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Regional Land Use and Ecological Security Assessment Based on GIS: A Case Study of Guiyang City

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Abstract

Ecological security research is a multidisciplinary field encompassing environmental science, geography and ecological ecology. This study selected Guiyang City as a case study for ecological security research. A total of 16 indicators related to ecological security were selected, and the PSR model was employed to construct an ecological security evaluation system for Guiyang City's land use, thereby conducting an analysis of the city's land ecological security. The results indicate that: (1) The surface landscape of Guiyang City is predominantly characterised by woodland and arable land. Over the past 15 years, land use in Guiyang has been favourable; whilst the area of land designated for construction has continued to increase, the area of arable land has shifted from a declining trend to an upward one. There have been no significant changes in water bodies or unutilised land, whilst the trend in woodland has been one of initial increase followed by a decrease. (2) Overall, Guiyang's ecological condition is sound, but its ecological security coefficient is gradually declining. The ecological security rankings for Guiyang in 2000, 2010 and 2015 were as follows: medium-high security index > high security index > medium security index > low security index > low-level security index.

Keywords

Ecological security, land use, land assessment

1. Introduction

In recent years, whilst China has experienced rapid economic development, environmental and ecological issues have become increasingly prominent. Frequent occurrences of soil erosion, land pollution and desertification have severely hampered regional sustainable development. The 14th Five-Year Plan, published in 2021, explicitly calls for optimising the pattern of land use and conservation, promoting green and low-carbon development, and strengthening environmental and

ecological governance (Yue, 2014). As an integral component of national security, ecological security encompasses two core aspects: firstly, the health and integrity of ecosystems themselves; and secondly, ensuring that human production and daily life are not threatened by environmental degradation (Wang, 2007). Conducting a scientific assessment of regional land ecological security is a fundamental task for identifying ecological risks, optimising land-use structures, and advancing the construction of an ecological civilisation.

Guiyang City is situated in central Guizhou Province and is characterised by a typical karst landscape, featuring undulating terrain and fragile ecosystems. Historically, food shortages led to the encouragement of land reclamation for farming, resulting in severe damage to forest resources; in the 1970s, the excessive exploitation of coal in areas such as Liupanshui and Bijie triggered a chain of ecological problems, including groundwater pollution and soil erosion (Xiao, Chen, & Guo, 2022). In recent years, with the acceleration of urbanisation, the continuous expansion of construction land and the excessive occupation of natural resources, the conflict between human activities and land use has become increasingly prominent. Consequently, conducting a dynamic assessment of land-use change and ecological security in Guiyang City to reveal its spatiotemporal evolution patterns holds significant practical importance.

Research on ecological security assessment can be traced back to the concept of environmental security in the 1940s. Subsequently, through the development of theories such as the ‘park system’, ‘garden city’ and ‘land-use differentiation strategy’, a research paradigm combining landscape ecology with land-use optimisation has gradually emerged (Xie, 2018). Internationally, Reshmidevi et al. utilised GIS and fuzzy inference systems to evaluate land suitability in agricultural catchments (Birkmann, 2007); Gabriel et al. constructed a multi-objective optimisation model for land use (Haber, 1990). Domestically, scholars such as Ma Keming began with a theoretical analysis of regional ecological security patterns, proposing the construction of a healthy pattern by eliminating interfering factors (Forman, 1995); Liu Yang et al. further integrated point, line, area and network elements into spatial layout to enhance the efficiency of land resource utilisation (Reshmidevi, Eldho, & Jana, 2009). In terms of evaluation models, the Pressure–State–Response (PSR) model and the Driving Forces–Pressure–State–Impact–Response (DPSIR) model are widely applied; among these, the PSR model has become the mainstream tool due to its clear logic and ability to intuitively reflect human–land relationships (Gabriel, Faria, & Moglen, 2006).

However, existing research has largely focused on macro-scales such as river basins or nature reserves, with relatively insufficient dynamic assessments of land ecological security in the south-western karst urban clusters; furthermore, most studies rely on static evaluations based on a single year, lacking in-depth analysis of long-term trends (Liu, Meng, & Zhu, 2010). Furthermore, the evaluation indicator systems often overlook key factors specific to karst regions, such as topographic undulation, vegetation cover and the distribution of ecosystem service values, thereby affecting the relevance of the evaluation results.

