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Evolving Trends and Influencing Factors of the Rural Green Development Level in Chongqing

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Abstract: Rural green development is a concrete practice of rural revitalization. Currently, research on quantitative evaluation methods for rural green development levels are not well developed. In this study, an evaluation model of the rural green development level in Chongqing City, China was developed based on the parameters of ecology, living, and production. An entropy weight method, Theil index, optimal scale regression model, and GIS were used to analyze the spatio-temporal characteristics, trends, and influencing factors of the rural green development level from 2018 to 2020 in Chongqing City. The results showed that: (1) the overall "ecology, living, and production" dimensions and the comprehensive index of the development level in the city were generally increasing, and the proportion of counties at a high-level increased from 23.68% in 2018 to 81.58% in 2020; (2) the Theil index of the city in was 0.0185, 0.0121, and 0.0114 in 2018, 2019, and 2020 respectively, indicating that the differences in development level among regions decreased as the development level increased; (3) the level of rural green development showed a clear upwards trend, and the proportion of counties with low-speed growth, medium-speed growth, and high-speed growth from 2018 to 2020 was 5.26%, 81.58%, and 13.16%, respectively; and (4) the optimal scale regression analysis showed that the factors with greater impacts on the rural green development level are social security and employment expenditure level of government finance, health expenditure level of government finance, with their contributions is 40.3% and 26%, respectively. The results from this study demonstrate the significance of exploring research methods for rural green development and ways to improve the level of rural green development.

Keywords: Chongqing; green development; Theil index; optimal scale regression analysis; GIS

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1. Introduction

The economic and social development of rural areas is as important as environmental protection, and it is crucial to coordinate the relationship between ecology, living, and production to achieve high-quality green development and promote the transition from disconnected to orderly rural development [1]. In 2018, the Chinese government released the National Rural Revitalization Strategic Plan (2018–2022), which requires achieving ecological beauty with clear mountains and clean water, moderate and comfortable living, and intensive and efficient production. Its core concept is to lead rural revitalization through the prioritization of green development in rural areas [2,3]. Currently, research on green development in rural areas mainly focuses on areas such as rural revitalization, beautification of countryside, green development, and rural tourism [4,5]. The key research directions include: (1) Exploration of the path and mode of rural green development—this makes up the highest proportion of the research and mainly identifies problems with regional green development at the macro level. It proposes to promote industrial green development in aspects such as clean production, environmental protection, and economic promotion, and explores how to achieve green development from the perspective of policy optimization and management decision-making [2,6]. (2) Study of the distribution patterns and influencing factors of green development at the macro level—this type of research rarely focuses on rural areas. Instead, it uses panel data, geospatial regression models, and other methods to explore the dynamic evolution laws of the spatio-temporal dimensions of regions, mainly in aspects such as economic development and industrial structures [7]. (3) Comprehensive evaluation of green development at the macro level. As a research hotspot in the field of green development, various evaluation methods such as green GDP, green development efficiency, and the human green development index have been established, focusing on the green level of economic development at the macro level [8]. Internationally, scholars pay more attention to urban green development, green economy, green industrial development, and other aspects [9–12]. The current research on green development mainly focuses on the national and regional levels. For example, Bilgaev comprehensively evaluated the impact of socio-economic factors on the green economic development of the Republic of Briat (Russia) by constructing composite indicators, and believes that the environmental status has the greatest impact [6]. Wang used a system dynamics model to analyze the impact of policies in the Tibetan areas of Sichuan on green development, believing that population and investment policies have a significant impact [2].

Overall, researchers have conducted a series of studies on green development at the global, national, provincial, and regional levels, forming clear research methods and paths [13,14]. However, research in the field of green development in rural areas mostly focuses on exploring and discussing the path and mode of achieving rural green development, lacking suitable quantitative evaluation methods for the green development levels of rural areas [15]. There is also insufficient research on spatiotemporal evolution laws and influencing factors of green development levels in rural areas, resulting in a lack of data and reference materials in line with the concept of rural green development during the implementation of the rural revitalization strategy. Rural areas are an important environment for human life, and the current proportion of rural areas in China is over 90%. The contradiction between "production–living–ecological space" in rural areas is significant, and there are many research results on the relationship between them. Zhao et al. conducted a functional balance study on the "production–living–ecological space" in rural areas [16]. Based on the perspective of "production–living–ecological", Liang et al. analyzed the impact of land use on landscape ecology risk in the Three Gorges Reservoir Area [17]. Liang et al. conducted a study on potential land use conflicts in the Chongqing region from the perspective of "production–living–ecological"[18]. These studies all believe that there are significant contradictions in the "production–living–ecological", and it is necessary to balance the relationship between them. Therefore, the green and sustainable development of rural areas is very important for the economic sustainability of the entire country, and is also an important foundation for China's rural revitalization strategy. Currently, scholars focus on national, provincial, or regional green development assessments and pay less attention to rural areas. Conducting green development assessments in rural areas can effectively compensate for the shortcomings. The purpose of rural green development is to improve the ecological environment quality, living standards, and reduce the amount of pollutants generated and resources consumed in rural areas. Therefore, rural green development is the only way for China to achieve rural revitalization strategy.

