The relationship between climate change and wars waged between nomadic and farming groups from the Western Han Dynasty to the Tang Dynasty period

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Abstract: In ancient China, shifts in regional productivity of agriculture and animal husbandry, caused by climate change, either induced wars or peaceful relations between nomadic and farming groups. During the period spanning the Western Han Dynasty to the Tang Dynasty, 367 wars were waged between these groups. While 69% of the wars were initiated by nomads, 62.4% were won by the farming groups. On a centennial timescale, the battlegrounds were mostly in northern areas (at an average latitude of 38.92° N) during warm periods, moving southward (at an average latitude of 34.66° N) during cold periods. On a decadal timescale, warm climates corresponded to a high incidence of wars (a correlation coefficient of 0.293). Whereas farming groups were inclined to initiate wars during dry and cold periods, their chances of achieving victory were reduced. The main reasons for this are, first, a warm climate provided a solid material foundation for nomadic and farming groups, contributing especially to enhanced productivity among the former. However, the overriding desire of nomadic groups to expand essential subsistence means led to wars. Second, during cold periods, farming groups moved to and settled in the South, while nomadic groups occupied the Central Plains. Thus, the locations of the battlefields also changed. While other factors also influenced these wars, climate change served as a backdrop, playing an indirect role in wars between these groups.

Keywords: ethnic conflicts; climate change; China; Western Han Dynasty; Tang Dynasty

1 Introduction

The association between violent conflicts and environmental change has attracted much research attention recently. Since 2007, more systematic researches on the effect of climate change on security issues have emerged. The theoretical model linking climate change to intrastate conflict incorporates case studies as well as conflict statistical studies. Three effects of climate change (natural disasters, sea-level rise, and increasing scarcity of resources) may lead to loss of livelihood, economic decline, and increased motivation for instigating violence (Buhaug Halvard et al., 2008). Climate change is a contributing factor to conflict (Collier et al., 2005; Homer-Dixon TF et al., 1993; Maxwell JW et al., 2000), acting in many cases as a 'threat multiplier' (CNA, 2007). The latest research, published in Science in August 2013, has found that even minor changes in

climate are linked to increases in violence and warfare in human populations (Solomon M. Hsiang et al., 2013).

The key factors in conflicts stemming from climate change vary from region to region. Webster's study of historical societies suggested that warfare is an adaptive ecological choice under the conditions of population growth and resource limitation (Webster, 1975). In Africa, most studies of influencing factors have focused on the role of precipitation in explaining the incidence of conflict, finding that modern conflicts are more likely in drier years or during prolonged droughts (Held IM et al., 2006; Hendrix CS et al., 2007). Over the last millennium, conflicts were more prevalent during colder periods not only in Europe (Tol Richard SJ et al., 2010), but also in China (Zhang DD et al., 2006), because reduced thermal energy input during a cold phase lowers the land-carrying capacity in a traditional agrarian society.

The impact process of climate change on conflict varies in different regions. Zhang (2006) concluded that in China the frequency of war varied in the last millennium according to geographical locations (northern, central vs southern China) because of differences in the physical environment and hence differential responses to climate change. This study also concluded that variations in the frequency of rebellion in China were highly correlated with climatic changes. The conflicts were more prevalent during colder periods. However, in northern China, the aberrant peaks, overshadowed by this correlation, were mainly due to instigations by nomadic invaders from the north (Zhang DD et al., 2006). This leads to the question of whether conflicts are more prevalent during colder periods when factors relating to regional divisions or types of violent conflicts are considered. This paper focuses on the relationship between climate change and wars of invasion between nomadic and farming groups in northern China in 206 BC–906 AD.

Rotational grazing and sedentary farming were two of the most important modes of economic production in ancient societies. These subsistence techniques gave rise to two groups: nomadic and farming groups. The nomadic group comprised a number of nomadic minorities, such as the Huns, Xianbei, Xiqiang, Khitan and Turks. The farming group was predominantly of Chinese Han ethnicity, and was a combination of ancient Huaxia people and other ethnic groups. The main tribes of the Huaxia were the Huang Di, Yan Di, and Chi You. The history of the exchanges and collisions between these two groups is an important part of China civilization (Tian Shu et al., 2008). In China, the northern nomadic tribes moved from place to place in search of water and grass for their herds. Nomadic settlements in the vast temperate arid or semi-arid steppes

offered harsh conditions; cold in winter and infrequent rainfall. In contrast, the farmers mainly of Chinese Han ethnicity adopted a self-sufficient way of production and distributed themselves in the eastern monsoon region, where the rainfall and high temperatures were synchronous, with relatively abundant precipitation. The natural climate conditions in these areas were comparatively favorable (Figure 1). Therefore, the farming group was mainly engaged in agricultural production and living a sedentary life.

The evolution of inter-group relations in China has a long and complex history, which, when combined with long-term historical documentation, is conducive to the relationship studies between climate change and group conflicts. Brest Hinsch (1998) referred to the climate change in East Asia, Europe, and North America and discussed the relationship between Chinese history and different climate change periods. He pointed out that China was traditionally an agrarian society, which was particularly vulnerable to the effects of climate change. He also summarized the periodic changes of warm and cold periods in China, and described the competition and integration of the ecological environment of the nomadic and farming civilization. Based on the ancient administrative divisions in the *Historical Atlas of China* (Tan Qixiang, 1982), Wang Huichang studied the latitude change of the southern boundary of the national regime established in the southward migration process of the northern nomadic groups starting with the Qin and Han Dynasties. From this, he concluded that in warm periods, the nomadic and farming groups maintained a peaceful relationship, while in cold periods, the nomads moved southward, leading to instability of the Central Plain regime and confrontations between the two groups (Wang Huichang, 1996).

Research on the relationship between climate change and different community group relations should involve not only empirical cases, but also the construction of proxy indicators and sequences. By conducting quantitative studies, we can better understand the impact of climate change. However, because the evaluation of different community group relations is complicated, there is a lack of reconstruction of long-term, continuous community group relation sequences with high resolution.