In light of these issues, this study takes Guiyang City as the research area and selects three time periods—2000, 2010 and 2015. With the support of remote sensing (RS) and geographic information system (GIS) technologies, a land ecological security evaluation index system based on the PSR model is constructed. The study systematically analyses the spatiotemporal characteristics of land use changes, calculates a comprehensive ecological security index, and classifies security levels. The study aims to reveal the patterns of evolution in land ecological security within karst regions, thereby providing a scientific basis for the optimisation of Guiyang’s territorial space and ecological conservation.

2. Research Methods

2.1 Pressure-State-Response Model

The Pressure-State-Response (PSR) model was developed through collaboration between the international academic community, economic organisations and political circles. This model features a relatively comprehensive and mature system of evaluation indicators; it is currently applied across a wide range of fields, is highly feasible and offers strong analytical capabilities. It is also a model widely used by numerous scholars and experts, primarily for assessing the extent of human activities’ impact on the ecological environment (Xu, Zhou, & Cheng, 2017). When constructing a PSR model, one should approach it from the three aspects of pressure, state and response. The concept of pressure indicators primarily refers to the negative impact of human social activities on the ecological carrying capacity and ecological capacity of environmental systems. It mainly encompasses three aspects of adverse effects on the ecological environment: firstly, natural factors; secondly, human factors; and thirdly, levels of socio-economic development. The concept of state indicators primarily refers to the current environmental quality, the allocation of natural resources, and the state of the ecosystem in a given region. State indicators also reflect the actual conditions of the region, namely its resource and environmental status and socio-economic development. The concept of response indicators primarily refers to the strategies humans adopt in response to changes in the ecological condition of their living environment. Response indicators reflect the measures taken by relevant government departments or individuals to maintain the sustainable development of resources when the regional carrying capacity of the ecological environment is reduced due to natural, human-induced or socio-economic factors.

2.2 Ecological Safety Assessment

This study will use ArcGIS software to conduct an overlay analysis of land use data for Huaxi District from 2005, 2010, 2015 and 2020 to conduct a superimposition analysis. This will ultimately yield changes in the area of land use types and the proportion of each land use type relative to the total area of the study area. From this, the primary land use types in Huaxi District and the changes in the area of each land use category can be determined. Furthermore, the land use transition matrix can be used to identify the patterns of transition between different land use categories in Huaxi District, whilst calculating the land use dynamism index will reveal the rate and magnitude of change in the area of land use types in Huaxi District. calculating the land use intensity reveals the extent to which land use

types in Huaxi District are influenced by human and natural factors; and calculating the land use diversity index provides an understanding of the variety of land use types and the complexity of land use in Huaxi District. Based on this research, the direction of evolution, dynamic changes and intensity of land use diversity in Huaxi District across different time periods can be determined, thereby enabling the formulation of appropriate optimisation proposals to address shortcomings identified in the evolution of land use diversity in Huaxi District.

2.3 Rate of Land-use Change

To determine whether an ecosystem is intact and healthy, an ecological security assessment must be conducted, involving a comprehensive analysis of factors affecting local ecological security, such as precipitation, land use patterns and conditions, changes in slope gradient, and greening rates. Only by ensuring the stability of the ecosystem can we safeguard various aspects of local security and stability, such as air quality, water resource conservation and climate regulation. This is also of paramount importance for the effective implementation of ecological civilisation and for aligning with China's philosophy of green and sustainable development (Chen & Wang, 2017). When conducting ecological security assessments, the first step is to investigate the various factors causing changes in the ecological environment and systems. This enables an objective analysis and evaluation of the current state of ecological security in the study area and any potential future fluctuations, thereby facilitating research into the various economic impacts within the region (Niu, 1989). When calculating ecological security indices, the comprehensive index method is typically employed. The composite index evaluation method combines multiple objectives in a rational manner, and uses this data to assess the safety status of the ecosystem. The objectives set encompass two aspects of the ecosystem's capacity: firstly, direct productive capacity; and secondly, indirect productive capacity. In addition, it should cover the processes of mutual influence between various factors within the ecosystem when it performs its service and supply functions. The formula for this is as follows:

$$Y_j = \sum X_i \times W_i \quad (1)$$

Where represents the comprehensive ecological security index of the j th grid cell, X_i denotes the standardised value of the i th indicator, and represents the weighting of the i th evaluation indicator.

The concept of ecological security has two dimensions. Firstly, it refers to the current health and integrity of the ecosystem. This concerns whether the ecosystem retains the integrity of its structure and the effectiveness of its functions when subjected to environmental influences; secondly, ensuring that human social activities and physical health are not adversely affected by severe environmental issues. Following the standardisation of ecological security values, the comprehensive ecological security evaluation index for land has been categorised into five distribution bands, thereby rendering the evaluation results clearer and more accurate. The five levels are: low level of security, mild level of security, moderate level of security, upper-moderate level of security, and high level of security (Table 1).

