, and the balance of the ecosystem. In terms of the living environment, rural revitalization emphasizes a people-oriented approach and improves the rural living environment through infrastructure construction. Environmentally friendly land use utilizes the development of science and technology to improve land carrying capacity and ecological environment capacity. The ultimate goals of both are to achieve a livable living environment.
- The coupling of economic benefits with industrial prosperity and affluent life. First, the idea of land use is the same, as both require the rational allocation of land resources to build a modern agricultural production and management system, engage in intensive use of land, and improve land use efficiency. Secondly, from the perspective of industrial development, the two are mutually reinforcing and complement each other. Guiding farmers to start employment and entrepreneurship will inevitably involve the development of new industries and new business forms, thus promoting the adjustment of the rural industrial structure. Environmentally friendly land use emphasizes optimizing the industrial layout and improving the village's infrastructure construction, which is conducive to the sustainable development of the rural economy and the improvement of farmers' income levels and quality of life.
- The coupling of social benefits with rural civilization and effective governance. The pursuit of social benefits by environmentally friendly land use and the requirement of rural civilization and effective governance by rural revitalization are coordinated and complement each other. On the one hand, the realization of environmentally friendly land use necessarily involves the dissemination and practice of environmental protection concepts, clearing up some obstacles for the construction of rural civilization, and the provision of experience. Issues such as tenure disputes arising in the process of land use require the management and mediation of grassroots organizations, which can promote the improvement of the governance capacity of grassroots organizations. On the other hand, the inheritance and development of excellent rural culture and the improvement of rural grassroots governance capacity are conducive to improving farmers' willingness to accept environmentally friendly land use.

3. Materials and Methods

3.1. Study Area

Hainan Province is located in the southernmost part of China and is bordered by the Qiongzhou Strait and Guangdong Province in the north. It has a tropical monsoon climate and abundant natural resources. Its terrain is high in the middle and low in the surrounding area. Mountains, hills, terraces, and plains form an annular layered landform, and its step structure is obvious. Hainan Province has jurisdiction in over 19 cities and counties, including 4 prefecture-level cities, 5 county-level cities, 4 counties, and 6 autonomous counties. As of the end of 2017, there were 18,685 natural villages in the province. The study area was set to 18 cities and counties in Hainan Province (excluding Sansha City). According to the land change survey data in 2017, the construction land area of 18 cities and counties (excluding Sansha City) in Hainan province accounts for 9.8% of the total land area, and the agricultural land area accounts for 84.3% of the total land area.

3.2. Data Source and Data Pre-Processing

The study intended to analyze the level of rural land use and the level of rural revitalization since the construction of the International Tourism Island in Hainan Province in 2010. The data used were downloaded from the online version of the Hainan Statistical Yearbook (2011–2018), China Rural Statistical Yearbook (2011–2018), China Statistical Yearbook (2011–2018), China Environmental Statistics Yearbook (2011–2018), China Forestry Statistical Yearbook (2011–2016), China Agricultural Machinery Yearbook (2011–2017), Report on the Work of Hainan Province Government (2011–2018), Statistical Communique of the Hainan Province on the National Economic and Social Development (2010–2017), Water Resources Communique of Hainan Province (2011–2018), and Environmental Status Communique of Hainan Province (2011–2018), among others.

We can divide the evaluation indicators into two categories. Positive indicators are the indicators in which the larger the index value, the better the evaluation result, including the surface water quality compliance rate and the forest disease prevention rate. Negative indicators are indicators with smaller index values and better evaluation results, such as the proportion of crops affected by wind and flood disasters and land desertification areas. Because there are differences in both the dimension and the magnitude of each of the selected indicators, the data need to be normalized. Referring to existing research [40], the formulas of the dimensionless method for different types of data are shown in Equations (1) and (2):

$$\text{Positive indicator : } X'_{ij} = \frac{X_{ij} - \min\{X_j\}}{\max\{X_j\} - \min\{X_j\}} \quad (1)$$

$$\text{Negative indicator : } X'_{ij} = \frac{\max\{X_j\} - X_{ij}}{\max\{X_j\} - \min\{X_j\}} \quad (2)$$

where X'_{ij} denotes the normalized value of indicator j in year i , X_{ij} is the original value, and $\max\{X_j\}$ and $\min\{X_j\}$ represent the maximum and minimum values of the indicator j in all of the years studied.