Figure 1 Distribution of the regions of the nomadic and farming groups during the Western Han Dynasty, the Western Jin Dynasty, and the Tang Dynasty (Tan Qixiang, 1982)

Note: Regions where the regime was established by the farming group in different periods are in green. Regions identified with other colors correspond to different regimes established by several nomadic ethnicities.

The period this paper examines (206 BC–906 AD) spanned 1112 years and underwent eight major dynasties, in which the Western Han Dynasty (206BC–24 AD), the Eastern Han Dynasty (25–220 AD), the Western Jin Dynasty (265–316 AD), the Sui Dynasty (581–617 AD), and the Tang Dynasty (618–906 AD) managed to unite the region by politically ruling both the southern and northern parts of China. In contrast, during the Three Kingdoms (220–280 AD), the Eastern Jin Dynasty (317–420 AD), and the Southern and Northern Dynasties (420–589 AD, and 386–581 AD, respectively), China was in turmoil. In the Eastern Han Dynasty and the Southern and Northern Dynasties, nomadic groups conquered the Central Plain and occupied the northern part of China. This paper focuses on the period from the Western Han Dynasty to the Tang Dynasty, constructs the sequence of the inter-ethnic wars at this time based on historical documents, and compares this sequence with that of simultaneous climate changes obtained from historical documents to analyze the influence of climate change on these wars.

2 Data and methods

2.1 Construction of the sequence of wars between nomadic and farming groups

To exchange and acquire natural resources and products, nomads and farmers have historically traded with each other, leading to migration, population mixing, and even cultural blending of these groups. However, there have also been disputes, conflicts, and wars between them. National cohesion was ultimately achieved either through peaceful communication or conflicts between nomadic and farming groups.

Data on the wars that occurred between nomadic and farming groups in China were obtained from the *Chronology of Wars in Chinese History* (The Chinese Military History editorial, 2003), which was compiled and edited by the Chinese Military History group at the Nanjing Academy of Military Sciences. The primary chronological data sources were the *Twenty-Four Histories*[1] and the *Draft of History of Qing Dynasty*[2]. These two sets of volumes are widely regarded as authoritative sources of traditional Chinese history and culture. Uniform standards for selecting and recording wars have been applied in the *Chronology*. In addition, the *Chronology* contains records of causes, processes, results, and characteristics of major wars. Thus, the information source on wars is reliable. However, many factors influence historical records and the inheritance and transmission of books. For example, during periods of war, historical records were reduced. The burning of books has also occurred in Chinese history. Consequently, there are contrasting periods, some characterized by especially rich records and some by sparse records (Zhang Wenhua, 2002). In other words, there is discontinuity and heterogeneity in the historical records (Figure 2). As a result, during periods of discontinuous historical records, there is a shortage of war records, leading to the underestimation of the frequency of war. According to the statistics, such periods entailing a lack of records amount to a total of 56 years, accounting for 5% of the entire stage.

Based on the records contained in the *Chronology*, we classified and selected 367 wars waged between nomadic and farming groups extending from the Western Han Dynasty to the Tang Dynasty. We noted the following information: the year when a war occurred, the name of the war, the initiator, the victor, the major battlefield, and its location (its present name and position by latitude and longitude).

The selection of the records was based on the following criteria.

(1) We only included wars waged between northern nomadic groups and established agricultural regimes in Central China. We excluded the following: wars between nomadic ethnic groups or tribes, wars between nomadic and separatist groups, peasant uprisings against agricultural regimes in the Central Plain, and wars

[1] The *Twenty-Four Histories* is a general term describing 24 historical books chronicling China's official history, excluding the Qing Dynasty, which has generally been written about and reviewed independently by later dynasties. The *Twenty-Four Histories* comprise the *Records of the Historian*, the *Book of Han*, the *Book of Later Han*, and so on.

[2] The *Draft of History of Qing Dynasty* is a draft of the official history of the Chinese Qing Dynasty, written in 1927 and comprising 536 volumes.

between minority ethnic groups in southwestern China and farmers or foreign countries.

(2) If the duration of a war was more than 1 year, the initial year was recorded according to details provided in the *Chronology*.

(3) In 363 records (accounting for 98.91% of the compiled data), it was clear who had initiated the war. However, in four records (1.09%), farming groups provided assistance (in the form of troops) to nomads embroiled in civil strife. In these instances, the farming groups were regarded as the initiators.

(4) In 355 records (96.72%), it was clear who the victors were. However, in 12 records, the victors were not identified. One side was referred to as an "effective defense" or "effective counterattack" in seven (1.91%) of these records. The opposing side was correspondingly described in terms such as "unable to conquer the adversaries" or "attempted attack failed." In these records, the defending side was categorized as the victor. In three records (0.82%), one side begged for a truce or made peace through marriage and was deemed the losing party. Two other records (0.54%) pertained to wars entailing multiple battlefields and varying outcomes of different wars. In these records, we classified the outcomes according to the war that was waged last.

(5) The location of the war was available in 351 records (95.64%). However, no relevant information was available for two specific situations, for which we consequently used other criteria. In 11 records (1.99%) the battlefield location was noted as being "on the border." In such situations, we referred to the *Historical Atlas of China* (Guo Moruo, 1996) using the midpoint of the border as the battlefield location. In five other records (1.36%), where the only details provided were of the involved armies, we used the locations of army camps as the battlefield locations.

We calculated the total number of wars, the average latitudes of the battlefields, the frequency of conflict initiation by nomadic versus farming groups, and the proportion of each group's victories on a decadal timescale. Consequently, we reconstructed the series of community group wars spanning the period extending from the Western Han Dynasty to the Tang Dynasty. Based on our analysis of the variation characteristics of the sequences, we divided the historical periods into several stages. We plotted the distribution of major battlefields as a scattergram and performed a spatial analysis of the distribution of the conflict regions. We further assessed whether there was a possible relationship between the wars and climate change using decadal and centennial timescales.