Table 1. Classification of Ecological Security Levels in Guiyang City

Grade	Safety value	System mode	System Characteristics
I	≥ 0.9	high security	The land resource ecological evaluation system is stable, with land resources virtually undamaged. It possesses a complete structure and well-developed functions, exhibiting no ecological issues and experiencing minimal ecological disasters, thereby truly achieving harmonious coexistence between humans and nature.
II	0.7~0.9	medium to high security	The land resource ecosystem is generally well-preserved, with only a minor portion experiencing damage; however, its functions remain intact. Areas affected by disturbances or damage typically exhibit self-repair capabilities, and no significant ecological issues are observed. Ecological disasters are also infrequent.
III	0.6~0.7	moderate safety	The service functions of the terrestrial ecosystem have degraded; the extent of ecological damage is generally moderate, and the ecosystem structure has undergone certain changes but remains largely intact. However, further disturbance or destruction would lead to additional deterioration, resulting in severe ecological issues.
IV	0.4~0.6	light safety	The land resource ecosystem has suffered significant damage and human interference, with substantial deterioration that has compromised its functionality. The ecosystem's structure is likely to deteriorate further, making reconstruction and restoration extremely challenging—a serious ecological issue.
V	≤ 0.4	low security	The land resource ecosystem has suffered significant human-induced interference and degradation, resulting in an incomplete ecosystem structure, weakened functions, and

considerable difficulties in restoration and reconstruction, with prominent ecological issues.

2.4 Developing an Evaluation Framework

The primary characteristics of the ecological security assessment process are its complexity and systemic nature. When conducting such assessments, it is important to note that the development of an indicator system requires the integration of knowledge from multiple disciplines; only in this way can a highly scientific and rational indicator system be established. Only by strengthening the development of the indicator system can the accuracy of ecological security assessment results be ensured. Furthermore, the development of the indicator system has a significant impact on the sustainability of the ecological security assessment. It is also important to recognise that when the environmental, economic and social conditions of the study area change, the indicator system employed will also need to be adjusted. In the PSR model, pressures and the corresponding indicators primarily reflect the key causes of the deterioration in the state of resources and the environment, as well as the need for further improvement and enhancement. Management of resources and the environment is of paramount importance; measures such as the efficient use of natural resources and the reduction of pollutant emissions must be implemented to alleviate the pressures facing these sectors. The PSR model comprises three components, with the ex-ante indicator—pressure—denoted by the letter P. At the pressure level, the government can undertake advance planning and design, and regulate the situation through relevant policies; the process indicator—response—is denoted by the letter R. At the response level, government administrative departments implement specific management activities; and the state (S) represents the final condition of the resources.

To ensure the accuracy and reliability of the research findings, this paper has selected indicators with high levels of scientific rigour, comparability and accessibility for analysis. It summarises relevant domestic and international research on how to conduct ecological security assessments. Furthermore, based on a thorough understanding and analysis of the study area, and in conjunction with the P-S-R theory, the specific circumstances of Guiyang City, environmental impact factors and data availability, the indicators have been carefully screened to construct the ecological security evaluation indicator system shown in Table 2. The Analytic Hierarchy Process (AHP) was employed to determine the weights of the indicators (Table 2).

Table 2. Ecological Security Evaluation Indicator System

Target layer/A	Policy level/B	Weight	Indicator Level/C	Weight
	natural	0.3921	terrain undulation	0.0432
	environmental		falling gradient	0.0476

Regional ecological security assessment	condition/B1		vegetation coverage rate	0.1736	
			water body coverage rate	0.0453	
			distribution of the value of ecological services	0.0824	
			density of population	0.037	
			human intervention index	0.0527	
	regional system pressure/B2	0.4223		per capita arable land area	0.1401
				Residential area buffer classification index	0.0649
				fertilizer load per unit area	0.0396
				volume of industrial wastewater discharged per unit area that fails to meet the standards	0.0457
				volume of industrial exhaust gas emissions per unit area that fail to meet the standards	0.0423
humanistic response/B3	0.1856		per capita gdp	0.0313	
			regional development index	0.0496	
			treatment rate for the three types of industrial waste	0.0661	
			the ratio of environmental protection expenditure to GDP	0.0386	

