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Spatiotemporal Evolution Analysis of Population Distribution in the Metropolitan Areas of the Three Central Cities in the Yellow River Basin

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ABSTRACT

Based on the worldpop population density data, this paper compares and studies the spatial distribution and change characteristics of population in the Yellow River Basin metropolitan area since 2000, and takes the three central urban metropolitan areas of Zhengzhou, Xi'an and Jinan as examples to analyze the characteristics of population distribution change within the metropolitan area. The results show that from 2000 to 2020, there was no significant change in the population distribution pattern of the metropolitan area in the basin, and the distribution of population density showed the pattern characteristics of "high in the southeast and low in the northwest", mainly concentrated in the middle and lower reaches of the basin, and showed a decreasing trend from the downstream to the middle to the upstream. (2) The steady population growth and rapid growth areas are mainly concentrated in the metropolitan areas of Xi'an, Zhengzhou and Jinan, while the population density of the metropolitan areas of Xining, Yinchuan, Hohhot and Lanzhou in the upstream areas is significantly low, and the surrounding areas of the central city show the phenomenon of population growth stagnation and a large number of agglomeration of shrinkage areas. (3) From 2000 to 2020, the maximum population density in the metropolitan area of the three central cities continued to increase, and the trend of expansion from the central city to the surrounding cities showed in the metropolitan area, indicating that the population distribution was gradually moving towards equilibrium.

KEYWORDS

Yellow River Basin, Metropolitan Area, Population Distribution, Spatiotemporal Evolution.

1. INTRODUCTION

In 2021, China proposed to "promote a new type of urbanization with people as the core, give full play to the leading role of central cities and urban agglomerations, and build a modern metropolitan area".Cultivating and developing a modern metropolitan area has become a national strategy, which is an important means for China to achieve high-quality urbanization development. The free flow of factors across regions is the process of redistribution of resources in geographical space, and it is also an important basis for promoting the integrated development of metropolitan areas[1], and population flow is an important carrier of the flow of capital, technology, information and other factors, and the highly mobile and closely connected population flow pattern is the basic feature of modern metropolitan areas in the future. In this context, it is of great significance to explore the evolution of population distribution and mobility characteristics at the metropolitan area level to accelerate the integrated development of metropolitan areas.At present, some research on the spatial distribution of population in metropolitan areas has accumulated some results. Theories of dynamic evolution of metropolitan areas, such as the urban evolution model[3] and the urban spatial circulation theory[4],

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believe that the population agglomeration and diffusion directions of metropolitan areas are different at different stages of development. Clark model[5], single-center model, multi-center model[6], and GIS[2].A variety of model tools provide method support and visual display conditions for the population distribution and evolution law of the metropolitan area. The existing research on the population distribution of metropolitan areas focuses on revealing the characteristics and influencing factors of the population distribution of typical metropolitan areas in foreign countries, but the conclusions have not yet reached a unified conclusion, and there are few studies on the population distribution of metropolitan areas in China.

Based on this, this paper selects the metropolitan area of the Yellow River Basin as the study area, and takes the representative metropolitan areas of Zhengzhou, Xi'an and Jinan as the case studies, based on the worldpop population density data, studies 2000Since then, the population distribution and change characteristics of the metropolitan areas of the three central cities have, provided a theoretical reference for promoting the integrated and coordinated development of the metropolitan areas.

2. DATA SOURCE AND SCOPING

2.1. Data Sources and Processing

The raster data of the spatial distribution of the Worldpop population applied in this study are from the official website of the Worldpop project (https://www.worldpop.org/), and the resolution is 1km.The accuracy of the data is based on multi-source spatial data such as land use data, nighttime light data, and national census data, and the calculation of random forest model has been verified by many parties for a long time and has been widely used in a large number of studies to explore the spatial distribution of urban population[7],[8],[9].

2.2. Metropolitan area scoping

In this study, five developing metropolitan areas and four nurturing metropolitan areas were selected to determine the scope of the metropolitan area in the Yellow River Basin. Among them, the development metropolitan areas are: Jinan metropolitan area (note: Laiwu in Jinan metropolitan area was merged into Jinan after 2019), Qingdao metropolitan area, Zhengzhou metropolitan area, Xi'an metropolitan area; There are 40 cities in the cultivation metropolitan area: Taiyuan metropolitan area, Hohhot metropolitan area, Lanzhou metropolitan area, Yinchuan metropolitan area, and Xining metropolitan area (Table 1-1).

