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Temporal and Spatial Distribution Pattern of Population at the South End of Hu Line in Recent 25 Years

Liang Yuting[1, 2, 3], Yu Huan[1*]

[1]School of Earth Sciences, Chengdu University of Technology, Chengdu 610059, China
[2]Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China
[3]Chinese Academy of Sciences University, Beijing 100101, China.

Abstract. The southern end of Hu Line mainly involves Sichuan and Yunnan provinces. In this paper, the spatial-temporal distribution pattern of population is analyzed by Standard Deviation Ellipse (SDE) and Exploratory Spatial Data Analysis (ESDA). The influence of human geography, natural geography and soil environmental factors on the spatial distribution of population and interactive interpretation are quantitatively calculated based on Geo-detector. The results show that: (1) the spatial distribution pattern of the population at the southern end of Hu Line is northeast-southwest. The spatial differences between the two sides are significant, the standard deviation ellipse turns weaker gradually, and the population distribution in southwestern China is balanced year by year. (2) The population concentration of the southern end of the Hu Line has been decreasing with the “U” type. Spatial aggregation occurs in high-density counties and surrounding high-density counties. The inaccessible regions appear in contiguous on the west side of the Hu Line. In less counties, there is a clear difference between the surrounding counties and the self, and the spatial distribution of the population tends to be balanced. (3) The dominant factors affecting the spatial distribution of population over the years are GDP density, nighttime lighting, road nuclear density, landforms, farmland production potential and elevation. (4) GDP density, road nuclear density, NDVI and NPP have a good interaction enhancement effect on population distribution. The first geographical intrinsic and the second geographic intrinsic evaluation index have the highest priority. The two-factor action intensity is greater than the single-factor action intensity, and the interaction type tends to be dominated by nonlinear enhancement. The spatial distribution of the population in the southern end of the Hu Line is mainly balanced by economic development and road construction. Night lighting, landform, farmland production potential, elevation, NDVI and NPP are potential factors for optimizing the population distribution at the southern end of the Hu Line.

1 Introduction

The "Hu Line" was proposed in 1935. It is one of the important contributions to the society in the field of human geography and science. It is a major geographical discovery that explores the relationship between man and land as well as the relationship between man and environment[1]. Hu Line portrays the first nature of the natural endowments of landforms and climate. It has world significance, and the so-called Hu Line in the United States has been broken [2]. In China, Hu Line can be further optimized and adjusted from the perspective of spatial statistical differentiation[3]. China's population distribution is consistent with the stepped contour of its topography, and there are also step-like changes[4]. The population distribution in China is dense in the east and sparse in the west. The population, urbanization level and economic development level have declined from west to east with the topographical steps in China[5]. Scientifically revealing the regional differentiation mechanism in poverty-stricken areas has become an important issue in implementing national poverty alleviation strategies[6]. One of the basic concepts of geography is that everything is related to everything else, but near things are more related to each other. This low is defined as " Tobler's First Law of Geography " (spatial correlation)[7]. The increasing number of large spatial reference datasets, GIS visualizations, and the complex capabilities of fast data retrieval and operations have created a need for new technologies for exploratory and verifiable spatial data analysis [8, 9]. Although there are many methods in the geo-analyzer's toolbox, there are only a few methods that are suitable for dealing with the "spatial distribution" aspects of these large data sets. [10]。 Wang J F’s team (2009) developed a model that can analyze spatial data in batches and quickly: Geographical Detector (Geo-detector). According to the real-time statistics of Geo-detector's official website (http://www.geodetector.org/): As of August 8, 2019, there are 571 relevant academic literatures at home and abroad.

We choose Sichuan and Yunnan provinces at the southern end of the Hu Line as research areas and then construct an index system that explains the spatial distribution pattern of population and geographical

*Corresponding author: liangyt_ing@163.com

background factors. In order to reasonably understand the impact mechanism of various impact indicators on the spatial distribution pattern of population, the factor detector is used to calculate q values of natural geographical factors, human geography factors and soil environmental factors. The interaction detector is used to reveal the interactive explanatory power of various factors on the spatial distribution pattern of the population. Based on the above process, this research provides a scientific basis for the optimization and adjustment of population distribution at the south end of Hu Line in recent 25 years.

2 Data resources

The research data includes 24 evaluation indicators, involving human geography, natural geography and soil environmental factors.

(1) Human geography factors: population density, GDP density, nighttime lighting, food production potential and farmland production potential data from the Resource and Environmental Science Data Center of the Chinese Academy of Sciences (http://www.resdc.cn/), the source of road nuclear density Produced by the STS project of the Chengdu Institute of Mountain Hazards and Environment, Chinese Academy of Sciences.