3.3. Method

Given the limitations mentioned earlier on rural development study cases and the general reduced accessibility data in this field, the evaluation of the environmentally friendly level of land use and rural revitalization level was used to measure the friendliness of land use and the revitalizing effect. In reference to the studies on the coupling relationship between urbanization and environment [28,30], the method used to quantify the relationship in this article was considered to be applicable. In reference to the study on coupling relationship modeling between land consolidation and new countryside construction [32], the coordination of coupling components (connotations, mode, and goals) can measure the coupling relationship between the environmentally friendly land use and rural revitalization. The methods of evaluation of the environmentally friendly level of rural land use, the evaluation of rural revitalization level, calculation of the coupling degree between environmentally friendly land use, and rural revitalization are explained below.

3.3.1. Indexes System

According to the concept and connotation of environmentally friendly land use, following scientific principles, comprehensive principles, purposeful principles, operability principles, comparability principles, and hierarchical principles [41], and on the basis of existing studies [42–44], this section establishes an evaluation index system for the environmentally friendly level of rural land use. This index system was divided into four levels: the goals layer, the criteria layer, the indicator layer, and the meta-index layer (Table 1).

Table 1. Index system for the environmentally friendly level of rural land use.

System	Primary Indicators	Secondary Indicators	Meta Indicators
Environmentally friendly level of rural land use	Ecological environment	Environmental pressure	Fertilizer used per unit of cultivated land
			Pesticides used per cultivated land area
			Plastic film used per cultivated land area
			Area of land desertification
			Area affected by wind and flood disasters
			Population density
		Ecological environment quality	Compliance rate of surface water quality
			Proportion of days with air quality above the second level
			Rate of forest cover
			Proportion of wetland area
		Environmental governance	Rate of forest disease prevention
			Rate of industrial solid waste disposal and utilization
			Proportion of investment of energy saving and environmental protection to GDP
			New area of soil erosion control
			Afforestation area of the project to return farmland to forests
			Area of nature reserve
	Land resource use	Land use benefit	Food possession per capita
			Ratio of agricultural input–output per unit area
			Investment of agricultural machinery per cultivated land area
			Index of multiple cropping
			Proportion of effective irrigation area of farmland
		Land use structure	Elastic coefficient of the area growth of construction land
			Index of land management diversity
			Rate of land reclamation
	Economic and social development	Economic development level	Disposable income per peasant
			Engel coefficient
			Proportion of value-added agriculture to GDP
		Social development status	Living area per capita in rural
			Index of urbanization level
			Proportion of students of working age
			Number of beds in the township hospital per thousand agricultural population

According to the overall requirements of the rural revitalization strategy, following the relevant principles, and referring to previous studies [45–49], an evaluation index system for rural revitalization level was constructed. This index was also divided into four levels (Table 2).

Table 2. Index system for rural revitalization.

System	Primary Indicators	Secondary Indicators	Meta Indicators
Rural revitalization	Industrial prosperity	Rural industrial structure	Proportion of non-agricultural output value to gross output value
			Proportion of non-agricultural industry practitioners to total laborers
		Agricultural development level	Investment of agricultural machinery per cultivated land area
			Gross output value of agriculture, forestry, animal husbandry, and fisheries
			Ratio of agriculture, forestry, and water expenditure to total expenses
			Proportion of effective irrigation area of farmland
	Ecological livability	Livable natural environment	Proportion of days with air quality above the second level
			Rate of forest cover
		Livable artificial environment	Total gas production from biogas digesters
			Number of civilized ecological villages
	Rural civilization	Civilized rural style	Popularity rate of rural sanitary toilets
			Proportion of science, education, and entertainment expenditure
		Cultural facilities construction	Rate of illiteracy
			Number of rural cultural stations
	Effective governance	Governance effectiveness	Number of computers per 100 households
			Number of people out of poverty
	Affluent life	Life quality of farmers	Number of renovated dangerous houses
			Engel coefficient of rural households
			Living area per capita in rural
		Rural public health and social security	Ratio of urban and rural residents' income
			Participation rate of new rural cooperative medical insurance
			Number of rural minimums Living standard guarantee
			Proportion of villages with health rooms

3.3.2. Evaluation Model

The entropy method was used to determine the index weight, which is an objective weighting method that determines the weight of an indicator on the basis of the size of the information provided by the observations of each indicator. It is widely used to determine the weight of indicators in the environmental field [50,51]. After determining the weight and processing data to be nondimensionalized, we utilized the multi-objective linear weighting method to establish a comprehensive evaluation model [52], as shown in Equations (3) and (4).

