

Non-equilibrium Analysis of Population Distribution in Northwest China from 2001 to 2016

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Abstract. This paper uses the population density, population concentration index, population center of gravity and population distribution Gini coefficient to analyze the spatial-temporal characteristics and non-equilibrium of county population distribution in Northwest China from 2001 to 2016. The results show that between 2001 and 2016, the population of northwestern China continued to grow, but the distribution was extremely uneven. The population density of different counties was much different, and the number of counties with negative annual growth increased; the population concentration index decreased slightly. The population center of gravity is located in the southeast of the geometric center which moves slowly from southeast to northwest. The Gini coefficient of population distribution fluctuates around 0.77.

Introduction

The spatial distribution of population can reflect the state of social and economic development of a region [1]. Due to the influence of specific natural, economic and social environment, the spatial-temporal changes of population often show significant differences and non-equilibrium [2], population changes and spatial redistribution will also act on the sustainable development of regional economy [3]. The spatial distribution and evolution trend of population is the starting point of studying many phenomena and laws [4]. A reasonable population distribution will accelerate the sustained and stable economic development, while the unreasonable population distribution will hinder economic development [5].

Northwest China includes Gansu, Shaanxi, Qinghai, Ningxia Hui Autonomous Region and Xinjiang Uygur Autonomous Region. It has jurisdiction over 360 county-level administrative units with a total land area of 3.1 million km2, accounting for 33.27% of the national land area. The population density of more than 70% of the county units is lower than the national average. Meanwhile, the population density of the suitable areas for human habitation is too high. Exceed the critical level of population density in arid and semi-arid areas designated by the United Nations. Therefore, it is significance to study the population quantity and its spatial distribution evolution in this region, explore the non-equilibrium degree of population distribution within the region, and further grasp the regularity of population spatial distribution, promote the rational distribution of population, optimize the allocation of resources, and realize the healthy development of economy.

Data and Methods

Data Sources

This paper takes 2001-2016 as the research period, and the demographic data are from the statistical yearbook of corresponding years. Data of administrative division boundaries are derived from the National Basic Geographic Information Center in 2015.

Research Method

Population Concentration Index. The concentration index is often used to analyze the concentration of population distribution [6], the equation is as follows:



$$C = \frac{1}{2} \sum \left| x_i - y_i \right| \quad . \tag{1}$$

Where, x_i is the proportion of the population of the regional unit i in the total population of the research area; y_i refers to the proportion of the unit land area of i region in the total area of the research area. The smaller the index C, the more balanced the population distribution in this region, and vice versa [7].

Center of Population. Suppose the research area is composed of n sub-units, (X_i, Y_i) is the geometric central coordinate of the *ith* sub-unit, P_i is the population of the sub-unit, then the center of gravity coordinate of the population in the research area is [8]:

$$\overline{x} = \frac{\sum_{i=1}^{n} P_i X_i}{\sum_{i=1}^{n} P_i} \qquad \overline{y} = \frac{\sum_{i=1}^{n} P_i X_i}{\sum_{i=1}^{n} P_i}$$

Population Distribution Gini Coefficient. The Gini coefficient of population distribution is an indicator that characterizes the imbalance of population distribution or the spatial heterogeneity of population distribution [9]. As shown in Fig. 1, A is unbalanced area; when the population distribution is completely unbalanced, the area A+B is completely unbalanced area. The ratio of A to A+B is the Gini coefficient G of population distribution:



Figure 1. A diagram of the Lorentz curve of population distribution

Results

Spatial and Temporal Distribution of Population Density

The average population density in northwest China increased from 30 people $/km^2$ in 2001 to 34 people $/km^2$ in 2016. The population density in this area shows the characteristics of dense southeast, sparse northwest and extremely uneven distribution. The areas with high population density are mainly distributed in the eastern and surrounding areas with superior natural environmental conditions, prominent geographical advantages, high level of economic development and great attraction to the population. The areas with low population density are mainly distributed in the areas with higher elevations or deserts and their edges are not suitable for human habitation.

