land

MDPI

Article

The Spatiotemporal Patterns of Human Settlement during the Longshan and Erlitou Periods in Relation to Extreme Floods and Subsistence Strategy in the Upper and Middle Qin River Reaches, Central China

Wenhua Gao [1,2], Hainan Hu [1], Weidong Hou [2], Pengjia Zhang [1], Panpan Gong [1], Wenyan Jia [1], Xiaoli Liu [1] and Kaifeng Li [1,2,*]

[1] College of Geography and Environmental Science, National Demonstration Center for Environment and Planning, Henan University, Kaifeng 475004, China; gaowenhua@henu.edu.cn (W.G.); 104753200189@henu.edu.cn (H.H.); zhpengjia@vip.henu.edu.cn (P.Z.); 104753200200@henu.edu.cn (P.G.); jwy@henu.edu.cn (W.J.); liuxiaolo@henu.edu.cn (X.L.)

[2] Laboratory of the Yellow River Cultural Heritage, Collaborative Innovation Center on Yellow River Civilization Jointly Built by Henan Province and Ministry of Education, Henan University, Kaifeng 475001, China; 10020116@vip.henu.edu.cn

* Correspondence: kfli@henu.edu.cn

Abstract: Human settlement numbers have significantly changed before and after ~4000 cal. y BP in the upper and middle Qin River reaches, but the external and internal factors driving this change remain unclear. In this study, we examine changing spatial and temporal patterns of the Longshan and Erlitou settlements in relation to extreme flooding at ~4000 cal. y BP and a variety of subsistence strategies during the Longshan and Erlitou periods. The results indicate that settlement number, settlement distribution, and subsistence strategies exhibited obvious shifts between the Longshan and Erlitou periods, and the episode at ~4000 cal. y BP was an extreme-flood-rich interval within and around the Qin River Basin. During the Longshan and Erlitou periods, millet-based agriculture dominated local subsistence strategy, and ancient people would prefer to reside in the areas suitable for farming, causing the valley plains in the upper and middle Qin River reaches to contain most Longshan and Erlitou settlements. However, the frequent occurrence of extreme floods at ~4000 cal. y BP, in conjunction with intergroup conflicts due to a large amount of population immigration during the late Longshan period, is likely to have jointly decreased the settlement number and shrunk the spatial range of human settlement distribution. Subsequently, with the end of the extreme-flood-rich episode and the increasing proportion of higher-water-requirement foxtail millet in cropping structures of human subsistence strategy, more Erlitou settlements were distributed in the wetter valley plains of the middle Qin River reaches.

Keywords: human settlement; spatiotemporal pattern; Longshan period; Erlitou period; extreme floods; subsistence strategy; Qin River Basin

check for updates

Citation: Gao, W.; Hu, H.; Hou, W.; Zhang, P.; Gong, P.; Jia, W.; Liu, X.; Li, K. The Spatiotemporal Patterns of Human Settlement during the Longshan and Erlitou Periods in Relation to Extreme Floods and Subsistence Strategy in the Upper and Middle Qin River Reaches, Central China. *Land* **2022**, *11*, 1088. https://doi.org/10.3390/land11071088

Academic Editors: Paolo Biagi and Elisabetta Starnini

Received: 22 June 2022
Accepted: 13 July 2022
Published: 15 July 2022

1. Introduction

The characteristics of past human activities are closely related to the environment around them. Relationships between past human activities and environmental variations are important issues and have been studied worldwide over the past three decades [1–10]. Abrupt climatic change events and associated dramatic environmental changes have been suggested as important factors behind the rise and fall of prehistoric and historic cultures [11–17]. The Holocene has witnessed several major abrupt climatic change events. The change that occurred at approximately 4000 cal. y BP (within a broad range from ~4200 to ~3800 cal. y BP) has been identified as a dramatic worldwide cooling and drying event (i.e., the 4.2 or 4.0 ka event) in a variety of natural archives [18–22]. The collapse of several agriculture-based ancient civilizations across the globe, such as ancient

Egypt [23,24], ancient India [25,26], and Mesopotamia [27,28], has been attributed to severe droughts induced by this event. However, human–environment interactions are much more complex [5,9,29,30]. Subsistence strategy and its variability have likely also affected the evolution of ancient cultures [14,31–33].