Evaluation model of the environmentally friendly level of land use:

$$P = \sum_{j=1}^n w_j \times X'_{ij} \quad (3)$$

where P represents the comprehensive evaluation value of the environmentally friendly level of land use, W_j denotes the weight of the indicator j , X'_{ij} is the standard value after dimensionless processing, and n is the number of indicators in the indicator system.

Evaluation model of the rural revitalization level:

$$L = \sum_{j=1}^n w_j \times X'_{ij} \quad (4)$$

where L represents the comprehensive evaluation value of the rural revitalization level, W_j denotes the weight of the indicator j , X'_{ij} is the standard value after dimensionless processing, and n is the number of indicators in the indicator system.

3.3.3. The Coupling Measure of Environmentally Friendly Land Use and Rural Revitalization

Environmentally friendly land use and rural revitalization influence and interact with each other. The environment–economic–society comprehensive benefits generated by the two depend on the degree of the coordinated development between the two. Measuring the coupling degree, coupling coordination degree and relative development degree of the level of environmentally friendly land use and rural revitalization level can reveal the coupling coordination stage and development regularity of the two in the region and provide a reference for the implementation of the rural revitalization strategy.

- **Coupling degree.** A coupling degree was used to describe the influence level of the interaction between systems or elements. According to the coupling concept and coupling model in physics, and drawing on Liao's measurement model [53], the formula for the coupling degree of the environmentally friendly level of land use and the rural revitalization level is given as follows:

$$C = \left\{ \frac{P \times L}{[(P + L)/2]^2} \right\}^k \quad (5)$$

where P and L represent the comprehensive evaluation value of the environmentally friendly level of land use and the rural revitalization level, respectively, and C is the coupling degree between environmentally friendly land use and rural revitalization. The value range of C is 0–1. The larger the C value, the closer the relationship between the two systems, and the greater the mutual influence.

According to previous studies [54], the coupling degree can be divided into four sections: when $0 < C < 0.3$, there is a low-level coupling relationship between environmentally friendly land use and rural revitalization, and the interdependence between the two is weak; when $0.3 < C < 0.5$, the two systems have a middle-level coupling relationship, and when the land use tends to be environmentally friendly, the economic, social, and environmental benefits of the rural revitalization are highlighted; when $0.5 < C < 0.8$, the coupling state of the two systems is gradually optimized and enters the running-in period. The improvement of land use patterns and land use structure plays an important role in the process of rural revitalization, and the two systems begin to be positively coupled; when $0.8 < C < 1.0$, the two systems continue to strengthen their contact, promote and develop each other, and achieve a high level of coupling.

- **Coupling coordination degree.** In the evaluation of the coupling degree, the development level of both subsystems may be low, but the overall coupling degree will be high. To avoid similar “pseudo-coordination” phenomena, it was necessary to further evaluate the coupling coordination degree of the two. Coupling coordination is a benign interconnection between two or more systems or system elements and is a relationship of proper cooperation, harmony, and benign circulation. The coupling coordination degree formula [53] can be used to reflect the coordination relationship between environmentally friendly land use and rural revitalization:

$$T = \alpha P + \beta L \quad (6)$$

$$D = \sqrt{C \times T} \quad (7)$$

where T represents a comprehensive evaluation index of environmentally friendly land use and rural revitalization, and α and β are undetermined coefficients, and $\alpha + \beta = 1$. This study assumed that environmentally friendly land use was of equal importance to rural revitalization, with an assignment of $\alpha = \beta = 0.5$. D is the coupling coordination degree. The larger the D value, the higher the coordination level of environmentally friendly land use and rural revitalization, and vice versa. Referring to the existing research [53] in combination with the actual situation in Hainan, the classification criteria and coordination level types of environmentally friendly land use and rural revitalization were given (Table 3).