Table 1-1 The metropolitan area of the Yellow River Basin includes cities

Metropolitan area	A city within a metropolitan area
Jinan metropolitan area	Jinan, Zibo, Laiwu, Tai'an, Liaocheng, Dezhou, Binzhou
Qingdao metropolitan area	Qingdao, Yantai, Weihai, Weifang, Rizhao
Zhengzhou metropolitan area	Zhengzhou, Kaifeng, Xinxiang, Jiaozuo, Xuchang, Luohe, Luoyang, Jiyuan, Pingdingshan
Taiyuan metropolitan area	Taiyuan, Jinzhong, Yangquan, Luliang, Xinzhou
Hohhot metropolitan area	Hohhot, Ulanqab
Yinchuan metropolitan area	Yinchuan, Shizuishan, Wuzhong
Xi'an metropolitan area	Xi'an, Xianyang, Weinan, Tongchuan
Lanzhou metropolitan area	Lanzhou, Baiyin, Dingxi
Xining metropolitan area	Xining, Haidong

3. THE OVERALL CHARACTERISTICS OF THE SPATIOTEMPORAL EVOLUTION OF POPULATION DISTRIBUTION IN METROPOLITAN AREAS

3.1. Overall characteristics of population distribution in the metropolitan area of the Yellow River Basin

Population density reflects the distribution of the population in an area [10],[11],[12], with the help ofdpop raster data on population density analysis of the spatial distribution pattern of the metropolitan area in the Yellow River Basin. Through the processing of the data, the spatial distribution of the population of each metropolitan area is obtained, as shown in Figure 3-1. From 2000 to 2020, there was no significant change in the population distribution pattern in the basin, and on the whole, the distribution of people flow was "high in the southeast and low in the northwest".The population distribution is significantly different, and the highest value of population density continues to increase over time. The population is mainly concentrated in the middle and lower reaches of the basin, and shows a decreasing trend from the lower reaches to the middle reaches to the upper reaches. The population density of Xining, Yinchuan, Hohhot, Lanzhou and other metropolitan areas in the upstream area is significantly low, while the population density of the metropolitan area with Taiyuan as the core is between the above two areas of high and low population density.

