Relationship between Climate Change and Wars between Nomadic and Farming Groups from the Western Han Dynasty to the Tang Dynasty period

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Abstract: In ancient China, the change in regional agriculture and animal husbandry productivity caused by climate change led to either wars or peaceful relations between nomadic and farming groups. From the Western Han Dynasty to the Tang Dynasty there were 367 wars between the two groups. The nomadic people initiated 69% of the wars, but 62.4% were won by the farmers. At a centennial timescale, the battlefields were mostly in the northern areas (average latitude 38.92°N) in warm periods, and the battlefields were moved southwards (average latitude 34.66°N) in cold periods. At decadal timescale, warm climates corresponded to a high incidence of wars (correlation coefficient is 0.293). In the periods being dry and cold, the farming groups were eager to initiate wars while the opportunity of victory reduced. The main causes which leading to the above results are following: ①Warm climate provided a solid material foundation for nomadic and farming groups, especially contributed to improve the productivity of nomadic group; meanwhile, the excessive desire for essential means of subsistence in nomadic group could led to wars. ②During the cold periods, people of farm group moved to the south and construct the south, meanwhile, nomadic group occupied the central plains, thus the battlefields also changed. There were other factors affecting the wars. As the background, climate change plays an indirect role in wars between groups.

Key words: ethnic conflicts; climate change; China; from the Western Han Dynasty to the Tang Dynasty

1 Introduction

The association between violent conflicts and environmental change has attracted much research attention recently. Since 2007, more systematic research on the effect of climate change on security issues has 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 obtain natural resources and products, nomads and farmers traded with each other, leading to migration, population mixing, and even culture blending. However, there were also disputes, conflicts, and wars. National cohesion was eventually achieved either through peaceful communication or

conflicts between the nomadic and farming groups.

Data relating to the wars between nomadic and farming groups were obtained from the *Chronology of Wars in Chinese History* (The Chinese Military History editorial, 2003), collected and edited by the Compiling Group of Chinese Military History from Nanjing Academy of Military Sciences. The data source of chronology was dominated by the *Twenty-Four Histories*[1] and *Qing History Draft*[2]. These two sets of books are often considered as authoritative sources of traditional Chinese history and culture. In the chronology, the standard of selecting and recording wars was unified. In addition, the chronology kept the records of causes, process, results, characteristics of main wars. So, information source of wars is reliable. However, due to the influence factors on the process of historical material accumulation and inheritance, at different periods in the history of China, there were some periods with the special rich records and some with few records, even some periods had the event of burning books(Zhang Wenhua, 2002). In other words, the historical records have discontinuity and heterogeneity (Figure 2). As a result, in the period of the discontinuous historical records, the war is short of record and the frequency of the war will be underestimated. According to statistics, such the period lacking of records is a total of 56 years, and it accounts for 5% of the whole stage.

Based on the records in this book, we classified and selected 367 wars between nomadic and farming groups from the Western Han Dynasty to the Tang Dynasty. We noted: the year that the war occurred, the name of the war, the initiator, the victor, the major battlefield, and the location of the battlefield (its present name, latitude and longitude position).

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

1) We used only wars between the northern nomadic group and farming group who established a regime in central China. We excluded: wars between nomadic ethnicity regimes or tribes, wars between nomadic

[1] The *Twenty-Four Histories* is the general term of 24 chronicle historical books about the official history of the Chinese except Qing Dynasty, generally written and reviewed by later dynasty independently. The *Twenty-Four Histories* including *Book of Han*, *Book of Later Han*, *Records of Three Kingdoms*, *Book of Jin*, *Book of Song*, *Book of Qi*, *Book of Wei*, *Book of Liang*, *Book of Chen*, *Book of Northern Qi*, *Book of Zhou*, *History of Southern Dynasties*, *History of Northern Dynasties*, *Book of Sui*, *Book of Tang*, *New Book of Tang*, *Five Dynasties History*, *New Five Dynasties History*, *History of Song*, *History of Liao*, *History of Jin*, *History of Yuan*, *History of Ming*.

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

groups and separatist groups, peasant uprisings within the Central Plain regime that was established by the farming group, and wars between minority ethnic groups in the Southwest and farmers or foreign countries.

2) If a war lasted for more than 1 year, the initial year was recorded according to the chronology.

3) In 363 cases (98.91% of the data) it was clear who initiated the war. In four cases (1.09%) farming groups lent 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 cases (96.72%), it was clear who were victorious. For 12 cases there was no information on who won; among these cases, seven (1.91%) described one side as “effective defense” or “effective counterattack”, or described the other side as “unable to conquer the adversaries” or “attempted attack failed”. In these cases, the defending side was categorized as the victor. In three cases (0.82%), one side begged for truce or made peace by marriage, and we considered them to be the losing party. The other two cases (0.54%) were related to wars that involved multiple battlefields and varying outcomes of different wars. For these, we classified the outcome according to the last war.

