



# Historical Evolution and Characteristics of Villages Based on ArcGIS Core Density Analysis

## A Case Study of Shandong Province, China

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**Abstract.** The village is the witness of the development of Chinese civilization and the carrier of cultural heritage. The study of the diachronic evolution of the village can deeply reveal the evolution mechanism of the development of Chinese civilization and the laws and characteristics of village development. Based on the core density analysis function of ArcGIS, taking Shandong Province as an example, on the basis of fully mining historical data, this paper analyzes the spatial distribution characteristics of villages in different time sections, analyzes the laws and dynamic mechanism of village development and evolution, and obtains a clear pattern of village evolution in Shandong Province. The research results show that the spatial analysis function of ArcGIS can play a great role in dealing with spatial analysis problems with a large time span.

**Keywords:** ArcGIS · nuclear density analysis · historical space · evolution characteristics

## 1 Introduction

The village is closely connected with the history and culture of the Chinese nation, and is the witness of the development of Chinese civilization and the carrier of cultural heritage. Under the impact of industrial civilization, the impact of rapid urbanization, the need for modernization and other multiple factors, the development of villages is facing unprecedented challenges, and the decline and extinction of villages are increasingly serious [1]. The current mainstream research on village issues focuses on village space [2], focusing on the form and structure of village space [3], the construction of traditional residential buildings, rural social changes, the protection and activation of traditional villages and residential buildings, etc. [4]. The systematic discussion of the natural geography and human factors behind the differences in village development is still insufficient, and it is urgent to comb the vertical evolution process of village origin, development and transformation on the time axis, Explore the reasons and driving mechanism of village evolution, clarify the evolution characteristics of village spatial

and temporal distribution pattern, and provide useful reference for scientific prediction of village development trend and formulation of targeted regional village development policies.

## 2 Materials and Methods

### 2.1 Study Area and Data Source

This paper takes the administrative region of Shandong Province as the research area, with a land area of 155800 square kilometers. Shandong Province is located in the eastern coast of China, with Shandong Peninsula in the east. The terrain is dominated by mountains and hills. The central mountains are protruding, and the central and southern parts are mountainous hills. The west and north belong to the North China Plain, which is low-lying and flat. It forms a landform with mountains and hills as the skeleton and plain basins crisscross.

There are two main sources of data: DEM digital elevation data comes from geospatial data cloud platform; The historical data of the village comes from the public historical data and the latest achievements of the settlement archaeology. Take historical villages as point elements, and use ArcGIS and traditional village coordinates in Shandong Province to make village spatial distribution map.

### 2.2 Analysis Method

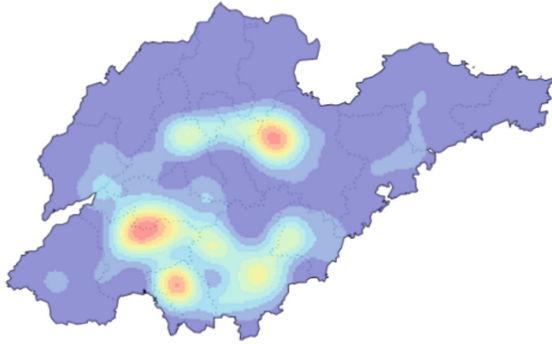
The nuclear density analysis tool of ArcGIS software is used to process the data, analyze the nuclear density of the village distribution in different historical periods in Shandong Province, and generate the nuclear density analysis chart to analyze the changes of the village distribution in different historical periods.

$$f_n(x) = \frac{1}{nh} \sum_{i=1}^n k\left(\frac{x - X_i}{h}\right) \quad (1)$$

where:  $f_n(x)$  is nuclear density;  $k\left(\frac{x-x_i}{h}\right)$  is kernel function;  $(x - x_i)$  is the distance from the valuation point  $x$  to  $x_i$ ;  $h$  is the bandwidth of kernel density function.

## 3 Results and Analysis

Taking the archaeological achievements of settlements as a reference, the development of villages in Shandong Province is preliminarily divided into four stages: the initial stage, the growth stage, the mature stage and the transformation stage [5].



**Fig. 1.** Nuclear density analysis of settlement distribution in Shandong Province during the period from Houli Culture to Dawenkou Culture.

