

# A Study on The Spatial and Temporal Characteristics of Land Use Types and Population Density in Urban Areas

-- A Case Study of Guangdong-Macao In-Depth Cooperation Zone in Hengqin

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**Abstract:** At present, China is experiencing a rapid urbanization phase, with a continuous outward expansion of urban land, which in turn puts enormous pressure on the city and its surrounding ecological environment and seriously hinders the sustainable development of the region. Therefore, this article takes Guangdong-Macao In-Depth Cooperation Zone in Hengqin as a research case to study the relationship between the spatial evolution of urban land and changes in population density, expecting to provide a basis for scientific planning of urban spatial development, which is of great significance for achieving sustainable urban development.

**Keywords:** City, Urbanization, Land use, Population, Hengqin, Macao.

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## 1. Research Background

Since the Industrial Revolution, human production activities have been changing the Earth's ecosystems, putting human survival and social development at serious risk [1]. Among the many factors, the impact of population agglomeration on land use change is particularly important. In recent years, with the rapid growth of population and the improvement of science and technology, the rate of land use change has accelerated significantly, and the resulting resource and environmental problems have received increasing attention from society [2]. Among them, each shift in land use patterns undergoes drastic changes at different time scales and spatial scales, directly affecting the stability of the Earth's surface ecosystem [3]. Therefore, exploring the interrelationship between population concentration and land use is an important basis for the rational regulation of the earth's ecological environment and the promotion of sustainable urban development.

In China, after the implementation of the reform and opening-up policy, urbanization has entered a new stage of development. Not only has a large number of rural population migrated to cities, but the distribution of population within cities, especially large cities, is also undergoing intense changes, and this has led to a series of problems such as urban transportation and land use changes. Guangdong Province is located in the southern part of China, and while there has been tremendous socio-economic development, there are also many problems with land use that cannot be ignored, such as sloppy land-use practices and outstanding conflicts between people and land, which are causing increasing social tensions in Guangdong Province and also restricting the healthy economic development of the region. If these problems are not solved in a timely, effective and reasonable manner, they will gradually hinder the economic growth of Guangdong Province and become a major obstacle to the stable development of the region. Taking the Guangdong-Macao In-Depth Cooperation Zone in Hengqin as a research case, this article studies the status of land use change and population

development in Hengqin, in order to provide inspiration for the harmonious development of land use and population in Guangdong Province.

## 2. Study Area Overview

Hengqin, located in Zhuhai, Guangdong Province, China, is adjacent to Hong Kong and Macao, covering an area of 106 square kilometers. On 14 August 2009, the State Council officially approved the Hengqin Overall Development Plan, making Hengqin a new vehicle for exploring a new mode of close cooperation among Guangdong, Hong Kong and Macao. On 16 December 2009, Hengqin New Area was officially established, implementing more special policies than the Special Economic Zone, and the development of Hengqin was launched in full swing. On 24 March 2015, the Political Bureau of the Central Committee of the Communist Party of China (CPC) considered and approved the overall plan of the Guangdong Free Trade Pilot Zone, and Hengqin was included in the scope of the Guangdong Free Trade Zone. On 5 September 2021, the CPC Central Committee and the State Council officially issued the "Overall Plan for the Construction of Guangdong-Macao In-Depth Cooperation Zone in Hengqin", which provides for the zoning and classification management of the cooperation zone according to the objective realities of the whole island of Hengqin, with Hengqin and the Macao Special Administrative Region set as the "first line" and Hengqin and the rest of the People's Republic of China will be designated as the "second line". In the future, Hengqin will become a new platform for the moderate and diversified development of Macao's economy, a key initiative for the in-depth implementation of the Outline of the Plan for the Development of the Greater Bay Area of Guangdong, Hong Kong and Macao, and a key initiative for the long-term prosperity and stability of Macao and its integration into the overall development of the country.

### 3. Analysis of Spatial and Temporal Changes in Land Use Types

The land use type data used in this analysis is derived from the Landsat series of remote sensing image data with a spatial resolution of 30m×30m. The land use types are divided into six categories, including: cultivated land, woodland, grassland, waters, construction land and unused land. The years used are 1980, 1990, 2000, 2005, 2010, 2015 and 2020. By analyzing and comparing the data, it can be found that (See Figure 1):

(1) In terms of spatial distribution, the area of woodland has the highest proportion, and the unused land has the smallest proportion. Cultivated land is mainly distributed around the woodland and in the southwest coastal area. Woodland is mainly distributed in the central and southern part of Hengqin and is narrow from east to west. Waters is mainly distributed in the northern half of Hengqin as well as in the southern coastal area. Construction land is mainly distributed in the east and north of Hengqin. Grassland is mainly distributed in the western part between the woodland.

