

Article

# Land Functions, Rural Space Governance, and Farmers' Environmental Perceptions: A Case Study from the Huanjiang Karst Mountain Area, China

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**Abstract:** Residents of rural areas live and depend on the land; hence, rural land plays a central role in the human–land relationship. The environment has the greatest direct impact on farmers' lives and productivity. In recent years, the Chinese government carried out vigorous rural construction under a socialist framework and implemented a rural revitalization strategy. This study was performed in a rural area of Huanjiang County, Guangxi Province, China. We designed a survey to measure rural households' perceptions of three types of rural spaces: ecological, living, and production spaces. The survey was administered to 379 farmers, and their perceptions and satisfaction with Ecological–Living–Productive spaces were evaluated with the use of structural equation modeling. Analysis of latent and observed variables indicates that: (1) Farmers' overall satisfaction with Ecological–Living–Productive spaces was moderate. The average satisfaction score for production spaces was lowest (2.881) while that for living spaces was highest (3.468) and that for ecological spaces was in between (3.351). (2) The three most important exogenous observed variables associated with living space satisfaction were house comfort > domestic water supply > domestic sewage treatment. The three most important exogenous observed variables associated with production space satisfaction were irrigation water > cultivated land quantity > cultivated land fertility. The three most important exogenous observed variables associated with ecological space satisfaction were garbage disposal > vegetation cover > flood and waterlogging. Based on the requirements of the rural revitalization strategy and the results of our analyses of rural households' spatial perceptions, we propose corresponding countermeasures and suggestions.

**Keywords:** environmental perceptions; land function; rural space; karst mountain area

## 1. Introduction

Rural space is defined as an area of land that rural residents live in and depend on. It plays a central role in the relationship between humans and the land. Rural land has direct impacts on the lives and production capacity of rural farmers [1] and, as such, has long been the focus of research on the relationship between humans and the land. Studies have proven that rural land, transportation, infrastructure construction, and public services all positively affect farmers' satisfaction and quality

of life; however, land factors have more significant impacts [2]. When farmers have higher quality land resources, their happiness is generally higher and they receive greater benefits [3]. Land has diverse functions, and effective functioning increases farmers' welfare and happiness [4]. Research on multifunctional land around the globe has evolved rapidly from the early studies of multifunctionality in agriculture [5]. In 2001, international organizations formally proposed the concept of agricultural multifunctionality and, with increased research attention, studies of multifunctional land use have gradually spread from the field of agriculture to various other fields [6,7]. Multifunctionality of land use considers that all types of land use interact. Overall, it relates to the products and services that the land can provide for residents of a certain area [8]. The multifunctionality of land use emphasizes land use versatility; as such, research on it is comprehensive and covers a wide range of topics.

In 2004, the EU Integrated Project SENSOR (Sustainability Impact Assessment: Tools for Environmental, Social and Economic Effects of Multifunctional Land Use in European Regions), first proposed the concept of multifunctional land use [9]. Specifically, it refers to the private and public products and services provided by different land use methods [10] in terms of society, economy, and the environment [11]. Following this, extensive research on land use versatility was performed. It should be noted that there are differing views within the academic community regarding the classification of land use functions. From the perspective of functional subjectivity, land use functions can be divided into three primary categories: economic, social, and ecological [12,13]. Economic functions include material production and economic development, social functions include transportation and residential functions, and ecological functions include environmental regulation and ecological maintenance capabilities [14]. More recently, a new method of categorizing land use was proposed as an increasing number of scholars have begun to study land use from the perspective of production, living, and ecological functions [15–17]. Here, living functions refer to the space's capacity for human production and life [18], production functions refer to the various products and items of value produced by the land [19], and ecological functions refer to the ability of the land to adjust ecologically and maintain human survival [20]. With the increased interest in the theory of sustainable development over recent years, the Ecological–Living–Productive land use model has become a focus of research within the field of multifunctional land use.

Perception is the act of recognizing certain facts [21]. It is the first step in understanding the surrounding environment and the beginning of all behavior [22–24]. Environmental perceptions are the perceptions that people form regarding their natural surroundings and social environment [25–27]. Current studies on the environmental perceptions of farmers focus on their risk perceptions [28], how their perceptions impact behavioral decision-making [29], their perceptions of and adaptation to climate and environmental change [30], and their perceptions of land degradation [31]. In terms of the risk perceptions of farmers, there are many studies of their effects on livelihood [32], environmental risk in the breeding industry [33], agricultural production and operation [34], and the risk perception of farmers in response to climate change [35]. Research on farmers' perceptions primarily examines their influences on behavioral decision-making, analyses perceptions, and adaptive behaviors, and investigates consistency in perceptions and behavior [36]. In particular, there is a relatively large body of literature on farmers' perceptions of climate change and their adaptive behaviors in poor and arid areas [37], and the effects of perceived value on farmers' input behaviors [38], planting decisions, and satisfaction with new residential areas [39,40]. Further, analysis of farmers' perceptions was also applied in the context of the evaluation and analysis of policies such as the rural revitalization policy and the countryside home appliance policy in China [41], the latter of which provides subsidies for farmers to purchase home appliances. Farmers' perceptions of climatic and environmental changes are affected by factors such as soil fertility, land tenure, age, years of education, time spent in agriculture, and use of social networks [42]. Further, many farmers report perceived changes in local temperature and precipitation [43]. Farmers' perceptions of land degradation mainly relate to land erosion, soil erosion, fertility loss, and land fragmentation [44]. Research shows that farmers' understanding of land degradation is a key social factor in controlling land erosion and soil erosion [45].

