Postprint: The Relationship between Neolithic Site Distribution and Topography in the Lanzhou Basin

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Abstract

Investigating the relationship between archaeological sites and environmental factors such as topography facilitates understanding of the mechanisms underlying human-environment interactions. Based on GIS spatial analysis and binary logistic regression modeling, this study examines the spatial distribution characteristics, change patterns, and influencing factors of Majiayao and Qijia culture sites from the Neolithic period in the Lanzhou Basin, quantitatively investigating the relationship between topographic and other environmental elements and site distribution. The results indicate that Neolithic Majiayao, Banshan, Machang, and Qijia culture sites are all distributed along the Yellow River, primarily concentrated in areas with gentle slopes on river terraces. The nearest horizontal distance to the river ranges from 318.6 to 17,721.7 m. Neolithic sites, particularly Machang sites, exhibit significant spatial clustering. From the Majiayao type to the Banshan type and then to the Machang type, the proportion of single-type sites gradually increased from 53.3% to 92.6%. The distribution center of the Machang type is closest to the Yellow River. Topographic and other environmental elements significantly influence the spatial distribution of sites; the probability of site occurrence is primarily affected by slope, aspect, and nearest distance to the Yellow River, with the model achieving an explanatory power of 65.0%. By introducing historical period and modern settlements for comparison, historical period settlement distribution is influenced by elevation and slope, while modern settlement distribution is primarily affected by elevation, slope, and distance to rivers. The evolution of settlement distribution and influencing factors may be impacted by the development of social productivity.

Full Text

Relationship between the Distribution of Neolithic Cultural Sites and Topography in the Lanzhou Basin

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Abstract: Research on the relationship between human settlements and environmental factors such as topographic features has important significance for understanding the mechanisms of man-land interactivity. The Lanzhou Basin, Gansu Province, China is a typical valley region and is surrounded by a series of imposing mountains and hills whose relative relief is indeed immense. Using the methods of GIS spatial analysis and binary logistic regression model, the spatial and temporal distribution of Neolithic Majiayao and Qijia cultural sites and the influencing factors were analyzed respectively in this study; then, the relationships between the distribution of human settlements and topographic factors at a longer timescale from Neolithic culture to modern settlements were investigated. The results show that the distribution scope of Neolithic sites was large. The Neolithic cultural sites including Majiayao, Banshan, Machang and Qijia are situated along the Yellow River, mainly sitting on the river terraces with smaller slopes above the river floodplain. This may be related to limited ability of humans to withstand floods at that time, and river terraces provided favorable conditions for primitive settlement formation. The range of the closest distances to the Yellow River was from 318.6 m to 17721.7 m. The Neolithic sites had significant spatial agglomeration, especially the Machang cultural site. From Majiayao, Banshan to Machang, the proportion of the sites of single type was increased gradually from 53.3% to 92.6%, which reflected relatively unstable lifestyle and noncontinuous cultural development. The distribution centers of the sites of Machang type are the closest ones to the Yellow River. The overlay of sites and the changes of distribution centers indicated that the migration and evolution of the sites were mainly triggered by climate change dated back to 4200 years ago. Topography and environmental factors remarkably influenced the distribution of cultural sites, and the slope, aspect and the distance to the Yellow River determined the probability if there was a site. The model can explain approximately 65.0% of the existence of the Neolithic sites. By contrast, the occurrence of historical sites was influenced by elevation and slope, whereas that of modern settlements was influenced by elevation, slope and the distance to the Yellow River. The change of settlements distribution and influencing factors could be explained by development of social productivity.

Keywords: Lanzhou Basin; Neolithic cultural sites; topography; spatiotempo-

ral distribution; logistic regression model

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1. Study Area and Data

1.1 Study Area The Lanzhou Basin is located between 102°36 58 –104°34 29 E and 35°34 20 –37°07 07 N. The study area encompasses the Yellow River valley and its surrounding mountainous regions, covering a total area of approximately 3,000 km². The basin is characterized by a typical valley topography with significant relative relief, surrounded by mountains and hills. The elevation ranges from 1,500 m to 2,926 m above sea level.

1.2 Data Sources Topographic data were derived from the ASTER 30m Digital Elevation Model (DEM) obtained from the USGS Earth Explorer (http://earthexplorer.usgs.gov/). ArcGIS software was used to process the DEM and extract topographic parameters including elevation, slope, and aspect. The spatial distribution of Neolithic cultural sites was obtained from archaeological survey data and historical records.

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2. Methods

GIS spatial analysis and binary logistic regression modeling were employed to analyze the relationship between site distribution and topographic factors. The statistical analysis methods are summarized in Table 2.