As a significant ecological barrier in the upper reaches of the Yangtze River, Chongqing attaches great importance to promoting rural green development in the region. In recent years, with the implementation of pollution control, beautification of countryside construction, the creation of eco-friendly residential areas, the rural revitalization strategy, and other work, the ecological and environmental quality of the region has significantly improved, with an overall surface water quality rating of excellent in 2021 and with 326 days of good air quality [19]. However, as a typical mountainous area, Chongqing still faces multiple complex, rural issues, such as environmental pollution, uneven development, and resource waste, as the green development model is yet to be fully formed. At the same time, it is still unclear about the changes in the level of green development in rural areas of Chongqing after the implementation of the 2018 rural revitalization strategic plan. Therefore, compared to previous studies, we have conducted a more comprehensive evaluation model for the level of green development in rural areas from the three dimensions of "ecology, life, and production". In this study, 38 districts and counties in Chongqing Municipality were selected as the research area. Geographic and statistical methods, such as an entropy weighting method, Theil index, spatial clustering analysis, and regression model, were used to analyze the spatiotemporal characteristics and developing trends of rural green development in Chongqing from 2018 to 2020. We identified the contributions of different influencing factors to the level of rural green development, including urbanization level, aging level, contribution level of total assets, education expenditure level of government finance, health expenditure level of government finance, social security and employment expenditure level of government finance, etc. The results of this study provide a reference for promoting and achieving rural revitalization under the guidance of rural green development in Chongqing Municipality.

2. Materials and Methods

2.1. Study Area

In total, 38 districts and counties in Chongqing were selected in this study, among which Yuzhong was not included because there is no rural area available, and Wansheng Economic Development Zone was treated as a separate district (it is directly managed by the Chongqing government and does not have spatial conflicts with other districts). For convenience of description, the study areas were divided into "one area and two groups (the main urban area, southeast area, and northeast area)". The main urban area includes 21 districts and counties (i.e., Changshou, Fuling, Nanchuan, and all districts and counties located to the west of Nanchuan), the southeast area includes 6 districts and counties (i.e., Wulong, Pengshui, Shizhu and all areas located to the south of Shizhu), and the northeast area includes 11 districts and counties (i.e., Dianjiang, Fengdu, Zhong, Liangping, Wanzhou, and areas located to the north of Wanzhou) [20]. In 2021, the GDP of Chongqing was CNY 2.789 trillion, an increase of 8.3% from the previous year. The rural population was 9.533 million, accounting for 29.68% of the total population, and the per capita disposable income of rural residents was CNY 18,100, an increase of 10.6%. The energy consumption per CNY 10,000 GDP decreased by 3.5% compared to the previous year. The environmental air quality is good, with an average concentration of $PM_{2.5}$ at 35 $\mu g/m^3$. The water quality is relatively good, with 95.9% of the sections having class I–III water quality, and the centralized drinking water sources meet the national standard. However, due to complex terrain and uneven distribution of resources in Chongqing, there are significant differences in the level of rural development in different regions. The main urban area has a higher level of economic development due to its transportation and geographical advantages, while some districts and counties in the southeast and northeast areas are not as developed.

2.2. Data Sources

The data were obtained from Chongqing Statistical Yearbook (http://tjj.cq.gov.cn/, accessed on 7 November 2022), Water Resources Bulletin (http://slj.cq.gov.cn/, accessed on 27 November 2022), Soil and Water Conservation Bulletin (http://slj.cq.gov.cn/, accessed on 30 November 2022), Ecological Environment Status Bulletin (http://sthjj.cq.gov.cn/, accessed on 18 November 2022), and various districts and counties' National Economic and Social Development Statistics Bulletin (the website of each district and county government).

2.3. Methods

2.3.1. Construction of the Evaluation Model for Rural Green Development Level

The steps to develop the evaluation model for the green development level in rural areas of Chongqing include initial and secondary selection of indicators, determination of indicator weights, and model construction.

1. Index Selection and Screening

Relevant literature and data on rural green development research at home and abroad are consulted extensively to ensure completeness and comprehensiveness as much as possible. The ecology dimension generally focuses on the conditions of water, atmosphere, soil, and ecology, the living dimension generally focuses on the conditions of medical, educational, economic, and transportation, and the production dimension generally focuses on the conditions of production efficiency and material consumption. Yang et al. mainly considered factors such as rural per capita income, transportation network, and agricultural output value in their research on rural vitality [3]. Maja et al. constructed a smart rural assessment method from aspects such as housing, environmental change, education, culture, and water resources [21]. However, rural areas are highly integrated areas of ecological, living, and production space. Constructing evaluation methods from these three perspectives can comprehensively identify the level of green development in rural areas. For example, Kong et al. constructed a comprehensive evaluation model for village protection based on the three dimensions of "production, life, and ecology" [22]. Nie et al. conducted research on spatial reconstruction and evaluation of driving factors in tourism rural areas from three dimensions: production, life, and ecology [23]. Therefore, an evaluation model for the rural green development level in the southwestern mountainous area is constructed, which includes ecological, living, and production dimensions. The index selection mainly uses theoretical analysis methods to comprehensively sort out the indicators in the "ecological, living, and production" aspects. The index screening is based on the initial selection and involves screening necessary indicators through expert questionnaire surveys.

Initially, 39 indicators were selected around the 3 dimensions of ecology, living, and production (Table A1). After obtaining advice from experts, the indicators were optimized to 23. The initial 39 indicators, as well as the 23 indicators formed after expert consultation, are listed in the Appendix A. These 23 indicators were synthesized into 12 comprehensive indices through index synthesis, with each dimension involving 4 indices. The ecological dimension includes water, air, soil, and ecology. The living dimension includes medical care, education, consumption, and transportation. The production dimension includes overall efficiency, economic energy consumption, economic water consumption, and agricultural material consumption. The specific indicators and their meanings are shown in Tables 1 and 2.

Table 1. Meaning and weight of the "ecological, living, and production" dimension.

Primary Index	Explanation	Properties	Weight
Ecological Dimension	Water, air, soil, ecology and other ecological dimensions supporting the ability for rural green development.	Positive	0.30
Living Dimension	Medical, education, consumption, transportation, and other living dimensions supporting the ability for rural green development.	Positive	0.35
Production Dimension	Energy consumption, material consumption, human consumption, water consumption, and other production dimensions supporting the ability for rural green development.	Positive	0.35

Table 2. Meaning and weight of evaluation indicators for rural green development level.

