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Coupling and Coordination Development, Spatiotemporal Evolution, and Driving Factors of China's Digital Countryside and Inclusive Green Growth in Rural Areas

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Abstract: Inclusive green growth is an effective strategy for achieving sustainable development in rural areas. In the digital economy era, it is crucial to examine whether rural digital development and inclusive green growth can be harmoniously integrated. This study investigates the spatial and temporal evolution of the coupled coordination between digital village construction and rural inclusive green growth in China. Utilizing panel data from 30 provinces from 2011 to 2022, we assess development levels using the entropy weighting method and analyze interdependencies with a coupling coordination model. The results indicate an upward trend in coupling coordination, with significant regional disparities, and it is slowly taking on the characteristics of spatial clustering. Economically advanced regions exhibit higher coordination levels, attributed to stronger economic foundations and better fiscal resources, enabling effective investments in digital infrastructure and green growth initiatives. Additionally, factors such as urbanization rate, innovation levels, reduction in natural disasters, increased financial support for agriculture, and improved large-scale operations positively contribute to this coordination. These findings offer insights for targeted regional development strategies, enhancing the synergy between digital transformation and sustainable rural development.

Keywords: digital rural development; rural inclusive green growth; coupled coordination; spatial and temporal evolution

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1. Introduction

Since its inception at the Rio+20 Summit in 2012, the notion of "inclusive green growth" has gained prominence globally as an exemplar of sustainable development that harmoniously integrates environmental tolerance and social equity [1] (pp. 144–155). Many nations have begun to adopt new development models centered on "inclusive green growth" since the United Nations unveiled new sustainable development objectives in 2016. One approach to inclusive green growth entails sustainable and efficient natural resource utilization while ensuring that the pollution levels remain within the planet's tolerance capacity. This approach also entails a paradigm shift in how society perceives the interplay between economic, social, and environmental development [2,3] (pp. 3–20, pp. 115–121). Green growth, which relies on advancements in green technology and the development of renewable energy sources, ensures a fundamental living environment, offering safer conditions and healthier food options. This approach not only contributes to environmental sustainability but also fosters the realization of the potential and creativity of professionals in this sector, enhancing their personal development and career fulfillment. In order to meet the public's demand for an improved environment, it is imperative that the inclusive development of society be supported by green growth, which entails a paradigm shift in economic development facilitated by a rational upgrading of the industrial structure and the promotion of environmental decarbonization and greening. Green growth should be predicated on socially inclusive growth; as Maslow's Hierarchy of Needs posits, individuals only attain the necessities that are fundamental for their survival. Since the advent of the Industrial Revolution, the rapid economic development of nations and regions, particularly in rural areas, has inevitably given rise to numerous disadvantages [4,5] (pp. 1–25, pp. 196–202). For instance, the "cake" of rural economic development has not been equitably distributed, resulting in significant disparities between urban and rural regions, and the degradation of ecosystems, the environment, and agricultural resources is progressively becoming more prominent [6] (pp. 41–65). Despite facing numerous challenges in rural development, the Chinese government has demonstrated a strong commitment to its improvement. Initiatives began in earnest in 2003 with the adoption of the "scientific outlook on development" as a guiding ideology. By 2005, this commitment had expanded to include the goal of "building a resource-saving and environmentally friendly society". The importance of these initiatives grew following the 18th National Congress of the Communist Party of China, which introduced the "five-in-one" strategy. This strategy emphasizes ecological civilization and integrates it into all aspects of socioeconomic development, promoting a shift towards greener production methods. As the world's most populous developing country and its second largest economy, China's approach to inclusive green development in rural areas is poised to enhance the quality of rural life domestically and also offers a sustainable development model that could influence global economic progress, particularly among other developing nations.

The digital economy, in the wake of the agricultural and industrial economies, has emerged as a significant catalyst for present and forthcoming global economic progress [7,8] (pp. 34–57, pp. 303–311). In recent years, China has been actively advancing its Digital China strategy. This strategy employs contemporary information technologies, such as the Internet, big data, and artificial intelligence, to upgrade the nation's governance systems and capabilities. Its goal is to significantly boost the digitalization of society and the economy, facilitating a significant advancement in information technology development. The construction of digital villages represents a specific application of the Digital China initiative in rural areas. As digital technologies have been unprecedentedly integrated into the rural economic and social fields in recent years, building digital villages is essential for advancing rural development, enhancing agricultural productivity and efficiency, and markedly boosting the living standards of rural communities. By integrating modern information technologies, rural areas can broaden e-commerce opportunities, increase access to educational and healthcare services, spur economic growth, and strengthen their ability to manage themselves sustainably and effectively. For instance, India's Digital India program aims to transform rural areas through digitalization, improving economic opportunities and social inclusion. Similarly, the European Union's Smart Villages strategy focuses on leveraging digital technologies to promote sustainable development in rural regions. These comparisons highlight the broader applicability of digital rural development strategies. These strategies address various challenges in rural communities, from social and economic issues to environmental concerns. In comparing China's digital village strategy with India's Digital India program and the EU's Smart Villages strategy, we observe several commonalities and differences. All three initiatives emphasize the enhancement of digital infrastructure, improvement of rural residents' quality of life, and promotion of sustainable development through digital technologies. However, there are notable differences in their approaches. India's program focuses more on e-governance and transparency, while China's strategy emphasizes the coordinated development of economy and environment. The EU's strategy places a stronger emphasis on social inclusion and community engagement alongside economic diversification. These comparisons highlight the universal applicability of digital rural development strategies and the potential for cross-regional learning and adaptation of best practices. Because digital village construction and the rural economy structure have progressed and changed at a rapid rate, it is crucial to determine whether inclusive green growth development and digital village construction can coexist. The relationship between the development of digital villages and that of inclusive green growth in rural areas is predominately shaped by the following three factors:

(1) The economic impact of digital village development: Digital village projects can effectively reduce the economic disparities between urban and rural areas by enhancing the agricultural efficiency, expanding agricultural product markets, promoting rural entrepreneurship and employment, improving educational resources, and strengthening infrastructure and services. Specifically, smart agricultural technologies reduce costs and increase the incomes of farmers, and online market platforms enable farmers to directly reach a broader consumer base, increasing their product profitability. Digital tools provide new job opportunities and platforms for entrepreneurship in rural areas, while online education and training courses enhance skill sets and employment competitiveness. Improved infrastructure further enhances quality of life and economic vitality. These measures not only directly improve the economic levels of rural areas but also help narrow the economic gap between rural and urban areas by promoting equal access to resources. Moreover, by leveraging technological spillover and industrial competition, digital village construction can facilitate the upgrading and transformation of industrial infrastructure [9] (pp. 10–24). In the analysis of industrial competition mechanisms, the construction of digital villages facilitates rural enterprises and producers in accessing broader markets through advanced digital technologies and Internet platforms. This access encourages them to enhance the quality of their products and services to meet the needs of a more diverse consumer base. Regarding the spillover effects of technology, the high-tech solutions introduced by digital village initiatives—such as big data, the Internet of Things (IoT), and artificial intelligence (AI)—are not only directly implemented in agricultural production but also enhance the technological capabilities of other local economic sectors. The introduction and application of these technologies can lead to technological spillover effects, where technical knowledge and innovations are disseminated from one economic sector to others, elevating the overall technological standard and production efficiency of the region. Additionally, spillover has the potential to significantly boost the overall productivity factor of both the local and neighboring regions, enhance the performance of agricultural socialized services, and optimize the business environment for micro and small enterprises. Consequently, these improvements can directly impact the output level of the digital village [10,11] (pp. 5–10, pp. 61–80). For instance, in Guan County, Shandong Province, an innovative approach was taken to establish the "Guan County Agricultural Custody Full-Industry Chain Elements Trading Service Platform". Since its official launch, the platform has achieved a transaction volume exceeding CNY 4 million, saving over 10% in costs for villagers and social service entities.
(2) The effect that digital village development has on inclusivity: Digital rural construction promotes the development of rural digital governance by strengthening the hierarchical structure of the government and financing sector. This is primarily accomplished through the restructuring and optimization of three elements: rural people, land, and money [12,13] (pp. 41–53, pp. 114–132). Digital rural construction accelerates the supply of digital infrastructure, ensures livelihood services, and helps farmers meet their individualized needs [14,15] (pp. 27–40, pp. 132–140).
(3) The impact of digital village construction on the environment: The construction of digital villages has created a technical conduit for the transformation of the "two mountains" and is capable of resolving the issues of "de-energizing", "de-polluting", and "value transformation". Moreover, it has demonstrated considerable momentum in the domains of public low-carbon consumption oversight, green environmental transformation, and social governance oversight [16,17] (pp. 54–65, pp. 165–175). Over time, it has emerged as a novel trajectory that is spearheading sustainable development, low-carbon production, and green environmental protection. Specific

measures include deploying digital technologies for environmental monitoring systems to track the water, air, and soil quality in rural areas in real time, enabling timely responses to environmental issues. Precision and eco-friendly agricultural techniques, such as drip irrigation and organic farming, are promoted to reduce the use of fertilizers and pesticides, thereby minimizing their negative impacts on the environment. Environmental education and awareness are enhanced through digital platforms to increase the participation of rural residents in environmental protection. Furthermore, identifying and addressing new challenges brought about by digitalization, such as the management of electronic waste, ensures that technological debris does not compromise the environmental goals of projects.

The current body of literature primarily examines the effects of digital village development on the individual dimensions of inclusive green growth, such as the environment, society, and economy dimensions. However, research that specifically investigates the interplay between digital village development and coupled and coordinated development, which would further support the bidirectional relationship theory, is scarce. Furthermore, while numerous studies have examined inclusive green development in China as a whole, rural inclusive green growth has not been the focus of any of them. In order to accomplish this, in the present study, we endeavored to address the following three inquiries: Does the development of digital communities in China align with the principles of inclusive green rural expansion? What are the salient features that define its temporal and spatial progression? What are the factors affecting the coupling and harmonization of digital village development with inclusive green growth in the countryside?

Evaluation of the integrated and synchronized progress of digital village development and inclusive rural green growth is critical in this regard for the attainment of sustainable development objectives globally, with a particular emphasis on rural regions. Examining 30 provinces in China from 2011 to 2021, in this study, we attempted to construct an indicator evaluation system based on the connotations of the two indices. We used the indicator evaluation system, with some adjustments, to measure the rural inclusive green growth and digital village construction coupling coordination degrees of 30 provinces in China from 2011 to 2021. In addition, we analyzed the spatial and temporal evolution characteristics of the degrees of the coupling coordination of the two indices and their modified coupling coordination degrees using statistical analysis software and ArcGIS 10.8, providing a theoretical and practical foundation for advancing the coupling and synergy mechanism between rural inclusive green growth and digital village construction. The primary contributions of this study are as follows: Prior research has predominantly examined inclusive green growth at the macrolevel; however, it has not specifically examined inclusive green growth in rural areas characterized by rural attributes. In this study, we developed China's rural inclusive green growth indicator system by taking into account international comparability and the current state of affairs in China. The indicator system is based on the three dimensions of rural social inclusion, rural economic growth, and rural green development, with the connotation of rural inclusive green growth. Additionally, we analyzed the theoretical two-way relationship between digital village construction and rural inclusive green growth, as well as the temporal aspect of this relationship.

The subsequent sections are structured as follows: Section 2 undertakes a theoretical analysis of the coordinated and coupled relationship between digital village construction and rural inclusive green development in China. Section 3 constructs a systematic indicator system for rural inclusive green growth and digital village construction in China. The system measures the degree of coupling coordination between the two initiatives, with specific adjustments made. The spatial and temporal evolution of the coupled coordination degrees between rural inclusive green growth in China and digital village construction, as well as its revised coupled coordination degrees, are analyzed in Section 4. A summary of the study's conclusions and policy implications is presented in Section 5.

2. Theoretical Analysis

In light of the emergence of the digital economy, the progress of rural communities is inextricably linked to digital technology. The primary indicators of the digital village development contribution to inclusive green growth in rural areas are as follows:

(1) The information access effect: Agricultural business entities are susceptible to risk due to the unpredictability and volatility of the information on the market [18] (pp. 141–153). By mitigating the information asymmetry that exists between producers and the market, the establishment of a digital countryside enables the primary agricultural production and management sector to gain a more precise understanding of the market dynamics, facilitate timely decision making, and analyze its own resource endowment in accordance with the market demand through the utilization of big data models, which, in turn, improves the mode of production and fosters the advancement of high-quality agriculture [19] (pp. 68–89). Furthermore, as an outcome of resource integration, digital empowerment that facilitates rural governance modernization positively contributes to the safeguarding of farmers' rights. The implementation of big data technology and government affairs processing ensures the transparent, precise, and digitally intelligent progression of both. Moreover, it regulates the "use of people, money, and power" within the village, thereby safeguarding the rights and interests of farmers [20] (pp. 72–81). For example, in the area of personnel management, digital development can enhance the efficiency of systems that record and track the performance and duties of village officials and staff. Public access to this information ensures transparency and fairness in hiring processes. In terms of financial management, utilizing e-governance platforms to disclose rural financial expenditures, project bidding, and contract execution improves the fund usage transparency, allowing villagers to directly oversee the financial activities of their village committees. Regarding land management, establishing an electronic land registration system that records the rights to use each parcel of land and any ownership changes ensures the legality and transparency of land transactions and usage. An electronic land registration system would not only help prevent illegal land occupation and misuse but would also protect the land rights of farmers, thereby avoiding social issues caused by land disputes. Furthermore, information access not only offers rural inhabitants convenient access to healthcare but also access to a wide array of learning opportunities, and it also contributes to the achievement of urban–rural co-governance [14] (pp. 27–40) and the closing of the educational divide between the urban and rural sectors [21] (pp. 62–76). Telemedicine platforms provide professional medical counseling, diagnosis, and treatment services to rural residents, thereby addressing the issue of the limited medical resources in these regions. By facilitating access to online educational platforms, rural inhabitants can attain learning resources equivalent to those of their urban counterparts, thereby narrowing the educational divide that exists between the two regions.

