buildings

MDPI

Article

Investigations on Driving Factors of Coordination Development of Rural Infrastructure and Ecological Environment: The Case of Western China

Lihong Han [1], Yanwei Wang [1], Junwei Li [2] and Shuhong Fang [3,*]

[1] College of Architecture and Engineering, Yunnan Agricultural University, Kunming 650201, China; hanlihong@ynau.edu.cn (L.H.); 2009030@ynau.edu.cn (Y.W.)
[2] Yunnan Traffic Science Research Institute, Kunming 650032, China; lijunwei2587@gmail.com
[3] Oxbridge College, Kunming University of Science and Technology, Kunming 650101, China
* Correspondence: 2004028@ynau.edu.cn; Tel.: +86-(0871)-6522-5196

Abstract: The coordinated development of rural infrastructure and ecological environment is an effective way to improve agricultural productivity. The primary focus of the current research is how the two can work together to promote regional economic development in rural areas and in related fields. This study takes the western region as the research object, constructs an evaluation index system for rural infrastructure and ecological environment, and uses the Min-max Scaling method, coupling coordination model, gray GM (1, 1) model, and standard deviation elliptical model for evaluation. The trends and driving factors for the coordinated development of rural infrastructure and ecological coupling in the region from 2012 to 2021 are analyzed. The main results are as follows: (1) Except for Tibet, Qinghai, and Ningxia, the coupling degree of rural infrastructure and the ecological environment in western China reached the maximum level during the research period, also the coordination degree showed a gradual upward trend. (2) A prediction for the development and evolution of rural infrastructure and the ecological environment in western China indicates a trend of agglomerative development in the southern region. (3) By strengthening the construction of reservoirs, improving sanitary conditions, improving cultivated land use area and forest coverage, and controlling soil erosion, the coordinated development of the two can be effectively promoted. The purpose of this study is to promote the sustainable and coordinated development of rural infrastructure and ecological environment, and to provide a reference for policy formulation in the relevant sectors and other countries and regions with similar situations.

Keywords: rural infrastructure; ecological environment; western China; coupling coordination; trend forecasting; driving factor; sustainable development

Citation: Han, L.; Wang, Y.; Li, J.; Fang, S. Investigations on Driving Factors of Coordination Development of Rural Infrastructure and Ecological Environment: The Case of Western China. *Buildings* **2024**, *14*, 858. https://doi.org/10.3390/buildings14040858

Academic Editor: Adrian Pitts

Received: 23 January 2024
Revised: 12 March 2024
Accepted: 19 March 2024
Published: 22 March 2024

1. Introduction

Currently, the construction of rural infrastructure and the challenges of the rural eco-environment exhibit complex and diverse characteristics globally. Compared with developed countries, the construction of rural infrastructure lags behind in developing countries. This is principally due to the level of national scientific and economic development, as well as the degree of resource supply and other factors. For example, rural infrastructure in the United States and developed European countries is more advanced than in underdeveloped regions such as China, India, and Africa, and this has had a major impact on local economic development. In developed countries, ecological environmental protection has also received sufficient attention from the government and society, resulting in the adoption of more advanced technologies and the achievement of better sustainable development results. However, this has not produced a significant impact on developing countries and economically underdeveloped areas, and some countries are still facing serious problems of ecological environment in rural areas. For instance, the poor or even lacking agricultural infrastructure in some provinces and cities in western China, and the excessive use of pesticides, fertilizers, and agricultural film in agricultural production, has resulted in a certain degree of pollution, affecting the local agricultural and rural sustainable development and ecological environment protection.

In recent years, while maintaining the steady development of the urban economy, China has paid more attention to the development of its rural economy, especially in the underdeveloped areas of western China, and has formulated a series of strategies for the large-scale development of the western region, rural revitalization, and the construction of beautiful rural areas. China's construction of rural infrastructure and development of ecological environment protection are the necessary conditions for rural revitalization. Issues related to accelerating the construction of rural infrastructure, increasing the protection of the ecological environment, and achieving coordinated development have become the focus of current discussions among all sectors of society and hot topics in research in related fields. With the continuous advancement of the strategy to revitalize the countryside, a wide variety of results have been achieved in the coordinated development of rural infrastructure construction and the ecological environment. Although China has made significant progress in the level of rural infrastructure construction and ecological environmental protection, in some areas, rural infrastructure development and ecological environment governance are still regarded as independent systems, and each has its own promotion plan, which ignores the interaction between the two. In fact, the construction of rural infrastructure is closely related to the protection of the ecological environment, and the coordinated development of the two can achieve the effective use of resources and the sustainable development of the environment through reasonable planning.

Compared to the research of previous scholars, the research object and scope of the study chosen in the paper are different. Through the study of rural infrastructure and ecological environment in western China, this paper has made a certain contribution to the progress of knowledge and practical application development in this field. Therefore, the scope of this paper is 12 economically underdeveloped provinces in western China. The research object is the coordinated development of rural infrastructure and ecological environment. The theoretical basis is the theory of coupling coordination, the theory of sustainable development and the theory of systems. The coupling coordination degree model, the gray GM (1, 1) model, the standard deviation ellipse model and the obstacle degree model were adopted. This paper analyzes the coupling and coordination of rural infrastructure and ecological environment, the spatiotemporal evolution, the prediction of development trend and the driving factors in the western region. The full application of theoretical knowledge to practice is conducive to promoting rural economic development while protecting the ecological environment and can provide reference for relevant departments.

The paper is structured into eight parts, the first part is the introduction. The second part is the literature review. The third part is the research methods and data sources. The fourth part is the analysis of coupling and coordinated development. The fifth part is the analysis of spatiotemporal evolution and trend prediction. The sixth part is the analysis of driving factors. The seventh part is the discussion, and the eighth part is the conclusion.

2. Literature Review

Current studies have explored the coordinated and internally coupled development of infrastructure from various perspectives. Firstly, Wang, Li, and others have analyzed the coupling and coordination of integrated infrastructure by combining transportation infrastructure and informatization [1], green rainwater infrastructure [2], and the overall infrastructure elasticity [3]. These studies reveal that the positive, coordinated development of integrated infrastructure can bolster local economic growth, that green rainwater infrastructure significantly impacts urban development and hydrological sustainability, and that resilient infrastructure contributes to enhanced disaster resilience within infrastructure systems. Secondly, research has delved into the coupled and coordinated relationships between infrastructure and population [4], as well as infrastructure and living standards [5]. Lu and colleagues determined that understanding the coordinated relationship between infrastructure and population is crucial for the healthy development of urban areas. Lastly, discussions have focused on the coupled and coordinated development between the economy and infrastructure construction [6,7]. The findings indicate that the coordinated development of multiple systems can create synergistic effects, providing benefits to the sustainable development of the local economy.

The efficiency of ecological environment governance is crucial in advancing the modernization of the national environmental governance system and capabilities [8]. Current research primarily focuses on several key aspects. Firstly, there is a focus on tourism and the ecological environment [9,10]. Understanding the delicate relationship between these two elements is crucial for the sustainable development of cities; for the sustainable development of rural areas, Gajić et al., through a study of rural service quality [11] and tourist decision making [12], found two studies to improve the development of rural tourism to a certain extent. Secondly, some researchers have established a coupled coordination model to validate the interconnected development of urbanization and the ecological environment [13,14]. Their work underscores the importance of studying this coordination for the realization of sustainable urban development [15]. Fang also posits that the coupled and coordinated development of urbanization and ecosystems will be a future research hotspot and frontier in sustainable development science [16]. The third aspect centers on the relationship between the social economy and the ecological environment. Li et al. utilized a coupled coordination model to analyze the interplay between the social economy and the ecological environment, emphasizing its extreme importance for the sustainable development of cities [17–20]. Lastly, Zhang et al. engaged in a comprehensive discussion of three connected areas: tourism, urbanization, and the ecological environment. Their research constitutes a multidimensional reference for the coupled and coordinated development of the ecological environment [21].

Research on the coordinated development of infrastructure and the ecological environment encompasses two key aspects. On one hand, the analysis of the coupling and coordination relationship between the rural economy and the agricultural, ecological environment reveals that continuous improvement in agricultural infrastructure is pivotal to promoting high-quality development in the agricultural and rural economy [22]. Conversely, the construction of a coupled coordination model delves into the environmental benefits of urban infrastructure [23], the quality of infrastructure and ecological environment [24], and the multifaceted economic, social, and environmental benefits of urban infrastructure [25]. It also explores the coupling coordination relationship between economic, social, infrastructural, and ecological resilience [26], providing a comprehensive understanding of the current coordinated development status of urban infrastructure. Simultaneously, related surveys using infrastructure construction as a control to measure ecological footprint demonstrate that infrastructure plays a crucial role in the promotion of the sustainable development of the ecological environment. The above has laid the foundation for the research on the coordinated development of infrastructure and the ecological environment.

