ISSN: 2414-1895 DOI: 10.6919/ICJE.202510_11(10).0003

Research on Urbanization Process of Zhanjiang City's Municipal Area based on Remote Sensing Information

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Abstract

The data source mainly used is landsat TM/OLI image, and the application supervision supervised method is used to extract the urban construction land information of Zhanjiang City area in 2000, 2005, 2010 and 2015, combined with Zhanjiang Yearbook data. Analyze its temporal and spatial variation characteristics and its driving force. The research results show that: (1) The construction land of Zhanjiang City has increased from 18.43 square kilometers to 163.90 square kilometers. (2) Urbanization showed internal development from 2000 to 2010 and expanded outward from 2010 to 2015. (3) The driving factors of urbanization are mainly population growth, government policies,and population growth.

Keywords

Zhanjiang City; Remote Sensing Image; Driving Force; Building Land; Time and Space Changes.

1. Introduction

Since the beginning of the 21st century, China's urbanization has been accelerating continuously and has entered a peak period. The scale of cities and their populations has been growing rapidly, and the economy has been developing at a high speed. The rapid development of urbanization has a significant impact on the surface morphology. Since the 21st century, the form and pattern of urban construction land in the urban districts of Zhanjiang City have undergone considerable changes. The expansion of urban construction land has been rapid, and the urbanization process has been accelerating. Monitoring the dynamic changes of cities using remote sensing and geographic information systems is one of the application directions of urban remote sensing. It can accurately grasp the coverage changes of urban construction land use [1]. By using geographic information systems as a tool to process and analyze spatial data, the characteristics of the changes in urban construction land in the urban districts of Zhanjiang City can be further obtained. The spatial expansion of urbanization is an indicator of the level of urbanization [2, 3]. Therefore, conducting research on specific issues in a certain area, using remote sensing technology to monitor the dynamic situation of urban land use, and studying the patterns and regularities of land use changes, the result is to grasp the situation and changes of urban land use, thereby providing technical support for planning, decision-making, and management by government departments. During the process of urbanization, various problems arise, such as various contradictions in the utilization of land resources and unregulated land use methods. Therefore, how to handle the relationship between humans and nature requires analysis from various aspects. At the same time, if people need to understand the changes in land and make scientific predictions, it is necessary to analyze the driving factors. Although the natural environment plays a dominant role, it does not change within a few decades [4, 5]. Human behavioral interference has a more significant impact on land use changes, and human factors have a decisive influence in a short period of time. This article only analyzes the driving factors related to the urban districts of Zhanjiang City and analyzes the process of land changes.

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2. Overview of the Study Area and Data Processing

Zhanjiang is located in the southwest of Guangdong Province, at the intersection of Guangdong, Guangxi and Hainan provinces. Its longitude and latitude are 109°40'E and 20°13'N. The geographical area includes the entire Leizhou Peninsula and part of it. It is currently a prefectural-level city of Guangdong Province. To the east is the South China Sea, to the south it is separated from Hainan by the Qiongzhou Strait, to the west is the Beibu Gulf, and to the northeast is Maoming City. The climate type of Zhanjiang is tropical monsoon climate. Summer has both rain and heat at the same time. The climate is greatly influenced by the ocean. There are many typhoons in summer, and it is prone to typhoon disasters. Most of Zhanjiang is plains and hills, and its natural resources and marine resources are very abundant.

The total area of Zhanjiang City is 13,200 square kilometers. It has four districts under its jurisdiction. According to the size from small to large of the districts, they are Chiguan District, Xiashan District, Poutou District and Maziang District. It governs three county-level cities and two counties, namely Leizhou City, Lianjiang City, Wuchuan City, Xuwen County and Suixi County. This article studies the overall area of the four districts under the jurisdiction of Zhanjiang City (Fig. 1 shows the schematic map of the administrative districts of Zhanjiang City).]