(2) The technology diffusion effect: Digital technology enables the agricultural sector to achieve green and low-carbon transformation with regard to production. By leveraging agricultural big data platforms, the agricultural Internet of Things (IoT), GIS, and other technological advancements, one can efficiently acquire data pertaining to the physical conditions of light, humidity, temperature, air, soil water content, and nutrients, in addition to the nutritional statuses and health levels of crops. These data can then be transmitted to an intelligent growth control system where they are processed, and automated AI generates production and management strategies to mitigate these factors [22,23] (pp. 37–48, pp. 118–129). The digital empowerment of rural life ultimately benefits the pastoral ecosystem. The real-time monitoring and control of intelligent waste classification management and rural sewage treatment as well as an increase in their precision and efficacy in order to reduce environmental pollution are possible with the digital supervision and intelligent analysis systems of the entire process [24,25] (pp. 70–90, pp. 263–275). Furthermore, equipment and

personnel limitations frequently prevent the real-time monitoring of environmental changes and emissions from pollution sources in conventional rural environmental monitoring. Furthermore, by implementing remote sensing technology and sensors, it is possible to achieve the real-time monitoring of the rural environment to obtain early warnings, which would enhance the capacity for detecting natural disasters and issuing timely warnings, enabling appropriate actions to be taken to safeguard the rural ecological environment at its origin. Moreover, it would contribute to the development of a picturesque and harmonious countryside [26] (pp. 58–67).

Inclusive green growth implementation in rural regions has the following effects on digital village development:

(1) The "support" effect: Rural areas that are digitally empowered persistently encounter unidentified risks and challenges due to their innovative and disruptive nature. Increasing the human capital of farmers, promoting income growth, accelerating the urban–rural integration and development process, mitigating the digital "negative energy" effect at its source, and providing internal and external support for the "steady progress" construction of digital villages are all inclusive green growth objectives in rural areas [27] (pp. 68–77).

(2) The subsequent "lead effect": This approach to inclusive green rural development will direct the construction of digital villages. Rural regions that experience external disturbances or policy disruptions will expose any shortcomings and deficiencies in the establishment of rural harmony and the advancement of industrial integration. Promoting the high-quality development of rural areas and accelerating the participation of farmers in all spheres of the digital economy, life, and ecology while deploying rural digital infrastructure construction in accordance with local conditions [28] (pp. 21–35) is a crucial means of accelerating the digital empowerment effect. Furthermore, the digital hard and soft environments have significantly advanced and transformed the rural development model, which constitutes a substantial area of inquiry and application in the realm of digital village construction.

(3) The "feedback" effect: Promoting the government's financial tax revenue increase, improvement in the rural public service system, and the construction of a beautiful countryside, the rural inclusive green growth development model can reduce the cost of environmental pollution remediation, thereby mitigating the issues of inadequate funds for rural digital infrastructure construction, the lack of digital participation among farmers, and the challenge of the sustainable development paradigm [29] (pp. 113–135). The feedback mechanism is as follows: "Digital village construction–rural inclusive green growth–digital village construction".

Based on the above analysis, we propose the hypothesis that the construction of digital villages is coupled and coordinated with inclusive green growth in villages (Figure 1).

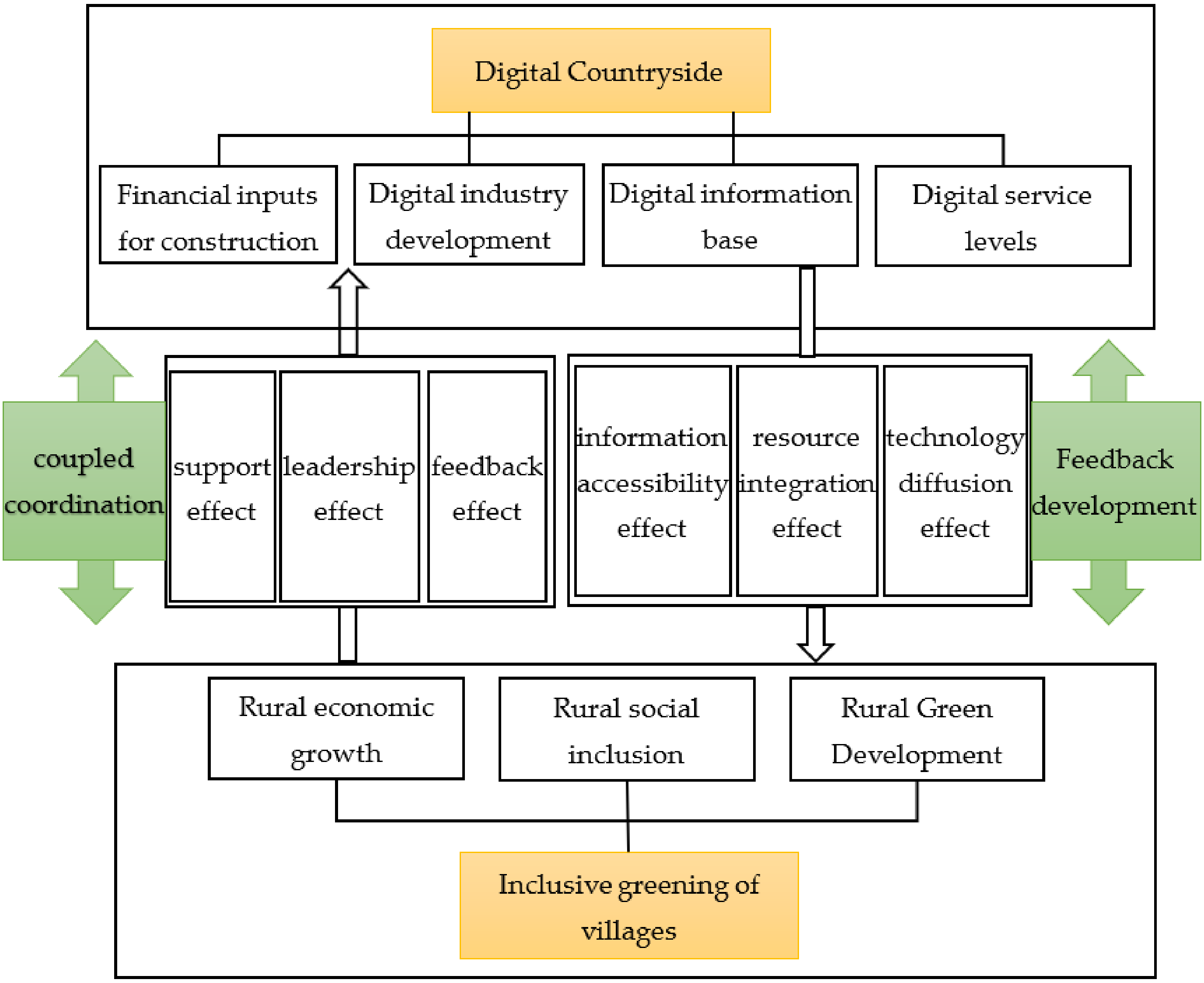

Figure 1. The mechanism diagram of coupling coordination between digital village construction and rural inclusive green growth.

3. Research Design

3.1. Construction of an Evaluation Indicator System for Digital Village Construction and Inclusive Green Rural Growth

3.1.1. Level of Development of Digital Villages

In this study, we selected the most influential and dominant indicators from an input–output perspective to construct the measurement system (Table 1). This selection was based on the research results of existing scholars [30,31] (pp. 21–33, pp. 101–111) and the Digital Village Development Action Plan (2022–2025), as well as on other policy documents and references. The measurement system is constructed using the Digital Village Construction Guide 2.0 and other relevant policy documents. Because land resources are relatively fixed in nature, they are primarily expressed in terms of labor, technology, and capital when constructing the input indicators and in terms of rural digital industry development when constructing the output indicators.

Table 1. Evaluation indicators for digital village development.

Level 1 Indicators	Secondary Indicators	Interpretation of Secondary Indicators
Financial inputs for construction	Investment in agricultural production	Investment in fixed assets in agriculture, forestry, and fisheries
	Financial investment in agriculture	Balance of agriculture-related loans
	Investments in information technology applications such as the Internet of Things	Fixed asset investment in rural transport, storage and postal services
Digital industry development	digital base	Number of Taobao villages
	Level of digital transactions	E-commerce sales and purchases
	Level of network payments	Digital Index of Rural Financial Inclusion
	Smartphone penetration rate	Rural year-end mobile phone ownership per million households
Digital information base	Computer penetration rate	Rural year-end computer ownership per million households
	Radio and television penetration	Rural cable broadcasting and television penetration rate
	Internet penetration	Number of rural Internet broadband access subscribers
	Agro-meteorological observatories	Rural meteorological observation operations
Digital service levels	Scope of services for information technology applications such as the Internet of Things	Rural delivery routes
	Digital Talent Service Workforce	Agricultural technicians
	Level of consumption of digital services	Consumption expenditure on transport and communications per rural household

The provision of construction capital input serves as the fundamental economic underpinning for rural development. In accordance with the research of Zhu Honggen and Chen Hui [30] (pp. 21–33) and Yin Haodong et al. [32] (pp. 48–56), construction capital investment was chosen to represent the investment in digital rural development. Specifically, investments in information technology applications such as the Internet of Things, agricultural production investment, and agriculture-related financial investment were considered. The foundation of assessing the establishment of digital villages lies in the progress of digital industry. To this end, the Action Plan for the Development of Digital Villages (2022–2025), the Guidelines for the Construction of Digital Villages 2.0, and the No.1 Document of the Central Government in 2023 all unequivocally advocate for the promotion of the "digital commerce and agricultural development" strategy and the "vigorous development of e-commerce of agricultural products". As a result, the digital base, digital transaction level, and online payment level were the primary metrics utilized in this study. The digital information base serves as the technological foundation for progress, encompassing livelihoods as well as production. As a consequence, in this study, we made use of the findings of Fei Wang et al. [33] (pp. 122–143) to assess the penetration of agro-meteorological observation stations, smartphones, computers, radio, television, and the Internet. The digital service level is the exogenous force of development, and the Outline of Digital Rural Development Strategy emphasizes the need to reinforce talent support, among other things, and accelerate digital technology adoption in order to empower rural production and life. Consequently, we evaluated the level of digital service consumption, the digital talent service team, and the service scope of information technology applications such as the Internet of Things in accordance with the findings of Zhu Honggen and Chen Hui [30] (pp. 21–33).

3.1.2. Level of Inclusive Green Rural Development

The indicator system construction method and the data inclusion analysis method are the primary determinants of inclusive green growth measurement. However, the data inclusion analysis method measures the process of transforming the input factors into output factors, which is not suitable for the inclusive green growth investigated in this study. Hence, we employ the indicator system construction approach, grounded in the framework of development economics. Drawing inspiration from the scholarly consensus regarding inclusive green growth, which characterizes it as a coordinated development process encompassing the economy, society, and environment dimensions [2] (pp. 3–20) and the accessibility of indicator data, it is recommended that assessment indicator systems for rural inclusive green growth be constructed using the three dimensions of rural economic growth (Table 2). Regarding the aspect of rural economic development, the 2023 Central Rural Work Conference underscored the importance of integrating a double-cycle strategy that consciously incorporates efficiency and quality improvements. Hence, in consideration of the research conducted by Ji Zhiheng [34] (pp. 25–44) and Liu, Z.Y. and Zhe Vakas [35] (pp. 28–44), we selected labor productivity and land productivity as indicators of rural economic growth efficiency. The proportion of GDP attributable to the primary sector, the degree of agricultural mechanization, and the disposable income per capita of rural inhabitants were chosen as the indicators of the rural economy expansion potential. To assess the rural external trade and domestic consumption capacities, the agricultural product market turnover as a percentage of the primary production value and the proportion of consumer good retail sales in settlements and rural areas as a percentage of the total consumer good retail sales were chosen as indicators. Regarding the aspect of rural social inclusion, the 2023 Central Economic Conference underscored the importance of "concentrating on high-quality development, efficiently protecting and enhancing people's livelihoods, with the ultimate goal of ensuring that the benefits of development increasingly and equitably benefit all individuals' livelihoods in order to strengthen the level of livelihood protection". In this study, we selected the urban–rural income gap, village health rooms, rural hospitals, health workers, rural cultural stations, number of rural old-age pension service organizations, expenditure on the rural minimum subsistence guarantee, number of rural residents with minimum subsistence guarantees, average level of education, number of participants in pension insurance, and number of participants in health insurance by combining the rural characteristics and referencing the works of Liu Chengkun and Zhang Minghong et al. [36] (pp. 1–7) and Xu Xue and Wang Yongyu [37] (pp. 64–83). The Strategic Plan for Rural Revitalization (2018–2022) explicitly specifies that in the context of green rural development, agricultural and rural habitat improvement and the acceleration of green development should be prioritized, which entails the implementation of green production methods and the establishment of green living environments. Hence, this research draws inspiration from the investigations conducted by Jia Jin et al. [38] (pp. 70–82) and Yan Zhoufu and Wu Fangwei [39] (pp. 90–103), which assessed the greening of rural life through indicators such as the forest coverage, number of public toilets, and rate of harmless domestic waste treatment. The greening of rural production was quantified through the proportion of model counties dedicated to recreational agriculture, the intensity of the fertilizer and pesticide application, and the intensity of the forest coverage.

Table 2. Rural inclusive green growth indicator construction.

