

## Article

# Spatial and Temporal Dynamics of Territorial Spatial Conflicts and Construction Land Expansion in Guizhou Province: A 40-Year Perspective

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**Abstract:** Territorial spatial conflicts (TSCs) refer to a contradiction of utilization resulting from the inconsistency of the needs and objectives of different subjects of interest for spatial resources in planning, utilization, and management. This research aimed to unveil the TSCs, construction land expansion (CLE), and their relationship in Guizhou Province from 1980 to 2020, both temporally and spatially. This paper established indicators to assess CLE, including construction land expansion velocity, construction land expansion intensity, and construction land expansion pattern to analyze the expansion characteristics of construction land in Guizhou Province. At the same time, the territorial spatial conflict indicator (SCII) was constructed to study the TSCs in Guizhou Province, and its evolution pattern was explored through the cold hotspot analysis. On this basis, it investigated the relationship and linkage between TSCs and CLE through the ordinary least squares (OLS) regression model and geographically weighted (GWR) regression model. Furthermore, this paper also constructed an economic elasticity coefficient and a population elasticity coefficient to analyze the collaborative relationship between TSCs and GDP along with population volume. The research revealed that while the velocity and intensity of CLE in Guizhou Province have escalated over time, this expansion displayed considerable geographical variation across various locations. Simultaneously, the TSCs intensified, demonstrating a slight positive correlation with the expansion. The study of the spatial and temporal evolution characteristics and response relationship between the TSCs and CLE provided a reference for the optimization of regional territorial space. It is highly valuable and significant in fostering efficient utilization of land resources, adjusting to economic and social transformations, and improving the scientific rigor of spatial planning.

**Keywords:** territorial spatial conflicts; construction land expansion; collaborative analysis; Guizhou Province; socio-economic factors



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## 1. Introduction

Since 1949, China has undergone a profound transformation, notably characterized by a significant surge in population. As of 2020, the population of Chinese has escalated to 1.412 billion, cementing its position as the globe's most densely populated country. Population increase profoundly affected the allocation of resources [1], societal framework [2],

and economic progress [3]. As the population grew, the demand for land resources increased [4], which has significantly increased our territorial spatial conflicts (TSCs). TSCs are a phenomenon that stems from the differences between different stakeholders over the mode and structure of land use in the process of territorial spatial resource utilization, which in turn triggers spatial competition and conflicts of rights and interests between people and land. A comprehensive analysis of this topic was essential for comprehending and addressing disputes over land resource utilization, and it facilitated the rational allocation and sustainable management of land resources. Existing research results on TSCs are enriched and varied, covering a wide range of aspects such as conflict drivers, measurement methods, and mitigation mechanisms. In terms of research perspectives, while earlier explorations were mostly based on land cover changes in geography [5], nowadays, there is a greater shift toward research on TSCs (production, living, and ecology) conflicts based on the functional division of territorial spatial conflicts [6,7]. In terms of driving factors, natural factors, such as the limited area and suitability of land, as well as human factors arising from the different needs of production, life, and ecology, are the main drivers of territorial spatial conflicts [8]. In terms of measurement methods, participatory surveys, game theory, the pressure–state–response (PSR) model and its extension model, multi-objective evaluation, and landscape ecological risk assessment are widely used [9–11]. These research results provide multidimensional theoretical support and methodological guidance for understanding and resolving territorial spatial conflicts. In this study, the territorial spatial conflicts indicator (SCII) was constructed using a landscape ecological risk model to measure TSCs in terms of external pressure, vulnerability, and stability. Studies showed that the extent of TSCs was affected by a variety of factors, including economic development [12], land use structure [13], and changes in social needs [14]. But fewer researchers have explored the causes of TSCs, and there is a certain lack of academic attention to the causes. Among them, the construction land expansion (CLE) has accelerated the rise in TSCs to a certain extent. For example, some studies have pointed out that the conversion of other land use types to construction land is one of the main causes of territorial spatial conflicts [9]; others have shown that the increase in construction land space will increase territorial spatial conflicts to a certain extent [15]. Therefore, the purpose of this paper is to study the relationship between TSCs and CLE and explore how CLE affects TSCs in terms of temporal and spatial changes.

The construction land expansion (CLE), as a distinctive sign of the alteration of various types of land use in the process of urbanization, especially the transfer from cultivated land toward urban construction land [16], has profoundly affected the land cover and use patterns, the regional variability of this phenomenon intuitively reflected the balanced state of urbanization development. For instance, the swift expansion of construction land in recent years has led to a scattered spatial layout of land [17], which reduced the efficiency of land use to a certain extent. In order to accurately portray the multidimensional profile of CLE, the research perspective spans the micro levels as well as macro levels [18,19]. The macro level focused on the CLE characteristics at the global, national, urban agglomeration, and even individual city levels [19,20]. At the micro level, the study examined the process of CLE, covering key indicators such as construction land density and landscape ecology index [18]. These two levels of cross-scalar research strategy help to reveal the complexity and diversity of CLE. At the same time, researchers used a series of advanced evaluation indexes separately to deeply explore the characteristics of CLE, such as construction land expansion velocity (CEV) [19,21], construction land expansion intensity (CEI) [22,23], and construction land expansion pattern (CEP) [24]. Different kinds of methods significantly enrich our consideration to the dynamics of CLE. However, few studies have combined all these methods to analyze CLE comprehensively and deeply. In addition, the current

research on CLE is a multidisciplinary and comprehensive field that requires scientific methods and appropriate scales to assess its wide-ranging impacts and provide scientific support for urban planning and administration. Therefore, this study will comprehensively consider three ways to systematically analyze the spatial and temporal evolution characteristics of CLE in Guizhou Province from a long-term perspective from 1980 to 2020.

However, TSCs, as a key contradiction in the process of land use, have also had a profound and complex chain impact on regional population and economic patterns. In the economic field, TSCs had a positive or negative impact on regional economic growth [25]. From the population level, TSCs have led to the deterioration of the living environment, the unreasonable layout of public service facilities, and the spatial mismatch of employment opportunities, which will promote the unbalanced migration of the population in the region [10]. Therefore, it is of great strategic significance to deeply analyze the internal relationship between TSCs and regional GDP and population to optimize the spatial pattern of land and promote regional coordinated development. On this basis, this study constructs the model of economic elasticity coefficient ( $C_{GDP}$ ) and population elasticity coefficient ( $C_{POP}$ ), and analyzes the collaborative relationship between TSCs and GDP and population in Guizhou Province.

With the acceleration of urbanization and industrialization, there is a sharp contradiction between the expansion of construction land and the protection of cultivated land and ecological construction. The land spatial planning of Guizhou Province points out that all kinds of land use are extremely fragmented, that urban and rural construction space is scattered, and that agricultural and ecological space are intertwined; in addition, problems such as difficult spatial classification management and collaborative governance occur frequently. Therefore, it is necessary to study the relationship between the territorial spatial conflicts and the expansion of construction land in Guizhou, so as to optimize the territorial spatial pattern and promote the coordinated development of regions. In this paper, the correlation between TSCs and CLE was analyzed by using the ordinary least squares (OLS) model and geographically weighted regression (GWR) model. Combining these two methods, it can analyze the complex relationship between TSCs and CLE from macro and micro levels, and provide more scientific and accurate decision support for land and space planning and management. It was expected that this study could provide solid theoretical support for future spatial planning and land use administration in Guizhou Province.

## 2. Data Sources and Research Methodology

### 2.1. Research Area and Data Sources

#### 2.1.1. Research Area

Guizhou Province is located in southwestern China, in the eastern portion of the Yunnan-Guizhou Plateau (shown in Figure 1), with undulating terrain, developed karst landforms, more mountains and less flat land, and scarce land resources. Guizhou serves as a significant land transportation hub in southwest China, encompassing an area of 176,000 km<sup>2</sup>, comprising six prefectural-level municipalities and three autonomous prefectures, which collectively contain 88 counts. The Guizhou Province exemplifies a karst landform, with mountains and hills comprising over 90% of its total area, resulting in restricted habitable space for the population and significant conflicts between human and land use. As a result, monitoring the expanding trend for constructing land in Guizhou Province is crucial for the region's rational development, strategy, and usage of land.

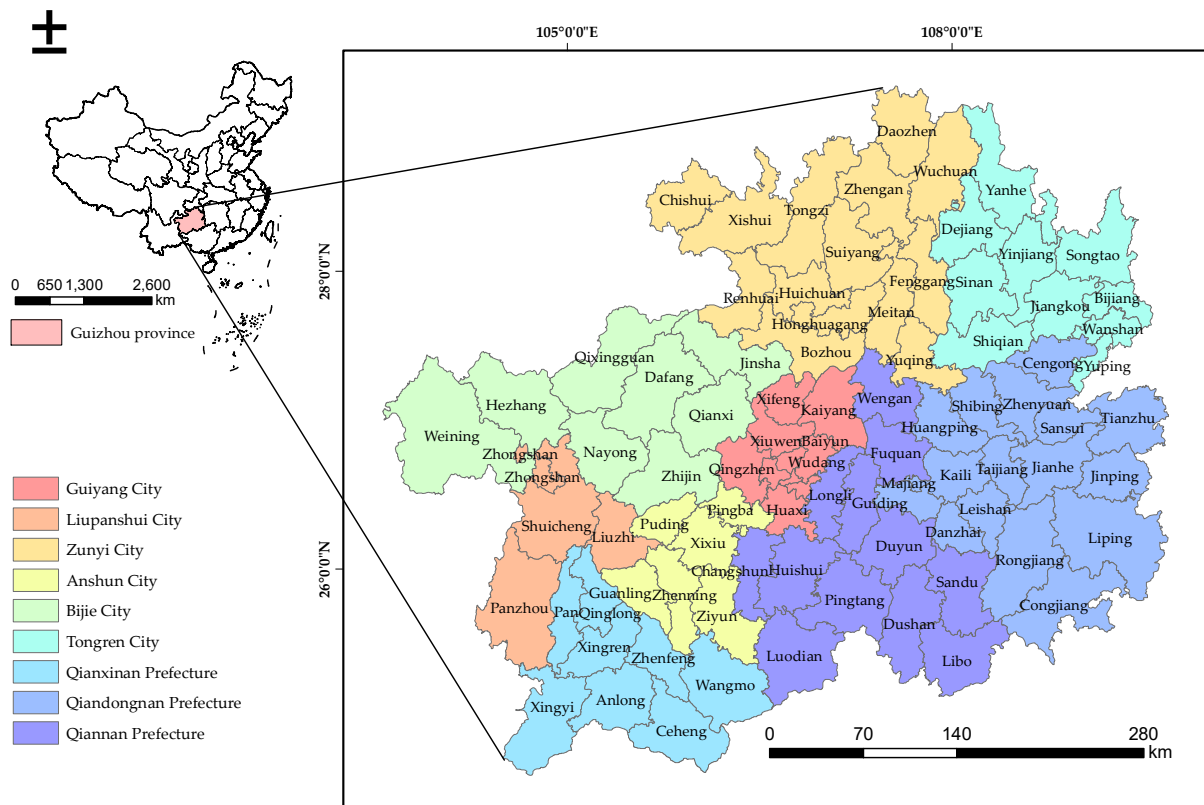


**Figure 1.** Research area.

### 2.1.2. Data Sources

This research utilized land use data from Guizhou Province for the years 1980, 1990, 2000, 2010, and 2020, obtained from the Data Centre for Resource and Environmental Sciences of the Chinese Academy of Sciences (CAS) (<https://www.resdc.cn/AchieveInfo.aspx?Id=224>, accessed on 1 March 2024) with a resolution of 30 m, all applied data images have consistency in 1980–2020. The land use classification in this paper adopts the first-level land use classification standard of the Chinese Academy of Sciences (CAS), which is mainly based on the Classification of Land Use Status Quo (GB/T 21010-2017), and combines remote sensing technology and field surveys to classify land use into the following categories: 1. Cultivated land: land used for planting crops, including paddy fields, drylands, etc. 2. Forest land: land used for forestry production, including forested land. 3. Grass land: land dominated by herbaceous plants and used for grazing or ecological protection. 4. Water land: including rivers, lakes, reservoirs, and other waters and land for their ancillary facilities. 5. Construction land: land used for urban and rural construction, such as residential, industrial, mining, and transport land. 6. Unused land: land that has not yet been developed and utilized, such as deserts and bare land. The data were geometrically corrected, the accuracy was verified, and the projected coordinate system used was Krasovsky-1940-Albers. The CLE data in the study was obtained from land use data utilizing the software of ArcGIS 10.7 as well as Fragstats 4.2.1, and the process specifically used tools such as data reclassification, extraction, raster calculator, intersection, etc. Data on GDP and population were sourced from Guizhou province's statistical yearbooks for the years 1980, 1990, 2000, 2010, and 2020.