(2) Natural geographical factors: The DEM data is derived from the 30m resolution digital elevation model data provided by the geospatial data cloud platform (http://www.gscloud.cn/), and the geomorphic data is derived from the map of the People's Republic of China (1:1000000). Annual average precipitation, annual average temperature, water supply value, wetness index, biodiversity, ecological importance, ecological sensitivity and NDVI data are from the Resource and Environmental Science Data Center of the Chinese Academy of Sciences (http: //www.resdc.cn/). NPP data is from the National Earth System Science Data Sharing Platform (http://www.geodata.cn/).

(3) Soil environmental factors: soil effective water content, soil organic matter, soil erosion, soil type, soil conservation value, soil total phosphorus content, soil total potassium content and soil total nitrogen content, eight evaluation indicators, all from cold regions District Science Data Center (http://westdc.westgis.ac.cn/).

3 Population Distribution Pattern at the South End of Hu Line

3.1 Spatial distribution pattern of population

There was significant spatial heterogeneity in the spatial distribution of population in 1990, 2000 and 2015. The SDE direction angle from 1990 to 2000 to 2015 was reduced from 29.993° to 28.152° to 27.587°. The spatial distribution pattern of the population is northeast-southwest, the population distribution center was on the east side, and the SDE center gradually moved to the southwest end. The population distribution in the southwestern region is more balanced.

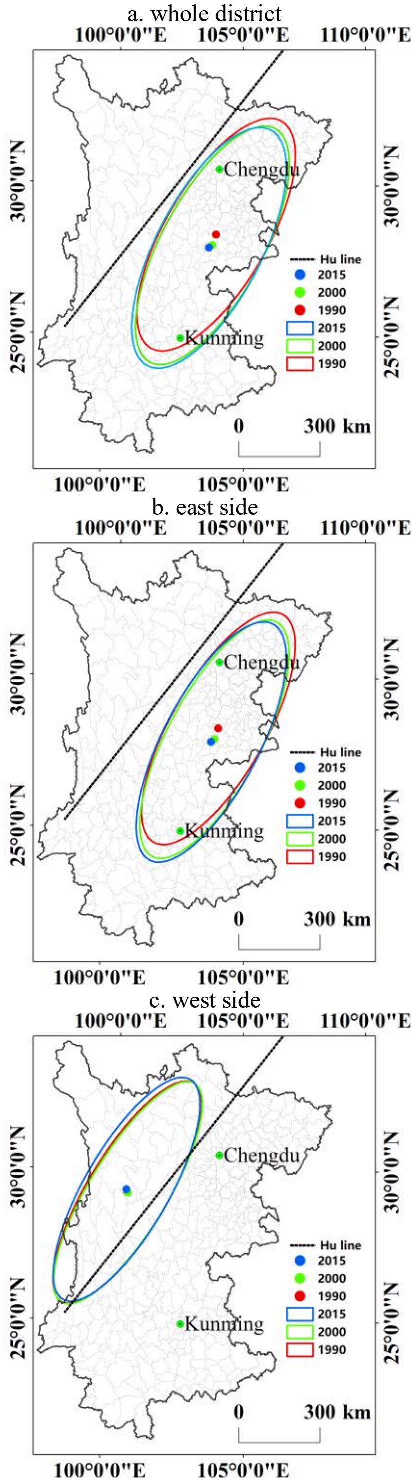
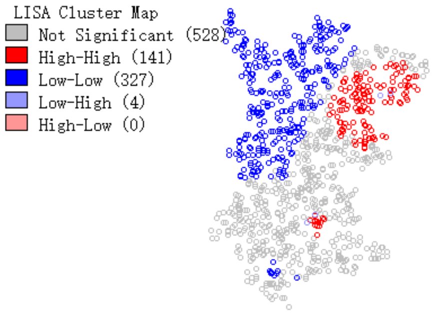


Figure 1 The SDE distribution of the population density on both sides of the southern end of the Hu Line in 1990, 2000 and 2015

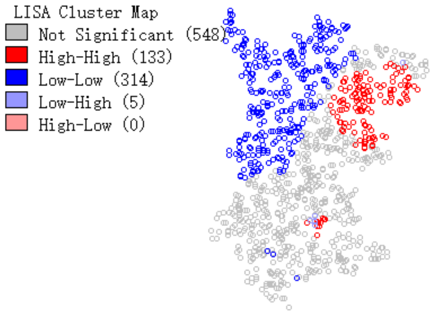
3.2 Spatial heterogeneity of population distribution

The spatial distribution of population density in 1990, 2000 and 2015 showed significant spatial autocorrelation, and the degree of aggregation showed a “U” change, and its value decreased year by year. Spatial aggregation occurs in high-density counties and surrounding high-density counties. The inaccessible regions appear in contiguous on the west side of the Hu Line. In less counties, there is a clear difference between the surrounding counties and the self, and the spatial distribution of the population tends to be balanced.