Table 3. The level of the coupling coordination degree.

Coupling Coordination Degree	Coordination Level	Coupling Coordination Degree	Coordination Level
0–0.09	Extreme imbalance	0.5–0.59	Reluctant coordination
0.1–0.19	Serious imbalance	0.6–0.69	Primary coordination
0.2–0.29	Moderate imbalance	0.7–0.79	Intermediate coordination
0.3–0.39	Mild imbalance	0.8–0.89	Good coordination
0.4–0.49	On the verge of imbalance	0.90–1	Excellent coordination

Relative development degree. To reflect the relative development level of environmentally friendly land use and rural revitalization, the formula for the relative development degree [55] is given as follows:

$$E = \frac{P}{L} \quad (8)$$

where E presents the relative development degree of environmentally friendly land use and rural revitalization. When $E < 1$, rural revitalization was ahead of development. When $E = 1$, the two developed synchronously. When $E > 1$, rural revitalization lagged.

4. Results and Suggestions

4.1. Evaluation of the Environmentally Friendly Level of Land Use

Adopting the index system of Table 1 in Section 3.3.1, which is constructed on the basis of the existing literature [42–44] and the actual situation of Hainan, determining the index weight of the level of environmentally friendly land use by the entropy method, and using Equation (3) to calculate the score for the ecological environment status, the score of land resource utilization level, the score of economic and social development status, and the comprehensive score of the level of environmentally friendly land use in Hainan province from 2010 to 2017. The results were as follows (Table 4).

Table 4. The scores of the level of environmentally friendly land use in Hainan Province.

Year	Ecological Environment	Land Resource Utilization Level	Economic and Social Development Status	The Level of Environmentally Friendly Land Use
2010	0.5603	0.5189	0.2757	0.4315
2011	0.3020	0.5432	0.2787	0.3429
2012	0.3451	0.5132	0.3655	0.3890
2013	0.5038	0.4265	0.4022	0.4447
2014	0.2438	0.6261	0.5772	0.4649
2015	0.2997	0.4929	0.5113	0.4297
2016	0.6354	0.4334	0.7151	0.6266
2017	0.6785	0.5691	0.9343	0.7635

The comprehensive evaluation results show that the score of the level of rural environmentally friendly land use in Hainan Province in 2017 was 0.76, which was at the upper-middle level. The ecological environment and land resource utilization levels were in the middle stage, with scores of 0.67 and 0.57, respectively, and the economic and social development is in good condition, with a score of 0.93. On the basis of the results of the past years, the level of rural environmentally friendly land use in Hainan province was generally on the rise from 2010 to 2017 (Figure 2).

Figure 2. Trends in the evaluation of the level of rural environmentally friendly land use in Hainan province from 2010 to 2017.

From the three sub-indicators, the scores of the ecological environment in the rural areas of Hainan Province generally showed an upward trend but declined in 2011 and 2014, independently, in different degrees. Further analysis of the data for the meta-index layer found that the environmental pressures in rural areas of Hainan Province were relatively large, and environmental governance efforts were reduced in 2011, mainly regarding the increase of pesticides used per unit of cultivated land, serious crop damage by wind and flood disaster, the lower compliance rate of surface water quality, and the decline of the forest disease prevention rate and industrial solid waste disposal rate. In 2014, the use of pesticides and fertilizers per unit of cultivated land, the population density, and the increase in the area of crops damaged by wind and flood disasters led to an increase in environmental pressure. Indeed, the intensity of environmental governance is decreasing, mainly in terms of the reduction of the rate of industrial solid waste disposal and utilization, the area of soil erosion control, the afforestation area (for the returning farmland to forest project), and the proportion of investment in energy-saving and environmental protection for the GDP.

The utilization of land resources has been at a medium level and the fluctuation range was shown to be small, but the efficiency of land use and the level of intensive use of land were shown to be low. Further analysis of the data of the past eight years, the possession of food per capita, and the multiple cropping index showed a downward trend, wherein the index of land management diversity fell sharply. The ratio of agricultural input–output per unit area and the elastic coefficient of growth of construction land also had a large fluctuation range and showed no growth trend.