3. Overview of the Study Area

Guiyang, the provincial capital of Guizhou, is situated in the central part of the province. Its longitude ranges from 106°07' to 107°17', whilst its latitude ranges from 26°11' to 26°55'. It can be seen that its geographical location lies on the watershed between the Pearl River and Yangtze River basins. It features a subtropical monsoon climate with humid characteristics, with an average annual temperature of around 15.3°C and a long-term average annual precipitation of approximately 1,096 mm. In 2015, Guiyang's total GDP stood at 289.116 billion yuan, with a population of 4.6218 million and an urbanisation rate as high as 73.25%. Guiyang is divided into six districts, three counties and one city: the six districts are Yunyan, Nanming, Guanshanhu, Wudang, Huaxi and Baiyun; the three counties are Xiuwen, Kaiyang and Xifeng; and the city is Qingzhen.

The topography of Guiyang features higher elevations in the west and lower elevations in the east, with the central region sloping towards the east, south and north. Guiyang City is situated at a relatively high altitude, with an average elevation of 1,100 metres. The topography of Guizhou Province comprises four main types: plateaus, mountains, hills and basins, with plateaus and mountains accounting for the

largest proportion of the province’s land area. As the only province in China without any plains, Guizhou faces severe issues of land degradation and soil erosion due to both geographical conditions and human activity.

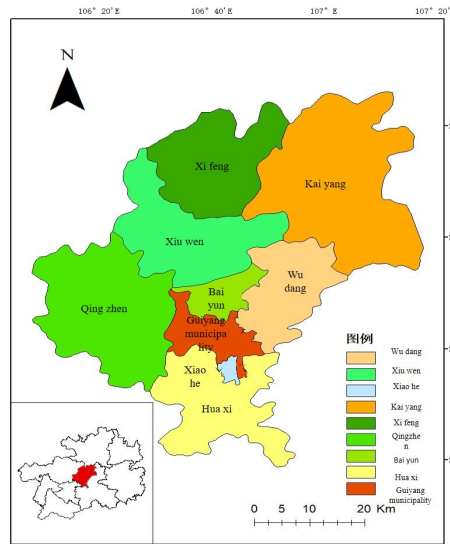


Figure 1. Study Area Diagram

4. Key Characteristics and Spatial Patterns of Ecological Security

4.1 Analysis of Current Land Use

The distribution of land cover in Guiyang City is characterised by a high proportion of forest and arable land, which occupy a significant area; conversely, other land types, such as built-up areas, water bodies, grassland and undeveloped land, cover a smaller area. Furthermore, forest land accounts for the largest proportion of the land cover, comprising approximately 50% of the region’s total area; arable land ranks second, accounting for around 30% of the region’s total area (Table 3).

Table 3. Changes in Land Use Types and Areas in Guiyang City

Land use type	2000		2010		2015	
	Area/hm ²	Percentage	Area/hm ²	Percentage	Area/hm ²	Percentage
Plough	236500	29.44%	225700	28.12%	228900	28.49%
Forest land	386300	48.09%	393800	49.06%	383300	47.72%
Meadow	152900	19.03%	138000	17.19%	143600	17.88%
Water body	9800	1.22%	13400	1.67%	10000	1.24%
Construction land	17200	2.14%	31000	3.86%	37000	4.61%
Unutilized land	600	0.07%	800	0.10%	500	0.06%

Amount to	803300	100.00%	802700	100.00%	803300	100.00%
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As can be seen from Figure 2, the various land categories in Guiyang City have undergone changes of varying degrees. The area of arable land fluctuated from 236,500 km² in 2000 to 225,700 km² in 2010 and then to 228,900 km² in 2015, showing a pattern of initial decline followed by an increase; overall, however, the area of arable land is on a downward trend. This may be attributed to the impact of economic development and the national ‘converting farmland to forest’ policy, as well as the expansion of rural and urban areas and the construction of infrastructure and roads, which have required the conversion of large tracts of farmland to forest. During periods of stable economic growth, the demand for land has decreased slightly. Similarly, the area of forest land has fluctuated, first increasing from 386,300 km² to 383,300 km², and then decreasing. Data indicates no significant change in the area of water bodies and unutilised land in Guiyang. The area of land for construction has seen the greatest increase, doubling since 2000. This is driven by the advancement of urbanisation and the rapid expansion of the city in recent years. The urban agglomeration effect has led to an increase in the rural surplus labour force, thereby boosting demand for housing. At the same time, transport infrastructure and industrial enterprises have further increased the demand for land for construction, resulting in a continuous expansion of the local area designated for construction.