### 3.1 Initial Stage: The Emergence of Primitive Settlements Before the Longshan Culture Period

#### 1) The period of Post-Li Culture: the embryonic form of settlement

In the post-Li culture period from 6300 BC to 5300 BC, half-cave houses appeared and fixed settlements were formed. In the post-Li culture period, the earliest settlement form in Shandong Province appeared in the floodplain area of the northern part of the central Shandong mountains, and started a long process of settlement evolution.

#### 2) Beixin Culture period: the appearance of complete settlement form

In the period of Beixin Culture from 5300 BC to 3800 BC, human beings began agricultural farming and settlement life, and a complete settlement pattern appeared. The settlements in the period of Beixin Culture were mainly found in the south and north sides of the Taiyi Mountains, and concentrated in the transitional section from the piedmont alluvial plain to the riverside platform around the central and southern mountains around Shandong.

#### 3) Dawenkou Culture period: the initial establishment of settlement system

The number of settlements in the Dawenkou culture period from 3800 BC to 2300 BC increased rapidly, and the spatial distribution gradually expanded, forming a hierarchical structure of “settlement - central settlement - settlement group”. The settlements in the Dawenkou culture period were mainly distributed along the river, and the location of settlements developed from the flood plain to the platform on both sides of the river, the Yishu River basin, the Wensi River basin, the Xue River basin and the Mi River basin. The Weihe River basin and other regions became the main settlement distribution areas during the Dawenkou culture period (Fig. 1).

### 3.2 Growth Stage: Early Village Development Accompanied by Cities

#### 1) Longshan culture and Yueshi culture period: the formation of early villages accompanied by cities

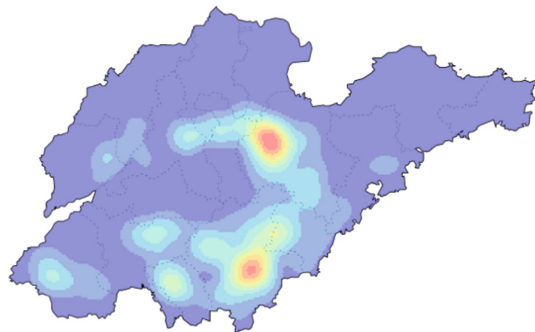
During the period of Longshan Culture (2300 BC–1700 BC), settlements sprang up like bamboo shoots on the terraces on both sides of the river (or ancient river) in the surrounding areas of Taiyi Mountain, and gradually spread throughout Shandong. During the period of Longshan Culture, the typical hierarchical settlement groups in Shandong were mainly distributed in three regions: the settlement groups in southeastern Shandong, the settlement groups in northern Shandong and the settlement groups in western Shandong (Fig. 2). The settlement structure, urban construction technology, urban defense system and social organization of the Yueshi Culture period (1700 BC–1300 BC) have made new development on the basis of the Longshan era. At this time, the distribution range of settlements in this period continued to spread around with the Taiyi Mountain system as the center. One important manifestation is that a large number of settlements appeared in the Jiaodong Peninsula area east of the Jiaolai River.

## 2) Shang and Zhou Dynasties: the expansion of early villages in Shandong

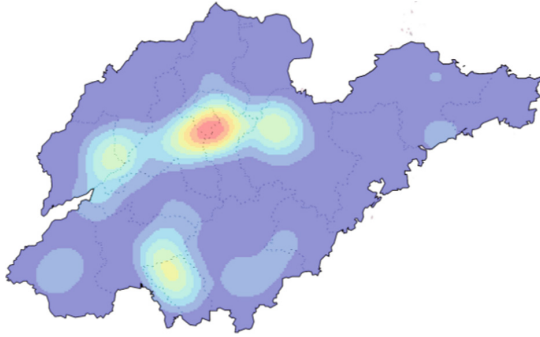
The distribution of settlements in Shandong in the Shang Dynasty can be roughly divided into three regions: one is the southwest area of the old land of Shandong in the Shang Dynasty, and the other is the south-central, northwest and central and western areas of northern Shandong, where the northern Shandong area is the main distribution area, the third is the area to the east of the Yihe River in southern Shandong, and the east of the Weihe River in northern Shandong. On the whole, the distribution of settlements in Qilu area during the Western Zhou Dynasty, the small and medium-sized settlements formed settlement groups with the Fengguo as the center, and formed two distribution areas in a larger regional space, one is the Lubei settlement area with Zibo as the center, and the other is the settlement area with Jining and Zaozhuang as the center (Fig. 3).