2.2 Climate change sequences

157 To improve the reliability of our sequence comparison, we used temperature and precipitation as the
158 comparative references for two sequences each.
159 The following two temperature sequences of other scholars were used:
160 (1) Reconstructed temperature data, based on historical documents, indicate a series of temperature
161 variations during the winter half-year in eastern China over the last 2,000 years (Ge QS et al., 2003, 2010).
162 This reconstruction was based on the pioneering research of Chu (Chu KC, 1973), whose historically
163 reconstructed series on China's climate change are widely accepted (J G, 1973). Temperature variations for
164 the winter half-year (October–April), in relation to the mean value calculated for the period 1851–1950, were
165 constructed using a 30-year timescale resolution. These were based on historical documents that provided
166 details on agricultural production. Results obtained for eastern China (east of 105° E, 25°–40° N) indicated
167 temperature variations in the farming regions.
168 (2) A composite series reconstructed by Ge et al. (Ge QS et al., 2013), based on partial least squares
169 regression, shows the occurrence of temperature variations, at a decadal resolution, over the last 2,000 years
170 in China. The mean temperature from 1851 to 1950 was applied as a reference value. To reconstruct a
171 temperature anomaly series for China, they selected 28 published proxy temperature series. The proxies
172 included sediments, stalagmites, historical documents, tree rings, and ice cores. A nationwide reconstruction
173 was developed using proxy temperature data with relatively high confidence levels for five regions (the
174 Northeast, Northwest, Central East, Tibetan Plateau, and Southeast).
175 For the dry/wet ratio series, we used two sequences for comparative purposes as follows.
176 The first series, constructed by Zheng et al. (Zheng JingYun et al, 2006), was a dry/wet ratio series of
177 eastern China over the last 1,500 years. This series covers the period from 105 AD to 2000 AD in eastern
178 China (extending to North China, the Yangtze-Huaihe region, and the Jiangnan area). The series was
179 reconstructed by applying the drought and flood grades of 48 sites based on Chinese historical records. It
180 indicates changes in dryness/wetness in farming regions. The positive values refer to higher precipitation and
181 the negative values refer to lower precipitation.
182 The second series, constructed by Shao et al. (Shao XM et al, 2010), focuses on the ring-width index with
183 31-year moving averages for the northeastern Qinghai-Tibetan Plateau. The Qinghai-Tibetan Plateau is a
184 region sensitive to recent global climate change. The tree-ring width chronology of Qilian juniper indicates

precipitation changes and can reflect changes in humidity in western China. The positive values refer to higher precipitation and the negative values refer to lower precipitation.

3 Analysis

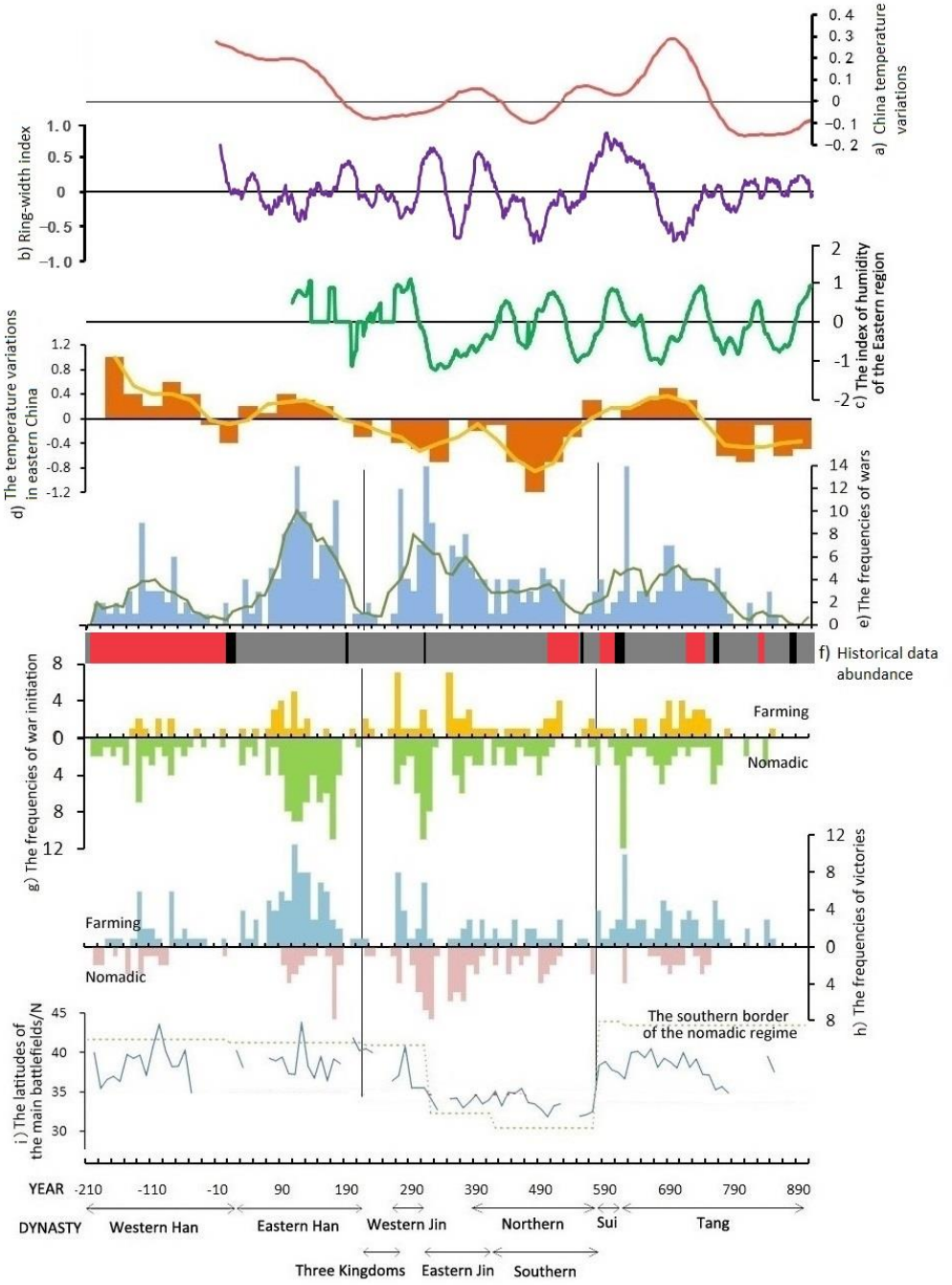

Figure 2 Sequence of wars between the northern nomadic and farming groups

a) China temperature variations during 1~910AD.Ensemble temperature reconstructions based on PLS methods at centennial timescales (smoothed by a 5-point FFT filter) (Ge QS et al, 2013); b) Ring-width index with 31-year moving averages