In summary, current research on land space functions is relatively mature. The focus in this field has changed from early studies of multifunctional agriculture to contemporary studies of multifunctional land use, primarily discussions of land space Ecological–Living–Productive functions. Farmers' perceptions have also led to discussions in several related fields, such as natural disaster risk, climate change, adaptability of farmers' livelihoods, and land degradation; and an increasing number of comprehensive multidisciplinary studies have been conducted. However, studies that have evaluated perceptions of rural spaces have not combined perspectives of production, living, and ecological land use functions. The current study addresses this gap by analyzing farmers' perceptions of, and satisfaction with, rural production spaces, living spaces, and ecological spaces. More importantly, our research is novel as it focuses on farmers' socioeconomic identity to explore its impact on their perceptions of different land spaces. We consider farmers' direct perceptions or evaluations of the internal components of different land spaces and analyze their impacts on their overall evaluation of space, which is a very different approach to that used in previous studies. The main factors affecting perception and satisfaction, as related to production, living, and ecological functions, are analyzed using structural equation modeling (SEM). Finally, based on our results, we propose measures to improve land use quality and suggestions for rural space management.

## 2. Study Area and Data Sources

### 2.1. Study Area

Huanjiang County, Guangxi Province, China, is located between 24°44'–25°33' N and 107°51'–108°43' E (Figure 1). It covers a total area of 4553 km<sup>2</sup> and is the third largest county in Guangxi. Huanjiang County has 12 townships under its jurisdiction (Table 1) and 149 administrative villages, of which Chuanshan town has the largest area and contains 20 administrative villages with a total area of 66,440.32 ha. The smallest town is Dachai township, which has eight administrative villages under its jurisdiction covering 12,838.92 ha. According to the Statistical Yearbook, the total permanent population in 2016 was 374,312, of which the rural population was 324,101 (86.6%). Huanjiang County is one of 28 poverty-stricken counties in Guangxi and has very poor economic development. As an example, in 2016, the GDP of Huanjiang County was only 4.53 billion yuan, ranking last economically among Guangxi's counties. Huanjiang County is in the low-latitude region near the Tropic of Cancer. The climate reflects a transition from the southern subtropical climate to the mid-lying subtropical monsoon climate, with abundant light, heat, and humidity. As the main landform types in this area are karst landforms, the hydrological features mainly include surface water and groundwater.

### 2.2. Data Sources

The sampling locations were chosen with consideration of two factors: the distance from each sample village to the administrative center of the county, and the level of economic development. In choosing the sampling locations, we also considered Tobler's first law: the closer the object, the higher the similarity. We tried our best to avoid selecting sample points that were spatially homogeneous. A stratified sampling method was adopted to select 16 sample villages from the 141 villages in Huanjiang County. This study was carried out in two stages using the Participatory Rural Assessment (PRA) method [46]. The first stage was completed between 16–26 May 2016. The first stage involved a survey of the actual situation in Huanjiang County; it involved surveying farmers and holding interviews with key personnel. In the second stage, from 4–14 June 2017, an 11-day in-depth field survey was conducted in Huanjiang County. Data were collected through written questionnaires and face-to-face interviews. We recognized that we may not fully understand the situations of the local villages, especially in those where labor is exported. To select representative villages and avoid ones with no farmers, we consulted local guides and village officials. Questionnaires were completed by interviewers and a total of 363 valid questionnaires were obtained. The questionnaire comprised questions on household characteristics and the basic conditions of farmers, land characteristics, farming conditions, and

satisfaction with the Ecological–Living–Productive spaces, among others. The average time taken for the semistructured interviews was 1.5 h. Prior to the survey, the project leader conducted centralized training and field drills with 12 research staff to ensure they had the necessary field survey skills and understood the ethical requirements. In addition, to avoid farmers’ misunderstanding the questions due to low education (most were educated to middle high or senior middle school levels, 47.3% and 31.5%, respectively) or differences in local dialect, we selected interviewers able to use the local dialect. During the survey period, one person was responsible for reviewing each questionnaire to ensure that high-quality data were obtained.