The archaeological culture of China also experienced remarkable changes at ~4000 cal. y BP; the contemporaneous abrupt climatic event was proposed to have played an important role in the demise of Neolithic cultures in China [34,35]. Specifically, the drying and cooling induced by the event occurring at ~4000 cal. y BP was widely accepted as the trigger of cultural collapses on the monsoon fringe of northern China [36–38], while this drying and cooling change in climate might be insufficient to collapse the cultures in the presently humid and warm parts of China [34,39]. The dramatic environmental variations (i.e., abnormal or extreme floods) associated with this event have been widely found in the middle and lower reaches of the Yangtze River and Yellow River, and their relations with local cultural transformation have been intensively discussed [40–49]. It is noteworthy that when other contemporaneous Neolithic cultures declined across China at ~4000 cal. y BP, only the archaeological culture in the Central Plains witnessed the most marked sociopolitical transformation and successfully evolved into the more advanced state-level culture, the Erlitou culture [50,51]. Consequently, possible impacts of the abrupt climatic event occurring at ~4000 cal. y BP, especially associated environmental changes (i.e., extreme floods) on the crucial cultural evolution in the Central Plains, have attracted wide academic attention [40,45–49,52–54].

The Qin River Basin is located in the north part of the Central Plains (Figure 1a), and local archaeological cultures during the Longshan (from ~4400 to ~4000 cal. y BP) and Erlitou (from ~3900 to ~3500 cal. y BP) periods had been obviously influenced by those in the southern Shanxi and northern Henan regions [55–57]. In comparison with the previous Longshan period, the number of local human settlements had clearly decreased during the Erlitou period [58–60]. Moreover, extreme floods associated with the abrupt climatic change event occurring at ~4000 cal. y BP were also widely found within and around the Qin River Basin (Figure 1a). However, the spatiotemporal pattern of the cultural evolution before and after ~4000 cal. y BP and its relationship to extreme flood and subsistence strategy variety has been rarely studied in the Qin River Basin.

In this study, we first selected the upper and middle Qin River reaches to analyze the changes in human settlement distribution patterns during the Longshan and Erlitou periods. Then, we reviewed the geological evidence of extreme floods occurring at ~4000 cal. y BP within and around the Qin River Basin, and collected archaeobotanical data with floatation results in the surrounding areas. Finally, the spatiotemporal variation in human settlements between the Longshan and Erlitou periods and its relationship to extreme flood and variety of subsistence strategies was examined.

2. Study Area

The Qin River Basin, situated in the eastern part of the Loess Plateau (Figure 1a), is a major tributary of the Yellow River, with a drainage area of ~1.35×10^4 km^2 and length of ~485 km [61]. Topographically, the Qin River Basin inclines from north to south, with elevation dropping from ~2500 m above sea level (asl) to ~100 m asl (Figure 1c). Climatologically, the Qin River Basin is strongly affected by the East Asian Monsoon system, with more than 70% of the total precipitation occurring during summer. The mean annual precipitation ranges from 550 mm to 750 mm and presents a decreasing trend from south to north; the mean annual temperature ranges from 9 °C to 14 °C [61]. The river is divided into upper, middle, and lower sections at Zhangfeng and Wulongkou (Figure 1c). Moreover, there are four landscape types in the Qin River Basin; from north to south, they are as follows: stony mountain region, earth–rock hilly region, valley region, and alluvial plain region, with stony mountain region and earth–rock region mainly distributing in the upper reaches, valley region in the middle reaches, and alluvial plain region in the lower reaches (Figure 1c).

Table 1. Records of extreme floods occurring at ~4000 cal. y BP within and around the Qin River Basin (see Figure 1 for their locations).