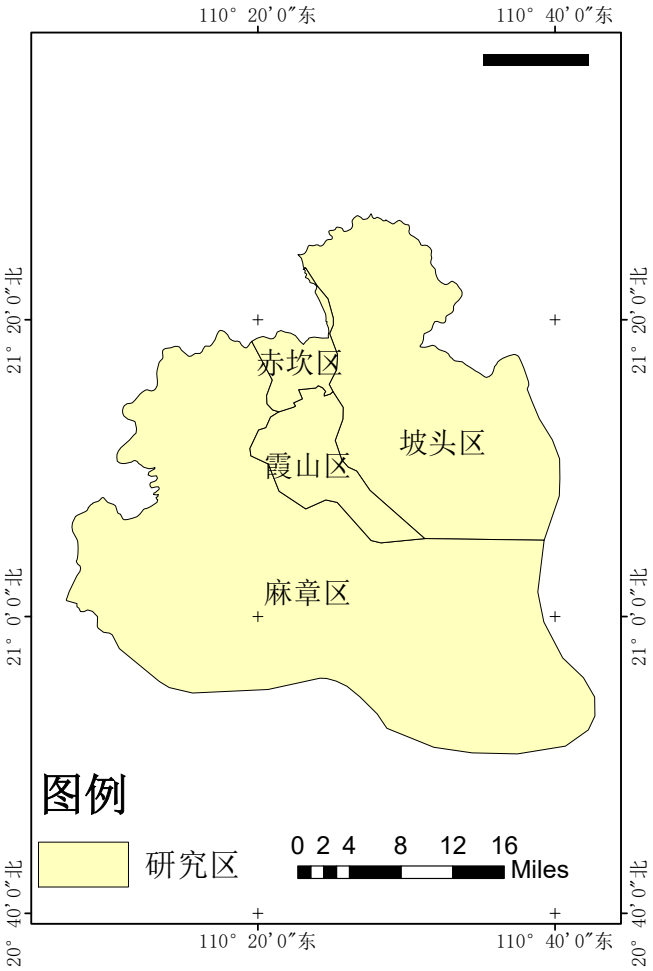

Fig. 1 The study area of the sub-district of Zhanjiang City

2.1 Data Acquisition

This study selected Landsat TM/OLI imagery as the data source for several key reasons: The medium spatial resolution of Landsat images enables accurate recognition and differentiation of specific land

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categories. With a 16-day temporal resolution, the satellite provides timely updates suitable for urbanization monitoring research. Additionally, Landsat offers abundant multispectral band characteristics with spatial resolutions ranging from 30 to 100 meters, ensuring sufficient data availability.

The remote sensing image data used were Landsat imagery from November 2000, November 2005, October 2010, and October 2015. The projection coordinate system selected was UTM (Universal Transverse Mercantile Coordinate), specifically WGS 84,49 NORTH. To ensure image processing quality, the cloud cover in all four selected images was below 10%, indicating good image quality. Since Landsat 4 and 5 were decommissioned in 2013, the imagery from these satellites was used for the years 2000,2005, and 2010. For the year 2015, Landsat 8 OLI imagery currently in service was adopted.[6, 7]

The main data of driving force analysis are taken from the statistical data of Zhanjiang city, including the statistical yearbook of Zhanjiang city over the years, and other data include the geographical chronicles of Zhanjiang city, the administrative division map of Zhanjiang city and some basic maps.

