# Spatial Growth Patterns of Newly-Built Towns in Hui Ethnic Settlement Areas: A Case Study of Hongsibao Town, Wuzhong City, Ningxia (Post-print)

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## Abstract

Newly built towns in Hui ethnic minority concentrated areas of Northwest China generally refer to new towns with a relatively high proportion of Hui population constructed in regions suitable for production and living during the building of a moderately prosperous society through poverty alleviation projects, ecological migration projects, and large-scale village consolidation to address development weaknesses. These towns are profoundly influenced by government actions and urban planning, and differ significantly from ordinary towns in their growth process, which combines spatial self-organization and other-organization. This study takes Hongsibu Town in Wuzhong City, Ningxia, located in the new Yellow River water-lifting irrigation area of central Ningxia, as a case study. Using remote sensing imagery from three periods (2005, 2010, and 2016) and employing methods such as the land use dynamic degree model, spatial autocorrelation model, and kernel density estimation, it explores the spatial growth pattern characteristics of newly built towns in Hui ethnic minority concentrated areas. The results indicate: (1) Hongsibu Town has gradually transformed from an early land use pattern dominated by residential land to a composite land use pattern led by residential-industrial and mining storage-park green space land. As a newly built town, Hongsibu Town' s urban spatial growth in the initial stage primarily formed an urban core area based on public service and infrastructure land, commercial service land, and urban courtyard land, presenting a star-shaped primitive growth pattern. With the increase in urban population, the urban spatial growth rate accelerated, and the space exhibited axial-belt and leapfrog mixed expansion growth. Under the guidance of urban planning, the proportion of ecological land such as parks and green spaces, residential communities dominated by high-rise buildings, and industrial and mining storage land in land use types increased significantly, and the land use pattern

gradually shifted toward a composite land use pattern. (2) Global Moran' s I index research demonstrates that after nearly ten years of urban construction, particularly under the influence of scientific and rational urban planning, the spatial autocorrelation of various land use types has gradually strengthened, and the spatial pattern shows an agglomeration trend. Based on three rounds of urban planning and land use planning, characterized by the mixed layout of functional land uses, the overall pattern of urban land use has not undergone drastic changes, with only minor adjustments made on the original foundation. Urban spatial growth tends toward stability, land use types and structural proportions tend toward rationality, and the effectiveness of new-type small town construction is beginning to emerge. (3) As a small town inhabited by the Hui ethnic group, the spatial distribution pattern of mosques in Hongsibu Town has changed little, generally showing a characteristic of relatively dense distribution in the southwest and relatively sparse distribution in the northeast, which is closely related to the widespread distribution of agricultural settlements in each period. In recent years, the town has witnessed a transformation of mosques from low-density sprawl to high-density sprawl. This change is mainly influenced by the Hui cultural characteristics of having multiple religious sect systems, and the spatial distribution shows a high consistency with the randomness of population distribution among various sects.

## Full Text

## Preamble

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## 1. Study Area

Hongsibu Town, established in 2000, is a newly built town in the Hongsibu District of Wuzhong City, Ningxia Hui Autonomous Region. The study area is located between 105°43 -106°14 E and 37°28 -37°37 N, with a north-south length of approximately 80 km and an east-west width of approximately 40 km, covering a total area of 2,767 $km^2$. The town administers 5 administrative villages and 1 residents' committee, with a total population of 92,150 as of 2016. The region is characterized by a semi-arid climate, with the terrain sloping from southwest to northeast. The study area represents a typical newly built town in a Hui nationality area, where urban development has been strongly influenced by government planning and policy implementation, including poverty alleviation projects, ecological migration programs, and village consolidation initiatives.

## 2. Data and Methods

### 2.1 Data Sources

Three periods of remote sensing imagery from 2005, 2010, and 2016 were used as the primary data source. The images were processed using ArcGIS 10.1 software for geometric correction, radiometric calibration, and image enhancement. A supervised classification method was employed to extract land use information, with classification accuracy reaching 85.25% and a Kappa coefficient of 0.8. The land use classification system included six categories: construction land, industrial and mining land, agricultural land, ecological green space, water bodies, and unused land.

### 2.2 Analysis Methods

**Land Use Dynamic Degree Model:** The land use dynamic degree model was applied to quantify the rate and intensity of land use change during the study period. The model calculates the annual change rate of different land use types based on area transitions between periods.

**Spatial Autocorrelation Analysis:** Global Moran' s I index was used to measure the spatial autocorrelation and clustering patterns of land use types. The Moran' s I values were calculated for each time period to assess the degree of spatial agglomeration.

**Kernel Density Estimation:** Kernel density analysis was performed to examine the spatial distribution patterns of mosques and their relationship with residential areas. This method helps identify hotspots of religious facility distribution and their evolution over time.

## 3. Results

### 3.1 Land Use Change Analysis

From 2005 to 2016, the total construction land area in Hongsibu Town increased from 1,108.65 $hm^2$ to 1,905.94 $hm^2$, representing a net increase of 797.29 $hm^2$ (71.9% growth). The most significant changes occurred in industrial and mining land, which expanded by 243.32 $hm^2$, and residential land, which increased by 211.00 $hm^2$. Agricultural land decreased correspondingly, with a net reduction of 719.37 $hm^2$. The land use structure transformed from a simple residential-dominated pattern to a complex composite pattern characterized by mixed residential-industrial functions and enhanced green spaces.

### 3.2 Spatial Autocorrelation Characteristics

The Global Moran' s I index for land use showed a consistent increasing trend: from 0.2680 in 2005 to 0.6366 in 2010, and further to 0.7040 in 2016 ($p < 0.001$ for all years). This indicates that the spatial autocorrelation of land use types strengthened significantly over time, with increasingly prominent spatial agglomeration. The low initial value suggests a dispersed, random distribution pattern in the early development stage, while the higher values in later periods reflect the formation of functional zones and structured urban spatial organization under planning guidance.

### 3.3 Spatial Distribution of Mosques

Kernel density analysis of mosque distribution revealed a stable spatial pattern from 2005 to 2016, with relatively high densities in the southwest and relatively sparse distribution in the northeast. This pattern closely correlates with the spatial distribution of the Hui population across different periods. However, a gradual trend toward higher density clustering emerged, reflecting the influence of Hui cultural and religious practices on settlement patterns. The spatial distribution of mosques remained highly consistent with the population distribution of different Hui denominations throughout the study period.

## 4. Discussion

The spatial growth of Hongsibu Town exhibits distinct characteristics of planned development in ethnic minority areas. Four key findings emerge: (1) The town evolved from a simple residential model to a composite land use structure dominated by residential-industrial functions with integrated green spaces. Initial growth focused on public service infrastructure, commercial land, and urban courtyards in a star-shaped pattern, later transitioning to axis-band expansion with salutatory changes. (2) Spatial autocorrelation strengthened progressively, indicating that planned functional zoning led to more stable and rational land use structures. (3) Mosque distribution patterns remained consistent with Hui population distribution but showed increasing density, reflecting the deep influ-

ence of ethnic culture and religious practices on spatial organization. (4) The spatial growth mechanism combines top-down planning guidance with bottom-up cultural factors, creating a unique pattern that differs from spontaneous urban self-organization processes.

This study demonstrates that newly built towns in Hui nationality areas follow distinct spatial evolution pathways shaped by both government planning and ethnic cultural characteristics. The findings provide important theoretical and practical insights for urban construction in northwestern China's ethnic minority regions.

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