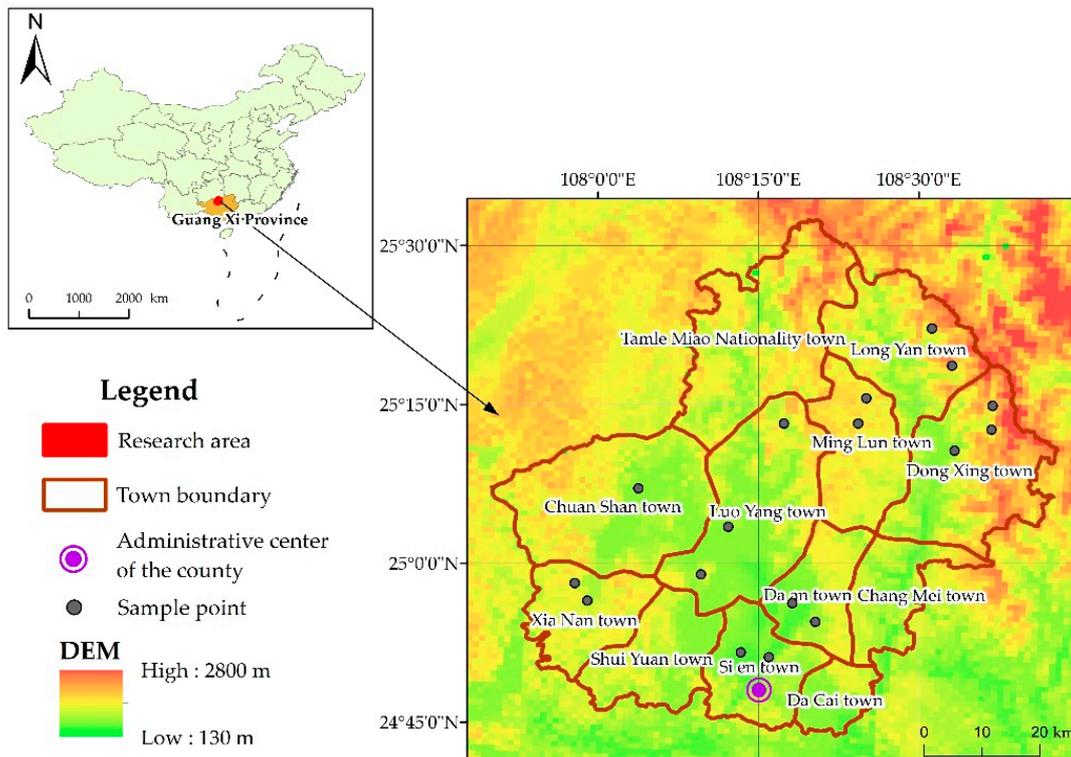


Figure 1. Map of Huanjiang County and its townships.

**Table 1.** Area and number of administrative villages in Huanjiang County townships in 2018.

Town Name	Sien Town	Dacai Xiang	Shuiyuan Town	Luoyang Town	Chuanshan Town	Xia'nan Xiang	Da'an Xiang	Changmei Xiang	Minglun Town	Dongxing Town	Longyan Xiang	Xunle Xiang
Number of administrative villages	14	8	13	16	20	11	7	6	16	11	13	14
Area (km <sup>2</sup> )	27,799.1	12,838.9	35,498.2	46,759.2	66,440.3	25,386.5	22,087.0	23,816.8	45,774.6	49,513.6	40,998.5	58,359.4

### 3. Research Design and Research Methods

#### 3.1. Data Sources and Scale Design

Based on previous research results, we designed a series of Likert scales to investigate farmers' satisfaction with their local living space [47,48]. Question responses were rated on a 5-point Likert scale as "strongly disagree" (1), "disagree" (2), "general or inaccurate" (3), "agree" (4), and "strongly agree" (5). We put forward a basic hypothesis that the total rural space satisfaction level of rural households was based on satisfaction with three aspects: living, production, and ecology. Rural households wholly depend on their living spaces. A review of the literature suggested that in addition to rural households' perceptions of their own housing conditions, other factors within the living space should be considered [49]. Therefore, to fully assess perceptions of living spaces, we measured perceptions related to road traffic, house comfort, neighborhood relations, domestic water conditions, domestic sewage treatment, local medical treatment, and convenience of shopping at the local market, and used them as observed variables. In terms of perceptions of production spaces, the observed variables included cultivated land quantity, cultivated land fertility, cultivated land access, agricultural facilities, job opportunities in the village, and sufficient irrigation water. The observed variables for ecological space perception included characteristics of rocky desertification in karst areas, the evaluation of local rocky desertification, river water quality, flood and waterlogging, garbage disposal, and vegetation coverage. Among them, the amount of cultivated land, the severity of rocky desertification, and increases in floods and waterlogging were negative evaluation indicators.

#### 3.2. Research Methods

This study used SEM, which is a useful multivariate analysis method primarily used to estimate and test causal relationships between variables [50]. SEM has the advantages of combining factor analysis and path analysis, and processing multiple dependent variables at the same time to give simultaneous estimates of the structure of factors and the relationships between them. It allows for measurement of error in independent and dependent variables and it has been widely used in various disciplines. The analysis process was based on a covariance matrix analysis that included both observed variables and indirectly observable latent variables [51]. An SEM consists of two parts: a measurement model and a structural model [52]. In this study, the satisfaction evaluation of ecological, living, and productive spaces formed the observed variables, and the remaining 18 evaluation factors were used as latent variables. Therefore, an SEM model is appropriate. The expressions of the equations follow:

