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# Temporal and Spatial Characteristics of Urban Morphological Evolution in Chenggong District of Kunming Based on GIS

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**Abstract.** In recent years, with the acceleration of urbanization and the rapid growth of urban population, the impact of urban human activities on the ecological environment system has become more and more significant. How to scientifically analyze the evolution characteristics of urban spatial form and demarcate the urban extension boundary scientifically and reasonably is of great significance to grasp the urban development context, construct a scientific and reasonable urban spatial form framework and guide the healthy and sustainable development of the city. This paper takes the Chenggong District of Kunming City, which has been developing rapidly in recent years, as the research object. It uses the Landsat remote sensing satellite image data onto different periods to extract the information on the land use type of the study area, and then combines the GIS technology to analyze the temporal and spatial characteristics of the urban form evolution in the Chenggong District. Finally, qualitative analysis is carried out in the aspects of the natural environment, policy orientation, economy and society in combination with the evolution of urban form. After introducing the four types of indicators: extended annual speed, extended dynamics, extended intensity and extended comprehensive index, the urban form evolution of Chenggong District was quantitatively analyzed. It was found that Chenggong District was in the stage of rapid development of urbanization in the past 15 years. There is obvious differentiation in the pattern the southwest and northwest directions are the main expansion directions, and the southeast direction is the slowest. Natural factors have greatly restricted the expansion of Chenggong District. The development of economic construction and policy planning has become the main driving factors for urban land expansion and space-time evolution.

## 1. Introduction

Urban spatial morphological structure refers to the interaction and interrelationship between urban functional space or city within a certain area, and the location relationship, distribution form, agglomeration scale and degree of space and phenomenon reflecting this relationship[1]. In recent years, with the rapid development of cities, the urban form has undergone major changes, and urban form change is an important indicator for scientific measurement and evaluation of urban expansion. By analyzing the characteristics of urban form evolution by linking it with urban land use change, it can provide a certain spatial reference to urban land space optimization and environmental protection in the context of rapid urbanization[2-6]. Rapid urbanization is the main problem driving the



transformation of urban and surrounding land uses types. Foreign scholars have studied urban spatial structure earlier and the theory has become more and more perfect. Due to the late start of relevant research in China, the study of urban morphological structure mainly focuses on the use of mathematical deduction and mathematical models[7-13]. This paper uses GIS spatial analysis technology to analyze the internal spatial structure and urban form evolution of Chenggong District of Kunming City. This paper discusses the characteristics and evolutionary factors of urban evolution law, and provides a scientific basis and decision support for guiding the future urban development of Chenggong district. It also provides reference and reference for other quantitative urbanization morphological evolution quantitative analysis research.

## 2. Research area overview

Chenggong District is located in the southeast of Kunming City, Yunnan Province. It is located at 102° 45' -102° 59' east longitudes and 24° 21' -24° 45' north latitude. In 2003, Yunnan Province launched a modern new Kunming construction and took the lead in developing Chenggong County. In 2011, administrative center of Kunming moved to Chenggong. In the same year, Chenggong County was established. At present, the administrative center and the university city of Kunming City are established in the area of Chenggong district, with a resident population of about 400,000. However, along with the rapid development of Chenggong district, problems such as advanced urbanization of the land and insufficient urbanization of the population have emerged.

## 3. Data Sources and Data Processing

The data of the indicators required in this paper are from Chenggong Yearbook (2014) and Kunming Yearbook (2014). The remote sensing data were obtained from the Landsat series of satellites on February 9, 2002, May 6, 2007, April 20, 2013, and March 14, 2017.

This paper analyzes the spectral and spatial information of ground objects based on the differences of different features in remote sensing images. Select corresponding features, and divide the pixels in the remote sensing image into different categories to obtain the information corresponding to the actual feature of the remote sensing image[14-16]. Supervised classification method is used to extract various land use information in Chenggong District, which mainly obtains remote sensing information of construction land in Chenggong District.

## 4. Research method

### 4.1. Analysis of construction land expansion speed

This In order to reveal the evolution law of urban construction land in the study area and the more accurate quantitative analysis of the expansion speed of construction land in the Chenggong District, the urban expansion annual speed index is introduced to characterize the overall scale and trend of the construction land in each stage. The calculation formula is:

$$V = \frac{U_b - U_a}{T} \quad (1)$$

In the formula, V represents the annual expansion speed,  $U_a$  is the construction land area in the first year of the study year span,  $U_b$  is the construction land area in the last year of the study year span; T is the time span, the unit is the year.

### 4.2. Analysis and analysis of urban expansion dynamics

Introduce the urban expansion dynamics index, which refers to the annual change rate of construction land in quantity, and quantitatively analyze the rate of change in urban land use. The formula is as follows:

$$K = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\% \quad (2)$$

In the formula, K is the extended dynamic degree;  $U_a$  is the construction land area in the first year of the research year span,  $U_b$  is the construction land area in the last year of the research year span; T is the time span, and the unit is the year.

#### 4.3. Urban expansion intensity analysis

The index of urban expansion intensity is actually the standardization of the average expansion rate of construction land by unit land area. The formula is as follows:

$$UI = \frac{U_b - U_a}{U} \times \frac{1}{T} \times 100 \quad (3)$$

In the formula, UI is the expansion intensity;  $U_a$  is the construction land area in the first year of the study year span,  $U_b$  is the construction land area in the last year of the study year span, U is the total land area of the study area; T is the time span, the unit is the year.