3. Urbanization Process Analysis

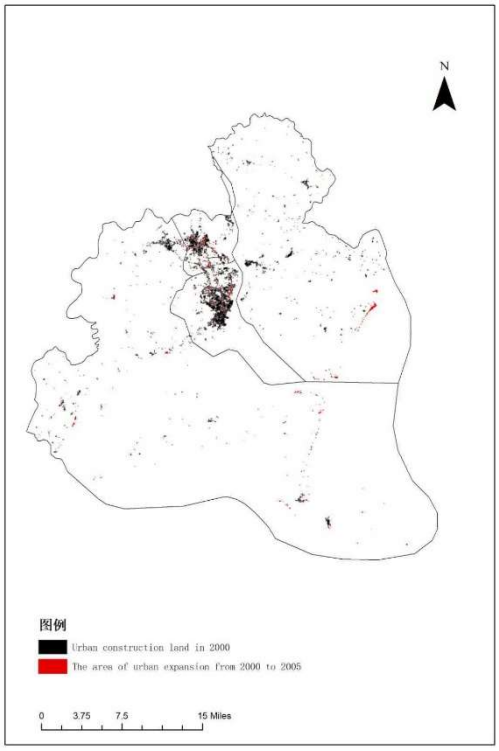

Fig. 2 Urbanization process of municipal districts from 2000 to 2005

By comparing the overlay maps from 2000,2005,2010, and 2015 with the urban floor area statistics, it is evident that Zhanjiang's urbanization has shown significant acceleration during 2000-2015. The rapid economic growth led to substantial expansion of urban construction land and notable changes in land use patterns, particularly intensified industrial facility development. According to the statistical table, the city's total built-up area increased from 18.43 km² in 2000 to 163.90 km² in 2015, representing a net increase of 145.47 km². From 2005 to 2010, construction land experienced substantial growth, with the most dramatic expansion occurring between 2010 and 2015. During this period, urban built-up land grew by 71.71 km², achieving a 77.78% annual growth rate and an average annual increase of 15.56%.

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Over the past 15 years, with Chikan District in Xiashan District as the core and Machang District in Potou District as a secondary development area, most construction land has expanded outward. The urban areas of Xiashan and Chikan Districts have seen concentrated growth in both scale and distribution. Potou District experienced expansion in its northeastern and southeastern sections, though these developments remained relatively scattered, clustering near Xiashan District. Donghai Island witnessed dramatic changes with a sharp increase in construction land during this period. While urbanization accelerated and spatial scales continued to expand, it also brought adverse effects such as reduced arable land and diminished forest areas adjacent to the city center.

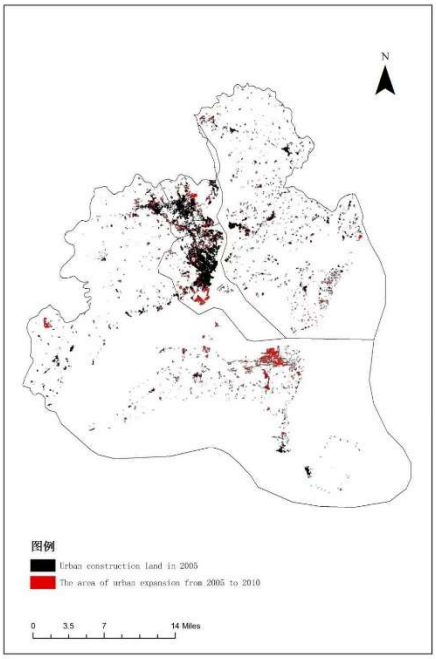

Fig. 3 Urbanization process of municipal districts from 2005 to 2010

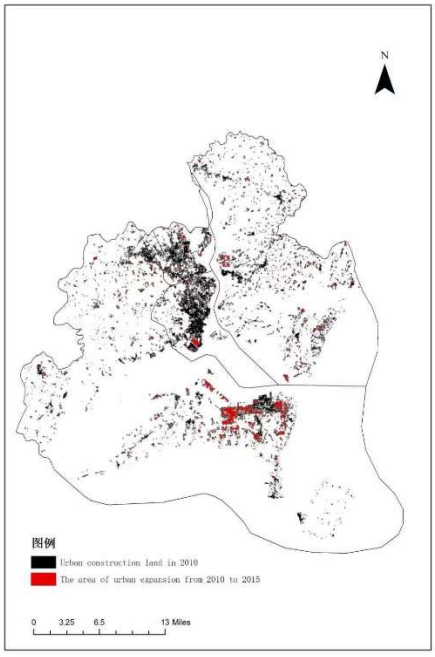

Fig. 4 Urbanization process of municipal districts from 2010 to 2015

4. Analysis of Urbanization Driving Forces

The expansion of urban construction land signifies a nation's or region's transition from agricultural to non-agricultural populations, driving population concentration. This process involves converting rural land into urban areas to accumulate wealth, while transforming production and organizational methods. To continuously enhance agglomeration benefits during urbanization, land adjustments are essential-manifested through increased urban construction land and expanded city sizes. Throughout this process, other land types are converted into building sites, with ongoing planning and adjustments to land use accelerating urbanization.

