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The Impact of Rural Location on Farmers' Livelihood in the Loess Plateau: Local, Urban–Rural, and Interconnected Multi-Spatial Perspective Research

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Abstract: With the strengthening of regional and urban–rural interactions, farmers' livelihood activities are becoming increasingly complex, and environmental factors that influence farmers' livelihoods have multi-spatial effects. Consequently, comprehending farmers' livelihoods from a multi-spatial perspective is imperative. Based on surveys conducted in 65 villages and 451 households in Jia County on the Loess Plateau, China, rural locations were deconstructed into natural, traffic, and positional advantages to explore the relationships and mechanisms between the rural environment and farmers' livelihood stability from local, urban–rural, and interconnected multi-spatial perspectives. We found that 77% of the villages achieved a moderate or high Rural Location Advantage Index (RLAI) rating; 45% still lack natural advantages and are mainly located in hilly and sandy areas because of the fragile ecological environment of the Loess Plateau. Additionally, the Livelihood Stability Index (LSI) was moderate overall, but with significant spatial heterogeneity, and 72% of farmers possess strong transition capacity and have shifted away from relying on monoculture as their primary livelihood strategy. While a certain coupling correspondence exists between the LSI and RLAI, the interaction is intricate rather than a simple linear agglomeration process. The spatial variation in the LSI results from the superposition or interaction of multi-spatial location factors. The rural–urban spatial location factors are the key control element of the LSI and the interaction between rural–urban and local spatial location factors has the greatest influence on the LSI. It is simple for interconnected spatial location factors to produce a scale correlation effect, and have non-negligible effects on farmers' livelihoods when they interact with other spatial location factors. Understanding the impact of rural location on farmers' livelihood from a multi-spatial perspective is of great practical significance for identifying the causes of spatial heterogeneity in livelihoods and enhancing multi-level policy coordination on rural revitalization and livelihood security.

Keywords: livelihood stability; location advantage; geographic detector model; muti-spatial perspective; the Loess Plateau

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1. Introduction

Rural poverty has emerged as a worldwide issue for regional sustainable development [1]. Spatial variation in farmers' livelihoods exists at scales as small as counties and villages and as large as nations and regions. Farmers engage in agriculture-based livelihood activities without a stable income and are more vulnerable to the external environment, frequently leading to crises in their means of subsistence [2]. In addition to individual differences of farmers, the external environment plays an important role in the process of farmers' livelihood activities [3]. It is generally accepted that the better the external environment, the more stable farmers' livelihoods are. However, factors like capital, resources and labor force have intensified interaction and accelerated flow at multiple spatial scales with urbanization, resulting in an increase in the multilocal and complex factors of rural livelihoods [4,5]. According to alternative development theory, farmers are more likely to turn to non-agricultural activities for stable livelihoods under a chaotic external environment (conflict, natural disasters, backward development, etc.) [6]. It can be seen that there is no longer a completely positive correlation between farmers' livelihoods and their external environment. The factors affecting livelihood stability are no longer limited to the rural local space, but exhibit multi-spatial correlations throughout the human–land system [7]. Given the increasing regional and urban–rural interaction, it is imperative to adopt a muti-spatial perspective to understand farmers' livelihoods, to shed light on the complex and dynamic rural issues faced by developing nations [8].

Since the introduction of its Targeted Poverty Alleviation strategy (TPA) in 2013, China has lifted nearly 100 million rural residents out of poverty. Owing to China's vast territory and diverse geographical regions, it is inevitable that resources will exhibit heterogeneous characteristics. Farmers' livelihoods frequently exhibit the phenomenon of overcoming poverty and living with poverty concurrently within a certain range [9]. Then, is the spatial difference of regional resources consistent with the spatial difference of the level of farmers' livelihoods? Do farmers with better external conditions have more stable livelihoods? How do rural location conditions affect the livelihood of rural households? Which factors are most important to the farmers' livelihood stability from the multi-spatial perspective? A scientific response to these questions will make differences and inequalities in specific locations transparent and plain, as well as facilitating the implementation of measures for village revitalization and livelihood protection. Farmers' livelihoods have been widely considered by various disciplines. Scholars have extensively discussed the impact of the external environment on farmers' livelihoods in various regions, and found that geographical location, terrain conditions, resource endowment, ecological environment, infrastructure level, and institutions are significant driving factors of farmers' livelihoods [10–14]. Nonetheless, there are the following restrictions: (1) Changes in the external environment are generally regarded as abnormal factors, and the impact of sudden perturbations of certain factors (natural disasters, virus spread, dam construction) on farmers' livelihoods is usually felt [15,16]. The long-term and continuous influence of the normal factors such as geographical location, as well as the correlation and coupling between factors and farmers' livelihoods, are ignored. (2) Farmers' livelihood activities are spatial-scale dependent [17]. Existing studies generally focus on the impact of changes in local conditions on farmers' livelihoods, and rarely discuss the specific ways and degrees of impact from the perspective of multi-spatial interaction [18]. (3) In terms of research scope, macro, medium and micro regional scales are all involved. The county scale has received more attention because of its relatively independent and complete political, economic and social functions [19,20]. However, the specific experience and quantitative research are uncommon on typical poverty-stricken regions with gully, sandstorm and mountainous morphologic areas in the county.

In view of the intricacy and multi-spatial trend of the external environment's impact on farmers' livelihoods, this study aims to enhance the multi-spatial comprehension of rural livelihoods by introducing two concepts: (1) Stability. The concept of stability, originally derived from ecology, pertains to the capacity of an ecosystem or biome to persist despite external disturbances or changes in internal parameters [21]. Although concepts such as resilience and adaptability have been widely applied by scholars in livelihood research, stability is an overarching concept and can be fully or partially described by the six properties of constancy, resilience, persistence, resistance, elasticity, and the domain of attraction [22]. To measure the state of farmers' livelihood by stability itself contains recovery and adaptation thinking. When applied to research on livelihoods, it emphasizes the dynamic ability of farmers' livelihood systems to remain impervious to risks and maintain stability. Compared with the concepts of adaptability and resilience, livelihood stability is more comprehensive and inclusive. It places greater emphasis on the fact that farmers are not easily destroyed and will not alter in response to various disturbance factors in different locations [23]. Consequently, the concept of stability is more appropriate for livelihood studies from multi-spatial and cross-scale perspectives. (2) Location advantage. It is an important economic concept which reflects the current state and potential for comprehensive regional development. Location advantage refers to the objective existence of favorable environmental factors in a region. Unilateral advantage is often difficult to convert to a regional advantage, so it encompasses a region's natural environment, transportation infrastructure, urban radiation, policy opportunities, and many other aspects [24]. The concept of location advantage has been applied to residential areas, tourist attractions, enterprise site selection, local roads, and urban development [25–28]. In the research into rural residential resettlement arrangements, locational advantage also demonstrates originality [29]. We apply this concept to multi-spatial livelihood studies in order to precisely quantify rural location conditions in various topographic areas. Due to its abundant geographical spatial connotations, the concept of location advantage can help to identify multiple influencing factors of farmers' livelihoods from a multi-spatial perspective.