Primary Index	Order Number	Secondary Index	Explanation	Calculation	Properties	Weight
Ecological Dimension	1	Water resource carrying index	Reflects the water resource status, production water capacity, and the ability to resist the risk of water pollution based on natural conditions and meteorological conditions.	Calculated by (1) the production water coefficient and (2) the production water modulus	Positive	0.285
	2	Air comfort index	Reflects the air quality status and the ability to resist the risk of atmospheric pollution.	(3) Comprehensive environmental air quality index	Negative	0.225
	3	Soil disturbance index	Reflects the status of surface soil resources and the ability to resist the risk of soil erosion and pollution caused by it.	(4) Soil erosion area ratio	Negative	0.265
	4	Green coverage index	Reflects the forest resource reserve status, ecological resource quality, and the ability to resist ecological destruction risks.	(5) Forest coverage rate	Positive	0.225
Living Dimension	5	Medical development index	Reflects the degree of health care resources and the ability to resist health risks in residents.	Calculated by (6) the permanent population and (7) the number of hospital beds	Positive	0.26
	6	Educational development index	Reflects the degree of compulsory education resources and the level of the teachers' qualifications.	Calculated by (8) the number of students in ordinary middle schools, (9) the number of students in primary schools, (10) the number of teachers in ordinary middle schools and (11) the number of teachers in primary schools.	Positive	0.26
	7	Consumption capacity index	Reflects the economic status of residents, their economic level, and consumption capacity.	Calculated by (12) per capita GDP and (13) per capita disposable income of rural residents	Positive	0.29
	8	Transportation convenience index	Reflects the level of convenience of residents' transportation and travel.	Calculated by (14) the length of highways and (15) the area of the region	Positive	0.19
Production Dimension	9	Overall efficiency Index	Reflects labor productivity and the level of economic growth dependence on human resources.	Measured by (16) the overall labor productivity.	Positive	0.20
	10	Economic energy consumption index	Reflects the energy consumption of the economy and the dependence of the economy on energy.	Calculated by (17) the output value of the secondary industry and (18) energy consumption of industrial enterprises with annual revenue over a certain amount.	Negative	0.215
	11	Economic water consumption index	Reflects the water consumption status of economic and agricultural activities and the dependence of economic and agricultural development on water resources.	Calculated by (19) the water consumption per CNY 10,000 of GDP and (20) the Effective utilization coefficient of irrigation water in farmland.	Negative	0.27
	12	Agricultural material consumption index	Reflects the intensity of input of fertilizers and pesticide pollutants and the dependence of agricultural development on fertilizers and pesticides.	Calculated by (21) the sown area of crops, (22) the amount of fertilizer applied, and (23) the amount of pesticides used.	Negative	0.315

2. Determination of Index Weights

To ensure the scientific validity of the index weights involved in the evaluation of rural green development levels, this study uses a combination of subjective and objective methods to determine the index weights, employing expert scoring [24] and entropy weighting methods [25]. Finally, the weights of all indicators are determined through a comprehensive weighting method (as shown in Tables 1 and 2). The entropy weighting method is an objective weighting method that can effectively avoid the bias of subjective human factors in assigning index weights [26]. The specific calculation steps are as follows: (i) calculate the proportion of the kth sample under the rth index (PP_{kr}, using Formula (1)); (ii) calculate the entropy value of the rth index (e_r, using Formula (2)); (iii) calculate the redundancy of information entropy and the weight of each index (Q_r, using Formula (3)). Here, x_{kr} represents the value of the kth sample under the rth index.

$$PP_{kr} = x_{kr}/\sum_{k=1}^{n} x_{kr}, k = 1, \ldots, n, r = 1, \ldots, m \tag{1}$$

$$e_r = -(1/\ln(n))\sum_{k=1}^{n} PP_{kr}\ln(PP_{kr}), r = 1, \ldots, m \tag{2}$$

$$Q_r = (1 - e_r)/\sum_{r=1}^{m}(1 - e_r) \tag{3}$$

3. Model Construction for Evaluating Rural Green Development

Since the level of green development in rural areas should reflect developmental aspects, it is crucial to consider the development status of the region. Thus, to incorporate both the current level and the inter-annual changes of regional indicators (i.e., trends), a combined approach is employed to construct a model for evaluating the level of rural green development and to reflect the resource status of various indicators in the region.

$$E_{it} = Q_W \times W_{it} + Q_A \times A_{it} + Q_S \times S_{it} + Q_G \times G_{it} \tag{4}$$

$$L_{it} = Q_M \times M_{it} + Q_{Edu} \times Edu_{it} + Q_C \times C_{it} + Q_R \times R_{it} \tag{5}$$

$$P_{it} = Q_{Eec} \times Eec_{it} + Q_{Cec} \times Cec_{it} + Q_{Mc} \times Mc_{it} + Q_{Wc} \times Wc_{it} \tag{6}$$

$$RGD_{it} = Q_E \times E_{it} + Q_L \times L_{it} + Q_P \times P_{it} \tag{7}$$

$$RGDL_i = GD_{i,t} - GD_{i,t-1} \tag{8}$$

where, i is the region, t is the year, E_{it}, L_{it}, and P_{it} are the ecological dimension index, living dimension index, and production dimension index of region i in year t, respectively. Q is the weight of the corresponding index. W, A, S, G, M, Edu, C, R, Mc, Eec, Wc, and Cec are the water resource carrying index, air comfort index, surface disturbance index, green coverage index, medical development index, education development index, consumption capacity index, transportation convenience index, overall efficiency index, economic energy consumption index, economic water consumption index, and agricultural material consumption index, respectively. RGD_{it} is the comprehensive index of rural green development level in region i in year t, and $RGDL_i$ is the change index of rural green development level in region i from previous year to year t. The comprehensive index of rural green development level is divided into four levels: low level, relatively low level, relatively high level, and high level, using the natural breakpoint method of ArcGIS software. The trend of rural green development level change is divided into four levels: level degradation, level slow growth, level moderate growth, and level high-speed growth according to <0, [0,0.01 N), [0.01 N,0.05 N), and ≥0.05 N, where N is the number of years between intervals.