(2) In terms of time trends, from 1980 to 2020, the area of cultivated land first increases and then decreases. The area of woodland accounts for almost the same proportion and the highest proportion of the total area. The area of grassland and waters decreases year by year; and the construction land increases year by year. Among them, the area of waters and

woodland has the highest proportion in 1980, the area of cultivated land has the highest proportion in 2000, and the construction land has the highest proportion in 2020.

(3) In terms of spatial and temporal changes, the area of woodland and its spatial distribution remained almost unchanged from 1980 to 2020, while the area of waters gradually shrank, with the distribution of waters shrinking significantly from a large area in the northern part of Hengqin to a line of waters in an east-west direction by 2020. In 1980, the cultivated land was mainly distributed in the southern foothills of the northern woodland. In 1990, part of the southwestern coastal area of Hengqin became cultivated land. In 2000, the cultivated land area expanded to the north, and some water areas in the northwest were converted into cultivated land. By 2015, the northwest region of Hengqin was transformed from cultivated land into waters and construction land, and the surrounding waters in the eastern region of Hengqin were transformed into cultivated land. Grassland area is minimal in 2015, with some additional grassland in the northern part of Hengqin in 2020. Construction land was only scattered in the northern and eastern parts of Hengqin from 1980 to 1990. After 2000, the northern foothills of the northern woodland, the middle of the southern woodland and the waters in the eastern region gradually developed into construction land. Half of the large water area is almost entirely converted into construction land.

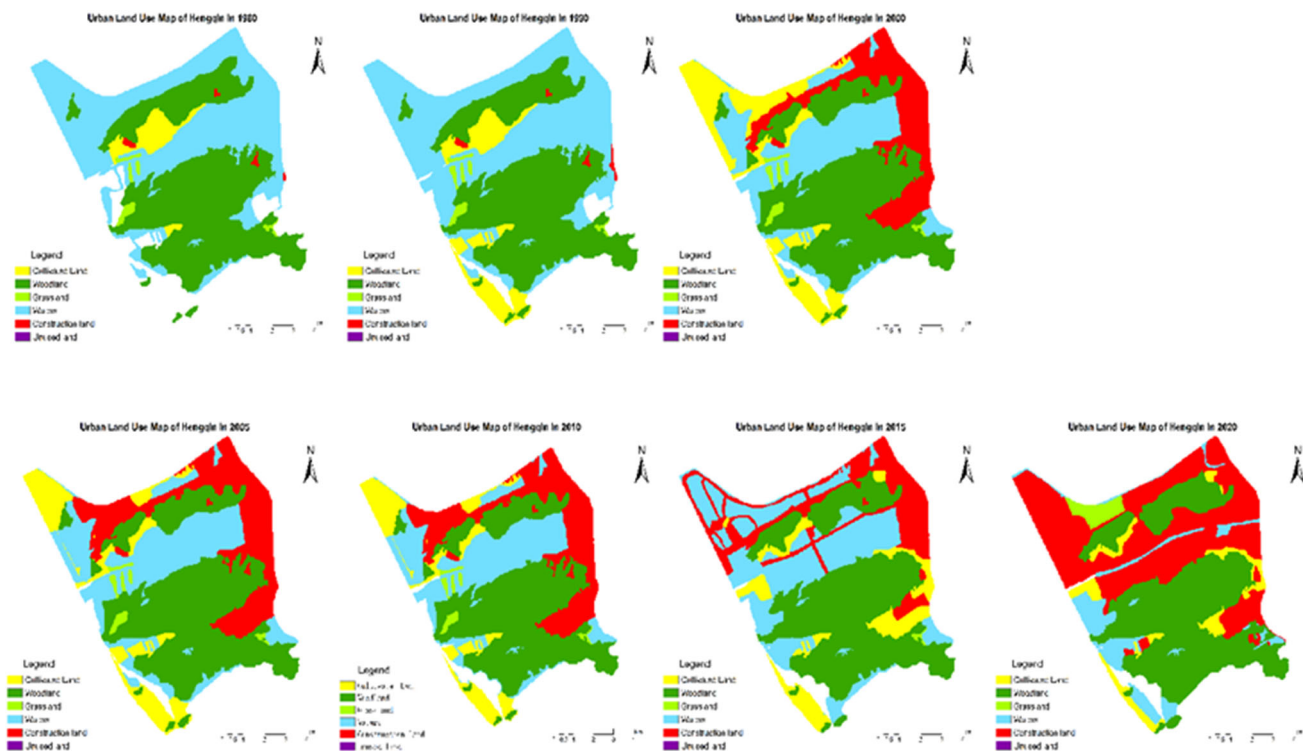


Figure 1. Land use type distribution map of Hengqin (1980, 1990, 2000, 2005, 2010, 2015 and 2020)