Level-1 Indicators	Secondary Indicators	Interpretation of Secondary Indicators
Rural economic growth	Land productivity	Gross agricultural output/area sown under crops
	Labor productivity	Gross output value of agriculture, forestry, animal husbandry, and fishery/number of persons employed in the primary sector
	Percentage of agricultural economics	Primary sector as a percentage of GDP
	Level of agricultural mechanization	Total power of agricultural mechanization level
	Per capita disposable income of rural residents	Gross disposable income per rural inhabitant/population of rural inhabitants
	Foreign trade	Agricultural market turnover/value of primary production
	Rural consumption levels	Share of retail sales of consumer goods in townships and rural areas in total retail sales of consumer goods
Rural social inclusion	Urban-rural income gap	Average income of urban residents/average income of rural residents
	Village health offices	Number of rural health centers
	Rural hospitals and health workers	Number of rural hospitals and health personnel
	Rural Cultural Stations	Total number of cultural stations established in rural areas
	Number of rural elderly services	Number of institutions established in rural areas specializing in the provision of elderly services
	Expenditure on rural minimum subsistence guarantee	Expenditure on funds corresponding to the minimum subsistence level provided by the government to ensure the basic livelihood of rural low-income families
	Number of rural residents guaranteed minimum subsistence allowance	Number of people eligible for the rural minimum subsistence guarantee who are eligible to receive the minimum subsistence guarantee provided by the government
	Average rural educational attainment	Average level of education of people living in rural areas
	Number of pension insurance participants	Number of pension insurance participants for the year
	Number of participants in medical insurance	Number of persons enrolled in health insurance during the year
Rural green development	Percentage of model counties for leisure agriculture	Number of leisure agriculture demonstration counties as a proportion of the total number of counties and districts
	Green Food Certification Index	Green food back in the day
	Fertilizer intensity	Fertilizer use/cultivated land area
	Pesticide Intensity	Pesticide use/cultivated land area
	Intensity of agricultural plastic film use	Agricultural plastic film use/cultivated land area
	Forest Coverage	Forest cover
	Soil erosion control area	Soil erosion control area
	Number of public toilets	Total number of toilets for public use
	Harmless treatment rate of domestic waste	Non-hazardous domestic waste disposal rate

3.2. Coupled Coordination Degree Model

The coordinated relationship between systems that foster one another is referred to as coupling [40] (pp. 72–90). Coupling denotes the synergistic development that results from the interactions and influences between systems. The model's extensive application within the economic domain underscores its notable degree of rationality. An investigation was conducted to examine the correlation between rural inclusive green growth and digital villages through the development of a coupling model of the two:

$$C_{t,i} = \sqrt{\frac{DE_{t,i} \times DF_{t,i}}{\left(\frac{DE_{t,i} + DF_{t,i}}{2}\right)^2}} \quad (1)$$

The coupling degrees between the Digital Rural Development Index ($DE_{t,i}$) and the Rural Inclusive Green Growth Index ($DF_{t,i}$) for region i in year t are denoted by $C_{t,i}$. Before the coupling can be calculated, the values of these indices must be normalized and shifted due to their numerical differences. The coupling index quantifies the degree of interdependence between inclusive green rural growth and digital village development, ranging from 0 to 1. A lesser value indicates that the progress of both entities is hindered and disorderly; conversely, a greater value signifies that the two entities foster one another and are advancing in unison.

Nevertheless, it is challenging to precisely ascertain the coupling degree between the particular digital village and rural inclusive green growth development levels. The coupling degree (C) is 1 when DE = DF. In the event that the two indices exhibit similarity, the coupling degree remains high despite their low development rates. Hence, to conduct a thorough evaluation of the degree of coordination and development of rural inclusive green growth and digital villages, in this article, we employ a coupling coordination degree model, drawing inspiration from the research conducted by Zhu et al. [30] (pp. 21–33), Pi, Jiancai and Song, Daqiang [40] (pp. 72–90), and Liu, Tan et al. [41] (pp. 1–36):

$$T_{t,i} = \alpha DE_{t,i} + \beta DF_{t,i} \quad (2)$$

$$D_{t,i} = \sqrt{C_{t,i} \times T_{t,i}} \quad (3)$$

The rural inclusive green growth and digital village coupled coordination degree ($D_{t,i}$) value ranges from 0 to 1, with greater values signifying enhanced coordination between them and lower values signifying the opposite. The combined development level of the two is represented by the comprehensive evaluation index ($T_{t,i}$), wherein α and β represent the contribution of digital communities to rural inclusive green growth, respectively, and $\alpha + \beta = 1$. In this study, the equal importance of both variables was assumed, denoted as $\alpha = \beta = 0.5$. The relationship between rural inclusive green growth and digital villages can be described as follows: if $DE - DF > 0.1$, digital villages are surpassing rural inclusive green growth in terms of development; if $DF - DE > 0.1$, digital villages are falling behind rural inclusive green growth; and if $DE - DF \leq 0.1$, the two are at more comparable levels of development. Drawing inspiration from the research conducted by Liu Chunyu et al. [42] (pp. 1–14) and Tan Juntao et al. [43] (pp. 3827–3834), in this study, we categorized the degrees of coupling coordination between rural inclusive green growth and digital village development into four distinct classifications (Table 3).

Table 3. Coupling coordination metrics and types.

Type of Coupled Coordination	Low Coupling Coordination	Moderate Coupling Coordination	Highly Coupled Coordination	Extreme Coupling Coordination
D-value interval	$0 < D \leq 0.3$	$0.3 < D \leq 0.5$	$0.5 < D \leq 0.8$	$0.8 < D \leq 1$

Digital villages and inclusive green growth may be related, according to a comprehensive analysis of multiple indices. In this study, we calculated the digital village and rural inclusive green growth coupled coordination degrees at the provincial level in China from 2011 to 2021 using Equations (2) and (3), as shown in Appendix A. The digital village and rural inclusive green growth coupled coordination degrees were examined in greater detail using the coupled coordination degree model.

3.3. Modified Coupled Coherence Model

To enhance the rigor of the research content presented in this article, a robustness test was performed. Equation (3) states that the coupled coordination degree model will be simplified in the previous iteration when the combined contribution of rural inclusive green growth and digital villages is 0.5:

$$D_{t,i} = \sqrt[4]{DE_{t,i} \times DF_{t,i}} \tag{4}$$

Implementing this simplification could potentially compromise the model's validity. Therefore, Shujia Wang et al. [44] (pp. 793–810) proposed a modified coupled model that can effectively resolve this issue:

When $DE_{t,i} > DF_{t,i}$,

$$C'_{t,i} = \sqrt{[1 - (DE_{t,i} - DF_{t,i})] \times \frac{DF_{t,i}}{DE_{t,i}}} \tag{5}$$

When $DE_{t,i} < DF_{t,i}$,

$$C'_{t,i} = \sqrt{[1 - (DF_{t,i} - DE_{t,i})] \times \frac{DE_{t,i}}{DF_{t,i}}} \tag{6}$$

Appendix B presents the updated linked coordination of digital villages and rural inclusive green growth at the provincial level in China for the period of 2011–2021, derived from a thorough investigation of the indicators and Equations (5) and (6).

4. Results and Interpretations

4.1. Modified Coupled Coherence Model

Figure 2 shows that, when looking at China as a whole, the average value of the Digital Village Index since 2011 has demonstrated an increasing trend annually. This is a result of the 2012 introduction of the "digital transformation" concept; the building of digital infrastructure and the encouragement of the use of Internet technology; the creation of national strategies like "Broadband China", "Internet Plus", and "big data"; as well as the quick advancement of information technology construction. A number of technological advancements in the field of digital technology, including software, electronic information, and communication networks, have continued to support the development of the Internet ecosystem and the ongoing digital infrastructure modernization under the policy's guidance. In order to accomplish the digital transformation of rural areas, China is also actively promoting the digital village strategy, which entails the integration of digital technology into rural economic and social development and improvement in the digital literacy of farmers. Additionally, the Rural Inclusive Green Development Index has exhibited a consistent annual development pattern, albeit with intermittent variations, which is due to the firmly established political system in China. China's strategic decision to "vigorously promote the construction of an ecological civilization" was announced in 2011, and since then, the green concept has emerged as the guiding principle of future development. In terms of development growth rate, the growth rate of the Digital Countryside Index from 2011 to 2021 shows a downward and then upward trend, while the Rural Inclusive Green Development Index generally maintains stability, slowly meandering upward. In 2014, there was a negative growth rate of rural inclusive green development. On the whole, the growth rate of digital village development is greater than rural inclusive green growth. In the past three years, the growth rate of digital villages has been maintained at around 10%, while rural inclusive green growth has been maintained at around 5%. The primary rationale for this phenomenon is that once digital villages and rural green inclusiveness reach a specific stage of development, additional progress becomes impracticable, resulting in a marginal deceleration in their respective growth rates. This signifies that China's digital villages and rural green inclusiveness are gradually transitioning from an initial stage of immature development to one of stability.

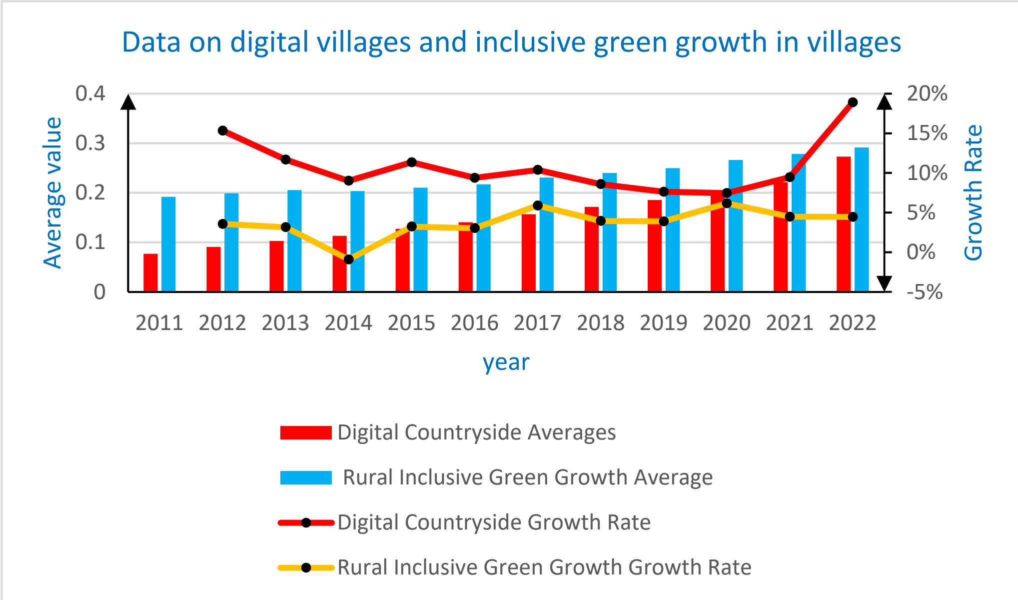

Figure 2. Mean and growth rate of the Provincial Digital Village Index and the Rural Inclusive Green Growth Index, 2011–2021. (The horizontal axis represents the year, and the vertical axis represents the numerical value).

As illustrated in Figure 3, the index trends across all regions are essentially the same: upward. It is noteworthy to mention that while both inclusive rural development and digital village development exhibit considerable regional variation, they are fundamentally distinct. "Diminishing from east to west" is the degree of digital village development; the eastern and central regions have considerably more developed digital villages than the western region. When considering the digital countryside expansion rate, it is noteworthy that the eastern region has maintained a commendable degree of digitalization throughout the entire time span. Although the central and western regions are experiencing some growth, it is evident that their overall levels of development are lagging. An exhaustive examination reveals that, in terms of digital village development, the eastern region is at the forefront, with the central region following suit, whereas the western region is falling behind. This is a result of the east's stronger innovation capacity and economic foundation, as well as its more rapid digital technology advancement. Additionally, technological spillovers from the east and comparatively stronger economic conditions in the central region could prove advantageous. In contrast, the western region's comparatively low economic development level and inadequate investment in digital infrastructure development and maintenance render it relatively weak. "Green inclusive development in rural areas is greatest in the center, second greatest in the east, and least in the west".

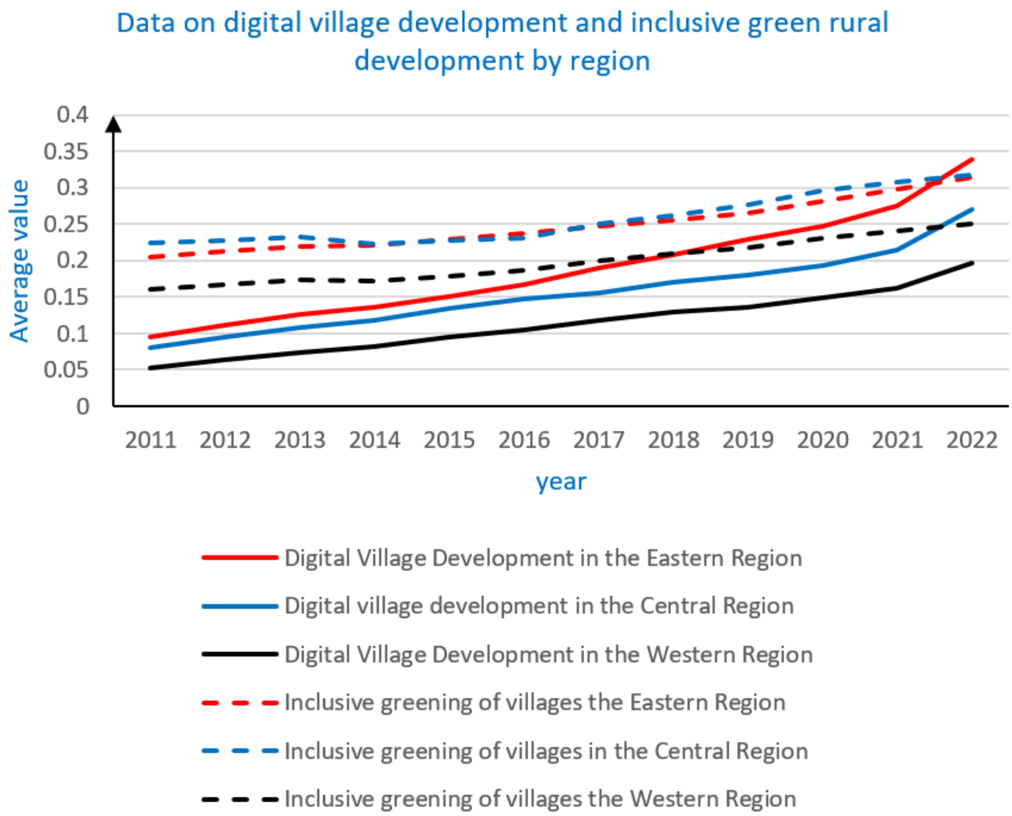

Figure 3. Digital rural development and rural inclusive green development means by region, 2011–2021. (The horizontal axis represents the year, and the vertical axis represents the numerical value).

For a more comprehensive examination of the factors contributing to the variability observed in inclusive green rural development, the twelve-year averages of the Level-1 indicators from the Digital Rural Inclusive Green Development Index for every region from 2011 to 2022 are displayed in Figure 4. It is evident that the rural green development indicator exhibits minimal variation among the three regions. The eastern region exhibits a superior level of rural economic development in comparison to the central and western regions. Conversely, the central region surpasses the eastern and western regions by a significant margin in the rural social inclusion indicator. China's balanced regional development strategies, exemplified by the "Rise of Central China" and "Western Development" policies, have yielded favorable outcomes for the central region. Notably, increased resource investment and government attention have been directed towards rural revitalization and ecological development. Furthermore, as a result of its comparatively advantageous natural circumstances, the central region has prioritized sustainable development models and green agriculture, including eco-tourism and rural tourism, in order to further encourage inclusive green growth in rural regions. Although the eastern region is experiencing more rapid economic development, its focus is primarily on urban and coastal areas. Although rural regions do benefit from economic spillovers, there may still be disparities in the social inclusiveness between urban and rural areas, particularly in education, healthcare, and social services. In contrast, the western region is afflicted by more severe environmental challenges, including desertification and drought, in addition to infrastructure deficiencies that hinder the rate and caliber of its rural inclusive green expansion.