5) For 351 cases (95.64%) the location of the war was given. In two special situations, there was no relevant information, and we thus used other criteria. There were 11 cases (1.99%) that recorded the battlefield location as “on the border”. In this situation, we referred to the *Historical Atlas of China* (Guo Moruo, 1996) and used the middle point of the border as the battlefield location. In five other cases (1.36%), as only the information of the armies involved was recorded, we used the locations of army camps as the battlefield location.

We calculated the total number of wars, the average latitude of the battlefields, the frequency of nomadic versus farming groups’ initiation of the conflict, and the proportions of their victory, at decadal timescale. We reconstructed the series of community group wars from the Western Han Dynasty to the Tang Dynasty. By analyzing the variation characteristics of the sequences, we divided up the historical periods into several stages, drew a scattergram of the major battlefield distribution, and made a spatial analysis of the transfer and distribution of the conflicted regions. We also analyzed the possible relationship between the wars and climate change at decadal and centennial timescales.

2.2 Climate change sequence

In order to increase the reliability of the sequence comparison, we adopted two sequences reflecting temperature and two sequences reflecting precipitation as the basis of comparison.

Two temperature sequences are:

(1) The series which was reconstructed based on historical documents, shows the winter half-year temperature variations series in eastern China over the past 2,000 years (Ge QS et al, 2003； 2010). Mr. Chu Kochen pioneered the research of Chinese past climate change (Chu KC, 1973) and his results on climate series reconstruction have been widely accepted (J G, 1973). The series of the temperature variations (with respect to the mean value for the period 1851–1950) of the winter half-year (from October to April) was constructed based on historical documents that were closely related to agricultural production. The resolution is at a 30-year period timescale. The series in eastern China (east of 105° E, 25°–40° N) reflects the temperature variation in the farming regions.

(2) The composite series which was reconstructed by using partial least squares regression, shows temperature variations in China at a decadal resolution over the past 2,000 years (Ge QS et al, 2013). The reference value is the mean temperature from 1851 to 1950. Twenty- eight published proxy temperature series were selected for reconstruct China temperature anomaly series, and the proxies included sediments, stalagmites, historical documents, tree rings and ice cores. The reconstruction is developed using proxy temperature data with relatively high confidence levels from five regions (Northeast, Northwest, Central East, Tibet Plateau, Southeast) across China.

For the dry/wet ratio series, we adopted two sequences for comparison.

(1) One is the “dry/wet ratio series of eastern China over the past 1,500 years” (Zheng JingYun et al, 2006). This series covers the period from 105 AD to 2000 AD in eastern China (including North China, Yangtze-Huaihe region and Jiangnan area). The series reconstructed with drought and flood grades of 48 sites based on Chinese historical records. It reflects the dryness/wetness change in the farming regions. The positive values refers to the precipitation being more, and the negative values refers to the precipitation being less.

(2) The other series is the “ring-width index with 31-year moving averages from the northeastern Qinghai-Tibetan Plateau”(Shao XM et al, 2010). The Qinghai-Tibetan Plateau is a region sensitive to recent global climate change. The tree-ring width chronology of Qilian juniper indicate precipitation changes and it can reflect the changes on humidity in western China. The positive values refers to the precipitation being

more, and the negative values refers to the precipitation being less.