from the northeastern Qinghai-Tibetan Plateau (Shao XM et al, 2010); c) Annual humidity index of China from 105 AD to 910AD (smoothed by a 31-point FFT filter) (Zheng JingYun et al, 2006); d) Temperature variations in eastern China and three-point moving average curve for winter half-yearsduring 200BC~910AD (30-year period timescale) (Ge QS et al, 2003；2010); e) frequency of war and five-point moving average values(green solid line); f) Plentiful degree of historical records , red indicates a rich phase of the historical data, gray indicates the plentiful degree is normal, black regions mean the data has been broken(Zhang Wenhua, 2002); g) frequency of wars initiated by the farming and nomadic groups; h) frequency of victories of farming and nomadic groups; i) latitude of the main battlefields (north latitude/N, blue solid line), changes of the southern border of the nomadic region in each dynasty (green dotted lines) (Wang Huichang, 1996).

3.1 War sequences between nomadic and farming groups

3.1.1 War frequency

A total of 367 wars (an average of 3.3 wars per decade) were waged between agricultural and nomadic groups, spanning the period from the Western Han Dynasty to the Tang Dynasty (Figure 2). The wars fought between these two groups were concentrated during different periods. Wars were more frequent (14 wars/decade) during three periods (111–120 AD, 311–320 AD, and 621–30 AD) compared with other periods. Based on the descending order of the frequency of war during each dynastic period, the top 15% of periods (with frequency $\geqslant$7 wars/decade) were categorized as high-incidence periods. There were 18 such periods covering 169 wars. In other words, 46% of all the wars occurred during 16% of the entire timespan (1,112 years). The periods during which the frequency of war was one or less per decade, were regarded as low incidence periods. During these 41 periods, only 20 wars occurred (covering 36% of the time span and 5% of the total wars). Periods entailing an absence of war mainly occurred during the late period of a dynasty or between dynasties in the Central Plain when surplus power for initiating wars or resisting enemies was lacking. However, records were lacking for the period of dynastic succession.

A statistical classification of wars during different dynastic periods suggests that decadal war frequencies during the Eastern Han, Western Jin, and Eastern Jin dynasties were considerably above the average frequency (3.3 wars/decade), and that there was a high incidence of group wars during these dynastic periods (Table 1). A total of 14 high-incidence periods of war occurred during the timespan of these three dynasties, accounting for 78% of all the high-incidence periods. During other dynastic periods, the decadal war frequency of war was below the average. These were, therefore, considered low incidence periods.

Table 1 Frequency of wars between the farming and nomadic groups from the Western Han Dynasty to the Tang Dynasty in China

Dynasty	Total	Frequency (times/ decade)	High-frequency periods
Western Han	46	2.00	-130s
Eastern Han	102	5.28	90s–130s；150s–170s
Three Kingdoms	3	0.66	
Western Jin	38	7.45	270s；300s–320s；350s
Eastern Jin	48	4.66	370s
Southern and Northern	41	2.43	
Sui	9	2.50	
Tang	80	2.78	620s；680s–690s
Sum/average	367	3.30	

3.1.2 Initiators and victors of war

Table 2 shows the frequency of war initiation and victory for farming and nomadic groups. Initiators of war were predominantly nomadic groups while war victors were predominantly farming groups. This distribution was particularly marked for politically unified dynasties (the Western Han, Eastern Han, Sui, and Tang dynasties). During the Western and Eastern Han dynastic periods, farming groups initiated far fewer wars but were mostly victorious. This pattern persisted until the Sui and Tang dynasties, during which the number of wars initiated by farming groups was slightly increased; again, they largely remained victorious. Conversely, nomadic groups were the primary instigators of war, achieving victories only during periods of political turbulence (i.e., during the Western Jin, Eastern Jin, Southern, and Northern dynasties). However, most of the wars that occurred during the era of the Three Kingdoms were initiated by farming groups, who achieved few victories.

Table 2 Frequency of war initiation and victories of farming and the nomadic groups

Dynasty	Farmers				Nomads			
	Total	Percenta	Total	Percenta	Total	Percenta	Total	Percenta

	initiation	ge (%)	victories	ge(%)	initiation	ge (%)	victories	ge (%)
Western Han	11	23.91	28	60.87	35	76.09	18	39.13
Eastern Han	21	20.59	78	76.47	81	79.41	24	23.53
Three Kingdoms	3	100	1	33.33	0	0	2	66.67
Western Jin	11	28.95	19	50	27	71.05	19	50
Eastern Jin	19	39.58	16	33.33	29	60.42	32	66.67
Southern and Northern	17	41.46	19	46.34	24	58.54	22	53.66
Sui	3	33.33	9	100	6	66.67	0	0
Tang	28	35	59	73.75	52	65	21	26.25
Total/Average	113	30.8	229	62.4	254	69.2	138	37.6

3.1.3 Classification of war periods

We divided the series into three periods based on the frequency of war and the distribution of the conflict regions during different dynastic periods (Figure 2). The first period comprised the periods of the Western and Eastern Han dynasties (206 BC–220 AD). There was a low incidence of wars at the beginning of this period (the Western Han Dynasty) and a high incidence of wars during the latter (Eastern Han) period. There were 148 wars (40% of the total), with an average of 3.4 wars/decade, increasing to 5.3 wars/decade during the late period. Farming groups initiated and won 21.6% and 71.6%, respectively, of the conflicts that occurred during this period.

The second period encompassed the Three Kingdoms and the Wei, Jin, Southern, and Northern dynasties (221–580 AD). During this period, 130 wars occurred (36% of the total and 3.6 wars/decade). The frequency of wars initiated by farming groups was significantly higher during this period (38.5% of the total) compared with farmer group-initiated wars during the earlier period. However, this group achieved only 42.3% of the total victories.