### 2.2. Study Structure

This paper utilized land use data from 1980 to 2020 to investigate the expansion signatures of construction land and territorial spatial conflicts in Guizhou Province (shown

in Figure 2). In stage 1, we initially developed the Construction Land Expansion Velocity Index (CEV) and the Expansion Intensity Index (CEI) to examine alterations in construction land area and assess the extent and relative strength of CLE in Guizhou Province over the past 40 years. Simultaneously, we built the Construction Expansion Pattern Index (CEP) to calculate alterations in the public borders of CLE and ascertain the manner of development. Then, this paper employed the landscape ecological risk model to create the territorial spatial conflicts indicator (SCII), which would illustrate the intensity of TSCs within the region. TSCs were expressed in terms of external pressures, vulnerability, and stability. On this basis, the change in TSCs ( $SCII_C$ ) was constructed to measure the degree of change in TSCs. Meanwhile, the cold hotspot analysis method was used to analyze the spatial and temporal evolution characteristics of TSCs in Guizhou province. In stage 2, the relationship between CLE and TSCs was examined employing the OLS model and GWR model. In stage 3, it used the data of TSCs, GDP, and population in Guizhou Province to employ  $C_{GDP}$  and  $C_{POP}$ , so as to evaluate the collaborative relationship between them.

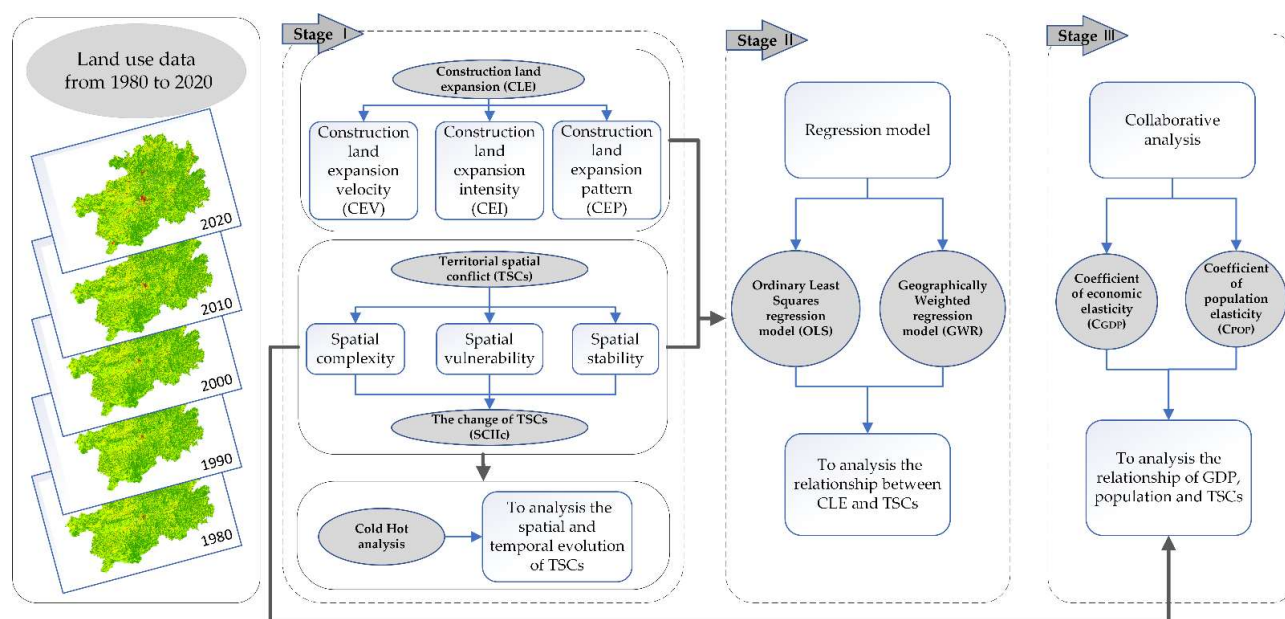


**Figure 2.** Research framework.

### 2.3. Research Methodology

#### 2.3.1. Study on Construction Land Expansion

##### (1) Assessment of CEV

The CEV [18,21] is the ratio of the alteration in construction land area throughout the study period to the length of that period within a specific region, serving as an indicator of the rapidity of CLE within a defined research period. The equation was as follows:

$$CEV = \frac{U_B - U_A}{\Delta T} \quad (1)$$

where  $U_B$  represents the area of construction land at the conclusion of the study period,  $U_A$  denotes the area of construction land at the commencement of the study period, and  $\Delta T$  is the research period.

##### (2) Acquisition of CEI

The CEI is a measure of the relative intensity of CLE, which is calculated by quantifying the alteration with the area of construction land in a given area relative to the product of the entire area of the study area and the duration of the study period [21–23]. This indicator

considers both the absolute increase in construction land area and integrates the whole size of the research region together with the time length, thereby offering a more accurate representation of the rate and vigor of construction land development. The equation was as follows:

$$CEI = \frac{U_B - U_A}{U \times \Delta T} \times 100 \quad (2)$$

where  $U$  denotes the entire area of the research region, and the other indices convey an identical significance as CEV.

### (3) Calculation of CEP

The CEP [24,26,27] is defined as the ratio of the length of the common boundary between new and existing construction land to the perimeter of the new construction land, utilized to discern the expansion pattern. The equation was as follows:

$$CEP = \frac{B_{com}}{B_{new}} \quad (3)$$

where  $B_{com}$  denotes the unified border width separating the additionally acquired construction land and the previous construction land, whereas  $B_{new}$  represents the border width of the additionally acquired construction land. The expansion patterns can be classified as three categories: filled type ( $0.5 < CEP \leq 1$ ), spread type ( $0 < CEP \leq 0.5$ ), and enclave ( $CEP = 0$ ) [24].

## 2.3.2. Study on TSCs

### (1) Assessment of SCII

The SCII [11,28,29] is a territorial spatial conflicts model according to the landscape ecological risk model. Based on relevant research, the construction of the territorial spatial conflict intensity model comprised three components: spatial complexity, spatial vulnerability, and spatial stability. The formula was as follows:

$$SCII = CI + FI - SI \quad (4)$$

where SCII is the territorial spatial conflicts index; CI is the spatial complexity index, expressed as the area-weighted average fractal dimension; FI is the spatial vulnerability index, and the specific values of each land use type are obtained by direct assignment (cultivated land-4, forest land-2, grass land-3, water land-5, construction land-1, and unused land-6) [29]; and SI is the stability, expressed as the density of patches. Each landscape pattern index was calculated by using the landscape index software Fragstats 4.2.1.

### (2) Acquisition of $SCII_C$

With reference to the formula for changes in the area of construction land,  $SCII_C$  is a measure of how much TSCs is changing by calculating the rate of change in SCII. The larger the  $SCII_C$ , the faster the SCII is increasing. Conversely, it indicates a slower increase in SCII. The formula was as follows:

$$SCII_C = \frac{SCII_b - SCII_a}{\Delta T} \quad (5)$$

where  $SCII_b$  denotes the SCII at the ending of the study duration,  $SCII_a$  represents the SCII at the commencement of the study duration, and  $\Delta T$  signifies the duration of the research period.

### 2.3.3. Characteristics of Spatial and Temporal Evolution Through Cold Hotspots Analysis

This paper explored the characteristics of spatial and temporal evolution within TSCs in 88 counties of Guizhou Province using the cold hotspot analysis [30–32]. Based on the relevant documentation, areas with obvious TSCs were identified as hot spots, and areas with reduced conflicts were identified as cold spots, hence clarifying the geographical pattern of territorial disputes in Guizhou Province. The equation was as follows:

$$Gi^*(d) = \frac{\sum_j^n Wij(d)X_j}{\sum_j^n X_j} \quad (6)$$

$$Z(Gi^*) = \frac{Gi^* - E(Gi^*)}{\sqrt{Var(Gi^*)}} \quad (7)$$

where  $Wij(d)$  is the spatial weights,  $E(Gi^*)$  is the mathematical expectation of  $Gi^*$ ,  $Var(Gi^*)$  is the coefficient of variation in  $Gi^*$ .

### 2.3.4. Regression Models to Analyze the Correlation Between Construction Land Expansion and Territorial Spatial Conflicts

#### (1) OLS model

Using OLS [33,34], the optimal function corresponding to the data were determined by reducing the squared error. The unknown data that minimizes the sum of the squared discrepancies between the estimated and real data are thus determined. This study used Ordinary Least Squares (OLS) to examine the link between CEV, CEI, CEP, and SCII<sub>C</sub>. The equation was as follows:

$$E_i = \beta_0 + \sum_{i=1}^n \beta_i x_i + \varepsilon_i \quad (8)$$

where  $E_i$  represents the individual variation, which refers to SCII<sub>C</sub>,  $\beta_0$  denotes the consistent term,  $x_i$  signifies the regression coefficient for  $i$ th individual variation, including CEV, CEI, and CEP,  $\varepsilon_i$  indicates the variance of random error term, and  $n$  refers to the number of individual variations.

#### (2) GWR model

The GWR model [35–37] was employed to explore the spatially varying relationships between construction land expansion and territorial spatial conflicts. Unlike the Ordinary Least Squares (OLS) model, GWR incorporates geographical coordinates into the regression parameters, allowing for the analysis of spatial non-stationarity in the data. In this study, we utilized an adaptive bandwidth approach in the GWR model. The adaptive bandwidth method was chosen because it adjusts the bandwidth size based on the local data density, which is more suitable for regions with heterogeneous spatial distributions like Guizhou Province. This approach ensures that the model captures local variations more effectively compared to a fixed bandwidth method. The equation was as follows:

$$E_i = \beta_0(u_i, v_i) + \sum_{j=1}^n \beta_j(u_i, v_i)x_{ij} + \varepsilon_i \quad (9)$$

where  $E_i$  is the individual variation in unit  $i$ , which refers to SCII<sub>C</sub>,  $(u_i, v_i)$  is the geographical coordinate of unit  $i$ ,  $\beta_0$  is the consistent term,  $\beta_j$  is the regression coefficient of the  $j$ th individual variation,  $x_{ij}$  is the value of the  $j$ th individual variation in unit  $i$ , including CEV, CEI and CEP,  $\varepsilon_i$  is the variance of random error term, and  $n$  is the number of individual variations.

### 2.3.5. Collaboration Between TSCs and GDP as Well as Population

#### (1) Coefficient of economic elasticity ( $C_{GDP}$ )

This paper presented an in-depth analysis of the data on TSCs and GDP in Guizhou Province to construct an economic elasticity coefficient,  $C_{GDP}$  [29]. This coefficient was designed to quantitatively assess the extent to which TSCs affected economic development and to explore the collaborative effects between the two. The equation was as follows:

$$C_{GDP} = \sqrt[N]{\frac{GDP_b}{GDP_a}} - 1 / \sqrt[N]{\frac{SCII_b}{SCII_a}} - 1 \quad (10)$$

where  $GDP_a$  represents the GDP at the beginning of the study period and  $GDP_b$  denotes the GDP at the end of the study period,  $SCII_a$  and  $SCII_b$  denote the SCII values for the beginning and end of the study period, while  $N$  represents the duration of the research period.

