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Spatiotemporal characteristics of cultural sites and their driving forces in the Ili River Valley during historical periods

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Abstract: This study applies ArcGIS to analyze the spatiotemporal distribution of cultural sites in the Ili River Valley in northwestern China. It explores relationships between the sites' spatiotemporal evolutionary characteristics, human history, and the natural environment. The results indicate that the numbers and proportions of the sites, and the frequency of their occurrence, exhibited an inverted V-shaped change trend during six historical periods. The "high in the east and low in the west" spatial distribution pattern of the first three periods shifted to the one the "high in the west and low in the east" during the latter three periods, demonstrating a change in the spatial center of gravity of human activities. The sites were mainly distributed on slopes of grades 1–5, with their proportions increasing from 75% during the Spring and Autumn Period (770 BC–476 BC)–Qin Dynasty (221 BC–207 BC) to 93.75% during the Qing Dynasty–Modern period. The concentrated distribution of site elevations shifted from grades 4–8 during the Spring and Autumn Period–Qin Dynasty, and the Western Han (206 BC–8)–Southern and Northern Dynasties (420–589), to grades 1–4 during the latter three periods. The number of sites showed a shifting trend from high-elevation mountains and hills to low-elevation plains, and from high slopes to low slopes. In particular, the sites exhibited a special "moist" evolutionary pattern of migration from middle and upstream areas to downstream areas, as opposed to the migration pattern of sites located in typical arid areas. The study also considered factors influencing the distribution and spatiotemporal evolution of cultural sites, notably, human factors and natural factors.

Keywords: Ili River Valley; historical periods; cultural sites; spatiotemporal distribution; driving forces

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1 Introduction

Cultural sites are the combined products of human and natural environments, reflecting the cultural forms of specific historical periods. A study of cultural sites can help to deepen understanding of human–land relationships associated with environmental evolution and social and cultural changes of different historical periods. Since the 1930s, scholars both within and outside of China have engaged in the study of cultural sites (Anderson, 1998; Li *et al*., 2007; Out, 2008; Ohlendorf *et al*., 2003; Kohler-Schneider and Caneppele, 2009). They had undertaken extensive and in-depth explorations of factors influencing the evolution of cultural sites; natural factors such as climate, hydrology, and geomorphology, and human factors such as culture, agriculture, animal husbandry, technology, and productivity, have made contributions to this field (Haug *et al*., 2003; Li *et al*., 2013; Núñez *et al*., 2002; Polyak and Asmerom, 2001; Turney and Brown, 2007; Wu *et al*., 2009; Xiong *et al*., 2000; Yasuda *et al*., 2004; Zheng *et al*., 2008; Zhong *et al*., 2008). These studies have mainly focused on aspects such as the spatiotemporal distribution characteristics of sites, the relationship between distribution characteristics and environmental evolution, driving forces of spatiotemporal evolution, and models of sites (Gu *et al*., 2005; Perdue, 1982, 1987; González-Sampériz *et al*., 2009; Guo *et al*., 2013; Dong *et al*., 2011; Zhu *et al*., 2003; Zhu *et al*., 2005; Zong *et al*., 2011). Technological developments related to remote sensing and the Geographic Information System (GIS) have provided new research methods and approaches such as satellite imagery (Deng *et al*., 2011), spatial analysis based on ArcGIS and Mapinfo (Huang *et al*., 2005), and trend surface analysis (Dornkamp, 1972) that have been widely used in studies of cultural sites. Studies of sites have largely focused on human–land relationships from the perspective of environmental archaeology (Zheng, 2005). In particular, quantitative studies conducted in hotspot archaeological areas have been predominant (Li *et al*., 2011). Moreover, prediction models applied to cultural sites have also constituted a key research type (Carr, 1985; Kohler and Sandra, 1986; Kohler, 1988; Ni, 2009). However, there have been relatively few comprehensive and comparative studies in this area (Wu *et al*., 2007).

Most of the cultural sites that have been studied in China are concentrated in the eastern provinces and in the basins of the Yangtze and Yellow rivers. The main fields of study of cultural sites in the Ili River Valley have been history (Tian, 2009), archaeology (Wang and Wang, 1983), anthropology (Zhou and Chen, 1994), and climatology and sedimentology (Li *et al*., 2008; Jiang *et al*., 2008), with few sites having been studied from a geographical perspective. Located on the Silk Route, Xinjiang is a place where four major world civilizations have intersected. The Ili River Valley's strategic location along the northern portion of the ancient Silk Road, combined with its unique geographical location and long history, has led to the concentration of Xinjiang's cultural sites in this area. Studies of this region, therefore, need to be strengthened, both in terms of depth and breadth. Consequently, the Ili River Valley was selected for this study, which aimed to explore the spatiotemporal evolutionary characteristics of cultural sites in this region since the period of the Xia Dynasty (about 2146 BC–1675 BC), and to provide an analysis of human historical and environmental factors that have influenced the sites' formation, distribution, and migration patterns. We applied ArcGIS software to analyze the formation and distribution characteristics of the cultural sites. We hope that the findings of the study will provide a scientific basis for the comprehension, protection, development, and use of cultural sites in the Ili River Valley and, more broadly, in Xinjiang.

2 Study area and methods

2.1 Study area

The Ili River Valley is located in northwest of Xinjiang in China (80°09'–84°56'E and 42°14'–44°50'N). Surrounded on three sides by mountains, its geomorphological outline is that of "two valley among three mountains." Its landforms and elevation are shown in Table 1. This valley, covering an area of 586.56 km^2, extends, lengthwise, for 360 km from east to west, and is 275 km at its widest stretch from south to north. The climate is temperate and humid, falling within the temperate continental climate zone. The annual average tempera-

Table 1 Geomorphological types in the Ili River Valley

Elevation (m)	Geomorphological types, distribution range, and characteristics
501–800	Piedmont alluvial-pluvial fan along an inclined plain, alluvial plain and valley plain: Piedmont alluvial-pluvial fan along an inclined plain is mainly distributed in the piedmont belt where branches such as Kunes River, Kashi River and Tekes River flow out of the mountain. Alluvial plain was formed by alluvial plains of brances such as Kunes River, Kashi River and Tekes River and alluvial plain of the Ili River which are confluence of the above branches, and its ground is a little fluctuant with shapes of a beam or a belt caused by cutting of the brook. Terraces on either side of the river have flat ground with weak cutting. Valley plain is in the river valley zone of Ili River and branches such as Kunes River, Kashi River and Tekes River, including modern river of small scale, flood land and low terrace where vegetation such as secondary forest of river valley and meadow grows.
801–1800	Low mountains and hills zone covered by loess: It is mainly distributed in low mountains and hills on either side of the valley, piedmont alluvial-pluvial fan and high terrace, including hills and terraces of western Zhaosu Basin and Tekes Valley, central Awulale Mountains, high hills and terraces of northern Kashi River Valley, low mountain and hills and high terraces at an elevation of 800–1800 m of eastern Kunes Valley.
1801–2700	Middle mountain zone of erosion effect: It is mainly distributed at 1800–2700 m in mountain area of such as Borohoro Mountain, Nalati Mountain and Haerketawu Mountain. Steep slope topography is dominated here with intense water erosion, deep canyons, and vertical and horizontal valley. There are middle fluctuant middle mountains (fluctuation altitude of 500–1000 m) and large fluctuant middle mountains (fluctuation altitude of 1000–1500 m). It has lush forest and fine pasture, and is a place for forest production.
2701–3800	Subalpine zone of periglacial effect: It is mainly distributed in 2700–3800 m in mountain area of such as Borohoro Mountain, Nalati Mountain and Haerketawu Mountain. According to the elevation and the fluctuation altitude, this zone can be divided into low fluctuant middle mountains (fluctuation altitude of less than 500–1000 m), middle fluctuant high mountains (fluctuation altitude of 500–1000 m) and large fluctuant high mountains (fluctuation altitude of 1000–1500 m). It is mainly separated by transverse ridge and valley, the ancient glacier sites spread all over, micro periglacial landforms develop. Subalpine meadow is for summer pasture.
>3801	High mountains or extremely high mountains zone of ice and snow effect: It is mainly distributed in high mountains or extremely high mountains area such as Haerketawu Mountain and Biqike Mountain. According to the elevation and the fluctuation altitude, this zone can be divided into middle fluctuant high mountains (fluctuation altitude of 500–1000 m) and large fluctuant high mountains (fluctuation altitude of 1000–1500 m). Modern glaciers and permanent snow distribute widely.