3 Analyses

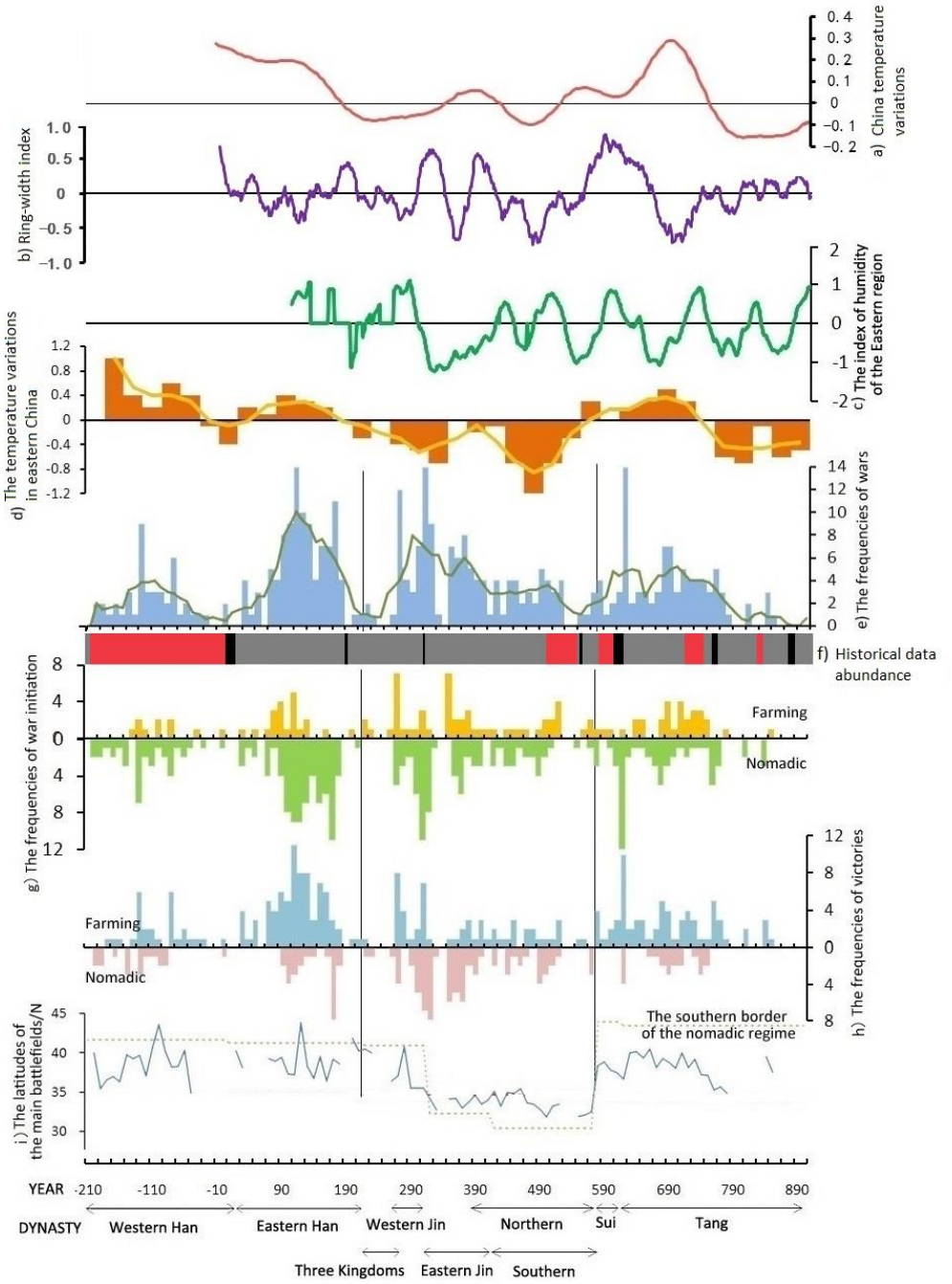

Figure 2 Sequence of wars between the northern nomadic and farming groups

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 (average 3.3 times per 10 years (3.3/10a)) occurred between the farming and nomadic groups from the Western Han Dynasty to the Tang Dynasty (Figure 2). The wars between the two groups were concentrated in different periods. Wars were more frequent (14 wars/10a) within three periods (111 AD–120 AD, 311 AD–320 AD, and 621 AD–30 AD). Based on the descending order of the frequency of war in each dynasty, the first 15% of periods with a frequency of more than (or equal to) 7 wars/10a were regarded as high incidence. There were 18 such periods that accounted for 169 wars. In other words, during 16% of the time span (1,112 years), 46% of the wars occurred. The last 15% of the periods, which witnessed wars less than (or equal to) 1 war/10a, were regarded as low incidence. In these 41 periods, only 20 wars occurred (36% of the time span, 5% of the wars). Periods of no wars occurred mainly in the late period of a dynasty or during periods between dynasties in the Central Plain, when there was no extra power to initiate wars or resist enemies. However, we do note that the period of replacement of dynasties was lack of records..

Statistical classification of wars in different dynasties suggested that in a 10-year period during the Eastern Han Dynasty, the Western Jin Dynasty and the Eastern Jin Dynasty, the frequency of war was far higher than the average (3.3 wars/10a), and these dynasties were the periods with a high incidence of group wars (Table 1). There were 14 high-incidence periods of wars within these three dynasties, making up 78% of all the high-incidence periods. In other dynasties, the frequency of wars, at decadal timescale, was lower than the average, and were considered to be 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/10 years)	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 the victors

Table 2 shows the frequency of initiation and victory for farming and nomadic groups. The nomadic groups were dominant in initiation, while the farming groups were dominant in victories. This distribution was particularly distinct in politically united dynasties (the Western Han Dynasty, the Eastern Han Dynasty, the Sui Dynasty, and the Tang Dynasty). During the Western and Eastern Han Dynasties, the farming groups initiated far fewer wars but achieved most of the victories. This pattern persisted until the Sui and Tang Dynasties, in which the wars initiated by farming groups slightly increased, but in most cases they were still victorious. In contrast, the nomadic groups were mainly the instigators, and they achieved victories only during periods of political turbulence (i.e., the Western Jin Dynasty, the Eastern Jin Dynasty, the Southern and Northern Dynasty). However, during the Three Kingdoms, the farming groups initiated most of the wars but achieved few victories.