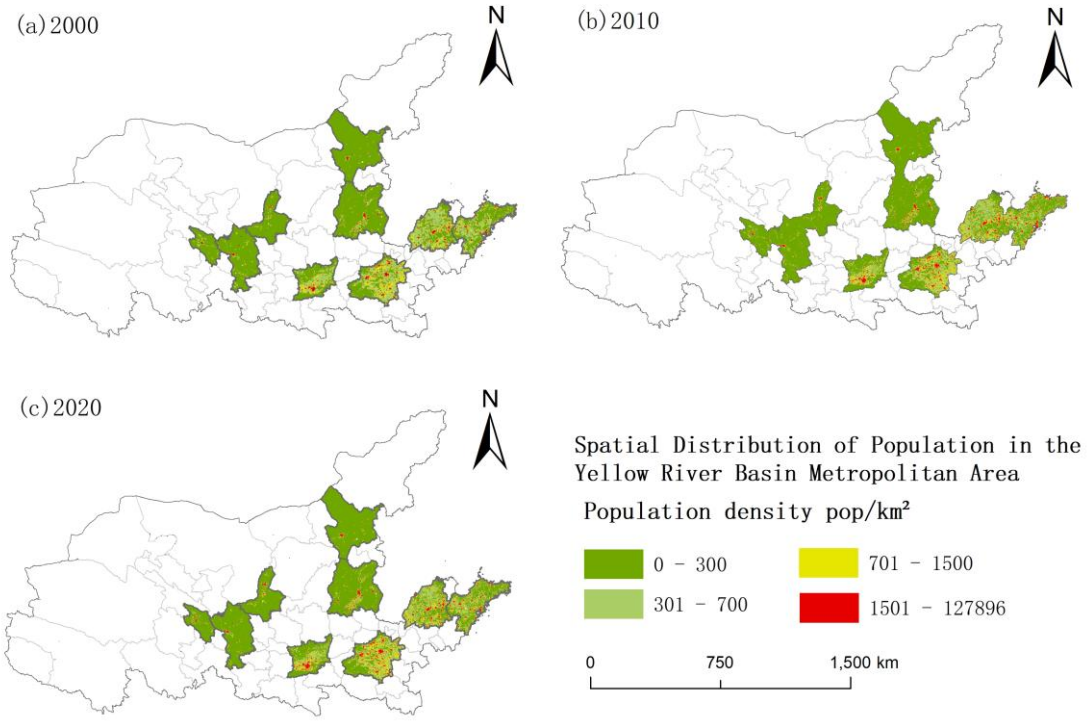

Fig. 3-1 Distribution pattern of population density in the metropolitan area of the Yellow River Basin from 2000 to 2020

3.2. Overall growth characteristics of population density in metropolitan areas

Based on the statistical population raster data, the population density change from 2000 to 2020 was calculated, and the standard deviation was used to divide and display the population density in the metropolitan area, so as to further intuitively understand the spatial difference of population density growth in the metropolitan area, as shown in Figure 3-2. The study shows that from 2000 to 2020, the steady population growth and high-speed growth areas are mainly concentrated in the metropolitan areas with Xi'an, Zhengzhou, Jinan, Qingdao and other cities as the core, and the central

cities of the other metropolitan areas have also achieved rapid population growth, but the surrounding areas show the phenomenon of population growth stagnation and a large number of agglomeration of shrinkage areas, such as Xining, Yinchuan, Hohhot and Lanzhou in the upstream areas. It can be understood that the population has not changed much during this period. According to the research results, Zhengzhou, Xi'an, Jinan and Qingdao metropolitan areas were selected to analyze their internal population distribution characteristics.

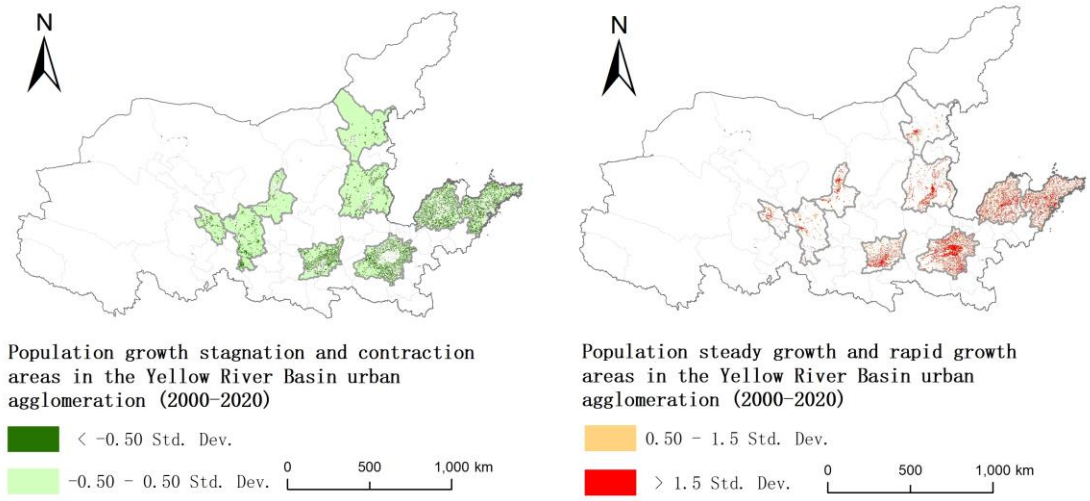

Fig. 3-2 Spatial distribution pattern of population growth in the metropolitan area of the Yellow River Basin from 2000 to 2020