We are particularly concerned with the livelihoods of rural people living in poverty in the Loess Plateau. Since the national rural revitalization strategy (RVS) was proposed in 2017, efforts have been made to enhance rural environmental conditions, agricultural productivity, and public service, which has systematically altered rural administration [30,31]. However, issues of soil erosion, ecological degradation, and farmer poverty resulting from the combination of an inherently fragile natural environment and long-term, extensive human utilization have garnered significant attention from government agencies and academic institutions [32–34]. Furthermore, the Loess Plateau contains a variety of distinct terrains, including terraces, beams, and hills. Given its multiple yet fragile environmental background, the Loess Plateau presents a good case study for the impact exploration of the external environment on rural livelihoods from a multi-spatial perspective, based on surveys conducted in 65 villages and 451 households located in Jia County, a county with three distinct topographic regions on the Loess Plateau. By building a bridge between rural location conditions (community level) and farmers' livelihood stability (household level), and utilizing a geographic detector model, we quantitatively analyzed the effects of rural environment on farmers' livelihoods from three spatial perspectives: (1) local perspective, (2) urban–rural perspective, and (3) interconnection perspective. This study contributes to: (1) a focus on long-term and continuous external environment of farmers' livelihoods and the correlation and coupling between rural location factors and farmers' livelihoods, that is beneficial to propose persistent countermeasures for rural man–land relationships, (2) the development and integration of a multi-spatial perspective into livelihood studies, providing a more nuanced understanding of the complex and dynamic issues of rural livelihoods, and (3) demonstrating empirical insights in a typical county with complex topography that can serve as a reference for addressing similar rural livelihood challenges in other regions with similar geographical characteristics worldwide [35,36].

2. Conceptual Considerations and Analysis Framework

Based on the theory of "man-land relationship regional system", a multi-spatial research framework on the impact of rural location on farmers' livelihood systems was constructed (Figure 1). The administrative division system in China has obvious hierarchical characteristics, and the province, city, county, township, and administrative village are five interacting organizational levels from high to low. The county urban–rural system consists mainly of one county capital, several townships, and multiple rural communities. Capital, resources, and labor forces flow between these administrations of different sizes and levels. As an important part of urban–rural regional systems, the rural community is the most basic spatial entity carrying out rural economic activities. There are natural links between rural communities and farmers' livelihoods in geographical space, resource space and economic space [35]. Various geographical locations mean that rural communities have different characteristics like resource endowment, functional positioning, and interaction frequency [37]. These differentiation characteristics can be regarded as spatial factors of different scales, and their impact on farmers' livelihoods has cross-scale effects, resulting in spatial heterogeneity of rural livelihood assets, livelihood strategies and livelihood outcomes [38]. According to the three-tier organizational structure of the county urban–rural regional system, the impact of rural location on farmers' livelihoods can be developed from local, urban–rural and interconnection perspectives [18]. Firstly, local conditions are mainly based on natural conditions (e.g., land, water source), which influence the quantity and quality of farmers' natural capital and the convenience of irrigation, thereby affecting their livelihood levels. The more favorable the natural conditions, the simpler it is for farmers to obtain a higher agricultural input–output ratio and a stable livelihood [39]. However, farmers in the Loess Plateau face severe challenges because they are highly dependent on agricultural revenue and natural resources, making them more vulnerable to disruptions caused by droughts, floods, and other natural disasters. Farmers with inadequate natural conditions will reduce the scale of planting and investment and turn to non-agricultural livelihoods because of inadequate economic returns. Natural location conditions have an effect on farmers' livelihoods at a local scale. Secondly, urban–rural conditions are mainly related to the position of rural communities in the urban–rural regional system. The spatial spillover effect of urban infrastructure, technological progress and economic development generally declines with distance [40], and different positions determine the extent to which it is driven by urban radiation. For farmers with superior positional conditions, such as suburban households, the excess household labor is easier to absorb, with more nonagricultural employment opportunities and more stable sources of income, and nonagricultural transformation is simpler to achieve. Positional location conditions have an effect on farmers' livelihood at an urban–rural scale. Thirdly, interconnection conditions are mainly related to traffic conditions. As a link between rural and urban areas, transportation has a cross-scale interconnection effect on farmers' livelihoods by affecting the efficiency of the introduction of production factors (e.g., technology, capital, and information). Moreover, traffic conditions have an effect on farmers' livelihood modes and choices by influencing the sales scope of agricultural products. In short, location conditions are closely connected with the entire livelihood system through local impacts, urban–rural impacts and interconnected impacts, by influencing the structure and accumulation of farmers' livelihood capital, selection of livelihood modes, and output of livelihoods.

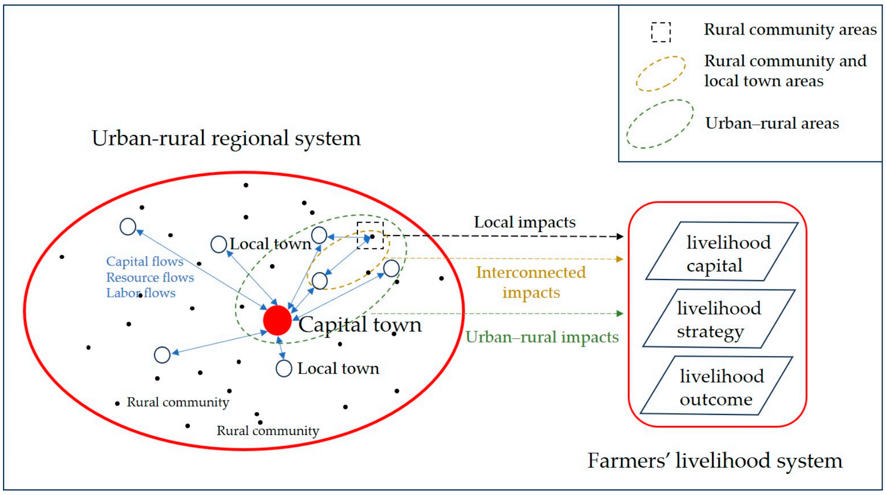

Figure 1. Framework of the influence of rural location on household livelihood systems.