This paper analyzes the spatiotemporal changes of urban construction land in the study area over the past 15 years, combined with statistical data from Zhanjiang City's Statistical Yearbook (2000-2015) and urban development policies. The study examines how government policies, economic factors, transportation infrastructure, and population growth have influenced land use patterns.

4.1 Government Policy Factors

Government policies serve as the cornerstone and decisive factor in urban land use planning. Their primary purpose is to ensure rational utilization of regional land resources while establishing standardized land management systems. These policies not only drive urbanization but also maintain

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it within sustainable parameters, preventing issues stemming from excessive urban expansion. Although government policies are challenging to quantify through numerical metrics, their strategic significance remains paramount.[8, 9]

The China-ASEAN Free Trade Area was officially established in 2010. As a pivotal hub within the trade zone, Zhanjiang City can access trade through two channels: one bypassing China and Vietnam, and the other traversing the South China Sea and Beibu Gulf. With the gradual growth of the China-ASEAN Free Trade Area, Zhanjiang is poised to develop into a new growth pole. Building on this foundation, the deepening implementation of the national Western Development Strategy has positioned Zhanjiang as a natural geographical advantage connecting the southeastern coast with the southwest, making it a sought-after region for investors. In 2009, the Zhanjiang Old Economic and Technological Development Zone merged with the Donghai Island Economic Development Pilot Zone to form the new Zhanjiang Economic and Technological Development Zone. In 2010, the State Council-approved "National Main Functional Zones Plan" designated the Beibu Gulf as a key development area, clarifying its development direction and intensity. As Zhanjiang lies within this strategic zone, it has gained new opportunities for development. Provincial leaders and the government will promote comprehensive opening-up and implement reform pilot programs related to national-level economic and technological development zones. For key development targets such as Zhanjiang Port and Donghai Island, the municipal government has actively reported on pilot reforms for the Free Trade Zone. To boost the production and scale of Zhanjiang's heavy industries and other secondary sectors, policies have introduced larger-scale tax reductions. The development of national key industrial projects in Donghai Island also accelerates Zhanjiang's urbanization process. Under the development policy, detailed planning rules have also been issued. In the Zhanjiang City Land Use Master Plan (2006-2020), it is clearly stipulated that under the condition of not changing the built-up area, the spatial distribution adjustment shall be made in accordance with certain rules, but it is not allowed to exceed the urban expansion boundary.

In summary, the continuous refinement and meticulousness of government policies have imposed stricter requirements and planning standards on land utilization. Each policy formulation to some extent accelerates or slows urbanization processes, thereby influencing land use patterns. This demonstrates that government policies play a decisive role in shaping urban development.

4.2 Economic Development is Fundamental

Social and economic development are deeply intertwined with land use. Economic growth drives transformations in land utilization, while these changes, in turn, fuel further economic expansion-a mutually reinforcing cycle. Urbanization serves to meet the needs of humanity and society, with economic progress accelerating its expansion. To secure more urban construction land, continuous adjustments to land use patterns become essential. As substantial capital flows into urban development through economic investments, such land allocation subsequently stimulates economic growth, creating a self-reinforcing dynamic. Over the past 15 years (as shown in Table 1), the merger of Zhanjiang Economic and Technological Development Zone (located between Chikan District and Xiashan District) with Donghai Island Economic Development Pilot Zone (in Machang District) has not only reshaped land use patterns but also significantly boosted regional economic growth.