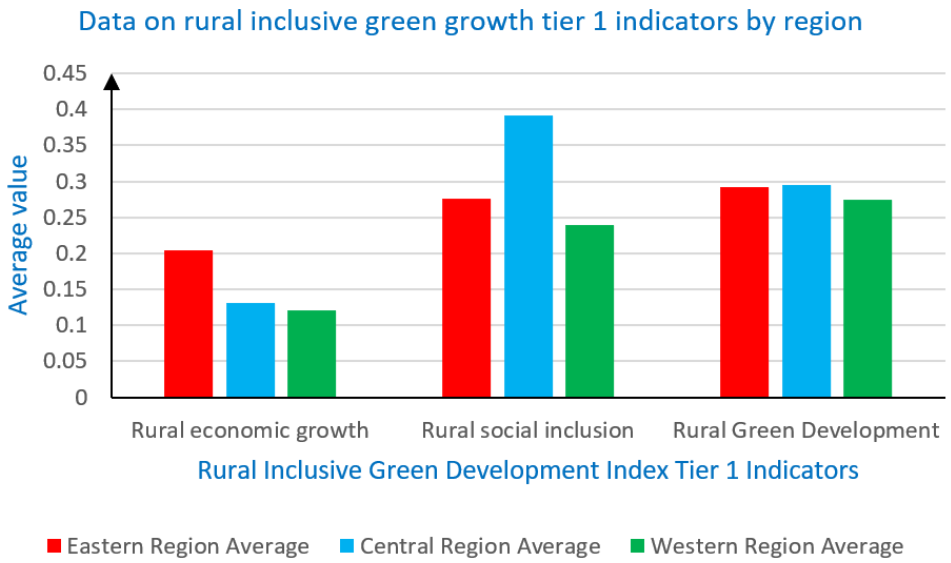

Figure 4. Digital rural development and rural inclusive green development means by region, 2011–2021. (The horizontal axis represents the specific classification of inclusive green development, while the vertical axis represents numerical values.)

4.2. Time-Series Evolution of the Coupled Coordination Degree of Digital Villages and Inclusive Rural Green Growth

The digital village and rural inclusive green growth coupling coordination degrees from 2011 to 2022 were assessed using the evaluation index system of digital villages and rural inclusive green growth, which was established previously and is based on the coupling degree and coupling coordination degree model (Appendix A). Based on the data presented in Appendix A, the digital village and rural inclusive green development coupling coordination degrees in 30 provinces of China have been predominantly between 0.20 and 0.75 over the past decade. The average coupling coordination degree of China's rural inclusive green growth and digital countryside was 0.5072% in 2021, representing a high coupling coordination level. From 2011 to 2021, the mean coupling coordination degree of China's rural inclusive green growth and digital countryside was situated at the moderate coupling level. In contrast to the full sample period from 2011 to 2022, during which the coupling coordination between the two indices was estimated to have a mean value of 0.4209, the coupling coordination between them was below the mean value for the subsequent six years. A steady growth was observed in the chronological evolution of digital villages and inclusive rural green growth between 2011 and 2016, which may have been facilitated by proactive policy orientation, infrastructure development, and social participation. However, China's rural areas underwent uneven development during this time, with some regions presumably receiving more attention and inputs than others, resulting in their overall underdevelopment. The implementation of strategies such as "Digital China" and "Rural Revitalization" has increased the government's support for rural digitalization, including policy guidance, financial investment, and project support. This has facilitated the deep integration of digital technology and rural development, resulting in a rapid increase in coordination during the rapid development phase (2016–2021). This demonstrates that China has consistently augmented the input provision for inclusive development and digitalization, rationalizing the input–output structure of the two systems. The advancement of ecological environmental protection has accompanied the development of the digital countryside, and the coupling between the two has been significantly improved.

The adjustment of the Chinese mean for the coupled harmonization of the digital countryside and rural inclusive green development indices is dependent on the year 2013 with respect to the leading or lagging relationship between their development. The advancement of digital villages fell behind the comprehensive green expansion of rural regions from 2011 to 2013 (type a) due to the fact that the majority of China's rural areas had not yet developed a robust Internet infrastructure at this time. Inadequate network coverage hindered the access to, distribution of, and utilization of digital information. Consequently, rural inhabitants were unable to fully benefit from digital resources and services. Furthermore, the adoption and integration of new technologies were impeded by traditional ways of life and attitudes. The inadequate provision of network coverage in rural regions has resulted in the restricted availability and utilization of digital information, impeding residents' ability to fully benefit from digital services and resources. Digital Villages and Rural Inclusive Green Growth in Synergy since 2014 (type c) indicates that digital villages and inclusive green rural development are, on the whole, becoming progressively more supportive and mutually reinforcing. From 2011 to 2013, digital village development lagged behind rural inclusive green growth (type a). However, from 2013 onwards, digital village development and rural inclusive green growth have developed synergistically (type c), which indicates that, since 2011, digital villages have expanded at a faster rate than rural inclusive green growth, reflecting a transition from pioneering to adaptive and synergistic development. This is due to the delayed emergence of digital villages, whereas rural inclusive development was promoted and implemented to some degree from 2011 to 2013, thereby establishing a foundation. Digital village promotion may have been hampered in its infancy by a variety of obstacles, including technological preparedness challenges, infrastructure development obstacles, and so forth. As a result, the development of digital villages has lagged behind that of inclusive green rural growth. Nevertheless, as time has progressed, the notion of digital villages has garnered traction, policy backing has been established, and technological advancements have developed, fostering synergies between digital villages and inclusive rural green growth. The swift assimilation of digital communities subsequent to 2013 can be ascribed to the expeditious advancement of digital technologies, more profound policy execution, and the broader societal approval of digitalization. The transition from inclusive green rural growth surpassing digital villages to their tandem development signifies the progressive integration of digitalization into rural development and the gradual establishment of a virtuous cycle wherein the advancements of digital villages and inclusive green rural growth are supportive and mutually reinforcing.

The validation of the revised coupling model revealed that it substantially enhanced the coupling's discriminatory and usage validity (see Appendix B). The coupling coordination degree outcomes computed using this model indicate that, as depicted in Figure 5, the values of the coupling coordination degrees between digital villages and rural inclusive green growth in provincial-level regions of China have decreased. However, this has not altered the trajectory of the coupling coordination degree development in each province and city; in fact, this result is essentially identical to previous empirical findings, and it continues to hold true. The modified coupled model performed admirably on the robustness test. The mean coupling coordination between the modified digital village and rural inclusive green development indices in China is 0.3684, with a mean coupling coordination value range between 0.15 and 0.65, indicating a moderate level of coordination.

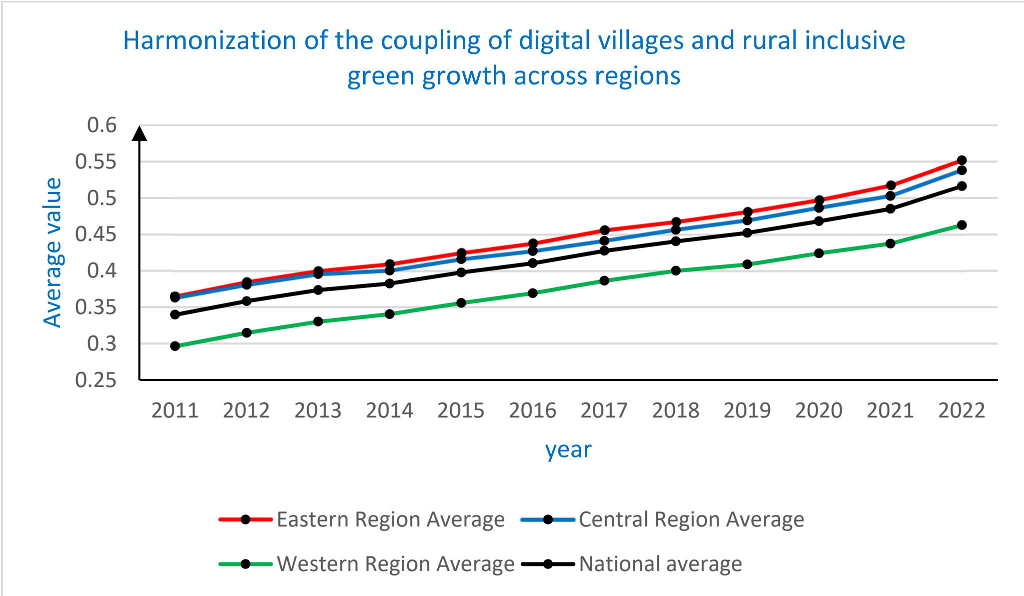

Figure 5. Harmonization of the coupling of digital villages and inclusive green growth in villages by region, 2011–2021. (The horizontal axis represents the year, and the vertical axis represents the numerical value).

4.3. Spatial Evolution of the Coupled Coordination Degree of Digital Villages and Rural Inclusive Green Growth

In order to conduct a more comprehensive spatial comparison of the provinces and to fully account for the results of the digital village and rural inclusive green growth time-series evolution analysis, in this study, we evaluated the coupling coordination degree of each province of China using three time points: 2011, 2016, and 2021. We utilized ArcGIS 10.8 to map the spatial differentiation with an emphasis on depicting the coupling coordination level and corrected coupling coordination level for each province and city and displaying these data through the use of color differentiation.

As depicted in Figure 6, the coupling coordination degree trends are essentially the same across all regions at the regional level; each region experiences an annual increase. Nevertheless, the eastern region has the most pronounced coupling coordination degree, followed by the central region, whereas it is the least pronounced in the western region. Furthermore, while the central and eastern regions exhibit coordination degrees that surpass the Chinese average, that of the western region remains significantly divergent from the Chinese average. The eastern region had already attained a coupling coordination degree value of 0.4 as of 2013, signifying that, by 2022, it had successfully transitioned from a state in which digital rural development lagged behind rural inclusive green growth (type a) to one in which the two advance synergistically (type c). In contrast, the center achieves synergy between the two in 2015 (type c), while the west completes the transition in 2014. As of the year 2022, the coupling coordination degree in the eastern region was 0.5516, while it was 0.5379 in the central region and 0.4627 in the western region. It is noteworthy that while digital country-side development in the central region falls behind rural inclusive green development, the level of integration and coordination between the two is greater than in the eastern region. One potential explanation for this discrepancy is that while the average rate of rural economic growth in the central region is comparatively lower than that in the eastern region, it offers specific benefits in terms of promoting rural social inclusion and facilitating sustainable development in the countryside. Conversely, the eastern region's rapid economic growth may give rise to challenges such as environmental pollution and resource overexploitation, despite its more developed technological and information infrastructures. Furthermore, in contrast to the central region's sluggish economic development, the establishment of digital villages commenced belatedly and progressed at a sluggish rate. However, in promoting inclusive green rural development, the central region may have adopted more proactive and adaptable strategies, such as emphasizing ecological preservation and promoting green agriculture, which has assisted in enhancing its coupling coordination. Moreover, as part of the regional coordinated development strategy of the Chinese government, additional policy support and resource allocation may have been directed toward the promotion of rural green growth and digitalization in the central region, facilitating improved coupling coordination between digital village construction and inclusive rural green development in this area. Nevertheless, the central region faces obstacles such as an inadequate support capacity for fundamental digitalization, a weak foundation in the digital technology industry, and a scarcity of human resources. As a result, the progress of digital countryside construction has been impeded by the developed eastern regions, perpetually falling behind that of rural inclusive green development. Consequently, despite the eastern region having a lower degree of coupling coordination than the central region, the implementation of digital village construction and inclusive green growth in rural areas has experienced a postponement in their synergistic development.

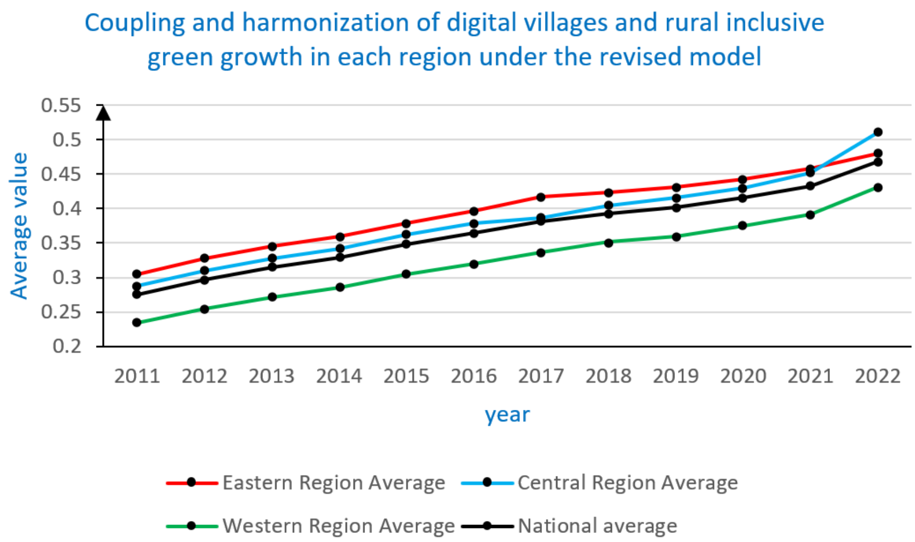

Figure 6. Degree of harmonization of the coupling of digital villages and rural inclusive green growth in each region under the revised model, 2011–2021. (The horizontal axis represents the year, and the vertical axis represents the numerical value).