4. SPATIOTEMPORAL CHARACTERISTICS OF POPULATION DISTRIBUTION IN METROPOLITAN AREAS OF THE THREE CENTRAL CITIES

4.1. Population distribution characteristics of Zhengzhou metropolitan area

According to the spatial distribution of population in Zhengzhou metropolitan area in 2020 (Figure 4-1), the population concentration areas are mainly distributed in Zhengzhou, central cities such as Luoyang, Kaifeng, Xinxiang and Pingdingshan, and spread to the surrounding areas over time. From 2000 to 2020, the steady population growth and rapid growth areas were mainly distributed in Zhengzhou, while most of the other cities were in the stagnation and contraction of population growth, and the population growth rate was relatively small, or even negative. This may be due to the improvement of economic development and transportation conditions, and the central cities with stronger comprehensive strength have attracted the population of the surrounding cities, which has a siphon effect on the population of the surrounding areas. The urban entity area with a population density of≥1500 people/km² was selected as the main urbanization area, and the metropolitan area was selected through 2000, 2010 and 2020.It can be seen that the maximum value of population density in the metropolitan area continues to increase over time, is 82150/ km² and 91349/ respectively. km² and 93983/km². In general, the spatial distribution of population in Zhengzhou metropolitan area shows a trend of gradual expansion from the central city to the surrounding cities.

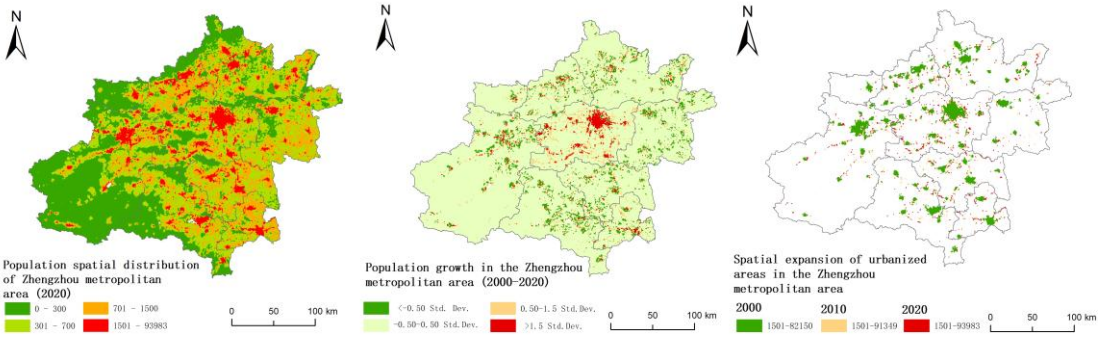

Fig. 4-1 Population distribution and spatial pattern of change in Zhengzhou metropolitan area from 2000 to 2020

4.2. Population distribution characteristics of Xi'an metropolitan area

From the perspective of the spatial distribution of population in Xi'an metropolitan area in 2020 (Figure 4-2), the highly concentrated population areas are mainly distributed in the southeast of Xi'an and Xianyang, and from 2000 to 2020, the stable population growth and rapid growth areas are mainly distributed in Xi'an, Xianyang, Tongchuan and Weinan are mostly in the area of population growth stagnation and contraction, and the population growth rate is relatively small and negative, and the spatial expansion of the population in the urbanized areas in 2000, 2010 and 2020 indicates that the people in the metropolitan area have increased over time.The highest values of mouth density continued to increase , 127896/km², 151114/km² and 171552/km², respectively. During the study period, Xi'an was the main population expansion area, and the population of its surrounding cities also expanded from 2010 to 2020.

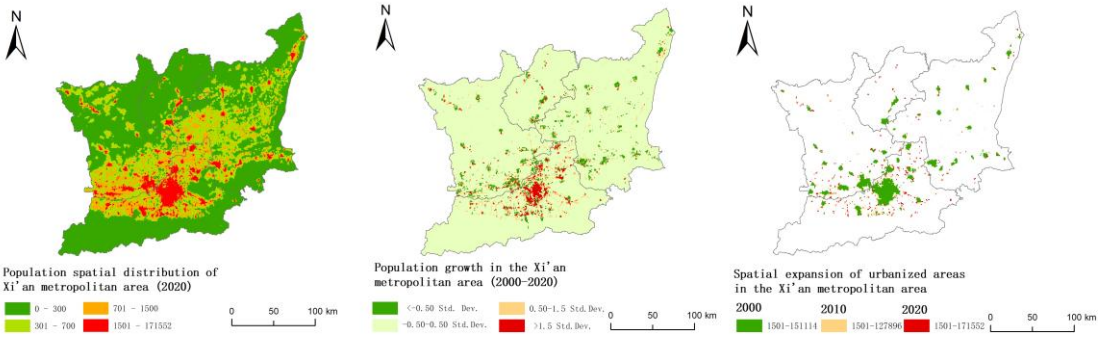

Fig. 4-2 Population distribution and spatial pattern of change in Xi'an metropolitan area from 2000 to 2020