Scholars have conducted research in a variety of fields, involving infrastructure, the ecological environment, and their coupled and coordinated development, covering the interplay between infrastructure and economic development, population growth, and the improvement of living standards. Additionally, there has been an interest in the coupled development of tourism and the ecological environment, urbanization and the ecological environment, and other related fields. This body of work offers valuable insights for relevant departments in formulating policies. However, there remains insufficient research on the coupling and coordination of the spatiotemporal evolution of rural infrastructure and ecological environment, as well as the trend prediction of future sustainable development. Further exploration is needed, particularly in two areas. (1) There is limited literature focusing on rural areas as the primary research object or examining the coupling and coordination relationship between rural infrastructure and the ecological environment. (2) Research to predict the coordinated development trend between rural infrastructure and ecology in western China is lacking.

Accordingly, this article proposes the following innovations: (1) With the goal of promoting the sustainable development of the rural economy and taking rural infrastructure and ecological environment as the main research objects, four models were established: coupling degree model, coordination degree model, gray GM (1, 1), and the obstacle degree model to analyze the sustainable and coordinated development of rural infrastructure and ecological environment. (2) Taking the economically underdeveloped areas in the western region as the research area, a new method is proposed. This paper analyzes the coupling and coordinated development level and spatiotemporal evolution characteristics of rural infrastructure and ecological environment. This paper studies the coordinated development trend, spatiotemporal evolution law, and driving factors of the rural infrastructure and ecological environment in this region. The findings and recommendations are intended to inform and guide decision making.

3. Materials and Methods

3.1. Construction of Indicator System

In order to effectively evaluate the coordinated development of rural infrastructure and ecological environment in western China, on the basis of the existing research, this paper constructs an evaluation index system of rural infrastructure and ecological environment that is more suitable for the current rural economic development in western China [27–30]. This paper studies the coupling and coordination level, dynamic evolution law, development trend prediction and driving factors of rural infrastructure and ecological environment. Also, this paper evaluates the development level of rural infrastructure using three categories: productive, living, and social infrastructure. Specifically, four indicators are selected to measure productive infrastructure, while two indicators each are used for evaluating living and social infrastructure. Concurrently, the development level of the ecological environment is evaluated on the basis of three aspects: ecological environment pressure, status, and response. Four indicators assess ecological environment pressure, two evaluate its status, and another two gauge the response to the ecological environment. The selection of data indicators prioritizes rationality, operability, and accessibility. The details of the indicator system are presented in Table 1.

Table 1. Rural infrastructure and ecological environment evaluation indicator system.

Criterion Layer	Indicator Layer	Unit	Indicator Properties
Productive infrastructure	Total power of agricultural machinery (A1)	Ten thousand kilowatts	+
	Reservoir capacity (A2)	Billion cubic meters	+
	Irrigated area of cultivated land (A3)	Thousand hectares	+
	The number of reservoir seats (A4)	Seat	+
Living infrastructure	Rural electricity consumption (A5)	Billion kilowatt hours	+
	Solar water heaters (A6)	Million square meters	+
Social infrastructure	Health center beds (A7)	Sheet	+
	Township Health Centers (A8)	Piece	+
Ecological environment pressure	Agricultural fertilizer use (B1)	Ten thousand tons	–
	Pesticide use (B2)	Ton	–
	The amount of agricultural film used (B3)	Ton	–
	Agricultural diesel usage (B4)	Ten thousand tons	–

Table 1. *Cont.*

Criterion Layer	Indicator Layer	Unit	Indicator Properties
Ecological environment status	Forest coverage (B5)	%	+
	Cultivated land use area (B6)	Thousand hectares	+
Ecological environment response	Total area of afforestation (B7)	Hectare	+
	The area under water and soil erosion control (B8)	Thousand hectares	+

Note: '+' denotes positive indicators, and '−' denotes negative indicators. '+' Positive indicators denotes that the larger the value, the better the outcome, whereas '−' negative indicators denotes that the larger the value, the worse.

3.2. Methods

3.2.1. Research Methods

In this study, the Min-max Scaling method, the entropy value method, the coupling degree model, the coupling coordination degree model, the gray GM (1, 1) model and the obstacle degree model were used to analyze the coupling coordination, spatiotemporal evolution, development trend prediction, and driving factors of rural infrastructure and ecological environment. The Min-max Scaling method is a preprocessing method that is used to eliminate the influence of dimensions between different indicators. In order to avoid the different units of indicator data, the extreme value standardization method is required to preprocess the data. The entropy method is an objective weighting method, which is not affected by subjective factors and the results obtained are more objective. The coupling degree model reflects whether there is a correlation between the two systems, while the coupling coordination degree model reflects the level of coordinated development of the two systems at a certain stage. The gray GM (1, 1) model is a predictive model, which is suitable for small sample data and predicting short-term data. The obstacle degree model is designed to explore the driving factors and influencing factors of rural infrastructure and ecological environment. Firstly, the Min-max Scaling method was used to preprocess the data, and the entropy method was used to weight the data. Secondly, the coupling degree model and the coupling coordination degree model are used to analyze the coupling and coordinated development level of rural infrastructure and ecological environment, and the gray GM (1, 1) model is used to predict the coordinated development trend of western China in the next decade. Finally, the obstacle degree model is used to detect the driving factors and influencing factors of rural infrastructure and ecological environment.

3.2.2. Standardization Processing

The diversity of units across different indicators can impact the calculation results in a study. To address this issue, the Min-max Scaling method is employed to process original data. The specific steps for this method are outlined as follows:

Positive indicators:

$$Y_{ij} = \frac{y_{ij} - \min y_{ij}}{\max y_{ij} - \min y_{ij}} \tag{1}$$

Negative indicators:

$$Y_{ij} = \frac{\max y_{ij} - y_{ij}}{\max y_{ij} - \min y_{ij}} \tag{2}$$

where Y_{ij} represents the standardized value; y_{ij} is the original data of the j indicator in i year in the system; max y_{ij} and min y_{ij} are, respectively, the maximum and minimum values in the original data of the j indicator in i year in the system. In the data operation, there will be a case of 0. As such, when calculating the data, all data are non-negatively shifted and 0.00001 is added to all values.

3.2.3. Determine the Weight

In this study the entropy method was used to calculate the weights of the processed data, and the specific steps are as follows:

(1) For the j indicator, calculate the proportion (P_{ij}) of the i sample:

$$P_{ij} = \frac{Y_{ij}}{\sum\limits_{i=1}^{n} Y_{ij}} \tag{3}$$

(2) Calculate the entropy value of each indicator (m_j):

$$m_j = -\frac{1}{\ln n} \sum_{i=1}^{n} P_{ij} \ln(P_{ij}) \tag{4}$$

(3) Calculate the difference coefficient of the indicator (X_j):

$$X_j = 1 - m_j \tag{5}$$

(4) Calculate indicator weight (W_j):

$$W_j = \frac{X_j}{\sum\limits_{i=1}^{m} X_j} \tag{6}$$

(5) Calculate the comprehensive evaluation index $U1$ and $U2$ of rural infrastructure and the ecological environment:

$$U1 = \sum_{j=1}^{m} W_j Y_{ij} \tag{7}$$

$$U2 = \sum_{j=1}^{m} W_j Y_{ij} \tag{8}$$

where $j = 1, 2, 3, \ldots, m$ refers to the number of indicators, $U1$ and $U2$ represent the comprehensive evaluation index of rural infrastructure and ecological environment, respectively, W_j represents the weights of rural infrastructure and ecological environment indicators, and Y_{ij} represents for standardization data.

Through the above formulas (Equations (3)–(6)), the index weights of rural infrastructure and ecological environment are obtained, and the specific weights are detailed in Table 2.

Table 2. Rural infrastructure and ecological environment indicator weight.

Criterion Layer		**Productive Infrastructure**			**Living Infrastructure**		**Social Infrastructure**	
Indicator layer Weights	A1 0.090	A2 0.135	A3 0.129	A4 0.198	A5 0.097	A6 0.103	A7 0.139	A8 0.109
Criterion layer		Ecological Environment pressure			Ecological environment status		Ecological environment response	
Indicator layer Weights	B1 0.178	B2 0.057	B3 0.050	B4 0.113	B5 0.174	B6 0.143	B7 0.130	B8 0.155

3.2.4. Model Building

(1) Coupling degree (C) model

The term ‘coupling relationship’ refers to the mutual influence of and interdependence between two or more systems. The strength of this relationship is measured on the basis of the degree of coupling. Referring to previous research [31,32], a coupling degree model between rural infrastructure and the ecological environment is constructed. The specific equation is as follows:

$$C = \frac{2\sqrt{U1U2}}{U1 + U2} \tag{9}$$

where $U1$ and $U2$ are the comprehensive evaluation indexes of rural infrastructure and the ecological environment, respectively, and C is the coupling degree of rural infrastructure and ecological environment, and its range is [0, 1]. The larger the coupling degree (C), the stronger the correlation and higher the coupling degree between the two; conversely, the smaller the coupling degree (C), the weaker the correlation and the higher the coupling degree between the two. For low scores, when the coupling degree (C) is 0, there is no correlation between the two.

