# Spatial Differentiation Characteristics and Influencing Mechanisms of Coupling Coordinated Development of Agriculture-Culture-Tourism in China: A Postprint

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## Abstract

Exploring long-term integration mechanisms for agriculture-culture-tourism constitutes a crucial initiative for achieving rural sustainable development and implementing the rural revitalization strategy. Accordingly, this study selects catalog data that characterize the development level of agriculture-culture-tourism as the research object, and comprehensively employs methods such as the coupling coordination degree model (Coupling coordination degree, CCD) and geographic detector to quantitatively investigate the spatial differentiation characteristics and influencing mechanisms of spatial coupling and coordinated development of agriculture-culture-tourism in China. The results indicate: (1) The three industries of agriculture, culture, and tourism exhibit prominent asynchrony in development levels and significant unevenness in spatial distribution. (2) The integrated development of agriculture-culture-tourism demonstrates a pattern of "culture-tourism leading, agriculture lagging behind," with moderate spatial coupling coordination. (3) The spatial coupling and coordinated development of agriculture-culture-tourism exhibits significant agglomeration characteristics, displaying local differentiation features bounded by the Hu Huanyong Line. (4) The explanatory power intensity for spatial differentiation of agriculture-culture-tourism coupling coordination follows the order: innovation level > social culture > physical geography > economic development, with innovation capability being the dominant driving force. (5) The spatial differentiation of agriculture-culture-tourism coupling coordination development is influenced by complex multi-factor coupling effects, wherein the interaction between innovation level and social culture dimensions is significantly stronger than interactions among other factors.

## Full Text

# Spatial Differentiation Characteristics and Influencing Mechanisms of the Coupling Coordinated Development of Agro-Culture-Tourism in China

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### Abstract

Exploring the long-term integration mechanism of agro-culture-tourism represents a crucial measure for achieving sustainable rural development and implementing the rural revitalization strategy. This study selects directory data that characterize the development level of agro-culture-tourism as research objects, and comprehensively employs the coupling coordination degree model and geodetector methods to quantitatively investigate the spatial differentiation characteristics and influencing mechanisms of agro-culture-tourism coupling coordination development in China. The results indicate: (1) The development levels of agriculture, culture, and tourism exhibit prominent asynchrony and spatial imbalance, each forming unique spatial distribution patterns. (2) The integrated development of agro-culture-tourism demonstrates the characteristics of "cultural tourism taking the lead while agriculture lags behind," with spatial coupling coordination being generally moderate. (3) The agglomeration characteristics of agro-culture-tourism spatial coupling coordination development are significant, presenting a local differentiation feature bounded by the Hu Huanyong Line. (4) The explanatory strength for the spatial differentiation of agro-culture-tourism coupling coordination development is ranked as: innovation level > sociocultural > physical geography > economic development, with innovation capacity being the dominant force. (5) The spatial differentiation of agro-culture-tourism coupling coordination development is influenced by complex multi-factor coupling effects, where the interaction between innovation level and sociocultural dimensions is significantly stronger than interactions among other factors.

**Keywords:** agro-culture-tourism; fusion mechanism; influencing factors; coupling coordination degree model; geodetector

# 1. Data and Methods

## 1.1 Data Sources

The directory data for measuring agro-culture-tourism coupling coordination, including traditional villages, agricultural product geographical indications, and One Village One Product programs, were obtained from lists published by various ministries and commissions as of June 2021. Location coordinates were extracted using the Gaode Map API and cross-validated through Baidu Maps. Among the influencing factors for agro-culture-tourism coupling coordination development, data for the physical geography dimension were sourced from the Resource and Environment Science and Data Center of the Chinese Academy of Sciences (https://www.resdc.cn/), including nighttime light data from 2020 and road data from OpenStreetMap (https://openstreetmap.org/) updated in 2020. Other influencing factors were derived from the *China City Statistical Yearbook 2020*. All data were aggregated and statistically compiled at the prefecture-level city administrative unit. Additionally, administrative boundary base map data supporting the research were obtained from the National Geospatial Information Public Service Platform and unified using ArcGIS 10.6 software.