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

Dynasty	Farmers				Nomads			
	Total initiation	Percentage (%)	Total victories	Percentage (%)	Total initiation	Percentage (%)	Total victories	Percentage (%)
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 distribution of the conflict regions in different dynasties (Figure 2).

The first period includes the Western and the Eastern Han Dynasties (206 BC–220 AD), with a low incidence of wars in the beginning of this period (Western Han Dynasty) and high-incidence in the latter portion (Eastern Han). There were 148 wars (40% of the total), with an average of 3.4 wars/10a, increasing to 5.3 wars/10a in the late period. Farming groups initiated 21.6% of the conflicts during this period and were victorious 71.6% of the time.

The second period includes the Three Kingdoms, the Wei Dynasty, the Jin Dynasties, and the Southern and the Northern Dynasty (221–580AD). There were 130 wars in total (36% of the total, 3.6 wars/10a). The frequency of wars initiated by the farming groups in this period was significantly higher than that of the earlier period, rising to 38.5% of the total, but they achieved only 42.3% of the victories.

The third period was the Sui Dynasty and the Tang Dynasty (581–906 AD), which was a low-incidence period. In this period, there were 89 wars in total (24% of the total, 2.7wars/10a). Besides the high incidence of wars during the alternation periods of different dynasties, the frequency of war decreased overall. As in the first period, the farming groups initiated fewer conflicts (34.8% of the total), but won most of them (76.4%).

3.2 Distribution and change in the conflict regions between farming and nomadic groups

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

In the second period (221–580 AD), wars mainly broke out between the ethnic Xianbei and the Hun against the Western Jin Dynasty, as well as between the Eastern Jin Dynasty and the nomadic tribes that invaded the North China Plain (usually called the Central Plain). During the Western Jin Dynasty, the border between the two groups ran from the northeast of the Tianshan Mountains and Hexi Corridor, 36°N north of the Qinling Mountain, the Yellow River to the Great Wall of that time (40°N). During the Eastern Jin Dynasty, the border was near the Qinling Mountain and the Huaihe River, around 33°N (Guo Moruo, 1996). The main battlefields were at 105°E-120°E, 30°N-38°N and scattered along the Qinling Mountain, the North China Plainand west of Shandong Peninsula (Figure 3b), which shows that these latitudes were notably to the south (around 3–4 latitudes).

Wars in the third period (581–906 AD) were mainly between the nomadic groups like the Tuyuhun, Turk, Khitan, Tibet, and Uyghur tribes, and the Sui and Tang Dynasties. The border between the minorities in the north and the dynasties in the the North China Plain was along the 42°N region (Guo Moruo, 1996). The conflicts were widely distributed within 98°E-113°E, 33°N-42°N, mainly in the northwestern region. Furthermore, some of the wars extended to present-day Kazakhstan and Kyrgyzstan, with scattered sites in the Tianshan Mountains, Hexi Corridor (high-incidence regions), the Loess Plateau south of the Yellow River and north of the Qinling Mountain, regions east of the plain and west of the Taihang Mountain, and regions along the Great Wall north of the North China Plain (Figure 3c).

An overall examination of the these periods showed that the battlefields were mainly distributed in the

Hexi Corridor, the Loess Plateau south of Yellow River and north of Qinling Mountain, and the whole North China Plain. These regions were the adjoining areas of the nomadic and farming groups in the semiarid ecological transitional band. Meanwhile, they were on the fringes of the agricultural production areas. This region corresponds to the location of the 400-mm isohyets, the demarcation line between the monsoon region and non-monsoon region and the Great Wall, which are all extremely sensitive to climate change.

The battlefields in the first period (the Western and the Eastern Han Dynasties) and the third period (the Sui and Tang Dynasties) were far away from the capitals of the farming regime and mainly in the north. In contrast, the battlefields in the second period (the Three Kingdoms, the Western and Eastern Jin Dynasties, and the Southern and Northern Dynasty) were near the capitals of the farming areas, even directly south of the capital.