### 4. Analysis of Spatial and Temporal Changes in Population Density

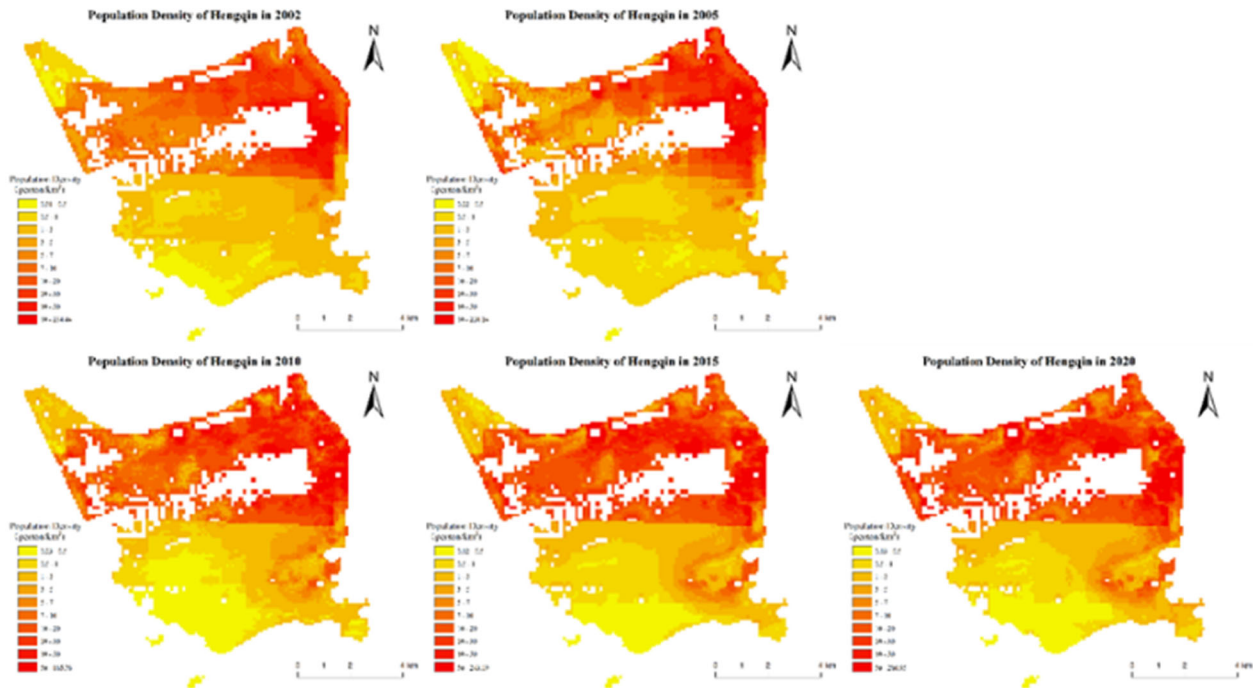
The population density data used in this analysis is derived from the TIFF format population density spatial open-source data provided by the Worldpop website, with a spatial resolution of 1km x 1km. The years of data used are 2002, 2005, 2010, 2015 and 2020. By analyzing and comparing the data, it can be found that (See Figure 2):

(1) In terms of spatial distribution, the population density of Hengqin generally shows the characteristics of high in the north and low in the south, and a decreasing trend from the northeast to the southwest.

(2) In terms of temporal trends, from 2002 to 2020, Hengqin's areas with a population density of less than 0.5 persons per square kilometer show an expansion followed by a contraction, while areas with a population density greater than 10 persons per square kilometer show an overall trend of expansion up to 2020.

(3) In terms of spatial and temporal characteristics, from 2002 to 2020, areas with a population density of less than 0.5 persons per square kilometer are mainly concentrated in the southern half of Hengqin, while areas with a population density of more than 10 persons per square kilometer are

mainly concentrated in the northern half. In particular, after 2010, the population in the southeast and north areas of Hengqin gradually increases, with the largest concentration of people reaching over 240 persons per square kilometer.



relationship between various types of land, improve the overall land utilization rate, ensure the spatial allocation of land resources is reasonable, so that it can better match the sustainable development of the modern economy, avoid unnecessary loss of land resources and environmental pollution, and so on. To improve the quality of life of the people, and ultimately to achieve the harmonious development of man and nature.

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