#### (2) Coefficient of population elasticity ( $C_{POP}$ )

As with the  $C_{GDP}$ , this paper constructed a population elasticity coefficient,  $C_{POP}$ , from data on territorial spatial conflicts and population data in Guizhou Province.  $C_{POP}$  was used to explore the effect of population counts on territorial spatial conflicts and to analyze the synergies between the two. The equation was as follows:

$$C_{POP} = \sqrt[N]{\frac{POP_b}{POP_a}} - 1 / \sqrt[N]{\frac{SCII_b}{SCII_a}} - 1 \quad (11)$$

where  $POP_a$  represents the POP at the beginning of the study period and  $POP_b$  denotes the POP at the end of the study period,  $SCII_a$  and  $SCII_b$  convey an identical significance as  $C_{GDP}$ , while  $N$  represents the duration of the research period.

## 3. Results

### 3.1. Spatial-Temporal Evolutionary of Construction Land Expansion

#### 3.1.1. Spatiotemporal Distribution of CEV and CEI

From 1980 to 2020, the total area of construction land in Guizhou Province increased significantly, from 54,500  $hm^2$  to 244,100  $hm^2$ , with a growth rate of 342.83%. In this study, it used the Natural Breakpoint approach to categorize the CEV values at the county level into six distinct classifications: reverse expansion (−26,514–0), low-speed expansion (0.01–27,477), medium–low-speed expansion (27,477.01–104,697), medium-speed expansion (104,697.01–180,396), medium–high-speed expansion (180,396.01–318,267) and high-speed expansion (3,182,670.01–550,800) (shown in Figure 3). Between 1980 and 1990, reverse expansion accounted for the major part (shown in Figure 3a). During this period, land resource administration and protection policies were gradually strengthened, such as the establishment of the State Land Administration in 1986. Simultaneously, in traditional agricultural societies, people preferred to retain land for agricultural production. From 1990 to 2000, the expansion of construction land in Guizhou Province was mainly at a low speed (shown in Figure 3b). In comparison to the years 1980 and 1990, the rate of construction land expansion has increased. National policies, such as the issuance of the 1990 Interim Regulations on the Granting and Transfer of Urban State-owned Land Use Rights, were one of the main reasons for this change. Between 2000 and 2010, the number of counties with the medium–low speed of CLE increased from three in 1990–2000 to more than two dozen, with a few other counties showing the medium speed of expansion (shown in Figure 3c). In 2009, the Guizhou Provincial Government introduced a policy of expanding domestic demand to promote economic growth, and the increase in rural

infrastructure, railways, highways, and airports directly contributed to the expansion. From 2010 to 2020, construction land in Guizhou accelerated at a faster speed than in any other decade between 1980 and 2010 (shown in Figure 3d). During this period, the government issued a series of policies to support industrial development, such as the 2010 Opinions on Accelerating the Development of Industrial Parks. The implementation of these policies has enabled Guizhou Province to experience a transition from traditional agriculture to modern industry and services. Industrial upgrading has created a new demand for construction land, including industrial parks, logistics centers, and commercial complexes.

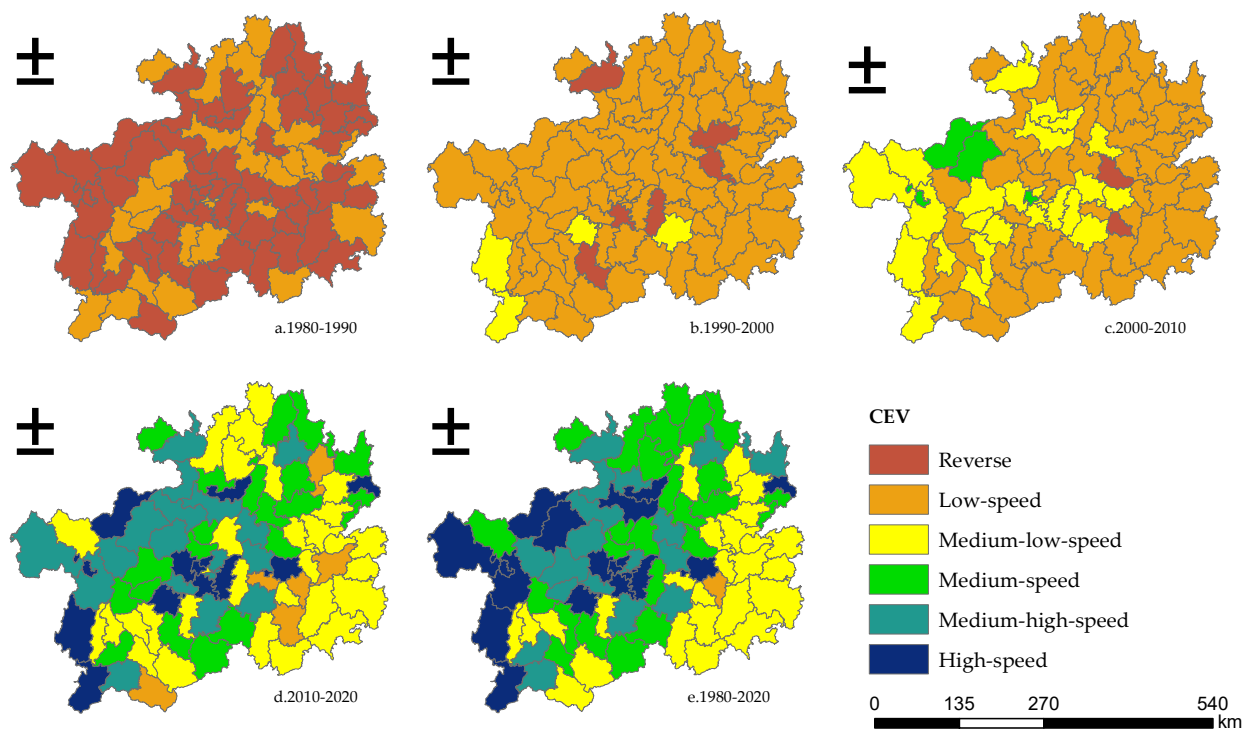


**Figure 3.** CEV in Guizhou Province from 1980 to 2020.

Spatially, the CLE within Guizhou Province (1980–2020) showed considerable variation among counties (shown in Figure 3e). Expansion with high speed was mostly focused on the western and central areas, including Xingyi City, Pan County, Shuicheng County, and Weining County, as well as Qingzhen City, Huaxi District, and Guanshanhu District. The rapid expansion in these regions was attributable to the promotion of local policies and the implementation of key projects. In Guanshanhu District, for example, the development of the city core was completed in 2012. In addition, a series of landmark projects, such as the Guizhou Financial City and Guanshan Lake Park, further accelerated the pace. The counties experiencing medium–high-speed expansion were mostly located in the central part of Guizhou Province, covering Renhuai City, Jinsha County, and Zijin County, which were close to the core of the high-speed expansion and closely followed by the speed of development. Taking Renhuai City as an example, in recent years, the city has adhered to the new development concept and pushed forward the land acquisition work according to the law, which has effectively promoted the high-quality development of the economy and society. Among other things, land acquisition and piecemeal development may be one of the key factors leading to the rapid increase in the area of construction land. The regions with medium–low-speed expansion rates were mostly focused on southeastern Guizhou Province, covering most of the counties in Qiandongnan Prefecture, such as Congjiang, Rongjiang, and Tianzhu counties. These regions placed high importance on land use efficiency. In Rongjiang County, for example, the General Plans for Land Use of

Rongjiang County clearly stipulate the control targets for cultivated land retention and the overall scale of construction land, which have been strictly enforced. As of 2018, the area of construction land in Rongjiang County only accounted for 1.36% of the total area of the county. Such strict planning and enforcement of land resources had effectively limited the disorderly expansion of construction land. Conversely, Leishan County was the only county that showed a low speed of expansion. Owing to efficient land use, Leishan County has controlled the growth of construction land.

Similarly to the CEV methodology, the CEI was classified into six distinct categories. The categories were reverse expansion ( $-1.09954 \times 10^{-5}$ – $0$ ), low-strength expansion ( $0.001$ – $1.13947 \times 10^{-5}$ ), medium-low-strength expansion ( $1.1394701 \times 10^{-5}$ – $4.34179 \times 10^{-5}$ ), medium-strength expansion ( $4.3417901 \times 10^{-5}$ – $7.48103 \times 10^{-5}$ ), medium-high-strength expansion ( $7.48103 \times 10^{-5}$ – $1.319855 \times 10^{-4}$ ), and high-strength expansion ( $1.31985501 \times 10^{-4}$ – $2.284171 \times 10^{-4}$ ) (shown in Figure 4). The correlation between CEV and CEI was notably significant, evidenced by the greater intensity of expansion in regions experiencing rapid construction land growth, whereas areas with slower construction land expansion exhibited a more moderate intensity of expansion.

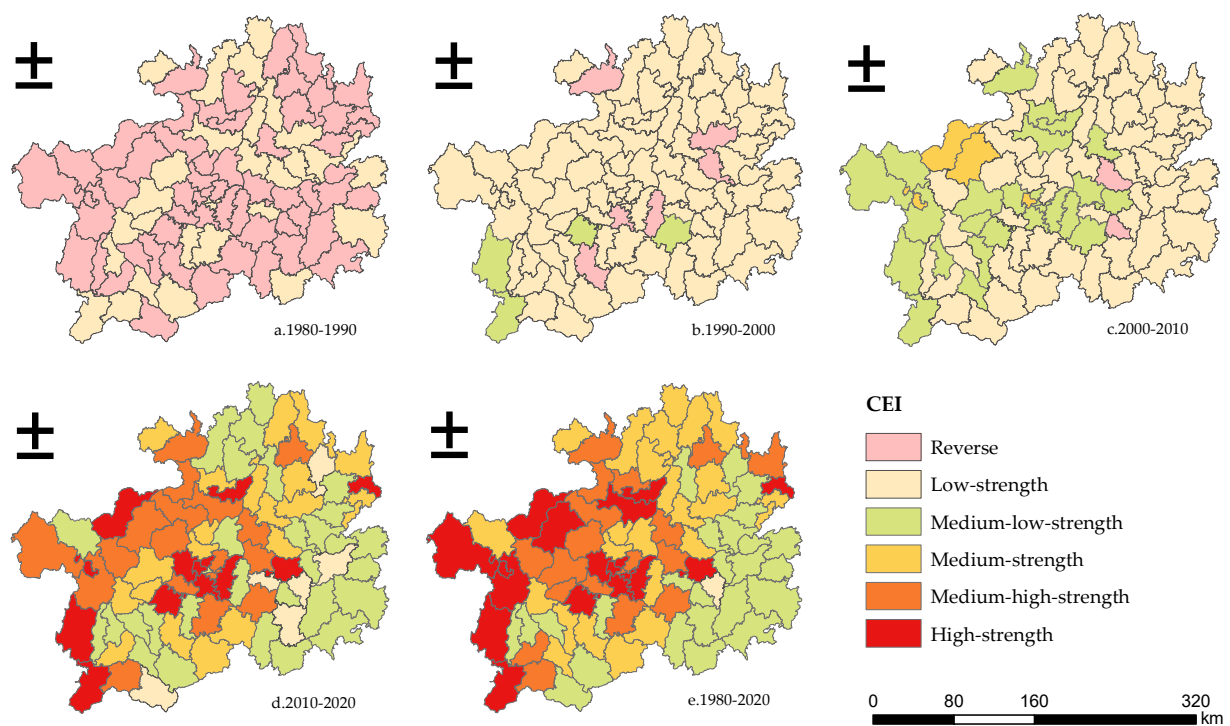


**Figure 4.** CEI in Guizhou Province from 1980 to 2020.

### 3.1.2. Construction Land Spatial Expansion Pattern (CEP)

The results of expansion patterns are shown in Figure 5. The expansion patterns can be classified into three categories: filled type ( $0.5 < CEP \leq 1$ ), spread type ( $0 < CEP \leq 0.5$ ), and enclave ( $CEP = 0$ ). Among them, the filled type was the addition of new construction land within or on the edge of existing built-up areas to improve land use efficiency. It reduced urban sprawl and protected farmland and natural ecology. This model promoted urban renewal and redevelopment, and increased land density. Spread type refers to an expansion of new construction land into the urban fringe or countryside at low densities, leading to territorial spatial conflicts, agricultural and ecological pressures, and increased infrastructure costs. However, it can provide space for urban development and relieve internal land pressures. The enclave type refers to the discontinuity of new construction land from existing construction land. It may result in the fragmentation of land use along

with increased complexity of urban management, with major environmental consequences. However, it can also provide new opportunities for urban development, especially when resources are unevenly distributed or when a specific geographical location is required.