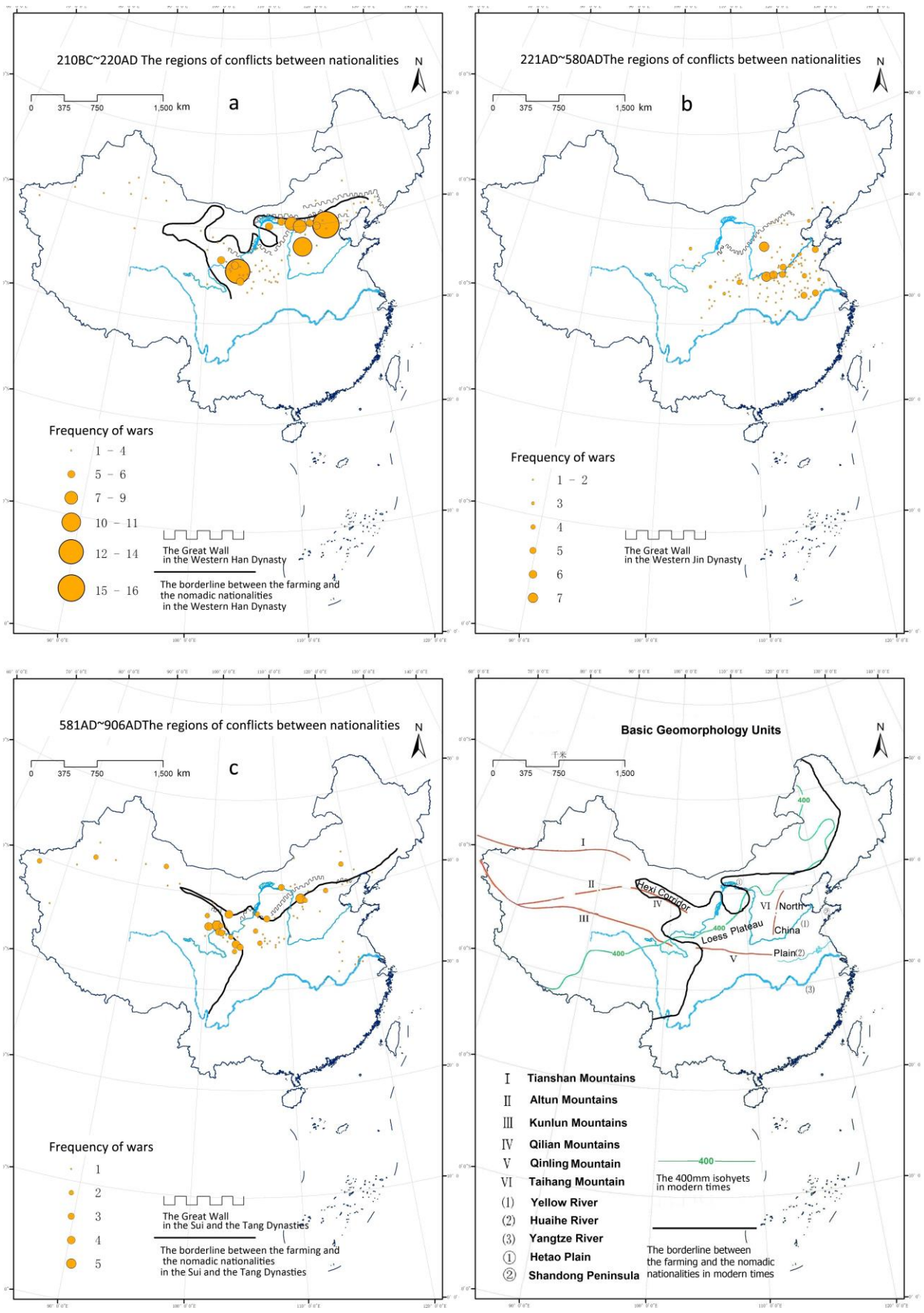

Figure 3 Distribution of ethnic relations in China from the Western Han Dynasty to the Tang Dynasty

and basic geomorphology units

3.3 Impact of the climate on the ethnic wars

3.3.1 Climate change from the Western Han Dynasty to the Tang Dynasty

National temperature variations change in China shows (Ge QS et al, 2013): （1）There were warm periods during 200BC~180AD(the Western and Eastern Han Dynasties),and 541~760AD(the Sui and before the middle of the Tang Dynasties).（2）There were two cold periods: 181AD~540AD (the Wei and Jin Dynasties, and the Northern and Southern Dynasties) and 761AD~910AD(Late Tang Dynasty). There was consistency between the changes of the temperature in the eastern farming area and the whole country in China(Ge QS et al, 2003；2010), but differences existed in the range of temperature change. Such differences were caused by the difference of temperature in the each region. The periods with evident regional differences are: 271AD~360AD, 451AD~570AD, 781AD~840A. In these periods, the eastern temperature variations were lower than the whole country's. For example, during 450~ 570AD, the eastern region was relatively cold, while it was the warmest century in the northeast region in history(Hong YT et al, 2000；Chu GQ et al, 2012).

At a centennial timescale, the fluctuation of temperature in China was consistent with the Northern Hemisphere. The temperature sequence reconstructions of northern hemisphere show that(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 sequences indicated that there were warm periods at 1AD~270AD, 841AD~1290AD; and 271AD~840AD was warm and cold alternately. The warm period in 1AD~200AD corresponded with Rome Climate-optimum; the cold period in 201AD~550AD corresponded with the first part of DACP (Dark Age Cold Period). But there were some differences on the start and end time of temperature change of each period between China and Northern Hemisphere.