The third period comprising the Sui and Tang dynasties (581–906 AD), was a low incidence period for wars. During this period, there were 89 wars in total (24% of the total and 2.7 wars/decade). Apart from the high incidence of wars during the transition periods of different dynasties, there was an overall decrease in the

war frequency. Farming groups initiated fewer conflicts (34.8% of the total), but won the majority (76.4%) of these.

3.2 The distribution and changes in conflict regions relating to farming and nomadic groups

The main combatants in wars that occurred during the first period (206 BC–220 AD) comprised an ethnic group (e.g., the Hun, Qiang, Xianbei, or Wuhuan) and the farming social groups who established the Western and Eastern Han dynasties. The border between the territories of the Hun, Wuhuan, and Xianbei ethnic groups and that of the Han Dynasty was located at approximately 44° N, and extended southeast to 41° N (Guo Moruo, 1996). The main conflict regions were located from 33° N to 42° N and from 100° E to 118° E. They were distributed along the Hexi Corridor and on the Loess Plateau, south of the Yellow River and north of the Qinling Mountain (high-incidence regions); in regions to the east of the Hetao Plain and to the west of the Taihang Mountain (high-incidence regions); and in regions adjoining the Great Wall north of the North China Plain. In summary, the major battlefields were mostly located in border regions (Figure 3a).

During the second period (221–580 AD), wars mainly broke out between the Xianbei ethnic group or the Hun Dynasty against the Western Jin Dynasty, as well as between the Eastern Jin Dynasty and the nomadic tribes that invaded the North China Plain (commonly known as the Central Plain). During the period of the Western Jin Dynasty, the border between the two groups extended from the northeastern part of the Tianshan Mountains and Hexi Corridor, north of the Qinling Mountain (36° N), along the Yellow River and up to the Great Wall of that time (40° N). During the period of the Eastern Jin Dynasty, the border was located near the Qinling Mountain and the Huaihe River at around 33° N (Guo Moruo, 1996). The main battlefields were notably situated at: 105° E–120° E and 30° N–38° N, scattered along the Qinling Mountain, the North China Plain, and the area west of the Shandong Peninsula (Figure 3b).

Wars that occurred during the third period (581–906 AD) were mainly fought between nomadic groups like the Tuyuhun, Turks, Khitan, Tibetan, and Uyghur tribes with the Sui and Tang Dynasties. The border between the territories of minorities in the north and the dynasties located on the North China Plain passed through the 42° N line of latitude (Guo Moruo, 1996). The conflicts were widely distributed within a range of 98° E–113° E and 33° N–42° N, mainly in the northwestern region. Furthermore, some of the wars extended to present day Kazakhstan and Kyrgyzstan, with sites scattered in the Tianshan Mountains, the Hexi Corridor (high-incidence regions), and the Loess Plateau south of the Yellow River and north of the Qinling Mountain;

in regions east of the plain and west of the Taihang Mountain; and in regions adjoining the Great Wall north of the North China Plain (Figure 3c).

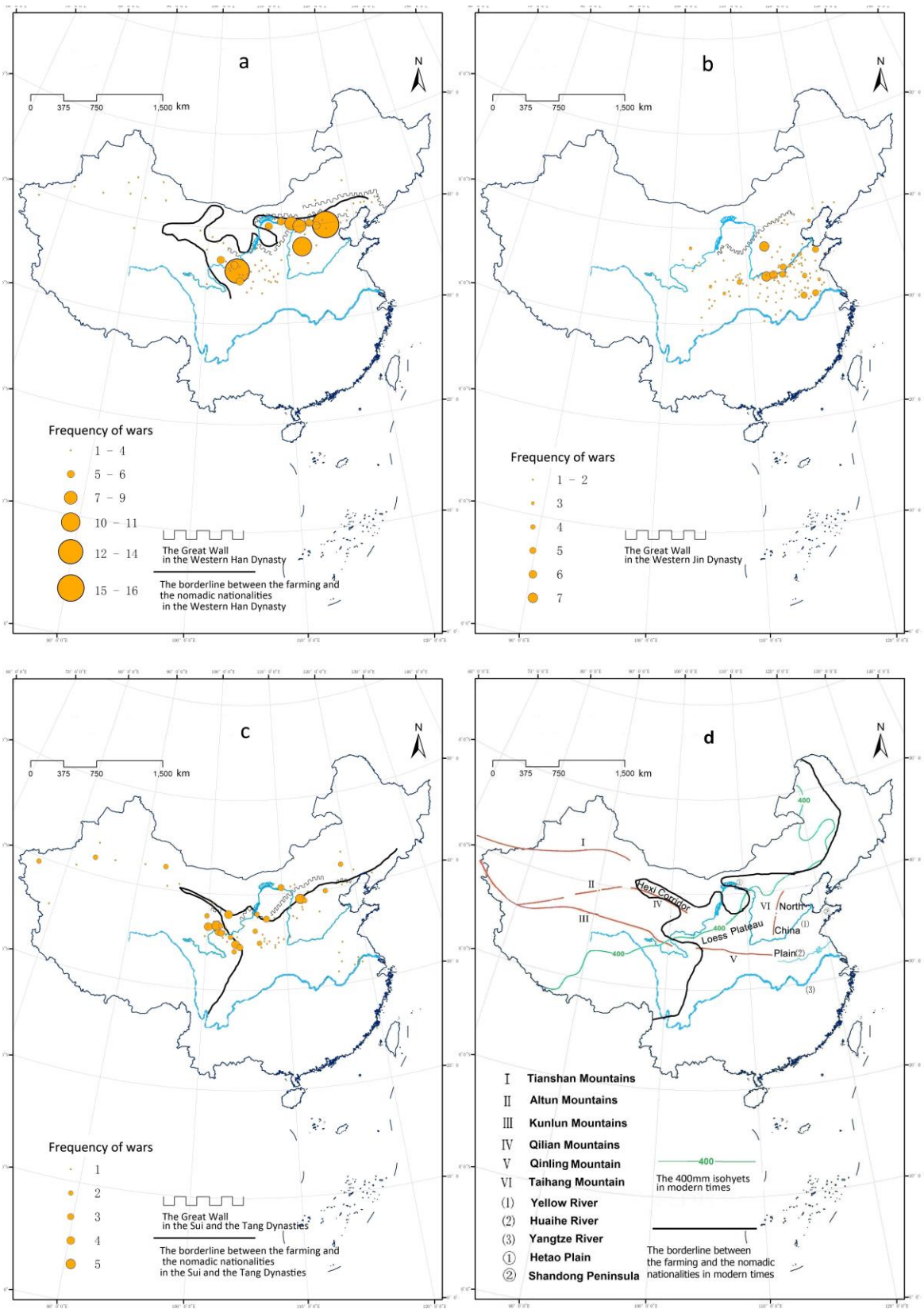

Figure 3 Distribution of ethnic wars in different periods (a. 210BC–220AD; b. 221–580AD; c.