2.3.2. Theil Index

The Theil index can measure the differences in regional development using entropy from information theory. It can measure overall differences, differences within regions, and differences between regions [27,28].

$$T_{theil} = \sum \frac{Y_i}{Y} \times \ln \frac{(Y_i/Y)}{(X_i/X)} \tag{9}$$

$$T_{inter\text{-}theil} = \sum \frac{Y_z}{Y} \times \ln \frac{(Y_z/Y)}{(X_z/X)} \tag{10}$$

$$T_{in\text{-}theil} = \sum \frac{Y_i}{Y} \times \ln \frac{(Y_i/Y_z)}{(X_i/X_z)} \tag{11}$$

T_{theil} is the overall difference among regions, Y_i is the composite index of rural green development level of the ith county, Y is the total number of counties (i = 1, 2, 3 ... n), X_i is the number of counties included in the ith region, and X represents the total number of counties. $T_{inter\text{-}theil}$ and $T_{in\text{-}theil}$ are the differences between and within regions, respectively. Y_z is the total composite index of rural green development level in the zth area (three areas were divided in this study, including the main urban area, northeast urban area, and southeast urban area), and X_z is the number of counties included in the zth area.

2.3.3. Optimal Scale Regression Method

The optimal scaling regression model is an extension of the standard linear regression model. The basic idea is to use the principle of optimization to iteratively assign the best quantified value to each influencing factor based on analyzing the strength of the impact of the influencing factors on the dependent variable and obtain the best regression equation [29]. Its advantage is that it can obtain the importance coefficient and visually display the degree of influence of each independent variable on the dependent variable. In this study, the comprehensive index of a rural green development level is taken as the dependent variable, and 6 indices such as the urbanization level, aging level, contribution level of total assets, education expenditure level of government finance, health expenditure level of government finance, social security and employment expenditure level of government finance. The optimal scaling regression analysis tool is selected in SPSS for calculation.

3. Results

3.1. Rural Green Development on Ecology, Living, and Production

The results of green development on ecology, living, and production dimensions are shown in Figure 1, where clear upward trends were found for all dimensions. In the ecological dimension, a clear "low in the west, high in the east" feature is evident. Except for Hechuan, Yubei, Jiangbei, and Dadukou, which maintained a low level during the 2018–2020 period, other districts and counties had different degrees of improvement. In 2020, the proportion of districts and counties with high, relatively high, relatively low, and low levels were 26.31%, 34.21%, 28.95%, and 10.53%, respectively. Regarding the living dimension, a clear "low in the central area, high in the north and south" feature is observed. During the 2018–2020 period, Nanan, Kaizhou, Chengkou, Wuxi, and Youyang consistently maintained a low level. Jiangbei, Changshou, and Wansheng Economic Development Zone consistently maintained a high level. The level of districts and counties such as Shizhu and Yunyang fluctuated. In 2020, the proportion of districts and counties with high, relatively high, relatively low, and low levels were 10.53%, 39.47%, 36.84%, and 13.16%, respectively. As for the production dimension, it shows a clear "dispersed distribution" feature. During the 2018–2020 period, Shizhu, Wansheng Economic Development Zone, Jiangjin, and Yongchuan consistently maintained a low level. Yubei and Bishan consistently maintained a high level. The level of counties and districts such as Chengkou, Wushan, and Qianjiang fluctuated. In 2020, the proportion of districts and counties with high, relatively high, relatively low, and low levels were 28.95%, 31.58%, 28.95%, and 10.52%, respectively.