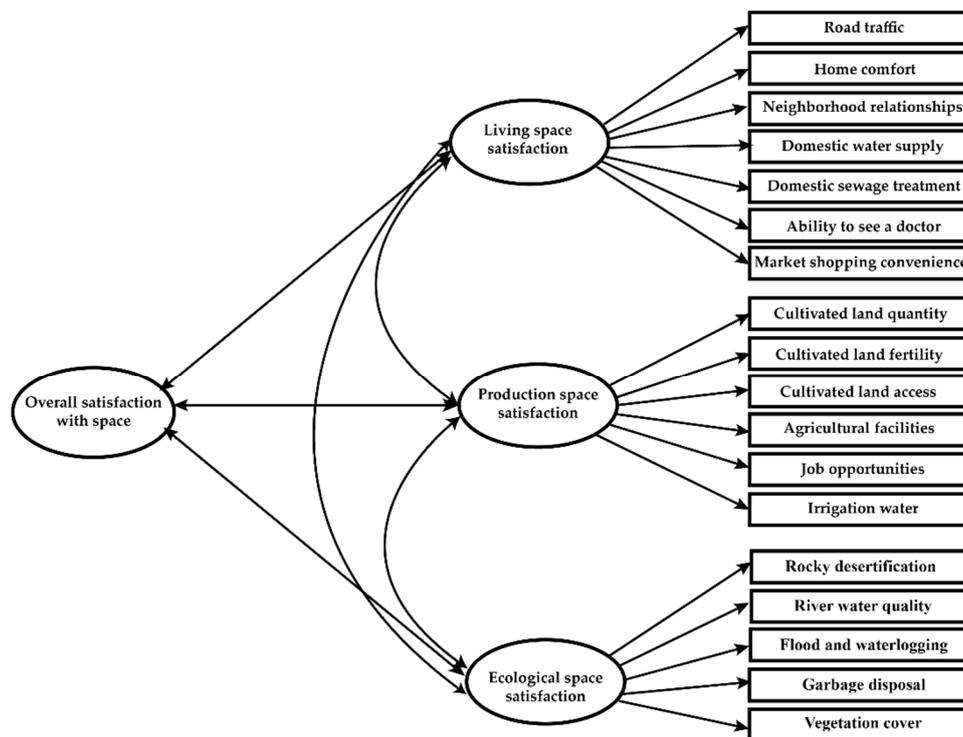
$$X = \Lambda_X \Psi + v \quad (1)$$

$$Y = \Lambda_Y \vartheta + \zeta \quad (2)$$

$$\vartheta = Q\vartheta + \mathcal{T}\psi + \sigma \quad (3)$$

In the three equations, Models 1 and 2 are measurement models representing measurement levels, and Model 3 is the SEM.  $X$  is an exogenous observed variable vector that can be directly measured and  $\Psi$  is an exogenous latent variable vector;  $Y$  is an endogenous measurable variable vector and  $\vartheta$  is an endogenous latent variable vector.  $\Lambda_X$  and  $\Lambda_Y$  refer to factor loading matrices, which are expressed as the correlation between exogenous observed variables and corresponding exogenous latent variables, and between endogenous observed variables and corresponding endogenous latent variables, respectively.  $Q$  is the unique matrix of endogenous latent variables.  $\mathcal{T}$  refers to the effect of exogenous latent variables on the corresponding endogenous latent variables.  $v$ ,  $\zeta$ , and  $\sigma$  are error terms used in the measurement model and structural equation. SEM data analysis was primarily performed using AMOS (Analysis of Moment Structure) software and basic data processing and inspection were conducted in SPSS (Statistical Product and Service Solutions) 17.0 software.

Based on the principles of SEM and the Likert scale measurement system, this paper established a structural equation as follows (Figure 2).



**Figure 2.** Model of the relationships between farmers' satisfaction and their Ecological-Living-Productive spaces.

## 4. Results and Discussion

### 4.1. Reliability and Validity of Measures

Prior to data analysis, the classic alpha (Cronbach) coefficient was used to analyze the credibility and validity of the survey data at different levels. Cronbach's alpha is a measure of internal consistency, that is, how closely related a set of items are as a group. A high alpha value is often used (along with substantive arguments and possibly other statistical measures) as evidence that the items measure an underlying (or latent) construct [53]. Some classic studies have demonstrated that the coefficient has a strong effect on the reliability index of the measured data; the higher the coefficient, the higher the reliability [54]. The test results are shown in Table 2. It can be seen that the  $\alpha$  coefficient (CA) value (0.762) exceeds the required value of  $\geq 0.7$ . Thus, the scale is reliable. Further, the three latent variables were tested separately and returned CA values of 0.724, 0.821, and 0.773, respectively, all of which were  $> 0.7$ , indicating consistency in the data. Factor analysis was then performed to analyze the validity of the data. The overall KMO (Kaiser-Meyer-Olkin) value was 0.844, and those of the three latent variables were all  $> 0.7$  and highly significant. Bartlett's test of sphericity was applied to the KMO values, which showed that the data collected in this study were suitable for factor analysis.

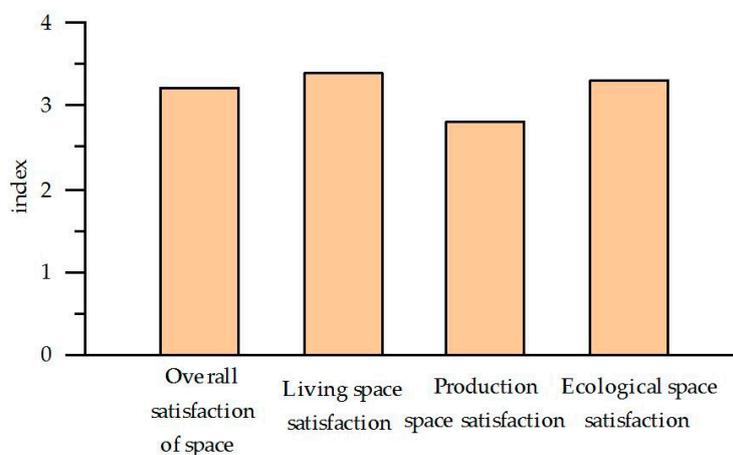
**Table 2.** Reliability and validity analysis.