Region	No.	Site	Proxies [1]	Dating Method	Sample No.	Dating Materials	Dating Data (y BP)	Dating Data (cal. y BP)	Time (cal. y BP)	References
Qin River Basin	1	Q02010-1	FS	14C	Q02010-1	Bulk	3846 ± 120	4253 ± 162	4250	[62]
	2	Q02017-1	FS	14C	Q02017-1	Bulk	3910 ± 150	4335 ± 195	4340	[62]
	3	Q02020-1	FS	14C	Q02020-1	Bulk	3587 ± 210	3886 ± 268	3890	[62]
	4	Q02026	FS	14C	Q02026	Bulk	3686 ± 130	4000 ± 160	4000	[62]
Adjacent area of the Qin River Basin	5	PJCK	SWD	OSL	PJCK-1 PJCK-2	- -	- -	4370 ± 530 4300 ± 660	4400–4300	[63]
	6	FHXC	SWD	OSL	OSL-3 OSL-2 OSL-1	- - -	- - -	3910 ± 580 4020 ± 450 4190 ± 580	4200–3900	[64]
	7	CHZ	SWD	OSL	CHZ-2 CHZ-3	- -	- -	4290 ± 175 4170 ± 130	4200–4000	[65]
	8	YGZ	SWD	OSL	YGZ-3 YGZ-4 YGZ-5	- - -	- - -	4010 ± 240 4030 ± 260 4190 ± 100	4200–4000	[66]
	9	Zhoujiazhuang	FS	AMS ^{14}C	H78 H93 H79 H87	Charcoal Charcoal Charcoal Charcoal	3570 ± 35 3615 ± 35 3630 ± 35 3960 ± 80	3949 ± 46 3930 ± 43 4395 ± 117 4409 ± 116	4400–4000	[45]
	10	Xijincheng	FS	Archaeological culture	-	-	-	late Longshan period	4200–4000	[45]
	11	Mengzhuang	FS	Archaeological culture	-	-	-	late Longshan period	4200–4000	[67]
	12	Erlitou	FS	OSL	L2 L3	- -	- -	3805 ± 248 4044 ± 338	4000–3800	[45]
	13	TXC	SWD	OSL	TXC-2 TXC-3	- -	- -	4030 ± 400 4080 ± 450	4000–3800	[49]

[1] FS—flood sediments; SWD—slackwater deposits.

Table 2. The counted results of plant remains from selected archaeological sites around the study area (see Figure 1 for their locations).

No.	Name	Period	Foxtail Millet	Broomcorn Millet	Rice	Wheat	Soybean	References
1	Xijing	Longshan	100	18	0	0	0	[68]
2	Zhoujiazhuang1	Longshan	61	9	0	0	0	[68]
	Zhoujiazhuang2	Longshan	9135	772	142	0	0	[69]
3	Jiajiabao	Longshan	66	11	0	0	0	[68]
4	Shangyukou	Longshan	44	5	2	0	0	[68]
5	Hucun	Longshan	166	20	2	1	0	[68]
6	Zhangjiazhuang	Longshan	337	13	0	0	0	[68]
7	Chengjiazhuang	Longshan	99	22	1	0	0	[68]
8	Nanbaishi	Longshan	105	10	0	0	0	[68]
9	Shuinan	Longshan	131	50	0	4	0	[68]
10	Taosi	Longshan	9160	606	30	13	0	[70]
11	Xijincheng	Longshan	740	5	82	1	8	[71]
12	Shangcun	Longshan	243	83	0	0	0	[72]
13	Dalaidian	Longshan	3341	216	1	2	44	[73]
14	Gouxi I	Erlitou	148	3	0	0	0	[68]
15	Beiyang	Erlitou	3408	178	0	0	0	[68]
16	Jiajiabao	Erlitou	522	32	7	0	3	[68]
17	Xinzhuang	Erlitou	783	47	0	0	0	[68]
18	Daze II	Erlitou	517	21	0	0	0	[68]
19	Guojiazhuang	Erlitou	639	42	0	0	0	[68]
20	Yueyabao I	Erlitou	26	2	0	0	0	[68]
21	Zhangdeng	Erlitou	2342	154	0	10	1	[74]