(2) Coupling coordination degree (D) model

The degree of coupling is used to explain whether two or more systems are related, while the degree of coupling coordination is used to explain the degree of mutual development between said systems. This study introduces the coupling coordination degree model to measure the level of mutual development between rural infrastructure and the ecological environment in western China. Based on the coupling degree model, a coupling coordination degree model of rural infrastructure and the ecological environment is constructed. The specific equation is as follows:

$$D = \sqrt{C \times T} \tag{10}$$

$$T = aU1 + bU2 \tag{11}$$

where D represents the degree of coordination between rural infrastructure and the ecological environment; C represents the coupling degree between rural infrastructure and ecological environment; and T represents the coordinated development index of rural infrastructure and the ecological environment. In this study, a and b are the contribution coefficients, $a + b = 1$. Referring to the previous study [33], rural infrastructure and ecological environment are equally important, i.e., $a = b = 0.5$. In the process of coupling and coordinated development of rural infrastructure and ecological environment, the larger the coupling coordination degree (D), the more mutually reinforcing the two. The lower the coupling coordination degree (D), the more the two influence each other. The coupling coordination between rural infrastructure and ecological environment can be taken in the range of [0, 1]. Based on previous research [34,35], ten classes (levels, layers) of coupling and coordination degrees are distinguished (Table 3).

Table 3. Coupling and coordination degree classification of rural infrastructure and ecological environment.

Coupling Degree (C)	Interval Division	Coupling Coordination Degree (D)
Minimum coupling	[0.00, 0.09)	Extreme Imbalance
Low-level coupling	[0.10, 0.19)	Severe Imbalance
Low-level coupling	[0.20, 0.29)	Moderate Imbalance
Antagonistic coupling	[0.30, 0.39)	Mild Imbalance
Antagonistic coupling	[0.40, 0.49)	Borderline Imbalance
Running-in coupling	[0.50, 0.59)	Barely Coordination
Running-in coupling	[0.60, 0.69)	Primary Coordination
Running-in coupling	[0.70, 0.79)	Intermediate Coordination
High-level coupling	[0.80, 0.89)	Good Coordination
Maximum Coupling	[0.90, 1.00]	Optimal coordination

Table 3 shows that when the coupling degree between rural infrastructure and the ecological environment is at a stage of extreme imbalance, there will be minimum coupling [0.00, 0.09). Equally, severe and moderate imbalance both result in low-level coupling [0.10, 0.29). This indicates that the degree of interaction between the rural infrastructure and the ecological environment is small, and that they are in the stage of independent development. When the two are in the mild imbalance and borderline imbalance stages of antagonistic coupling [0.30, 0.49), the degree of development between the two are different and the expectations of mutual enhancement and coordinated development have not been achieved. When both are in the reluctant coordination, primary coordination, or intermediate coordination stages of being barely coordinated [0.50, 0.79), this means that both have begun to enter a healthy development state. When both are in the stage of good coordination with high coupling [0.80, 0.89) and optimal coordination with maximum coupling [0.90, 1.00], both interact and develop in a coordinated manner to a large extent, promoting mutual development.

(3) Obstacle degree model

In order to identify the factors that affect the coordinated development of rural infrastructure and the ecological environment in western China, this paper introduces the obstacle degree model to analyze the main driving factors that affect the coordinated development of rural infrastructure and ecological environment. This article refers to previous research results [36,37] in order to construct an obstacle degree model. The specific equation is as follows:

$$G_j = \frac{X_{ij}W_j}{\sum\limits_{j=1}^{n} X_{ij}W_j} \tag{12}$$

where G_j is the j index obstacle degree; X_{ij} is the index deviation degree, calculated with $X_{ij} = 1 - Y_{ij}$, Y_{ij} is the standardized value; and W_j is the index weight, which is often used to express factor contribution.

3.3. Regional Overview

China is a large agricultural country, and the coordinated development of infrastructure in rural areas and the ecological environment is of great significance to the country's economic and social development. China is divided into three major regions according to geographical location and economic development, namely, the eastern region, the central region and the western region. The western region includes the following provinces: Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang. The specific partition diagram is shown in Figure 1.

The eastern region is the most economically and technologically developed area in China, with relatively mature rural infrastructure and ecological environment. Regarding rural infrastructure, the government has played a significant role by encouraging modern agricultural development, increasing investment in agricultural science and technology, and enhancing agricultural production's efficiency and quality. Additionally, the government has actively promoted the construction of rural social affair service systems, thereby improving public services in rural areas. In terms of the ecological environment, the government's guidance has induced farmers to use modern science and technology to develop ecological agriculture. This includes adopting ecological planting and breeding methods to protect ecological environments. The technological leadership and unique geographical location of the eastern region have facilitated the coordinated development of its rural infrastructure and ecological environment, establishing it as a leading demonstration area for rural development in China.

Figure 1. Geographical division of China.

In recent years, central China has made significant strides in advancing rural infrastructure and enhancing the ecological environment, two goals aligned with the national strategy of building a moderately prosperous society. These improvements include the continuous construction and enhancement of rural roads, water supply and power supply infrastructure, and communication networks, leading to markedly improved living conditions for rural residents. Additionally, the region has actively engaged in ecological environment protection, implementing initiatives such as ecological civilization construction, rural garbage classification, and sewage treatment. These efforts have collectively contributed to a substantial improvement in the ecological environment.

However, compared to the central and eastern regions, the western region of China faces unique challenges due to its fragile ecological environment, characterized by high altitudes, numerous deserts, and multiple basins. These geographical conditions complicate construction efforts. Furthermore, the region struggles with insufficient policy support, delayed technological advancement, and lower education levels. These challenges, compounded by a general lack of environmental awareness, have resulted in a significant gap in rural infrastructure development compared to the more developed central and eastern regions. The western region continues to grapple with issues including outdated infrastructure and inadequate ecological protection. In the first 30 years, China focused on the development of the eastern and central regions, while the development of the western region was relatively slow. In terms of population density, the population density is relatively high in the eastern and central regions, and the population density in the western region is relatively low. In terms of the speed of economic development, the economic development speed of the eastern and central regions is relatively fast, while the economic development of the western region is lagging behind. In terms of the geographical location, the eastern and central regions are mostly plains, and the western regions are mostly plateaus. In order to narrow the development gap, the Chinese government has launched strategies such as the large-scale development of the western region and rural revitalization. Strategies such as the large-scale development of the western region have provided strong support for the coordinated development of rural infrastructure and the ecological environment in the western region.

Therefore, an urgent question that arises is how to promote the sustainable development of rural infrastructure while simultaneously safe guarding the ecological environment. This paper compares the differences in economic development, population density, and geographical characteristics between western China and central and eastern China in order to tap their potential for coordinated and sustainable development. In order to comprehensively assess the coordinated development of rural infrastructure and the ecological environment in western China, this study focuses on 12 provinces, autonomous regions, and municipalities, including Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang. Considering the scientific rigor, accuracy, accessibility, and operability of the data, this research specifically selected data from these 12 regions for a period spanning from 2012 to 2021. The data utilized in this study were sourced from the "China Rural Statistical Yearbook" and the "China Statistical Yearbook", as shown in Tables S1 and S2.

4. Coupling and Coordination Analysis of Rural Infrastructure and Ecological Environment

4.1. Coupling Degree Analysis

This study employs the coupling degree (C) model (Equation (9)) to analyze the interaction between rural infrastructure and the ecological environment across 12 provinces, autonomous regions, and municipalities in western China, spanning a period from 2012 to 2021. This approach facilitated the assessment of the interconnection of these two aspects in the region. The resulting trends depicting this coupling and its changes over the period are illustrated in Figure 2.