Latent Variable	Observation Variable	$\alpha$ Coefficient	KMO Value	Bartlett		
				Approximate $X^2$	df	Significance (p)
Living space satisfaction	X1–X7	0.724	0.769	363.258	163	0.000
Production space satisfaction	X8–X13	0.821	0.742	763.498	174	0.000
Ecological space satisfaction	X14–X18	0.773	0.809	641.347	236	0.000
Overall	X1–X14	0.762	0.844	1498.245	561	0.000

KMO: Kaiser–Meyer–Olkin; df: degree of freedom.

#### 4.2. Overall Evaluation of Satisfaction with the Ecological–Living–Productive Spaces

This study measured satisfaction with the Ecological–Living–Productive spaces overall, as well as with each type of space separately (Figure 3). The overall satisfaction of farmers in Huanjiang County was moderate, with a score of 3.233 out of a possible total of 5. This indicates that farmers were neither satisfied nor dissatisfied with the local living space. Analysis of satisfaction with different types of space revealed that farmers had the lowest satisfaction with production spaces (2.881) and the highest with living spaces (3.468), with ecological space satisfaction falling between these values (3.351). This indicates that new rural construction, rural environmental quality, and infrastructure construction carried out in Huanjiang County in recent years were relatively effective, as farmers perceive that the quality of the living environment has significantly improved. However, the production space satisfaction scores were relatively low, which reflects, to some extent, farmers' dissatisfaction with the local agricultural production environment.



**Figure 3.** Overall evaluation of satisfaction with Ecological–Living–Productive spaces.

#### 4.3. Satisfaction with Land Space Characteristics Based on Farmers' Attributes

We found that the satisfaction of farmers varied according to the attributes of household income level, gender, education level, age, household size, and household location, especially household income level, education level, and household location (Table 3). Among them, farmers with higher incomes tended to be more satisfied with the overall space. It should be noted that farmers with an annual income of <20,000 CNY had very low satisfaction with production spaces. Farmers with higher education levels were more satisfied with the overall and individual spaces. In terms of the geographic position, farmers in the Valley region had significantly higher satisfaction with the overall space than those living in the Middle Mountain and low-lying regions, who also had the lowest satisfaction score for production spaces.

**Table 3.** Satisfaction scores for land spaces based on farmers' attributes.

Items	Farmer Household Attributes	Percentage (%)	Overall Satisfaction	Living Space Satisfaction	Ecological Space Satisfaction	Production Space Satisfaction
<b>Household income level (CNY/Year)</b>	20,000 and less	23.3	2.902	3.046	3.229	2.431
	20,000–50,000	40.3	3.294	3.573	3.197	3.112
	50,000–100,000	28.9	3.264	3.468	3.351	2.973
	100,000 and more	7.5	3.471	3.663	3.681	3.069
<b>Gender</b>	Male	59.4	3.268	3.503	3.214	3.087
	Female	40.6	3.198	3.496	3.091	3.007
<b>Education level</b>	Elementary school and below	14.9	3.102	3.482	3.233	2.591
	Junior high school	47.3	2.976	3.143	2.891	2.894
	Senior middle school	31.5	3.475	3.673	3.691	3.061
	University and above	6.3	3.379	3.564	3.495	3.078
<b>Age</b>	25 and below	8.6	3.281	3.485	3.561	2.797
	26–40	25.3	3.161	3.507	3.475	2.501
	41–60	36.8	3.287	3.695	3.177	2.989
	60 and above	29.3	3.203	3.415	3.169	3.025
<b>Household size(person)</b>	3 and below	21.4	3.196	3.219	3.335	3.034
	4–5	57.9	3.273	3.557	3.491	2.771
	6–8	13.1	3.187	3.269	3.227	2.765
	9 and more	7.6	3.276	3.305	3.272	3.251
<b>Household location</b>	Middle Mountain	19.4	3.076	3.383	3.566	2.279
	Low-lying land	37.9	3.091	3.678	3.598	2.297
	Valley	42.7	3.532	3.706	3.439	3.453

#### 4.4. Exploratory Factor Analysis

Principal component analysis is commonly used for exploring the influences of observed variables. Orthogonal rotation was applied to the data to explore the correlations between factors and extract common factors (Table 4). The results show that three variables (Ecological–Living–Productive space satisfaction) explain 62.17% of overall satisfaction with spaces in Huanjiang County. However, within some of the common factors, there were differences in the interpretation of the survey ratings. In order to further explore and test the reliability of the variables and measure the degree to which the observed variables explain the latent variables, we analyzed the combined validity of the survey. The test results are shown in Table 5. The combined reliability of the three-dimensional variables was greater than the reference standard of 0.50, which shows that the scale designed in this paper has relatively high convergent validity and discriminant validity.

#### 4.5. Modification of the Rural Households' Ecological–Living–Productive Space Satisfaction Model

An initial model of Ecological–Living–Productive space satisfaction was established through analysis of the data. Then, the maximum likelihood estimation algorithm was used to estimate and modify it. The parameters of the Ecological–Living–Productive space equation were obtained through repeated experimentation and verification. The SEM of overall satisfaction, the detailed parameter estimates, and the standardized path coefficients are shown in Figure 4. The  $\chi^2$  test value of the rural households' Ecological–Living–Productive space satisfaction model was 211.634. Combined with the degrees of freedom, the absolute fit index (137.354/69) was 1.991, which is within the specified range (1–3). The reduced index IFI (increasing fit index), relative fit index NFI (canonical fit index) and TLI (Tucker–Lewis index) were 0.976, 0.915, and 0.943, respectively, which are all greater than the reference standard of 0.9. The RMSEA (root-mean-square error of approximation) value was 0.074, which is less than the standard of 0.1. These findings indicate that the model generally fit the data well, indicating that it is reasonable to model the three latent variables in the household Ecological–Living–Productive space satisfaction model.

