Spatial Patterns and Driving Forces of Oasis Rural Settlements in the Ebinur Lake Basin (Postprint)

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Abstract

By understanding the spatial patterns of oasis rural settlements and revealing their influencing mechanisms, this study aims to provide a basis for settlement management and planning in the construction of beautiful villages in the northwestern border oasis. Based on GIS technology, quantitative statistical methods, and field investigation surveys, an analysis was conducted on the spatial patterns and influencing factors of oasis rural settlements in the Ebinur Lake Basin, Xinjiang. The results show that: (1) The oasis rural settlements in the Ebinur Lake Basin are generally characterized by small scale, low density, and high fragmentation of cores, exhibiting distribution patterns of medium-low density radial type on alluvial-proluvial fan plains, low-density linear type along river sides, medium-high density strip type, and high-density agglomeration type in the Jinghe Basin. (2) Significant local-scale variation in settlement size is observed, with cold spots mostly being Xinjiang Production and Construction Corps regiment farms and hot spots mostly being local township villages. (3) Settlements are mainly distributed in areas below 800 m elevation, within 2 km of rivers, and within 1 km of roads, and are profoundly influenced by policy and institutional factors. The development of rural settlements is more constrained by human behavior; however, under the natural conditions of the Ebinur Lake Basin oasis, including special topography and geomorphology, significant elevation differences, and the Bortala River and Jinghe River traversing the entire region, the pattern and further development of rural settlements are restricted.

Full Text

Spatial Pattern and Driving Force of Oasis Rural Settlements in the Ebinur Basin

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Abstract: Understanding the spatial distribution patterns and influencing mechanisms of oasis villages provides a basis for settlement management and planning in the process of beautiful countryside construction as well as the implementation of rural revitalization strategy in oasis regions. The scale, agglomeration degree, and distribution characteristics of oasis rural settlements in the Ebinur Basin, Xinjiang Province were analyzed using GIS technology, statistical measurement, and field survey methods. The results showed that oasis villages in the Ebinur Basin were clustered at small scales, with 75.8 percent of villages having areas of 1.4 hm^2, far below the average value of 7.3 hm^2. In Xinjiang, there are two systems: the Xinjiang Production and Construction Corps (XPCC) and the local system, with obvious differences in rural settlement scales. Compared with the local system, XPCC had a shorter development history, so the number of its rural settlements was smaller. XPCC implemented water-saving irrigation and enterprise management modes to improve agricultural production and management, and because of this large-scale industrial agriculture, most villages in XPCC were cold spots through Getis-Ord Gi*, meaning the scale of rural settlements was small. While in local townships, though large contractors had contracted land for agricultural cultivation, rural settlements still maintained considerable quantity and scale on the basis of small-scale peasant economy. The overall density was very low and the relative high-density area was dispersive. Significant natural features were strongly presented in oasis rural settlements: villages distributed in alluvial and diluvial fan plains were of middle and low density in fan-beaming shape; on the sides of rivers, rural settlements were of low density in linear shape as well as middle-high density in stripe shape; in the Jinghe Basin, rural settlements were of high density in block shape. The effects of elevation, river, topography, transportation, and policy system on oasis rural settlements were analyzed. Buffer analysis of elevation, river, and road showed that rural settlements were mainly distributed under 800 m sea level, within 2 km from the river, 1 km from the road, and were deeply affected by the policy system. It concluded that rural settlements were more subject to human behaviors, including built roads, government policies such as Construction of Beautiful Countryside, Counterpart Support for Xinjiang, Poverty Alleviation Policy, local investment attraction, and so on. However, the pattern of rural settlements and its further development was limited to a great extent in the Ebinur Basin due to its special topography with high mountains surrounded on three sides of the region (west, north, and south), large elevation difference, and two rivers (Bortala River and Jinghe River) running through the entire area. Improving local economy development level and strengthening the advantages of transportation might be effective means in alleviating the limitations.

Keywords: oasis; rural settlements; spatial pattern; distribution characteristics; Ebinur Basin

1 Study Area

The Ebinur Basin is located between 43°38 ~45°52 N and 79°53 ~85°02 E, in the western part of the Junggar Basin. It is a typical temperate arid region with an average annual precipitation of less than 200 mm. The study area includes all administrative units of the Ebinur Basin, covering 36 counties and cities with a total area of over 3000 km^2. The data sources include: (1) Landsat 8 imagery from 2015 with 30 m resolution for land use classification; (2) DEM data with 30 m resolution and its derived slope data with 90 m resolution; (3) vector data of administrative boundaries and transportation networks.

2 Methods

2.1 Getis-Ord General G

The Getis-Ord General G statistic was used to analyze the overall spatial agglomeration pattern of rural settlements in the study area. The formula is:

$$G(d) = \frac{\sum_i \sum_j W_{ij}(d) x_i x_j}{\sum_i \sum_j x_i x_j}$$

where d is the distance threshold, $W_{ij}(d)$ is the spatial weight matrix, and x_i and x_j are the attribute values of features i and j. The standardized Z-score is calculated to test significance. When $G(d)$ is higher than expected, it indicates high-value clustering; when lower, it indicates low-value clustering.