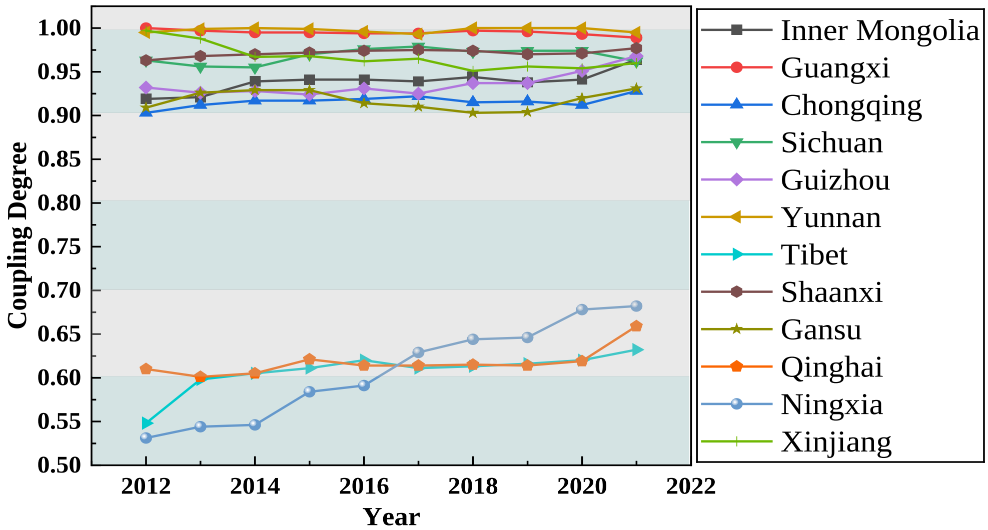

Figure 2. Trend chart of coupling degree between rural infrastructure and ecological environment in western China.

From 2012 to 2021, the coupling degree between rural infrastructure and the ecological environment reached its maximum in the interval of [0.903, 1.00] in Inner Mongolia, Guangxi, Chongqing and the other nine provinces, autonomous regions and municipalities. This indicates a strong correlation between rural infrastructure and the ecological environment in these nine regions. Conversely, in Tibet, Qinghai, and Ningxia, the coupling degree settled at [0.544, 0.682], signifying a running-in coupling stage. This suggests a lower correlation between rural infrastructure construction and the ecological environment, impacting the coordinated development of the two. Overall, most areas in western China experienced maximum coupling during this period, demonstrating significant correlations. However, some regions remained in the running-in stage of coupling. Understanding these coupling correlations is crucial for improving the coordination between rural infrastructure and the ecological environment, ultimately leading to sustainable collaborative development.

4.2. Coordination Analysis

Based on the coupled coordination degree (*D*) model, this paper calculates the coordination degree between rural infrastructure and the ecological environment in western China. The three-dimensional line chart below, dubbed Figure 3, reflects the trend of coordinated development between rural infrastructure and the ecological environment in western China from 2012 to 2021.

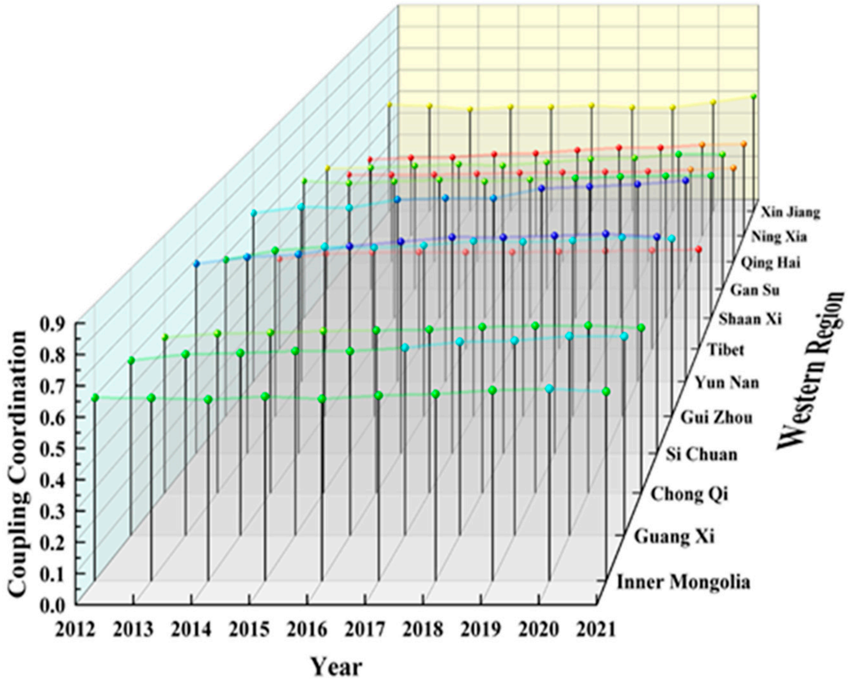

Figure 3. Trend chart of Coordination between rural infrastructure and ecological environment in western China.

According to Figure 3, the coordinated development of rural infrastructure and the ecological environment in various provinces, autonomous regions, and municipalities in western China shows a positive growth trend. This article lists the coordination degree data and coordination classification types for the four years of 2012, 2015, 2018, and 2021; the years for which we analyzed the coordinated development level of rural infrastructure and ecological environment in various western regions. The details are shown in Table 4.

From 2012 to 2021, there was a notable evolution in the coordination between rural infrastructure and the ecological environment across various regions. In Inner Mongolia, Guangxi, and Guizhou, the development progressed from a barely coordination stage to a primary coordination stage. In contrast, Chongqing, Shaanxi, and Gansu remained consistently in the barely coordination stage during this period. Meanwhile, the Sichuan and Yunnan regions advanced from the primary coordination stage to the intermediate coordination stage. However, Tibet persisted in the mild imbalance stage, while Qinghai and Ningxia changed from mild imbalance to borderline imbalance. Notably, the Xinjiang region improved, moving from the near-imbalance stage to the stage of barely coordination. Table 4 illustrates that by 2021, most regions in the western area showed a gradual improvement in the synergy between rural infrastructure and the ecological environment. However, Tibet, Qinghai, and Ningxia continued to face challenges, remaining in stages of mild and borderline imbalance. This lag in coordinated development was attributed to several factors: the inadequate promotion and implementation of local policies; limited and low investments in productive, daily, and social infrastructure; and the minimal impact from factors like ecological protection awareness, environmental pressure, and response in the local areas.

Table 4. Classification table of coordination degree and coordination type of rural infrastructure and ecological environment in western China.

District	2012		2015		2018		2021	
	Coordination Degree	Type	Coordination Degree	Type	Coordination Degree	Type	Coordination Degree	Type
Inner Mongolia	0.596	Barely Coordination	0.600	Primary Coordination	0.608	Primary Coordination	0.616	Primary Coordination
Guangxi	0.590	Barely Coordination	0.622	Primary Coordination	0.653	Primary Coordination	0.671	Primary Coordination
Chongqing	0.544	Barely Coordination	0.566	Barely Coordination	0.580	Barely Coordination	0.577	Barely Coordination
Sichuan	0.685	Primary Coordination	0.748	Intermediate Coordination	0.780	Intermediate Coordination	0.782	Intermediate Coordination
Guizhou	0.584	Barely Coordination	0.630	Primary Coordination	0.651	Primary Coordination	0.663	Primary Coordination
Yunnan	0.649	Primary Coordination	0.701	Intermediate Coordination	0.744	Intermediate Coordination	0.774	Intermediate Coordination
Tibet	0.357	Mild Imbalance	0.384	Mild Imbalance	0.386	Mild Imbalance	0.395	Mild Imbalance
Shaanxi	0.561	Barely Coordination	0.566	Barely Coordination	0.573	Barely Coordination	0.583	Barely Coordination
Gansu	0.509	Barely Coordination	0.526	Barely Coordination	0.548	Barely Coordination	0.567	Barely Coordination
Qinghai	0.377	Mild Imbalance	0.381	Mild Imbalance	0.389	Mild Imbalance	0.406	Borderline Imbalance
Ningxia	0.340	Mild Imbalance	0.363	Mild Imbalance	0.392	Mild Imbalance	0.408	Borderline Imbalance
Xinjiang	0.487	Borderline Imbalance	0.477	Borderline Imbalance	0.474	Borderline Imbalance	0.525	Barely Coordination

5. Spatiotemporal Characteristics and Trend Prediction Analysis of Rural Infrastructure and Ecological Environment

5.1. Time Series Analysis

This study uses panel data relating to rural infrastructure and the ecological environment in western China from 2012 to 2021 for analysis, utilizing the coupling coordination model to calculate the coordination degree between rural infrastructure and the ecological environment in western China. This research explores the coordinated development of rural infrastructure and the ecological environment in the western region from 2012 to 2021, as shown in Figure 4. The coupling coordination and time have a linear relationship, and the R2 = 0.9886.

Figure 4 shows that the coordinated development level of rural infrastructure and ecological environment in western China exhibits a slow growth trend. Although the overall coordination degree of rural infrastructure and ecological environment in western China was in a barely coordination state from 2012 to 2021, from the data point of view, it increased from 0.523 (2012) to 0.581 (2021), and the level of coordinated development improved (and continues to improve) annually. This can be accounted for in the following manner. Due to the influence of rural infrastructure construction and ecological environment protection in western China, ranging from independent to coordinated development, the level of coupled and coordinated development between both increased year by year. Based on the above analysis, this article believes that the coupled and coordinated development of rural infrastructure and ecological environment in western China will continue to rise in the future.