Note: Data from related documentation (Zhao, 2000; Yuan and Mao, 2008).

ture is 10.4°C, and annual rainfall is 417.6 mm, with up to 600 mm of rainfall in the mountain areas. The Ili River Valley is the most humid region in Xinjiang, and is consequently known as the "Oasis of Central Asia" or the "lush southern-type fields north of the Great Wall" (Yuan and Yang, 1990).

Since ancient times, the Ili River Valley has been home to multiple Chinese ethnic groups. Different nations, such as the Sakas during the pre-Qin period (before 221 BC), the Rouzhis and Wusun during the period extending from the Western Han Dynasty (206 BC–8) to the Wei (220–265) and Jin dynasties (265–420), the Turkics and Uighurs during the Sui (581–618)–Tang (618–907) dynasties, and the Mongolians during the Yuan (1206–1368) and Ming (1368–1644) dynasties have successively occupied the Valley (Zhou and Chen, 1994). The Ili River Valley is a place through which the northern portion of the Silk Road passes. Consequently, it encompasses a considerable number of cultural sites with strong pastoral cultural characteristics at varying altitudes, in different landform areas, and during different periods. It is thus a typical area of cultural sites in Xinjiang.

2.2 Data collection and methods

For this study, data for 1029 cultural sites were collected mainly from archaeological excavations conducted in the Ili River Valley over several years. The sites were classified based on the standards of the Chinese Archaeological Survey, which cover all types of cultural relics within ancient sites. Between 2010 and 2014, the authors of this paper carried out many detailed, systematic, and scientific investigations on dozens of key cultural sites in the study area. These investigations pertained to the size, time period, characteristics, landform, altitude, and human history of each of the sites. During data processing, all cultural sites were classified based on the dynasties during which they appeared, and a few sites were excluded because the dynastic periods were unknown. Based on the archaeological, chronological systems, and the political and economic characteristics of each historical dynasty associated with cultural sites in the study area, extending from the Xia Dynasty to the modern period (after 1949), the historical dynasties are divided into six periods. These were: the Xia–Western Zhou dynasties (about 1029 BC–771 BC); the Spring and Autumn Period (770 BC–476 BC)–Qin Dynasty (221 BC–207 BC); the Western Han–Southern and Northern Dynasties (420–589); the Sui–Tang dynasties; the Song (960–1279)–Yuan–Ming dynasties; and the Qing Dynasty (1644–1911)–Modern period.

To further explore spatial changes relating to human activities in the Ili River Valley during these historical periods, first, data from SRTM DEM of 90 m resolution, topography and drainage system diagrams, and site points for each period were extracted and vectorized using ArcGIS. Second, the distribution of cultural sites for each period was illustrated on a topographical map using colored layers corresponding to different altitudes within the Ili River Valley (see Figures 1–6). The spatiotemporal distribution characteristics of the cultural sites and human–land relationships within the Ili River Valley during the different historical periods were subsequently explored. Thus, a comprehensive analysis was carried out that included the spatial distribution scale, number, position, and frequency of occurrence of the sites, as well as human and historical factors, and natural environmental factors such as landform and climate change.

3 Distribution of cultural sites

3.1 Spatiotemporal distribution characteristics of cultural sites during different historical periods

Spatiotemporal distribution characteristics of cultural sites in the Ili River Valley during different historical periods can be specified in the following aspects, including the number of sites and their proportion in the total number of sites during the six periods, frequency of occurrence, site types, and the geomorphic characteristics, elevation and spatial pattern of the sites' distribution.

3.1.1 The Xia–Western Zhou dynasties

Of the six periods, the Xia–Western Zhou dynasties exhibited the longest time span, the fewest cultural sites, and the lowest frequency of their occurrence, accounting for only 0.29% of the total number of sites during the six periods. It can thus be termed the initial phase. One of the three sites was found in western Huocheng County, while the other two were located in eastern Nileke County. Regarding geomorphological types, a piled tomb was located alongside the western shore of the Guozigou River in Huocheng County at an altitude of 501–700 m. The site of a copper mine was located along the southern shore of the Kashi River, along the northern slope of the Awulale Mountains, at an altitude of 1201–1600 m. A Qiongkeke site was found in a terraced area, along the southern shore of the Kashi River, at an altitude of 1001–1200 m (Figure 1).

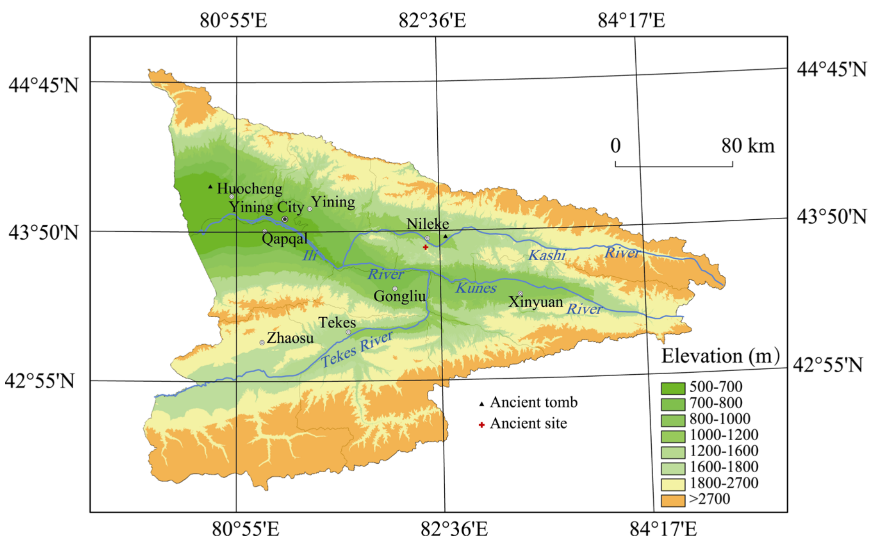

Figure 1 Cultural sites in the Ili River Valley during the Xia–Western Zhou dynasties

3.1.2 The Spring and Autumn Period–Qin Dynasty

The number of sites during this period was 338, accounting for 32.8% of the total number of sites, with a frequency of occurrence of 60.04 sites/100 years. Thus this period can be termed the development phase. Site types tended to be rich and included two types that did not occur during the Xia–Western Zhou dynasties. Regarding the geomorphic characteristics of the cultural sites, 82.54% were distributed in low mountain and hill areas covered by loess. The specific distribution areas were low mountains, hills, and high terraces of the Kunes Valley in the east, the Awulale Mountains in the central area, along the Kashi River in the north, and the high hills and terraces of the Zhaosu Basin and Tekes Valley in the west. Regarding elevation, most of the cultural sites (107) were situated on low rolling hills at an altitude of 1201–1600 m. The second highest number of sites (82) occurred in low hills at 801–1000 m, with sites at these two altitudes collectively accounting for 55.91% of the sites for this period. Only 24.26% of the sites were distributed in the plains and valley at an altitude below 800 m. The distribution range of the sites extended from the central region during the former periods to cover the entire Ili River Valley, gradually forming three concentrated regions: eastern Xinyuan County, central Gongliu County, and northern Nileke County. They presented a spatial distribution pattern of “high in the east and low in the west” (Figure 2).