## 3) The Spring and Autumn Period and the Warring States Period: The spatial pattern of villages under the influence of Qilu culture has initially formed

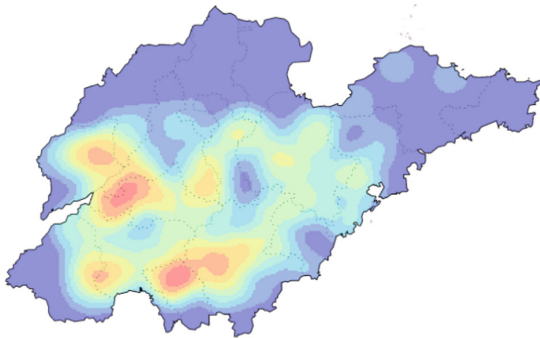
During the Spring and Autumn Period and the Warring States Period, there were more than 400 cities in Shandong, which were divided into the north and south sides of Shandong by the Great Wall of Qi, and developed into different spatial forms under the influence of Qi culture and Lu culture. From architecture to settlement layout, they were deeply affected by culture (Fig. 4).



**Fig. 2.** Nuclear density analysis of settlement distribution in Shandong Province during the Longshan Culture period.



**Fig. 3.** Analysis of the nuclear density of the settlement distribution in Shandong Province during the Shang Dynasty.

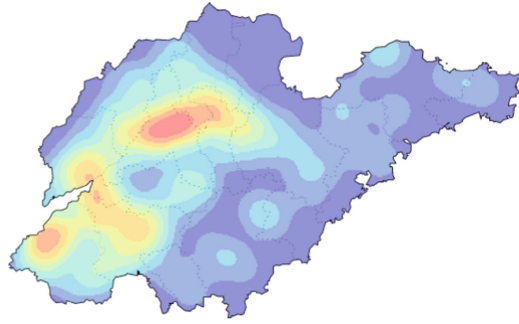


**Fig. 4.** Analysis of the nuclear density of the settlement distribution in Shandong Province during the Spring and Autumn Period and the Warring States Period.

### 3.3 Maturity Stage: Village Institutionalization and Formation of Village Community

#### 1) Qin and Five Dynasties: the formation and consolidation of village institutionalization

During the Qin and Han dynasties, the country was unified, and the scattered and small number of settlements outside the national system gradually increased, and a large number of scattered rural settlements appeared outside the city walls. From the perspective of space, it is mainly distributed in the western and southwestern regions of Shandong, which are fertile in land, dense in river network, and developed earlier, and dotted around the Taiyi Mountains. On the whole, it is sparse in the east and dense in the west, with more inland and less coastal areas. During the Western Han Dynasty, the number of rural settlements increased rapidly and the scope of spatial distribution expanded. The distribution around the Taiyi Mountains was zonal. At the same time, the number of rural settlements in the coastal area of Jiaodong increased, and the spatial distribution was balanced. During the Eastern Han Dynasty, the rural settlements in western Shandong



**Fig. 5.** Nuclear density analysis of village distribution in Shandong Province during the Tang Dynasty.

maintained a sustained growth, while the number of rural settlements in the eastern and eastern Shandong increased slowly, and the overall spatial distribution again appeared to be sparse in the east and dense in the west.

The Sui and Tang Dynasties was an important turning point in the development of ancient villages in China. At that time, the number of villages increased significantly and the distribution scope gradually expanded. According to the analysis of historical and demographic data, the villages in Shandong Province during the heyday of the Tang Dynasty were mainly distributed along the Jishui River in the northern part of the central mountain area of Shandong Province, as well as Heze, Jining and Liaocheng areas in the southwest of Shandong Province (Fig. 5).

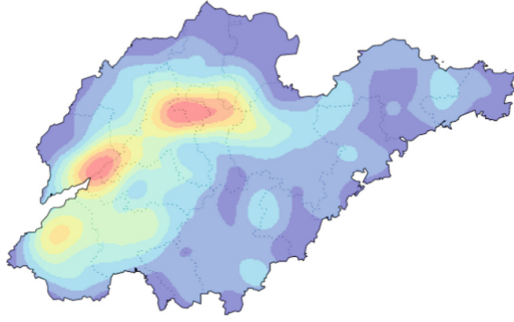
## **2) Song Dynasty - late Qing Dynasty: establishment and maturity of village community**

The Song and Yuan Dynasties was an important stage in the development of villages. The number of villages connected by towns and cities as economic ties continued to increase. The spatial distribution pattern was further concentrated on the basis of the distribution of villages in the Tang Dynasty. The distribution area of villages in the northern part of the central mountain area of Shandong in Jinan and Zibo regions expanded and formed a cluster core area. The western region of Shandong formed a cluster core area of villages at the intersection of the Yellow River and the canal. In addition, the number of villages in Yantai, Weihai also showed an increasing trend [6].