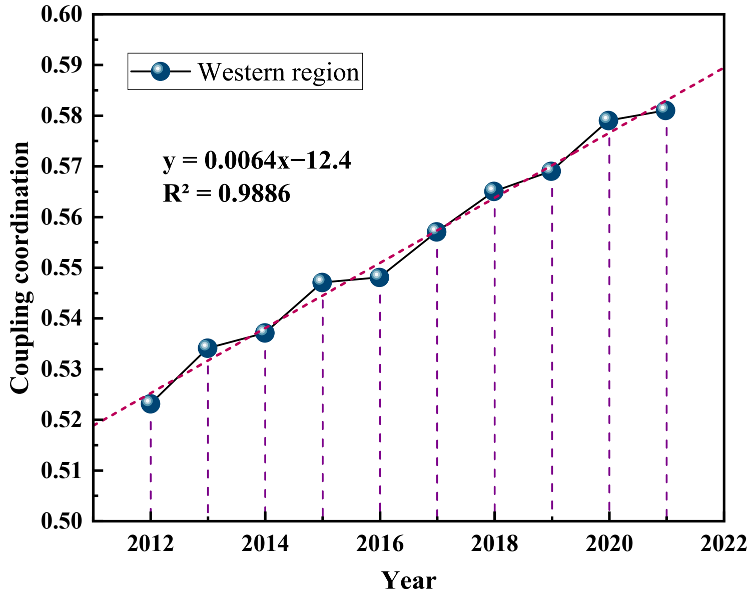

Figure 4. Time series change map of coordination between rural infrastructure and ecological environment in western China.

5.2. Spatial Analysis

This study calculates the coupled and coordinated development of rural infrastructure and ecological environment in western China based on the coupling coordination degree model, utilizing ArcGIS10.8 software to map the rural areas in western China for the years 2012, 2015, 2018, and 2021. The spatial characteristic distribution map of the coordination degree between infrastructure and ecological environment is shown in Figure 5.

This research documents the distribution of rural infrastructure and the ecological environment across various provinces, autonomous regions, and municipalities in western China for the years 2012, 2015, 2018, and 2021, as presented in Table 5. It can be intuitively seen that the coordinated development of rural infrastructure and the ecological environment in western China has changed over the past ten years. Overall, the study period reveals a positive trend in the coordinated development of rural infrastructure and the ecological environment in this region. Specifically, Sichuan, Yunnan, Inner Mongolia, Guangxi, Guizhou, and Xinjiang all exhibited significant improvements. However, Tibet consistently showed a mild imbalance. To address this, we recommend that investments in rural infrastructure and the ecological environment in Tibet be increased to expedite the region's coordinated development. The progression in Sichuan and Yunnan is noteworthy; these regions moved from the primary coordination stage in 2015 to the intermediate coordination stage by 2021. Based on current trends, it is expected that Sichuan and Yunnan will continue to advance towards a state of benign and coordinated development.

Table 5. Spatial distribution of coordinated types of rural infrastructure and ecological environment in western China.

Type	2012	2015	2018	2021
Mild Imbalance	Tibet; Qinghai; Ningxia.	Tibet; Qinghai; Ningxia.	Tibet; Qinghai; Ningxia.	Tibet
Borderline Imbalance	Xinjiang	Xinjiang	Xinjiang	Qinghai; Ningxia.

Table 5. *Cont.*

Type	2012	2015	2018	2021
Barely Coordination	Inner Mongolia; Guangxi; Chongqing; Shaanxi; Guizhou; Gansu.	Chongqing; Shaanxi; Gansu.	Chongqing; Shaanxi; Gansu.	Chongqing; Shaanxi; Xinjiang; Gansu.
Primary Coordination	Sichuan; Yunnan.	Inner Mongolia; Guangxi; Guizhou.	Inner Mongolia; Guangxi; Guizhou.	Inner Mongolia; Guangxi; Guizhou.
Intermediate Coordination		Sichuan; Yunnan.	Sichuan; Yunnan.	Sichuan; Yunnan.

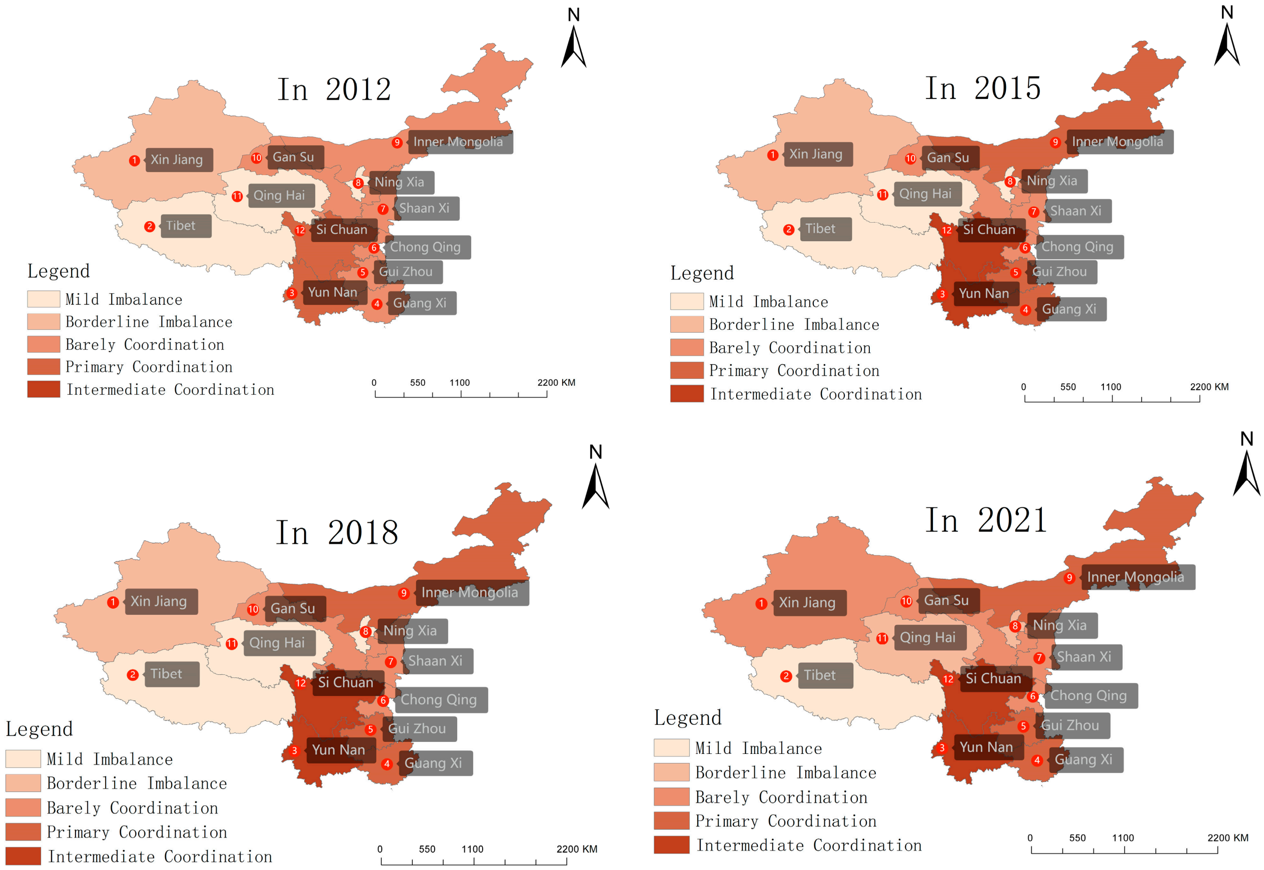

Figure 5. Spatial distribution map of coordination between rural infrastructure and ecological environment in western China in 2012, 2015, 2018, and 2021.

5.3. Trend Prediction

Utilizing the gray GM (1, 1) model and employing SPSSAU24.0 software, we predicted these aspects for the years 2025, 2028, and 2031. The focus was to analyze the trend of coordinated development between these provinces, autonomous regions, and municipalities in western China over the next decade. To ensure the accuracy of our predictions, we applied residual testing and posterior difference test methods. The results confirmed that the model's accuracy was generally satisfactory, indicating the reliability of the prediction data for subsequent analysis. Based on this foundation, we determined the standard deviation ellipse parameters for the predicted values of the years 2025, 2028, and 2031. These are shown in Figure 6, where the darker the color in the diagram is, the better the coordination will be.