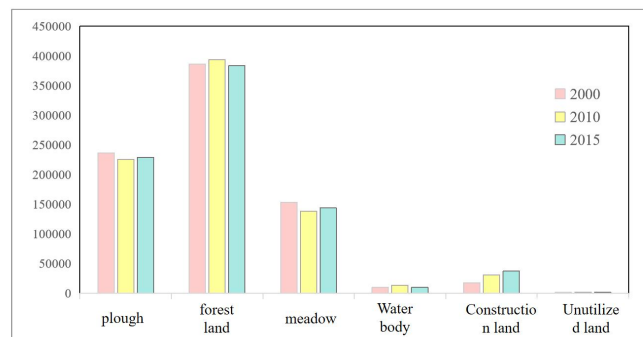


Figure 2. Area of Land Use Types in Guiyang City from 2000 to 2015

4.2 Spatial Atlas Analysis

In the context of land-use activities, humans and the land engage in interactions and transformations, such as energy conversion, the exchange of materials and value, and the exchange of information. Furthermore, land-use analysis requires the comprehensive consideration of various natural factors, including water, soil, air, topography and biota. Spatial analysis is a method that combines analytical data with attribute data to examine the spatial characteristics of research subjects within a region, such as their spatial distribution, morphology and patterns of change and development. Spatial pattern analysis refers to the process of generating LUCC (Land Use Change Classification) patterns through statistical analysis of surveyed data. By analysing these patterns, one can identify the key characteristics of land use type transformations within a specific geographical area over a given period.

This enables an understanding of regional land change trends and influencing factors, ultimately revealing the specific directions of land use transformation and the underlying patterns of their attributes.

Figure 3 illustrates that the main trend in the geospatial changes of various land use types in Guiyang City over the 15-year period from 2000 to 2015 was the conversion of arable land to construction land, which was particularly widespread in the city centre and Xiaohe District. Furthermore, the primary characteristic of land use spatial changes over the past 15 years has been a diffusion from the urban centre to the surrounding areas; changes between forest land and arable land were mainly observed in areas with relatively gentle topography; The data indicates that the conversion between forest land and grassland occurs primarily in three areas: Qingzhen City, Kaiyang County and Xiuwen County. As these areas are located at a considerable distance from the urban centre, they are less affected by construction activities and can be regarded as the result of natural succession.

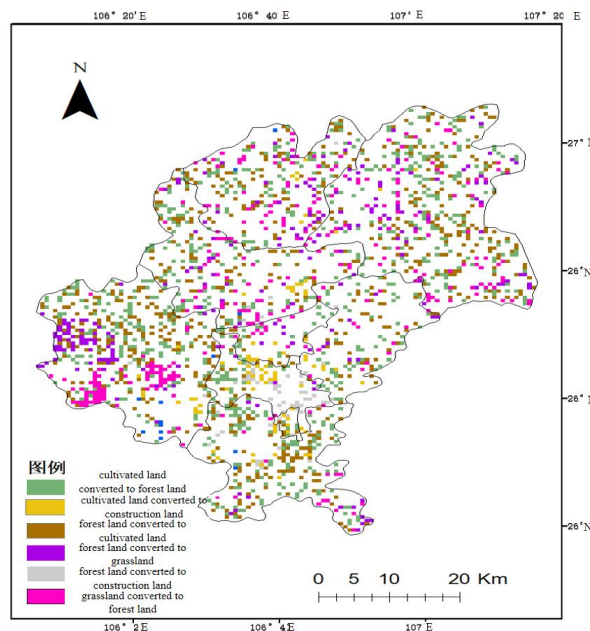


Figure 3. LUC Transfer from 2000 to 2015

Figure 4 shows that, during the study period from 2000 to 2010, the trends in the geospatial attributes of various land-use types in Guiyang City were characterised by the conversion of arable land into construction land within the urban area. Over the past decade, development in Guiyang has primarily spread from the centre to the periphery and from the main city outwards; simultaneously, as the steepness of the terrain decreases, forest land and arable land are more likely to be converted into one another; The conversion of forest land to grassland occurred primarily in areas outside the central urban district. As shown in Figure 4, during the latter part of the 10–15-year period within the 15-year study span, overall changes were relatively minor, consisting mainly of the conversion of farmland to construction land in a pattern of outward expansion from the Guiyang municipal area.

