Street-Scale Spatial Distribution Characteristics of Basic Education Resources in Xi' an: Postprint

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Date: 2019-11-15T00:00:00+00:00

Abstract

Based on POI data of educational facilities and taking streets as the research scale, this study analyzes the spatial distribution characteristics of basic education resources in the main urban area of Xi' an using ArcGIS standard deviational ellipse, kernel density estimation, and GeoDa' s Exploratory Spatial Data Analysis (ESDA). The results show that: in terms of spatial layout, Xi' an' s basic education resources exhibit characteristics of "sparse in the outer areas and dense in the inner areas, sparse in the east and dense in the west, sparse in the north and dense in the south" ; in terms of direction, their spatial layout presents a "northeast-southwest" orientation. Kindergartens and primary schools are mainly concentrated in the central urban area, with a small portion concentrated in the periphery, while middle schools are mainly concentrated in the central urban area. H-H type areas are mainly concentrated in the southern and northern parts of the city, while L-L type areas are mainly concentrated in special zones within the central urban area. Overall, research on the spatial distribution characteristics of basic education resources in Xi' an at the street scale can clearly reflect the spatial pattern of basic education resources in Xi' an, and can provide a theoretical basis for relevant government departments to rationally plan the layout of educational facilities.

Full Text

Preamble

DOI: 10.12118/j.issn.1000-6060.2019.06.27
Journal: ARID LAND GEOGRAPHY (ChinaXiv Partner Journal)

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Abstract

Based on POI data for educational facilities, this study analyzes the spatial distribution characteristics of basic education resources in the main urban area of Xi' an City, Shaanxi Province, at the street scale using ArcGIS' s standard deviation ellipse, kernel density estimation, and GeoDa exploratory spatial data analysis (ESDA). The results show: (1) From the spatial distribution perspective, basic education resources in Xi' an City exhibit a pattern of high density in the city center and low density in peripheral areas, high density in the west and low density in the east, and high density in the south and low density in the north. In terms of distribution direction, there appears to be a line from northeast to southwest with high density along this axis. (2) Location-wise, kindergartens and primary schools gather in bulk to form a multi-center layout, while middle schools are mainly concentrated in the city center. (3) From the perspective of spatial agglomeration characteristics, High-High districts are mainly concentrated in the south and north of the city, while Low-Low districts are mainly concentrated in special areas of the central urban zone. Overall, the spatial distribution characteristics of basic education resources in Xi' an City at the street scale can clearly reflect the spatial pattern of basic education resources, which could provide a theoretical basis for relevant government departments to rationally plan the layout of educational facilities.

Keywords: Xi' an City; basic education; spatial distribution; POI

Methodology

This study employs exploratory spatial data analysis (ESDA) techniques to investigate spatial patterns of educational resource distribution. Kernel density estimation is applied to visualize the concentration of facilities, with the estimation function:

$$f_n(x) = \frac{1}{nh^2\pi} \sum_{i=1}^{n} K\left(\frac{1-((x-x_i)^2+(y-y_i)^2)}{h^2}\right)$$

where K represents the kernel function, h is the bandwidth parameter, and n denotes the number of observations.

Spatial autocorrelation is measured using Moran' s I, yielding values of 0.2857, 0.2319, and 0.2558 (all significant at $P < 0.001$), which indicates significant positive spatial autocorrelation in the distribution of basic education resources. The standard deviation ellipse analysis further reveals a directional distribution pattern oriented from northeast to southwest. This pattern is particularly pronounced for primary schools and kindergartens, which form multiple subcenters throughout the urban area, while middle schools demonstrate greater centralization in the core city.

Results and Discussion

The analysis identifies distinct spatial clustering patterns that challenge conventional assumptions about urban resource distribution. High-High clusters (areas with high resource density surrounded by similarly high-density areas) are predominantly located in the southern and northern parts of the city. Conversely, Low-Low clusters are found in specific central urban districts, suggesting that central location does not uniformly guarantee high resource availability.

The multi-center distribution of kindergartens and primary schools reflects residential planning and population distribution patterns. In contrast, the centralized distribution of middle schools may indicate potential accessibility challenges for students in peripheral areas. These findings provide empirical evidence for urban planners and education administrators seeking to optimize the spatial allocation of educational resources and address equity concerns in service provision.

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Note: Figure translations are in progress. See original paper for figures.