About the change of humidity, differences existed in years and decades, even in regions. The warm period of Han Dynasties was relatively wet. During this period, the number of years with more rainfall in the east accounts for 87.5% of the total(Zheng JingYun et al, 2006), the number of years with less rainfall in the west accounts for 61.7% of the total(Shao XM et al, 2010). In the Sui and Tang Dynasties warm period, the east was partial dry, the number of years with less rainfall accounts for 56.8% of the total. The west was partial wet, the number of years with more rainfall accounts for 57.3% of the total. Although the humidity of this period fluctuated slightly, it rarely went beyond the normal level.

The first cold period (181AD~540AD), the whole country was partial dry. In the east, 55.8% of the total year were partial dry and both of the south and north were dry. In the west, 65.3% of the total year were partial dry. In the second cold period (761AD~910AD), the east was partial dry, and the number of years with less rainfall accounts for 65.3% of the total. The west was partial wet, and the number of years with more rainfall accounts for 56% of the total.

3.3.2 Ethnic wars and climate change

At a centennial or longer timescale, there was no correlation between the wars and climate change (Figure 2, Table 3). However, in terms of the spatial variable, group wars between farmers and nomadic tribes corresponded to climate changes (Figure 2i, Figure 3). In warm periods, the battlefields were mostly in the northern areas (average latitude 38.92°N). In the cold period, the battlefields were in the areas of average latitude 34.66°N(in south of the farming-grazing transitional zone). The conflicts between the nomadic and farming groups took place in some areas which are sensitive to climate change.

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

Stage	Cold-warm phase	Wet-dry phase	Average of war frequency every 10-year	Proportion of wars initiated by farming groups	Proportion of wars won by the nomadic groups
200BC~180AD	Warm	East-wet, North-drought and South-flood; West-dry;	4	21.1%	71.8%
181AD~540AD	Cold	Nation-dry, East and West-drought;	3.6	38.2%	43.5%
541AD~760AD	Warm	East-dry, North-drought and South-flood; West-wet;	3.6	40.5%	69.6%
761AD~910AD	Cold	East-dry, West-wet;	1	13.3%	100%

At decadal timescale, a warm climate corresponded to a high incidence of wars, while a cold climate corresponded to a low incidence of wars. Pearson correlation coefficient between the frequency of wars and national temperature variations is 0.293(Correlation is significant at the 0.01 level (2-tailed)). Especially in

the second warm period (541~760AD), the correlation coefficient is 0.571(Correlation is significant at the 0.01 level (2-tailed)). In the decades of nationwide temperature variations being above or equal to 0°C, the average frequency of wars is 4.3 times/10a. while in the decades of nationwide temperature variations being lower than 0°C, the average frequency of wars is 2.6 times/10a. The decades with the frequency of wars being above or equal to 4 times/10a, the average temperature variations is 0.1℃. In the 18 high-incidence periods of group wars, 13 of them (72%) broke out in a warm period, with an average temperature variations of 0.28°C. Statistical result showed that 20.6 percent of the warm periods were also high-incidence periods of group wars.

The farming groups maintained a low proportion of initiation, with no significant correlation with temperature change. While the nomadic groups were always the aggravating side. However, in the cold decades, the proportion of the farming groups initiating wars increased (Table 4). The farming groups had a greater chance of winning, especially in the warm period. Positive correlation existed between the temperature variations and the proportion of farming victory, the correlation coefficient is 0.173(Correlation is significant at the 0.1 level). However, in the cold period, the two groups had almost the same chance of winning the wars（Table 4）. In short, in the warm decades, the proportion of wars initiated by nomadic groups is large, but the farming groups implemented effective defense. In the cold decades, the proportions of wars initiated by two sides were quite, and the proportion of wars won by the farming groups decreased.

Table 4 **Ethnic wars with climate change at 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%

At decadal timescale, there was no significant correlation between the frequency of wars and the dry/wet series. In contrast, in the decades with the east being dry, the proportion of wars initiated by the farming groups increased, but the proportion of victory was not high (Table 4). On the contrary, in the decades with the east being wet, the number of wars initiated by the farming groups is less, but the proportion of victory increased. In the periods being dry and cold, the farming groups were eager to initiate wars while the opportunity of victory reduced.