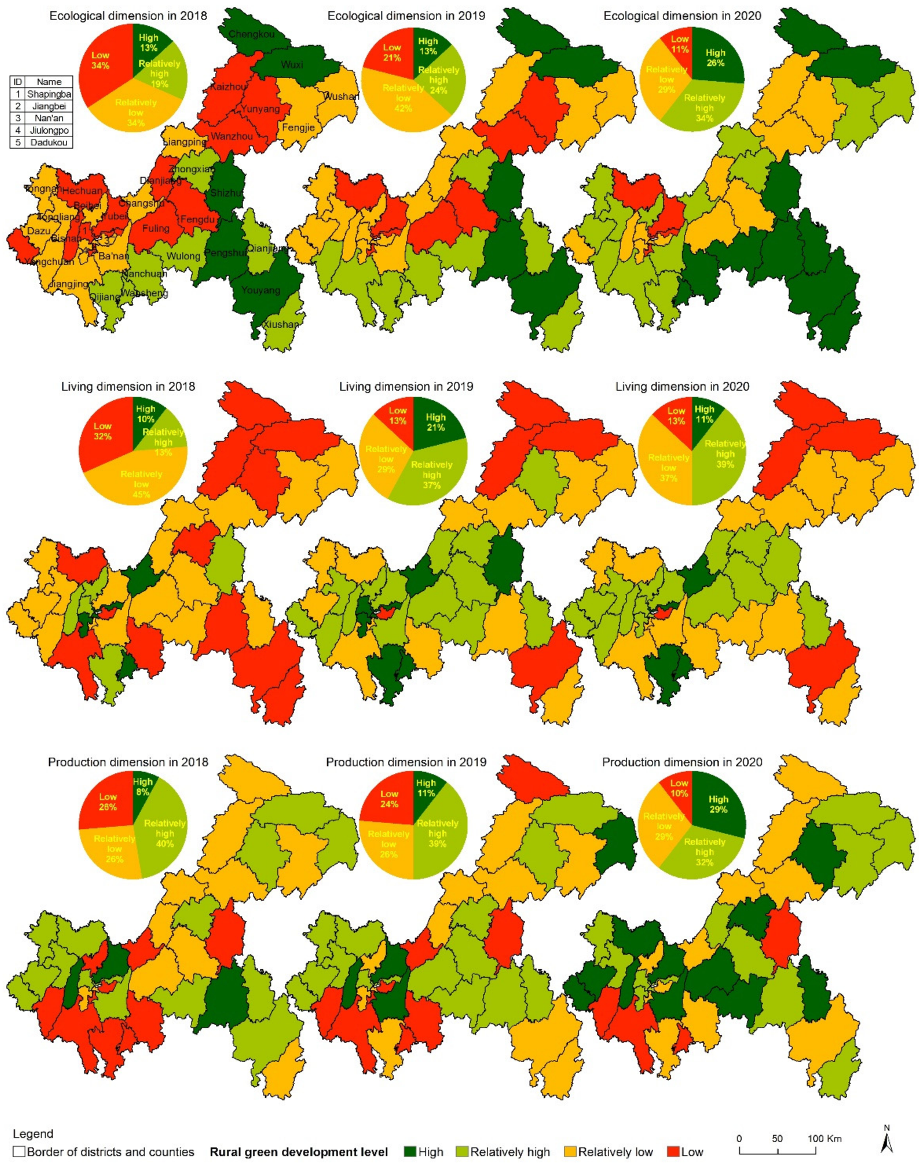

Figure 1. The distribution of the development level on ecology, living, and production dimensions in Chongqing from 2018 to 2020.

3.2. Comprehensive Index of Rural Green Development

3.2.1. Temporal and Spatial Evolution of Various Districts and Counties

The comprehensive index of the rural green development level shows a clear, overall, upwards trend (Figure 2). The proportion of districts and counties with high, relatively high, relatively low, and low levels were 5.26%→21.05%→47.37%, 18.42%→34.21%→34.21%, 39.48%→31.58%→10.53%, and 36.84%→13.16%→7.89% in 2018, 2019, and 2020, respectively. In 2018, only Pengshui and Qianjiang were in the high-level category. In 2019, Wulong, Shizhu, Zhong, Wansheng, Jiulongpo, and Bishan were added to the high-level category. In 2020, there were 18 districts and counties in the high-level category, including Qijiang. During 2018 and 2020, Dadukou, Nanan, and Kaizhou were all at low levels. The low levels in Dadukou and Nanan were mainly related to low green coverage, medical development, and agricultural consumption index, while the low level in Kaizhou was because of the low land surface disturbance and living dimension level. This indicated that a high economic level was not necessarily correlated with a high level of rural green development.

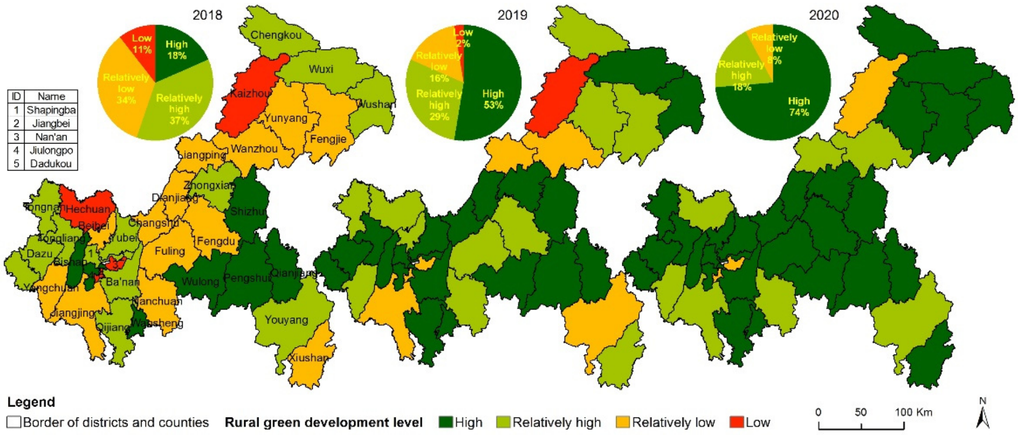

Figure 2. Distribution of rural green development level in Chongqing from 2018 to 2020.

3.2.2. Regional Disparity Evolution

The results of the Theil index (Figure 3) showed that the Theil index of Chongqing City in 2018, 2019, and 2020 was 0.0185, 0.0121, and 0.0114, respectively, indicating a downward trend year by year. This suggests that the regional differences in the green development level of rural areas at the city level are narrowing, which is closely related to the promotion of the rural revitalization strategy, ecological civilization, and the beautification of rural construction work. The results of regional differences showed a trend of decreasing differences followed by an increase in the city level between 2018 and 2020 (0.0069, 0.0033, and 0.0041, respectively). The results of intra-regional differences showed that both the city and each region were showing a trend of gradually decreasing in differences. The Theil coefficients of intra-regional differences in the city in 2018, 2019, and 2020 were 0.0116, 0.0088, and 0.0073, respectively. Overall, the Theil coefficient in the main urban area was higher, indicating that the difference within the region is the largest. This is related to factors such as uneven economic development, large differences in ecological background, and differences in agricultural production intensity. Secondly, in the northeast urban agglomeration of Chongqing, the southern region of Liangping District, Dianjiang, and other areas are mainly agricultural, while the northern region of Chengkou, Wuxi, Wushan, and other areas belong to regions with abundant forest resources. This is an important factor leading to large differences within the region. The intra-regional differences in the southeast urban agglomeration of Chongqing are the smallest, mainly because the ecological background and economic development of each district and county within the region are relatively similar. They are all in the Wuling Mountain area, and except for Qianjiang District, the economic level differences among other districts and counties are relatively small.