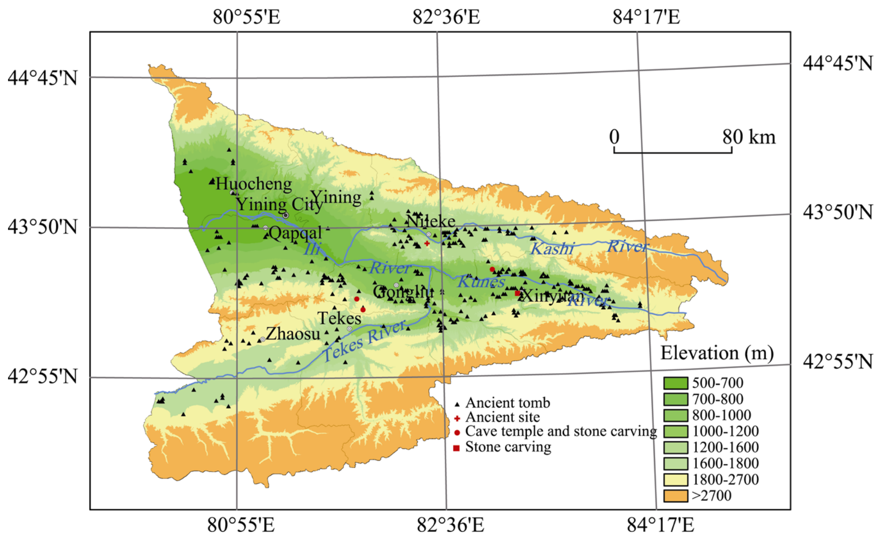

Figure 2 Cultural sites in the Ili River Valley during the Spring and Autumn Period–Qin Dynasty

3.1.3 The Western Han–Southern and Northern dynasties

The largest number of cultural sites (422) occurred during the Western Han–Southern and Northern dynasties. These accounted for the highest proportion (41.01%), as well as the highest frequency of occurrence (53.90/100 years). This period can, therefore, be considered the peak phase. While the types of cultural sites decreased, ancient tombs remained predominant. The geomorphological types of the sites’ locations were similar to those found during the Spring and Autumn Period–Qin Dynasty. Some 79.62% of the sites were distributed in the Kashi River Valley, Awulale Mountains in the central area, the Kunes Valley in the east, and the hills and high terraces of the Zhaosu Basin and Tekes Valley in the west. Low mountains and hills and high terraces on either side of the Kunes Valley in the east contained 62.32% of the cultural sites. Low rolling hills at altitudes of 1201–1600 m were the locations for the largest number of cultural sites (129), with the second largest number of sites (108) being found in low hills at altitudes of 801–1000 m. Sites at these two altitudinal ranges accounted for 53.62% of the total number of sites during this period. There was little change in the distribution range of the sites, with the continuation of the three concentrated regions (the counties of Xinyuan, Gongliu, and Nileke) and the consolidation of a distribution pattern of “high in the east and low in the west.” The sites’ proportion was greater than that of the previous period, and spatial concentricity was further strengthened (Figure 3).

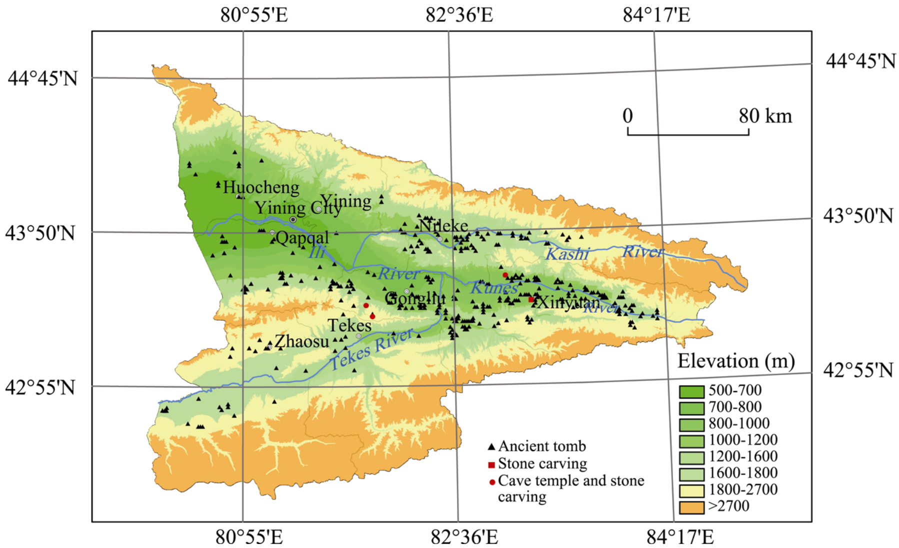

Figure 3 Cultural sites in the Ili River Valley during the Western Han–Southern and Northern dynasties

3.1.4 The Sui–Tang dynasties

The number (101), proportion (9.82%), and frequency of occurrence (30.98 sites/100 years) of cultural sites declined during the period of the Sui–Tang dynasties. This period can thus be termed the descent phase. The distribution of cultural sites during this period was relatively uniform on various landform types within an altitudinal range of 501–800 m. Of the total number of sites during this period, 20.79% were distributed in an piedmont alluvial-pluvial fan along an inclined plain and in alluvial and valley plains; 63.37% of the sites were distributed along a belt of low mountains and hills at 801–1800 m; and the remaining sites were distributed along an eroded belt of middle mountains at 1801–2700 m. Low rolling hills at altitudes of 1201–1600 m contained the most cultural sites (24), followed by low hills at 801–1000 m where 18 sites were located. The sites at these altitudes collectively accounted for 41.58% of the sites found for this period. Site distribution exhibited a decentralizing trend and regional concentricity was poor. The distribution barycenter of sites shifted towards the west, which contained 71.29% of the sites, resulting in the formation of a site distribution pattern of “high in the west and low in the east” (Figure 4).