## 1.2 Methodology

**1.2.1 Measurement Model for Agro-Culture-Tourism Spatial Coupling Coordination Evaluation Index System Construction.** Agro-culture-tourism integrated development refers to the formation of distinctive agricultural-tourism brands centered around specific themes or local folk cultures, based on resource endowments. Examples include agricultural geographical indication products, One Village One Product initiatives, characteristic tourism towns, and key tourism villages. Therefore, this study utilizes published directory data that can represent agro-culture-tourism development levels to replace universal indicators such as tourism revenue and agricultural output value from statistical yearbooks (Table 1). Considering the substantial differences in sample capacity among various indicators, Z-score standardization was applied to each indicator. To effectively avoid the subjectivity of subjective weighting methods and the neglect of decision-maker information by objective weighting methods, this study adopts combined weights integrating the entropy method and principal component analysis (objective weighting) with the analytic hierarchy process (subjective weighting). The analytic hierarchy process solicited opinions from five experts in agricultural economics, with weights calculated using Yaahp software.

**Spatial Coupling Coordination Measurement Model.** Spatial coupling coordination refers to the interactive and mutually influential relationship between two or more entities, where one entity produces feedback effects due to changes in another. The coupling coordination degree model is employed to evaluate the interaction relationship and coordinated development level among "agriculture-culture-tourism." The specific formulas are:

$$C = 3 \times \sqrt[3]{\frac{Q_i \times F_i \times L_i}{(Q_i + F_i + L_i)^3}}$$

$$D = \sqrt{C \times Z}$$

$$Z = \delta Q_i + \alpha F_i + \beta L_i$$

where $C$ represents the coupling degree among "agriculture-culture-tourism," with its magnitude proportional to the coupling strength (the numerical value does not represent advantage or disadvantage); $Q_i$, $F_i$, and $L_i$ represent the development levels of characteristic agriculture, local culture, and rural tourism in region $i$, respectively; $D$ denotes the coordinated development level of the coupling system; $Z$ is the comprehensive evaluation index of the three components; and $\delta$, $\alpha$, and $\beta$ are 待定 coefficients. Following consultation with experts in rural development and construction, the coefficients were assigned as: $\delta_1 = 0.6$, $\alpha_1 = 0.4$; $\delta_2 = 0.6$, $\alpha_2 = 0.4$; $\delta_3 = 0.5$, $\alpha_3 = 0.5$.

Based on existing research, the coordinated development level $D$ values are classified into five unequal intervals: $D \in [0.00, 0.15]$ indicates severe imbalance; $D \in (0.15, 0.25]$ indicates moderate imbalance; $D \in (0.25, 0.40]$ indicates basic coordination; $D \in (0.40, 0.60]$ indicates moderate coordination; and $D \in (0.60, 1.00]$ indicates high coordination.

**1.2.2 Spatial Autocorrelation Analysis** Spatial autocorrelation examines the correlation of spatial elements' own distribution and can test whether agro-culture-tourism spatial coupling coordination exhibits agglomeration characteristics. This study employs global Moran's $I$ to test whether spatial dependency exists in agro-culture-tourism spatial coupling coordination, and local spatial autocorrelation (LISA cluster map) to examine whether local area agglomeration or differentiation features exist.

**1.2.3 Geodetector** Geodetector is a spatial analysis model for detecting spatial differentiation of phenomena and their driving mechanisms. This study utilizes this model to detect influencing factors of agro-culture-tourism coupling coordination development spatial differentiation, identifying the degree to which factors explain spatial differentiation and the effects of two-factor coupling interactions. The calculation formula is:

$$q = 1 - \frac{1}{n\sigma^2} \sum_{i=1}^{m} n_i \sigma_i^2$$

where $q$ is the influence index of agro-culture-tourism coupling coordination development spatial differentiation; $n$ is the number of prefecture-level cities