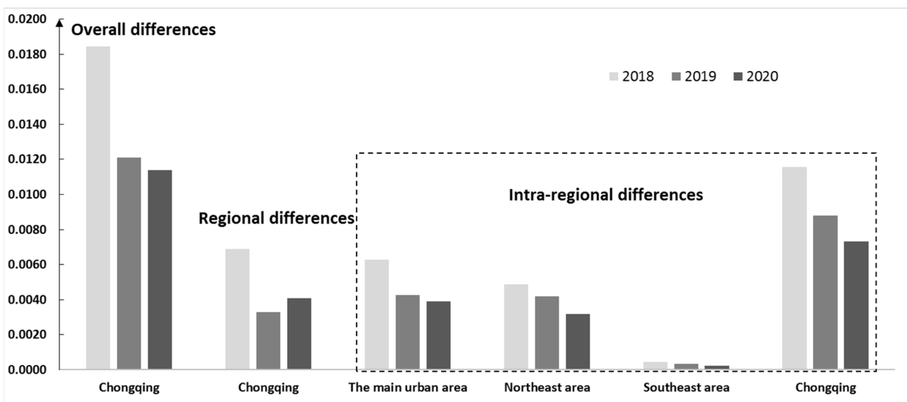

Figure 3. Evolution of differences in the rural green development levels.

3.3. Trends of Rural Green Development

The trends of rural green development in each district and county of Chongqing City are shown in Figure 4. An overall increasing trend was found in the studied areas. During 2018 to 2019, only Chengkou and Youyang experienced a decrease in the development level. A decrease in production dimension level was the main reason for the overall decrease in Chengkou, while decreases in ecological dimension and living dimension levels could explain the decrease in Youyang County. High-speed growth development was observed in 11 districts and counties including Hechuan, Changshou, etc., low-speed growth was observed in only Kaizhou, and medium-speed was observed in 24 districts/counties including Banan, Fuling, etc. During 2019 and 2020, decreased development level was only found in Shizhu, Shapingba, and Jiulongpo, which was caused by the decrease of living dimension levels in Shizhu, the decrease in ecological dimension and severe decrease in living dimension level in Jiulongpo, and the decrease in living dimension level in Shapingba. During 2018 and 2020, the city was on an upward trend of development level, with the proportions of low-speed growth, medium-speed growth, and high-speed growth districts and counties of 5.26%, 81.58%, and 13.16%, respectively. The low-speed growths in Shizhu and Jiulongpo were both due to the fall back after a significant increase during 2018 to 2019.

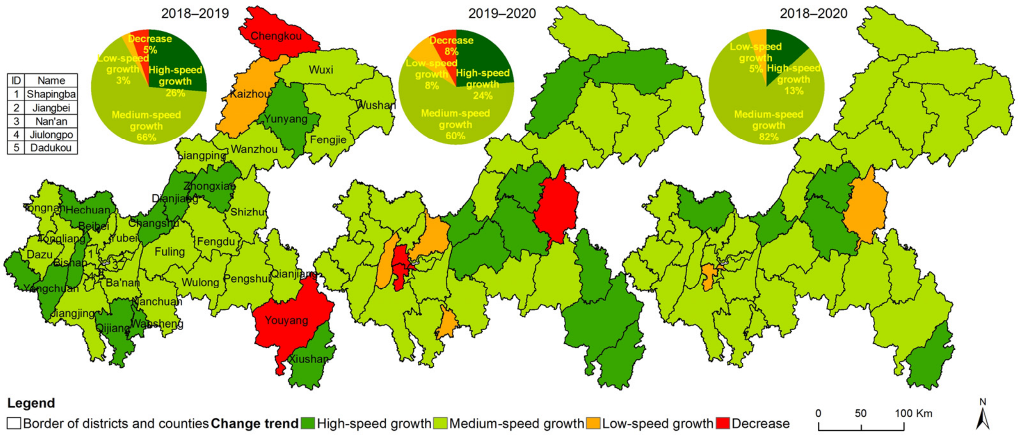

Figure 4. Distribution of the change trend of rural green development level in Chongqing.

Factor Analysis of Rural Green Development

We have calculated the level of green development in rural areas as mentioned above, but the level of green development is not only influenced by indicators related to "production–living–ecological", but also by urban development, aging, asset status, and government regulation. Therefore, further in-depth research is needed for the factors that affect the level of rural green development, which has a reference value for the government to formulate rural green development policies. We select urbanization level, aging level, contribution level of total assets, education expenditure level of government finance, health expenditure level of government finance, social security and employment expenditure level of government finance as influencing factor indicators.

The optimal scale regression model was used to assess the factors affecting rural green development. The R^2 of the model was 0.183, and the p value was <0.01, which also passed the F test, indicating the statistical significance of the model. As shown in Table 3, most indexes passed the significant test at the 1% level, with the exception of the urbanization level and aging level. Tolerance, defined as the proportion of the impact of the factor on rural green development that cannot be explained by other factors, reflected the collinearity between factors (the higher the better). The results of the tolerance indicated that the tolerance of the education expenditure level of government finance were relatively low. However, the overall tolerance was acceptable, indicating that the collinearity situation was limited, and the optimal scale regression effect was great.

Table 3. Optimal scale regression analysis of the influencing factors of rural green development.

Variable	p-Value	Importance Coefficient	Tolerance
Urbanization level	0.272	−0.034	0.494
Aging level	0.190	0.122	0.534
Contribution level of total assets	0.003	0.161	0.911
Education expenditure level of government finance	0.007	0.088	0.709
Health expenditure level of government finance	0.002	0.260	0.589
Social security and employment expenditure level of government finance	0.008	0.403	0.939

The importance coefficient results showed that the factors affecting rural green development were, from the most to least important, social security and employment expenditure level of government finance > health expenditure level of government finance > contribution level of total assets > education expenditure level of government finance. This indicated that social security and employment expenditure level of government finance and health expenditure level of government finance had the greatest impact on rural green development, with their contributions being 40.3% and 26%, respectively.