3.1.5 The Song–Yuan–Ming dynasties

There was little change in the numbers and proportions of cultural sites during the Song–Yuan–Ming dynasties compared with the Sui–Tang dynasties. However, the frequency of occurrence (15.20 sites/100 years) dropped quickly. This period can thus be termed the lag phase. Types of cultural sites found during this period were ancient tombs, ancient ruins, cave temples, and stone carvings. The geomorphic features of the areas where sites were located were similar to those of the previous period. Low rolling hills at altitudes of 1201–1600 m contained the most cultural sites (23), followed by low hills at altitudes of 801–1000 m, where 22 cultural sites were found. Sites at these two altitudes accounted for

43.27% of the sites for this period. The distribution range of the sites presented greater proliferation than during the previous period, while concentricity was further weakened. The western region of the Ili River Valley contained 69.23% of the cultural sites. Two of the centers of concentration, Zhaosu and Qapqal counties, had been consolidated, and the “high in the west and low in the east” spatial pattern of the sites’ distribution was more apparent compared with the previous period (Figure 5).

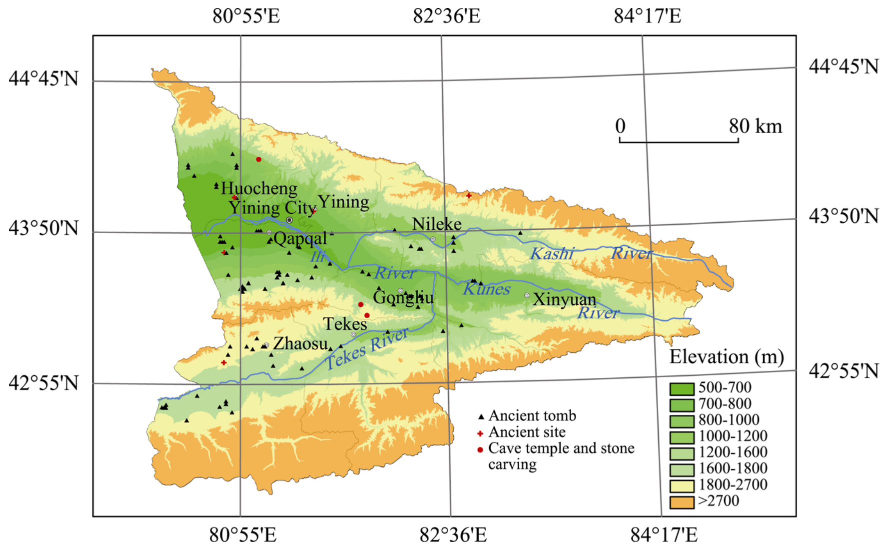

Figure 4 Cultural sites in the Ili River Valley during the Sui–Tang dynasties

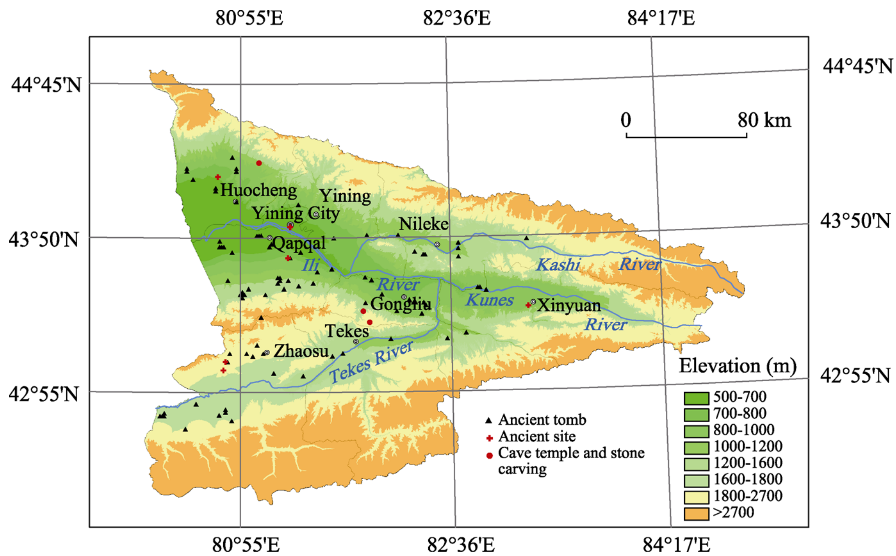

Figure 5 Cultural sites in the Ili River Valley during the Song–Yuan–Ming dynasties

3.1.6 The Qing Dynasty–Modern period

Of the entire period, commencing with the Spring and Autumn Period–Qin Dynasty, the Qing Dynasty–Modern period evidenced the lowest number, proportion, and frequency of occurrence of sites. It can thus be termed the decline phase. However, this period was also the phase when cultural sites' types were the most abundant. Regarding the geomorphological types and altitudes of the sites' locations, 81.97% of the cultural sites were distributed in a piedmont alluvial-pluvial fan along an inclined plain and in alluvial and valley plains, while only 14.75% of the sites were distributed along a belt of low mountains and hills at 801–1800 m. This situation contrasted sharply with the previous five periods when a higher proportion of sites were situated along the belt of low mountains and hills. The distribution range of cultural sites narrowed significantly during this period. The proportion of sites in the counties of Huocheng, Qapqal, and Yining was 83.61%, and a concentrated center of cultural sites was eventually established in the west. The distribution pattern of "high in the west and low in the east" was most apparent during this period (Figure 6).

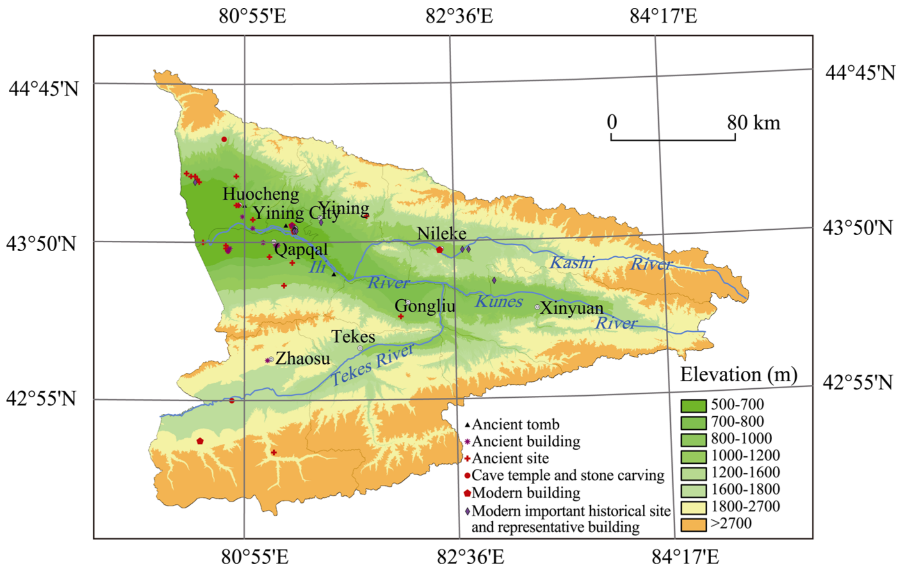

Figure 6 Cultural sites in the Ili River Valley during the Qing Dynasty–Modern period

To sum up, the numbers and proportions of sites in the Ili River Valley, and the frequency of their occurrence, exhibited an inverted V-shaped change trend depicting first an increase and then a decrease during historical periods. The numbers, proportions, and frequency, respectively, were: 3, 0.29%, and 0.23 sites/100 years during the Xia–Western Zhou dynasties and 338, 32.85%, and 60.04 sites/100 years during the Spring and Autumn Period–Qin Dynasty. While the number and proportion of sites increased to 422 and 41.01%, respectively, during

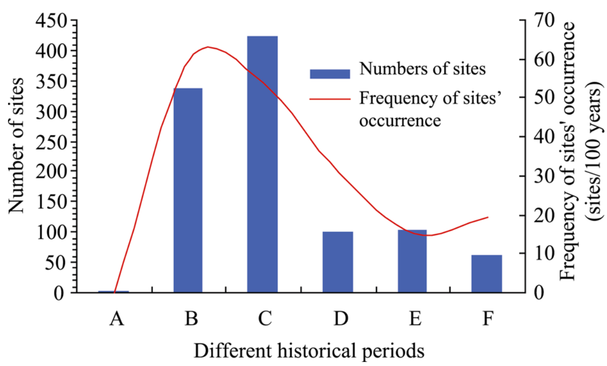

Figure 7 Number and frequency of occurrence of cultural sites in the Ili River Valley during historical periods.