a. 1990



b. 2000



c. 2015

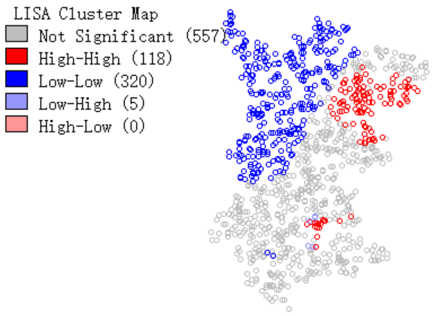


Figure 2 LISA maps of population density in 1990, 2000 and 2015

4 Detection of the driving factors of population distribution pattern at the south end of Hu Line

4.1 An indicator system of influencing factors

We collected 24 influencing indicators, of which soil available water content, soil type, soil erosion and landform were type variables. Due to the large difference in the value of each influencing factor, according to the requirements of the use of Geo-detector, the remaining continuous variables need to be reclassified. Finally, we found that the Natural Break method with 32 categories can reach the highest precision, thus obtaining the highest q-statistics and the best geographical divisions.

4.2 Factor detector

To detect the spatial statistical relationship between 24 geographical background factors and population density in 1990, 2000 and 2015, we use the factor detector to calculate the single factor explanatory power of each evaluation index on population density. The results show that the dominant factors affecting the spatial distribution of population over the years are GDP density (77.2%, 34.7%, 96.1%), nighttime lighting (15.6%, 25.0%, 72.4%), road nuclear density (70.6%, 70.0%), landforms (66.8%, 32.5%, 55.2%), farmland production potential (54.2%, 10%, 25.4%) and elevation (63.0%, 13.6%, 23.0%). The spatial distribution of population in 1990, 2000 and 2015 is dominated by the second geographical nature such as GDP density, nighttime lighting, road nuclear density, landform, farmland production potential and DEM. The second geographical nature such as social economy, transportation convenience and other factors continue to increase, and gradually occupy the dominant position. Although the force of the first geographical nature is weakening, it still continues to play an indispensable role.

4.3 Interaction detector

The results of interaction detector between population and various geographical background factors show that (Table 1): the interaction types are mainly nonlinear enhancement and bilinear enhancement, with a total of 276 interaction results, of which 209 are nonlinear enhancement type, accounting for 75.72% and 67 are bilinear enhancement type, accounting for 24.28%. The results of interaction detector show that the two-factor action intensity is greater than the single-factor action intensity, and the dominant type is nonlinear enhancement. The single factor explanatory power of GDP density reaches 96.10%. The GDP density significantly enhances the explanatory power of the remaining 23 evaluation indicators on the spatial distribution of population. All the interaction values of GDP density are above 95%, and they are bilinear enhancement.

Table 1 The partial results of interaction detector (from high to low)

driving factors(D_1/D_2)	**C=PD,H($D_1 \cap D_2$)**	**A=PD,H(D 1)+ $P_{D,H}(D_2)$**	**interaction**
GDP/Landform	0.981	1.513	Bilinear
GDP/NPP	0.980	1.177	Bilinear
GDP/Soil phosphorus	0.980	1.116	bilinear
……			
Soil effective water/Biodiversity	0.101	0.096	Nonlinear
Soil erosion/Wetting index	0.088	0.062	Nonlinear
Soil effective water/Soil erosion	0.072	0.050	Nonlinear

Note: D represents impact factors; H represents population density; $P_{D,H}$ is the explanatory power of D to H, that is the contribution rate. Let the interactive explanatory power be $P(D_1 \cap D_2)$. If $P(D_1 \cap D_2) < \min(P(D_1), P(D_2))$, it is nonlinear weaken. If $\min(P(D_1), P(D_2)) < P(D_1 \cap D_2) < \max(P(D_1), P(D_2))$, it is one-factor nonlinear weaken. If $P(D_1 \cap D_2) > \max(P(D_1), P(D_2))$, it is bilinear enhancement. If $P(D_1 \cap D_2) = P(D_1) + P(D_2)$, the two factors are independent of each other. If $P(D_1 \cap D_2) > P(D_1)+P(D_2)$, it is nonlinear enhancement.

5 Conclusions

Based on the previous research and the existing research basis, this paper proposes the optimization of the southern end of the Hu Line. The standard spatial ellipse analysis tool and exploratory spatial data analysis (ESDA) are used to analyze the spatial distribution pattern of the population. Using Geo-detector to obtain single-factor explanatory power and interactive detection results, we quantitatively analyzed the driving factors of the population distribution pattern at the southern end of the Hu Line. Regardless of whether it is the second geographical nature factor that is gradually becoming dominant, or the first geographical nature factor with a downward trend, it is an important factor in the analysis of population spatial distribution. The spatial distribution of population in the southwestern region is mainly balanced by the density of GDP and the density of roads. The nighttime lighting, landforms, farmland production potential, elevation, NDVI and NPP are potential factors for the optimization of the southern end of the Hu Line.

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