581–906AD.) and basic geomorphology units (d) in China

An overall examination of these periods revealed that the battlefields were mainly distributed in the Hexi Corridor, the Loess Plateau south of Yellow River and north of Qinling Mountain, and throughout the entire North China Plain. These regions adjoined those of nomadic and farming groups located in the semiarid ecological transitional band on the fringes of agricultural production areas. The location of this region corresponds to that of the 400 mm isohyets, demarcating monsoon and non-monsoon regions, and the Great Wall, all of which are extremely sensitive to climate change.

The battlefields during the first period (the Western and the Eastern Han dynasties) and the third period (the Sui and Tang dynasties) were located mainly in the North, at a considerable distance from the capitals of the agriculturalist governing regime. Conversely, the battlefields during the second period (the Three Kingdoms, the Western and Eastern Jin dynasties, and the Southern and Northern dynasties) were located near the capitals of the agricultural areas, and even directly south of the capital.

3.3 Impact of the climate on ethnic wars

3.3.1 Climate change from the period of the Western Han Dynasty to that of the Tang Dynasty

Ge et al. (2013) made the following observations in relation to changes in temperature variations in China. First, warm periods occurred from 200 BC–180 AD (during the Western and Eastern Han dynasties) and 541–760 AD (the Sui Dynasty and up to the middle of the Tang Dynasty). Second, there were two cold periods in 181–540 AD (the Wei and Jin Dynasties and the Northern and Southern Dynasties) and 761–910 AD (the late Tang Dynasty). Moreover, while temperature changes in the eastern farming area were parallel with those in the country as a whole (Ge QS et al., 2003, 2010), there were differences in the range of temperature changes. Such differences were caused by regional temperature differences. Regional differences were evident during the following periods: 271–360 AD, 451–570 AD, and 781–840 AD. During these periods, temperature variations in eastern China were lower than those of the whole country. For example, while the period from 450–570 AD was relatively cold in the eastern region, it was the warmest century, historically, in the northeastern region (Hong YT et al, 2000；Chu GQ et al, 2012).

On a centennial timescale, China's temperature fluctuation was parallel with that of the Northern Hemisphere. The temperature sequences of the Northern Hemisphere have been reconstructed by a number of scholars (Loehle C., 2007；Loehle C. et al, 2008；Mann ME et al, 2008；Mann ME et al, 2009；Ljungqvist FC,

2010；Mcshane BB et al, 2011；Christiansen B et al, 2012). Most of these sequences indicate that warm periods occurred from: 1–270 AD and from 841–1290 AD, while there were alternate warm and cold periods from 271–840 AD. The warm period from 1–200 AD corresponded to the Rome Climate-optimum, while the cold period from 201–550 AD corresponded to the first part of the Dark Age Cold Period. However, there were some differences in temperature changes at the beginning and ending of each period between China and the Northern Hemisphere.

There were year-wise, decadal, and even regional differences relating to changes in humidity. The warm period experienced during the Han Dynasty was relatively wet. During this period, the number of high rainfall years in the East comprised 87.5% of the total period (Zheng JingYun et al, 2006). The number of low rainfall years in the West comprised 61.7% of the total period (Shao XM et al, 2010). During the warm period experienced at the time of the Sui and Tang dynasties, the East was partially dry, with the number of low rainfall years comprising 56.8% of the total period. The West, conversely, was partially wet, with the number of high rainfall years comprising 57.3% of the total period. Although the humidity of this period fluctuated slightly, it rarely exceeded the normal level.

During the first cold period (181–540 AD), the whole country was partially dry. In the East, 55.8% of the total year was partially dry, and the southern and northern regions were both dry. In the West, 65.3% of the total year was partially dry. During the second cold period (761–910 AD), the East was partially dry, and the number of low rainfall years comprised 65.3% of the total period. The West was partially wet, with the number of high rainfall years comprising 56% of the total period.

3.3.2 Ethnic wars and climate change

On a centennial or longer timescale, no correlation was found between wars and climate change (Figure 2, Table 3). However, in terms of the spatial variable, group wars between farmers and nomadic tribes were associated with climate changes (Figure 2i, Figure 3). During warm periods, the battlefields were mostly distributed in northern areas (at an average latitude of 38.92° N). During cold periods, the battlefields were located in areas at an average latitude of 34.66° N (south of the farming-grazing transitional zone). The conflicts that erupted between nomadic and farming groups occurred in some areas that are sensitive to climate change.

Table 3 Ethnic wars in cold and warm periods on a centennial timescale

Stage	Cold-warm phase	Regional wet-dry phase	Average of war frequency per decade	Proportion of wars initiated by farming groups	Proportion of wars won by the nomadic groups
200BC–180AD	Warm	Eastern China (wet), North-drought and South-flood; Western China (dry)	4	21.1%	71.8%
181–540AD	Cold	Whole China(dry)	3.6	38.2%	43.5%
541–760AD	Warm	Eastern China (dry), North-drought and South-flood; Western China (wet)	3.6	40.5%	69.6%
761–910AD	Cold	Eastern China (dry); Western China (wet)	1	13.3%	100%

On a decadal timescale, a warm climate was associated with a high incidence of wars, while a cold climate was conversely associated with a low incidence of wars. The Pearson correlation coefficient between the frequency of wars and country-level temperature variations was 0.293 (the correlation was significant [two-tailed] at the 0.01 level). During the second warm period (541–760 AD), the correlation coefficient was 0.571, with a correlation that was significant (two-tailed) at the 0.01 level. During decades of countrywide temperature variations above or equal to 0 °C, the average war frequency was 4.3 wars per decade. Conversely, during decades of countrywide temperature variations below 0 °C, the average frequency of wars was 2.6 wars per decade. The average variation in temperature was 0.1 °C during decades characterized by four or more wars. Of the 18 high-incidence periods of group wars, 13 (72%) broke out during warm periods, with average temperature variations of 0.28 °C. Statistical analysis revealed that 20.6% of the warm periods were also high-incidence periods of war.