4. Discussion

4.1. Construction of an Evaluation Model for Rural Green Development Level Should Be in Line with Regional Reality Characteristics

Compared with existing research, the construction of an evaluation model for rural green development level incorporates aspects such as regional ecological environment, living standards, and production structure into the evaluation index system, which is more in line with the practical characteristics of rural areas in Chongqing. We have also fully incorporated reasonable indicators that have been used by scholars in non-rural areas. For example, Han considered economic, social, and environmental indicators in the assessment of green development level in the ASEAN region [30]. Jiang used indicators such as energy consumption per unit of GDP and pollution status in the study of green development level in the Shandong Peninsula urban agglomeration [31]. Wang used indicators such as environmental pollution and ecological space in the comprehensive evaluation of green development in the Dongliao River Basin [32]. Yue used indicators such as personnel efficiency, economy, and environmental impact in the evaluation of green development efficiency in resource-based cities in the Yellow River Basin [33]. Therefore, the rural green development level assessment model proposed in this study was based on the summary of existing research results, constructing an evaluation model from the ecological dimension, living dimension, and production dimension, and combining statistical and geographical methods to conduct temporal and spatial feature analysis, trend analysis, and influencing factor analysis for development levels. This model could have great academic and practical application value for the construction of rural green development research methods and the improvement of the rural green development level in Chongqing City. However, in order to make the model more universally applicable, more geographical and spatial data should be incorporated to optimize the model.

4.2. Rural Development Should Pay Attention to Balancing the Relationship between Ecology, Life, and Production

To analyze the differences in rural green development among different districts, counties, or regions, we introduced the Thiel index and achieved good results. We have found that there is a certain imbalance in the relationship between ecological protection, people's lives, and economic development in various districts, counties, or regions. For example, Dadukou and Nanan belonged to areas with high economic levels, but the green coverage index, medical development index, and agricultural material consumption index in the region were relatively low. At the same time, we believe that environmental quality, education level, and economic energy consumption are the key factors that affect the level of rural green development. This is consistent with Cui's research on green development in cities along the Yangtze River Economic Belt, which believes that economy and environment are key factors [34]. Han's research in the ASEAN region also believes that slow economic growth and environmental protection pressures have a significant impact on the level of green development [30]. Xue found in his research on green development in Belt and Road that Europe has the highest level of green development in terms of balanced natural, economic, and social dimensions, while Africa has the lowest level of green development due to imbalanced development [35]. Currently, China is accelerating the construction of a beautiful country, and Chongqing City, as a mountainous city in the western region, has a more complex internal situation.

4.3. Pandemic Infectious Diseases Such as COVID-19 Have Little Impact on Rural Green Level

The outbreak of COVID-19 in 2020 has had a negative impact on the global and Chinese economy. We expect it to have a certain impact on economic indicators in rural green development, such as the consumption capacity index, overall efficiency index, and economic energy consumption index. We analyzed the research results and found that the proportion of areas where the consumption capacity index and overall efficiency index decreased in 2020 was 15.79% and 18.42%, respectively. However, the proportion of areas where the economic energy consumption index increased was as high as 78.95%. This may be related to the prevention and control policies of COVID-19 implemented by China. The economic energy consumption index is mainly controlled by the economy of urban areas, and the other two indexes are mainly controlled by the economy of rural areas. In general, the population density of cities is high, the prevention and control policy of COVID-19 is very strict, and many enterprises and stores have been closed for a long time, so its economic impact on urban areas is greater than that on rural areas. This is consistent with the research results conducted by Janssens et al. in rural areas of Kenya. They believe that although the work income of people in rural areas is reduced due to COVID-19, gifts and borrowing are also reduced, and household consumption such as food expenditure is still at the level before the COVID-19 outbreak [36]. Zhao and Rasoulinezhad found that COVID-19 poses a serious challenge to economic poverty in different regions of Asia, but has little impact on poverty in larger or developed economies [37]. This is consistent with the actual situation in China, where due to strong government regulation, significant achievements have been made in poverty alleviation in rural areas. Therefore, pandemic infectious diseases such as COVID-19 will affect some indicators of rural green development, but will not affect the overall level of rural green development.

4.4. Suggestions and Prospects

From this study, the overall level of green development in rural areas in the city was good, but attention should be paid to the following aspects: (1) during the development process, the balance between ecological protection, people's living, and economic development should be emphasized. (2) The reasons for the degradation phenomenon that appeared during the development process in some districts and counties should be further analyzed for continuous improvement. For example, the living dimension level in Shizhu and the ecological dimension level in Jiulongpo both declined during the period of 2019–2020. (3) The green development of different rural areas in the city should stabilize the advantages in other aspects while highlighting their local advantages. For example, the ecological advantages of the Yudongnan urban agglomeration and the Yudongbei urban agglomeration were obvious and should be further strengthened in terms of improving the living and production dimensions.

Although we have proposed evaluation indicators and methods for rural green development, further research is needed on the grading standards for each indicator in the future, such as determining the grading values of high, correlated high, correlated low, and low levels for different indicators. Meanwhile, due to data limitations in the Yearbook and Bulletin, we have only evaluated the evolution trend of rural green development level from 2018 to 2020. In the future, we will conduct long-term series research to more clearly identify the evolution laws and trends of rural green development level. We will also evaluate the impact of the implementation of major national strategies over a longer period of time.

5. Conclusions

This study constructed a model for evaluating the level of rural green development in a region based on ecological, living, and production dimensions, with Chongqing as the research area. The spatiotemporal characteristics, trends, and influencing factors of the rural green development level in the region from 2018 to 2020 were analyzed using an entropy weight method, Theil index, optimal scale regression model, and GIS method. The following conclusions were drawn:

1. The overall trend of the ecological dimension, living dimension, production dimension, and comprehensive result of the rural green development level in the city shows continuous improvement. Based on the comprehensive index, the proportion of counties with high-level and relatively high-level grades has increased from 5.26% and 18.42% to 47.37% and 34.21%, respectively, from 2018 to 2020;
2. The Theil index results showed that the difference in the rural green development level among counties in the city has decreased with the improvement of the development level. The Theil index in the city was 0.0185, 0.0121, and 0.0114 in 2018, 2019, and 2020, respectively;
3. The trend in rural green development level change showed an overall upwards trend in the city. All counties showed an upwards trend from 2018 to 2020, with the proportion of counties with slow growth, medium growth, and high growth being 5.26%, 81.58%, and 13.16%, respectively;
4. The results of the optimal scale regression model showed that the factors that had the greatest impact on the rural green development level are social security and employment expenditure level of government finance and health expenditure level of government finance, with their contributions being 40.3% and 26%, respectively.