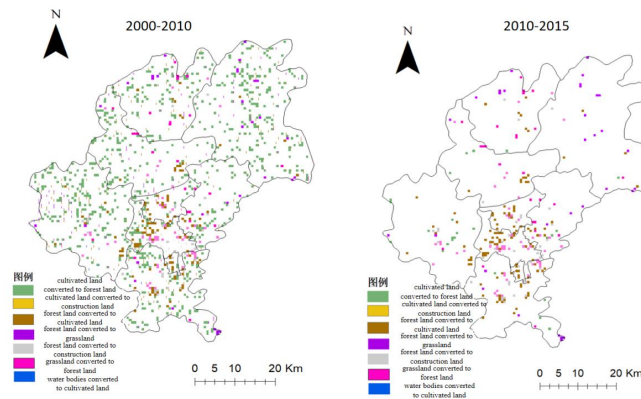


Figure 4. LUCC Transfer (2010-2015)

5. Ecological Security Assessment

5.1 Systematic Analysis of Land Ecological Security Pressure

Through the calculation of ecological security indicators, the analysis results are presented as follows (Figure 5). The findings indicate that overall, the land ecological security pressure index in Guiyang City from 2000 to 2015 exhibited a fluctuating trend of initial decline followed by an increase and subsequent decrease, dropping from an initial value of 0.2790 to a final value of 0.1993. Specifically, the index decreased from 0.2790 to 0.1341 between 2000 and 2007, rose from 0.1181 to 0.2594 between 2007 and 2012, and finally declined from 0.2465 to 0.1993 during the 2012-2015 period. According to current ecological security classification standards, the pressure index remained in an unstable and unsafe state from 2000 to 2007; it essentially entered a fully unsafe phase from 2010 to 2013, with 2012 marking a relatively high-risk period. Subsequent years saw no significant improvements, and the pressure index continued to rise, ultimately reaching a fully unsafe level. Thus, although the land ecological security pressure index in Guiyang experienced notable fluctuations over the 15-year period from 2000 to 2015, it remained predominantly in a relatively unsafe or unsafe state overall. An analysis of the pressure layer indicators reveals the following potential causes: During 2000-2007, Guiyang City experienced rapid socioeconomic development and continuous improvement in living standards, accompanied by a significant population increase—population density rose from 420 people/km² to 504 people/km², with the natural population growth rate reaching 4.6% in 2007. The combination of population pressure and insufficient land supply in Guiyang exacerbated human-land conflicts, resulting in a notable decline in the land ecological pressure index compared to 2000. From 2012 to 2015, both population density and growth rates decreased, alleviating pressure on the land ecosystem's capacity. Additionally, the industrial structure shifted steadily from agriculture (particularly aquaculture) toward finance and real estate, while the share of secondary industries such as manufacturing and commerce declined. Although the land ecological pressure index showed slight reduction during this period, the overall ecological pressure situation still requires further improvement.

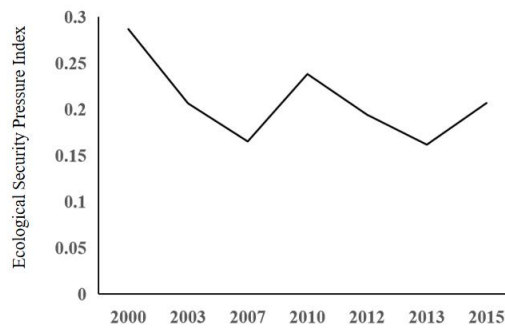


Figure 5. Land Ecological Security Pressure Index (2000-2015)

5.2 Systematic Analysis of Land Ecological Security Status

Through the calculation of ecological security indicators, the analysis results are presented as follows (Figure 6). The findings indicate that from 2000 to 2015, the overall land ecological security index in Guiyang exhibited a fluctuating pattern of initial decline followed by an increase and subsequent decrease, with minimal amplitude variation—falling from an initial value of 0.1596 to 0.0727 by the end of the period. The index experienced two turning points during the study period: 0.1114 in 2007 and 0.1349 in 2012. Analysis of the indicators and adherence to land ecological security standards reveal that the index remained in an unsafe state throughout 2000-2015, primarily due to the continuous decline in per capita cultivated land area (from 0.3 hm² per person to 0.064 hm² per person) and the significant reduction in the proportion of cultivated land. As cultivated land decreased, the security index correspondingly declined; however, the urbanization rate rose from 23.87% to 73.25%, markedly increasing land scarcity. Concurrently, the expansion of construction land areas led to greater imbalance in land supply, exacerbating ecological security challenges. Land ecological security showed slight improvement in 2012, with a per capita cultivated land area of 0.076 hm² per person and an urbanization rate of 68.13%. The highest urbanization rate (68.13%) in 2015 corresponded to the lowest per capita cultivated land area, resulting in Guiyang's lowest land ecological security index for that year.