Note: A. Xia–Western Zhou dynasties; B. Spring and Autumn Period–Qin Dynasty; C. Western Han–Southern and Northern dynasties; D. Sui–Tang dynasties; E. Song–Yuan–Ming dynasties; F. Qing Dynasty–Modern period the Western Han–Southern and Northern dynasties, the frequency of sites decreased to 53.9 sites/100 years. All three figures then decreased sharply to 101, 9.82%, and 30.98 sites/100 years, respectively, during the Sui–Tang dynasties and to 104, 10.11%, and 15.20 sites/100 years during the Song–Yuan–Ming dynasties. During the Qing Dynasty–Modern period, the number and proportion of sites continued to decrease to 61 and 5.93%, respectively, while the frequency of occurrence increased to 19.49 sites/100 years (Figure 7).

3.2 Elevation changes of cultural sites during different historical periods

Elevation was subdivided into 16 grades: 500–600 m, 601–700 m, 701–800 m, 801–900 m, 901–1000 m, 1001–1100 m, 1101–1200 m, 1201–1300 m, 1301–1400 m, 1401–1500 m, 1501–1600 m, 1601–1700 m, 1701–1800 m, 1801–1900 m, 1901–2000 m, and more than 2001 m. The 500–600 m category was defined as grade 1, continuing sequentially up to the category of more than 2001 m, defined as grade 16. Based on this classification of elevation, we calculated the statistics relating to the number of cultural sites during different historical periods, and related these graphically to the percentage of each elevation category (Figure 8). We then analyzed changes in elevation of cultural sites in the Ili River Valley during the different periods. The analysis revealed the following elevation change characteristics of cultural sites.

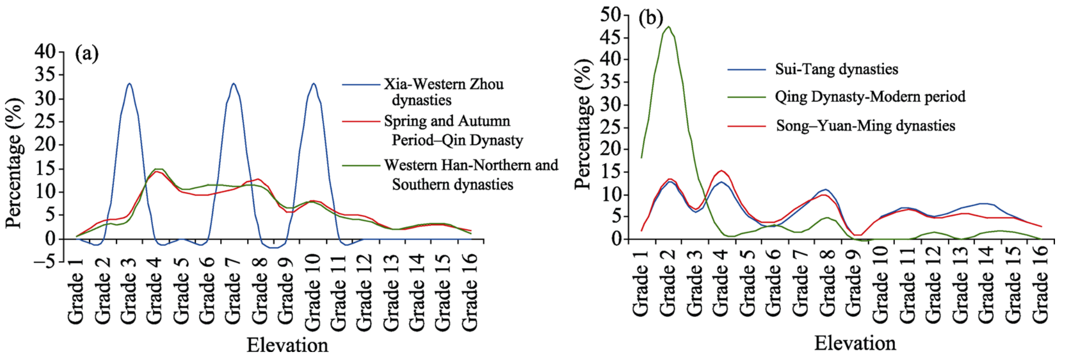

Figure 8 Changes in the proportion of cultural sites distributed at different altitudes in the Ili River Valley during historical periods

3.2.1 Elevation changes of sites during the Xia–Western Zhou dynasties

The elevation percentage curve of cultural sites during the Xia–Western Zhou dynasties differed significantly from those of other periods. The main reason for this difference was that the sample size during this period was too small (only three sites) to be statistically significant.

3.2.2 Elevation changes of sites during the Spring and Autumn Period–Qin Dynasty and the Western Han–Southern and Northern dynasties

Numbers of cultural sites were the highest for the Spring and Autumn Period–Qin Dynasty and the Western Han–Southern and Northern dynasties. Thus, the actual distribution status of the sites could be ascertained based on their elevation percentage curves. The distribution of sites was concentrated at elevations of grades 4–8 during these two periods, with cumulative percentages of over 56% for both periods. There were two peak values in the elevation percentage curves of cultural sites for grade 4 (801–900 m) and grade 8 (1201–1300 m), respectively. There were few sites at elevation grades above 11 (1501–1600 m).

3.2.3 Elevation changes of sites during the Sui–Tang dynasties and the Song–Yuan–Ming dynasties

The elevation percentage curves of cultural sites during the Sui–Tang dynasties closely matched those of the Song–Yuan–Ming dynasties, but the curves were more flattened. Compared with the Spring and Autumn Period–Qin Dynasty and the Western Han–Southern and Northern dynasties, there was a significant change in the elevation percentage curves of cultural sites during the Sui–Tang dynasties and the Song–Yuan–Ming dynasties, with the sites' distribution gradually shifting to lower altitudes. The number of peak values on the curves changed to three. Although two values were associated with grades 4 and 8, respectively, the elevation grade of the third was lower at 2 (601–700 m). In addition, the percentage of sites located within elevations of grades 8–10 (1201–1500 m) showed a significant reduction, with the proportion of sites at these elevations decreasing from 26% during the Spring and Autumn Period–Qin dynasties, and the Western Han–Southern and Northern dynasties to 15% during the Sui–Tang dynasties and Song–Yuan–Ming dynasties. In sum, the above described elevation changes of the sites reflect an evident trend of an increase in the number of sites in areas at relatively low altitudes.

3.2.4 Elevation changes of sites during the Qing Dynasty–Modern period

The elevation percentage curves of cultural sites changed significantly during the Qing Dynasty–Modern period, and their distributional elevation dropped again. First, most of the sites (81.97%) were distributed at elevations of grades 1–3 (500–800 m). Second, the number of peaks on the curves declined, from three during the Sui–Tang dynasties and Song–Yuan–Ming dynasties to one during the Qing Dynasty–Modern period. At the same time, there was a significant change in the elevations of the peaks from grade 4 and grade 8, respectively, during the previous two periods to grade 2 (601–700 m) during this period. The proportion of sites at elevations of grades 1–2 increased from 4% during the Spring and Autumn Period–Qin Dynasty and Western Han–Southern and Northern dynasties to 14% during the Sui–Tang dynasties and Song–Yuan–Ming dynasties, further increasing to 65.57% during the Qing Dynasty–Modern period. Of these sites, the proportion of sites at an elevation of grade 2 accounted for 47.54% of the total number of sites during this period. This rapidly rising percentage indicated that there was a significant shift in the distribution of cultural sites to lower altitudes.