involved in the regression ($n = 285$); $m$ is the number of influencing factors ($m = 18$); $n_i$ is the sample size of influencing factors in city $i$; $\sigma^2$ is the global discrete variance of agro-culture-tourism coupling coordination development; and $\sigma_i^2$ is the discrete variance of city $i$. The model is valid when $\sigma_i^2 \neq 0$. When $q = 0$, it indicates that agro-culture-tourism coupling coordination development within prefecture-level cities presents random distribution, unaffected by influencing factors; conversely, stronger factor explanatory power is indicated. Through interaction detection, the interaction types are determined by comparing the magnitude relationship between $q$ values, with specific details referenced in existing literature.

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## 2. Results and Analysis

### 2.1 Spatial Distribution Characteristics of Agro-Culture-Tourism Development Levels

The development levels of agriculture, culture, and tourism across provinces exhibit asynchrony, with significant inter-provincial disparities and apparent regional polarization effects (Figure 1). At the municipal scale, natural breaks classification reveals five levels for observing spatial differences in agro-culture-tourism development levels. The results show (Figure 2) that high-level characteristic agriculture development areas are located in the Yellow River and Yangtze River basins, as well as in Xinjiang's oasis regions and Heilongjiang Province (Figure 2a), representing China's major grain-producing areas. In northern, western, and southern border regions of Xinjiang and Inner Mongolia, natural geographical conditions are unsuitable for agricultural and pastoral production. In Jilin and Liaoning provinces, the lack of agricultural characteristics due to large-scale farming results in relatively low development levels.

Local culture forms a "core-periphery" pattern bounded by the Hu Huanyong Line (Figure 2b), though not completely aligned with the population geography pattern. Henan and Shandong, as populous provinces, are paradoxically local culture "depression areas," while Guizhou, Chongqing, and other ethnic minority concentration areas with sub-high population density have formed diverse ethnic cultures. Northwest and Northeast China were historically occupied by nomadic peoples for extended periods, while the Qinba mountainous region in central China and the rocky desertification areas in Yunnan-Guangxi-Guizhou of Southwest China have underdeveloped local cultures due to resource scarcity and sparse populations.

The spatial distribution of rural tourism is relatively balanced (Figure 2c), with many high-development-level cities also located west of the Hu Huanyong Line, such as Hulunbuir City and Ganzi Tibetan Autonomous Prefecture, which are famous tourism cities. From a regional perspective, inter-provincial agro-culture-tourism coordination development levels are relatively balanced in

central China, followed by western China, while eastern China shows the most significant polarization effect.

### 2.2 Spatial Coupling Coordination Development Level of Agro-Culture-Tourism

Inter-provincial coupling coordination levels of agro-culture-tourism show significant differentiation, distinct from development levels themselves, with substantial amplitude variation in "agriculture-culture-tourism" coupling coordination across provinces. Shandong, Zhejiang, Sichuan, and Hubei provinces exhibit the highest agro-culture-tourism coupling coordination levels, benefiting from profound agricultural foundations and recent adjustments in rural transformation development. For instance, Shandong ranks first nationally in the number of national agricultural industrialization demonstration bases, while Sichuan actively promotes urban agriculture and develops surrounding rural areas through central city leadership. In contrast, Tianjin, Shanghai, Ningxia, and Hainan show poor agro-culture-tourism coupling coordination development due to weak agricultural foundations and high urbanization levels. Although Guizhou, Shanxi, and Hunan have high local culture development levels, their asynchronous development with agriculture and tourism results in lower coupling coordination levels.