2.2 Getis-Ord Gi*

The Getis-Ord Gi* statistic was used to identify local hot spots and cold spots of rural settlement scales. The formula is:

$$G_i^*(d) = \frac{\sum_j w_{ij}(d) x_j}{\sum_j x_j}$$

The standardized Z-score is:

$$Z(G_i^*) = \frac{G_i^* - E(G_i^*)}{\sqrt{var(G_i^*)}}$$

A positive $Z(G_i^*)$ indicates hot spots (high-value clustering), while a negative value indicates cold spots (low-value clustering).

2.3 Kernel Density Estimation (KDE)

KDE was used to analyze the spatial density distribution of rural settlements. The formula is:

$$f(x, y) = \frac{1}{nh^2} \sum_{i=1}^{n} k\left(\frac{d_i}{h}\right)$$

where $f(x, y)$ is the density estimate at location (x, y), n is the number of observations, h is the bandwidth, k is the kernel function, and d_i is the distance between observation i and location (x, y).

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3 Results

3.1 Scale Characteristics of Rural Settlements

The statistical analysis shows that the Ebinur Basin contains 1,716 rural settlements with a total area of 12,584.6 hm^2 and an average area of 7.3 hm^2 per settlement. The scale distribution is highly skewed: 75.8% of settlements are smaller than 8 hm^2, with an average size of only 1.4 hm^2; 14.2% range from 8-18 hm^2; and those larger than 18 hm^2 account for 10.0% of the total.

The Getis-Ord General G analysis reveals a clustering pattern at the 200 m scale. The Z(G) value of -2.02 indicates significant low-value clustering at the 5% significance level, meaning small-scale settlements tend to cluster together.

3.2 Spatial Distribution Patterns

The KDE analysis shows three distinct distribution patterns: (1) fan-beam type on alluvial/diluvial plains with medium-low density; (2) linear and stripe types along river corridors with low to medium-high density; (3) block type in the Jinghe Basin with high density.

Buffer analysis reveals strong proximity effects: 36.5% of settlements are located within 0-2 km of rivers, 21.4% within 2-4 km, and 14.5% within 4-6 km. Similarly, 48.6% of settlements are below 400 m elevation, 28.8% between 400-800 m, and 16.9% between 800-1200 m.

3.3 Influencing Factors

Topography: Settlements are concentrated in areas with slopes less than 5°, primarily on alluvial fans and river terraces. The basin' s unique topography—surrounded by mountains on three sides with significant elevation differences—creates a narrow distribution space.

Water resources: Proximity to the Bortala and Jinghe Rivers is the dominant factor, with 78.4% of settlements within 5 km of water sources. The density decreases exponentially with distance from rivers.

Transportation: Road accessibility shows a clear threshold effect, with 65.3% of settlements within 1 km of major roads. The XPCC system shows more road-oriented patterns due to planned infrastructure development.

Policy systems: The dual management system (XPCC vs. local) creates distinct settlement patterns. XPCC settlements are smaller and more dispersed due to large-scale agricultural operations, while local settlements maintain traditional clustered patterns based on smallholder farming. Recent policies including Beautiful Countryside Construction, Counterpart Support for Xinjiang, and Poverty Alleviation have further influenced settlement consolidation and relocation.

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4 Discussion

The spatial pattern of oasis rural settlements in the Ebinur Basin reflects the interplay between natural constraints and human adaptation. The mountainous terrain limits available land to narrow corridors along rivers, creating linear settlement patterns. Water availability remains the primary determinant, with settlements clustering within 2 km of rivers. The dual governance system (XPCC and local) produces contrasting patterns: XPCC' s industrial agriculture favors dispersed, small settlements, while traditional smallholder farming maintains larger, clustered villages.

Policy interventions have accelerated settlement consolidation, particularly through relocation programs for poverty alleviation. However, topographical constraints limit expansion options. Improving transportation infrastructure could mitigate isolation effects and support economic development. Future settlement planning should balance ecological carrying capacity, water resource sustainability, and socioeconomic benefits, considering the basin' s unique environmental and institutional context.

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[13] [Other references with similar formatting···]

[Figure 1: see original paper] Location of the study area
[Figure 2: see original paper] Spatial distribution of oasis rural settlements
[Figure 3: see original paper] Spatial density of oasis rural settlements in Ebinur

Basin
[Figure 4: see original paper] Distribution of oasis rural settlements at different elevations in Ebinur Basin
[Figure 5: see original paper] Distribution of oasis rural settlements at different gradients in Ebinur Basin
[Figure 6: see original paper] [Additional figure references…]

Scale of oasis rural settlements in Ebinur Basin
[Additional table references…]

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

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