The logistic regression model was constructed as:

$$logit(P) = \alpha + \beta_1 \chi_1 + ... + \beta_m \chi_m$$

where P represents the probability of site occurrence, α is the intercept, $\beta_1 ... \beta_m$ are coefficients, and $\chi_1 ... \chi_m$ are topographic variables.

The probability of site occurrence is calculated as:

$$P(1) = \frac{\exp(\alpha + \beta_1 \chi_1 + ... + \beta_m \chi_m)}{1 + \exp(\alpha + \beta_1 \chi_1 + ... + \beta_m \chi_m)}$$

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3. Results

3.1 Distribution by Elevation Neolithic cultural sites are distributed across a wide elevation range. Statistical analysis shows significant variation in site distribution across different elevation zones (Table 3). The majority of sites are concentrated in the elevation range of 1,650–1,880 m, which corresponds to the Yellow River terrace formations.

Chi-square test results ($\chi^2 = 52.093$, $p < 0.05$) indicate that the distribution of sites across elevation zones is statistically significant, with 95% confidence level.

3.2 Distribution by Slope Site distribution shows strong preference for gentle slopes. Approximately 95.4% of Neolithic sites are located on slopes less than 20°, with the highest concentration (40.7%) on slopes between 10°-20° (Table 4). This pattern reflects the limitations of early agricultural practices and settlement construction capabilities.

The mean slope values for different cultural types range from 11.9° to 12.4°, with Machang sites showing the lowest mean slope (9.9°), indicating their preference for the flattest terrain.

[Figure 2: see original paper]

3.3 Distance to Yellow River The proximity to water sources is a critical factor. The closest distances of sites to the Yellow River range from 318.6 m to 17,721.7 m (Table 5). Machang cultural sites demonstrate the strongest tendency for river proximity, with 92.6% located within 2 km of the river.

The spatial agglomeration analysis reveals that the distribution centers of Machang sites are closest to the Yellow River, followed by Banshan and Majiayao sites.

[Figure 4: see original paper]

3.4 Directional Distribution The directional distribution analysis shows that Neolithic sites exhibit distinct orientation patterns. The standard deviational ellipses indicate that site distributions are elongated along the Yellow River valley, reflecting the influence of river corridor geography.

[Figure 3: see original paper]

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4. Logistic Regression Models

Separate logistic regression models were developed for different periods:

Neolithic Period Model:

$$P(1) = \frac{1}{1 + e^{-(128.9700 - 0.0822E + 0.0653S)}}$$

Historical Period Model:

$$P(1) = \frac{1}{1 + e^{-(17.0244 - 0.0119/100D - 0.0089E - 0.1360S)}}$$

where E is elevation, S is slope, and D is distance to the Yellow River.

The Neolithic model achieves 96.7% accuracy, while the historical period model reaches 88.1% accuracy. The models explain approximately 65.0% of site occurrence probability, with slope, aspect, and distance to the Yellow River being the primary determinants for Neolithic sites.

[Figure 7: see original paper]

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5. Discussion

The distribution patterns reveal that Neolithic populations preferred river terraces with gentle slopes, which provided both water access and flood protection. The progressive increase in single-type site proportions from Majiayao (53.3%) to Machang (92.6%) suggests evolving settlement strategies and increasing specialization.

The spatial agglomeration of Machang sites near the Yellow River indicates enhanced adaptation to fluvial environments. The migration of distribution centers over time reflects responses to climate changes, particularly the 4.2 ka BP aridification event that significantly impacted settlement patterns in the region.

Topographic factors have consistently influenced human settlement patterns, though their relative importance has shifted with technological development. While Neolithic settlements were primarily constrained by slope and water access, modern settlements incorporate additional considerations including elevation and infrastructure development.

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6. Conclusions

(1) Neolithic cultural sites in the Lanzhou Basin are widely distributed across elevations ranging from 318.6 m to 17,721.7 m in distance from the Yellow River, with predominant clustering on gentle slopes (0–30°). This distribution reflects early human adaptation to floodplain environments and topographic constraints.

(2) The sites exhibit significant spatial agglomeration, particularly Machang cultural sites, which show the strongest preference for river proximity. The changing distribution centers indicate that site migration and evolution were primarily triggered by climate change around 4,200 years ago.

(3) Topographic factors including slope, aspect, and distance to the Yellow River significantly influence site distribution probability. The logistic regression model explains approximately 65.0% of Neolithic site occurrence. Historical and modern settlement patterns show evolving relationships with these factors, reflecting developments in social productivity and adaptive capacity.

(4) The integration of GIS spatial analysis with logistic regression modeling provides an effective framework for investigating long-term human-environment interactions in topographically complex regions.

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