International Journal of Computer Information Systems and Industrial Management Applications
ISSN 2150-7988 Volume 18 (2026) pp. 1-9

https://doi.org/10.70917/ijcisim-2026-2306
Article

A Study on the Historical Evolution of Kyrgyz Settlement in the Northeastern Region Based on GIS Spatial Analysis

Bo Yu [1,2,*] and Tursunai Omurzakova [3]

[1] Osh State University, Osh City, Osh Region, 723500, Kyrgyzstan
[2] School of Marxism, Shandong Huayu University of Technology, Dezhou, Shandong 253000, China
[3] Director of the Institute of Humanities and Regional Studies of the Southern Branch of the National Academy of Sciences of the Kyrgyz Republic, Osh Region, 723500, Kyrgyzstan
* Correspondence author: Yubotoug@163.com

Abstract: The Kyrgyz people, known as the “mountain nomads”, are an ancient ethnic group with a long history and a rich culture. Drawing on relevant historical documents and survey data regarding the Kyrgyz people, this study employs GIS spatial analysis and geographic detection methods to construct an index of factors influencing the spatial distribution of traditional Kyrgyz villages. It explores the spatial distribution characteristics of the Kyrgyz people’s settlement history in Northeast China and the mechanisms by which these influencing factors operate. The results indicate that the overall evolutionary process of Kyrgyz villages, as reflected in different historical periods, exhibits a shift from a concentrated distribution toward a random distribution. The spatial evolution trend of settlement density distribution gradually shifted from an inverted U-shape in the early Qing Dynasty to a straight-line shape by the time of the founding of the People’s Republic of China, with the disparity between the central region and the eastern and western regions gradually narrowing. The local variation in Kyrgyz traditional villages is influenced by the combined effects of multiple factors, most of which are of the two-factor enhancement type.

Keywords: GIS spatial analysis; geographic detector; Kyrgyz; settlement history evolution

1. Introduction

The Kyrgyz ethnic group is one of the ethnic minorities in China. In the Qing Dynasty, it was called "Bulut". Currently, the Kyrgyz ethnic group in China mainly resides in the Kizilsu Kyrgyz Autonomous Prefecture of Xinjiang Uygur Autonomous Region, and a small number of people also live in the affluent villages such as Wujiazi Village in the northeastern region [1-2]. The Kyrgyz ethnic group in the northeastern region retains its unique language, religious beliefs, and customs, which differ somewhat from those in the Kizilsu Kyrgyz Autonomous Prefecture of Xinjiang Uygur Autonomous Region [3-5]. Over a long period of time, the Kyrgyz ethnic group in the northeastern region has been highly concerned and studied by scholars and experts from both China and abroad, especially the historical evolution of their settlement in the northeastern region, which has been the focus of attention and research.

With the continuous development of society and economy, geographic information system (GIS) spatial analysis provides support for the historical evolution of the Kyrgyz ethnic group's settlement in the northeastern region. GIS, as an important component of modern information technology, is profoundly changing the way humans perceive and transform the world [6-7]. With the support of computer software and hardware, GIS can comprehensively process geographical distribution data in the entire or part of the Earth's surface, including collection, storage, management, calculation, analysis, display, and description, etc. [8-10]. Spatial analysis is the core function of GIS, enabling us to extract deep spatial relationships, patterns, and trends from geographical data, providing support for scientific decision-making [11-13]. In the research on the historical evolution of the Kyrgyz ethnic group's settlement in the northeastern region, GIS spatial analysis can reveal important information or general

patterns hidden behind the spatial data, that is, by spatializing data such as population distribution and place names, it can reveal the spatial laws and historical connections behind them, providing strong support for in-depth research on the historical evolution of the Kyrgyz ethnic group's settlement in the northeastern region.