#### 4.4. Extended comprehensive index analysis

All of the above three indexes only calculate the expansion of the city from a single perspective. Therefore, combined with the above three factors, the normalization process is introduced, and the extended comprehensive index is introduced. The formula is as follows:

$$SI = \frac{U_b - U_a}{U_a} \times \frac{1}{U} \times \frac{1}{T} \times 10000 \quad (4)$$

In the formula, SI is the extended comprehensive index;  $U_a$  is the construction land area in the first year of the study year span,  $U_b$  is the construction land area in the last year of the study year span, U is the total land area of the study area; T is the time span, the unit is the year.

#### 4.5. Analysis of Spatial Characteristics of Urban Form Evolution

Using Arcgis tools to make a map of the construction land in the Chenggong District. First selects the midpoint of the image as the point buffer analysis of the point buffer. The buffer distance is set to 2km and the buffer number is 10. Then create a line layer and divide the buffer into 8 parts. Finally, the construction of the Chenggong District in 2002, 2007, 2013 and 2017 will be superimposed with the map layer. Among them, different colors represent the distribution of construction land in different periods. The result is shown in Figure 1.

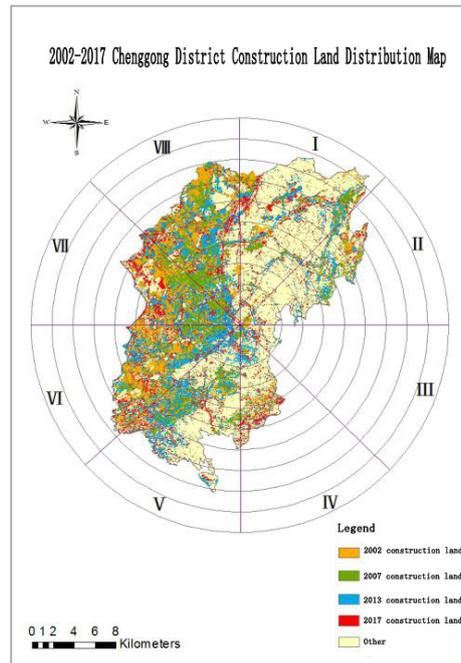


Figure 1. Urban morphology evolution of Chenggong District

The distribution map of the construction land in Chenggong District can reflect the spatial and temporal characteristics of the urban form evolution of the Chenggong District in the past 15 years. The construction land is expanding continuously, and it presents a continuous expansion method. On the basis of 2002 to 2007, while the construction land expanded outward, it began to spread a certain distance to the east, but the construction land is still distributed in the V—VIII quadrant. In 2013, on the basis of 2007, there was a filling expansion of construction land, and the expansion changed significantly. Construction land in 2017 is almost full of VI-VIII quadrant. Therefore, the main expansion direction of the construction land in the Chenggong District in the past 15 years is the V-VIII quadrant, namely the northwest and southwest directions. This expansion is mainly affected by geographical factors. The southeast and northeast of Chenggong District are all high mountains. The terrain is high in the east and the west is low. Therefore, the expansion of construction land in Chenggong District is mainly concentrated in the western region.

## 5. Results and analysis

The expansion of urban space can be considered as the result of the interaction of internal factors and external factors. Internal adaptive factors such as climate, hydrology, topography and other geographical environments allow the city to retain its initial shape and characteristics during development and become an important condition limiting urban land expansion[17]. External driving factors affect urban development speed and urban form as well as spatial and regional patterns, including urban innovation factors, urban agglomeration factors, and urban location factors. Among them, economic development and population growth are the fundamental driving force for urban land expansion[18]. The spatial expansion of urban land use in Chenggong District of Kunming City and the temporal and spatial evolution of urban form is formed in a timely manner under the natural environment, policy orientation, economic and social factors. In terms of natural factors, southeast and northeast of Chenggong District are both high mountains and adjacent to Yangzonghai in the east. The terrain is high in the east and low in the west, so the development center of Chenggong District is relatively flat northwest and southwest. In terms of policy, Chenggong District, as the administrative center of Kunming City, has gathered a number of universities and high-tech industrial parks. The construction of a large number of public service facilities has led to significant changes in the urban

area of Chenggong District. In terms of social factors, the population of Chenggong District has changed the spatial form of Chenggong District with the migration of a large number of people and the rapid development of public transportation.

## 6. Conclusion and discussion

In the context of rapid urbanization, the emergence of urban functional form space leads to the evolution of urban spatial structure. With the support of GIS technology, through the processing and analysis of remote sensing data, this paper studies the expansion and evolution of urban construction land in Chenggong District of Kunming City from 2002 to 2017, and discusses the driving factors of its expansion. Using spatial analysis technology, quantitative analysis of urban spatial structure evolution in Chenggong District of Kunming City, reveals the characteristics of agglomeration and diffusion of internal functional space and the evolution of urban form. The conclusions are as follows: First, the urban form evolution of Chenggong District has obvious spatial and temporal characteristics. The area of construction land in Chenggong District has been growing at a high speed in the past 15 years. The expansion and change in 2002-2007 are obvious, 2007-2013 the expansion change is most significant, and the expansion rate slows down in 2013-2017, but the change is still obvious. The second is to analyze the dynamic mechanism of the spatial evolution of the Chenggong District. It is considered that scientific planning is the core of the evolution of spatial form. Economic space agglomeration is the main driving force, and administrative management is the decisive factor. Finally, relevant opinions on optimizing land development are proposed for the future development of Chenggong District in Chenggong District.

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