The sustainable development trend of rural economy and society is obvious. Economic and social conditions have improved greatly in the past eight years, and the overall trend is on the rise.

4.2. Evaluation of Rural Revitalization Level

Similarly, the index system of Table 2 in Section 3.3.1 was adopted, which was constructed on the basis of previous literature [45–49] and the requirements of the rural revitalization strategy. The entropy

method was also used to calculate the weight value of the index of the rural revitalization level and Equation (4) was used to calculate the scores of industrial prosperity, ecological livability, rural civilization, effective governance, affluent life, and the comprehensive score of the rural revitalization level in Hainan Province for 2010–2017. The results are as follows (Table 5).

Table 5. The scores of the rural revitalization level in Hainan Province for 2010–2017.

Year	Industrial Prosperity	Ecological Livability	Rural Civilization	Effective Governance	Affluent Life	Rural Revitalization
2010	0.0787	0.2664	0.5186	0.2922	0.1096	0.2424
2011	0.0952	0.4061	0.4136	0.2299	0.1787	0.2492
2012	0.3862	0.5255	0.3085	0.7631	0.2366	0.4462
2013	0.6373	0.6338	0.4204	0.1723	0.3656	0.4134
2014	0.7289	0.5639	0.7629	0.2661	0.6725	0.5827
2015	0.7307	0.5489	0.4979	0.5692	0.7515	0.6302
2016	0.7688	0.7278	0.5481	0.8945	0.8581	0.7789
2017	0.9639	0.7698	0.8766	0.9373	1.0000	0.9244

The comprehensive evaluation results show that the implementation of rural revitalization in Hainan Province in 2017 was good, with a composite score of 0.92. Among the selected factors, ecological livability and rural civilization construction need to be further strengthened. Judging from the results of the past year, the rural revitalization level in Hainan province from 2010 to 2017 was generally on the rise and accelerated slightly since 2014 (Figure 3).

Figure 3. Trends of the rural revitalization level in Hainan Province for 2010–2017.

The scores of the five sub-indicators generally showed an upward trend from 2010 to 2017. The scores of the indicators of rural civilization and effective governance fluctuated greatly, the scores of industrial prosperity and affluent life indicators increased significantly, and the status of ecological livability has been shown to be improving. Further analysis of the meta-indicator data is as follows.

The change of the indicator ‘industrial prosperity’ can be divided into three phases. The period of 2010–2011 was a period of slow growth. On the other hand, 2011–2013 was an accelerated growth period, which may have been due to the economic development brought about by the construction of international tourism islands in Hainan Province, which have promoted the development of rural industries, such as tourism, and promoted the employment and income of farmers. The years of 2013–2017 were a stable growth period, which may have been due to the significant growth of the proportion of non-agricultural industry practitioners to total laborers; investment of agricultural

machinery per cultivated land area; and the ratio of agricultural, forestry, and water expenditure to total expenses.

The change of the indicator ‘ecological livability’ can be divided into three phases. The period from 2010 to 2013 was rising and featured a faster rate of growth; the ecological quality declined from 2013 to 2015, mainly due to a slight decrease in air quality; and 2015–2017 was a rising phase (but with reduced speed). This increase mainly manifested in the improvement of the rate of forest cover, the total gas production from biogas digesters, the number of civilized ecological villages, and the popularity rate of rural sanitary toilets.

The changes in the indicator ‘rural civilization’ can be divided into four phases. In 2010–2012, the score of rural civilization declined year by year, according to the data of the meta-indicators, and the consumption of science, education, and entertainment by farmers decreased significantly in the previous three years; it gradually increased in 2012–2014 and significantly declined in 2014–2015, during which the number of township cultural stations also decreased. The upward trend resumed in 2015–2017, and the rate of increase accelerated because of the increase in the proportion of science and education entertainment expenditures and the number of township cultural stations, as well as the reduction of the illiteracy rate.