4.3. Population distribution characteristics of Jinan metropolitan area

From the perspective of the spatial distribution of population in Jinan and Qingdao metropolitan areas in 2020 (Figure 4-3), the highly concentrated population density areas are mainly distributed in Qingdao, Jinan, Zibo, Tai'an and other cities.From 2000 to 2020, the steady population growth and rapid growth areas were mainly distributed in the two central cities of Jinan and Qingdao, while most of the other cities were in the stagnation or contraction of population growth, and the population growth rate was relatively small, or even negative growth, population of the surrounding cities gradually concentrated in the central cities. Through the spatial expansion of population in urbanized areas in 2000, 2010 and 2020, it can be seen that the maximum value of population density in the metropolitan area continues to increase over time, and the population in the metropolitan area is divided Cloth is also gradually moving towards equilibrium.

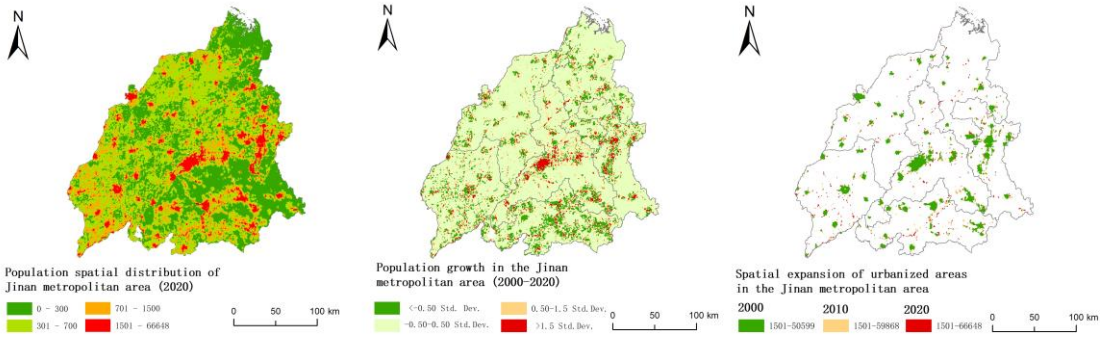

Fig. 4-3 Population distribution and spatial pattern of change in Xi'an metropolitan area from 2000 to 2020

5. CONCLUSIONS AND RECOMMENDATIONS

Taking the Yellow River Basin metropolitan area as the study area, and taking the representative three central metropolitan areas of Zhengzhou, Xi'an, Jinan and Qingdao as case studies,, this paper studies the spatiotemporal evolution characteristics of the population distribution of the metropolitan areas of the three central cities since, 2000 by using the population density data :

(1) During the study period, there was no significant change in the population distribution pattern in the basin, and on the whole, the population density distribution in the basin was "high in the southeast and low in the northwest".The pattern characteristics are mainly concentrated in the middle and lower reaches of the basin, and show a decreasing gradient from the downstream to the middle to the upstream. The population density of Xining, Yinchuan, Hohhot, Lanzhou and other metropolitan areas in the upstream area is significantly low, while the population density of the metropolitan area with Taiyuan as the core is between the above two areas of high and low population density.

(2) The steady population growth and high-speed growth areas are mainly concentrated in the metropolitan areas with Xi'an, Zhengzhou, Jinan, Qingdao and other cities as the core, and the central cities of Xining, Yinchuan, Hohhot and Lanzhou have also achieved rapid population growth, but the surrounding cities show the phenomenon of population growth stagnation and a large number of agglomerations in the shrinkage area, and the population growth rate is relatively small. There is even a phenomenon of negative growth.

(3) From 2000 to 2020, the highest value of population density in the metropolitan area of the three central cities continued to increase, indicating that the population agglomeration capacity in the metropolitan area was strong, and with the passage of time, there was a trend of expansion from the central city to the surrounding cities, indicating that the population distribution was gradually moving towards equilibrium.

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