Based on the findings of the time-series analysis examining the digital countryside and rural inclusive green growth coupled coordination degrees (as depicted in Figure 7), the provincial level can be categorized into two stages: Stage I (2011–2016) and Stage II (2017–2022). Figure 7 illustrate the coupling coordination degree and its adjusted values between digital village construction and rural inclusive green growth in various provinces of China for the years 2011, 2016, and 2022. The top three figures depict the temporal and spatial evolution of the coupling coordination degree between digital village construction and rural inclusive green growth. The bottom three figures illustrate the temporal and spatial evolution of the adjusted coupling coordination degree for digital village construction and rural inclusive green growth. Based on the coupling coordination degrees of digital village construction and rural inclusive green growth in 2011, 2016, and 2022, it can be observed that in 2011, most of the eastern and central regions of China were in a state of moderate coupling coordination, while the western regions were mostly in a state of low coupling coordination. By 2016, some provinces in the eastern regions began to reach a state of high coupling coordination, the central regions remained in moderate coupling coordination, and the number of provinces in the western regions with low coupling coordination decreased. Notably, Sichuan Province in the western region advanced to a state of high coupling coordination, benefiting from the Western Development Strategy, which provided more policies and resources. By 2022, the eastern and southern regions had largely achieved a state of high coupling coordination, and the remaining regions were in a state of moderate coupling coordination. Overall, the coupling coordination degree of digital village construction and rural inclusive green growth in China was at a moderately high level. Based on the adjusted coupling coordination degrees for 2011, 2016, and 2022, it is evident that the overall trend has been one of significant improvement, reflecting the effectiveness of national strategies and investments in promoting digital and green development in rural areas. In 2011, the adjustments show a slight increase in coordination levels, with moderate coordination becoming more widespread. In 2016, the adjustments reflect a substantial rise in high and extreme coordination in the eastern and central regions. By 2022, the adjusted values reveal a significant enhancement in coordination, with high and extreme coordination levels becoming more prevalent across the country. This analysis highlights the consistent upward trend in coupling coordination over time, with significant regional disparities, and the notable progress in economically advanced regions due to stronger economic foundations and better fiscal resources. Significantly, in the year 2018, Zhejiang Province and Guangdong Province underwent a shift from a phase of collaborative development between digital villages and rural inclusive green growth (stage c) to a phase in which digital village development surpassed rural inclusive green growth (stage b). Jiangsu Province also achieved digital village development (stage b) in 2019, which was prior to the achievement of rural inclusive green growth. Zhejiang Province is among the forerunners of the digital economy and e-commerce in China, particularly in urban centers such as Hangzhou. Utilizing its digital economy, Zhejiang Province has actively promoted rural e-commerce and Internet + Agriculture initiatives, thereby facilitating the digital upgrading of the real economy and accelerating the digital transformation of rural areas through the promotion of the Internet's in-depth integration with traditional manufacturing sectors. Guangdong Province, a prominent economic province in China, possesses a robust innovation capacity and an extensive industrial foundation, particularly in the Pearl River Delta area. These attributes furnish favorable circumstances and substantial drive for the digital transformation of rural regions. Constant improvements in the market and consumer demand in rural areas of Guangdong Province as a result of economic growth have fostered the growth of e-commerce and digital services, thereby contributing to the advancement of the digital countryside. Jiangsu Province exhibits a commendable and equitable degree of economic progress. Notably, the disparity in development from the southern to the northern regions of the province has progressively diminished. This progress has prompted the establishment and implementation of digital infrastructure in rural areas and actively advocates for the modernization of agriculture, with a particular emphasis on the advancement of smart agriculture and the utilization of digital technology to enhance the operational effectiveness and product quality. According to a comparative analysis, the spatial aggregation effect of the coupling coordination degrees of the provinces and cities has become more pronounced after eleven years of development. Moreover, the western region exhibits comparatively low coupling coordination degrees, whereas the provinces and cities with high coupling coordination degrees have progressively migrated towards the eastern and central regions.

After modifying the model, the calculated coupling coordination degrees decreased, resulting in a modification to the spatial distribution map. Six provinces and municipalities in China exhibited low coupling coordination levels in 2011, while the remaining provinces and municipalities demonstrated medium coupling coordination levels. Shandong, Jiangsu, Zhejiang, and Guangdong in the eastern region had achieved high coupling coordination degrees by 2016, while Qinghai and Chongqing in the western region had achieved medium coupling coordination degrees. The remaining provinces maintained their current coordination levels. As of 2022, fifty percent of the provinces in the eastern and central regions had achieved high coupling coordination degrees. In contrast, the western region is represented solely by Sichuan Province at a high level of coordination. Hainan and Qinghai continue to operate at low coupling coordination levels, while the remaining provinces maintain medium coupling coordination levels. The "gradually weakening from east to west" trend remains evident according to the color level differentiation map. Regardless of whether Stage I or Stage II pertains to spatial evolution, Hainan and Qinghai provinces have maintained their low coupling coordination levels despite increases in their coupling coordination degrees; thus, the spatial evolution is relatively minor. In contrast, China's digital countryside and rural inclusive green growth coupling coordination degrees underwent stage changes in the remaining provinces between 2011 and 2022; the spatial evolution is evident, exhibiting greater magnitude in the eastern provinces, while it maintains greater stability in the central and western provinces.

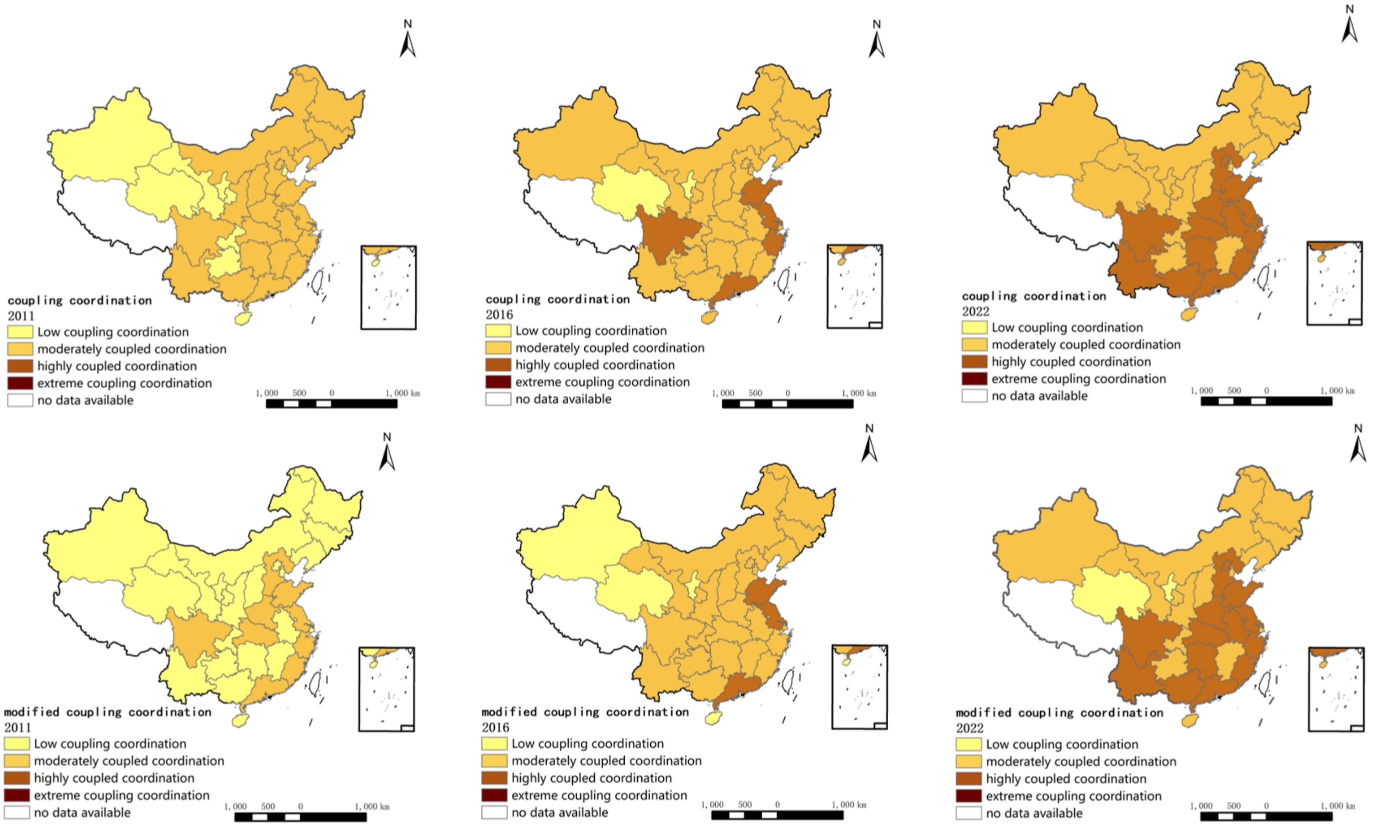

Figure 7. The temporal and spatial evolution of coupling coordination degree and its adjusted values between digital village construction and rural inclusive green growth in China (2011, 2016, 2022). Note: Based on standard maps from the Ministry of Natural Resources Standard Map Service website, GS (2023) 2767 (http://211.159.153.75/browse.html?picId=%224o28b0625501ad13015501ad2bfc2187%22, accessed on 16 May 2024), with no modifications to the base map boundaries.

4.4. Kernel Density Estimation Results

The benefits of using kernel density estimation for assessing coupling coordination lie in its ability to smooth data distribution and provide continuous density estimates, thereby making the distribution characteristics of the data clearer and more intuitive. This method can identify potential patterns, peaks, and distribution shapes within the data, aiding in understanding the variations and trends in coupling coordination. Kernel density estimation does not rely on distributional assumptions, making it suitable for various types of data, particularly non-normal distributions, and providing more reliable results. Compared to histograms, kernel density estimation can reveal more distribution details, facilitating a comprehensive analysis of coupling coordination. It also allows for easier comparison of coupling coordination across different regions or time periods, identifying differences and commonalities. Therefore, we constructed a kernel density model to examine the coupling coordination degree of digital villages and inclusive green growth in rural areas.

Let D be a random variable and D_1, D_2, ... D_n be a sample. The kernel density estimate of the probability density function f(x) at any point D can be expressed as:

$$f(x) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{D_i - d}{h}\right) \tag{7}$$

In this context, K(·) denotes the kernel function, n represents the sample size, h is the bandwidth, and d indicates the mean. This study employs the Gaussian kernel density function for calculations, which is expressed as:

$$K(d) = \frac{1}{\sqrt{2\Pi}}\exp\left(-\frac{d^2}{2}\right) \tag{8}$$

From 2011 to 2022, the coupling coordination degree in the western region mainly ranged from 0 to 0.6, with peak values concentrated between 0.2 and 0.4. The peaks gradually shifted to the right, indicating a steady improvement in the coupling coordination degree. This reflects the region's continuous enhancement in coordination among various factors, driven by infrastructure development, educational improvements, and national policy support such as the "Belt and Road" initiative (Figure 8).

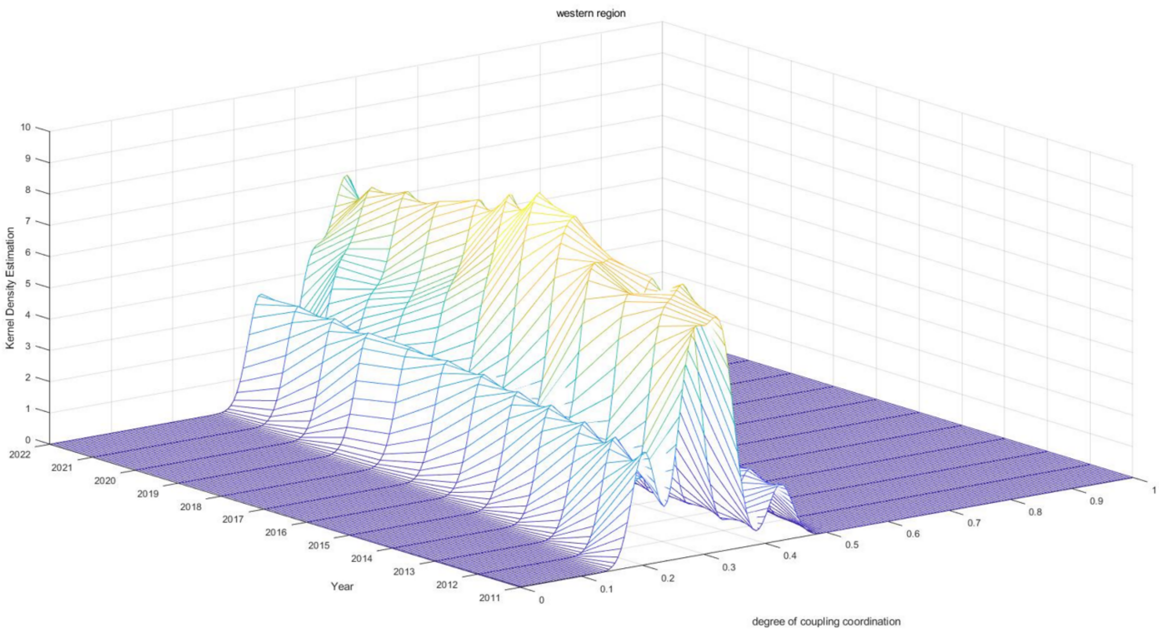

Figure 8. Kernel density map of the coupled harmonization of digital village construction and rural inclusive green growth in the western region.

From 2011 to 2022, in the central region, the coupling coordination degree also ranged from 0 to 0.6, with peak values fluctuating significantly between 0.2 and 0.5. The evident multi-peak pattern shows an initial increase followed by a decrease, highlighting the complexity and diversity of industrial restructuring and urbanization processes. This fluctuation is particularly influenced by resource and environmental pressures, as well as economic transitions (Figure 9).