**Table 4.** Exploratory factor analysis of Ecological–Living–Productive spaces.

Latent Variable	Observation Variable	Standardized Coefficient Load	Error Variation	Composite Reliability	Average Variance Decimation (AVE)
Living space satisfaction	Road traffic	0.589	0.438	0.727	0.307
	Home comfort	0.358	0.361		
	Neighborhood relationships	0.750	0.476		
	Domestic water supply	0.502	0.298		
	Domestic sewage treatment	0.523	0.705		
	Ability to see a doctor	0.613	0.813		
	Market shopping convenience	0.702	0.472		
Production space satisfaction	Cultivated land quantity	0.654	0.317	0.699	0.287
	Cultivated land fertility	0.476	0.461		
	Cultivated land access	0.442	0.607		
	Agricultural facilities	0.532	0.578		
	Job opportunities	0.471	0.441		
	Irrigation water	0.564	0.392		
Ecological space satisfaction	Rocky desertification	0.711	0.439	0.621	0.364
	River water quality	0.433	0.573		
	Flood and waterlogging	0.391	0.641		
	Garbage disposal	0.535	0.324		
	Vegetation cover	0.626	0.517		

Table 5. Combined test of survey validity.

Observed Variables	Factor Loadings		
	Component 1	Component 2	Component 3
Road traffic	0.736	0.013	0.160
Home comfort	0.815	0.149	0.043
Neighborhood relationships	0.512	0.214	0.081
Domestic water supply	0.807	0.121	0.112
Domestic sewage treatment	0.778	0.235	0.217
Ability to see a doctor	0.449	0.042	0.141
Market shopping convenience	0.722	0.193	0.217
Cultivated land quantity	0.235	0.757	0.037
Cultivated land fertility	0.188	0.532	0.128
Cultivated land access	0.181	0.761	0.052
Agricultural facilities	0.073	0.811	0.034
Job opportunities	0.214	0.423	0.120
Irrigation water	0.369	0.797	0.201
Rocky desertification	0.216	0.078	0.765
River water quality	0.124	0.023	0.496
Flood and waterlogging	0.103	0.072	0.658
Garbage disposal	0.241	0.165	0.798
Vegetation cover	0.207	0.253	0.590
Eigenvalue	17.268	5.697	4.021
Variance (%)	39.452	13.761	8.957
Cumulative variance(%)	39.452	53.213	62.170

Extraction method: principal component analysis

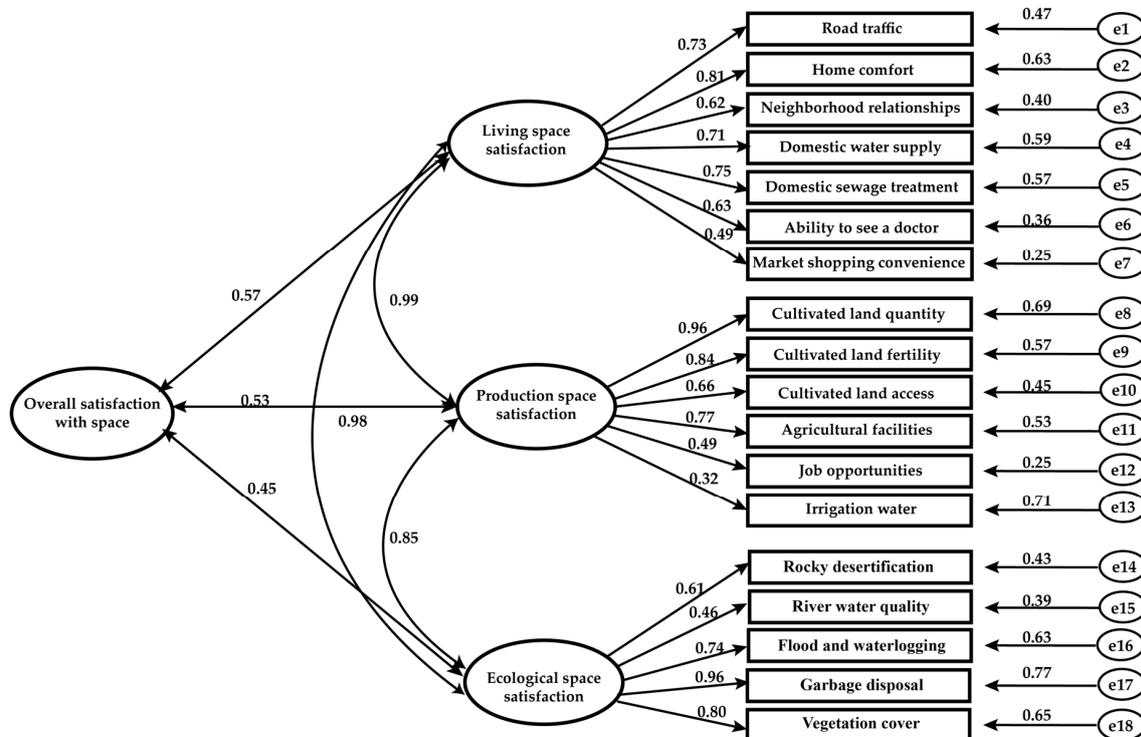


Figure 4. Estimated standardized path parameters of the Ecological-Living-Productive space satisfaction model.