At the municipal scale (Table 2), nearly half of the prefecture-level cities demonstrate basic coordination, followed by moderate imbalance, moderate coordination, and severe imbalance, while high coordination accounts for no more than 2.50%, indicating that agro-culture-tourism coupling coordination development requires further strengthening. The overall ranking of coupling coordination development levels from strong to weak is: $D_{\text{culture-tourism}} > D_{\text{agriculture-tourism}} > D_{\text{agriculture-culture}}$. Rural tourism has effectively integrated with local cultural heritage to the greatest extent. As rural areas have become primary destinations for cultural tourism and leisure in recent years, villages combining local culture have frequently become internet-famous attractions (e.g., Zhagana, Thousand Households Miao Village). $D_{\text{agriculture-culture}}$ is relatively weak, and $D_{\text{agriculture-tourism}}$ shows the lowest coupling coordination degree. Although initiatives like One Village One Product and agricultural product geographical indications have promoted the exploration and development of traditional agriculture, traditional agricultural products characterized by intensive cultivation are less easily transformed compared to capital-operated rural tourism under the market economy system and large-scale operation mode.

### 2.3 Spatial Differentiation Characteristics of Agro-Culture-Tourism Coupling Coordination Development

Spatial autocorrelation tests at the municipal scale for agro-culture-tourism spatial coupling coordination indicators were conducted using ArcGIS 10.6. The global Moran's $I$ values for $D_{\text{agriculture-culture-tourism}}$, $D_{\text{agriculture-culture}}$, $D_{\text{culture-tourism}}$, and $D_{\text{agriculture-tourism}}$ are 0.285, 0.298, 0.317, and 0.309, re-

spectively, all significant at the 99.99% confidence level ($P < 0.001$), indicating agglomeration patterns. This demonstrates that prefecture-level cities with high (or low) agro-culture-tourism spatial coupling coordination levels are geographically concentrated, with agglomeration degrees ranked as: $D_{\text{culture-tourism}} > D_{\text{agriculture-tourism}} > D_{\text{agriculture-culture}} > D_{\text{agriculture-culture-tourism}}$.

From the LISA cluster map perspective, high-high clusters and low-low clusters are significantly more numerous than high-low and low-high clusters, indicating prominent spatial coupling coordination asynchrony and an interwoven distribution pattern (Figure 4). Overall, high-high clusters are concentrated in the core and peripheral radiation areas centered on Guizhou, the North China Plain, and the Yangtze River Delta, where agro-culture-tourism spatial coupling coordination development levels exceed surrounding prefecture-level cities (Figure 4a). These regions rely on developed economic environments or possess rich local culture and characteristic agricultural resources, presenting favorable agro-culture-tourism coupling coordination development trends with significant spatial polarization characteristics.

Specifically, the clustering characteristics of $D_{\text{agriculture-culture}}$, $D_{\text{culture-tourism}}$, and $D_{\text{agriculture-tourism}}$ show considerable similarity, with differences primarily concentrated in Xinjiang. $D_{\text{agriculture-culture}}$ and $D_{\text{culture-tourism}}$ in Xinjiang mainly exhibit low-low patterns, gradually diffusing outward to Gansu, Inner Mongolia, and Qinghai (Figures 4b and 4c), while $D_{\text{agriculture-tourism}}$ shows high-high patterns across most of Xinjiang (Figure 4d), indicating that local culture development in Xinjiang significantly lags behind rural tourism and characteristic agriculture.

### 2.4 Influencing Factors of Spatial Differentiation in Agro-Culture-Tourism Coupling Coordination Development

**2.4.1 Index System Construction** To reveal influencing factors of agro-culture-tourism coupling coordination development spatial differentiation, this study references relevant research and combines China's agro-culture-tourism development stage and characteristics to construct a multi-dimensional index system from physical geography, economic development, socioculture, and innovation level, including elevation, per capita GDP, population density, patent authorization quantity, etc. (Table 4). Since the *China City Statistical Yearbook* contains statistical data for 285 prefecture-level cities, cities outside this scope were excluded to ensure data consistency. Finally, the coordinated development degrees and influencing factor values of 285 prefecture-level cities were compiled. Through R language calculations of geodetector model explanatory power under different classification methods for each factor, natural breaks classification into five levels yielded the optimal explanatory power for detecting factor explanation strength and analyzing variable interactions.