3. Materials and Methods

3.1. Study Area and Data Collection

This study was conducted in Jia County, east of the Loess Plateau (Figure 2). This area experiences a semi-arid continental monsoon climate with 403.8 mm annual precipitation distributed unevenly throughout the year. This location exemplifies the traditional agricultural practices of China. The county has a total area of 2029.82 km^2, of which 86.7% is covered with loess. The terrain is elevated in the northwest, while it is flat in the southeast. Due to soil erosion, three distinct geomorphic regions were formed: a hilly and sandy region in the north, a hilly and gully region in the southwest, and a hilly and stony region along the southeastern Yellow River. The Mu Us Desert is connected to hilly and sandy regions and accounts for 30.4% of the total area. The soil is of low quality and has weak water- and fertilizer-retention capacities. Agricultural production is primarily based on the rotation of cereals and grass. The southwest hilly and gully region, which covers 52.2% of the county area, is dotted with ravines and suffers severe soil and water loss. Most agricultural production consists of oil and cash crops. The southeastern bank of the Yellow River comprises 17.4% of the county's undulating rock area, where stone gullies are deep, soil erosion is severe, and agricultural production is intercropped with valley jujubes. Affected by natural disasters, such as landslides, droughts, and summer rainstorms, agricultural production and farmers' livelihoods face significant challenges. In addition, the topography of the study area is extremely diverse, as are the livelihood outputs and strategies of producers in each region.

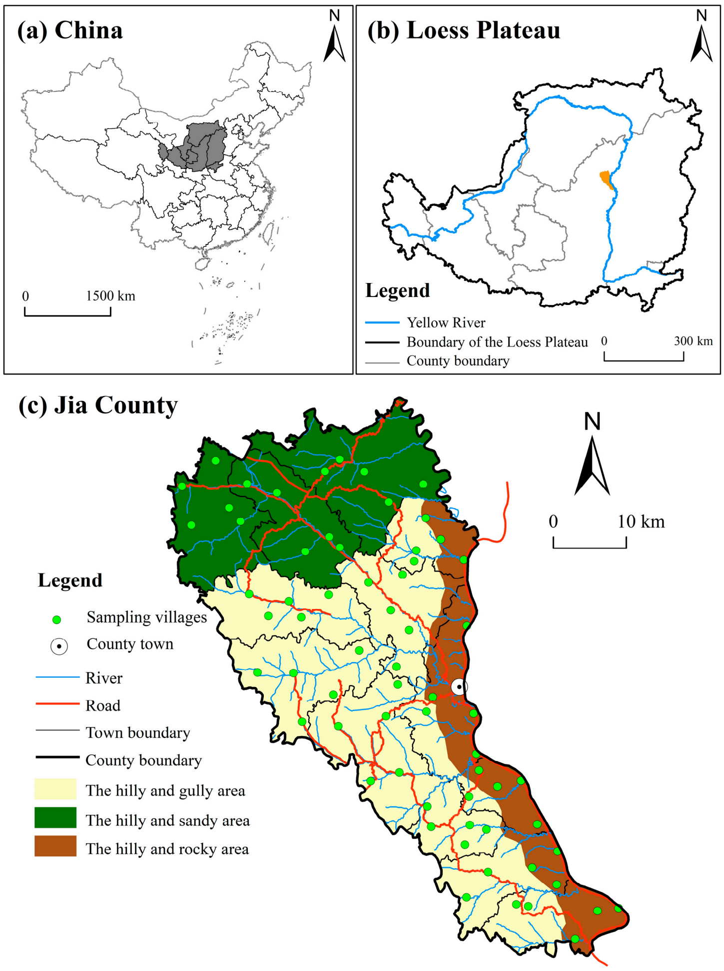

Figure 2. Location of the sample county and villages.

The research data comprise: (1) Geospatial DEM data with 30 m resolution obtained from the geospatial data cloud (http://www.gscloud.cn) accessed on 15 June 2021; (2) Space vector data from the Bureau of Statistics, Bureau of Natural Resources, meteorological department, and other government agencies for road, water system, administrative boundary, and village patch information; and (3) data from a questionnaire survey. Microlevel survey data were collected from rural households in Jia County from 2017 to 2021. We chose five villages from each town using the stratified convenience sampling approach for a total of 65 sample villages, and 52 interview materials and audio recordings were acquired by questioning key figures in each village (e.g., village cadres, leaders, and cooperative members). Then, 5–7 rural residents in each village were interviewed to learn about their basic family information, livelihood capital, livelihood strategy, and subjective perceptions. With an efficiency rate of 99.1%, 451 valid questionnaires were collected from the three topographic regions: 105 from the wind-sand area, 234 from the gully area, and 112 from the rocky area.

3.2. Approaches to Measuring Livelihood Stability

In essence, livelihood stability is characterized by actors' assets, abilities, and strategies for maintaining their livelihood standard in the face of external or internal pressures and is also a key component of farmers' sustainable livelihoods [41]. Existing livelihood stability measurement frameworks differ in terms of composition dimensions and content. At present, a more widely used evaluation method is the sustainable livelihood approach framework (SLA), which characterizes livelihood stability primarily by livelihood capital [42]. However, the framework focuses exclusively on the stock of livelihood capital, and to some extent ignores the adaptability of farmers themselves [43]. Many studies have also shown a positive correlation between total income and non-farm income share, and diverse livelihood systems are more stable than undiversified ones [44]. Therefore, on the basis of buffer capacity (livelihood capital), we added adaptive capacity and transition capacity to jointly measure the stability of farmers' livelihoods. Based on the preceding discussions and adjusted to the reality of the study area, we complemented the SLA framework with concepts of adaptation and livelihood diversity. The livelihood stability index (LSI) measurement framework was created using three essential dimensions: (1) buffer, (2) adaptive, and (3) transition capacities (Table 1). These three dimensions can be further deconstructed into 11 indicators based on the literature, expert consultations, and field experience. According to the SLA approach, buffer capacity is the ability of a livelihood system to withstand disturbances and maintain its original structure, function, and feedback, which can be represented by farmers' livelihood capitals. Adaptive capacity is defined as the ability to adapt to potential threats, capitalize on an advantageous opportunity, or cope with consequences, including the level of education, understanding of policies and farmers' skill levels. These are related to the ability of farmers themselves, and are essential for building livelihood stability for rural households [33]. Transition capacity emphasizes the ability to utilize recombining sources of experience and knowledge to realize livelihood transformation, that is, traversing thresholds into a new livelihood style by utilizing crises as opportunities for novelty and innovation [45]. We chose livelihood diversity and the income dependence indicator to present transition capacity. In addition, the majority of farmers in the studied area rely on traditional dry farming, which has long been constrained by drought and water scarcity. We therefore added the indicator of resource dependence.