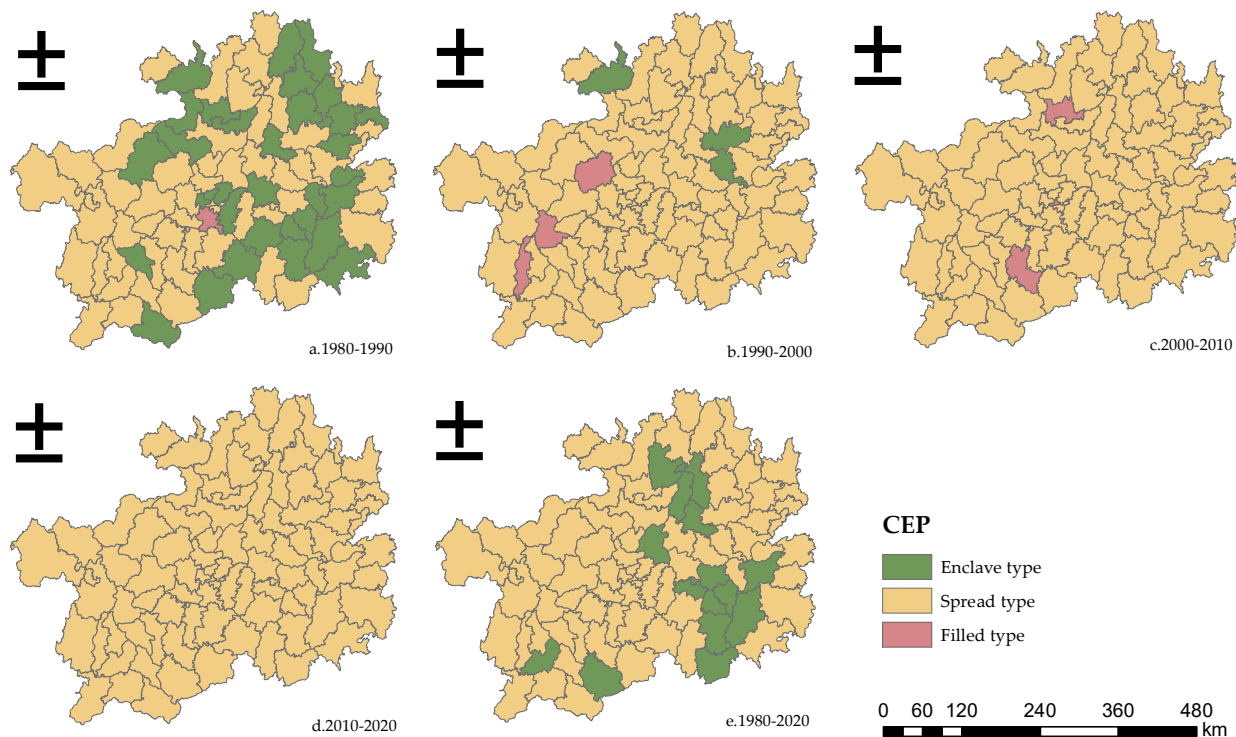


**Figure 5.** CEP in Guizhou Province from 1980 to 2020.

From 1980 to 1990, the expansion patterns of construction land in Guizhou Province covered filled, spread, and enclave types (shown in Figure 5a). During this period, only Huaxi District in Guiyang City presented the filled expansion strategy. There were several industrial park projects within the Huaxi District, including the Surface Treatment Industrial Park and the Yanlou Innovative Industry Incubation Base. These projects were situated inside or next to existing construction zones, therefore improving land use efficiency and fostering industrial growth. The enclave-type expansion was mainly focused on the eastern and central zones of Guizhou Province, covering areas such as Yanhe and Dejiang counties in Tongren City, as well as Congjiang, Rongjiang, and Leishan counties in Southeast Guizhou. While these areas have broadened the space for urban development, they have also exacerbated the problem of land fragmentation. Most of these counties were located in mountainous or inaccessible areas, such as Leishan County, which was situated on the slope of the transition from the Yunnan-Guizhou Plateau to the Xianggui hilly basin. Such geographical conditions forced construction land to adopt an enclave expansion strategy in order to make full use of the limited suitable space for construction. The spread-type expansion was evenly distributed in all regions of Guizhou Province; for example, Tianzhu County in the east, Libo County in the south, Weining County in the west, and Daochen County in the north. In Daochen County, for example, there were rivers such as the Furong River and Meijiang River in the planning area, and development sites should be located as far away from the rivers as possible to avoid causing damage to the river ecosystem and water pollution. This principle not only guided the direction of expansion of construction land but also shaped its development pattern.

Between 1990 and 2000, the number of counties with enclave-type expansion in Guizhou province decreased significantly compared to the previous decade, while the number of counties with spread-type expansion increased (shown in Figure 5b). Xishui

County had remained an enclave-type expansion, with the relocation of the county seat from Tucheng Town to the current Donghuang Town in 1998 being the main reason for the enclave-type expansion in Xishui. Shiqian and Shibing counties changed from spread-type expansion to enclave-type expansion. Particularly in Shibing County, the development of railway and highway projects, as well as the implementation of the ‘village to village’ and ‘group to group’ projects, greatly contributed to the enclave-type expansion of construction land. Meanwhile, Pu’an County, Liuzhi Special Zone, and Qianxi County have shifted from spread to filled expansion. Among them, Pu’an County has effectively improved the utilization rate of its land stock by accelerating the pace of urban village transformation. While promoting the redevelopment and utilization of low-use land, it achieved the goal of saving and intensifying construction land. In addition, most counties were still expanding their construction land through spread-type expansion while reserving more space for future urban development.

Between 2000 and 2010 (shown in Figure 5c), of the 88 counties in Guizhou Province, only Huichuan District and Ziyun County showed filled-type expansion, while the remaining 66 counties showed spread-type expansion. During this period, Huichuan District actively implemented the policy of linking urban and rural construction land to increase and decrease land use, expanding the application of surplus indicators in poverty alleviation areas and optimizing the structural layout of urban and rural land use. The strategy not only facilitated the development of new construction land within or on the edge of existing construction land but also promoted the economical and intensive use of land resources.

From 2010 to 2020, all 88 counties in Guizhou Province showed spread-type expansion (shown in Figure 5d). According to the General Plans for Land Use of Guizhou Province (2006–2020), Guizhou was committed to building a new spatial layout for urbanization, moderately increasing the scale of urban construction land, broadening the supply channels of construction land, and enhancing the efficiency of the use of existing construction land. This strategy led to the continuous extension of new construction land to the urban fringe and rural areas. At the same time, the intrinsic demand for urban development was one of the key factors driving the continued expansion of construction land.

From a spatial point of view, between 1980 and 2020, Guizhou Province saw two primary forms of increase in county construction land, namely, spread type and enclave-type expansion. In the enclave-type expansion, 15 counties are involved, including Libo, Sandu, and Rongjiang counties in the south and Suiyang, Meitan, and Fenggang counties in the center. Taking Libo County as an example, the county was endowed with rich natural landscape resources such as the Daqikong Scenic Area and the Zhangjiang Scenic Zone. In order to protect and rationally develop these resources, it was necessary to build tourism facilities and infrastructure around the scenic spots, thus promoting the development of enclave-type expansion. In addition, spread-type expansion involves 73 counties. In recent years, Guizhou Province has implemented a series of major projects, such as urban complex projects and real estate development projects, which have promoted the outward expansion of construction land. At the same time, Guizhou Province strengthened the implementation and supervision of cultivated land protection policies in the course of economic development, and continuously promoted the development of land conservation and utilization, which to a certain extent has also limited the sprawling expansion of construction land. These factors worked together to promote the spreading expansion of construction land in Guizhou Province.

### 3.2. County Territorial Spatial Conflicts

#### 3.2.1. Territorial Spatial Conflicts (TSCs)

TSCs refer to the contradictions and conflicts that arise between different land use subjects within a certain territorial scope as a result of the imbalance in the mode, intensity, and time distribution of land use. TSCs serve as a comprehensive indicator that identifies and evaluates potential conflict areas in territorial spatial conflicts. It can help decision-makers identify high-risk areas and take corresponding measures to mitigate conflicts and promote sustainable land use. Territorial spatial conflicts can be divided into five levels in this paper, including low conflicts, medium–low conflicts, medium conflicts, medium–high conflicts, and high conflicts (shown in Figure 6).

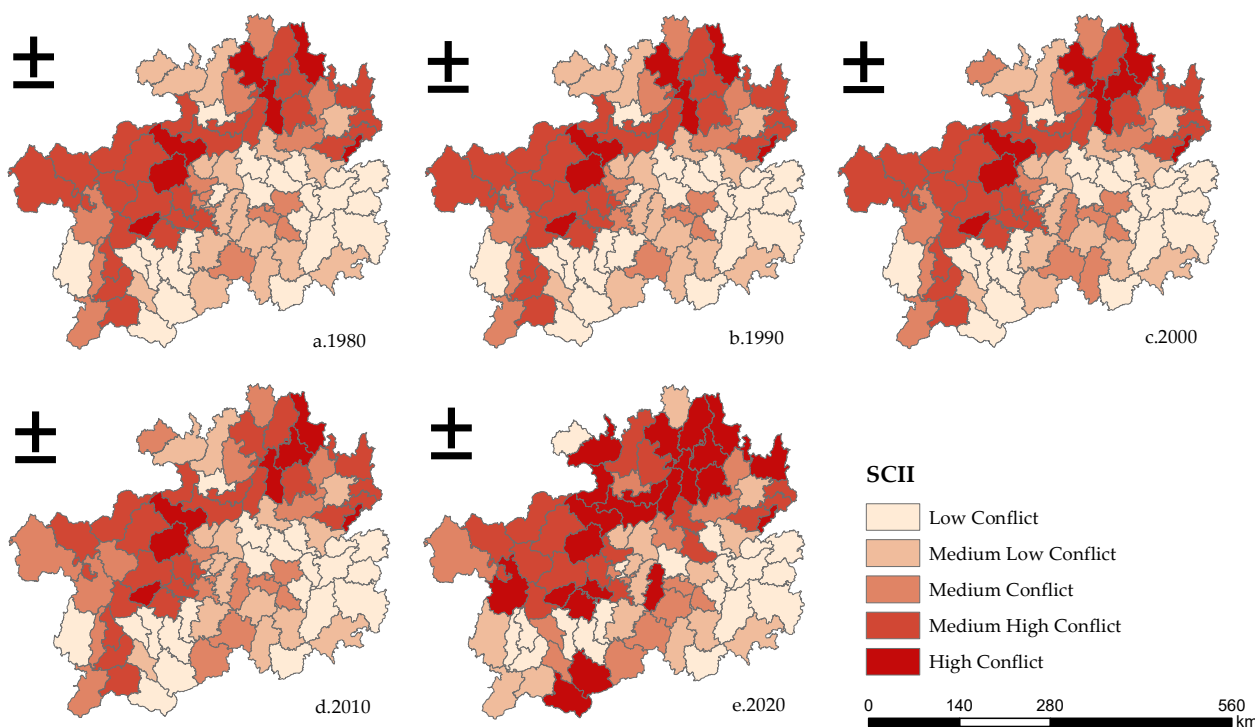


**Figure 6.** SCII in Guizhou Province from 1980 to 2020.

Between 1980 and 2020, county territorial spatial conflicts in Guizhou Province underwent significant changes. In 1980, counties in high conflicts included Jinsha, Qianxi, Puting, Zheng'an, Fenggang, Yanhe, and Sanping counties, and Jinsha, Qianxi, Puting, Fenggang, Yanhe, and Sanping counties were consistently in high conflicts over the four decades. By 2020, the number of high-conflict County counties increased from 7 in 2010 to 22, and the major new counties included Xishui County, Renhuai City, and Huichuan County in Zunyi City. Medium–high conflicts zones were mostly located in the western and northern regions of Guizhou Province, with Bijie City and Zunyi City as the main representatives. For high conflicts and medium–high conflict areas, it was necessary to comprehensively pay attention to territorial spatial conflicts and contradictions caused by uneven planning orientation and inconsistent objectives. Low conflicts and medium–low conflicts areas were primarily found in the eastern and southern regions of Guizhou, represented by Qian-dongnan and Qiannan. Low-conflicts areas included Tianzhu County, Yinping County, and Liping County, while medium–low conflicts areas included Dushan County, Sandu County, and Duyun City. Overall, from 1980 to 2020, the quantity of counties exhibiting significant territorial spatial conflicts in Guizhou Province has risen, while the number of counties with high conflicts has decreased, and the overall territorial spatial conflicts showed an

upward trend. Therefore, each local government should take appropriate measures to adjust and mitigate according to the specific situation.