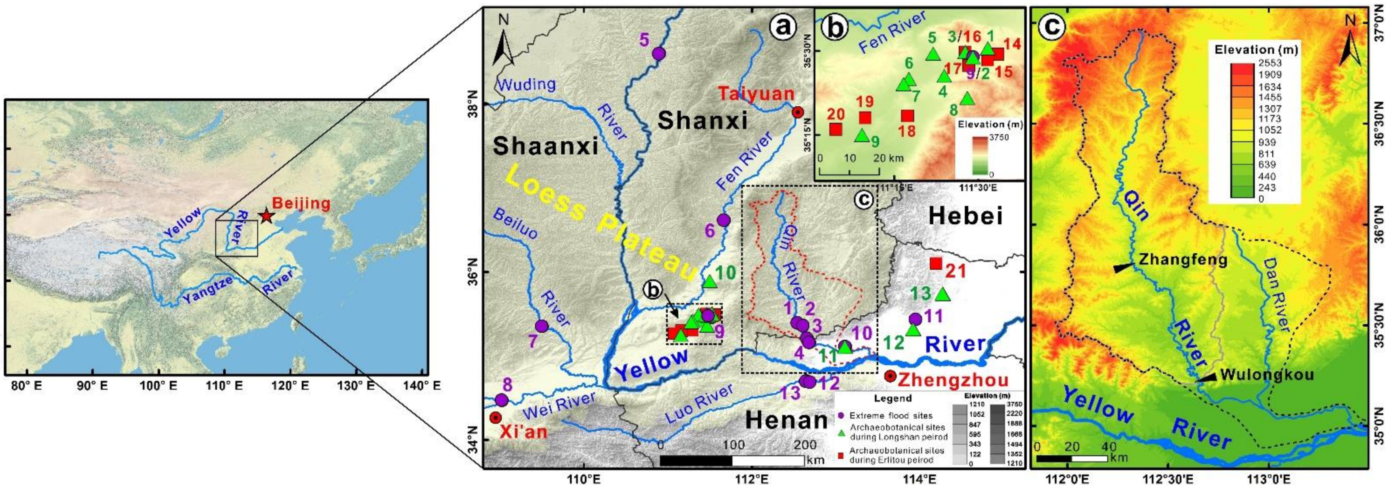

Figure 1. Study area. The labeled sites are extreme flood records that occurred at ~4000 cal. y BP within and around the Qin River Basin (purple circles, no. 1–13), and selected archaeobotanical records during Longshan (green triangles, no. 1–13) and Erlitou (red boxes, no. 14–21) periods around the Qin River Basin. Detailed information on the records of the extreme floods and archaeobotanical results are given in Tables 1 and 2, respectively. (**a**) A large-scale geographic context of the Qin River Basin. (**b**) Map showing the locations of serval selected archaeobotanical records. (**c**) Topographical background of the Qin River Basin, and the locations of Zhangfeng and Wulongkou, which divide the Qin River into upper, middle, and lower sections.

Due to its proximity to the core area of the Central Plains, archaeological discoveries in the Qin River Basin have suggested that local archaeological cultures had been dramatically affected by the archaeological cultures from the southern Shanxi and northern Henan regions during the Longshan and Erlitou periods [55–57]. Although no record of subsistence strategy was collected from the Qin River Basin (Table 2), the close similarities of ceramic assemblages clearly indicate that much communication has existed among these archaeological cultural regions [55–58]. It thus can be inferred that the subsistence strategies in the Qin River Basin would have been very similar to the southern Shanxi and northern Henan regions.

Owing to easy channel migration in low reaches of the river [61], the lower reaches of the Qin River are not included in this study in order to eliminate uncertainty on the impact analysis of extreme floods occurring at ~4000 cal. y BP. In addition, it should be mentioned that although the Dan River is the biggest tributary of the Qin River, due to its location joining the Qin River at the lower floodplain (Figure 1c), this tributary is also not included in this study. Finally, only the upper and middle reaches of the Qin River are included in the present study (Figure 1c).

3. Materials and Methods

The primary archaeological data in this paper are from the fascicle of the Chinese Cultural Relics Atlas in Shanxi Province [58]. Moreover, some data are also taken from relevant archaeological survey or excavation reports [55,75]. The data from the Chinese Cultural Relics Atlas in Shanxi Province were compiled based on the administrative unit of county in a unified format and map projection, and we digitized the data using ArcGIS software and positioned the locations (i.e., longitudes and latitudes) of the digitized sites. For the archaeological data from relevant archaeological survey or excavation reports, the locations were determined on Google Earth based on their textual description (including location and attributes). Then, all human settlements were plotted on the relief map obtained from the Shuttle Radar Topography Mission (SRTM4.1) digital elevation model (DEM) (http://www.gscloud.cn/, accessed on 20 May 2022) with a spatial resolution of 30 × 30 m. First, the spatial analysis tools of ArcGIS were used to map the temporal and spatial distribution between the Longshan and Erlitou periods, and calculate the statistical results of human settlements at different elevations and slopes. Furthermore, buffer analysis was also used to discuss the distance between human settlements and the rivers.