The Kyrgyz are one of China's ethnic groups with a long history. Their ancestors migrated from the Yenisei River basin, and today they are primarily distributed north and south of the Tianshan Mountains in Xinjiang. This paper focuses on the Kyrgyz population in Heilongjiang Province, in the Northeast region of China. Data were collected online, with sources verified based on historical documents, local annals, and archaeological survey results. Using historical document analysis, GIS spatial analysis, and geographic detection tools, this study constructs an indicator system for the spatial distribution of traditional Kyrgyz villages based on three factors—geographic, economic, and cultural—to summarize the spatial distribution characteristics of Kyrgyz settlement sites in the study area and analyze the spatial distribution patterns of traditional Kyrgyz villages across multiple scales, as well as the mechanisms by which influencing factors operate.

2. Data Sources and Research Methods

2.1. Overview of the Study Area and Subjects

From the 16th century through the 18th century, Tsarist Russia continuously annexed Kyrgyz territory, resulting in the loss of vast tracts of land along the Yenisei River. This forced the Kyrgyz people to migrate to the Lake Issyk-Kul region in what is now the western Tianshan Mountains. By the late Ming and early Qing dynasties, they had evolved into the Kyrgyz people. In the 19th century, as the Qing government gradually declined, Tsarist Russia once again annexed vast territories belonging to China in Central Asia. Consequently, the Kyrgyz people became a transnational ethnic group, with a relatively small number residing in China. As of 2025, there were more than 204,000 Kyrgyz people nationwide, primarily concentrated in Xinjiang—mainly in the Kizilsu Kyrgyz Autonomous Prefecture—with the remainder distributed across regions such as Ili, Tacheng, Aksu, and Kashgar. However, a group of Kyrgyz people also lives in Heilongjiang, which is thousands of miles away from Xinjiang. They have lived in this vast land of "white mountains and black waters" for more than 270 years—over a century longer than the history of large-scale Han Chinese migration to Heilongjiang.

In the history of the Kyrgyz people, three large-scale migrations played a decisive role in the formation of the ethnic group in the Xinjiang region; these migrations also constitute the primary origins of the Kyrgyz people living in Xinjiang today, whether in concentrated communities or scattered settlements.

The first migration took place in the 70s AD, when the Han Dynasty, in alliance with the Jiankun, Dingling and Wujie tribes, overthrew the Xiongnu's rule over the northern grasslands. The Xiongnu were forced to migrate westwards, and some members of the Jiankun tribe (the Kyrgyz) followed in their wake, settling in the Tien Shan Mountains and Central Asia. It was during this period that the ancient Kyrgyz began to appear in historical records outside the Yenisei River basin.

The second migration took place in the 840s, when the Kyrgyz defeated the Uighurs, forcing the latter to migrate westwards – to what are now Kucha, Jimasar, Ili and Uqcha. Although this migration is generally regarded as a large-scale westward movement of the Uyghurs, some Kyrgyz tribes also migrated with them to the Tianshan region, marking the second major wave of migration in Kyrgyz history. It should be noted that the Kyrgyz settled in the north-east of Heilongjiang Province are not descendants of this group—their ancestors were part of the third wave of migration (17th–19th centuries): due to oppression by the Mongols and incursions by Tsarist Russia, a branch of the Kyrgyz people was resettled by the Qing court to the east, specifically to the Nenjiang River basin in Heilongjiang Province, where they have lived for over 270 years.

The third migration took place between the 17th and 19th centuries. The Kyrgyz people suffered oppression at the hands of the Mongols, and this oppression was made even worse by the wanton plundering of the local territory by the invading Russian forces. Faced with enemies superior in both numbers and strength, the Kyrgyz people once again undertook a large-scale migration involving the entire tribe. On this occasion, they reached Kashgar south of the Tianshan Mountains, the Fergana Basin in Central Asia, and the Hindu Kush and Karakoram mountain ranges on the Pamir Plateau, where they engaged in nomadic pastoralism.