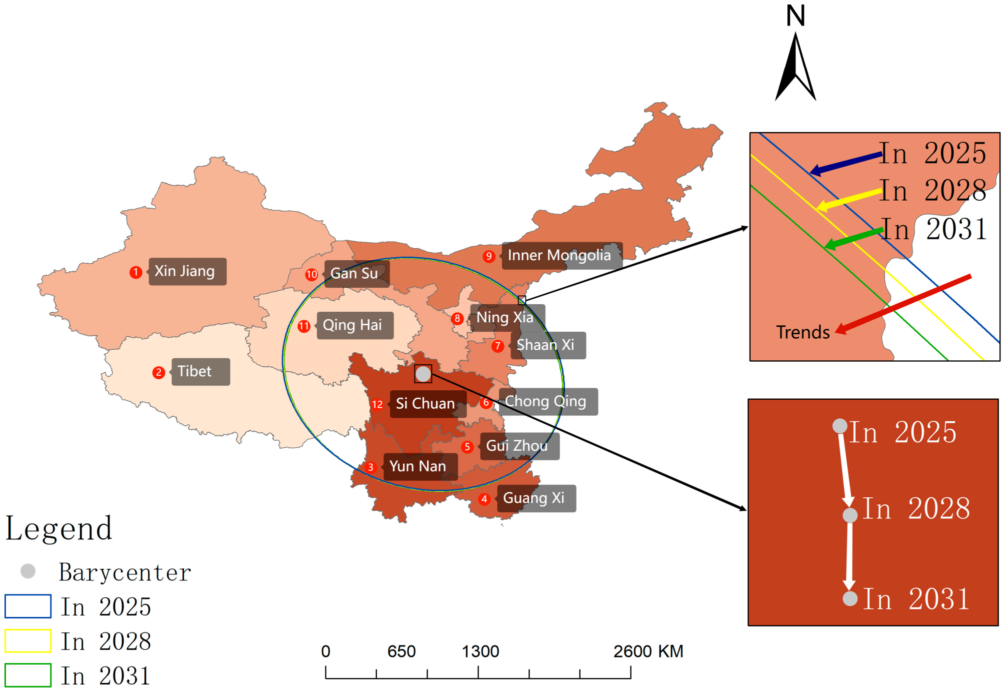

Figure 6. Standard deviation elliptical distribution of coupling coordination degree between rural infrastructure and ecological environment in western China.

It is predicted that the overall development of rural infrastructure and ecological environment in 12 provinces in the western region will show a trend of agglomeration to the south in the future. The focus on the coupling and coordination of rural infrastructure and ecological environment in the western region will shift significantly from the northwest (2021) and southeast (2025) to the south (2025–2031). This shift suggests that the southern region will become increasingly influential in shaping the rural infrastructure and the ecological environment in the future, particularly in the core area of the coupled and coordinated spatial distribution pattern. Regarding spatial distribution changes, the area of the standard deviation ellipse is projected to decrease from 305.189 km in 2022 to 297.04 km in 2031. Simultaneously, the ellipse's long axis and short axis dimensions will fall from 11.126 km and 8.732 km in 2022 to 10.846 km and 8.718 km in 2031, respectively. These figures indicate that, over the next decade, there will be a concentrated development of rural infrastructure and the ecological environment in southern China. This development highlights the significance of regions like Sichuan and Yunnan, which exhibit intermediate coordination, and Guangxi and Guizhou, which display primary coordination, as key areas for promoting the sustainable and coordinated development in western China. Their progress can serve as a model and have a radiating and demonstrative effect on other areas.

Firstly, the development level and spatial–temporal evolution of rural infrastructure and ecological environment in western China from 2012 to 2021 were analyzed using a coupling coordination degree model. Secondly, according to the characteristics of the gray GM (1, 1) model, which can be applied to trend forecasting, the model is used to predict the coordinated development trend of the western region in the next ten years. Finally, the results show that: (1) In the past decade, the coordination degree of rural infrastructure and ecological environment in western China has been in the stage of poor coordination, but its coordination degree has a slow upward trend. (2) In the next decade, the coordinated development of rural infrastructure and ecological environment will show a trend of spatial distribution and agglomeration, and the center of gravity will move to the south.

6. Analysis on Driving Factors of Coordinated Development of Rural Infrastructure and Ecological Environment

6.1. Analysis of Driving Factors at Rural Infrastructure Indicator Layer

Based on the Obstacle Degree (G) model (Equation (11)), the driving factors at the rural infrastructure indicator layer in western China were calculated, and finally the main driving factors affecting the coordinated development of rural infrastructure in western China from 2012 to 2021 were obtained. Due to the large number of indicators, the study only listed the top three factors in 2012, 2015, 2018, and 2021 for analysis, as shown in Table 6.

Table 6. Table of major driving factors to the coordinated development of rural infrastructure in the western region from 2012 to 2021.

Western China	2012	2015	2018	2021
Inner Mongolia	A4; A7; A2	A4; A2; A7	A4; A2; A7	A4; A7; A2
Guangxi	A4; A6; A7	A4; A2; A6	A4; A2; A6	A4; A6; A7
Chongqing	A6; A5; A2	A6; A8; A5	A6; A8; A7	A6; A8; A4
Sichuan	A6; A2; A7	A2; A6; A7	A2; A6; A8	A6; A2; A8
Guizhou	A2; A6; A5	A2; A6; A5	A2; A6; A5	A6; A2; A8
Yunnan	A6; A4; A7	A6; A2; A4	A6; A4; A7	A6; A4; A7
Tibet	A6; A4; A7	A7; A8; A5	A8; A7; A5	A8; A7; A3
Shaanxi	A4; A7; A2	A4; A2; A7	A4; A2; A7	A4; A7; A2
Gansu	A4; A2; A7	A2; A4; A7	A2; A4; A7	A4; A2; A7
Qinghai	A4; A2; A6	A4; A2; A7	A4; A2; A7	A4; A2; A7
Ningxia	A4; A6; A7	A4; A7; A6	A4; A6; A7	A4; A6; A7
Xinjiang	A4; A7; A2	A2; A4; A7	A4; A2; A7	A4; A7; A2

Table 6 reveals various factors for the coordinated development of rural infrastructure in western China. Specifically, in 2012 and 2021, the number of reservoir seats (A4) and the number of health center beds (A7) were identified as the most significant factors, both tied for the top position. This suggests that these years saw A4 and A7 as drivers in the development of rural infrastructure. In 2015, the primary factor was reservoir capacity (A2), indicating its critical role in influencing the coordinated development during that year. The scenario shifted by 2018, with health center beds (A7) emerging as the predominant factors.

A comprehensive review of the driver factors frequency in Table 6 over the four years reveals that the number of reservoir seats (A4) and health center beds (A7) are the most recurrent issues, both appearing 34 times and sharing the first rank. Following closely is reservoir capacity (A2), occurring 32 times. These findings highlight that the number of reservoir seats (A4), health center beds (A7), and reservoir capacity (A2) are the principal factors to the coordinated development of rural infrastructure in western China. Notably, two of these drivers pertain to productive infrastructure (A4 and A2), while one (A7) is associated with social infrastructure. This analysis underscores that the drivers within rural water conservancy-related productive infrastructure and rural health and medical social infrastructure are pivotal in nudging the coordinated and sustainable development of rural infrastructure in a region.

6.2. Analysis of Driving Factors of Ecological Environment Index Layer

Equation (12) was used to calculate the factors that drive the coupled and coordinated development of rural infrastructure and the ecological environment in western China, and the indicators of the ecological environment indicator layer in western China from 2012 to 2021 were obtained. The details of our analysis are shown in Table 7.

Table 7. Table of major driving factors to the coordinated development of ecological environment in the western region from 2012 to 2021.

Western China	2012	2015	2018	2021
Inner Mongolia	B1; B5; B4	B1; B5; B4	B1; B5; B4	B1; B5; B4
Guangxi	B1; B8; B7	B1; B8; B7	B1; B8; B7	B1; B8; B6
Chongqing	B8; B6; B7	B8; B6; B7	B8; B6; B7	B6; B8; B7
Sichuan	B1; B7; B8	B1; B5; B8	B1; B5; B7	B1; B7; B6
Guizhou	B8; B7; B6	B8; B6; B5	B6; B8; B7	B7; B6; B8
Yunnan	B1; B8; B4	B1; B4; B8	B1; B7; B6	B1; B7; B6
Tibet	B8; B5; B6	B8; B5; B6	B8; B5; B6	B5; B8; B6
Shaanxi	B1; B4; B6	B1; B4; B6	B1; B4; B6	B1; B6; B4
Gansu	B5; B7; B6	B5; B7; B8	B5; B6; B7	B5; B7; B6
Qinghai	B5; B8; B6	B5; B8; B6	B5; B8; B6	B5; B6; B8
Ningxia	B5; B8; B6	B5; B8; B6	B5; B8; B6	B5; B6; B8
Xinjiang	B5; B8; B1	B5; B1; B8	B1; B5; B8	B5; B1; B8

Table 7 highlights various factors for the coordinated development of the ecological environment in western China. In 2012 and 2015, the area under water and soil erosion control (B8) was the most significant factor, ranking first among the influencing factors. This indicates that B8 was the primary factor during this period, significantly affecting the coordinated development of the region's ecological environment. Moving to 2018 and 2021, the number of occurrences of the cultivated land utilization area (B6) took the lead, signifying its impact on the coordinated development during these years.