Second, to explore the relationship of human settlement distribution pattern changes between the Longshan and Erlitou periods to extreme floods and the variety of subsistence strategies, the records of extreme flood occurring at ~4000 cal. y BP (Figure 1a; Table 1) and archaeobotanical data (Figure 1a,b; Table 2) during the Longshan and Erlitou periods within and around the Qin River Basin were collected. Here, it should be mentioned that our selections of the extreme floods were based on the following criteria: the strata unit representing the extreme floods must be well-dated by absolute dating methods or well-constrained by archaeological cultures (Table 1). Finally, human settlement distribution pattern changes and their relation to extreme floods and subsistence strategy variety were examined.

4. Results

4.1. Spatial Distribution Characteristics of Human Settlement

4.1.1. Spatial Distribution Variation in Human Settlement

Figure 2 illustrates the spatial distribution of human settlements in the upper and middle Qin River reaches between the Longshan and Erlitou periods. Regarding the number of human settlements, it is clear that there were many more Longshan settlements than Erlitou settlements, exhibiting significant change in the number of human settlements before and after ~4000 cal. y BP. During the Longshan period, human settlements were relatively ubiquitously spread across the study area, but the number of human settlements was smaller in the middle reaches than in the upper reaches of the Qin River (Figure 2a), while during the Erlitou period, although the total number of human settlements was relatively small, the number was seemingly larger in the middle reaches than in the upper reaches (Figure 2b).

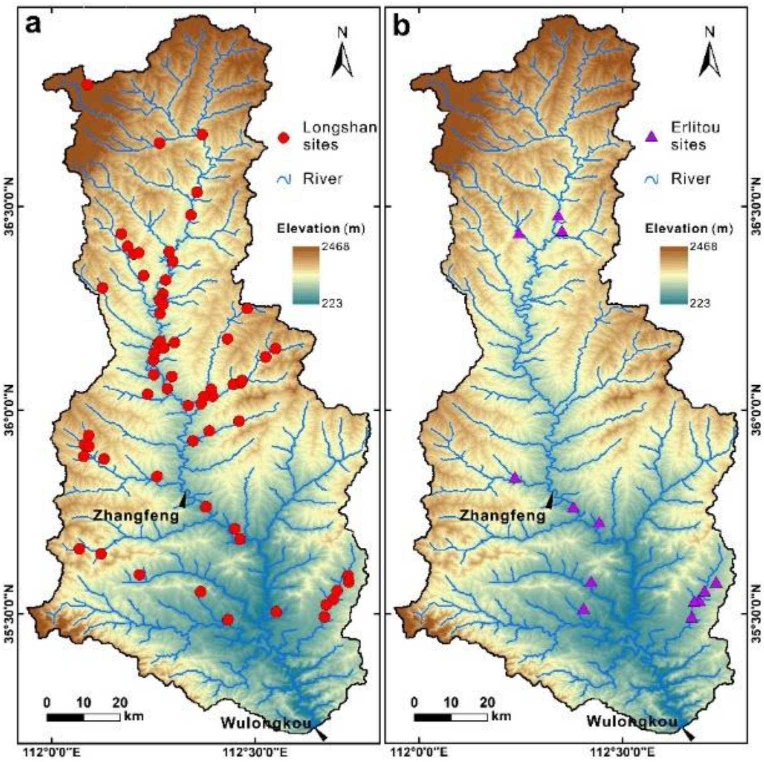

Figure 2. Human settlement distributions of the Longshan period (**a**) and the Erlitou period (**b**) in the upper and middle Qin River reaches.