Clearly, during the course of these migrations, both the Hindu Kush Mountains and the Karakoram Mountains on the Pamir Plateau lay within the boundaries of the Tashkurgan District; consequently, the Kyrgyz population of the region consists primarily of groups that arrived during the third wave of migration. Since the 19th century, they have lived and thrived here, making continuous progress in

various aspects of production, the economy, society and culture.

2.2. Data Sources and Processing

Most of the study area is located in Northeast China, particularly in the middle and upper reaches of the Heilongjiang River—a region traditionally inhabited by the Kyrgyz people. Since the landform conditions during historical periods have not changed significantly compared to the present, the topographic data used in this study were obtained from the Geospatial Data Cloud website (http://www.gscloud.cn/), specifically the GDEMV2 DEM data with a resolution of 30 m. The DEM data was loaded into ArcGIS 10.2 geographic information system (GIS) software for processing to determine the distribution of slope, aspect, and relief within the study area. Based on historical documents, local annals, and archaeological survey results, a total of 10 historical Kyrgyz village sites were identified. These sites were defined by the latitude and longitude of the centers of their archaeological remains; consequently, data on the slope, aspect, and relief of the corresponding locations were extracted from these coordinates to serve as typical representatives of the topographic and geomorphological zones where each village site is located; Regarding hydrological data, information on the distribution of river systems and lakes in the region since the Qing Dynasty was integrated to serve as indicators of water availability for settlement site selection, thereby supporting the analysis of spatial evolution.

2.3. Research Methods

2.3.1. Historical Document Analysis Method

Collect and review various historical materials and documents from multiple perspectives, through multiple channels, and using multiple methods to maximize the accumulation of raw data. Then, scientifically and reasonably screen and organize the existing materials in accordance with relevant standards to achieve standardized data processing.

2.3.2. Average Nearest Neighbor Index

The nearest-neighbor index is used to identify the spatial distribution patterns of Kyrgyz village sites. The nearest-neighbor index is a geographic indicator that measures the degree of proximity between point features in a geographic space. Based on the results of the nearest-neighbor index calculation, the degree of deviation of point features from a random distribution is assessed, thereby classifying the spatial distribution patterns of village sites into uniform, random, and clustered types. The formula for the nearest-neighbor index is:

$$R = r_1 / r_E = 2r_1\sqrt{n / A} \tag{1}$$

In the formula, R represents the nearest-neighbor index; r_1 represents the average distance between a village site and its nearest-neighbor village site, i.e., the actual nearest-neighbor distance; r_E represents the average distance to the nearest-neighbor point under the assumption of random distribution, i.e., the theoretical nearest-neighbor distance; n represents the number of cultural and tourism resources in the region; and A represents the area of the region.

2.3.3. Estimation of Nuclear Density

Nuclear density values gradually decrease as the distance from the Kyrgyz village sites increases. The formula for calculating nuclear density is:

$$f_n(x) = \frac{1}{nh}\sum_{i=1}^{n} k(\frac{x - x_i}{h}) \tag{2}$$

In the equation, n represents the total number of village sites, h represents the distance decay threshold, and $k(\frac{x - x_i}{h})$ represents the kernel function. The kernel density value is highest at village site x_i and gradually decreases as the distance from x_i increases, until it drops to 0 when the distance to village site x_i reaches the threshold h.

2.3.4. Geographic Detector

The factor analysis tool in the statistical analysis software can be used to analyze the influence of natural and cultural factors on the distribution of Kyrgyz village sites—that is, to determine the extent to which a given factor X explains the spatial variation of attribute Y. The q value is used as a measure, and its formula is as follows:

$$q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2} = 1 - \frac{SSW}{SST} \tag{3}$$

In the formula: h = 1, …, L represents the stratification—that is, the classification or partitioning—of the variable Y or factor X; N_h and N represent the number of units in layer h and the entire region, respectively; σ_h^2 and σ^2 represent the variance of variable Y in layer h and the entire region, respectively; SSW and SST represent the sum of within-layer variances and the total variance across the entire region, respectively; q has a range of [0,1]. The larger the q value, the more consistent the spatial distributions of X and Y are, and the stronger the explanatory power of the independent variable X on the attribute Y; conversely, the weaker the explanatory power.