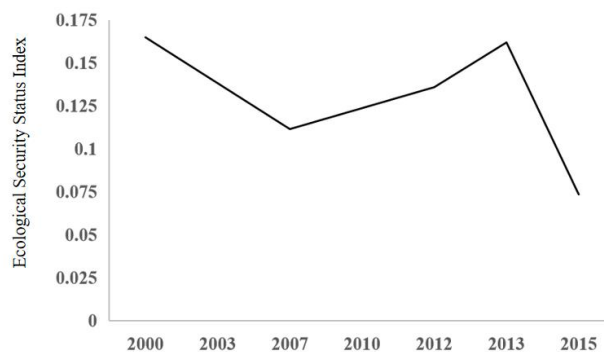


Figure 6. Land Ecological Security Status Index (2000-2015)

5.3 Analysis of the Land Ecological Security Response System

Through the calculation of ecological security indicators, the analysis yields the following results (Figure 7). The findings indicate that between 2000 and 2015, Guiyang's land ecological security index exhibited a fluctuating trend characterized by initial growth followed by decline and subsequent recovery. From 2000 to 2007, the index rose from an initial value of 0.0448 to a peak of 0.3276. The state index experienced two turning points during the entire study period: 0.1389 in 2007 and 0.0983 in 2012. Based on the land ecological security classification, the local ecological response index remained unstable between 2000 and 2013, indicating a trend toward insecurity. From 2013 to 2015, the index fluctuated between safe and unsafe levels. Further analysis of the index changes and their underlying causes reveals that rapid economic growth driven by shifts in Guiyang's industrial structure—along with accelerated increases in both rural and urban incomes—played a key role. Urban per capita income surged from 6,453 yuan to 27,241 yuan, while rural per capita income rose from 2,100 yuan to 11,900 yuan. These improvements in income and quality of life heightened public awareness of the importance of land protection. During this period, both the guaranteed crop yields under drought and flood conditions, the proportion of effectively irrigated land, and the afforestation area on barren mountains and sandy lands increased. The effectively irrigated area rose from 12.1% to 31.2%, while the afforestation area on barren mountains and sandy lands expanded from 3,384.47 hectares to 3,974.67 hectares. This indicates that during the study period, Guiyang City implemented numerous measures to address land use issues and improve land ecology, resulting in a continuous increase in the land ecological security response index.

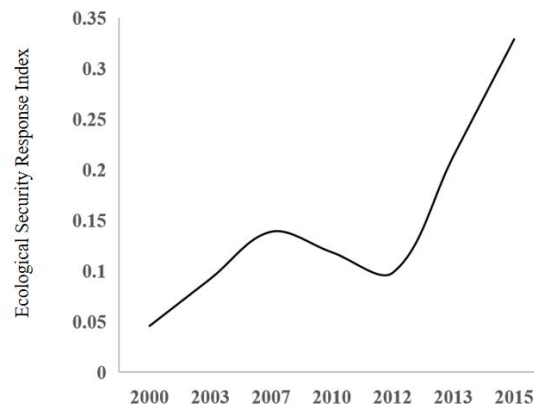


Figure 7. Land Ecological Security Response Index (2000–2015)

5.4 Analysis of the Land Ecological Security Response System

In order to analyse the survey results more clearly, this paper has established five categories for assessing the level of an area's ecological security index: low ecological security, moderate ecological security, high ecological security, and very high ecological security.

Utilising the spatial analysis functions of ArcGIS, and based on the PSR model and ecological

classification standards, the results are presented in the urban ecological security distribution maps for Guiyang City for the years 2000, 2010 and 2015 (Figure 8). Analysing the entire study period, Guiyang's comprehensive ecological security index shows a gradual upward trend from bottom to top and from left to right; however, the fluctuations in the distribution of ecological security do not exhibit significant variations. The central urban area of Guiyang has the lowest ecological security index, whilst Kaiyang County has the highest.

Subsequently, the ecological security index for Guiyang City was further calculated, using the three years 2000, 2010 and 2015 as examples. The index range for 2000 was 0.106–0.978, whilst that for 2010 was 0.081–0.954, and finally, the range for 2015 was 0.075–0.967. In terms of average values alone, these were 0.691, 0.657 and 0.672 respectively. Furthermore, survey data from these three years indicate that over 65 per cent of the region's area was classified as having moderate or higher ecological security, with the respective percentages being 69.2 per cent, 66.7 per cent and 67.4 per cent. During the survey period outlined above, the overall land conditions in the study area were generally favourable; however, the region's ecological security index has been on a gradual downward trend, and the authorities should pay greater attention to this issue.