### 3.2.2. The Changes in Tscs

This paper analyzed the degree of territorial spatial conflicts in Guizhou Province and precisely measured the extent of this change using the SCII<sub>C</sub> index. This research categorized the speed of SCII<sub>C</sub> into six types: reverse, low-speed, medium-low-speed, medium-speed, medium-high-speed, and high-speed, aiding in a more intricate comprehension of the dynamic nature of conflict shifts across various periods (shown in Figure 7).

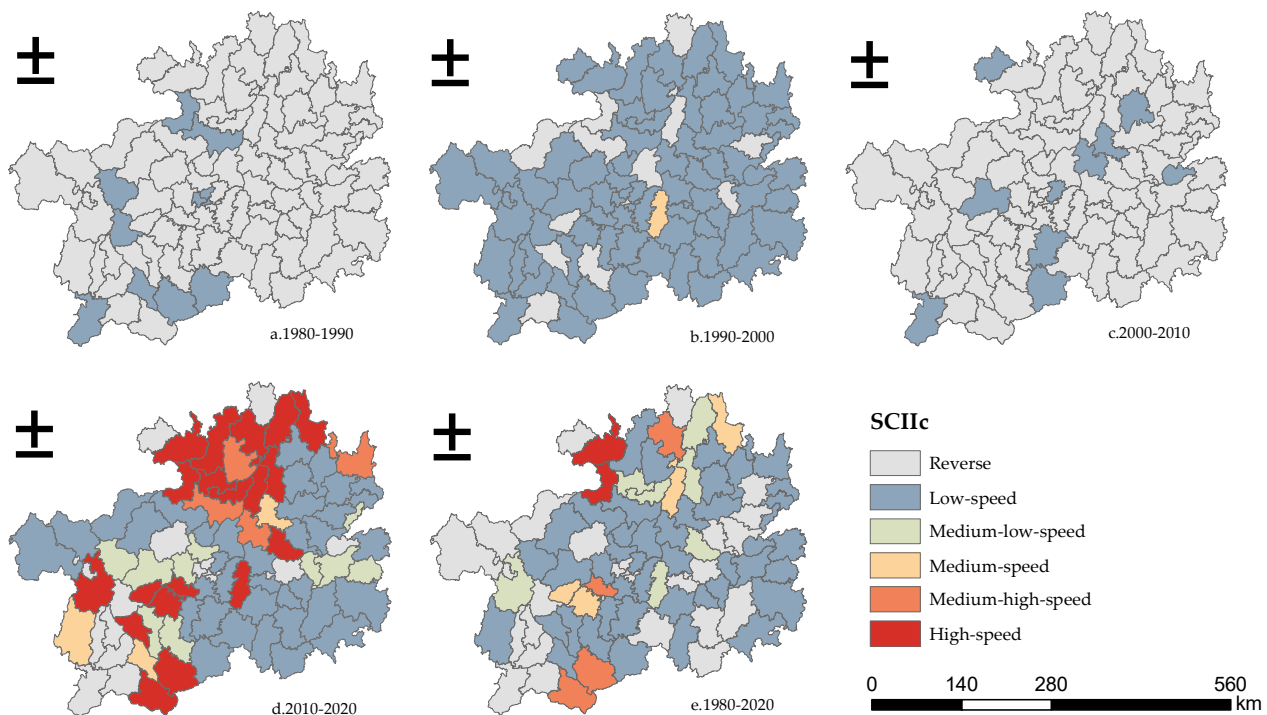


**Figure 7.** SCII<sub>C</sub> in Guizhou Province from 1980 to 2020.

Between 1980 and 1990, changes in TSCs in the counties of Guizhou Province mainly showed a reverse trend (shown in Figure 7a). During this period, only a few counties, such as Wangmo County, Luodian County, Zhenfeng County, and Xingyi City, achieved a low speed of growth, while most of the other areas experienced reverse growth. In 1980, Guizhou Province issued the Instruction on Relaxing Agricultural Policies, proposing the adoption of a variety of management approaches to management, an initiative which, to a certain degree, facilitated the rational allocation and utilization of land resources. By 1990, Guizhou Province had completed the afforestation of 236,467 hectares and planted 64,858,000 trees, and these forest protection and restoration measures significantly affected spatial vulnerability. In the same year, Guizhou Province also accumulated 66,667 hm<sup>2</sup> of artificial grassland and built 26 nature reserves. Together, these measures have contributed to the reverse growth of territorial spatial conflicts in Guizhou.

Between 1990 and 2000, the growth speed of territorial spatial conflicts increased significantly, in contrast to the previous decade (shown in Figure 7b). During this period, only twelve counties grew in a reverse direction, while Guiding County maintained a medium-speed growth, with the rest of the counties showing low growth speed. The Guizhou Provincial Land Use Master Plan issued in 1999 emphasized the importance of cultivated land protection, and explicitly prohibited the desertion and destruction of cultivated land. At the same time, the plan states that priority will be given to securing

land requirements for key construction projects such as transport and water conservancy, a policy direction that may have further exacerbated tensions and conflicts over land use. The implementation of these key construction projects, coupled with the intrinsic drive for economic development in Guizhou Province, combined to drive an increase in territorial spatial conflicts.

During the period from 2000 to 2010, the growth speed of territorial spatial conflicts in most counties in Guizhou Province reversed to a negative growth trend, with only 10 counties, including Chishui City, Xingyi City, and Luodian County, maintaining a low growth speed (shown in Figure 7c). This trend had a positive significance for the optimization and adjustment of land space. Throughout this period, the execution of the farmland-to-forest and grassland restoration program, the comprehensive initiation of the natural forest protection initiative, and the advancement of the rocky desertification mitigation project were all pivotal in mitigating territorial spatial conflicts.

In the period 2010–2020, the growth speed of territorial spatial conflicts in Guizhou Province was significantly higher than that of the previous three decades, with high-speed changes and medium-high-speed changes (shown in Figure 7d). The results showed that the counties with a high rate of increase in territorial spatial conflicts consisted of nineteen counties, including Xishui, Renhuai, Tongzi, etc., which were mostly focused on the northern part of Guizhou represented by Zunyi. These areas had a rapid increase in territorial spatial conflicts, and local governments should pay enough attention to the rationality of their spatial planning. There were four counties with medium to high growth rates, namely Suiyang County, Bozhou District, Weng'an County, and Songtao County. The growth speed of these areas was only as small as that of the high-growth areas, and they should also be paid attention to.

During the four decades from 1980 to 2020, changes in territorial spatial conflicts in Guizhou Province mainly showed a trend of low and reverse growth. This suggested that most counties had relatively reasonable territorial spatial planning, and conflicts were within acceptable limits. However, the situation in Xishui County and Renhuai City was significantly different, as their growth rate far exceeded that of the other 86 counties, showing a high growth speed. The high growth speed of Xishui County and Renhuai City highlighted the challenges and opportunities of their national spatial planning, which should be planned and adjusted in a more refined and rational manner.

### 3.2.3. Cold Hotspots Analysis

This study employed the “Cold Hotspots analysis” model within ArcGIS 10.7 to examine the TSCs in Guizhou Province. In this model, CONTIGUTTY-EDGES-CORNERS was selected for the conceptualization of spatial relationships, which was mainly used to deal with spatial relationships between faceted elements (e.g., administrative districts), and ENCLIDEAN-DISTANCE is selected for the distance method, which is suitable for geographic analyses at small scales. In addition, normalization, distance range, or distance threshold were default options. The analysis indicated that the Gi index ranged from  $-2$  to  $3$ . The outcomes were categorized towards five tiers utilizing the Natural Breakpoint approach according to the Gi value: hot spot, sub-hot spot, no significance, sub-cold spot, and cold spot, as shown in Figure 8. Zones with less agglomeration were designated as cold and sub-cold zones, while areas with different levels of agglomeration were designated as hot and sub-hot zones. Significant hot or cold spots were absent from areas with minimal agglomeration. By analyzing the spatial distribution of the study data, regions with low values clustered (cold spots) and high values clustered (hot spots) can be identified. Cold hotspot analysis of county TSCs in Guizhou Province can identify whether regional TSCs

was spatially correlated, i.e., whether there was a clustering phenomenon in which certain regions had higher or lower SCII values than the average.