3. Research Findings and Analysis

3.1. Historical Chronology

3.1.1. The Evolution of Settlement Numbers

A statistical analysis of the number of Kyrgyz village settlements across different periods, as shown in Table 1, reveals that changes in the number of traditional Kyrgyz villages exhibit the following characteristics: Overall, the number of village settlements has shown a continuous upward trend, but there are differences in the newly-added settlement scale across different periods. From the early Qing Dynasty through the mid-Qing period, the growth of village settlements was mild; the largest expansion occurred in the late Qing Dynasty, and then the expansion momentum slowed somewhat after the founding of the People's Republic of China. The newly-built villages reached the peak in the late Qing Dynasty among all historical stages.

Table 1. The Number Variation of Rural Settlements in Different Period

Time	New Village	Total number of village settlements
Early Qing Dynasty	2	4
During the Qing Dynasty	1	6
After the Qing Dynasty	6	10
The new China has been established	5	13

3.1.2. The Overall Evolution of Spatial Patterns

Using the ArcGIS nearest-neighbor distance analysis method, the average nearest-neighbor distances for the Kyrgyz people across different historical periods were calculated, as shown in Table 2. Based on the average nearest-neighbor distances for newly added village settlements and the total village settlements in each historical period, and through repeated testing, the bandwidth for newly added village settlements in each period was determined to be 2,500 m, and the bandwidth for all village settlements in each period was determined to be 2,000 m. These settings clearly illustrate the changes in the spatial distribution of Kyrgyz village settlements across different historical periods.

Table 2. The Average of Nearest Neighbor Distance of Rural Settlements in Different Period

Period of history	Average value of the nearest distance to the newly added village settlement(m)	The average value of the closest distance between all village settlements(m)
Early Qing dynasty	2553.23	2074.0372
Mid-Qing Dynasty	1347.31	1027.3451
The late Qing Dynasty	3516.72	1554.2568
The founding period of the new China	1103.58	897.483

Using ArcGIS to calculate the nearest-neighbor index for Kyrgyz village settlements across different periods, as shown in Table 3, reveals that prior to the mid-Qing Dynasty, the spatial distribution of these

settlements followed a pattern of spatial clustering. As the number of Kyrgyz village settlements increased and their distribution expanded, the degree of clustering gradually decreased. During the period following the founding of the People's Republic of China, the large-scale increase in the number of Kyrgyz village settlements led their spatial distribution to become more uniform. However, due to the flat terrain and scarcity of river systems in the central regions, coupled with socioeconomic changes, the small-scale clustering of these settlements resulted in a random spatial distribution pattern for Kyrgyz village settlements during this period.