3.3 Slope changes of cultural sites during different historical periods

The slopes of cultural sites in the Ili River Valley during different historical periods were analyzed using ArcGIS, and were subdivided into 14 grades according to the geographical conditions (Figure 9). These were: 0–1°, 1°–3°, 3°–5°, 5°–7°, 7°–9°, 9°–11°, 11°–13°, 13°–15°, 15°–17°, 17°–19°, 19°–21°, 21°–23°, 23°–25°, and 25°–76°. The category 0–1° was defined as grade 1 with the sequence extending up to 25–76° at grade 14. Based on the statistics calculated for the number of cultural sites during the different historical periods, we discovered the following features of the slopes of cultural sites during these periods.

3.3.1 Slope changes of sites during the Xia–Western Zhou dynasties

All of the cultural sites during the Xia–Western Zhou dynasties were distributed on flat or gently sloped land of grades 1–4 (0–7°). The fewest sites were found during this period,

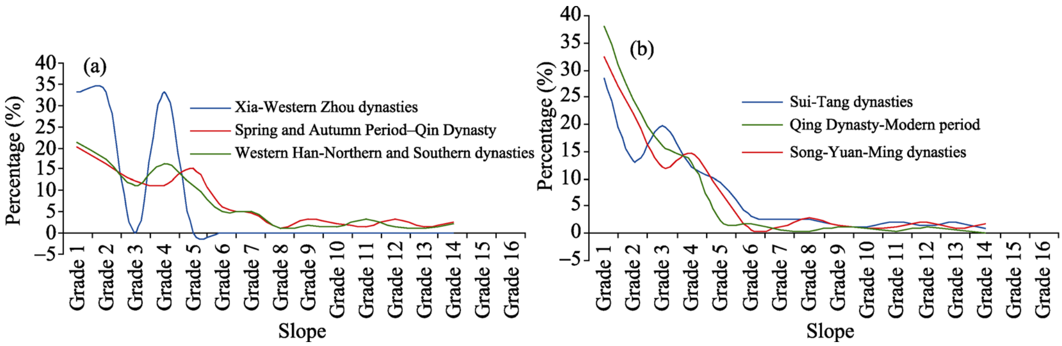

Figure 9 Proportionate changes of cultural sites distributed along slope grades in the Ili River Valley during historical periods

leading to a dramatic heave of proportion in the slope curve.

3.3.2 Slope changes of sites during the Spring and Autumn Period–Qin Dynasty and the Western Han–Southern and Northern dynasties

The slope curve of cultural sites during the Spring and Autumn Period–Qin Dynasty basically matched that during the Western Han-Southern and Northern dynasties, with the number of cultural sites showing a gradual reduction with increasing slope. Moreover, sites were mainly distributed on slopes of grades 1–5, with about 75% in each of the two periods. The proportion of sites distributed mainly on slopes of grades 1–2 slowly increased from 33.14% during the Spring and Autumn Period–Qin Dynasty to 38.48% during the Western Han–Southern and Northern dynasties, with many sites located on grade 1 slopes (7°–9°) and grade 4 slopes (5°–7°). Few of the sites were located on grade 7 slopes. Thus, the distribution of sites exhibited a shifting trend toward areas with low slopes.

3.3.3 Slope changes of sites during the Sui–Tang dynasties and the Song–Yuan–Ming dynasties

The slope curve of cultural sites during the Sui–Tang dynasties and that during the Song–Yuan–Ming dynasties demonstrated high consistency. There was a reduction in the number of cultural sites in line with increasing slope. The sites' distribution showed an evident trend of a continual shift to areas with low slopes. Though the distribution of sites was concentrated on slopes of grades 1–5 during these two periods, their proportions (over 83% for both periods) were higher than those during the Spring and Autumn Period–Qin Dynasty and Western Han–Southern and Northern dynasties (75%). The highest proportions were found on slopes of grades 1 (41.95%) and 2 (54.35%), which were twice those of the previous two periods. There was an evident decrease in the proportion of sites on slopes above grade 7 from 19% during the previous two periods to 13%.

3.3.4 Slope changes of sites during the Qing Dynasty–Modern period

The distribution of cultural sites during the Qing Dynasty–Modern period further showed a concentrated trend in relation to slope, with up to 93.75% of sites found on slopes of grades 1–5 and only a few sites located in areas with steep slopes. This illustrated a distribution trend of shrinkage and concentration of sites, with human activities tending to occur in broader and flatter areas. The proportion of sites on slopes of grade 1 increased to 38.52%. This rapidly rising percentage reflected the significance of the shifting trend in slope distribution to areas with low slopes.

On the whole, the numbers of cultural sites during each period decreased with increasing slopes in the Ili River Valley. Although most sites were found to be mainly distributed on slopes of grades 1–5, they showed a shifting trend from high to low slopes over time. Although the peak value of each slope curve was located on a grade 1 slope, the proportion of sites increased from 20% during the Spring and Autumn Period–Qin Dynasty, and the Western Han-Southern and Northern dynasties, to 28% during the Sui–Tang dynasties, and the Song–Yuan–Ming dynasties, and then to 38.52% during the Qing Dynasty–Modern period. The number of cultural sites situated on slopes above grade 7 showed an evident decline, indicating a descending trend in the slope distribution of the sites.

4 The evolution of cultural sites and an analysis of their driving forces

The distribution, rise and decline, and changes of cultural sites were the outcome of a combination of various factors, including natural factors such as geomorphology and hydrology and human factors such as regime changes, economic development, business and trade, and transport. Natural factors (especially water resources) constituted the environmental base for the survival and development of ancient peoples. However, these factors were complex, with their interplay having different influences during different historical periods and in different regions. Second, there were diverse factors influencing the evolution and development of cultural sites, and the natural geographical environment had a basic influence on the spatiotemporal distribution of the sites. However, human activities were the most important factors influencing the strength of impact and pace of change, and the direction of migration. Changes in the spatiotemporal distribution of cultural sites in the Ili River Valley during historical periods were found to have the following characteristics.

4.1 Temporal change characteristics of cultural sites

The sporopollen records of sand deposition in the Ili River Valley during the late Holocene (about 3.78–0 ka BP) reveal that the study area had an overall drought climate during 3.7–2.78 ka BP (the Xia–Western Zhou dynasties) (Jiang *et al*., 2011). The Xia–Western Zhou dynasties mark the historical stage when the study area transitioned from a primitive to a slavery society. Sakas living in upstream areas of the Ili River had learned the basics of how to use bronze for production activities (Wang, 2004). Overall social productivity was low and a combination of the primordial pastoral economy and hunting prevailed. Moreover, the study area was located in northwestern China, where transport, business and trade exchanges were relatively underdeveloped. Consequently, few sites remain for this period.

The 2.78–2.10 ka BP record corresponded to the Spring and Autumn Period–Qin Dynasty in the study area. During this period, the wind speed was weak and the climate was humid (Li *et al*., 2010). The opening up of the Hexi Corridor led to greater commercial communication between the Central Plains and the West through the Ili River Valley (Tian, 2009). Bronze and iron, which originated in the Central Plains, were promoted and used (Yang, 2009). Around about 200 BC, the Wusun Tribe gradually migrated to this area and established the Wusun State with the Sakas and Yuezhi (Jian *et al*., 2009). Animal husbandry developed in this area, which provided pasture for nomadic tribes. Political and social environment tended to be stable, commerce developed, and there was a steady increase and expansion of production and living settlements. Thus, the Ili River Valley gradually emerged as the main location of nomadic people in northern Xinjiang, and as one of the political centers of this area.