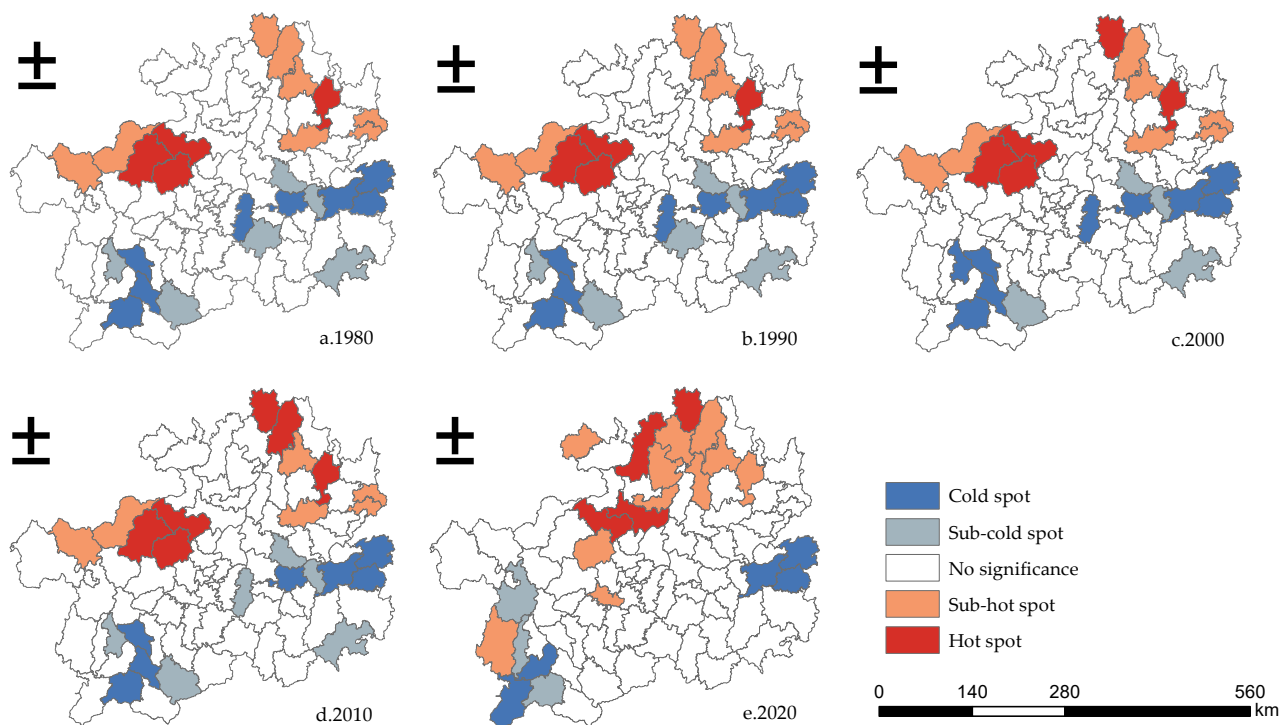


**Figure 8.** The cold hotspots analysis in Guizhou Province from 1980 to 2020.

In terms of administrative divisions, the distribution of cold hotspots in 1980 and 1990 showed a similar trend. Specifically, the hotspots were mainly concentrated within Bijie City, Zunyi City, and Tongren City, indicating that these two regions had high SCII value during this period. In contrast, the cold spots were mainly distributed in areas such as Tianzhu County, Yinping County, and Jianhe County within Qiandongnan Autonomous Prefecture, which were agglomerations of counties in areas with low territorial spatial conflicts. In 2000, compared with the previous two decades, Daozhen county changed out of a sub-hot spot for a hot spot, indicating that the territorial spatial conflicts in Chishui City increased during this period. At the same time, other counties had hardly changed. The outcome of the 2010 study showed that Wuchuan County changed from a sub-hotspot area to a hotspot area, and hotspot clustering became more pronounced in the northern region of Guizhou Province. Qinglong and Guiding changed from cold spot areas to sub-cold spot areas. In 2020, hot spot areas focused on counties such as Tongzi and Jinsha, and the clustering of hotspot and sub-hotspot areas in the northern part of Guizhou Province became more and more significant, while cold spot areas were mainly scattered in Xingyi and Jianhe.

In addition to Gi index,  $p$ -value and Z-score were also important findings in cold hotspot analyses. The results of the analyses showed that the Z-values of 11 counties, Daozhen, Wuchuan, Qixingguan, Dafang, Qianxi, Jinsha, Hezhang, Bijiang, Wanshan, Yinjiang, and Dejiang, were all greater than 1.96, and the  $p$ -values were all less than 0.05, which indicated that they were significant hotspots at the 95% confidence level. Among them, the Z-values of Dafang, Qianxi, Jinsha, and Yinjiang were greater than 2.58, and the  $p$ -values were less than 0.01, indicating that they were significant hotspots at 99% confidence level. The values of territorial spatial conflict in these regions were high and spatially clustered with the high values in the surrounding regions. The seven regions of Guanling, Zhenfeng, Anlong, Kaili, Tianzhu, Jinping, and

Jianhe have Z-values less than  $-1.96$  and  $p$ -values less than  $0.05$ , indicating that they were significant cold spots at the 95% confidence level. In particular, the Z-values of Zhenfeng, Tianzhu, Jinping, and Jianhe were less than  $-2.58$ , and the  $p$ -values were less than  $0.01$ , indicating that they were significant cold spots at the 99% confidence level. Contrary to the hotspots, these regions have lower values of territorial spatial conflict and were spatially clustered with the low values of the surrounding regions.

### 3.3. Regression Analysis

#### 3.3.1. OLS Regression Analysis

In this study, it used the OLS model to explore the correlation between SCIIc and CEV, CEI, as well as CEP. Through this approach, the key statistical indicators, including the determination coefficient ( $R^2$ ) and the regression coefficient, can be obtained, which provided us with an intuitive understanding of the data relationships and were clearly demonstrated in Figure 9.  $R^2$  was a statistic that measures the excellence of fit of a regression model. It indicated what proportion of the variation in the dependent variable can be explained by the independent variable. The value of  $R^2$  was between 0 and 1. The closer the value was to 1, the better the model fitted the data, i.e., the better the independent variable explains the dependent variable. Regression coefficients were the coefficients of the independent variables in a regression model, and they indicated the average amount of change expected in the dependent variable for each unit change in the independent variable. The absolute value of the regression coefficient indicated the strength of the independent variable's influence on the dependent variable. The greater the absolute value, the more pronounced the impact.

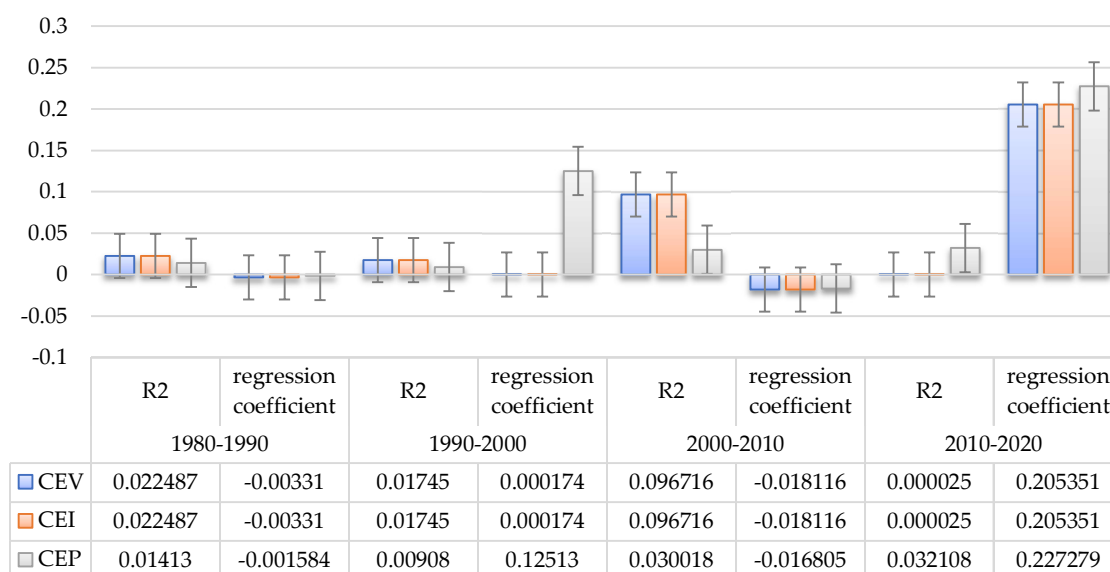


**Figure 9.** The regression coefficient and  $R^2$  in Guizhou Province from 1980 to 2020.

The results showed that the correlation between SCIIc and CEV, CEI, and CEP was dynamic in different periods. Specifically, the regression coefficients were negative, and the absolute values were less than 0.1 in the periods of 1980–1990 and 2000–2010, indicating that there was a slight negative correlation between CEV, CEI, CEP, and SCIIc. At the same time, the value of the coefficient of determination was far less than 1 or even less than 0.1, which meant that with the changes in CEV, CEI, and CEP, SCIIc would change in the opposite direction, but the correlation is not strong. During the decade 1990–2000, the regression coefficients were positive and had absolute values less than 0.01, suggesting a slight positive connection between SCIIc and CEV, CEI, and CEP. Meanwhile, the values

of the coefficients of determination were all less than 0.01, indicating that SCIIc increases with CEV, CEI, and CEP, but their increases are not uniform. In the period 2010–2020, the regression coefficient was positive. The absolute value of the regression coefficient increased more than tenfold during the period 2010–2020 compared to the previous three decades, reaching a value of 0.2, and the value of the coefficient of determination remained insignificant. The above information showed that SCIIc increased with CEV, CEI, and CEP during this period, which was a positive correlation. Remarkably, the highest determination coefficient,  $R^2$ , was close to 0.1 for the period 1980–2020, further confirming the existence of the above correlation, albeit with limited strength. In conclusion, by analyzing the data over different time periods, it was revealed that the correlation between SCIIc and CEV, CEI, and CEP was not constant but fluctuated over time. This conclusion was regarded as extremely important for understanding the link underlying territorial spatial conflicts along with construction land expansion, in addition to providing vital information for future territorial spatial planning and land use adjustment.

### 3.3.2. GWR Regression Analysis

Utilizing the OLS model, the GWR model was then used to investigate the spatial response association among SCII<sub>C</sub>, CEV, CEI, and CEP from 1980 to 2020, as shown in Figure 10. The GWR model enabled the model to adapt to the distributional characteristics of spatial data by introducing a spatial weight matrix. It more accurately represents the attributes of geographical data and serves as a superior regression model compared to classic regression models. To assess the robustness of our GWR model, we conducted a sensitivity analysis on the bandwidth selection. We compared the model performance using both fixed and adaptive bandwidths. The results indicated that the adaptive bandwidth approach provided a better fit to the data, as evidenced by higher  $R^2$  values and lower Akaike Information Criterion (AIC) values. These findings suggest that the adaptive bandwidth method is more appropriate for capturing the spatial heterogeneity in Guizhou Province. The findings suggested that the adaptive bandwidth method is more appropriate for capturing the spatial heterogeneity in Guizhou Province. So, we utilized an adaptive bandwidth approach in the GWR model.

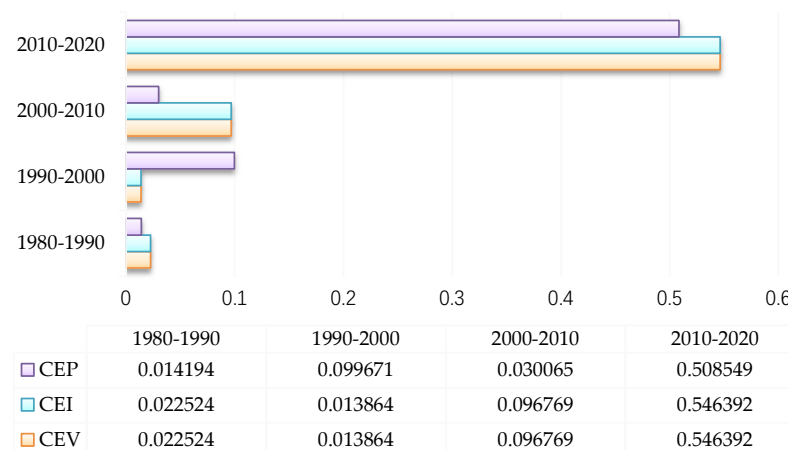


**Figure 10.** The  $R^2$  in Guizhou Province from 1980 to 2020.

The GWR model conclusions indicated that the  $R^2$  values for the period 1980–2010 are all below 0.1, which also indicated that there was a weak correlation between the changes in territorial spatial conflicts and the expansion of construction land. In this stage, the speed of construction land expansion was mainly reverse expansion, low speed expansion, and medium–low speed expansion. In the same period, the speed of SCII growth was mainly reverse growth, low speed growth, and medium–low speed growth. The magnitude of

their changes was all relatively minor, so their correlation was not so obvious. From 2010 to 2020, the  $R^2$  values clearly increased, all of them were higher than 0.5, and a strong correlation is shown between the change in TSCs and CLE. Within this decade, the changes in TSCs had escalated markedly in comparison to the preceding three decades, and CLE had also accelerated significantly so that the changes between the two showed a significant and strong link. This trend highlighted the profound impact of changes in land use types on TSCs in recent years.