4.1.2. Elevation, Slope, and the Distance from the Closest Rivers of Human Settlement

To further explore the spatial distribution characteristics of human settlements during the Longshan and Erlitou periods, the associated factors of elevation, slope, and the distance from the closest river of these settlements were analyzed. Figure 2 and Table 3 show that most human settlements (77.78%) were distributed at elevations between 800–1200 m asl during the Longshan period, with relatively smaller proportion distributing at elevations lower than 800 m asl and higher than 1200 m asl. During the Erlitou period, there was a higher proportion (84.62%) of human settlements distributing at elevations between 600–1000 m asl, especially in the elevation range of 600–800 m asl, accounting for 61.54%, likely suggesting that, in comparison with the previous Longshan period, the distribution elevation of human settlement had decreased during the Erlitou period (Figure 2).

Table 3. The elevation distribution of human settlements in the upper and middle Qin River reaches between the Longshan and Erlitou periods.

Elevation (m asl)	Longshan Period		Erlitou Period	
	Number	Proportion	Number	Proportion
<600	3	4.76%	0	0.00%
600–800	6	9.52%	8	61.54%
800–1000	25	39.68%	3	23.08%
1000–1200	24	38.10%	2	15.38%
1200–1400	4	6.35%	0	0.00%
>1400	1	1.59%	0	0.00%

Because slope gradient directly influences human choice of where to live and the suitability of the area around each human settlement for agricultural development, the slope data were extracted using ArcGIS 10.0 software from the DEM of the Qin River Basin (Figure 1c). The results of human settlement slope in this study were first classified into five levels based on slope gradient (Figure 3; Table 4), and then the slope was divided into three grades: an excellent grade (0–6°), a good grade (6–15°), and a poor grade (>15°). The results show that the Longshan and Erlitou sites were found to be concentrated within the 2–6° and 6–15° ranges, with 39 and 11 sites, respectively, accounting for 61.90% and 84.61% of the total number of human settlements (Table 4). However, compared to the Longshan period, the proportion of the human settlements on the excellent and good grades significantly increased during the Erlitou period from a previous 73.02% to 92.31% (Table 4).

Table 4. Statistical results of human settlements on different slopes in the upper and middle Qin River reaches between the Longshan and Erlitou periods.

Slope (°)	Longshan Period		Erlitou Period	
	Number	Proportion	Number	Proportion
0–2	7	11.11%	1	7.69%
2–6	14	22.22%	6	46.15%
6–15	25	39.68%	5	38.46%
15–25	13	20.63%	1	7.69%
>25	4	6.35%	0	0.00%

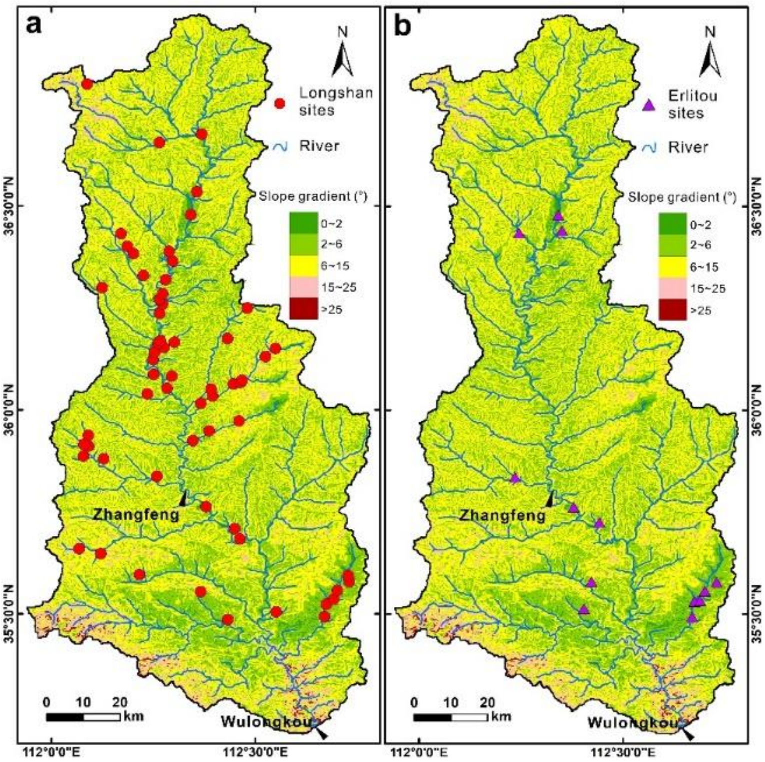

Figure 3. The slope distribution of human settlements during the Longshan period (**a**) and the Erlitou period (**b**).