Table 3. The nearest neighbor index for village settlements in different periods

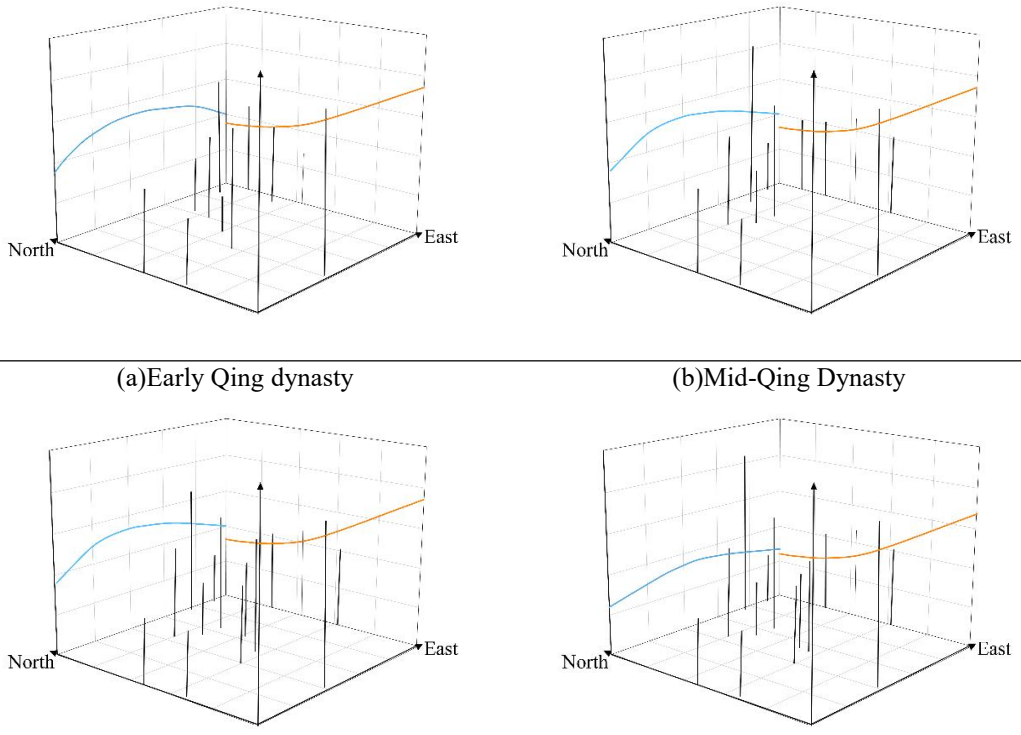
Period of history	Actual average value of the nearest neighbor distance(km)	Average value of the theoretical nearest neighbor distance(km)	Nearest neighbor index R	Distribution Pattern Type
Early Qing dynasty	3.238	4.156	0.743	Spatial Agglomeration Pattern
Mid-Qing Dynasty	1.773	2.242	0.804	Spatial Agglomeration Pattern
The late Qing Dynasty	1.964	2.443	0.761	Spatial Agglomeration Pattern
The founding period of the new China	1.254	1.206	1.043	Random Distribution Pattern

3.1.3. Regional Differences in Spatial Patterns

Using the ArcGIS kernel density analysis method, this study visualizes the distribution density of Kyrgyz villages in the Heilongjiang region across various historical periods. Settlements in the study area exhibit four distribution patterns: from the early to mid-Qing Dynasty (approximately the 17th–18th centuries), a "double-core" distribution pattern in the shape of the Chinese character "一" (Chinese word, means "one") was observed on one side of the Nen River, centered on the early migration settlements A and B; during the late Qing Dynasty (late 19th century), a "multi-core" distribution pattern emerged along the middle and lower reaches of the Nen River, with agglomeration centers concentrated in villages such as C, D, and E; after the founding of the People's Republic of China, settlements expanded further, the scope of agglomeration broadened, and a stable, belt-shaped "multi-core" spatial distribution pattern developed along both banks of the river, thereby establishing the spatial distribution pattern of Kyrgyz villages.

3.2. Spatial Trend Analysis

Trend surface analysis was employed to further explore the spatial distribution patterns and trends of coupling coordination. As shown in Figure 1, it can be observed that, in the east-west direction of the study area, the spatial evolution trend of settlement density distribution gradually shifted from an inverted U-shape in the early Qing Dynasty to a straight-line shape by the time of the founding of the People's Republic of China. This indicates that the trend of Kyrgyz village settlements—from high concentration in the central region to diffusion toward the eastern and western sides—has tended to level off, and the gap between the central area and the eastern and western regions gradually narrowed. The trend line in the north-south direction evolved from a diagonal line to an "L" shape, indicating that the coupling coordination index in the south was higher than in the north, and the density disparity between the south and the north gradually widened. With slow growth in northern settlements and continued expansion in southern settlements, this reflects a spatial pattern of a gradual southward shift in the Kyrgyz settlement centers.