As urbanization progresses, the dominant industries will transition from agriculture (primary sector) to manufacturing (secondary sector), ultimately shifting to services (tertiary sector). The level of economic development will also drive improvements in other sectors. No country or region has achieved sustained GDP growth during urbanization without massive conversion of land to construction purposes. Meanwhile, rising living standards in cities have created higher demands for residents' consumption patterns – requiring not only material goods but also cultural and intellectual enrichment. These evolving needs are stimulating diverse tertiary industries such as entertainment services, educational institutions, and real estate development.among the three major industries, the primary industry demonstrated relatively low growth momentum, with its output value increasing from 1.718 billion yuan in 2000 to 7.019 billion yuan in 2015. Meanwhile, the secondary and tertiary

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industries showed significant growth: The secondary industry maintained the largest share of total output, rising from 11.481 billion yuan to 50.334 billion yuan, while the tertiary industry saw the most substantial growth, increasing from 8.351 billion yuan to 50.669 billion yuan. Zhanjiang's secondary industry development has been centered around key sectors like steel and petrochemicals, supported by major enterprises such as CNOOC, Baosteel, and Chenming Company. Given that the petrochemical industry serves as Zhanjiang's dominant sector, it should play a leading role in driving the growth of related industries. The city should leverage the strategic positioning of Zhanjiang Port and Donghai Island, utilizing their policy advantages and geographical advantages to develop port-related industries. Additionally, developing transportation networks, import-export trade, and improving comprehensive supply systems are crucial. These developments have led to expanded land use for urban construction. Therefore, economic development remains the decisive force in urbanization.[10]

4.3 Sustained Population Growth Drives Urbanization Outward

Population growth drives urbanization, with increasing urban population proportions reshaping the distribution of primary industries and indirectly influencing land use patterns. On another front, population expansion directly impacts land utilization: growing populations inevitably lead to expanded residential areas and infrastructure development, altering land use types and distributions. Human activities and population growth inevitably encroach on other land use categories, making population growth an indispensable factor in urbanization. As shown in Figures 9 and 10, Zhanjiang's urban district population stood at 1.3993 million in 2000. By 2005, it had increased by 22,000 residents, reaching 1.6123 million permanent residents in 2010 with a population growth of 19,100 (13.44% growth rate). The population further increased by 61,000 in 2015, registering a 3.78% growth rate. During this period, the urban population share in permanent residents rose from 44.43% in 2000 to 65.28% in 2005. Although urban population surged significantly in 2010, the urban share slightly declined to 64.47%, before rebounding to 67.26% by 2015. Zhanjiang's total permanent population grew rapidly, with the urban population share rising most sharply between 2000 and 2005 before stabilizing. As urban populations expanded and living standards improved, people increasingly built more structures to maximize agglomeration benefits, accompanied by expanded public infrastructure. These developments ultimately led to structural changes in land use patterns. The rapid development of the real estate industry drives other secondary and tertiary industries, which in turn affects the proportion of industrial structure to a certain extent. In other words, the growth of population promotes the expansion of cities.

5. Conclusion

The information of urban construction land in the four periods of Zhanjiang city was obtained by using visual interpretation and supervised classification methods in remote sensing, and then the four periods of images were superimposed and analyzed by software to analyze the spatial and temporal changes of construction land, and the relationship between construction land changes and driving forces was discussed based on statistical data.

(1) Over the past 15 years, Zhanjiang's urban districts have witnessed rapid expansion, marked by a surge in construction land use. The city's built-up area expanded from 18.43 km² to 163.90 km², with 143.47 km² of new construction land developed. From 2000 to 2010, the growth was concentrated in Chikan District and Xiashan District, while from 2010 to 2015, expansion shifted to Potou District and Machang District.

(2) The driving force of the change of construction land in Zhanjiang is mainly the national policy that drives the development of zhanjiang's urbanization, which is manifested as the economic and technological development zone of Zhanjiang and the East Sea Island Economic Development Pilot Zone are the main areas of urbanization area increase in zhanjiang's urban district. The growth of population and economy, in turn, promotes the development of urbanization.

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