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Appendix A

Table A1. The meaning of 39 initial indicators selected from the perspective of "production–living–ecological".

Primary Index	Order Number	Indicators	Explanation	Expert Suggested Indicators	Reason for Exclusion	Properties
Ecological Dimension	1	Forest coverage rate	Reflect the ecological environmental of the region.	Yes		Positive
	2	Comprehensive environmental air quality index	Reflect the air environmental of the region.	Yes		Negative
	3	Production water coefficient	Reflect the water resource of the region.	Yes		Positive
	4	Production water modulus	Reflect the water resource of the region.	Yes		Positive
	5	Soil erosion area ratio	Reflect the situation of soil erosion in the region.	Yes		Negative
	6	Area of rocky desertification	Reflect the distribution of rocky desertification in the region.	No	The differences between different regions are significant and not representative.	Negative
	7	Area of ecological restoration	Reflect the ecological restoration status of the region.	No	The differences between different regions are significant and not representative.	Positive
Living Dimension	1	The proportion of water bodies with surface water reaching or better than Class III	Reflect the water safety situation of residents.	No	The proportion of each district has approached 100%, which is meaningless.	Positive
	2	Proportion of water bodies with surface water quality inferior to Class V	Reflect the water safety situation of residents.	No	The proportion of each district has approached 100%, which is meaningless.	Negative
	3	The compliance rate of water quality in water functional areas	Reflect the water safety situation of residents.	No	The proportion of each district has approached 100%, which is meaningless.	Positive
	4	The proportion of centralized drinking water sources with water quality reaching or surpassing Class III	Reflect the water safety situation of residents.	No	The proportion of each district has approached 100%, which is meaningless.	Positive
	5	Growth rate of per capita GDP	Reflect the economic situation of residents.	No	This indicator is duplicated with the per capita GDP indicator.	Positive
	6	Per capita GDP	Reflect the economic situation of residents.	Yes		Positive
	7	Per capita disposable income of rural residents	Reflect the economic situation of residents.	Yes		Positive
	8	Per capita consumption expenditure of rural residents	Reflect the economic situation of residents.	No	This indicator overlaps with the per capita disposable income indicator of rural permanent residents.	Positive
	9	Permanent population	Reflect the economic situation of residents.	Yes		-
	10	Number of hospital beds	Reflect the status of residents' medical resources.	Yes		Positive
	11	Number of students in ordinary middle schools	Reflect the status of residents' educational resources.	Yes		Positive
	12	Number of students in primary schools	Reflect the status of residents' educational resources.	Yes		Positive
	13	Number of teachers in ordinary middle schools	Reflect the status of residents' educational resources.	Yes		Positive
	14	Number of teachers in primary schools	Reflect the status of residents' educational resources.	Yes		Positive
	15	Length of highways	Reflect the convenient transportation conditions of residents.	Yes		Positive
	16	Area of the region	Represents the territorial area of a region.	Yes		-

Table A1. *Cont.*

Primary Index	Order Number	Indicators	Explanation	Expert Suggested Indicators	Reason for Exclusion	Properties
Production Dimension	1	Overall labor productivity	Reflect the level of productivity in the region.	Yes		Positive
	2	Output value of the secondary industry	Reflect the status of industries in the region.	Yes		Positive
	3	The proportion of the output value of the tertiary industry to GDP	Reflect the status of industries in the region.	No	The correlation between this indicator and rural areas is low.	Positive
	4	The proportion of employees in the tertiary industry among the workforce	Reflect the composition of industrial personnel in the region.	No	The correlation between this indicator and rural areas is low.	Positive
	5	Energy consumption of industrial enterprises with annual revenue over a certain amount	Reflect the status of industrial energy consumption in the region.	Yes		Negative
	6	Water consumption per CNY 10,000 of GDP	Reflect the status of industrial water consumption in the region.	Yes		Negative
	7	Water consumption per unit of industrial added value	Reflect the status of industrial water consumption in the region.	No	This indicator is duplicated with the water consumption per CNY 10,000 of GDP.	Negative
	8	Utilization rate of hazardous waste disposal	Reflect the status of industrial chain in the region.	No	The correlation between this indicator and rural areas is low.	Positive
	9	Comprehensive utilization rate of industrial solid waste	Reflect the status of industrial chain in the region.	No	The correlation between this indicator and rural areas is low.	Positive
	10	Effective utilization coefficient of irrigation water in farmland	Reflect the status of agricultural water use in the region.	Yes		Positive
	11	Comprehensive utilization rate of crop straw	Reflect the status of agricultural waste utilization in the region.	No	The difference in this indicator among different regions is too small and meaningless.	Positive
	12	Comprehensive utilization rate of livestock and poultry manure	Reflect the status of agricultural waste utilization in the region.	No	The difference in this indicator among different regions is too small and meaningless.	Positive
	13	Safe utilization rate of contaminated farmland	Reflect the safe utilization of agricultural land in the region.	No	The difference in this indicator among different regions is too small and meaningless.	Positive
	14	Sown area of crops	Reflect the scale of agricultural land in the region.	Yes		-
	15	Amount of fertilizer applied	Reflect the status of agricultural fertilizer use in the region.	Yes		Negative
	16	Amount of pesticides used	Reflect the status of agricultural pesticide use in the region.	Yes		Negative

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