Based on the analysis of the GWR model, this paper classified the local  $R^2$  into seven grades from high to low, which were higher, high, medium-high, medium, medium-low, low, and lower, as shown in Figure 11. During 1980–1990, the local  $R^2$  values in the northeastern region of Guizhou Province significantly exceeded those in other regions, with a continuous downward trend from the northeast to the southwest. This trend suggested that the CLE in the northeastern region of Guizhou Province better explained the changes in TSCs during this period, while the southwestern region was relatively poorer. However, this spatial distribution has changed significantly over time. Between 1990 and 2000, the spatial layout of local  $R^2$  changed markedly compared with the previous decade, showing a downward trend from the southwest to the northeast. It indicated that in this interval, the TSCs in the southwest were more strongly affected by CLE. Between 2000 and 2010, the local  $R^2$  values of  $SCII_C$ , CEV, and CEI exhibited a decreasing trend from north to south. It indicated that  $SCII_C$  in the northern part of Guizhou could better account for CEV and CEI in this period, while it gradually weakened towards the south. Unlike the 1980–2000 period, the spatial distribution of the local  $R^2$  of  $SCII_C$  with CEP was inconsistent with that of CEV and CEI in this period, showing a clear decreasing trend from northeast to southwest. It showed that the pattern for CLE in the northeast may better reflect the changing curve of TSCs during this era. From 2010 to 2020, the local  $R^2$  values in Guizhou Province began to show a trend of dispersion, with both high and low values scattered in various regions, without obvious spatial clustering characteristics. This decentralization trend meant that the connection and interaction between territorial spatial conflicts and construction land expansion between neighboring regions gradually weakened.

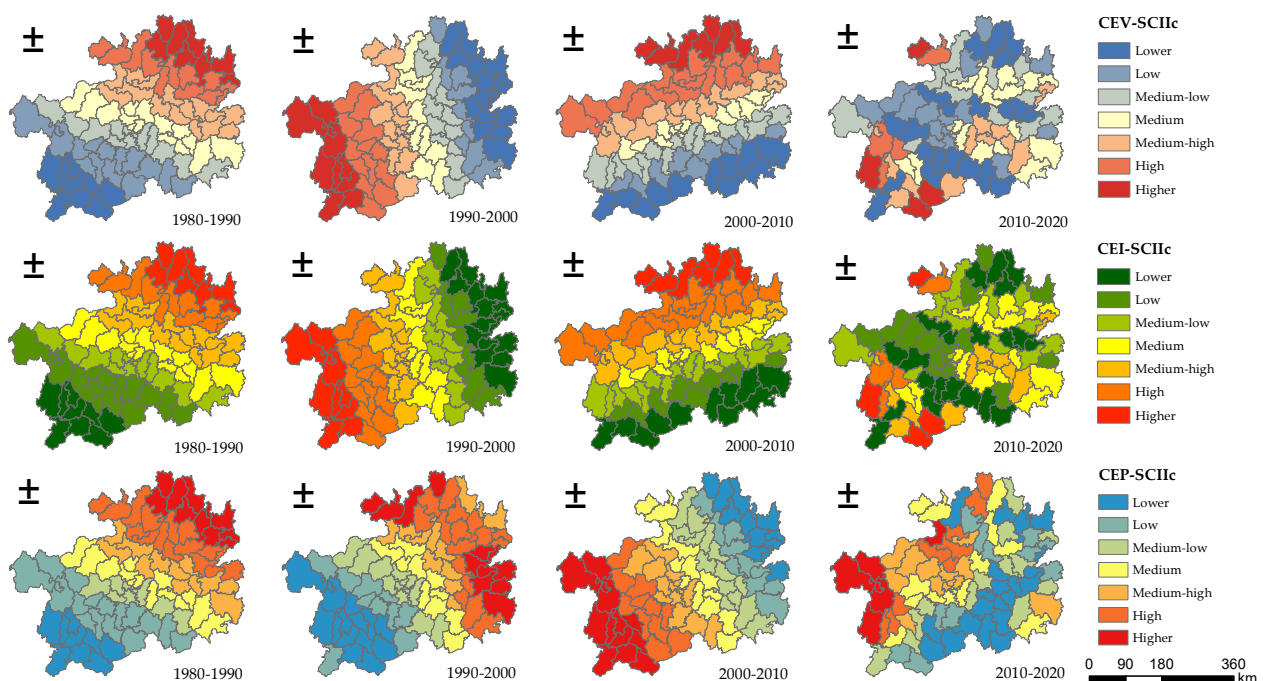


**Figure 11.** The local  $R^2$  in Guizhou Province from 1980 to 2020.

### 3.4. Collaborative Analysis of Territorial Spatial Conflicts with Economic and Social Factors

#### 3.4.1. Coefficient of Economic Elasticity (CGDP)

By analyzing the collaboration between TSCs and GDP, the collaborative relationship between them can be clarified. This study categorized the outcomes of the  $C_{GDP}$  model analysis for the 88 counties of Guizhou Province into four collaborative types, as shown in Figure 12.

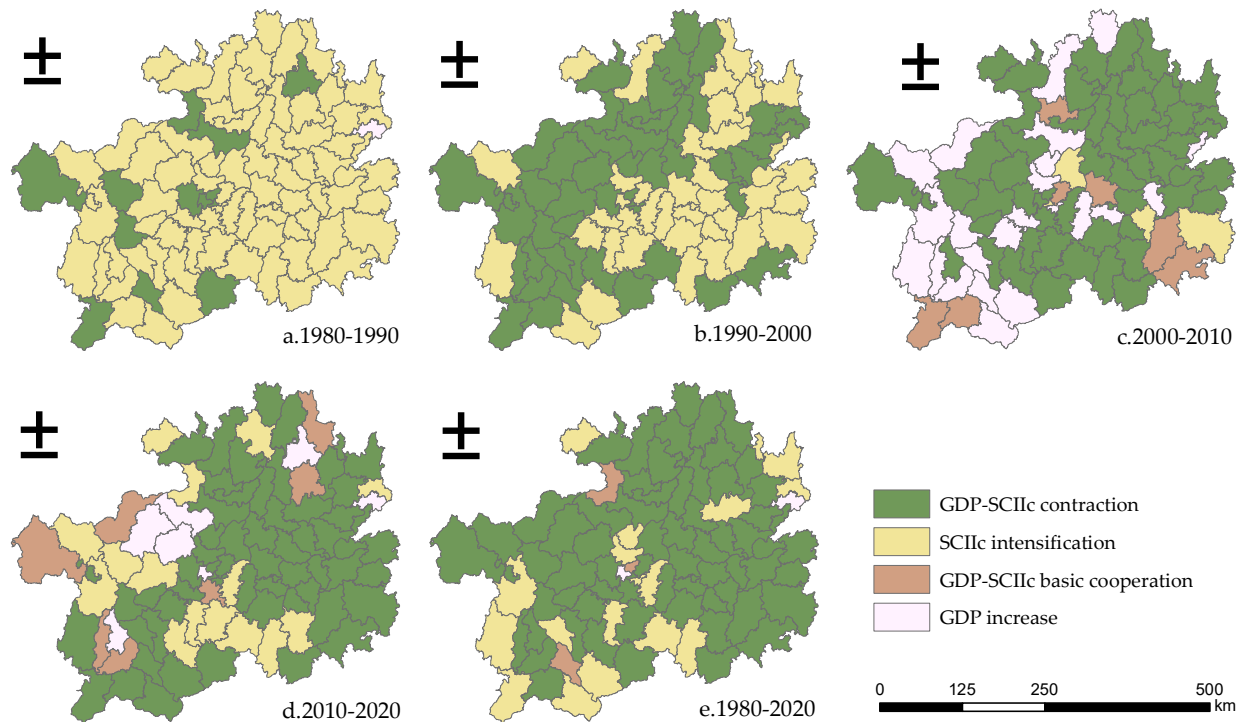


**Figure 12.** The  $C_{GDP}$  in Guizhou Province from 1980 to 2020.

From 1980 to 1990, the results of  $C_{GDP}$  in most counties were  $SCIIC$  intensification in Guizhou Province, except for a few counties, such as Weining County, Xingyi City, and Luodian County, which were GDP- $SCIIC$  contraction. It indicated that during this period, the growth of  $SCIIC$  in Guizhou Province was greater than the growth of GDP, and the economic growth could not catch up with the increase in  $SCIIC$ . From 1990 to 2000, its results for  $C_{GDP}$  continued to be dominated by GDP- $SCIIC$  contraction and  $SCIIC$  intensification. Compared to the previous decade, the number of counties with GDP- $SCIIC$  contraction had increased, reaching about fifty percent of Guizhou province. GDP- $SCIIC$  contraction was mostly located in the west as well as north, showing that GDP and  $SCIIC$  were changing in opposite directions.  $SCIIC$  intensification was predominantly concentrated in the south and east, indicating that  $SCIIC$  was increasing faster than GDP in these regions. From 2000 to 2010, in addition to the GDP- $SCIIC$  contraction and the  $SCIIC$  intensification, the results of  $C_{GDP}$  began to appear in both GDP- $SCIIC$  basic cooperation and GDP increase. The GDP growth primarily occurred in the southwestern region of the province, which was represented by Zhenfeng county. The GDP growth rate in these regions is higher than the growth rate of  $SCIIC$ , and the economic return on the use of territorial space was high. GDP- $SCIIC$  basic cooperation was mainly distributed in seven counties, including Xingyi City. The GDP growth and  $SCIIC$  magnitude of these regions were basically in a balanced state, which was important for the promotion of economic development and the coordination of territorial space. Only the  $C_{GDP}$  results of Liping County, Danzhai County and Kaiyang County showed an  $SCIIC$  intensification type, and the  $SCIIC$  growth rate of the three counties was larger than the GDP growth rate, which needed to be focused on the

rational allocation of their territorial space. For 2010–2020, the  $C_{GDP}$  results included all four types. GDP increase was distributed among seven counties, including Dafang, Qianxi, and Jinsha, suggesting that economic growth in these seven counties was in a better state. GDP-SCIIc basic cooperation was distributed in seven counties, including Weining and Pu'an, which were more consistent with economic growth and the growth of territorial spatial conflicts. The SCIIc intensification mainly contains 15 counties in the south and west of Guizhou, and these regions should pay extra ministration to the direct coordination of spatial arrangement and economic development.

Generally, the results for  $C_{GDP}$  over the four decades 1980–2020 varied between counties. The only county whose result was a GDP increase was Guanshanhu District, whose economy grew faster than the SCII. Zhenfeng County, Yunyan District, and Renhuai City were the GDP-SCIIc basic cooperation. The economic growth and SCII growth rates of these areas were basically collaborative, indicating that their territorial spatial allocation and economic development were relatively coordinated. 19 counties including Xingyi City, Pan County, Shuicheng County were SCIIc intensification. The increase in SCII in these areas was greater than the growth of GDP, and the harmonious relationship between economic development and spatial adaptation needs to be given greater consideration. GDP-SCIIc contraction occupied the majority of the province, indicating an inverse relationship between GDP and SCII in these regions.

#### 3.4.2. Coefficient of Population Elasticity (CPOP)

$C_{POP}$  provided a measure of the relationship between population growth and changes in TSCs. This study categorized the outcomes of  $C_{POP}$  in the 88 counties of Guizhou Province into four collaborative types, as shown in picture 13.