Table 1. Assessment system for evaluating livelihood stability.

Dimension	Indicators	Description	Attribute	Weight *
Buffer capacity	Human capital	Ratio of labor to the total population in a household	+	0.09
	Financial capital	Ratio of annual household income to total population	+	0.08
	Social capital	Proportion of trustworthy neighbors (1: 0–20%; 2: 20–40%; 3: 40–60%; 4: 60–80%; 5: 80–100%)	+	0.06
	Material capital	Housing condition: (1: dilapidated; 2: earth kiln; 3: stone brick kiln; 4: stone brick kiln; 5: building)	+	0.07
	Natural capital	Household cultivated area per person	+	0.07
Adaptive capacity	Education years	The schooling years of household labor force	+	0.11
	Policy awareness	Policy concern degree, rated on a 5-point Likert scale	+	0.09
	Participation in skill training	Amount of participation in technical training	+	0.11
Transition capacity	Livelihood diversity	Number of sources of income	+	0.12
	Income dependence	The extent to which a household relies on a single source of income for survival $D_{inc} = -\sum_{n=1}^{S} \frac{X_n(X_n-1)}{X(X-1)}$ where x_n is the household net income under the n_{th} income source; x is the total household income	-	0.11
	Resource dependence	The proportion of irrigated land to cultivated land	-	0.09

* Weight is calculated with the entropy evaluation method.

The comprehensive index method was used to measure the LSI, which was calculated using Equation (1):

$$LSI = w_1 \times l_1 + w_2 \times l_2 + w_3 \times l_3 \tag{1}$$

where l_1 represents the buffer capacity dimension, l_2 represents the adaptive capacity dimension, and l_3 represents the transition capacities, respectively. w_1, w_2 and w_3 denote the weights of each dimension.

Data standardization was performed using the following equations:

$$x_i = \frac{x - x_{min}}{x_{max} - x_{min}} (x \text{ is a positive indicator}) \tag{2}$$

$$x_i = \frac{x_{max} - x}{x_{max} - x_{min}} (x \text{ is a negative indicator}) \tag{3}$$

where x is the observed value in an array of observed values for a given variable; x_{max} is the highest value in the same array; and x_{min} is the lowest value in that array.

3.3. Approaches to Measuring Rural Location Advantage

According to location advantage theory, location advantage refers to an objective existence that can be conducive to industrial development and layout of the regional favorable factors [46]. It refers to the relative difference, not the absolute difference. Therefore, we evaluated rural location advantage from local, urban–rural scales, and interconnection perspectives. Variables were selected from three dimensions—(1) natural advantage, (2) traffic advantage, and (3) positional advantage—by referencing relevant studies and integrating them with the actual circumstances of the study area (Table 2) [32]. As there are three geographical divisions with great differences in Jia County, topography has the most basic impact on farmers' livelihoods in the natural environment [47]. Based on the aforementioned factors, slope gradient and elevation were chosen to evaluate the rural location advantage at local spatial scale. In addition, farmers are highly dependent on rain-fed agriculture and sensitive to the disturbance of drought in the Loess Plateau. Water source is one of the important local affecting factors. The position of the rural community in the urban–rural system affects the livelihood strategies of farmers and their access to high-level services [48], and the proximity to cities affects the patterns of rural employment and livelihood patterns [49]. Bert Ingelaere et al. emphasized that secondary towns occupy an intermediate position between rural and urban areas that are familiar to residents, and generally become their first choice for off-farm employment opportunities and income diversification [50]. Therefore, economic, administrative, and market distances were chosen to represent the rural location advantage at the urban–rural scale. Rural–urban interactions play significant roles in shaping rural lives. Tristan Berchoux et al. found that proximity to main traffic roads increases the village's access to external communication [35]. It can be seen that traffic advantage has interconnected impacts on farmers' livelihood by affecting the flow efficiency of capital, resources and labor forces in different sites. Traffic convenience, traffic accessibility, and internal traffic conditions were selected as the evaluation criteria for the rural location advantage at the interconnection scale.

Table 2. Assessment framework for evaluating rural location advantage.

Dimension	Indicators	Description	Attribute	Weight *
Natural advantage	Slope gradient	Average slope gradient of the village	−	0.12
	Elevation	Average elevation of the village	−	0.11
	Water availability	Distance to the river	−	0.14
Positional advantage	Economic distance	Distance to the regional capital	−	0.10
	Administration distance	Distance to the local town	−	0.09
	Market distance	Distance to the market fair	−	0.08
Traffic advantage	Traffic convenience	Whether township roads pass through (yes: 1; no: 0)	+	0.12
	Traffic accessibility	Distance to roads above county level	−	0.13
	Internal traffic	Ratio of hardened road length to village area	+	0.11

* Weight is calculated with the entropy evaluation method.

The comprehensive index method is used to measure the Rural Location Advantage Index (RLAI), which is calculated using Equation (4):

$$RLAI = a_1 \times r_1 + a_2 \times r_2 + a_3 \times r_3 \tag{4}$$

where r_1 represents the natural advantage dimension, r_2 represents the traffic advantage dimension, and r_3 represents the positional advantage dimension. a_1, a_2 and a_3 denote the weights of each dimension, respectively. Additionally, before entering the equation, as previously indicated, the data must be prenormalized.

3.4. Geographical Detector Model

The geographical detector model is a spatial analysis method used to calculate the relationships between geographical phenomena and their influencing factors [30]. Spatial differentiation and factor detection modules were used to analyze the relationship between rural location advantage factors and livelihood stability. Specifically, it was calculated using Equation (5):

$$q = 1 - \frac{\sum_{h=1}^{p} N_h \sigma_h^2}{N\sigma^2} \tag{5}$$

where q is the degree to which the *RLAI* factors can account for the *LSI* spatial difference, and the value range is [0, 1]. The strength of this interpretation increases with the q value. The *RLAI* factor categorization is represented by p. Class h and the entire sample size are denoted as N_h and N, respectively. The square deviations of class h and the entire sample are denoted as σ_h^2 and σ^2.