## 5. Discussion

According to the overall modeling results (Figure 4), the basic hypothesis—that the three latent variables underlie household Ecological–Living–Productive space satisfaction—is upheld. The three latent variables can be ranked according to the values of their coefficients as follows: living space satisfaction > production space satisfaction > ecological space satisfaction. This shows that most people in the rural areas of Huanjiang County are gradually becoming wealthier. Incomes have increased and living standards have gradually improved. While residents in these areas previously focused on production issues, they are now becoming increasingly concerned with improving their quality of life. This is also consistent with Maslow’s demand-level theory. The findings as they relate to the observed variables and their three corresponding exogenous latent variables are described below.

### 5.1. House Comfort, Domestic Water Supply, and Domestic Sewage Treatment Significantly Affect Farmers’ Perceived Satisfaction with Their Living Space

The standardized path map of exogenous observed variables that affect living space satisfaction indicates that there are clear differences in their strength of effect. These can be ordered according to their coefficient values as house comfort > domestic water supply > domestic sewage treatment > road traffic > neighborhood relationships > ability to see a doctor > market shopping convenience, with corresponding values of 0.63, 0.59, 0.57, 0.47, 0.40, 0.36, and 0.25, respectively.

Among them, the exogenous observed variable with the highest coefficient value was comfort of the house, which relates to the residential area and housing conditions. This finding indicates that rural housing areas and housing conditions are the primary factors influencing farmers’ satisfaction with their living spaces. This is consistent with studies that have reported that the condition of the house has a significant impact on farmers’ rural housing satisfaction [55]. Huanjiang County has a large variation in per capita housing area ownership, and there is an uneven spatial distribution in housing space areas. In our survey, the largest households were 150 m<sup>2</sup> per capita, while the smallest households were only 37 m<sup>2</sup> per capita. Therefore, vast differences in housing conditions likely led to significant differences in farmers’ satisfaction with their living spaces.

The second strongest exogenous observed variable was domestic water supply. Similar to the results of Yang (2016), we found that reduced water resources in this karst area have had adverse effects on the lives of farmers [56]. Due to the influence of eroded landforms, surface precipitation in this area rapidly moves deep underground [57], which makes it difficult for farmers in the area to access water. The third strongest observed variable was domestic sewage treatment. Consistent with the results of Zhong (2009) [58], we found that the treatment of rural garbage and sewage is an important influence on farmers’ evaluations of their living spaces. In recent years, local townships and villages have developed extensively; however, sewerage treatment in this area has not kept up. For example, a survey of farmers from a village in Luoyang Township indicated that the entire river became fouled after the construction of a breeding farm in the upper reaches of the village. As a result, the whole village smelled bad in the summer. Although some rural areas have begun to set up centralized garbage collection and treatment stations, there are generally few installations and the rural population is generally less conscious of environmental protection, which makes it difficult for rural wastewater to be effectively treated. The results of this study indicate that the above three factors have a significant influence on the degree of perceived satisfaction that farmers have in relation to their living spaces.

### 5.2. Irrigation Water Conditions and the Quantity and Quality of Cultivated Land Significantly Affects Farmers’ Satisfaction with Production Spaces

The standardized path map of exogenous observed variables that affect farmers’ satisfaction with production spaces indicates that the observed variables can be ranked as follows: irrigation water > cultivated land quantity > agricultural land fertility > agricultural facilities > cultivated land

access > job opportunities; the corresponding coefficient values are 0.71, 0.69, 0.57, 0.53, 0.45, and 0.25, respectively.

The strongest exogenous observed variable was irrigation water. Our results are similar to those of Wu (2009), indicating that the limited irrigation water in karst rural areas is a primary factor affecting farmers' agricultural production [59]. Our investigation also found that although precipitation in Huanjiang County was sufficient, it primarily occurred from May to September, which is also the season with the most severe waterlogging. The uneven seasonal distribution of precipitation, combined with the shortcomings of the karst geological environment discussed above, cause seasonal water shortages in rural areas that impact farmers' agricultural production. The second strongest observed variable that affected satisfaction with production spaces was cultivated land quantity. A previous survey found spatial imbalance and substantial variation in per capita cultivated land in Huanjiang County. The lack of cultivated land resulted in a shortage of basic resources required for farmers' livelihoods, leading to dissatisfaction with their own agricultural production spaces. The third strongest observed variable affecting farmers' satisfaction with their production spaces was cultivated land fertility. Due to variation in the geographical location of farmers, the conditions on the land they own also vary [60]. The long-standing local system of land distribution has divided the land that is within the jurisdiction of the village to village farmers, with little cross-regional land distribution between villages. The village location, therefore, determines the quality of land resources available to farmers to a large extent. Compared with farmers living in low-lying land or the Middle Mountain region, farmers in valleys have more paddy fields and less dry land. Generally speaking, paddy fields are dominated by partial loam soil, while dry land is mainly dominated by clay and sandy soils. Loamy soil is highly fertile, followed by clay, with sandy soil exhibiting the poorest fertility [61]. Thus, paddy field farmers tend to exhibit the highest levels of satisfaction. It is clear that differences in cultivated land fertility have an important impact on farmers' perceptions of production spaces.