The Roman Warm Period (200 BC–600 AD) corresponded to the Western Han–Southern and Northern dynasties in the study area (Jiang *et al.*, 2011) was characterized by a warm and humid climate. The Han Dynasty's policy of making peace with rulers of ethnic minorities in border areas through marriage strengthened communication and contact with the Wusun Tribe and promoted rapid social and economic development in the Ili River Valley (Lv, 2002). Following the Han court's dispatch of Zhang Qian to the western region, and the construction of the Silk Road, business communication was greatly boosted between the Valley and the Central Plains (Jian *et al.*, 2009). The successive establishment of several institutions, such as the Protectorate of the Western Regions, and the Officer of the Western Regions, further facilitated communication and exchange between the center and the western regions of China, strengthening national fusion and propelling the Silk Road into an era of prosperity (Jian *et al.*, 2009). A prosperous economy led to the development of urban defense with the construction of military fortifications, stone carving, and productive sites. A large number of cultural sites began to appear and are still in existence. Thus, of the six historical periods, this period evidenced the most sites.

The Ili River Valley underwent the Medieval Cold Period (600–900 AD), the Medieval Warm Period (900–1350 AD), and the Little Ice Age (1350–1850 AD) during the periods of the Sui–Tang dynasties and the Song–Yuan–Ming dynasties (Jiang *et al.*, 2011). Thus, human activities were limited to some extent during these periods. During the Sui–Tang dynasties, the Central Plains were once again reunified, and the central government strengthened its control over the western regions. The Protectorate of the Western Regions and the North Court Supervision Office were established in southern Tianshan and northern Tianshan, respectively (Qian, 1997). Consequently, the political position of northern Xinjiang was greatly improved. However, the Ili River Valley was neither the political center of the Turkic peoples, nor that of the Tang Dynasty that prevailed in the western regions. During this period, the governing regime in the western regions was changed several times, causing frequent wars that damaged production. Thus, the number of cultural sites that remained showed an evident decrease compared with the previous period.

During the Song–Yuan–Ming dynasties, the feudal production mode progressively spread to the frontier regions from central China, promoting the ongoing development of the feudal economy that existed in the Ili River Valley. After the establishment of the Mongolian Empire, travel on the Silk Road was unimpeded and business and trade prospered (Zhang, 1997). However, the Mongolian Empire lasted for less than 100 years, so the Silk Road once again began to decline after a short boom. The Maritime Silk Route brought prosperity during this time. During the early period of the Ming Dynasty, the Tibetan regime was powerful. After the latter period of the 15th century, the Ming government finally gave up Xinjiang. At the same time, with the development of shipbuilding and maritime technology, the Maritime Silk Route brought increasing prosperity, finally replacing the Northwest Silk Road to become the main trading gateway. During this period, social instability worsened in the Ili River Valley, which lost its status as an economic center. Therefore, the number of cultural sites during this period was almost the same as that during the Sui–Tang period.

Although the overall climate exhibited a trend of aridity in the Ili River Valley during the Qing Dynasty–Modern period (Jiang *et al*., 2011), which was not conducive to production activities. The Qing dynasty represented the summit of Chinese feudal society, and successors of the Qianlong Emperor attached great importance to governing the western regions. They pacified the armed rebellion of Huojizhan Khoja, reunified Xinjiang, and were victorious against Czarist Russia's aggression. During the middle phase of the Qing Dynasty, the government brought a large number of immigrants into the Ili River Valley to garrison the frontiers, exploit virgin land, and develop agricultural production. A general was appointed to administer Ili's military and political affairs, and the economy of the Ili River Valley rapidly evolved. However, with frequent wars in this area, the resulting social instability and disruption of traffic led to the complete decline of the Northwest Silk Road prior to the formation of the Republic of China. The period between the Republic of China and the foundation of the new China was a short one (only half a century). Most of the settlement sites established since the Qing Dynasty have not been abandoned and are still in use. However, the time period for the sites to evolve into cultural sites has not been sufficient. Consequently, a limited number of cultural sites remain for the Qing Dynasty–Modern period.

4.2 Spatial change characteristics of the cultural sites

4.2.1 Geomorphology, altitude, and slope change in the distribution of cultural sites

Throughout the historical periods under study, site numbers decreased with an increase in altitude and slope, evidencing a shifting trend from high to low elevations, and from high to low slopes. The greatest proportion of sites was distributed along slopes of grades 1–5, increasing from 75% during the Spring and Autumn Period–Qin Dynasty, and the Western Han–Southern and Northern dynasties, to over 83% during the Sui–Tang dynasties and the Song–Yuan–Ming dynasties, and further to 94% during the Qing Dynasty–Modern period. The concentrated distribution of sites shifted from elevations of grades 4–8 during the Spring and Autumn Period–Qin Dynasty, and the Western Han–Southern and Northern dynasties, to grades 1–4 during the latter three periods. The proportion of sites at elevations of grades 1–4 increased from 23% during the Spring and Autumn Period–Qin Dynasty, and the Western Han–Southern and Northern dynasties, to 34% during the Sui–Tang dynasties and the Song–Yuan–Ming dynasties, and further to 83% during the Qing Dynasty–Modern period.

In sum, the proportion of sites distributed in the zone of low mountains and hills at elevations of 801–1400 m, declined on the whole, while the proportion of sites distributed in a piedmont alluvial-pluvial fan along an inclined plain and alluvial and valley plains, at elevations of 501–800 m, showed an overall increase. There was a further concentration of sites within flat areas with gentle slopes of grades 1–5 (0–9°). Cultural sites showed that a migration process occurred with a shift from two high values to two low values. In other words, the site numbers showed a shifting trend from high elevation mountains and hills to low elevation plains, and from high to low slopes.

The reasons for the shift in the distribution of the sites from valley terraces to plains are as follows. First, during the era of the natural economy, characterized by lower levels of productivity, agricultural development was subjected to restrictions imposed by natural conditions. Communities, therefore, chose river terraces of grades 1–2 as survival locations, because they were close to water sources and able to resist floods. At the same time, being close to the mountains was convenient for hunting and gathering (Zhu *et al*., 2007). The evident distribution of most of the ancient sites in the low mountainous and hilly region on high terraces, and of many tombs on the hills, attests to this. Second, narrow terraces did not provide sufficient space for the growing population. The fertile plains formed by the fluvial outwash were more suitable for human cultivation and the development of a commodity economy. Third, improvement of production tools created the necessary conditions for the shift to the plains. Ancients used advanced tools for damming, flood protection, and water diversion irrigation. On terraces, flooding was not a concern, but diverting water for irrigation was difficult. Irrigating large areas and developing cities on a larger scale was easier in the plains for their low slopes.

4.2.2 The evolution of spatial distribution patterns of the sites

The spatial distribution pattern of the sites was “high in the east and low in the west” during the Xia–Western Zhou dynasties, the Spring and Autumn Period–Qin Dynasty, and the Western Han-Southern and Northern dynasties. Conversely, their spatial distribution pattern was “high in the west and low in the east” during the Sui–Tang dynasties, the Song–Yuan–Ming dynasties, and the Qing Dynasty–Modern period (Figures 1–6).