4. Results

4.1. Livelihood Stability Index

The calculated results demonstrate that the average value of the LSI in Jia County was 0.485. Additionally, we divided the LSI results of the 451 sampled households and their dimensionality capacities into three groups using the natural breakpoint method: low, medium, and high. Table 3 shows the detailed distribution of households in the three categories. According to Table 3, the proportion of households with moderate livelihood stability was the highest, reaching 42%, whereas the proportions of households with high and low stability were equal (29%). This demonstrates that most households in Jia County have moderate livelihood stability. From each constitutive dimension of the LSI, the proportion of households in the moderate grade was also higher than that in the low and high grades. Particularly in the transition capacity dimension, the proportion of low-grade households was the lowest (28%). This indicates that most farmers in Jia County no longer rely on a single source of income and are capable of non-agricultural transformation and diversified methods of living.

Table 3. Percentage distribution of the LSI and each dimension index.

Categories	LSI	Buffer Capacity	Adaptive Capacity	Transition Capacity
L [1]	0.29 (133 [4])	0.34 (152)	0.32 (144)	0.28 (126)
M [2]	0.42 (189)	0.38 (173)	0.52 (235)	0.49 (221)
H [3]	0.29 (132)	0.28 (126)	0.16 (72)	0.23 (104)

[1] L—Low, [2] M—Moderate, [3] H—High, [4] Values in parenthesis indicate the number of households.

To investigate the spatial pattern distribution of livelihood stability in Jia County, we used sampled villages as units and visualized the mean value of the LSI and its fractal index using ArcGIS 10.3 software (Figure 3). The greater the value, the larger the circle is. Farmers with a high LSI were distributed throughout all geographical regions, especially in the east along the Yellow River around the capital of the county. Farmers with moderate and low livelihood stability were widely distributed in the northern hilly and sandy region and western hilly and gully regions. From the dimension of buffering capacity (Figure 3b), the buffering capacity of farmers in the western and eastern stony regions was generally better than that of farmers in the northern sandy region. The northern part of the county is located on the southern border of the Mu Us Desert, which is eroded by wind and sand, forming a large expanse of dry river platforms and moving sandy lands. Low soil fertility, wide planting, and low harvest rates are not conducive to farmers' livelihoods and capital accumulation. From the adaptive-capacity dimension (Figure 3c), farmers in the hilly and stony region were still more adaptable than those in other regions. To integrate educational resources, most rural institutions have merged into the capital of the county since 2002, and the education gap between rural and urban areas has begun to widen. The educational level, agricultural skills, and policy awareness of farmers in the hilly and stony region, where the capital is located, have significantly improved, which is the reason for their higher adaptive capacity. From the transition-capacity dimension (Figure 3d), farmers have a relatively robust transformation ability in all regions. Under the influence of urbanization and non-agriculture, farmers are no longer restricted to a single agricultural livelihood strategy and typically turn to a non-agricultural or diversified livelihood mode.

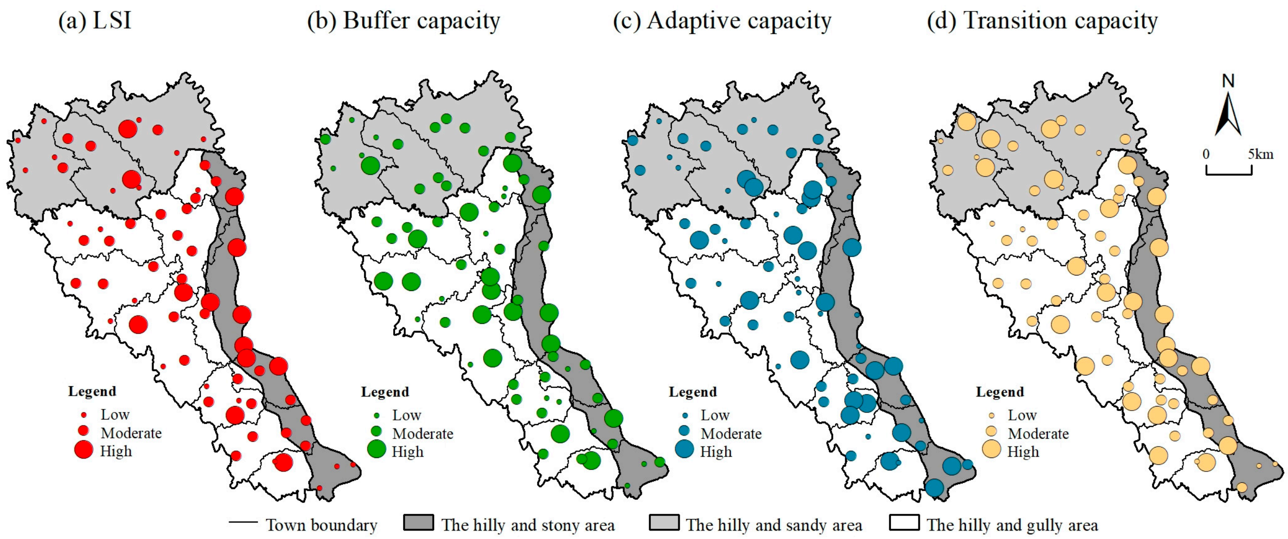

Figure 3. Spatial distribution of the Livelihood Stability Index and its dimensions.

4.2. Rural Location Advantage Index

The results demonstrate that the average RLAI value was 0.540. Using the natural breakpoint method, the RLAI and its dimension index results for the 65 sampled villages were classified as high, moderate, or low. This provided us with a grade for each village's RLAI and natural, traffic, and positional advantages, and 77% of the sampled villages achieved a moderate or high RLAI, as illustrated in Table 4. The percentage of villages with a high or moderate grade of traffic advantage was 78%. This demonstrates that through a series of authority control measures and policies, most villages in Jia County have relatively optimistic development conditions (natural environment, transportation conditions, and administrative level). Notably, the proportion of villages with low natural advantage was relatively high, reaching 45%. This is related to the delicate ecological environment of the Loess Plateau.

Table 4. Percentage distribution of the Rural Location Advantage Index and each dimension index.

Categories	RLAI	Natural Advantage	Positional Advantage	Traffic Advantage
L [1]	0.23 (15)	0.45 (29)	0.34 (22)	0.22 (14)
M [2]	0.51 (33)	0.41 (27)	0.40 (26)	0.69 (45)
H [3]	0.26 (17 [4])	0.14 (9)	0.26 (17)	0.09 (6)

[1] L—Low, [2] M—Moderate, [3] H—High, [4] Values in parenthesis indicate the number of households.