4.Dissussion

4.1Mechanism of the impact of climate change on the wars between the farming and nomadic groups

Our conclusions that groups wars were more prevalent during warmer periods are different from those of the study conducted by Zhang Dian (Zhang DD et al., 2006), who concluded that the frequency of wars in cold periods was higher than that of warm periods. One possible reason is that the frequency of war in our study only accounts for wars between the nomadic and farming groups without considering any other types of war (e.g., civil wars in cold periods lead to insufficient food). And the results can also be related to the selected temperature sequences. From Table 3 we can see that the vast majority of all wars were initiated by nomadic group and the frequency of war initiated occupy a large proportion in the total war frequency, however, farming groups got more victory; and the location of the key battleground also changed with climate. Why do the above aspects of wars change, what role does the climate play?

Firstly, nomadic economy has a strong dependence on agricultural products. Although agricultural economy on livestock products have a certain demand, there exists great gaps of the between the two groups. Northern nomadic groups and farming groups varied greatly in their economic stability. The nomadic economy relied highly on nature and applied few technologies to the production of goods. In addition, their simple socioeconomic structure was more vulnerable to natural disasters. These differences between the two groups resulted in an unbalanced complementary relationship in their product structures. Therefore, the nomadic groups had to resort to mutual trade and wars to obtain agricultural products and crafts from the farmers, which made them the primary initiators of wars. The purpose of nomadic groups waging war was to

373 open commodity circulation channels and ensure continuous access to more agricultural products. Compared
374 with farming group, in the cold-weapon era, one of the important characters of nomadic group was
375 combination of military and production. Advantages which fighting on horses and the accuracy of shooting
376 with the bow in nomadic group can get training in daily life, and farming group can not do this(Zhao Yuan et
377 al., 2013). The war plunder which cost less but obtained more was a way of getting a variety of agricultural
378 products and wealth for nomadic group .Therefore, nomadic group often became the side of launching in
379 wars. Nomadic group which living in the cold condition had the character of advocating force, and during the
380 period of strong of nomadic group(warm periods) wars which was predatory and expansionary were brought
381 to the central plains by the nomad(Ma Yamei, 2011). It was just because they did not intend to obtain a large
382 area of land and cities, they just wanted to use the lower cost to get higher interests through wars. This
383 became a kind of the most effective means of gaining wealth, and became a dynamic to inspire people in
384 nomadic group to plunder(Cui Ye, 2011).
385 Secondly, warm climate provided a good environmental condition for developing economy in both groups.
386 Good economic conditions in nomadic group can enhance the strength to against farming group, and also
387 provide a solid material foundation for waging wars(Wu Wenxiang et al., 2009). In the cold periods, to some
388 extent, strength of both groups was weakened, and extreme cold would weakened the ability to attack by
389 damaging nomadic livestock (especially horses). Two groups presented concession in the cold periods. In the
390 case of warm climate condition, livestock could proliferate more than double with abundant precipitation and
391 lush grass (Xiao Qiqing, 1972). By studying the history of vicissitude of nomadic group, results indicate
392 nomadic empire can often rise rapidly with strong horses and armies in good climate condition (Wu Wenxiang
393 et al., 2009). Besides, the population increased rapidly in warm periods, and the thirst for necessaries of life
394 led to wars. As is known to all, the characteristics of the monsoon climate of China is warm and wet over the
395 same period, cold and drought in the same period, and so are the historical period(Wang Huichang. 1996). In
396 the warm and wet period, nomads had relatively few natural disasters and lush, at this time, population
397 tended to increase rapidly. Nomadic group unilaterally pursued the quantity or the scale of the livestock in
398 order to maintain the basic livelihood, and eventually caused the imbalance of the grassland ecosystem and
399 grassland degradation in some areas(He Weiguang, 2002). Some regions near the 400mm rainfall line are the
400 transition areas, namely, semi-arid ecological transition zone. On account of feasibility of agricultural and

nomadic in these regions, contending for the areas intensified the conflict between both groups. On the other hand, with the growing demand of nomadic group for subsistence, food, cloth and other agricultural products had become necessary supplement and these can only obtain from the farming group(Wei Jianglin, 2011). By studying the Huns' population in Western Han Dynasty, Shang (2006) shows that the Huns'period with the largest population is the ones which are from Modu period to Junchen period. During the period, Huns often plundered wars against foreign and robbed a large number of population and wealth.

Thirdly, in the cold periods, both groups moved to the south, so did political boundaries and conflict zones. In the cold periods, to some extent, strength of both groups was weakened. However, farming group's economy was developed and accumulated abundant supplies, and the disaster areas can be granted subsidies by government regulation and control. Nevertheless, due to the unicity of nomadic economy, nomadic group would suffer more losses than farming group in the extreme cold condition. So nomadic group was going to launch wars to occupy more resources((for example: land with more suitable climate) under the pressure of excessive population and less production. As a result, the main conflict areas moved to south step by step. The strong desire of getting living space by winning in wars also contributed to the tenacious will of nomadic group in the cold periods. Nomadic continuously southward invasion and migration led to the frequent wars in the central plains, and forced agricultural people to move to the Yangtze River Basin and the south of Yangtze River. At this time, there were a large number of cultivated land be reclaimed in South China, and the environment in the south was more suitable for farming and living for human beings(Lan Yichun et al., 2005). Farming group brought a large number of labor force and advanced production technology to the south, and these conditions promoted the great development of the economy in the south and then attracted more farming people to migrate to the south. The decreased population of the north and deterioration of agricultural environment brought the more difficulties for supplies of soldiers and food, so the conflict areas were southward. In contrast, warm climatic conditions made the economic recovery of farming group, and the military power of two groups had gradually generated gap. The frequency of victory of farming group was gradually increasing, nomadic group was expelled from the central plains, and the main conflict zone gradually moved to the north again.