A detailed analysis of the frequency of these factors over the four years shows that the area under water and soil erosion control (B8) appears most frequently, with a total of 33 occurrences. This is followed by the cultivated land utilization area (B6), appearing 31 times, and then forest coverage (B5), noted some 27 times. These three factors—the area under water and soil erosion control (B8), cultivated land utilization area (B6), and forest coverage (B5)—emerge as the primary drivers to the coordinated development of the ecological environment in western China. Among them, two factors (namely, B8 and B5) relate to the ecological environment status, while one factor (B6) pertains to the ecological environment response. This analysis underscores that controlling soil erosion, managing cultivated land utilization, and maintaining forest coverage are key to achieving a coordinated and sustainable development of the ecological environment in the region.

7. Discussion

Compared with previous scholars' research, the research object of this paper is different. Scholars have conducted a lot of research on the coordinated development of infrastructure and the economy [38,39] and the ecological environment and tourism [40]. There are few studies on the coordinated development of rural infrastructure and ecological environment. On the other hand, the research areas of this paper are different. In the past, scholars have focused on the sustainable development of the urban economy, but there were few studies on rural, economically underdeveloped areas. So, take the less-developed rural areas in the west as an example. With the goal of promoting rural economic development, research on the coordinated development of rural infrastructure and ecological environment should be carried out. While strengthening the construction of rural infrastructure, it is of great practical significance to protect the sustainable and coordinated development of the ecological environment.

The analysis indicates that from 2022 to 2031, there will be a trend towards the coordinated development of rural infrastructure and the ecological environment in the western region of China, with greater concentration arising in the south. In order to foster sustainable and coordinated development in this region, it will be necessary to consider a tiered approach to construction and promotion. The first tier should include Yunnan, Sichuan, Guangxi, Guizhou, and Inner Mongolia. These areas, displaying relatively strong coordinated development, are all at or above the primary coordinated level, and show better development compared to other regions. They should be prioritized for rapid enhancement in coordinated development. Relevant departments should increase investments in scientific and technological innovation and construction in these areas, create brand influence, and serve as models for other regions.

The second tier comprises Chongqing, Shaanxi, Gansu, and Xinjiang, where development has barely reached a coordinated stage. In these regions, government departments should conduct detailed analyses of rural productive, daily, and social infrastructure, as well as identifying obstacles such as soil erosion and pollution sources that harm the ecological environment. Policies and regulations should be optimized to promote sustainable and coordinated development, alongside continued infrastructure construction and ecological protection measures.

The third tier includes Tibet, Qinghai, and Ningxia, which are either experiencing mild disorder or are on the verge of it. Challenges in these areas, such as lagging rural infrastructure and severe ecological environmental issues, hinder coordinated development. Government departments should focus on alleviating these problems, increasing investment in infrastructure like water conservancy, hydropower, and healthcare, and enhancing the management of resources and environmental issues like water loss, forests, and cultivated land.

Overall, with initiatives like the Western Development and Rural Revitalization project, China's western region has made significant progress in building rural infrastructure and enhancing the ecological environment. However, there remains a considerable gap compared to the central and eastern regions, necessitating further investment and construction efforts. It is recommended that regional departments formulate policies tailored to their specific coordination status. This will assist in strengthening rural infrastructure, particularly in areas like water conservancy and healthcare. Additionally, there should be a concerted effort to protect the ecological environment, leveraging technologies such as smart agriculture to increase forest coverage, prevent soil erosion, and enhance cultivated land utilization for sustainable development.

8. Conclusions

This article focuses on the coordinated development of rural infrastructure and the ecological environment. We construct an evaluation index system encompassing six aspects: productive infrastructure, living infrastructure, social infrastructure, pressure on the ecological environment, its current status, and response mechanisms. Utilizing panel data from 12 provinces, autonomous regions, and municipalities in western China for a period spanning from 2012 to 2021, we employ methods such as the entropy method, coupled coordination model, and standard deviation elliptical model. These are used to analyze the level and spatiotemporal evolution characteristics of coupled and coordinated development, trend predictions, and driving factors concerning the rural infrastructure and the ecological environment in western China. This study reaches several conclusions:

(1) From 2012 to 2021, the coupling degree of rural infrastructure and ecological environment in Tibet, Qinghai, and Ningxia was in the running-in coupling stage, while other regions were in the maximum coupling stage. This disparity highlights the differences in the correlation between both across different regions.
(2) The overall coordination between rural infrastructure and ecological environment in western China is gradually improving. However, in Tibet, the coordination remains at a mild imbalance stage, and it is on the verge of imbalance in Qinghai and Ningxia.
(3) Analyzing the standard elliptical distribution and the movement path of the center of gravity, we observed a clustering trend in the coordination degree between rural infrastructure and ecological environment in western China. Based on the standard ellipse predictions, the coordinated development in the next few years is expected to show spatial agglomeration, with the center of gravity moving southwards.

(4) The coordinated development level of rural infrastructure and ecological environment in western China is influenced by multiple factors. From 2012 to 2021, six primary drivers were identified. Within the rural infrastructure, three major drivers were noted, two related to productive infrastructure and one to social infrastructure. Likewise, in the ecological environment, three main driving factors were identified, two related to ecological environment status and one to ecological environment response.

Through the study of the coupling and coordinated development of rural infrastructure and ecological environment, this paper provides theoretical support for the sustainable development of rural economy. At the same time, it can formulate effective measures for relevant departments to promote the coordinated development of a rural economy and can also provide a reference for countries and regions in similar situations. In the future, we will consider comparing the coupling and coordinated development of rural infrastructure and ecological environment in other regions and the western region, to help narrow the gap between the western region and other regions.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/buildings14040858/s1, Table S1: The raw data on rural infrastructure. (Sourced from the "China Rural Statistical Yearbook" and "China Statistical Yearbook"); Table S2: The raw data of the ecological environment. (Sourced from the "China Rural Statistical Yearbook" and "China Statistical Yearbook").

Author Contributions: Conceptualization, L.H. and Y.W.; methodology, S.F.; software, S.F. and J.L.; validation, L.H., Y.W. and S.F.; formal analysis, L.H.; data curation, S.F. and J.L.; writing—original draft preparation, S.F. and J.L.; writing—review and editing, L.H. and Y.W.; visualization, L.H.; supervision, Y.W.; project administration, L.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by National Natural Science Foundation of China, grant number 72261035; Yunnan Provincial Joint Project of Applied Basic Research on Agriculture, grant number 202101BD070001-061; and Yunnan Provincial Academy and Provincial School Education Cooperation Humanities and Social Sciences Project, grant number SYSX202202.

Data Availability Statement: The data presented in this study are available in the respective references.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Wang, N.; Zhu, Y. The Integration of Traditional Transportation Infrastructure and Informatization Development: How Does It Affect Carbon Emissions? *Energies* **2022**, *15*, 7535. [CrossRef]
2. Wang, M.; Chen, F.; Zhang, D.; Rao, Q.; Li, J.; Tan, S.K. Supply–Demand Evaluation of Green Stormwater Infrastructure (GSI) Based on the Model of Coupling Coordination. *Int. J. Environ. Res. Public Health* **2022**, *19*, 14742. [CrossRef]
3. Li, G.; Cheng, G.; Wu, Z.; Liu, X. Coupling Coordination Research on Disaster-Adapted Resilience of Modern Infrastructure System in the Middle and Lower Section of the Three Gorges Reservoir Area. *Sustainability* **2022**, *14*, 14514. [CrossRef]
4. Lu, C.; Hong, W.; Wang, Y.; Zhao, D. Study on the Coupling Coordination of Urban Infrastructure and Population in the Perspective of Urban Integration. *IEEE Access* **2021**, *9*, 124070–124086. [CrossRef]
5. Xin, Y.; Wang, D.; Zhang, L.; Ma, Y.; Chen, X.; Wang, H.; Wang, H.; Wang, K.; Long, H.; Chai, H.; et al. Cooperative analysis of infrastructure perfection and residents' living standards in poverty-stricken counties in Qinghai Province. *Environ. Dev. Sustain.* **2022**, *24*, 3687–3703. [CrossRef]
6. Wang, K.; Zhang, L.; Zhang, L.; Cheng, S. Coupling coordination assessment on sponge city construction and its spatial pattern in Henan province, China. *Water* **2020**, *12*, 3482. [CrossRef]
7. Yang, L.; Yang, D.; Zhang, Y.; Qiao, X.; Tang, H.; Wang, G. Grey Associative Analysis of Infrastructure System and Economic Development Coupling in Xinjiang. *Prog. Geogr.* **2009**, *28*, 345–352.
8. Qian, M.; Cheng, Z.; Wang, Z.; Qi, D. What Affects Rural Ecological Environment Governance Efficiency? Evidence from China. *Int. J. Environ. Res. Public Health* **2022**, *19*, 5925. [CrossRef] [PubMed]
9. Tang, Z. An integrated approach to evaluating the coupling coordination between tourism and the environment. *Tour. Manag.* **2015**, *46*, 11–19. [CrossRef]
10. Duan, S.; Zhang, L.; Hsu, W.L. Sensitivity analysis of coastal city tourism and environmental systems based on coupling model. *Sens. Mater.* **2020**, *32*, 1913–1923. [CrossRef]