To further clarify the geographical spatial pattern of the RLAI and each dimensional advantage index of Jia County, the Kriging interpolation method was used to interpolate the entire county space with the data of 65 sample villages. The spatial distribution patterns of the RLAI and each dimensional advantage index were determined (Figure 4a). High RLAI areas were found in the county's central and eastern districts, primarily in hilly and stony regions. Low RLAI areas were prevalent in the county's northwest and northeast, mainly in the hilly and sandy and hilly and gully regions. Moderate RLAI areas were widespread and distributed, spanning all topographic regions. For the natural advantage from a local spatial perspective (Figure 4b), the eastern part of Jia County has a low elevation and relies on the Yellow River for water; therefore, this region has high natural advantages despite the county's overall complex terrain, broken surface, and lack of water resources. For the positional advantage from an urban–rural spatial perspective (Figure 4c), the areas with a high positional advantage were along the Yellow River in the eastern part of the county. Because the county government is positioned east of the county's geometric center, administrative radiation is weaker than that from the county seat, according to the principle of diminishing marginal benefits. The eastern part of the county is adjacent to the Yellow River. With the growth of the tourism industry along the Yellow River, the accelerated development of rural areas in this region has been driven by the expansion of tourism resources. For the traffic advantage from an interconnected spatial perspective (Figure 4d), the county's high-grade traffic arteries stretch from the eastern county seat to the eastern and western sides. Furthermore, the road network at the angle between the western and central and northeastern transportation corridors is sparse, resulting in a lack of traffic in this region. The spatial pattern of the RLAI was described as "decreasing gradually from the capital town to the north and south" due to the combined factors of local, urban–rural, and interconnected scales.

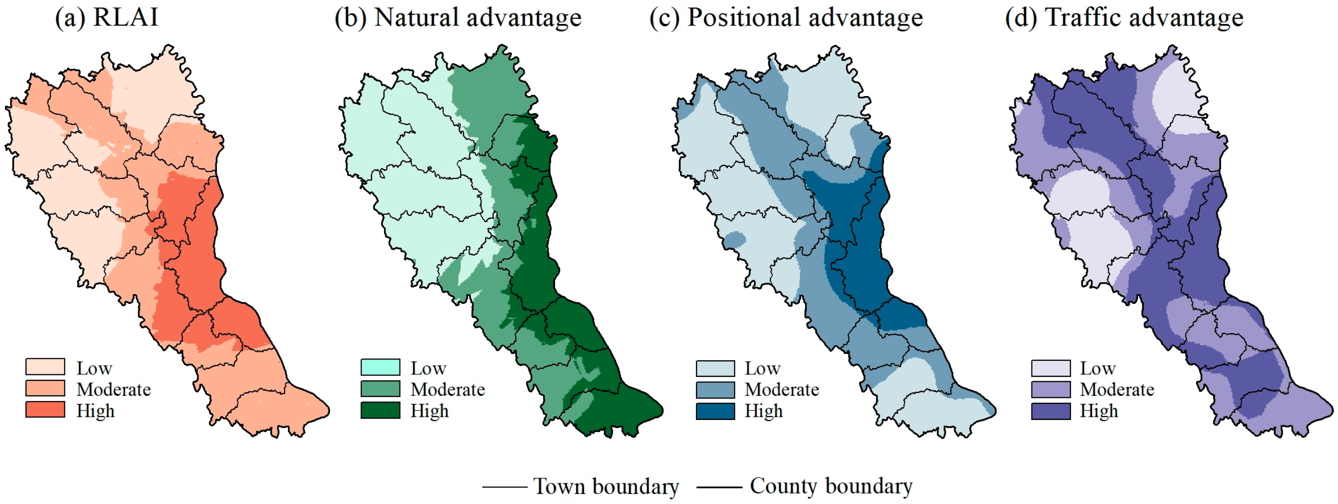

Figure 4. Spatial distribution of the Rural Location Advantage Index and its dimensions.

4.3. Relationship between the Rural Location Advantage Index and the Livelihood Stability Index

Through matching LSI and RLAI level statistics of all sample villages, it is possible to combine nine varieties of H-L, H-M, M-L, L-L, M-M, H-H, L-H, L-M, and M-H, as illustrated in Table 5. Villages with RSI levels equivalent to RLAI levels (L-L, M-M, and H-H) accounted for 56.92% of the total sample villages. The proportion of villages in the RAI superior group was slightly higher than that in the RSI superior group. There is a certain coupling correspondence between the LSI and RLAI, and the LSI has a certain lag relative to the RLAI.

Table 5. Statistics on the spatial coupling between the rural location advantage index and the livelihood stability index levels.

Spatial Coupling Categories	LSI Superior			Equivalent			RLAI Superior		
	H-L	H-M	M-L	L-L	M-M	H-H	L-H	L-M	M-H
Quantity	2	8	3	10	18	9	2	7	6
Percentage		20.00			56.92			23.08	

To explore the coupling correspondence between the LSI and RLAI more intuitively, the RLAI was taken as the horizontal coordinate and the LSI as the vertical coordinate to plot the situation of 65 sample villages into a scatter plot (Figure 5). As illustrated in Figure 5, most sample points are clustered around the "lower-left-upper right" trend line, indicating that there is a certain spatial correspondence between the LSI and RLAI, that is, there is a certain positive correlation between farmers' livelihood stability and their rural location conditions. Nonetheless, 43.08% of the sample villages were still discrete (i.e., the LSI and RLAI levels were distinct), indicating that the relationship between the two was complex and not entirely positive, necessitating additional analysis.