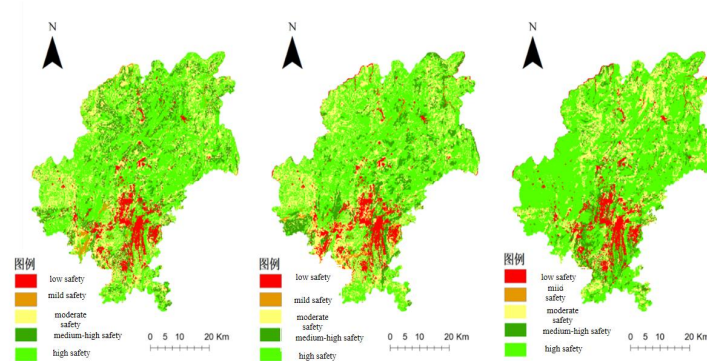


Figure 8. Distribution Maps of Urban Ecological Security in 2000, 2010, and 2015

6. Conclusion

This study integrates remote sensing data from satellite observations conducted in 2000, 2010, and 2015. Utilizing advanced techniques such as remote sensing analysis software, it investigates land use patterns and generates fundamental data on land utilization. Subsequently, multiple mathematical models—including maps of land use extent and spatial transitions—are developed to examine the spatiotemporal characteristics of LUCC (Land Use Change and Carbon Sequestration) in the Guiyang region over the past two decades. Building on these findings, the P-S-R model is employed to reconstruct the Guiyang ecosystem assessment framework. Advanced technologies like RS (Radar Satellite) and GIS are then applied to obtain ecological security spatial data for the region in recent years. The study ultimately yields the following conclusions:

- (1) The surface landscape of Guiyang is predominantly composed of forest land and cultivated land.

Over the past 15 years, the characteristics of land use are clearly observable: construction land, like other regions across the country, has continued to expand, increasing from 17,200 hm² to 37,000 hm²—a total increase of 19,800 hm². Cultivated land initially decreased but later recovered, shrinking from 236,500 hm² in 2000 to 228,900 hm² in 2015, a reduction of 7,600 hm². However, the current status of water bodies and unused land remains unclear, and the forest land area in this region first expanded before contracting.

(2) The spatial area attributes among various land types exhibited significant changes. From 2000 to 2015, all land types underwent variations and conversions to varying degrees. The area with relatively stable land use attributes totaled 1,038,371.67 hm², accounting for a substantial 80.85% of the surveyed area in this study. Among the lands where land use attributes changed, the largest area shift occurred from forest land to cultivated land, while the smallest was from water bodies to cultivated land. The intermediate categories included transitions from cultivated land to forest land, forest land to grassland, cultivated land to construction land, forest land to unused land, and grassland to forest land, collectively covering 92.58% of the total area affected by land use type changes.

(3) Based on the aforementioned research data, the surveyed area in this study demonstrates relatively stable land ecological security, although its ecological security index shows a gradual decline. Comparing Guiyang City's ecological security rankings from 2000, 2010, and 2015 reveals a consistent hierarchy: High Security Index > High Security Index > Moderate Security Index > Low Security Index > Lowest Security Index. However, the actual distribution of ecological security coverage in Guiyang remains unstable. For instance, the indices for 2000 ranged from 0.106 to 0.978, those for 2010 from 0.081 to 0.954, and for 2015 from 0.075 to 0.967; their average values were 0.691, 0.657, and 0.672, respectively. Data from these three years indicate that over 65% of the area achieved moderate or higher security levels, accounting for 69.2%, 66.7%, and 67.4% respectively.

7. Discussion

This study selected Guiyang City as a case study for ecological security research, identifying 16 indicators related to ecological security and employing the PSR model to establish a land ecological security evaluation system for the city, thereby conducting a comprehensive analysis of its land ecological security. However, due to the limitations of the authors' expertise, the paper exhibits several shortcomings: the research methodology relied solely on the PSR model without integrating multiple approaches, and the relatively short time span of the study resulted in limited comparability of findings. The study only yielded preliminary security assessment results and basic land use analysis, without further exploration of driving factors or future trends in land use—a direction worthy of deeper investigation. The selection of indicators in the data analysis phase involved subjective considerations, leading to discrepancies between the derived land use patterns and actual conditions. Future research should optimize indicator selection, deepen the analysis of underlying causes for lower ecological security rankings, and continuously refine the methodology for practical applications.

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