The proportion of farming groups as initiators of war remained low, showing no significant correlation with temperature change. Conversely, nomadic groups were consistently the aggravators. However, during cold decades, the proportion of farming groups that initiated wars increased (Table 4). The chances of victory for farming groups increased especially during warm periods. A positive correlation existed between

temperature variations and the proportion of farmers' victories, the correlation coefficient being 0.173 (the correlation was significant at the 0.1 level). However, during cold periods, the chances of victory in war were almost the same for the two groups (Table 4). In short, during warm decades, a large proportion of wars were initiated by nomadic groups, whereas farming groups defended themselves effectively. During cold decades, proportions of wars initiated by the two sides were similar, and the proportion of wars won by farming groups decreased.

Table 4 **Ethnic wars with climate change on a decadal timescale**

Decades under the different climatic conditions		Proportion of wars initiated by the farming groups	Proportion of wars won by the farming groups
Dividing decades according to the temperature	Decades with the temperature variations being above or equal to 0°C	34.5%	73.0%
	Decades with the temperature variations being lower than 0°C	45.7%	54.6%
Dividing decades according to the humidity of the east and west	Decades with East-dry and West-dry	42.0%	50.4%
	Decades with East-dry and West-wet	45.6%	68.7%
	Decades with East-wet and West-dry	35.0%	66.2%
	Decades with East-wet and West-wet	40.9%	69.9%

On a decadal timescale, there was no significant correlation between the frequency of wars and the dry/wet series. During decades when the East was experienced less rainfall, the proportion of wars initiated by farming groups increased, but the proportion of their victories was not high (Table 4). Conversely, during decades when the East was experienced higher rainfall, the number of wars initiated by farming groups was lower, but the proportion of their victories increased. During dry and cold periods, whereas farming groups were inclined to initiate wars, their chances of victory were reduced.

4. Discussion

4.1 The mechanism of impact of climate change on wars between farming and nomadic groups

Our finding that group wars were more prevalent during warmer periods differ from those obtained by Zhang et al. (Zhang DD et al., 2006), who reported that wars were more frequent during cold periods than during warm periods. One possible reason for this is that our study only examined the frequency of wars between nomadic and farming groups without considering other types of war (e.g., civil wars during cold periods resulting from insufficient food). The different results may also be related to the selected temperature sequences.

Table 3 indicates that the vast majority of all wars were initiated by nomadic groups. However, farming groups achieved more victories. Further, the locations of key battlegrounds also changed as climate change. This raises questions of why these changes occurred and what the role of the climate. These are addressed below.

A first point to consider is the strong dependence of the nomadic economy on agricultural products. Although there is some demand for livestock products within an agricultural economy, considerable gaps exist between nomads and agriculturalists. The economic stability of northern nomadic and agriculturalist groups differed greatly. The nomadic economy relied heavily on nature and applied few technologies for the production of goods. Moreover, their simple socioeconomic structure was more vulnerable to natural disasters. These differences between the two groups resulted in an unbalanced but complementary relationship in their productive structures. Therefore, nomadic groups had to resort to mutual trade and wars to obtain agricultural products and crafts from farmers, making them the primary initiators of wars. The purpose of waging war for nomadic groups was to expand commodity circulation channels and ensure a continuous supply of agricultural products. Contrasting with agriculturalists, one of the important characteristics of nomadic groups during the cold weapon era was their combination of military activity and production. Skills acquired through routine daily activities provided nomadic groups with advantages when fighting on horseback and shooting accurately with bows and arrows that were not available to farming groups (Zhao Yuan et al., 2013). They launched these wars not to acquire large territories and cities, but rather to procure a variety of agricultural products and wealth. Plunder during war and quickly evacuated after plunder, became the effective strategy of acquiring wealth and a motive force among nomadic groups(Cui Ye, 2011). Therefore, these groups often initiated wars. Nomadic groups living in cold climates

characteristically advocated force. During warm periods when they were strong, they waged predatory and expansionary wars in the Central Plains (Ma Yamei, 2011).

A second consideration is that a warm climate provided good environmental conditions for economic development within both groups. Good economic conditions for nomadic groups could enhance their strength against farming groups, while also providing them a solid material foundation for waging wars (Wu Wenxiang et al., 2009). During cold periods, the strength of both groups was weakened to some extent, while extreme cold undermined the ability of nomads to attack by affecting and inhibiting their livestock (especially horses). The two groups presented concessions during cold periods. In the case of warm climate conditions, livestock proliferated, more than doubling their numbers owing to the abundant precipitation and consequent availability of lush grass (Xiao Qiqing, 1972). An examination of historical vicissitudes of nomadic groups reveals that good climatic conditions were associated with a rapid rise of nomadic empires, bolstered by strong horses and armies (Wu Wenxiang et al., 2009). Moreover, populations increased rapidly during warm periods, and the requirement for life necessities led to wars. It is well known that China's monsoon climate can be typically warm and wet or cold and dry during the same period. During warm and wet periods, nomads enjoyed lush conditions and had relatively few natural disasters to contend with. Consequently, populations tended to increase rapidly. Nomadic groups pursued a goal of increasing the quantity or scale of their livestock to maintain their basic livelihoods, eventually causing degradation of grassland in some areas and an imbalance of the grassland ecosystem (He Weiguang, 2002). Some regions near the 400-mm rainfall line were transition areas, constituting a semi-arid ecological transition zone. Based on the feasibility of agricultural and nomadic occupations in these regions, competition over these areas intensified the conflict between the two groups. Among nomadic groups, there was an increase in subsistence requirements and demands for food, cloth, and other agricultural products, as necessary supplements that could only be obtained from farming groups (Wei Jianglin, 2011). Shang (2006), who conducted a study of the Hun population during the period of the Western Han Dynasty, found that the period when the Hun population was largest extended from the Modu period to the Junchen period. During this time, Huns often waged plundering wars against foreign groups, robbing them of large numbers of people and wealth.