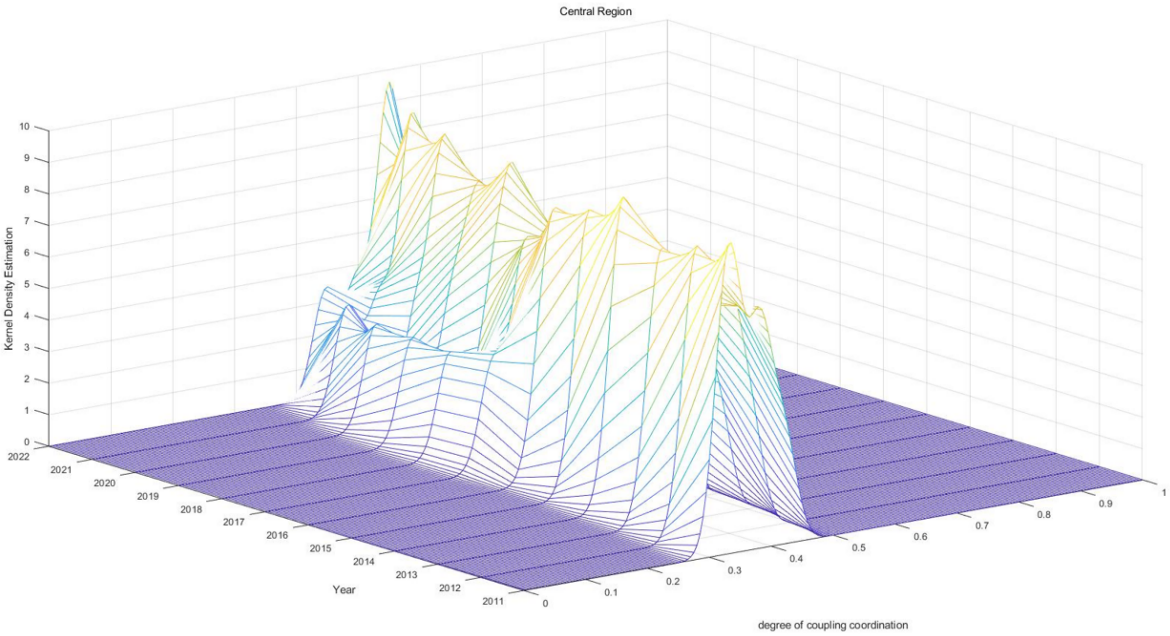

Figure 9. Kernel density map of coupled harmonization of digital village construction and rural inclusive green growth in the central region.

From 2011 to 2022, the eastern region's coupling coordination degree was mainly between 0 and 0.5, with peak values concentrated between 0.2 and 0.4. The peaks were narrower and higher, and their number gradually decreased, indicating a trend towards more balanced coordination. This improvement is attributed to the region's industrial upgrading, technological innovation, and sustainable development strategies, demonstrating its strengths in achieving comprehensive coordination (Figure 10).

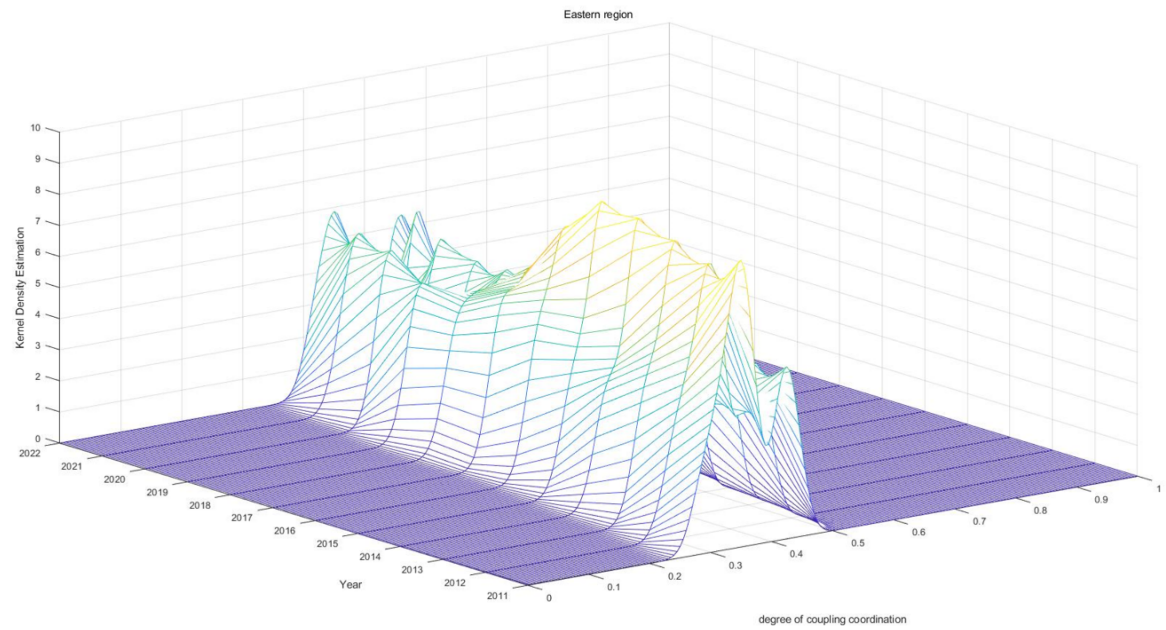

Figure 10. Kernel density map of coupled harmonization of digital village construction and rural inclusive green growth in the eastern region.

From 2011 to 2022, overall, across all regions, the coupling coordination degree mainly ranged from 0 to 0.6, with peak values concentrated between 0.2 and 0.5. The moderate fluctuations indicate a gradual improvement in the coupling coordination degree nationwide. This trend reflects the positive impacts of economic reforms, regional coordination development strategies, and the advancement of new urbanization initiatives, leading to enhanced coordination and sustainable development across the country (Figure 11).

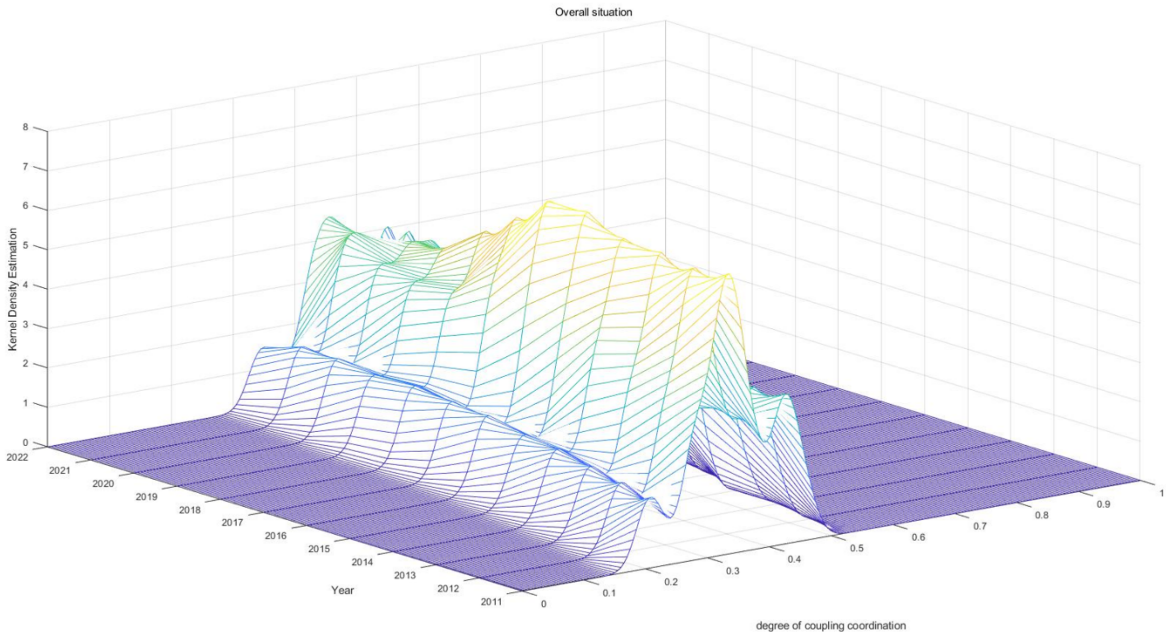

Figure 11. Kernel density plot of the coupled harmonization of digital village construction and rural inclusive green growth in China.

4.5. Domain-Wide Spatial Correlation Test

In this study, the Global Moran's I index is utilized to analyze the coupling coordination between digital village construction and inclusive green growth in rural China. Its benefits include revealing spatial autocorrelation, quantifying spatial patterns, detecting and locating clusters of high and low coupling coordination, providing significance testing to ensure the reliability of the analysis results, and offering robust support for policymakers. This helps in formulating precise and effective regional development strategies, thereby promoting coordinated regional development and optimal resource allocation.

Based on the analysis of Moran's I index from 2011 to 2022, the coupling coordination degree in the early period (2011 to 2020) showed an upward trend but did not reach significant levels. This indicates that during these years, the spatial distribution of variables did not exhibit a clear clustering pattern, possibly due to the initial implementation of regional policies, uneven economic development, and incomplete infrastructure development. However, in 2021 and 2022, the Moran's I index increased significantly, indicating notable spatial autocorrelation and a more pronounced clustering of similar values within regions (Table 4). This change can be attributed to the deepening of regional policies, economic restructuring and transformation, improvement of infrastructure, enhanced socioeconomic factors, and policy orientation and resource allocation. These factors have collectively increased spatial dependence and coordination among regions, promoting regional coordinated development and optimized resource allocation.

Table 4. Global Moran's I index of the coupled harmonization degree of digital countryside and rural inclusive green growth in China, 2011~2022.

Year	I	Z	P
2011	0.062	0.783	0.217
2012	0.069	0.837	0.201
2013	0.087	0.985	0.162
2014	0.083	0.949	0.171
2015	0.089	1.004	0.158
2016	0.076	0.896	0.185
2017	0.083	0.949	0.171
2018	0.114	1.202	0.115
2019	0.132	1.342	0.090
2020	0.134	1.357	0.087
2021	0.180	1.731	0.042
2022	0.228	2.120	0.017

4.6. Analysis of Factors Influencing Coupling Coordination Degree

Considering the influencing factors of digital rural construction and inclusive green growth in rural areas, this study employs a bidirectional fixed effects model for analysis. The following variables are selected as explanatory variables: (1) urbanization rate, measured by the ratio of urban population to total population; (2) industrial structure, measured by the ratio of the output value of the tertiary industry to that of the secondary industry; (3) innovation level, measured by the natural logarithm of the number of invention patent applications; (4) natural disasters, measured by the ratio of affected area to disaster area; (5) fiscal support for agriculture, measured by the natural logarithm of expenditure on agriculture, forestry, and water affairs; (6) scale of operation, measured by the ratio of grain sown area to total crop sown area; (7) education investment, measured by the ratio of education expenditure to total fiscal expenditure; and (8) environmental investment, measured by the ratio of environmental protection expenditure to total fiscal expenditure.

The coupling and coordination of digital rural construction and inclusive green growth in rural areas are influenced by multiple factors. Here is an explanation of how these eight control variables affect this process (see Table 5):

1. Urbanization Rate: The urbanization rate is an important indicator of the urbanization process in a country or region. As urbanization progresses, rural populations migrate to cities, potentially leading to a reduction in rural labor force, which affects rural economic development and construction. On the other hand, urbanization brings technology and capital to rural areas, promoting the coordinated development of rural construction and green growth.
2. Industrial Structure: Industrial structure refers to the proportion of different industrial sectors in the national economy. The ratio of the tertiary industry (services) to the secondary industry (manufacturing) reflects the level of economic development and structural adjustment. The development of the service industry can diversify the rural economy, reduce dependence on traditional agriculture, and promote green development and rural revitalization.
3. Innovation Level: The innovation level is usually measured by the number of patent applications. An increase in innovation capability can bring new technologies, products, and models, helping to improve agricultural productivity, reduce environmental pollution, and achieve green growth and sustainable development in rural areas.
4. Natural Disasters: Natural disasters have a direct impact on the rural economy and life. Areas frequently affected by disasters require more resources for post-disaster

reconstruction and risk prevention, which may limit investments in rural construction. However, strengthening disaster prevention and mitigation capabilities and ecological restoration can contribute to the long-term goals of green development in rural areas.

5. Fiscal Support for Agriculture: Fiscal expenditure on agriculture, forestry, and water affairs reflects the government's support for agricultural and rural development. This support can directly influence rural production conditions and quality of life through subsidies, infrastructure construction, and technology promotion, fostering the coordinated development of rural construction and green growth.
6. Scale of Operation: The ratio of grain-sown area to total crop-sown area reflects the level of specialization and scale of agricultural operations. Large-scale operations can improve agricultural productivity and resource utilization, promoting modern agricultural development and green growth in rural areas.
7. Education Investment: The proportion of education expenditure to total fiscal expenditure reflects the government's emphasis on education. Increased education investment can enhance the quality of the rural population and workforce skills, providing intellectual support and talent reserves for rural construction, and promoting inclusive green growth.
8. Environmental Investment: The proportion of environmental protection expenditure to total fiscal expenditure reflects the government's emphasis on environmental protection. Increasing environmental investment helps improve the rural ecological environment, reduce pollution and resource waste, and promote green development and sustainable construction in rural areas.

Table 5. Regression results of the bidirectional fixed-effects model.

Variant	National Region	Eastern Region	Central Region	Western Region
Urbanization rate	0.2124 ** (2.50)	0.1047 (0.85)	0.0115 *** (3.30)	0.9988 *** (4.39)
Industrial structure	0.5114 (0.68)	−0.0126 (−1.29)	0.0185 (1.00)	0.0301 * (1.80)
Innovation level	0.0023 ** (2.55)	0.0029 ** (2.40)	0.0025 (1.51)	0.0034 (1.38)
Natural disasters	−0.0014 *** (−2.87)	−0.0017 ** (−2.50)	−0.0021 ** (−2.12)	−0.0020 (−1.47)
Financial support for agriculture	0.0075 *** (5.33)	0.0041 * (1.79)	0.0084 ** (2.20)	0.0064 *** (3.14)
Large-scale business operation	0.2874 ** (2.23)	0.7376 *** (3.71)	0.2699 (1.04)	−0.0549 (−0.26)
Investment in education	−0.1371 ** (−2.44)	0.1893 * (1.70)	−0.2329 * (−1.97)	−0.2776 *** (−3.67)
Environmental inputs	−0.1696 (−0.53)	−0.0129 (−0.32)	0.1697 * (1.68)	−0.1453 (−1.60)
Year FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Observed value	360	156	72	132
R-squared	0.9983	0.9703	0.9820	0.9636

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, with t-values in parentheses.

The test results show that the coefficient of the urban population ratio is positive, indicating that an increase in the urban population ratio can contribute to the improvement of the coupling and coordination of digital rural development and inclusive green growth at the national level and across all regions. However, the coefficients are significant only at the national level and in the central and western regions. The industrial structure positively promotes the coupled and coordinated development at the national level and in the central and western regions, but only the coefficient for the western region is significant. Conversely, in the eastern region, industrial restructuring inhibits the coupling and coordination of the two aspects. The western region, rich in natural resources such as minerals and water, can better utilize these advantages to promote digital rural development and inclusive green growth through industrial restructuring, resulting in a significant coupled coordinated development effect. The eastern region, on the other hand, is relatively resource-poor and may face constraints in achieving similar effects through industrial restructuring.