**2.4.2 Single-Factor Detection Results** Factor detection results (Table 5) show that all 18 influencing factors passed the 99.99% confidence level test

($P < 0.001$), each demonstrating certain explanatory power for agro-culture-tourism coupling coordination development spatial differentiation, though with significant differences. From the overall explanatory strength perspective, the ranking is: innovation level > sociocultural > physical geography > economic development, reflecting human initiative, particularly innovation capacity, as the leading force in agro-culture-tourism coupling coordination development.

In terms of $q$ values, four factors exceed 0.2: museum quantity ($X_{13}$), library collection quantity ($X_{14}$), patent authorization quantity ($X_{18}$), and highway passenger volume ($X_9$). Museum quantity and library collection quantity reflect regional cultural construction levels and cultural heritage, indicating that regional culture forms the foundation for agro-culture-tourism coupling coordination development. Patent authorization quantity represents regional innovation levels and capacities. Under the second consumption revolution, innovation-led consumption trends have gradually penetrated rural development, becoming important support for agro-culture-tourism coupling coordination development. Highway passenger volume is a crucial indicator of comprehensive transportation levels and economic development vitality, playing a significant supporting role in agro-culture-tourism coupling coordination development.

Secondly, factors with $q$ values greater than 0.1 include student enrollment ($X_{15}$), elevation ($X_1$), and number of higher education institutions ($X_{16}$), indicating that regional higher education levels and suitable natural geographical conditions are important driving forces for agro-culture-tourism integration. For example, Tsinghua University Rural Revitalization Workstation practice teams and various university "three-rural" teams provide "intellectual" support for rural development, and plain areas are more conducive to rural infrastructure allocation, thereby affecting agro-culture-tourism integration. All other factors have $q$ values less than 0.1, with weaker explanatory power primarily in physical geography and economic development dimensions, revealing that natural geographical conditions and economic development levels are not the main constraints on agro-culture-tourism coupling coordination development, highlighting the importance of human initiative in adapting to and transforming environments.

**2.4.3 Factor Interaction Detection Results** Factor interaction detection results (Figure 5) show that the driving force of two-factor interactions is stronger than single-factor independent effects, including non-linear enhancement and two-factor enhancement modes, with non-linear enhancement significantly higher than two-factor enhancement. This indicates that agro-culture-tourism coupling coordination development is a complex phenomenon resulting from multi-factor coupling effects, where the combined effect of two factors in most cases exceeds the sum of individual factor effects.

Overall, interactions between innovation level and sociocultural dimensions are significantly stronger than those between physical geography and economic development dimensions. Regarding optimal interaction factors, the strongest

interactions are museum quantity ($X_{13}$) and library collection quantity ($X_{14}$) with patent authorization quantity ($X_{18}$), whose interaction intensities with other factors are significantly higher than interactions among other factors. This further reflects the important driving role of cultural background and innovation level in agro-culture-tourism coupling coordination development. In contrast, interactions between physical geography and economic development are significantly weaker than those between innovation level and sociocultural dimensions, with only highway passenger volume ($X_9$) showing relatively strong interactions.

The underlying reasons are twofold: First, marketization and urbanization waves have disintegrated numerous traditional villages, making local culture as regional cultural roots increasingly precious. Second, under differentiation and innovation-oriented consumption, unexpected rural experiences have become crucial for capturing consumers, requiring rural areas to attract more innovative talents and enhance rural innovation development levels.

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## 3. Discussion

With the rise of the network society, rural development in the digital economy era has encountered numerous opportunities but also faces challenges such as characteristic deficiency and insufficient momentum. Exploring the long-term integration mechanism of agro-culture-tourism is a fundamental approach to consolidating poverty alleviation achievements and connecting them with rural revitalization. This study systematically 梳理 ed representative elements of China's agro-culture-tourism integration development through relevant directories, highlighting local characteristics as the leading factor rather than universal statistical indicators from traditional yearbooks, thereby truly characterizing agro-culture-tourism development features.