A third consideration is that during cold periods, both groups (and consequently political boundaries and conflict zones) moved south. During cold periods, both groups were weakened to some extent. However, the

agricultural economy had developed and accumulated abundant supplies, so governments could regulate and control the disbursement of subsidies in disaster areas. Nevertheless, because of the unicity of the nomadic economy, nomadic groups suffered more losses than agriculturalists during conditions of extreme cold. They consequently launched wars to gain more resources such as suitable land under the pressure of an excessive population and limited production. As a result, the main conflict areas moved south, incrementally. The strong desire to obtain living space through victory in war also contributed to the tenacity of nomadic groups during cold periods. The continuous southward migrations and invasions of nomadic groups led to frequent wars in the Central Plains, compelling the farming groups to move to the Yangtze River Basin and south of the Yangtze River. During this period, a large area of cultivated land was available to be reclaimed in southern China. Moreover, the environment in this region was more suitable for farming and human habitation (Lan Yichun et al., 2005). Conditions induced by the introduction of a large labor force and advanced production technologies by farming groups who moved south promoted substantial economic development in the South, attracting more agriculturalists to migrate to this region. The decreased population in the North and the deterioration of the agricultural environment in this region increased difficulties in procuring supplies of soldiers and food. Consequently, the conflict areas also moved southward. Conversely, warm climatic conditions facilitated the economic recovery of farming groups, and the gap in the military power of the two groups gradually widened. The frequency of victories of farming groups gradually increased, with the expulsion of nomadic groups from the Central Plains, and the main conflict zone gradually moved back to the North.

4.2 Other factors influencing wars between the farming and nomadic groups

Evidently, there were many factors that influenced wars between farming and nomadic groups. The climate only played an indirect role in these wars, for example, producing constraints on regional productivity. Consequently, the climate has provided an environmental backdrop for the wars.

Many social and economic factors directly affected the wars. Social instability was one risk factor. For example, during the Western and Eastern Han dynasties (185 BC–219 AD), entailing a total of 98 recorded flood disasters, extensive flooding of farming areas spread to many other areas, and the sea even overflowed. The Han government's failure to completely solve the serious consequences of the flood led to intensified social conflicts (Duan Wei, 2002). Consequently, this was a good time for nomadic groups to launch attacks.

However, there are fewer records for periods of social instability or dynastic succession.

It should be noted that conflict was not the only interaction between the two groups—peace also prevailed between them. Peaceful associations, for example, marrying for the sake of peace, termed *He-Qin*[3], could reduce incidences of war. This practice mainly occurred during the time of the Han Dynasty. The statistics show that *He-Qin* occurred a total of 37 times during the periods of the Western and Eastern Han dynasties, mainly in the −150s, −110s, −50s, 50s, 190s, which were warm periods. During this period, the frequency of wars between farming and nomadic groups was reduced. During the Han Dynasties, the correlation between the frequencies of *He-Qin* and wars was high, with a correlation coefficient of −0.733. The correlation was significant (two-tailed) at the 0.01 level.

5. Conclusions

The reasons for changes in group relations are diverse and complex, influenced by political, economic, social, and cultural factors. However, climate change also plays a role in promoting change. From the period of the Western Han Dynasty to that of the Tang Dynasty, climate change influenced the relationship between nomadic and farming groups in a number of ways.

Wars between nomadic and farming groups regularly occurred. On a centennial timescale, there was no significant correlation between the number of wars and climate change. However, on a decadal timescale, a warm climate corresponded to a high incidence of wars, while cold periods corresponded to a low incidence of wars.

Overall, the majority of the wars were initiated by nomadic groups. This reflects the nomads' vulnerability, and their dependence on the farming economy rather than bearing a close relationship to climate change. However, during warm periods, most of the wars were won by farming groups, reflecting their economic strength. However, during cold periods, both sides won almost the same number of wars. The conflicts between the two groups mainly took place in the Hexi Corridor; the Loess Plateau, south of the Yellow River and north of the Qin Mountains; and in the North China Plain. Wars primarily occurred either at the territorial boundaries of the two groups or within the nomadic groups' territories. As the temperature decreased, the battlefields expanded southward into farming areas.

[3] Some feudal dynasties made peace through marital alliances with the rulers of minority nationalities in border areas.

The influence of climate change on wars between nomadic and farming groups can be examined based on the following four considerations. First, excessive population growth within nomadic groups, against the background of a warm climate, could have enhanced their desire to procure the essential means of subsistence, leading to wars. Second, warm climates provided a solid material foundation for nomadic and farming groups, contributing, especially, to improving the productivity of nomadic groups. Moreover, compared with cold periods, the fighting strength of both groups was enhanced during warm periods. Third, the nomadic economy was strongly dependent on the agricultural economy, with plundering during wars providing a low-cost means of obtaining high returns. Lastly during cold periods, agriculturalists moved southward and began to develop and construct regions south of the Yangtze River. During this period, nomadic groups occupied the Central Plains, resulting in changes in the boundaries of regimes and consequently of conflict areas.

We conclude with some further research prospects. As there are a limited number of documents and quantitative indices, proxy indicators and criteria other than war-related data are required to gain an in-depth understanding of group relations, and especially of their power and confrontations.

Moreover, we did not provide holistic coverage of the 2,000-year period examined in this research. Consequently, there are temporal limitations that impact on our conclusions about their relationships. The construction of the sequence also needs to be further extended. After the Tang Dynasty, China's economic center shifted to the South, while the North remained the political center. We suspect that ethnic relations may have changed as a consequence.

This case study revealed that the socioeconomic impacts of climate change differ regionally and for different aspects. In ancient China, peasant uprisings were more frequent during colder periods, and ethnic conflicts were a more serious concern during warmer periods. These results may indicate that multiple mechanisms contribute to the observed relationships and that different mechanisms dominate in different contexts. It seems likely that climatic changes influence wars through multiple pathways. Further research should aim to identify these mechanisms.

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