The level of innovation significantly promotes the coupled and coordinated development of digital rural development and inclusive green growth at the national level and across regions but not in the central and western regions, where the lack of infrastructure and resources may limit the impact of innovation. Effective innovation requires robust research institutions, talent pools, and technical support, which are more prevalent in the eastern region than in the central and western regions, thus limiting the level and effectiveness of innovation there.

Natural disasters significantly inhibit the increase in coupled coordination at the national level and in the eastern and central regions, but the effect is not significant in the western region. This may be due to the higher frequency of natural disasters in the eastern and central regions compared to the western region, where such events are less common, resulting in a negligible impact on the degree of coupling and coordination.

Financial support for agriculture significantly contributes to the coupling and coordination degree across the entire country and in each region, indicating that fiscal support can enhance coupling coordination to a considerable extent. Scale operation significantly promotes this coupling and coordination at the national level and in the eastern region, but the effect is less pronounced in the central and western regions. In the eastern region, where land resources are relatively dispersed, scale operations can integrate land resources and improve farming efficiency and output. However, in the central and western regions, where land resources are more concentrated but farming conditions (e.g., soil quality, water availability) are poorer, the benefits of large-scale operations are limited, making it difficult to significantly enhance the degree of coupling and coordination.

Educational inputs significantly contribute to the coupling and coordination in the eastern region but inhibit improvement at the national level and in the central and western regions. The eastern region, with its strong educational infrastructure and resources, can more effectively transform educational inputs into human capital, directly promoting economic development and social progress, thereby improving the degree of coupling and coordination. In contrast, the central and western regions, with relatively weaker educational foundations, may find it challenging to quickly convert new educational inputs into effective human capital, requiring a longer time to see improvements in educational quality and level.

Environmental inputs significantly contribute to the coupling and coordination in the central region but inhibit it at the national level and in the eastern and western regions. The central region may have clearer policy orientation and stronger implementation in environmental governance, ensuring that environmental protection expenditures are effectively utilized and achieve significant results, thus enhancing the degree of coupling and coordination. Conversely, in the national, eastern, and western regions, discrepancies between policy implementation effectiveness and the actual outcomes of environmental expenditures may lead to a high proportion of these expenditures failing to significantly improve coupling and coordination.

5. Conclusions and Recommendations

5.1. Conclusions

In this research, we utilized panel data from 30 Chinese provinces from 2011 to 2021 to systematically measure the development of digital villages and rural inclusive green growth.

By employing a relational coordination model, we assessed the coordinated development levels between these two aspects. The findings are as follows:

(1) Digital villages and inclusive green development in rural regions exhibit a consistent upward trajectory throughout China. The eastern region was at the forefront of the Digital Countryside Index's growth from 2011 to 2021, while the central region lagged behind. After 2014, the Rural Inclusive Green Development Index has continued to increase annually, with the eastern region outperforming the central region in terms of economic development and social inclusion. Collectively, the analyses demonstrate the increasing development of digital communities and inclusive green growth in rural areas.

(2) With regard to the time-series evolution, the rural inclusive green growth and China's digital countryside coupling coordination degree was minimal between 2011 and 2020 and peaked in 2021. The advancement of the digital countryside fell behind that of rural inclusive green growth (type a) from 2011 to 2016, and digital villages expanded in tandem with rural inclusive green growth (type c) between 2016 and 2021. The modified model's coupling coordination level results indicate that the values of the coupling coordination levels for the two indices have decreased, but this has not altered the trend of development for the coupling coordination levels in cities and provinces; this result is essentially consistent with previous empirical findings.

(3) With regard to spatial variations, the coupling coordination degree trends are essentially identical across all regions: they increase annually. Nevertheless, the coupling coordination degree is the lowest in the western region and the highest in the central region, followed by the eastern region. Furthermore, while both the western and central regions are situated above the average coordination level in China, this level is still considerably different from the average level in the eastern region. The eastern region's coupling coordination degree successfully completed the transition from rural inclusive green growth (type a), surpassing digital rural development to their synergistic development (type c) in 2014. Similarly, the central region accomplished this transition in 2021, whereas the western region had yet to do so as of 2021. Furthermore, following the correction, we observed a significant spatial evolution effect. From the results of Kernel density estimation, China's digital countryside and rural inclusive green growth coupling coordination shows an upward trend, with obvious stage characteristics.

(4) The increase in urbanization rate, the advancement in innovation levels, the reduction in natural disasters, the increase in financial support for agriculture, and the improvement in the capability of large-scale operations all contribute positively to the coupling and coordination of digital village construction and inclusive green growth in rural areas. These factors are crucial drivers in enhancing the synergy and alignment between digital rural development and sustainable, inclusive growth.

5.2. Recommendations

To enhance the synergistic growth of China's digital countryside and rural inclusive green development, the following policy recommendations are proposed: (1) the enhancement of digital infrastructure and green technology in the western region should be prioritized to reduce the disparities with the eastern and central regions; (2) region-specific policies that align with the local conditions should be implemented, such as advancing the integration of economic growth with environmental sustainability in the eastern region and reinforcing social inclusion initiatives in the central region; (3) the successful coordination model from the eastern region should be adapted to foster similar development across other regions; (4) mechanisms for coordinated action at both the local and national levels should be developed and refined to ensure cohesive strategy implementation; and (5) a comprehensive monitoring system should be set up to regularly evaluate the effectiveness of policies and their developmental impacts, adjusting the strategies as necessary to meet regional demands. These measures aim to drive more equitable and harmonized advancement in digital and green rural areas across China.

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Appendix A

Table A1. Coupled harmonization of digital villages and inclusive green growth in villages at the provincial level in China, 2011–2022. Note: a for digital villages lagging behind rural inclusive green growth, b for digital villages leading rural inclusive green growth, c for digital villages synergizing with rural inclusive green growth.

Region	Province	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
eastern part	Beijing	0.358 a	0.386 a	0.40 a	0.412 a	0.423 a	0.441 a	0.462 a	0.465 a	0.481 a	0.492 a	0.515 c	0.542 c
	Tianjin	0.287 a	0.306 c	0.327 c	0.333 c	0.348 c	0.361 c	0.37 c	0.364 a	0.373 a	0.398 a	0.416 a	0.441 a
	Hebei	0.417 a	0.432 a	0.445 a	0.455 a	0.466 a	0.483 c	0.499 c	0.512 c	0.527 c	0.55 c	0.564 c	0.598 c
	Shanghai	0.327 a	0.345 a	0.365 a	0.395 a	0.397 a	0.411 a	0.422 a	0.442 a	0.459 a	0.476 a	0.515 a	0.57 a
	Jiangsu	0.436 c	0.459 c	0.471 c	0.478 c	0.5 c	0.515 c	0.541 c	0.559 c	0.584 c	0.59 c	0.611 c	0.66 b
	Zhejiang	0.422 c	0.441 c	0.461 c	0.472 c	0.484 c	0.512 c	0.553 c	0.582 b	0.61 b	0.631 b	0.671 b	0.713 b
	Fujian	0.351 c	0.369 c	0.383 c	0.39 c	0.407 c	0.421 c	0.447 c	0.465 c	0.482 c	0.494 c	0.52 c	0.556 c
	Shandong	0.461 a	0.484 a	0.502 a	0.5 c	0.533 a	0.546 c	0.568 c	0.582 c	0.589 c	0.613 c	0.635 c	0.678 b
	Guangdong	0.446 a	0.465 a	0.478 c	0.488 c	0.508 c	0.531 c	0.559 c	0.582 c	0.608 b	0.635 b	0.659 b	0.699 b
	Hainan	0.222 a	0.245 a	0.264 a	0.278 a	0.294 a	0.3 a	0.312 a	0.32 a	0.328 a	0.336 a	0.351 a	0.376 a
	Heilongjiang	0.352 a	0.371 a	0.384 c	0.391 c	0.396 c	0.393 c	0.397 c	0.404 c	0.404 c	0.414 a	0.426 a	0.459 c
	Jilin	0.315 c	0.33 c	0.339 c	0.348 c	0.364 c	0.368 c	0.374 c	0.38 c	0.379 c	0.391 c	0.396 c	0.419 c
	Liaolin	0.355 a	0.37 c	0.383 c	0.384 c	0.402 c	0.409 c	0.423 c	0.419 a	0.428 a	0.442 a	0.446 a	0.462 c
	Average	0.365 a	0.385 a	0.400 c	0.410 c	0.425 c	0.438 c	0.456 c	0.467 c	0.481 c	0.497 c	0.517 c	0.552 c
central part	Shanxi	0.325 c	0.338 c	0.353 c	0.361 c	0.373 c	0.379 c	0.368 c	0.369 c	0.378 c	0.389 c	0.412 c	0.447 c
	Jiangxi	0.33 a	0.348 a	0.357 a	0.368 a	0.382 a	0.397 a	0.414 a	0.429 a	0.437 a	0.454 a	0.464 a	0.498 a
	Henan	0.421 a	0.436 a	0.454 a	0.463 a	0.473 a	0.483 c	0.513 a	0.529 c	0.543 a	0.568 a	0.586 a	0.631 c
	Hubei	0.381 a	0.4 c	0.414 c	0.418 c	0.434 c	0.444 c	0.462 c	0.473 c	0.488 c	0.499 c	0.518 c	0.555 c
	Hunan	0.382 a	0.401 a	0.415 a	0.415 a	0.435 a	0.449 a	0.466 a	0.482 c	0.502 c	0.516 a	0.529 c	0.555 c
	Anhui	0.339 a	0.36 a	0.379 a	0.376 c	0.398 c	0.409 c	0.424 c	0.455 c	0.466 c	0.491 a	0.508 c	0.542 c
	Average	0.363 a	0.381 a	0.395 a	0.400 a	0.416 c	0.427 c	0.441 c	0.456 c	0.469 c	0.486 c	0.503 c	0.538 c

Table A1. *Cont.*

Region	Province	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
western part	Neimenggu	0.325 a	0.344 c	0.361 c	0.371 c	0.379 c	0.388 c	0.401 c	0.402 a	0.409 a	0.42 a	0.428 a	0.45 a
	Guangxi	0.33 a	0.346 a	0.36 c	0.358 c	0.375 c	0.386 c	0.411 c	0.422 c	0.434 c	0.453 c	0.468 c	0.501 c
	Chongqing	0.295 a	0.315 a	0.322 a	0.331 c	0.344 c	0.359 c	0.376 c	0.388 c	0.401 c	0.42 c	0.435 c	0.471 c
	Sichuan	0.425 a	0.444 a	0.457 a	0.47 a	0.483 a	0.506 a	0.529 a	0.553 a	0.571 a	0.591 c	0.599 c	0.634 c
	Guizhou	0.269 a	0.288 a	0.307 a	0.322 a	0.348 a	0.366 a	0.391 c	0.423 c	0.429 c	0.445 c	0.46 c	0.483 c
	Yunnan	0.315 a	0.332 a	0.354 a	0.365 c	0.383 c	0.397 c	0.424 c	0.441 c	0.462 c	0.479 c	0.497 c	0.529 c
	Shanxi	0.34 a	0.351 a	0.364 a	0.373 c	0.385 c	0.397 c	0.41 c	0.43 c	0.437 c	0.45 c	0.461 c	0.489 c
	Gansu	0.281 a	0.3 c	0.314 c	0.324 c	0.343 c	0.351 c	0.357 c	0.365 c	0.372 c	0.384 c	0.396 c	0.419 c
	Qinghai	0.201 c	0.221 c	0.24 c	0.256 c	0.27 c	0.285 c	0.297 c	0.304 c	0.31 c	0.324 c	0.337 c	0.346 c
	Ningxia	0.203 c	0.227 c	0.247 c	0.261 c	0.278 c	0.289 c	0.3 c	0.31 c	0.309 c	0.323 c	0.334 c	0.341 c
	Xinjiang	0.275 c	0.293 c	0.305 c	0.313 c	0.326 c	0.337 c	0.352 c	0.36 c	0.36 c	0.376 c	0.396 c	0.426 c
	Average	0.296 a	0.315 a	0.330 a	0.340 c	0.356 c	0.369 c	0.386 c	0.400 c	0.409 c	0.424 c	0.437 c	0.463 c
national average		0.340 a	0.358 a	0.374 a	0.382 c	0.398 c	0.410 c	0.427 c	0.440 c	0.452 c	0.468 c	0.485 c	0.516 c

Appendix B

Table A2. Degree of coupling harmonization between digital villages and rural inclusive green growth based on the modified coupling model. Note: a for digital villages lagging behind rural inclusive green growth, b for digital villages leading rural inclusive green growth, c for digital villages synergizing with rural inclusive green growth.