### *5.3. Garbage Disposal, Vegetation Cover, and Flood and Waterlogging Significantly Affect Farmers' Satisfaction with Ecological Spaces*

The standardized path coefficients for the exogenous observed variables affecting satisfaction with ecological spaces can be ranked as follows: garbage disposal > vegetation cover > flood and waterlogging > rocky desertification > river water quality, with corresponding coefficients of 0.77, 0.65, 0.63, 0.43, and 0.39, respectively. The strongest path coefficient was for garbage disposal. The status of garbage disposal around farmers has become an important factor impacting their local ecological spaces. China is currently implementing a policy of habitat management in rural areas throughout the country, and the government of the study area has allocated funds to construct several centralized garbage collection points. However, some farmers do not have a strong awareness of environmental protection which, coupled with a lack of publicity of centralized waste disposal sites by some village leaders, sometimes results in garbage being dumped elsewhere. In rural areas where garbage disposal systems are better, the satisfaction of farmers is very high. The second strongest path coefficient was for vegetation coverage. Farmers with better vegetation coverage had a higher degree of satisfaction with it. Generally speaking, most farmers were positive about recent improvements in vegetation coverage in their region. The third strongest influential factor was rocky desertification, which can cause serious damage to the ecological functioning of the land [62]. Rocky desertification in karst areas slows the recovery rate of soil formation, seriously affecting farmers' satisfaction with ecological spaces [63].

### *5.4. Household Education, Income, and Location Significantly Affect Farmers' Satisfaction with Ecological–Living–Productive Spaces*

In the results presented in Section 4.3, it was shown that farmers with higher levels of education had higher satisfaction with land spaces. This is in contrast to previous studies, where residents with higher education also had higher expectations of their living spaces, resulting in generally low satisfaction [64]. In our work, the more educated farmers in the areas we studied typically had more

opportunities and resources (e.g., money) to choose a superior space to live in, and so were typically more satisfied with their land spaces. This also corroborates the conclusion that farmers with higher income levels have higher satisfaction with the overall local spatial environment. Our field research found that farming households with higher income levels also, typically, had more abundant farmland resources or more nonfarm income channels and, therefore, had higher overall satisfaction with the local subsistence environment. Geographical location is a cause of farmer inequity. Our study area was in a karst mountain area and farmer locations were of three broad categories: middle mountains, low-lying land, and valleys. Farmers in the valley area had more high-quality land resources such as water fields than farmers in other locations. They also had better access to transportation, so they had more opportunity to access a better life, and their overall satisfaction with local land spaces was higher. Therefore, differences and imbalances in resource endowments are important factors contributing to differences in farmers' ratings of spatial satisfaction.

## 6. Conclusions and Implications

In this study, SEM was used to simulate and analyze data on the perceptions of farmers with respect to Ecological–Living–Productive spaces. The findings indicate that karst landforms, lack of irrigation water, and land quality and quantity issues are key factors affecting perceptions of production spaces. These problems may become more influential at certain times, especially during the dry season (from December to March). The current findings, together with the available literature, clearly indicate that rural production spaces have become a highly significant problem for farmers. This finding is supported by their low satisfaction with production spaces, which included the lowest scores in the study. Domestic water was one of the most significant factors affecting living space satisfaction. Farmers' living space and ecological space satisfaction were relatively high, which can be closely linked to the Chinese government's recent implementation of a rural construction and revitalization strategy. This also suggests that, in terms of the governance of rural space in karst areas, issues related to living spaces and ecological spaces are no longer the primary issues. An important question for the future is: How can we increase the quality of karst rural production spaces? Based on our results, we propose that spatial governance of rural karst areas be strengthened in relation to the following aspects.

(1) Strengthening of water management. Underground water leakage has always been a key factor causing water shortages in karst areas. Therefore, increasing water use and storage infrastructure would help deal with rural irrigation and domestic water use problems.

(2) Improvements in land quality and redistribution of cultivated land resources should become a focus of governance in karst areas. Land management in the karst mountains, especially in relation to the prevention of soil erosion, remains a difficult problem. Due to China's traditional land distribution system, the reallocation and balancing of land resources among farmers will become an important future direction for land consolidation in the karst mountains.

(3) Continuous improvement in garbage treatment in rural areas is important for increasing rural space quality in karst mountains. With the current promotion of China's garbage classification system, the treatment of rural garbage and sewage will become a new priority for rural space management.

(4) Finally, ways of relocating farmers, especially those living in the middle mountains and low-lying land to valleys, should be the focus of government policy so that poorly-endowed farmers get access to better resources. Actively improving farmers' skillsets so they can obtain nonagricultural income could also be an important policy direction.

This study had some shortcomings that affected the results. We did not incorporate the socioeconomic characteristics of farmers into our econometric analysis. Instead, we only used descriptive statistical analyses to illustrate the possible causes of different land space satisfaction evaluations among farmers with different socioeconomic attributes. Therefore, in future research, we will focus on the impacts of farmers' socioeconomic characteristics on land space satisfaction and their implications for land consolidation. We also need to further investigate the role of rural governance.

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