The findings reveal several key insights. First, under capital context and consumption-driven forces, the phenomenon of "cultural tourism taking the lead while agriculture lags behind" in rural transformation development is prominent. In recent years, trends like live-stream marketing and the sharing economy have swept rural areas, where the "short, flat, fast" value concept runs counter to traditional rural society development, prompting academic reflection on the negative externalities of capital-driven rural revitalization. Therefore, this study recommends that rural development should promote parallel development of primary, secondary, and tertiary industries, coordinate agro-culture-tourism, carefully consider capital going to the countryside, conduct rural planning in advance, and demarcate land development boundaries to prevent disorderly development and resource waste during capital booms.

Second, the explanatory power and interaction effects between innovation level and sociocultural dimensions for agro-culture-tourism coupling coordination development spatial differentiation are significantly stronger than those of physi-

cal geography and economic development dimensions. Field research on rural revitalization in Tongren City, Guizhou Province, revealed that past rural designs lacked cultural excavation and development models suffered from path dependency, yet "intelligence" introduction has become a crucial fulcrum for rural revitalization. Taking Luya Village in Tongren as an example, despite being a fifth-batch national traditional village and third-batch national ethnic minority characteristic village with numerous ancient defense facility ruins and a long history of cinnabar mining, inadequate traditional culture excavation and lack of innovation in tourism development models resulted in extremely low integration among agriculture, culture, and tourism, with each sector "acting independently."

In 2020, the introduction of a research team utilizing cinnabar mine caves to develop edible mushroom cultivation technology created an off-season, high-quality edible mushroom brand, combining mountain cherry blossoms and red cinnabar to develop rural tourism. In 2021, the Tsinghua University Rural Revitalization Workstation practice team was introduced to excavate and organize village historical resources and improve the living environment. Today, Luya Village has formed an agro-culture-tourism integration business format combining mushroom cultivation, lotus planting and processing, cherry blossom viewing, and ancient village folk experience, becoming a rural revitalization demonstration village in Tongren City. Consequently, rural development requires combining cultural backgrounds, developing characteristic agriculture based on resource endowments, taking talent revitalization as guidance, strengthening cultural, industrial, and agricultural technology innovations, and forming a "people-land-industry" coordinated development pattern.

However, limited by the non-synchronism and availability of directory data, this study only discusses current spatial characteristics and influencing factors of China's agro-culture-tourism spatial coupling coordination, unable to explore evolutionary characteristics from a temporal dimension. Additionally, although the constructed influencing factor index system considers universal applicability at the national scale, it overlooks regional differences, resulting in relatively low practicality. Future research will combine specific case studies to explore location-specific index systems to guide rural revitalization practice.

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## 4. Conclusions

This study systematically 梳理 ed national directories of China's agro-culture-tourism development levels, employed the coupling coordination model to detect agro-culture-tourism spatial coupling coordination development characteristics, utilized spatial autocorrelation models to test spatial differentiation features, and finally applied geodetector to analyze influencing factors of spatial differentiation. The main conclusions are:

(1) The development levels of agriculture, culture, and tourism exhibit promi-

nent asynchrony and spatial imbalance, each forming unique spatial distribution characteristics.

(2) Under market-oriented operations, agro-culture-tourism integrated development shows the characteristics of "cultural tourism taking the lead while agriculture lags behind." Nearly half of prefecture-level cities demonstrate basic coordination, with generally moderate spatial coupling coordination. Moreover, from a global perspective, the agglomeration characteristics of agro-culture-tourism spatial coupling coordination development are significant, presenting a local differentiation feature bounded by the Hu Huanyong Line.

(3) The explanatory strength for spatial differentiation of agro-culture-tourism coupling coordination development is ranked as: innovation level > sociocultural > physical geography > economic development, reflecting human initiative, particularly innovation capacity, as the dominant force. The spatial differentiation of agro-culture-tourism coupling coordination development is also influenced by complex multi-factor coupling effects, where the interaction between innovation level and sociocultural dimensions is significantly stronger than interactions among other factors.

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*Note: Figure translations are in progress. See original paper for figures.*