The change of the indicator ‘effective governance’ can be divided into two phases. The first was the volatility period from 2010 to 2013, which may have been limited by the different capital investments each year and the lack of attention to the countryside. The second was the stable growth period of 2013–2017, which benefited from the stable development of Hainan’s economy on the one hand, and on the other hand, the effective rural construction and precise poverty alleviation strategy proposed by the state in 2013, increasing the emphasis on rural development and providing financial and policy guarantees for rural development.

The indicator “affluent life” is generally on the rise. This is mainly due to the good operation of the province’s macroeconomy, as urban development drives the rural economy.

4.3. Coupling Analysis of Environmentally Friendly Land Use and Rural Revitalization

Using Equations (5)–(8), we measured the coupling degree, coupling coordination degree, and relative development degree of the level of rural environmentally friendly land use and the rural revitalization level in Hainan Province from 2010 to 2017 (Table 6).

Table 6. Coupling results of environmentally friendly land use and rural revitalization in Hainan Province from 2010 to 2017.

Year	Coupling Degree	Coordination Degree	Coordination Level	Relative Development Degree	Type of Development
2010	0.8487	0.5348	Reluctant coordination	0.5619	Rural revitalization lag
2011	0.9505	0.5305	Reluctant coordination	0.7269	Rural revitalization lag
2012	0.9906	0.6432	Primary coordination	1.1471	Environmentally friendly land use lag
2013	0.9973	0.6541	Primary coordination	0.9296	Rural revitalization lag
2014	0.9749	0.7146	Intermediate coordination	1.2534	Environmentally friendly land use lag
2015	0.9297	0.7019	Intermediate coordination	1.4667	Environmentally friendly land use lag
2016	0.9767	0.8284	Good coordination	1.2431	Environmentally friendly land use lag
2017	0.9819	0.9103	Excellent coordination	1.2107	Environmentally friendly land use lag

The coupling degree of environmentally friendly land use and rural revitalization in Hainan Province was always at a high level from 2010 to 2017, although there was a small fluctuation in 2014 and 2015. This fluctuation was mainly affected by the increase in the areas affected by wind and flood disasters and the increase of environmental pressures in the year, which led to a decrease in the level of environmentally friendly land use and a slight decrease in the coupling degree with the level of rural revitalization (Figure 4).

Figure 4. Trend of the coupling relationship of environmentally friendly land use and rural revitalization in Hainan Province from 2010 to 2017.

The coupling degree of environmentally friendly land use and rural revitalization in Hainan Province was on the rise in 2010–2017, and the level significantly improved, from a reluctance coordination level in 2010 to an excellent coordination level in 2017. Combined with the change of the coupling degree between the two, it can be seen that the coupling relationship between environmentally friendly land use and rural revitalization in Hainan Province continuously improved.

From the perspective of the relative development degree, there was mainly a rural revitalization lag before 2014. The development of rural revitalization accelerated rapidly after 2014, and then remained stable after a small break, expressed as the environmentally friendly land use lag. The reasons for this result may be related to the implementation of the country building and precise poverty alleviation policies in 2013, at which point all sectors of society paid more attention to rural development, and funding and policy support for rural development increased significantly. The relative development degree gradually declined from 2015 and is approaching 1. It is predicted that the two will soon enter the coordinated development stage.

4.4. Suggestions

As shown by the calculation of relative development degree, environmentally friendly land use is lagging behind rural revitalization. On the one hand, to promote the simultaneous development of environmentally friendly land use and rural revitalization, Hainan province can focus on strengthening the promotion of environmentally friendly land use methods while vigorously promoting the implementation of the rural revitalization strategy. On the other hand, to maintain a high-level coupling relationship between the two and further improve the coupling coordination degree, the development level of rural revitalization needs to be maintained or improved further, and the goals of rural revitalization need to be fully realized. We can propose the following two aspects through meta-indicator analysis:

4.4.1. Improve the Ecological Environment and Optimize Land Resource Utilization

As shown in the evaluation results of the environmentally friendly level of land use, the scores of the ecological environment and land resource utilization levels are not in good condition, which means we need to improve the two aspects. Through the analysis of the meta-indicator data, we can get the following suggestions. First, we need to reduce pressures on the rural environment. This includes controlling the use of pesticides, fertilizers, and plastic films; improving soil quality; strengthening the prevention of wind and flood disasters; and increasing compensation for affected agricultural land. Second, we need to improve the ecological environment of rural human settlements. This includes paying attention to the treatment and prevention of pollutants, accelerating the full coverage of rural sanitation and sanitary latrines, improving the treatment capacity of domestic garbage and domestic sewage, and prohibiting the transfer of industrial and urban pollution to agricultural and rural areas. Third, we need to increase environmental governance. This includes increasing financial support such as providing special subsidies for environmentally friendly land use, increasing efforts to control soil erosion, promoting the implementation of afforestation projects in an orderly manner, and increasing the rate of forest disease prevention and control. Fourth, we need to improve the efficiency of land use. This includes strengthening infrastructure construction, such as farmland water conservancy, to promote agricultural scale development; increasing investment in agricultural machinery to increase land production capacity; and innovating agricultural technology to increase the land output rate.

4.4.2. Build Ecologically Livable Villages and Strengthen the Construction of Rural Civilization

As shown in the evaluation results of the rural revitalization level, the scores of ecological livability and rural civilization have room for improvement. First, we can improve the quality of agricultural operators and practitioners, raise the level of agricultural mechanization, advocate environmentally friendly agricultural production methods to improve the living environment of farmers, and build ecologically livable villages. Second, we need to increase investment in education, publicize the idea of environmentally friendly land use, protect traditional culture, and integrate modern civilization to accelerate the construction of rural civilization.

5. Conclusions and Discussion

5.1. Conclusions

This paper puts forward a theoretical framework for the coupling relationship between environmentally friendly land use and rural revitalization that can complement the existing study on land use and rural development and demonstrate the coupling relationship between the two from the perspective of connotations, modes, and goals. Connotation shows a coupling relationship that complements and promotes both environmentally friendly land use and rural revitalization. For the model, there is a coupling relationship in the financing mode, implementation mode, public participation mode, management mode, and technical mode. In terms of goals, the coupling relationship between the two is reflected in the coupling of ecological benefits and ecological livability, the coupling of economic benefits with industrial prosperity and affluent life, and the coupling of social benefits with rural civilization and effective governance.

This study conducted a quantitative study on the coupling relationship between environmentally friendly land use and rural revitalization which can verify the relevant theoretical research through empirical evidence. Because the coupling relationship between environmentally friendly land use and rural revitalization is finally reflected in the development level of the two, and its development level can be evaluated by constructing an indicator system, this paper constructed an evaluation index system for the level of environmentally friendly land use and the rural revitalization level. On this basis, a coupling measurement model for environmentally friendly land use and rural revitalization is proposed.

To analyze rural issues in a wider area rather than an internal village, this article took Hainan Province as the research unit to evaluate and measure the level of rural environmentally friendly land use, the rural revitalization level, and the coupling relationship between the two from 2010 to 2017. The results showed that both the level of rural environmentally friendly land use and the rural revitalization level generally increased during the past eight years, and the coupling degree and coupling coordination degree of the two have gradually increased as well. A high level of coupling was achieved in 2017 and showed a simultaneous development trend.

5.2. Discussion

Limited by the accessibility of rural data in the study area, the indicators selected in this paper are not comprehensive, which may affect the accuracy of the evaluation of the level of rural environmentally friendly land use and the rural revitalization level in Hainan Province. It is necessary to collect and supplement the data and further verify it in a follow-up study. Further, limited by the research energy, only the entropy method was used when determining the index weights. Multiple evaluation methods should be considered for a comparative study in the follow-up research.

This study only analyzed the level of rural environmentally friendly land use, the level of rural revitalization, and the dynamic changes of the coupling between the two since the construction of the international tourist island in Hainan. On the one hand, subsequent research could examine space by conducting a comparative study on the difference between cities and counties in Hainan Province and putting forward specific development strategies for cities and counties according to local conditions. On the other hand, because the rural revitalization strategy is located in the countryside, with the continuous improvement of statistics and collection of rural data, we could refocus our research object to the village level from a microscopic point of view and combine village-level rural development planning and national spatial planning to provide reference for grassroots organizations to solve practical problems.

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