(a)Early Qing dynasty (b)Mid-Qing Dynasty

(c)The late Qing Dynasty (d)The new China has been established

Figure 1. Trends in spatial variations of coupling coordination degree

3.3. An Analysis of the Mechanisms Underlying the Evolution of Settlement History

Based on factors such as topography, socioeconomic conditions, linear heritage, and cultural and social factors identified in previous studies on the determinants of the spatial distribution of traditional villages at various scales—including national and provincial levels—this paper identifies the key factors influencing the spatial distribution of Kyrgyz villages in Heilongjiang Province, Northeast China. These factors are categorized into three main areas: geographic, economic, and cultural, as shown in Table 4.

Table 4. Influencing factors of spatial distribution of traditional villages

Factor Type	Influencing Factors	Metric	Code
Geographical factor	Topographic Conditions	geomorphic type	$X1$
		Slope Direction	$X2$
	Climate change	Change in Temperature	$X3$
		Change in precipitation amount	$X4$
Economic Factor	Cultivable Land Conditions	Production potential of farmland	$X5$
	Demographic conditions	density of population	$X6$
	Economic condition	Per capita GDP (in ten thousand yuan)	$X7$
	Geographical Conditions	Road Network Density	$X8$
Cultural Factor	Cultural Density	Concentration of cultural heritage sites	$X9$
	Cultural Connection	Spatial distance to the region	$X10$
	Settlement Landscape	Traditional Settlement Landscape Zoning	$X11$

1) Multiscale Factor Analysis

Factor analysis quantitatively assesses the factor driving forces of independent variables on the dependent variable and identifies the dominant factors driving the spatial differentiation of a particular element by comparing the magnitudes of these driving forces. The nuclear density values of Kyrgyz villages (Y) are used as the dependent variable, and 11 influencing factors are used as independent

variables. In geographic analysis, the dependent variable is a numerical variable, while the independent variables are categorical variables; when independent variables are numerical, they must be discretized and converted into categorical variables through grading or classification methods. Except for landform types, aspect, and traditional settlement landscape zoning—which are already categorical variables—all other variables were divided into 8 categories using the natural break method.

(1) Regional Scale in the Northeast

After inputting variables related to the spatial distribution of traditional Kyrgyz villages in the Northeast into the model, the factor analysis results are shown in Table 5.

Landform types, settlement landscape zoning, transportation location, and the concentration of historical and cultural heritage are the primary factors influencing the spatial distribution of traditional Kyrgyz villages in Northeast China. The corresponding q values are 0.339, 0.338, 0.295, and 0.209, respectively, indicating a high level of significance and reliable experimental results. This indicates that the spatial distribution of traditional Kyrgyz villages in Northeast China is primarily influenced by factors such as geography and topography, cultural landscapes, transportation accessibility, and historical and cultural heritage. In addition, annual average precipitation, annual average temperature, and spatial distance from the study area all exert some influence on the spatial distribution of traditional Kyrgyz villages in Northeast China, though their driving forces are relatively weak.

Table 5. Results of factor analysis regarding the spatial distribution of traditional villages

	$X1$	$X2$	$X3$	$X4$	$X5$	$X6$	$X7$	$X8$	$X9$	$X10$	$X11$
q	0.339	0.129	0.138	0.121	0.058	0.098	0.041	0.295	0.209	0.122	0.338
p	0.000	0.252	0.011	0.014	0.553	0.041	0.572	0.000	0.022	0.025	0.000

Note: A higher q-value indicates a stronger driving force for that factor, while a lower p-value indicates a more significant result.

(2) Provincial Scale

At the provincial level, the results of the factor analysis are shown in Table 6. In the Northeast region and Heilongjiang Province, landform type, settlement landscape zoning, transportation location, and historical and cultural richness are all among the significant influencing factors, with only the degree of explanation differing; this is a normal variation resulting from the effects of geographic scale.