11. He, J.; Wang, S.; Li, Y.; Ma, H.; Liu, Q. Examining the relationship between urbanization and the eco-environment using a coupling analysis: Case study of Shanghai, China. *Ecol. Indic.* **2017**, *77*, 185–193. [CrossRef]
12. Gajić, T.; Đoković, F.; Blešić, I.; Petrović, M.; Radovanović, M.; Vukolić, D.; Mandarić, M.; Dašić, G.; Syromiatnikova, J.; Syromiatnikova, J. Pandemic Boosts Prospects for Recovery of Rural Tourism in Serbia. *Land* **2023**, *12*, 624. [CrossRef]
13. Gajić, T.; Vukolić, D.; Đoković, F.; Jakovljević, M.; Bugarčić, J.; Vrgović, I.; Glišić, S. Application of the PPM model in Assessing the impact of economic factors on the selection of an agro-tourism destination after COVID-19. *Econ. Agric.* **2023**, *70*, 755–771. [CrossRef]
14. Xiang, K.; Zhao, A.; Liu, H.; Zhang, X.; Zhang, A.; Tian, X.; Jin, Z. Spatiotemporal Evolution and Coupling Pattern Analysis of Urbanization and Ecological Environmental Quality of the Chinese Loess Plateau. *Sustainability* **2022**, *14*, 7236. [CrossRef]
15. Xu, D.; Cheng, J.; Xu, S.; Geng, J.; Yang, F.; Fang, H.; Xu, J.; Wang, S.; Wang, Y.; Huang, J.; et al. Understanding the Relationship between China's Eco-Environmental Quality and Urbanization Using Multisource Remote Sensing Data. *Remote Sens.* **2022**, *14*, 198. [CrossRef]
16. Fang, C.; Liu, H.; Li, G. International progress and evaluation on interactive coupling effects between urbanization and the eco-environment. *J. Geogr. Sci.* **2016**, *26*, 1081–1116. [CrossRef]
17. Li, W.; Yi, P.; Zhang, D.; Zhou, Y. Assessment of coordinated development between social economy and ecological environment: Case study of resource-based cities in Northeastern China. *Sustain. Cities Soc.* **2020**, *59*, 102208. [CrossRef]
18. Xu, M.; Chen, C.; Deng, X. Systematic analysis of the coordination degree of China's economy-ecological environment system and its influencing factor. *Environ. Sci. Pollut. Res.* **2019**, *26*, 29722–29735. [CrossRef]
19. Peng, B.; Sheng, X.; Wei, G. Does environmental protection promote economic development? From the perspective of coupling coordination between environmental protection and economic development. *Environ. Sci. Pollut. Res.* **2020**, *27*, 39135–39148. [CrossRef]
20. Liu, Y.; Li, N. Analysis on the coupling development path of economy and ecological environment under the rural revitalization strategy. *Fresenius Environ. Bull.* **2020**, *29*, 11702–11709.
21. Zhang, T.; Li, L. Research on temporal and spatial variations in the degree of coupling coordination of tourism–urbanization–ecological environment: A case study of Heilongjiang, China. *Environ. Dev. Sustain.* **2021**, *23*, 8474–8491. [CrossRef]
22. Liu, W.; Zhou, W.; Lu, L. An innovative digitization evaluation scheme for Spatio-temporal coordination relationship between multiple knowledge driven rural economic development and agricultural ecological environment—Coupling coordination model analysis based on Guangxi. *J. Innov. Knowl.* **2022**, *7*, 100208. [CrossRef]
23. Sun, Y.; Cui, Y.; Huang, H. An empirical analysis of the coupling coordination among decomposed effects of urban infrastructure environment benefit: Case study of four Chinese autonomous municipalities. *Math. Probl. Eng.* **2016**, *2016*, 8472703. [CrossRef]
24. Shen, J.; Zhang, Y.; Guo, B.; Zheng, S. Coupling Relationship Analysis between Quality Infrastructure and Ecological Environment Quality for Policy Implications. *Int. J. Environ. Res. Public Health* **2020**, *17*, 7611. [CrossRef] [PubMed]
25. Sun, Y.; Cui, Y. Analyzing the coupling coordination among economic, social, and environmental benefits of urban infrastructure: Case study of four Chinese autonomous municipalities. *Math. Probl. Eng.* **2018**, *2018*, 8280328. [CrossRef]
26. Lin, Y.; Peng, C.; Chen, P.; Zhang, M. Conflict or synergy? Analysis of economic-social-infrastructure-ecological resilience and their coupling coordination in the Yangtze River economic Belt, China. *Ecol. Indic.* **2022**, *142*, 109194. [CrossRef]
27. Yue, S.; Tan, C.; Yang, L.; Gong, D. Analysis and Prediction on Rural Eco-environmental Quality of Jinghe River Basin in Gansu Province During 2010-2019. *Bull. Soil Water Conserv.* **2021**, *41*, 365–372. (In Chinese)
28. Zheng, M.; Jiang, R. Evaluation and analysis on the development level of regional rural eco-environment—A case study of Shandong province. *Jiangsu J. Agric. Sci.* **2020**, *36*, 1583–1588. (In Chinese)
29. Zhang, Y. Research on the Coupling and Coordinated Development of Rural Infrastructure and Rural Economy in Henan Province. Master's Thesis, Zhengzhou University, Zhengzhou, China, 2021.
30. Zhang, J. An Analysis on the Coordinated Development of Rural Infrastructure and Rural Economy. *J. Yunnan Univ. Financ. Econ.* **2011**, *27*, 55–62. (In Chinese)
31. Dong, Y. Study on the Coupling and Coordination between Urban Innovation and High-quality Economic Development in China. *J. Tech. Econ. Manag.* **2022**, 42–47. (In Chinese) [CrossRef]
32. Wang, S.; Kong, W.; Ren, L.; Zhi, D. Research on misuses and modification of coupling coordination degree model in China. *J. Nat. Resour.* **2021**, *36*, 793–810. (In Chinese) [CrossRef]
33. Tao, C.; Xia, A.; Li, D.; Zhang, C. Research on the coupling coordination development of urbanization and ecological environment in Maanshan City. *Ecol. Sci.* **2021**, *40*, 129–138. (In Chinese)
34. Lv, Y.; Chen, J.; Qiu, K. Provincial tourism development level, coupling coordination and spatiotemporal evolution. *Stat. Decis.* **2022**, *38*, 114–118. (In Chinese)
35. Hua, J.; Hu, J. Analysis on the Coupling Relationship between Technology Innovation and High-Quality Economic Development. *Sci. Technol. Prog. Policy* **2019**, *36*, 19–27. (In Chinese)
36. Yang, X.P.; Wang, R.; Qin, Y.L.; Xuan, W. Evolution and Obstacle Factors of Green Development Level of Provincial Tourism Destinations in China. *Geogr. Geo-Inf. Sci.* **2023**, *39*, 120–128. (In Chinese)
37. Wang, C.; Yan, X. Spatiotemporal revolution and obstacles identification of urban resilience in Chengdu-Chongqing urban agglomeration. *J. Chongqing Univ.* **2023**, *29*, 21–33. (In Chinese)

38. Zhang, J.; Zhou, T. Coupling Coordination Degree between Ecological Environment Quality and Urban Development in Chengdu–Chongqing Economic Circle Based on the Google Earth Engine Platform. *Sustainability* **2023**, *15*, 4389. [CrossRef]
39. Sheng, Z.; Liu, Y.; Wang, X.; Chiu, A. The impact of charging infrastructure on coupling coordination of urbanization and ecological environment: Evidence from China. *Technol. Forecast. Soc. Chang.* **2024**, *199*, 122992. [CrossRef]
40. Tian, L.; Sun, F.; Zhang, Z.; Zhang, S. Coupling coordination and driving mechanism of tourism industry, urbanization, and ecological environment: A case study of Shandong, China. *Environ. Dev. Sustain.* **2023**. [CrossRef]