Comparing with 2001, the population density of the majority country increased in 2016, but the number of counties with negative annual changes in population density also increased. The number

(2)



of counties with negative annual growth in population density during the three study periods (2001-2006, 2006-2011 and 2011-2016) was 39, 77 and 98 respectively. The large population displacement is the main reason for the negative population growth in these areas.

Concentration of Population

The population concentration index of northwest China in 2001 and 2016 was 0.666 and 0.658 respectively, which decreased slightly during the 15-year period (Fig.2). In 2016, the population concentration index was the highest in Urumqi and the lowest in Zhongwei. The population concentration index increased in 27 cities, and the largest increase was in Jiuquan. The population concentration index decreased in the remaining 25 cities, and the largest decrease was in Haixi.



Figure 2. The population concentration index classification for 2001 and 2016

Population Centers of Gravity and Their Migration

From 2001 to 2016, the population gravity center of northwest China has been located in the southeast of the geometric center of the region ($91^{\circ}50'17''E$, $38^{\circ}50'20''N$), and continues to move slowly to the northwest (Fig. 3). The significant difference of natural population growth rate among provinces and is the main reason that causes the population center of gravity to move slowly to the northwest.



Figure 3. The Change of gravity center of population distribution of Northwest China in 2001-2016

Population Distribution Gini Coefficient

The Gini coefficient of population distribution in northwest China was over 0.7 from 2001 to 2016 (Table 1), indicating a significant imbalance in population distribution in this region.

year region	2001	2006	2011	2016
Northwest China	0.7764	0.7656	0.7752	0.7725
Qinghai	0.8114	0.8006	0.7951	0.7924
Xinjiang	0.6393	0.6006	0.6555	0.6504
Shaanxi	0.4405	0.4464	0.4389	0.4432
Gansu	0.6454	0.6504	0.6573	0.6373
Ningxia	0.2695	0.3017	0.3870	0.3927

Table.1 Gini coefficient of provincal population distribution

From 2001 to 2016, the Gini coefficient of population distribution in the whole region fluctuated between 0.7656 and 0.7764. In terms of provincial and district inspections, the Gini coefficient of population distribution in Ningxia is below 0.4, which is under the warning line. The Gini coefficient of population distribution in Qinghai has always been higher than the average level of the whole region, but it shows a slow decreasing trend. The Gini coefficients of population distribution in Shaanxi, Gansu and Xinjiang are basically stable, all of which are lower than the average level in the whole region. The Gini coefficient of population distribution in Shaanxi Province is significantly lower than that of Gansu and Xinjiang. The Gini coefficient of population distribution in Ningxia has the largest increase, with an increase of 45.69%. The main reason is that the mountain population has a greater intensity of concentration in cities and towns.

Conclusion and Discussion

The population distribution in Northwest China is extremely uneven. The high population density areas are always in the east part and around the capital cities. About half of the total number of cities and provinces have a reduced population concentration index. The overall concentration degree is slightly reduced, but not obvious. On the one hand, the surrounding population gathers in cities and towns, on the other hand, the migration of the population is the main reason for the decrease in population concentration in the northwestern region. Xinjiang's natural population growth rate ranks first in China, the high natural population growth rate is the main reason that Xinjiang's population growth rate is faster than that of other provinces and regions, which causes the population center of northwestern China to continue to move toward the northwest. The population distribution in northwest China has a high Gini coefficient and small change elasticity. The population distribution is significantly uneven, and the primary reason is that the natural environmental conditions within the region are limited, and national policies and traffic conditions play a decisive role in some important changes, causing the population distribution Gini coefficient to fluctuate and the different provinces within the region to change. Under the joint action of economic society [10], natural geography and environmental factors, spatial unbalance has become a long-term stable feature of population distribution in northwestern China.

The population gravity center of northwest China is moving steadily toward the northwest, mainly affected by the differences in the natural population growth rates of Xinjiang and Shaanxi. The population distribution Gini coefficient of the two provinces has increased to varying degrees, but they changed differently in the three periods. The relationship between the situation and the influence degree of various factors affecting the population disequilibrium in the northwest region needs further quantitative research and discussion in the future.

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