Spatiotemporal Evolution of Construction Land Expansion in the Central Yunnan Urban Agglomeration from 2010 to 2020

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Abstract: Based on the land use data of the Central Yunnan Urban Agglomeration (CYUA) for the years 2010, 2015, and 2020, the temporal and spatial characteristics of urban construction land expansion, including its stages, agglomeration, and direction, were analyzed. The results indicate that: (1) In terms of expansion rate and intensity: Between 2010 and 2020, the rate of construction land expansion in the CYUA showed a trend of "first increasing and then decreasing," while the expansion intensity gradually declined. Overall, the CYUA is a slowly expanding urban agglomeration, but there are significant differences in expansion intensity across different regions. (2) In terms of expansion patterns: The overall pattern is a coexistence of sprawl and infill, characterized by continuous infill within the cities and outward sprawl.
***Keywords*:** central Yunnan Urban Agglomeration (CYUA), construction land expansion, spatiotemporal characteristics, influencing factors

1. Introduction

The expansion of urban construction land is a hot topic in the field of geography, with research content including the characteristics of construction land expansion, research methods, and influencing factors. In terms of the study of expansion characteristics: Izuru Saizen by analyzing the changes in urban land use in the Osaka region of Japan from 1979 to 1996, concluded that urban land use was expanding in a disorderly manner[1]. Gu Chaolin categorized the types of urban growth into concentric circle, axial, dispersed cluster, and ribbon growth types[2]. Liu Xiaoping proposed the landscape expansion index to identify three expansion patterns: infilling, edge-expansion, and outlying[3]. In terms of the research methods employed: With the advancement of technology, GIS and RS technologies have been widely applied in the study of construction land expansion. Ademola K Braimoh simulated the expansion process of urban built-up areas in Lagos City by analyzing remote sensing images of urban land use[4]; C.M. Mertes utilized MODIS data to study the urban development processes in 15 countries across East and Southeast Asia from 2000 to 2010[5]; Liu Shenghe employed GIS spatial statistical analysis and used the annual average expansion intensity index to study the characteristics and patterns of urban land expansion[6]. In the exploration of influencing factors, Bao Liping conducted an in-depth study on the driving factors of urban construction land expansion[7]. Through analysis, it was concluded that social development, the growth of the non-agricultural population, and the construction of transportation infrastructure are the main forces driving the expansion of urban construction land, while national policies cause the expansion of urban construction land to exhibit periodic fluctuations. Hu Xiaomin explored the changes in landscape composition and configuration characteristics in Hunan Province over the past 30 years, arguing that topographic factors cause spatial differentiation in construction land expansion, and population growth and accelerated urbanization promote construction land expansion, thereby enhancing landscape heterogeneity[8].

2. Overview of the Study Area and Data Sources

2.1 Overview of the Study Area

The CYUA is located in the central and eastern part of Yunnan Province (22°59′34″—27°03′19″N, 100°43′7″—104°49′40″E). It is composed of Kunming City, Qujing City, Yuxi City, Chuxiong Yi Autonomous Prefecture, and seven counties and cities in the northern part of Honghe Hani and Yi Autonomous Prefecture, including Mengzi City, Gejiu City, Jianshui County, Kaiyuan City, Mile City, Luxi County, and Shiping County.

Figure 1. Geographical location map of the study area

2.2 Data Acquisition and Preprocessing

The land use data for the CYUA was sourced from the Resource and Environment Science and Data Center of the Chinese Academy of Sciences (http://www.resdc.cn). The study periods selected were 2010, 2015, and 2020. The land use data classification system adopts a three-tier classification system. The classification accuracy reaches 97.3%, with a resolution of 30 meters, meeting the precision requirements of the study.

3. Research Methodology

3.1 Expansion speed and intensity of construction land

The changes in construction land can be calculated using the expansion speed and expansion intensity, reflecting significant temporal variations in construction land. The formula is as follows:

$$S = \frac{U_b - U_a}{T}$$

$$V = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100$$

In the formula, S is the expansion speed of construction land; V is the expansion intensity of construction land; U_a and U_b are the area of construction land in the base year and target year of the stage, respectively. T is the time span. According to the expansion intensity, urban expansion types can be divided into five categories: high-speed expansion type ($V>20$), rapid expansion type ($14<V\leq20$), medium-speed expansion type ($10<V\leq14$), low-speed expansion type ($6\leq V\leq10$) and slow expansion type ($V<6$).