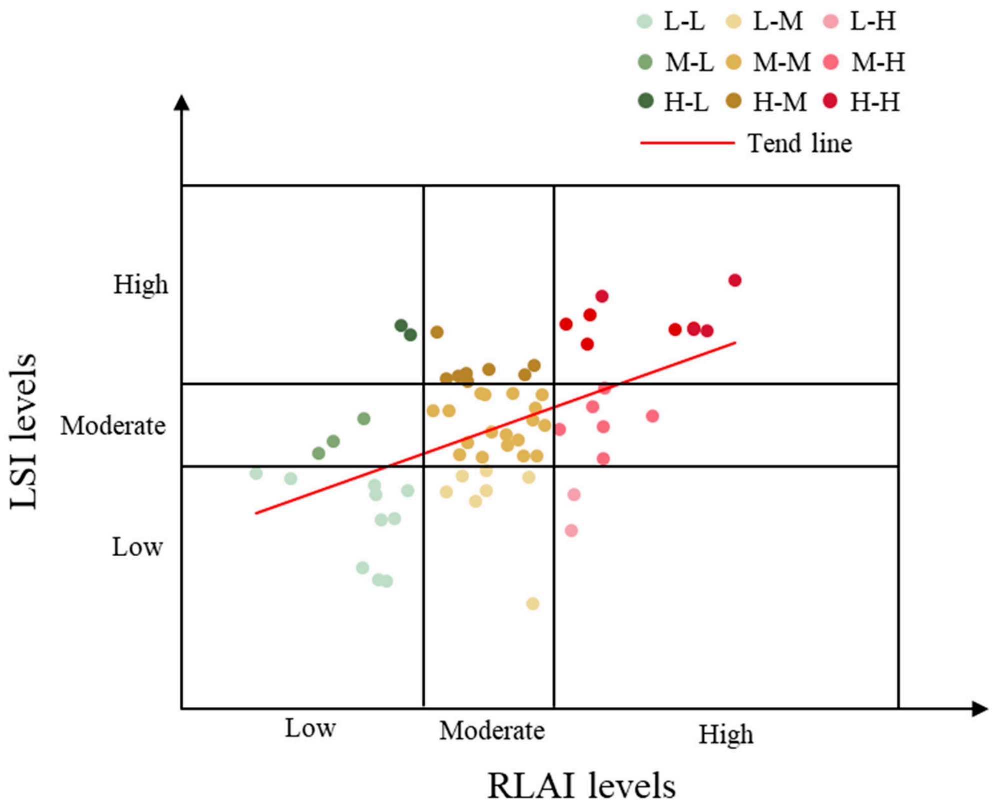

Figure 5. Spatial coupling between the rural location advantage index and the livelihood stability index.

Using a geographical detector model, we investigated the impact factors of the LSI to examine how rural location conditions influence farmers' livelihood stability from the muti-spatial perspective. First, the dimensions of each impact factor were reduced using a stepwise regression method, and indicators that were unsuitable for inclusion in the model were eliminated. The five location factors that passed the test were traffic accessibility, internal traffic, slope gradient, elevation, and economic distance. We then incorporated the LSI as the dependent variable and the five factors as independent variables into the geographical detector model to determine the explanatory power q value of each factor for farmers' livelihood stability (Table 6). The results demonstrated that the q values were in descending order: economic distance > elevation > slope gradient > traffic accessibility > internal traffic. The findings indicate that farmers' livelihoods are impacted by multi-spatial location factors.

Table 6. Explanatory power of each location factor for the livelihood stability index.

Location Factors	q	Sig.
Elevation (local scale)	0.196	0.01
Slope gradient (local scale)	0.173	0.01
Traffic accessibility (urban–rural scale)	0.162	0.01
Internal traffic (interconnected scale)	0.129	0.00
Economic distance (interconnected scale)	0.214	0.00

Based on the complex relationship between the LSI and RLAI, farmers' livelihood activities in villages are frequently subject to interaction by multi-spatial location factors, meaning that the combined effect of two or more spatial location factors is greater than that of a single spatial factor. To verify this hypothesis, we investigated the impact of multi-spatial factor interactions on farmers' livelihood stability using a geographical detector model. The results indicate (Table 7) that the explanatory power after the interaction of any two location factors is greater than the sum of it when the two factors operate alone; that is, it will have a "1 + 1 > 2" influence on livelihood stability. The explanatory power of the economic distance factor in the interaction was greater than that of other factors, indicating that the urban–rural scale factor is a significant control factor for livelihood stability, which is consistent with the single-factor detection results. The interactive explanatory power of economic distance and slope is the largest, which is 0.737, indicating that the interaction between urban–rural scale and local scale location factors has the greatest influence on livelihood. The interaction between slope gradient and elevation has an explanatory power of 0.640, indicating that the interaction of location factors within a local scale on livelihood stability cannot be overlooked. When traffic accessibility interacted with other factors, its explanatory power increased to more than 50%, showing that the interconnected scale factors easily form scale correlation effects on farmers' livelihoods when interacting with other scale factors. Therefore, the spatial variation in the RLAI is due to a combination of multi-spatial location factors.

Table 7. Effect of interaction between factors on the livelihood stability index.

	Elevation	Internal Traffic	Slope Gradient	Traffic Accessibility	Economic Distance
Elevation	-	-	-	-	-
Internal traffic	0.437	-	-	-	-
Slope gradient	0.640	0.398	-	-	-
Traffic accessibility	0.629	0.525	0.578	-	-
Economic distance	0.718	0.577	0.737	0.658	-

5. Discussion

5.1. Understanding Farmer's Livelihoods from a Multi-Spatial Standpoint

The distribution of rural poverty has obvious spatial heterogeneity [34,42], which is manifested in the inconsistent development level of rural communities and the income gap of rural households within the county. The spatial heterogeneity leads to the lack of precision and targeting of macro policy implementation. In order to fulfill the sustainable development aim of vigorous rural development and stable farmer livelihoods, China's rural revitalization policies frequently support development at the village level to eliminate poverty at the household level. The relationship between rural communities and peasant households is the most basic man–land relationship in urban–rural regional system. Having a solid understanding of the relationship is a forceful way to enhance actual effects of macro policies. The relationship between the rural community and farmers was investigated using the economic and ecological concepts of location advantage and stability to quantify the essential characteristics of village scale and household scale. With the advancement of urbanization, farmers' livelihood activities are no longer limited to the local space in rural areas, and the location conditions of villages should also be comprehensively considered based on different spatial scales of the urban–rural regional system. In view of this, we classified the evaluation indicators of rural location advantage into three categories: local, urban–rural, and interconnected, and identified the key factors affecting farmers' livelihood from a muti-spatial perspective. It is found that impacts of rural location conditions on farmers' livelihoods are complex, and livelihood stability is not a linear agglomeration process towards well-located villages. With increasing urban–rural interactions, non-agricultural livelihood plays a prominent role in the farmers' modern livelihood strategies. Even if local location conditions are insufficient, farmers can obtain stable livelihoods by going out for work or engaging in local non-agricultural livelihoods (such as sales, catering, etc.). An encouraging result for areas like the Loess Plateau, where natural conditions are essentially inadequate, is that the constraining effect of local location constraints on farmers' livelihoods is waning. Naturally, such a shift would require public investment in infrastructure like rural roads and electricity. Locational factors at local, rural–urban, and interconnected scales might not only affect rural livelihoods independently, but also produce cross-effects through mutual influence. Among them, the significant influence of rural–urban scale and interconnection scale location factors on the LSI further confirms that the increasing rural–urban interaction has a greater impact on farmers' livelihood activities. It reveals that it is fruitful to consider the intersection of multi-scale spatial factors and scale-dependence relationships in livelihood research.