The increased explanatory power of annual mean temperature among the influencing factors in Heilongjiang Province is due to the fact that some traditional villages are located in areas of moderate elevation with significant topographic variation, making them more sensitive to the annual mean temperature factor.

Table 6. Factor Detection Results

		$X1$	$X2$	$X3$	$X4$	$X5$	$X6$	$X7$	$X8$	$X9$	$X10$	$X11$
Northeast	q	0.339	0.129	0.138	0.121	0.058	0.098	0.041	0.295	0.209	0.122	0.338
Heilongjiang River	p	0.000	0.252	0.011	0.014	0.553	0.041	0.572	0.000	0.022	0.025	0.000

2) Multifactor Coupling Analysis

Building on the single-factor analysis, a multifactor interactive analysis of the spatial distribution of traditional Kyrgyz villages in Heilongjiang Province was conducted, yielding the results of the interactive analysis of spatial distribution differentiation in Kyrgyz villages in Heilongjiang Province, as shown in Table 7. The study indicates that the driving forces of two-factor interactions are stronger than those of single-factor effects, and the interactions are primarily of the nonlinear enhancement type. Compared with single-factor effects, the q-values for each influencing factor increased to varying degrees when acting in conjunction with other factors. Among these, settlement landscape zoning, transportation location, and landform type exerted stronger influences on other factors, with their effects multiplying during interactions. This further illustrates the dominant role these three key influencing factors play in the distribution and site selection of traditional Kyrgyz villages.

Table 7. Interaction detection results regarding the distribution differences among villages

	$X1$	$X2$	$X3$	$X4$	$X5$	$X6$	$X7$	$X8$	$X9$	$X10$	$X11$
$X1$	0.351										
$X2$	0.532	0.139									
$X3$	0.398	0.334	0.149								
$X4$	0.535	0.448	0.297	0.132							
$X5$	0.379	0.279	0.174	0.199	0.067						
$X6$	0.422	0.277	0.352	0.326	0.327	0.099					
$X7$	0.373	0.195	0.237	0.212	0.175	0.147	0.043				
$X8$	0.71	0.526	0.666	0.718	0.623	0.525	0.426	0.304			
$X9$	0.496	0.462	0.419	0.428	0.354	0.288	0.282	0.581	0.22		
$X10$	0.532	0.478	0.364	0.448	0.325	0.226	0.228	0.442	0.523	0.133	
$X11$	0.638	0.445	0.45	0.428	0.382	0.415	0.388	0.719	0.453	0.655	0.347

4. Conclusion

This study employs GIS-based spatial analysis methods, combined with historical records and archaeological survey data, to analyze the historical evolution and driving mechanisms of the Kyrgyz people's settlement in the Northeast region. The conclusions are as follows:

1) Since the Kyrgyz people migrated to the Northeast region in the early Qing Dynasty, the number of their villages and settlements has shown a continuous upward trend; however, the number and rate of growth varied across different periods, with the overall expansion momentum slowed after the founding of the People's Republic of China. The migration of this ethnic group followed an evolutionary trend of "slow growth—rapid growth—stable expansion."

2) The regional spatial pattern formed four typical spatial distribution models: a "slow-growing" linear "dual-core" pattern, a "multi-core" pattern with widespread growth, a large-scale growth belt with rapid growth, and a band-shaped "multi-core" pattern with stable growth.

3) The spatial evolution of settlement density distribution among Kyrgyz villages gradually shifted from an inverted U-shape in the early Qing Dynasty to a straight-line pattern by the time of the founding of the People's Republic of China, with the trend of settlement diffusion from the highly concentrated central area toward the eastern and western sides becoming more gradual.

4) Using geographic explorers to conduct multiscale factor analysis revealed that geographic, social, and cultural factors exert varying influences on the spatial distribution of traditional Kyrgyz villages at different scales.