The eastern area was the center of gravity of the sites’ distribution during the first three periods, with the numbers of sites in this area accounting for 66.67%, 76.92%, and 80.48% of the total number of sites, respectively, during the Xia–Western Zhou dynasties, the Springer and Autumn Period–Qin dynasties, and the Western Han–Southern and Northern dynasties. Over time, the spatial distribution pattern of the sites gradually changed. Following the Sui–Tang dynasties, the center of gravity of the sites’ distribution shifted from the east to the west. Consequently, the proportions of sites in the western areas were 75.12%, 60.08%, and 85.94%, respectively, during the latter three periods.

5 Discussion

The migration of cultural sites reveals two general patterns: “migration from downstream areas to middle and upstream areas,” and “migration from middle and upstream areas to downstream areas.” The first is a characteristic migration pattern of sites located in arid areas. The findings of research conducted by scholars in Xinjiang have confirmed this pattern (Qian, 1997; Xiong *et al*., 2000; Shu *et al*., 2007; Zhong *et al*., 2007). Water is the foundation of oases for survival in arid areas, with changes in water yields directly influencing whether an oasis thrives or disappears (Xiong *et al*., 2000). Xinjiang is located in a typically arid region of northwestern China, where availability of water resources is the main factor restricting human activities. The cultural sites are considered as the “footprints” of human activities, most of which were distributed on the two sides of rivers. Because the population grew explosively in the middle and upstream areas of the same river, it was necessary to expand reclamation and wasteland and develop irrigated agriculture to meet the necessities of life such as food and supplies. Consequently, excessive consumption of water resources by populations in the middle and upstream areas caused a reduction in water resources in the downstream areas. This greatly influenced human production and life in downstream areas.

Because the rivers were often cutoff in downstream areas, obtaining irrigation and domestic water supplies became difficult, and people were forced to abandon their original farmland and areas of residence, moving upstream along the same river to seek new homes and areas where irrigation was possible. Therefore, a common phenomenon was evident for many cultural sites in arid areas that were distributed along the same river, but in different positions in relation to the drainage basin. Those situated along the same river (drainage basin) were gradually abandoned, with a progressive shift from downstream areas to middle and upstream areas. This phenomenon thus constituted a “drought” pattern of migration from downstream areas to middle and upstream areas.

However, the sites in the study area were mainly distributed in the middle and upstream areas during the first three periods. Subsequently, they gradually migrated to downstream areas, as opposed to the “drought” pattern of migration from downstream areas to middle and upstream areas that occurred in others areas of Xinjiang. This distinctive pattern, which contradicts the evolutionary pattern of sites in arid areas, entailed migration from middle and upstream areas to downstream areas. It can be termed a “moist” pattern of migration, and its evolution is closely related to the unique topography, climate, hydrology, and other factors of the Ili River Valley. First, in the northern part of the Ili River Valley, the Keguqin and Borohoro Mountains provide a barrier against dry cold air coming in from Siberia. The Yilianhabierga Mountain in the east blocks hot air from the Junggar Basin. Further, the Haerketawu Mountain and Nalati Mountain in the south block the wind and dust from the Taklamakan Desert. Moist, warm air flows reach this area from the west. The unique geomorphology of “two valleys among three mountains,” forming a “pocket” has resulted in the Ili River Valley being the most humid area in Xinjiang. Moreover, although the Ili River Valley is located in an arid region, it experiences abundant rainfall. The annual average runoff depth of Ili River is 268 mm, which is 5.7 times the amount of the average value for Xinjiang. The annual runoff of 15.3 billion m^3 in Ili River accounts for 79% of the total runoff in Xinjiang. In addition, there are many rivers in the Ili River Valley, consequently the influence of water on the migration of the cultural sites has been relatively minor. Thus, the sites exhibited a special “moist” pattern of migration from middle and upstream areas to downstream areas.

Admittedly, human factors, including war, can lead to the disappearance of sites, cities, and oases in arid areas. However, they will not lead to the migration of cultural sites, distributed along the same river, from downstream areas to middle and upstream areas (Xiong *et al*., 2000). The main reason for this type of migration is that water resources and other natural factors are the lifeblood of human activities in arid areas. Conversely, when natural factors such as water resources are no longer the main bottleneck for human activities in relatively humid parts of arid regions, the migration of sites evidences a break from the primary “drought” pattern of migration from downstream areas to middle and upstream areas.

6 Conclusions

(1) A comparison of the numbers and proportions of the cultural sites, and the frequency of their occurrence, revealed that they all exhibited an inverted V-shaped change trend in the Ili River Valley during different historical periods. Further, the spatial distribution of cultural sites, and their process of evolution, was compared with the results of a comprehensive analysis of sporopollen records of sand deposition during the Late Holocene and climate

change in the Ili River Valley (Jiang *et al*., 2011). This revealed that there was no one-to-one correspondence between the evolutionary process of the spatial distribution of cultural sites and changes in the regional climate. However, the fact that the sites were consistently concentrated in a low-altitude and low-slope region of the study area during the latter three periods, indicated correspondences with the following phenomena experienced in the Ili River Valley. These were: the Medieval Cold Period, the Medieval Warm Period, and the Little Ice Age during the Sui–Tang dynasties and the Song–Yuan–Ming dynasties, and a cold period and overall dry climate during the Qing Dynasty–Modern period. The sites' distribution was also a response to human activities, including several historical waves of large-scale immigration to garrisons and vigorous land reclamation in this area.

(2) The evolutionary pattern of the sites' distribution shifted from "high in the east and low in the west" during the first three periods to "high in the west and low in the east" during the latter three periods. The proportions of sites in the eastern region during each of the first three periods were all over 66% of the total number of sites. During the latter three periods, however, they were all higher than 60% in the western region. The Ili River Valley has been historically populated by different nations, tribes, and country states, and has experienced alternations of cold and warm, and wet and dry climates. However, the center of gravity of its cultural sites evidenced an evolutionary movement from east to west, illustrating a change in the spatial center of gravity of human activities in the Valley.

(3) The numbers of cultural sites showed a shifting trend from high to low elevations, and from high to low slopes during different historical periods. The main distribution of the sites shifted from elevations of grades 4–8 during the Spring and Autumn Period–Qin Dynasty, and the Western Han–Southern and Northern dynasties, to elevations of grades 1–4 during the latter three periods. Although the sites were mainly distributed on slopes of grades 1–5 during each of the six periods, the proportion of sites situated on slopes of grades 1–2 increased from about 36% during the Spring and Autumn Period–Qin Dynasty and the Western Han–Southern and Northern dynasties to 62.52% during the Qing Dynasty–Modern period.

(4) As a result of unique factors, including the topography, climate, and hydrology of the Ili River Valley, the cultural sites exhibited a "moist" pattern of migration from middle and upstream areas to downstream areas, as opposed to the "dry" pattern of migration from downstream areas to middle and upstream areas of sites located in other parts of Xinjiang.

(5) Natural factors such as climate, geomorphology, and water resources, and human factors such as productivity, regime changes, economic development, trade, and transportation were the driving forces for the generation and migration of sites in the study area. While natural geographical and environmental factors exerted a basic influence, human activities were the most important factors that changed the strength of impact, pace, and pattern of evolution. The influence of natural geographical and environmental factors was prominent during the early phase, but the role of human factors was more prominent during the latter period. When the two sets of factors combined and worked together (a positive effect and a negative effect), the speed of evolution of the cultural sites was greatly accelerated.

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