From 1980 to 1990,  $C_{POP}$  results revealed that most of the districts were of the type of POP-SCIIc contraction, with population size and territorial spatial conflicts increasing in the opposite direction. Immediately afterward, 22 counties, including Chishui City, Weining County, Tongzi County, etc., were a population increase, and the population growth rate in these areas was faster than the SCII growth rate. Seven counties, such as Daozhen County and Zheng'an County, have POP-SCIIc basic cooperation, and the population growth rate and SCII growth rate were basically synchronized. Lastly, six counties, led by Luodian and Duyun, showed SCIIc intensification, which manifested itself as a rapid increase in SCII. The number of counties in Guizhou Province that showed the phenomena of POP-SCIIc contraction and population increase gradually decreased between 1990 and 2000, while the number of counties that showed the trend of SCIIc intensification increased to 21. This tendency revealed an overall acceleration of SCII growth in the province, i.e., the rapid intensification of territorial spatial conflicts, which had outpaced the population growth rate. For the period from 2000 to 2010, more than 80 percent of the counties in Guizhou province showed POP-SCIIc contraction, with a sharp increase in volume. The counties that showed population increase were sporadically distributed in the southwestern and central regions of Guizhou, where the population growth rate accelerated. It was worth noting that only Rongjiang and Leishan counties achieved POP-SCIIc basic cooperation during this period, and the number of SCIIc intensification dropped to zero. This variation demonstrated that the rate of increase in territorial spatial conflicts was lower than the rate of population growth during this time period. The number of counties exhibiting SCIIc intensification in Guizhou increased considerably between 2010 and 2020, accounting for about fifty percent of the total number in the province. This trend reflected the fact that the rate of territorial spatial conflict intensification in Guizhou Province far exceeded the rate of population growth during this period, and there was an urgent need to mitigate conflicts through refined territorial spatial planning effectively. However, only four counties, namely

Wanshan Special Zone, Liuzhi Special Zone, Dafang County, and Qianxi County, achieved POP-SCII<sub>C</sub> basic cooperation during this period, while the number of counties showing POP increase was zero, and the rest were in the state of POP-SCII<sub>C</sub> contraction.

The geographic spread of C<sub>POP</sub> outcomes in Guizhou between 1980 and 2020 is shown in Figure 13e. During this period, about ninety percent of the counties exhibited POP-SCII<sub>C</sub> contraction, i.e., the SCII in these areas was contrary to the population growth trend. Guanshanhu District and Wanshan Special Zone exhibit population increase, i.e., the rate of spatial growth in the country was less than the rate of population growth. Chishui City, Honghuagang District, Huaxi District, Weining County, Xingren County, and Pu'an County, on the other hand, show SCII<sub>C</sub> intensification, i.e., these areas urgently needed to pay attention to and resolve the incongruity between territorial spatial conflicts and population size. Qinglong County became the only county that achieved POP-SCII<sub>C</sub> basic cooperation, and maintained a better balance between changes in population size and territorial spatial conflicts.

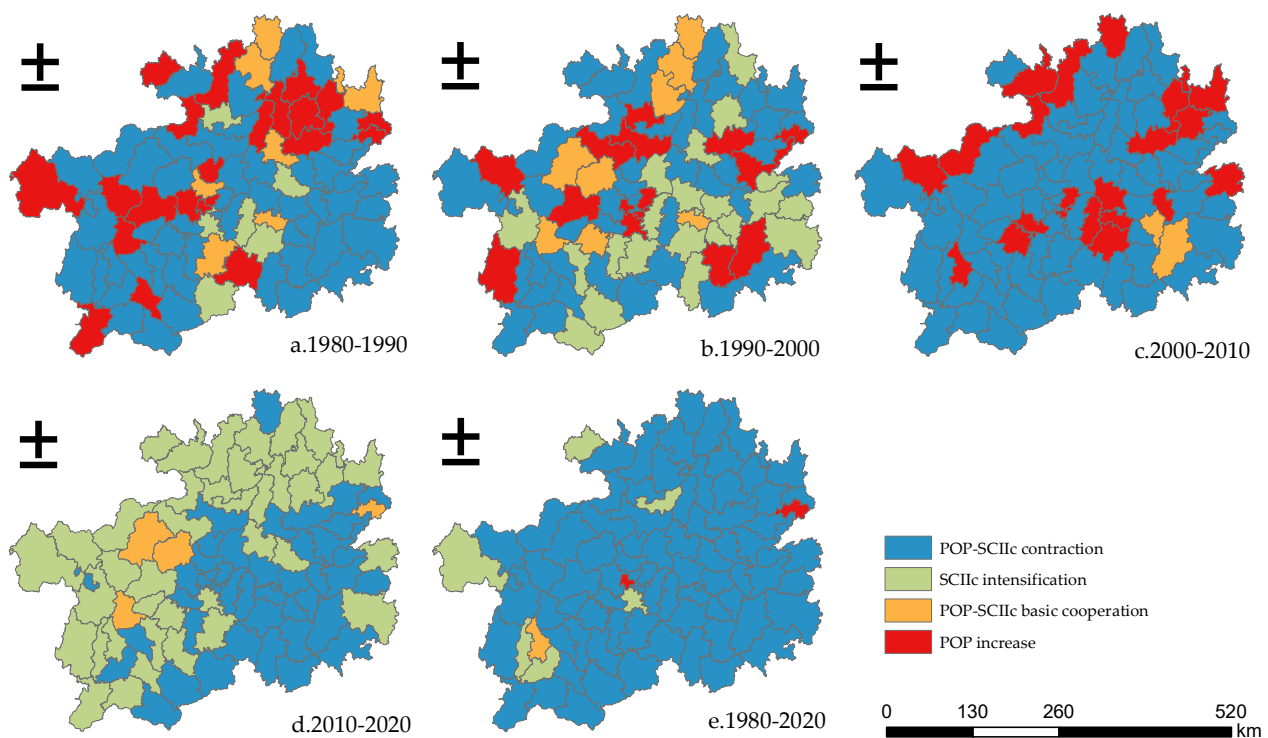


**Figure 13.** The C<sub>POP</sub> in Guizhou Province from 1980 to 2020.

#### 4. Discussion

This paper analyzed the spatial and temporal evolution of TSCs and CLE of Guizhou Province from 1980 to 2020, highlighting the land use challenges encountered during rapid urbanization and economic development. The research revealed that while the velocity and intensity of CLE in Guizhou Province have escalated over time, this expansion displayed considerable geographical variation across various locations. Furthermore, it identified the deficiencies in the existing literature about TSCs and seeks to address this gap by analyzing land use data alongside socio-economic elements in a cohesive manner. This study offered fresh perspectives and insights for future land spatial adjustment and planning by collaboratively analyzing the interaction between territorial spatial disputes and socio-economic issues.

#### 4.1. Main Conclusions

In this study, the TSCs and CLE in Guizhou Province from 1980 to 2020 exhibited dynamic evolution and interrelated characteristics. The CEV and CEI both increased over time, while the CEP exhibited significant variation across different stages, initially dominated by filled and enclave types, and later gradually shifting towards a spread type. This process exacerbated territorial spatial conflicts. The TSCs showed an overall upward trend, with an increasing number of high-conflict areas concentrated in the northwestern part. The relationship between TSCs and CLE demonstrated diverse correlations in various periods, with a weak correlation in the early stages and a significantly enhanced correlation from 2010 to 2020. In terms of causes, the demand for economic development, the acceleration of urbanization, and policy support collectively drove the expansion of construction land. On the other hand, resource constraints, the demand for agricultural development and cultivated land protection, and the need for ecological protection were the primary factors contributing to the increase in territorial spatial conflicts. This study thoroughly analyzed the bidirectional interactive relationship between the two, emphasizing that in the overall territorial spatial system, the irrationality of CLE is the direct cause of TSCs, and at the same time, the existence of TSCs further affected the patterns and paths of CLE. This interactive conclusion provides a more comprehensive theoretical basis for the optimization and conflict coordination of territorial spatial allocation, and also offers a new perspective and line of thinking for subsequent related research. This conclusion is roughly consistent with the existing research conclusions in Jiangsu Province [29].

#### 4.2. Management Policy Recommendations

This article examined the growth of construction land in Guizhou Province, assessing the changes in territorial spatial conflicts and their relationship with socio-economic factors. Therefore, considering the present situation in Guizhou Province, this study offered the following policy proposals.

##### (1) Optimization of land use structure

The identified trends in construction land expansion indicated a pressing need for a more strategic methodology in land use planning. Policymakers should optimize land use structures to harmonize urban development with environmental preservation. This may entail advocating for vertical development [38] instead of horizontal expansion where possible, fostering mixed-use developments, and prioritizing brownfield regeneration over greenfield development. This approach can mitigate pressure on land resources and improve land use efficiency.

##### (2) Clearing delineation of ecological and urban boundaries

The escalating territorial spatial conflicts highlighted the necessity of distinctly defining ecological and urban boundaries [39–41]. Establishing and maintaining urban growth boundaries can mitigate urban sprawl and safeguard ecologically vulnerable regions. This necessitated a coordinated endeavor to identify and delineate essential ecological areas and to include these in urban planning frameworks.

##### (3) Realizing human-land-coordinated development

The principle of human-land coordination highlighted the amalgamation of social, economic, and environmental goals in land management. Policies must seek to harmonize the demands and ambitions of the populace with the sustainable utilization of land resources. This may encompass community involvement in planning initiatives, investment in public infrastructure that promotes sustainable living, and the formulation of policies that advocate for sustainable agriculture and land management techniques.

#### (4) Reducing regional development gaps

The discrepancies in construction land expansion and territorial spatial conflicts across various regions of Guizhou Province underscore the necessity to rectify regional development imbalances. Policies must focus on underdeveloped regions through strategic investments in infrastructure, education, and technology to foster economic growth and alleviate pressure on land resources. This may also entail the advancement of regional economic collaboration to enable the exchange of resources and expertise.

#### 4.3. Contributions, Restrictions, and Prospective Work

Initially, it leveraged sophisticated geospatial analysis techniques, including Cold Hotspots Analysis, OLS, and GWR, which had rarely been combined in conjunction in prior research. This approach not only assessed the features of construction land expansion while simultaneously examining expansion patterns and the intensity of territorial spatial conflicts, thereby offering a novel perspective on land use changes. This article gathered and examined land use data from 1980 to 2020, enabling the identification of long-term patterns and cyclical variations in construction land expansion and territorial spatial conflicts. This addressed the limitations of prior research that were constrained by shorter data periods and incapable of properly capturing long-term changes. Third, it established a multidimensional indicator system comprising the CEV, CEI, CEP, and SCII<sub>C</sub>. These indicators provide dependable instruments for quantitative analysis, augmenting the systematic and scientific character of the investigation. Ultimately, by developing C<sub>GDP</sub> and C<sub>POP</sub>, it connected land use alterations to socio-economic indicators, elucidating the economic motivators and social consequences underlying land use changes, thus offering a more accurate foundation for policy development.

This study provided significant information, although it has limits. The dependence on historical land use data may inadequately reflect the latest alterations in land use patterns, especially during fast urbanization. The study predominantly concentrates on Guizhou Province, perhaps constraining the pertinency of the accumulations to other places with distinct geographical, economic, and cultural circumstances. Future studies should broaden the analysis to encompass more recent data and integrate new variables, including climate change effects, technological innovations, and policy alterations. Longitudinal studies that monitor the progression of land use and disputes over time can offer a more nuanced comprehension of these phenomena. Moreover, comparative analyses with other regions might provide insights into the applicability of the findings and the formulation of context-specific management solutions.

## 5. Conclusions

This study integrated land use data and diversified socio-economic data from 1980 to 2020 in Guizhou Province, with the help of constructed CLE indicators (CEV, CEI, and CEP) and TSCs, and combined cold hotspot analyses, OLS regression model and GWR regression model to deeply explore the spatio-temporal evolution of the relationship between CLE and TSCs. The study innovatively combined TSCs with socio-economic factors, providing a new perspective and analytical framework for rationally controlling the land space in Guizhou Province. The principal discoveries and contributions were as follows: The CLE in Guizhou from 1980 to 2020 exhibited variations in velocity, intensity, and pattern. The expansion escalated throughout time, predominantly in high-value locations located in the center and southern regions, including Guanshanhu District, Yunyan District, and Panxian County. Moreover, the territorial spatial conflicts in Guizhou Province exhibited temporal and regional variability, with a general upward trend over time. The incidence of high-conflict areas increased from 1980 to 2020, predominantly in the northwest region. The study found

that the relationship between construction land expansion and territorial spatial conflicts in Guizhou Province fluctuated over time and across different locations. Between 1980 and 1990, as well as from 2000 to 2010, the correlation was tenuous; nevertheless, it markedly intensified from 2010 to 2020, evidenced by elevated  $R^2$  values in GWR analysis.

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