References

1. Guo, Y., Chen, C., Xie, T., Cui, W., Meng, H., Jin, X., & Zhu, B. (2018). Forensic efficiency estimate and phylogenetic analysis for Chinese Kyrgyz ethnic group revealed by a panel of 21 short tandem repeats. Royal Society Open Science, 5(6), 172089.
2. Wen, S. Q., Du, P. X., Sun, C., Cui, W., Xu, Y. R., Meng, H. L., ... & Li, H. (2022). Dual origins of the Northwest Chinese Kyrgyz: the admixture of Bronze age Siberian and Medieval Niru'un Mongolian Y chromosomes. Journal of Human Genetics, 67(3), 175-180.
3. Halili, B., Yang, X., Wang, R., Zhu, K., Hai, X., & Wang, C. C. (2023). Inferring the population history of Kyrgyz in Xinjiang, Northwest China from genome-wide array genotyping. American Journal of Biological Anthropology, 181(4), 611-625.
4. Karatayev, O. (2019). KYRGYZ FROM HEILONGJIANG (FU-YU) OF THE PEOPLE'S REPUBLIC OF CHINA. Journal of history, 92(1), 4-16.
5. KOKaisl, P. (2012). Kyrgyz Minorities in China. Inner Asia, 14(2), 383-402.
6. Longley, P. A., & Cheshire, J. A. (2017). Geographical information systems. In The Routledge Handbook of Mapping and Cartography (pp. 251-258). Routledge.
7. Lü, G., Batty, M., Strobl, J., Lin, H., Zhu, A. X., & Chen, M. (2019). Reflections and speculations on the progress in Geographic Information Systems (GIS): a geographic perspective. International journal of geographical information science, 33(2), 346-367.

8. Huang, B. (2017). Comprehensive geographic information systems. Elsevier.
9. Jebur, A. K. (2021). Uses and applications of geographic information systems. Saudi Journal of Civil Engineering, 5(2), 18-25.
10. Murray, A. T. (2021). Contemporary optimization application through geographic information systems. Omega, 99, 102176.
11. Charles, A. C., Armstrong, A., Nnamdi, O. C., Innocent, M. T., Obiageri, N. J., Begianpuye, A. F., & Timothy, E. E. (2024). Review of spatial analysis as a geographic information management tool. American Journal of Engineering and Technology Management, 9(1), 8-20.
12. Gonçalves, A. B. (2021). Spatial analysis and geographic information systems as tools for sustainability research. Sustainability, 13(2), 612.
13. Fischer, M. M., Scholten, H. J., & Unwin, D. (2019). Geographic information systems, spatial data analysis and spatial modelling: an introduction. In Spatial analytical perspectives on GIS (pp. 3-20). Routledge.

About the Author

Bo Yu was born in Zhangqiu District, Jinan, Shandong Province, P.R. China, in 1994. He received the master's degree from Liaocheng University, P.R. China. He is currently a doctoral student at the Faculty of History and Law, Osh State University. His research interests include Ancient Chinese History and Ethnic History.

Tursunai Omurzakova born in Kyrgyzstan in 1958, is a Doctor of Historical Sciences. She has long been engaged in research on the history of the Kyrgyz people, the regional history of Central Asia, the political history of the former Soviet states, and historical figures. She serves as Director of the Institute of Humanities and Regional Studies of the Southern Branch of the National Academy of Sciences of the Kyrgyz Republic. She is the author of the university textbook Social History of Soviet Society and the academic monograph Kurmanjan Datka: Era, Personality, and Deeds. In addition, she compiled the Grade 9 textbook Modern History, which is used in Russian-, Uzbek-, and Tajik-language schools. Her main research areas include the history of the Kokand Khanate, the history of the Fergana region, as well as the preservation and transmission of the historical and cultural heritage of the Kyrgyz people.