4.2 Other factors affecting the wars between the farming and nomadic groups

Obviously, there were many factors affecting the wars between the farming and nomadic groups. The

429 climate only played an indirect role in the wars, because the regional productivity was limited by the climate.
430 So the climate provides an environmental background for the wars.

431 Many social and economic factors directly affected the wars. For example, the social instability was a risk
432 factor. For example, in the western and the eastern Han Dynasties warm period (185BC~219AD, a total of 98
433 flood disasters records), farming area had erupted a large flood which spread to many other areas, and even a
434 sea overflow appeared. Due to the fact that the Han government failed to completely solve the serious
435 consequences caused by the flood, and the fact made the social conflicts intensified(Duan Wei, 2002), and
436 turbulent situation in farming group was a good time for nomadic group to attack. Unfortunately, there were
437 less records in the periods of social instability or the change of dynasties.

438 There were not only conflicts but also peace between the two groups. Peace association, for example,
439 marring for the sake of peace——called "He-Qin"[3] could reduce the war. He-Qin mainly occurred in the Han
440 Dynasties. After the statistics, He-Qin was a total of 37 times during the Western and the Eastern Han
441 Dynasties. He-Qin occurred mainly in the -150s, -110s, -50s, 50s, 190s, and these periods are in a warm
442 period.In this period, the frequency of wars between farming and nomadic groups was reduce. During the
443 Han Dynasties, the correlation is high between the frequencies of He-Qin and wars, and the correlation
444 coefficient is -0.733 (correlation is significant at the 0.01 level(2-tailed)).

445 **5. Conclusions**

446 The reasons for the change in group relations are complex and diverse, and are influenced by political,
447 economic, social, and cultural factors. Climate change also plays a role in promoting change. From the
448 Western Han Dynasty to the Tang Dynasty, the nomadic and farming groups' relationship was affected by
449 climate change as follows:

450 1) Wars between the nomadic and farming groups took place with regularity. At a centennial timescale,
451 there was no significant correlation between the number of wars and climate change; however, at
452 decadal timescale, a warm climate corresponded to a high incidence of wars, while cold periods
453 corresponded to a low incidence.

454 2) Overall, the nomads initiated the majority of the wars, which had no close relationship to climate change.

[3] some feudal dynasties make peace with rulers of minority nationalities in the border areas by marriage

This reflects the nomads vulnerability, and their dependence on the farming economy. During warm periods, most of the wars were won by the farming groups, which reflected their strong economic strength. However, during the cold periods, both sides won almost the same number of wars.

3) 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 the North China Plain. The wars mostly took place either at the border of the two groups or in the nomads' territory. As the temperature decreased, the battlefields expanded southward into the farming areas.

4) The influence of climate change on wars between nomadic and farming groups may be achieved by the following four aspects: ①under the background of warm climates, the excessive growth of population in nomadic group could bring about desire for essential means of subsistence, and led to wars.② Warm climates provided a solid material foundation for nomadic and farming groups, especially contributed to improve the productivity of nomadic group; in addition, compared with cold periods, both groups had the strength to fight in warm periods.③ The nomadic economy had a strong dependence on the agricultural economy, and plundering by wars was a way of low cost and high income. ④During the cold periods, people of farm group moved to the south and started to develop and construct the regions south of the Yangtze River, meanwhile, nomadic group occupied the central plains which made the boundary of regime change, thus the conflict area also changed.

There are some further research prospects:

As there are a limited number of documents and quantitative indices, we need other proxy indicators and criteria than data related to wars to gain an in-depth understanding of group relations, especially their power and confrontations.

In addition, we did not cover the 2,000 years holistically in this research; therefore, there are temporal limitations in the conclusions about their relationships. Moreover, the construction of the sequence needs to be further extended. After the Tang Dynasty, China's economic center shifted to the south, while the north was the political center, and we suspect that ethnic relations may have changed.

This case study revealed that the socio-economic impacts of climate change are different in different regions and for different aspects. In ancient China, peasant uprisings were greater in colder periods, and ethnic conflicts were more serious in 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 be to identify these mechanisms.

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