5.2. Enhance Livelihood Stability Utilizing Rural Location Advantages

Farmers' livelihoods are a way for farmers to survive by utilizing internal and external resources, and it is helpful to understand how rural residents are connected with rural geographical environments. The geographical location of villages has a noticeable effect on rural economic activities and farmers' livelihoods, particularly in traditional agricultural planting areas. The limiting effects are more pronounced in regions with complex terrains and relatively low productivity, such as the Loess Plateau. Countermeasures and suggestions to improve farmers' livelihoods can be sought from a spatial perspective, which can be guided and managed from the following aspects. Combined with the resident population scale, industrial structure, and functional orientation of villages, appropriate policies should be adopted to gradually narrow the spatial imbalance in rural livelihoods. For villages in the northwest counties with poor natural conditions, fragmented land can be integrated through a land contractual-operation system. Agricultural intensification and industrialization can be accomplished through land leveling and terrace construction. Simultaneously, early warning and emergency mechanisms should be established to release meteorological disaster information in a timely manner to reduce damage to agricultural production caused by natural disasters. To address the scarcity of water supplies, water conservation projects such as reservoirs and irrigation canals should be developed. Sprinkler- and drip-irrigation techniques should be popularized. The construction of rural road networks should be encouraged to improve the travel environment for rural families in western, central, and northeastern villages with inadequate traffic conditions. To compensate for the weak links in agricultural development, rural infrastructure and public service supply should be enhanced; connectivity between urban and rural areas should be promoted. And more public services, such as education, healthcare, and social security should be provided to rural communities, especially in settlements at the edge of the county with poor position conditions, expanding income access for people experiencing poverty combined with agricultural subsidy policies [51]. Immigration policies should appropriately relocate the rural population to areas where farmers' livelihoods are unstable due to multiple location factors' superposition. Additionally, the labor force's educational background and agricultural expertise, non-agricultural transfers, and the supporting role of livelihood diversity in farmers' livelihood stability should be enhanced.

5.3. Study Limitations

Farming households are the most fundamental production and living units in rural areas, and their livelihoods are closely tied to the external environment. Most current re-search on the impact of external environment on farmers' livelihoods mainly focuses on the local scale, and the specific impact mode or impact degree are rarely discussed from the muti-spatial perspective [20,52]. Our research focused on county areas, investigating the human–land relationship in poor areas from the perspectives of local, urban–rural and interconnected scales. However, this research has some limitations, as follows: (1) Despite our efforts to incorporate relevant theories and existing research into the development of the index system and include key indicators to prevent any potential bias resulting from omitted components, data availability constraints limited our selection of indicators. Nevertheless, although we borrowed from pertinent theories and existing studies when building the assessment system and included key indicators to avoid the deviation of study results caused by the omission of components, the selection of indicators is constrained by data availability, which is not completely sufficient. Therefore, we ensured the accuracy of our findings by adjusting the index weights and verifying a series of models. Additionally, we integrated our intuitive field-research experience with previous research conclusions to compare and validate our results [48,49]. (2) We took the county area as the fundamental unit of analysis for the case study, and mainly considered the radiation driving effect of the capital and local towns on the rural area. Although it has stronger operability, the selection of scale has certain limitations. Future studies should incorporate the neighboring large cities into the interaction to explore the mechanism of rural spatial disparities while continuously enhancing the livelihood research methods. This will contribute to a more comprehensive multi-scale sustainable livelihood research experience. (3) Our research is mainly based on the current situation of a typical county. However, owing to the vast area and significant internal spatial heterogeneity within the Loess Plateau, there are variations in the livelihood strategies employed by farmers across different regions. In the future, longitudinal comparative analysis of time series should be strengthened to carry out dynamic tracking research on livelihood issues. Simultaneously, attention should be paid to horizontal comparative analyses among different counties to explore the common guidelines for multi-scale rural livelihood research [35].

6. Conclusions

Taking Jia County on the Loess Plateau as a case study, we integrated location theory with household livelihoods using survey and geospatial data and investigated the livelihood problems of farmers from a multi-spatial perspective. The three dimensions of buffer capacity, adaptive capacity, and transition capacity were used to construct a livelihood stability assessment framework, and the natural, traffic, and positional dimensions were used to deconstruct rural location advantage. The complex interaction between rural location advantage and livelihood stability was explored from local, urban–rural, and interconnected spatial perspectives. Our study provided new empirical evidence for multi-scale factors on the spatial differentiation of farmers' livelihoods. According to the results, 77% of the villages achieved moderate or high RLAI values. Owing to poor natural conditions, villages with a low RLAI are mainly distributed in hilly and sandy areas, which are related to the vulnerable ecological environment of the Loess Plateau. Overall, the LSI was moderate; however, spatial heterogeneity was evident. Most farmers possess strong transition capacity and no longer rely on monocultures for their livelihoods. There is a certain coupling correspondence between the LSI and the RLAI, but it is not a simple linear agglomeration process. The spatial variation in the LSI was due to the superposition or interaction of multi-spatial factors. The rural–urban spatial location factors are the key control element of LSI and the interaction between rural–urban and local spatial location factors has the greatest influence on LSI. It is simple for interconnected spatial location factors to produce a scale correlation effect, and have non-negligible effects on farmers' livelihoods when they interact with other spatial location factors.

According to our research, farmers' livelihoods are significantly affected by differences in geographical location within a county. These findings enhance our multi-spatial understanding of livelihoods and have implications for developing more effective policies to target rural revitalization and poverty reduction. Farmers' livelihoods are dynamic and significantly affected by geographical differences in the county area. They will take into account multiple factors (natural, human-made, and human–land interactions) and constantly modify their strategies with changes in their capital and the external environment. Farmers in different locations experience various external conditions and resources, resulting in different livelihoods. This is one of the reasons why livelihood issues are becoming increasingly complex. The spatial heterogeneity of farmers' livelihoods results from the superposition and interaction of multi-spatial location factors. We found that the combined effect of two spatial location factors was greater than the sum of their individual effects, resulting in a "1 + 1 > 2" impact on farmers' livelihood. Therefore, attention should be paid to the comprehensive effect of multi-spatial location factors in modern livelihood researches.

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