4. Results and Analysis

4.1 Overall Characteristics of Construction Land Expansion

The construction land area of the CYUA increased from 1815.8 km² in 2010 to 2661.6 km² in 2020, representing an expansion of 48.28%. The average annual expansion area was 86.7 km², indicating a growth trend in construction land area. Table 1 illustrates the basic characteristics of the construction land expansion in the CYUA between 2010, 2015, and 2020. Overall, from 2010 to 2020, the expansion rate of construction land in the CYUA exhibited a trend of "first rising and then declining," with the expansion intensity gradually decreasing. The CYUA is generally classified as a slow expansion type ($K < 6$), but there are significant differences in expansion intensity among different regions. Particularly after 2015, the intensity of expansion has gradually decreased. By analyzing the bar charts of construction land expansion intensity and speed changes in 2010, 2015, and 2020 (Figure 2 and Figure 3), it is evident that there are distinct regional characteristics, as illustrated in the figures.

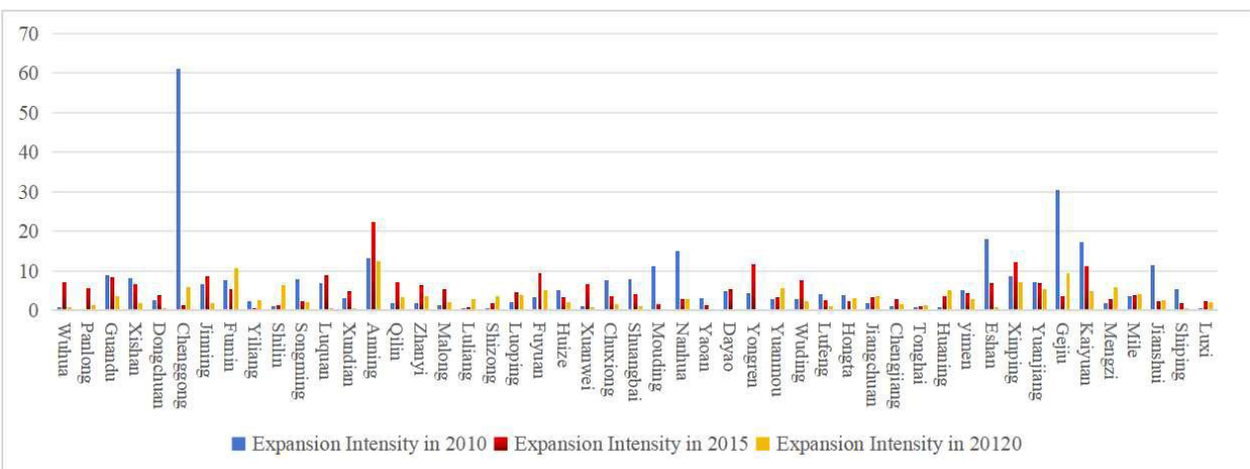

Figure 2. Bar Chart of Changes in Construction Land Expansion Intensity in the CYUA for 2010, 2015, and 2020.

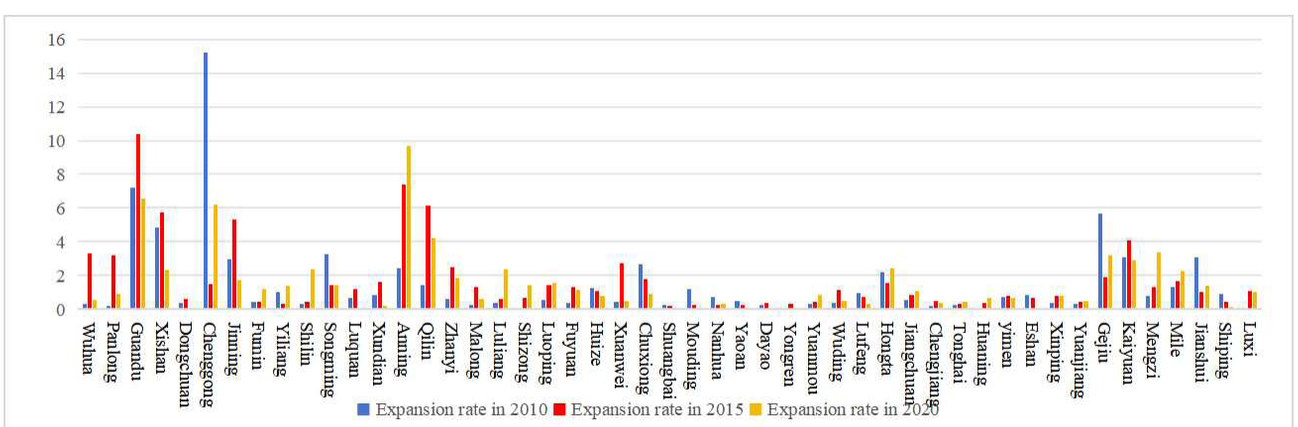

Figure 3. Bar Chart of Changes in Construction Land Expansion Speed in the CYUA for the Years 2010, 2015, and 2020.