Region	Province	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
eastern part	Beijing	0.293 a	0.316 a	0.338 a	0.35 a	0.362 a	0.372 a	0.401 a	0.404 a	0.424 a	0.436 a	0.467 c	0.508 c
	Tianjin	0.222 a	0.248 c	0.267 c	0.276 c	0.289 c	0.305 c	0.312 c	0.304 a	0.31 a	0.328 a	0.342 a	0.371 a
	Hebei	0.328 a	0.345 a	0.371 a	0.392 a	0.409 a	0.429 c	0.453 c	0.473 c	0.5 c	0.529 c	0.552 c	0.578 c
	Shanghai	0.257 a	0.273 a	0.295 a	0.326 a	0.332 a	0.349 a	0.356 a	0.361 a	0.374 a	0.389 a	0.421 a	0.473 a
	Jiangsu	0.404 c	0.437 c	0.452 c	0.469 c	0.499 c	0.509 c	0.539 c	0.545 c	0.556 c	0.554 c	0.578 c	0.59 b
	Zhejiang	0.369 c	0.39 c	0.41 c	0.424 c	0.447 c	0.494 c	0.533 c	0.528 b	0.522 b	0.536 b	0.553 b	0.561 b
	Fujian	0.306 c	0.329 c	0.341 c	0.36 c	0.384 c	0.406 c	0.435 c	0.461 c	0.477 c	0.491 c	0.507 c	0.521 c
	Shandong	0.388 a	0.417 a	0.438 a	0.447 c	0.477 a	0.509 c	0.554 c	0.578 c	0.585 c	0.598 c	0.601 c	0.595 b
	Guangdong	0.384 a	0.407 a	0.432 c	0.447 c	0.478 c	0.515 c	0.545 c	0.544 c	0.545 b	0.559 b	0.563 b	0.548 b
	Hainan	0.165 a	0.186 a	0.204 a	0.216 a	0.232 a	0.236 a	0.248 a	0.256 a	0.262 a	0.266 a	0.279 a	0.301 a
	Heilongjiang	0.286 a	0.31 a	0.328 c	0.342 c	0.344 c	0.34 c	0.346 c	0.348 c	0.347 c	0.354 a	0.367 a	0.416 c
	Jilin	0.26 c	0.279 c	0.292 c	0.305 c	0.322 c	0.33 c	0.337 c	0.337 c	0.33 c	0.337 c	0.341 c	0.373 c
	Liaolin	0.294 a	0.312 c	0.328 c	0.328 c	0.349 c	0.359 c	0.37 c	0.359 a	0.367 a	0.373 a	0.378 a	0.413 c
	Average	0.304 a	0.327 a	0.346 c	0.360 c	0.379 c	0.396 c	0.418 c	0.423 c	0.431 c	0.442 c	0.458 c	0.481 c
central part	Shanxi	0.268 c	0.287 c	0.304 c	0.313 c	0.331 c	0.345 c	0.319 c	0.318 c	0.324 c	0.333 c	0.36 c	0.415 c
	Jiangxi	0.251 a	0.27 a	0.282 a	0.295 a	0.313 a	0.329 a	0.344 a	0.361 a	0.367 a	0.381 a	0.391 a	0.44 a
	Henan	0.33 a	0.349 a	0.371 a	0.39 a	0.417 a	0.437 c	0.457 a	0.478 c	0.484 a	0.512 a	0.531 a	0.607 c
	Hubei	0.314 a	0.342 c	0.358 c	0.369 c	0.388 c	0.405 c	0.416 c	0.434 c	0.457 c	0.46 c	0.49 c	0.555 c
	Hunan	0.297 a	0.318 a	0.333 a	0.346 a	0.367 a	0.386 a	0.404 a	0.43 c	0.45 c	0.459 a	0.477 c	0.525 c
	Anhui	0.266 a	0.292 a	0.315 a	0.334 c	0.358 c	0.37 c	0.382 c	0.406 c	0.414 c	0.434 a	0.46 c	0.525 c
	Average	0.288 a	0.310 a	0.327 a	0.341 a	0.362 c	0.379 c	0.387 c	0.404 c	0.416 c	0.430 c	0.452 c	0.511 c

Table A2. *Cont.*

Region	Province	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
western part	Neimenggu	0.265 a	0.286 c	0.306 c	0.321 c	0.331 c	0.342 c	0.35 c	0.341 a	0.347 a	0.354 a	0.36 a	0.387 a
	Guangxi	0.264 a	0.284 a	0.302 c	0.308 c	0.332 c	0.347 c	0.364 c	0.384 c	0.396 c	0.412 c	0.445 c	0.5 c
	Chongqing	0.227 a	0.246 a	0.258 a	0.274 c	0.288 c	0.302 c	0.32 c	0.332 c	0.344 c	0.364 c	0.382 c	0.442 c
	Sichuan	0.328 a	0.349 a	0.362 a	0.381 a	0.403 a	0.426 a	0.451 a	0.489 a	0.515 a	0.544 c	0.557 c	0.633 c
	Guizhou	0.203 a	0.222 a	0.238 a	0.258 a	0.283 a	0.304 a	0.336 c	0.373 c	0.378 c	0.397 c	0.418 c	0.459 c
	Yunnan	0.253 a	0.272 a	0.291 a	0.307 c	0.331 c	0.345 c	0.372 c	0.395 c	0.42 c	0.443 c	0.467 c	0.521 c
	Shanxi	0.273 a	0.287 a	0.303 a	0.316 c	0.336 c	0.352 c	0.371 c	0.389 c	0.398 c	0.409 c	0.42 c	0.468 c
	Gansu	0.22 a	0.241 c	0.258 c	0.274 c	0.295 c	0.309 c	0.306 c	0.315 c	0.326 c	0.335 c	0.345 c	0.372 c
	Qinghai	0.158 c	0.18 c	0.199 c	0.216 c	0.234 c	0.248 c	0.256 c	0.261 c	0.264 c	0.272 c	0.281 c	0.287 c
	Ningxia	0.159 c	0.182 c	0.201 c	0.213 c	0.23 c	0.239 c	0.251 c	0.262 c	0.259 c	0.268 c	0.279 c	0.285 c
	Xinjiang	0.228 c	0.25 c	0.261 c	0.272 c	0.291 c	0.299 c	0.322 c	0.323 c	0.315 c	0.331 c	0.354 c	0.387 c
	Average	0.234 a	0.255 a	0.271 a	0.286 c	0.305 c	0.320 c	0.336 c	0.351 c	0.360 c	0.375 c	0.392 c	0.431 c
national average		0.275 a	0.297 a	0.315 a	0.329 c	0.348 c	0.365 c	0.382 c	0.393 c	0.402 c	0.415 c	0.432 c	0.469 c

References

1. Rammelt, C.F.; Gupta, J. Inclusive is not an adjective, it transforms development: A post-growth interpretation of Inclusive Development. *Environ. Sci. Policy* **2021**, *124*, 144–155. [CrossRef]
2. Zhou, X.L.; Wu, W.L. Measurement and analysis of inclusive green growth in China. *J. Quant. Technol. Econ.* **2018**, *35*, 3–20.
3. Zheng, C.D. Research on Poverty Reduction Policy in Concentrated Contiguous Special Difficulties Ethnic Areas Based on the Perspective of Inclusive Green Development. *J. South-Cent. Minzu Univ. Humanit. Soc. Sci.* **2016**, *36*, 115–121.
4. Xu, W.; Xu, F.; Liu, Y.; Zhang, D. Assessment of rural ecological environment development in China's moderately developed areas: A case study of Xinxiang, Henan province. *Environ. Monit. Assess.* **2021**, *193*, 1–25. [CrossRef] [PubMed]
5. Boraita, R.J.; Alsina, D.A.; Ibort, E.G.; Torres, J.M.D. Quality of life related to health and habits: Differences between adolescents in rural and urban environments. *An. Pediatría* **2022**, *96*, 196–202. [CrossRef]
6. Wei, M.S.; Yan, T.W.; Ros, H. Impacts of scale operation and technological progress on the green and low-carbon development of agriculture—A quasi-natural experiment based on the establishment of a major grain producing area. *Chin. Rural Econ.* **2023**, *2*, 41–65.
7. Sturgeon, T.J. Upgrading strategies for the digital economy. *Glob. Strategy J.* **2021**, *11*, 34–57. [CrossRef]
8. Pan, W.; Xie, T.; Wang, Z.; Ma, L. Digital economy: An innovation driver for total factor productivity. *J. Bus. Res.* **2022**, *139*, 303–311. [CrossRef]
9. Hao, A.M.; Tan, J.Y. The impact of digital village construction on the resilience of China's food system. *J. South China Agric. Univ. Soc. Sci. Ed.* **2022**, *21*, 10–24.
10. Li, B.Q.; Zhou, Q.X.; Yue, H.Z. An empirical test of the impact of digital village construction on industrial prosperity. *Stat. Decis.* **2022**, *38*, 5–10.
11. Zhao, J.J.; Wei, J.; Liu, T.J. Research on the impact and mechanism of digital village development on farmers' entrepreneurship. *China Rural Econ.* **2023**, *5*, 61–80.
12. Shen, F.W.; Ye, W.X. Digital village construction: A strategic choice for achieving high-quality rural revitalisation. *J. Nanjing Agric. Univ. Soc. Sci. Ed.* **2021**, *21*, 41–53.
13. Zhao, J.J.; Sun, X.L.; Su, L.L. The impact of digital village development on rural residents' household consumption—Based on matched data from county digital village index and China household tracking survey. *J. China Agric. Univ. Soc. Sci.* **2022**, *39*, 114–132.
14. Su, L.L.; Peng, Y.L. Digital education, digital literacy and farmers' digital life. *J. South China Agric. Univ. Soc. Sci. Ed.* **2021**, *20*, 27–40.
15. Han, R.B. Agile governance-driven rural digital governance. *J. South China Agric. Univ. Soc. Sci. Ed.* **2021**, *20*, 132–140.
16. Zha, R.B.; Zhong, C.B. Digital Rural Construction and County Ecological Environment Quality—Empirical Evidence from Comprehensive Demonstration Policies of E-commerce into Rural Areas. *Contemp. Econ. Manag.* **2023**, *45*, 54–65.
17. Du, J.J.; Zhang, Y.D.; Liu, B.M.; Dong, R.H. Impact of digital countryside on green total factor productivity in agriculture and its mechanism of action. *China Popul. Resour. Environ.* **2023**, *33*, 165–175.
18. Wang, X.S.; Xie, S.X. How have international agricultural commodity prices affected Chinese agricultural commodity prices? *Econ. Res. J.* **2012**, *47*, 141–153.
19. Xiong, X.; Nie, F.Y.; Zhu, H.B. How to effectively dock agricultural products e-commerce market for small farmers in western poverty-stricken areas—A case study of Xiushan County, Chongqing based on the perspective of limited capacity. *China Rural Econ.* **2023**, *4*, 68–89.

20. Fang, K.; Li, F.; Jin, M. Research on digital village public service system based on holistic governance. *E-Government* **2019**, *11*, 72–81.
21. Ma, W.; Zhang, R.Z. Research on the impact effect of the breadth and depth of digital finance on narrowing the development gap between urban and rural areas—Based on the synergistic effect perspective of residents' education. *J. Agrotech. Econ.* **2022**, *2*, 62–76.
22. Xie, K.; Yi, F.M.; Gu, F.T. Big data-driven digital transformation and innovation in agriculture. *Issues Agric. Econ.* **2022**, *5*, 37–48.
23. Wen, T.; Chen, Y.M. Integration and development of digital economy and agricultural and rural economy: Practice mode, realistic obstacles and breakthrough path. *Issues Agric. Econ.* **2020**, *7*, 118–129.
24. Zhang, Y.; Feng, M.W.; Yi, F.J. Research on the effect and mechanism of rural digital governance on farmers' waste classification. *World Agric.* **2023**, *11*, 78–90.
25. Bai, F.C.; Gao, P.; Zheng, W.L. Ecological resources empowering rural commons—The facilitating role of digital economy. *J. China Agric. Univ.* **2023**, *28*, 263–275.
26. Wen, Y.; Jiang, C. Attention Redistribution, External Resource Dependence and Digital Village Governance Performance—A Group Analysis Based on the TOE Framework. *Chin. Public Adm.* **2023**, *7*, 58–67.
27. Zhao, W.; Huang, L.; Li, W.; Peng, W.H. Divergence in the level of inclusive green development and its drivers in rural China. *Econ. Geogr.* **2023**, *43*, 68–77.
28. Zeng, Y.W.; Song, Y.X.; Lin, X.Z.; Fu, X.L. Ruminations on some issues of digital village construction in China. *China Rural Econ.* **2021**, *4*, 21–35.
29. Zhang, T.; Li, J.C. Network infrastructure, inclusive green growth and regional disparities—Causal inference based on dual machine learning. *J. Quant. Technol. Econ.* **2023**, *40*, 113–135.
30. Zhu, H.G.; Chen, H. Level measurement, spatial and temporal evolution and promotion path of digital village development in China. *Issues Agric. Econ.* **2023**, *3*, 21–33.
31. Lin, Y.M.; Cheng, Q.W.; Xu, A.X. Research on the Impact of Digital Village Construction on Urban-Rural Integrated Development-Empirical Evidence Based on Provincial Panel Data from 2012–2020. *J. Fujian Prov. Comm. Party Sch. CPC Fujian Acad. Gov.* **2023**, *4*, 101–111.
32. Yin, H.D.; Huo, P.; Wang, S.G. Digital transformation of agriculture and rural areas: Reality representation, influence mechanism and promotion strategy. *Reform* **2020**, *12*, 48–56.
33. Wang, F.; Sun, S.H.; Liu, T.J. Has the development of digital economy advanced the change of agricultural production methods-Evidence from prefecture-level cities in the Yellow River Basin. *China Rural Econ.* **2023**, *9*, 122–143.
34. Ji, Z.H. Spatial differences and driving mechanisms of high-quality agricultural and rural development in China. *J. Quant. Technol. Econ.* **2021**, *38*, 25–44.
35. Liu, Z.Y.; Zhe, V. Regional differences and distributional dynamics evolution of high-quality agricultural development in China. *J. Quant. Technol. Econ.* **2021**, *38*, 28–44.
36. Zhang, J.X.; Hou, Y.Z.; Liu, P.L.; He, J.W.; Zhuo, X. Target requirements and strategic path of high-quality development. *J. Manag. World* **2019**, *35*, 1–7.
37. Xu, X.; Wang, Y.Y. Measurement of China's rural revitalisation level, decomposition of regional differences and dynamic evolution. *J. Quant. Technol. Econ.* **2022**, *39*, 64–83.
38. Jia, J.; Li, X.F.; Shen, Y. Indicator system construction and empirical analysis of rural revitalisation strategy. *Financ. Econ.* **2018**, *11*, 70–82.
39. Yan, Z.F.; Wu, F.W. From binary division to integrated development—Research on evaluation index system of rural revitalisation. *Economist* **2019**, *6*, 90–103.
40. Pi, J.C.; Song, D.Q. Measurement and judgement of the coordinated development of China's manufacturing and real estate industries. *J. Financ. Res.* **2021**, *9*, 72–90.
41. Liu, T.; Xu, Z.Y.; Zhang, K.L. The impact of digital finance on the synergy between economic development and ecological environment. *Mod. Financ. Econ.—J. Tianjin Univ. Financ. Econ.* **2022**, *42*, 1–36.
42. Liu, C.Y.; Liu, Y.Y.; Ding, R.G. Coupling analysis of new urbanisation and ecological environment in Fujian Province. *Chin. J. Appl. Ecol.* **2018**, *1*, 1–14.
43. Tan, J.T.; Zhang, P.Y.; Li, J.; Liu, S.W. Spatio-temporal evolution characteristics of coordinated development of urbanisation and ecological environment in Jilin Province. *Chin. J. Appl. Ecol.* **2015**, *26*, 3827–3834.
44. Wang, S.J.; Kong, W.; Ren, L.; Zi, D.D.; Dai, B.T. Misconceptions and corrections of the domestic coupled coordination degree model. *J. Nat. Resour.* **2021**, *36*, 793–810.

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