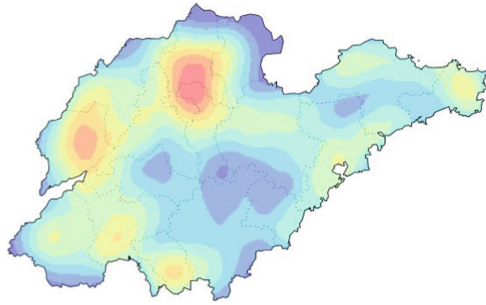
During the Ming and Qing dynasties, the rural development tended to be stable, and the migration of population, the prosperity of canals, and the construction of coastal defense, as well as the superposition of multiple factors, jointly affected and constructed the basic pattern of the spatial distribution of villages in Shandong today (Fig. 6, Fig. 7, Fig. 8).

## **3.4 Transformation Stage: Changes of Modern Villages Under the Transformation of Civilization**

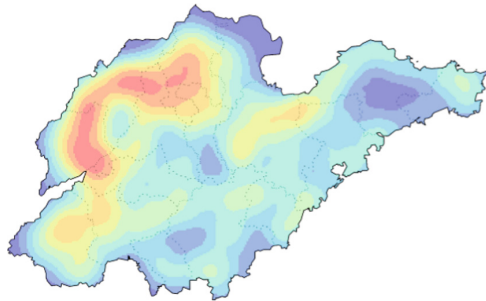
From the end of the Qing Dynasty to today, villages have been changing in the course of drastic social changes. In the process of conflict and integration between industrial



**Fig. 6.** Nuclear density analysis of village distribution in Shandong Province during the Song Dynasty.

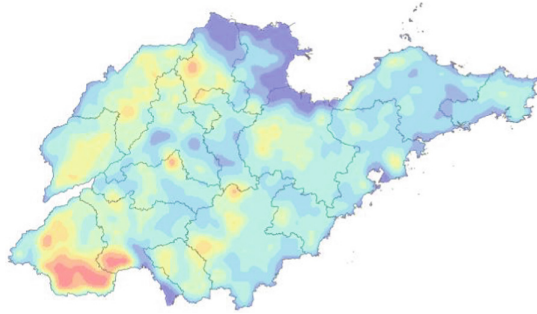


**Fig. 7.** Nuclear density analysis of village distribution in Shandong Province during the Ming Dynasty.



**Fig. 8.** Nuclear density analysis of village distribution in Shandong Province during the Qing Dynasty.

civilization and agricultural civilization, the rural society built on the basis of agricultural civilization began to embark on the path of transformation [7]. In terms of the spatial pattern of villages, the development of urbanization in the economically developed areas of eastern Shandong is more mature and the development of villages is relatively stable, while the level of urbanization in the western areas of Shandong is relatively



**Fig. 9.** Nuclear density analysis of village distribution in Shandong Province during the transition period.

low, the number of villages disappearing is more, and the regional imbalance of village development is more prominent (Fig. 9).

## 4 Conclusion

### 4.1 Conclusion

#### **1) The overall spatial distribution pattern of sparse in the east and dense in the west**

From the perspective of the spatial distribution of villages, the spatial differentiation of the core density of villages in Shandong Province is obvious, and the overall density shows the pattern characteristics of sparse in the east and dense in the west.

#### **2) The diachronic fluctuation development on the time axis**

From the diachronic evolution of the village distribution pattern, the villages in Shandong Province fluctuated in the tide of historical development, alternating peaks and valleys.

#### **3) Sub-regional development and evolution path with different characteristics**

Shandong Province can be roughly divided into three main village distribution areas, namely, the mountains and surrounding areas in central and southern Shandong, the northern Shandong plain area in western Shandong, and the Jiaodong Peninsula area, with different development paths from then on.

### 4.2 Discussion

The core density analysis method based on ArcGIS platform can clearly show the characteristics of village spatial distribution changes and spatial evolution in the historical process, providing a new idea and effective method for village research.

In the process of analyzing the historical spatial evolution of villages with nuclear density analysis method, the key factor is to collect sufficient and accurate historical data, which is the basis of scientific spatial analysis.



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