4.2 Spatial Variation Characteristics of Construction Land Expansion in the CYUA

The spatial distribution of construction land expansion in the CYUA exhibits two characteristics. On one hand, the newly added construction land is continuously filling the gaps around the original construction land, manifesting as infill expansion. On the other hand, the expansion is gradually shifting from point-based to area-based, showing a clear trend of sprawl.

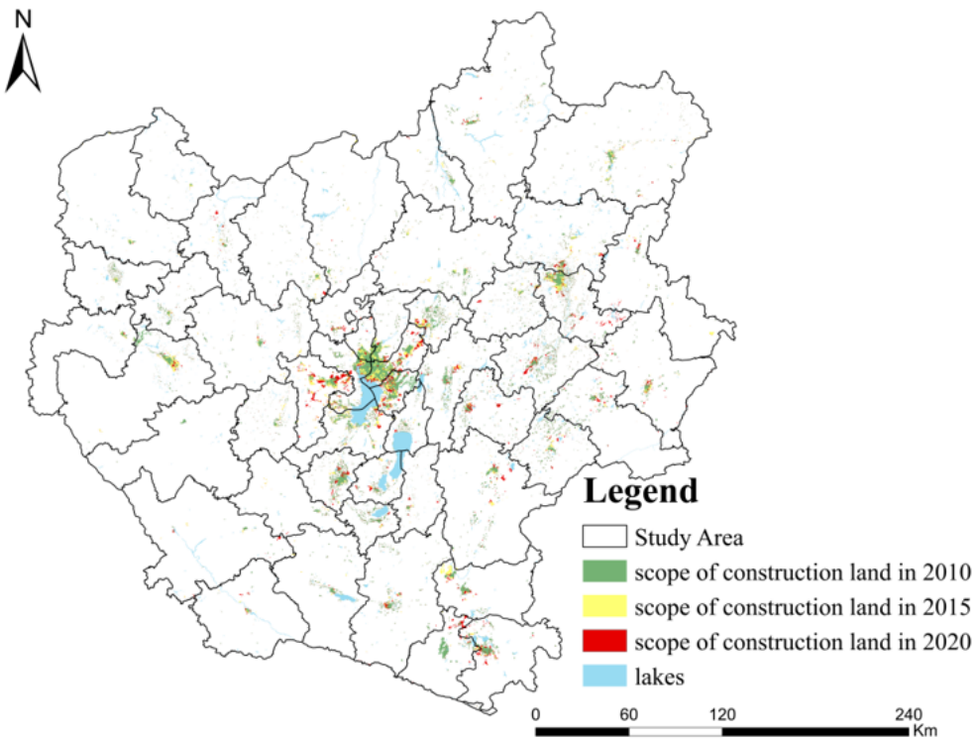

Figure 4. Changes in Construction Land in the Central Yunnan Urban Agglomeration in 2010, 2015, and 2020.

Specifically, Kunming has gradually developed a contiguous, radially expanding pattern centered around its core. The construction land on the northeastern shore of Dianchi Lake has progressively spread towards the southwestern shore, ultimately forming a complete "ring around Dianchi" construction belt. In addition to the "ring around Dianchi" expansion area, there are four expansion centers in the CYUA — Qilin District, Chuxiong City, Mengzi City, and Hongta District — all exhibiting radial outward expansion characteristics. Meanwhile, the peripheral regions exhibit different expansion characteristics compared to the core areas. Due to weak economic foundations and limited policy support, the expansion of construction land in these areas is more scattered, failing to form a stable contiguous expansion trend.

5. Conclusion

(1) The expansion characteristics of the CYUA are evident. In terms of expansion intensity and speed: from 2010 to 2020, the expansion speed of construction land in the CYUA exhibited a trend of "first rising and then falling," while the expansion intensity gradually decreased. Overall, the CYUA belongs to the slow expansion type.

(2) In terms of expansion patterns: they are mainly infill and sprawl types, manifested as continuous sprawl on the urban periphery and continuous infill within the city. Meanwhile, the area of construction land in various cities, districts, and counties continues to increase, showing an increasingly dense urban landscape layout.

(3) In addition, urban expansion is mainly driven by economic development and policy guidance, promoting the rapid development of the CYUA.

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