Generally, people lived close to rivers for the convenience of fetching water. However, people might not choose to live in areas too close to rivers because they are prone to flooding. Because the upper and middle reaches of the Qin River are mountainous and hilly regions with large valley slope, the river courses have had few changes since the Holocene epoch [61]. Thus, the buffer zone of rivers was analyzed using ArcGIS 10.0 software within a 1.5 km range at intervals of 500 m. The results show a close relationship between the human settlement distribution and the distance to the river during the Longshan and Erlitou periods (Figure 4; Table 5). Both Longshan and Erlitou sites were mainly distributed in a range of 1000 m beyond water courses, accounting for 92.06% and 84.62%, respectively.

Table 5. Statistical results of the distance between human settlements and rivers during the Longshan and Erlitou periods.

Distance from River (m)	Longshan Period		Erlitou Period	
	Number	Proportion	Number	Proportion
0–500	41	65.08%	9	69.23%
500–1000	17	26.98%	2	15.38%
1000–1500	4	6.35%	1	7.69%
>1500	1	1.59%	1	7.69%

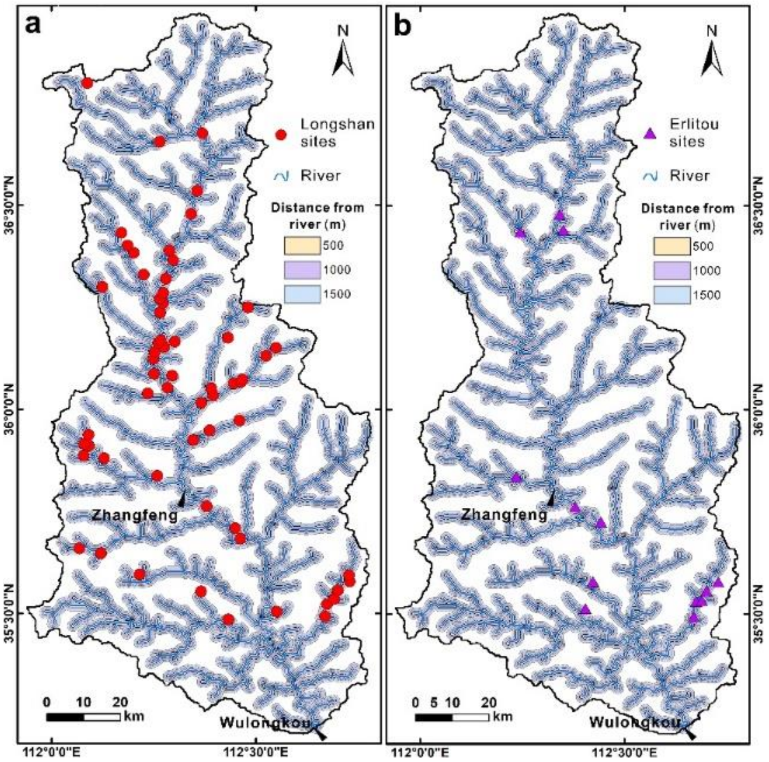

Figure 4. Distances between human settlement and river course in the upper and middle Qin River reaches during the Longshan period (**a**) and the Erlitou period (**b**).

4.2. Extreme Floods Occurring at ~4000 cal. y BP within and around the Qin River Basin

Many studies have reported extreme flood occurrences at ~4000 cal. y BP within and around the Qin River Basin [45,49,62–67]. However, several reported extreme-flood-indicating strata were not well constrained in their chronologies [76]. To explore the relationship between human settlement distribution and extreme floods, reliable chronologies of extreme flood occurring at ~4000 cal. y BP should be examined. As aforementioned, we purposely targeted the reported extreme floods that must be well dated by absolute dating methods or well constrained by archaeological cultures within and around the Qin River Basin, and thirteen records that contain evidence of extreme floods dated at ~4000 cal. y BP were selected (Table 1).

Table 1 and Figure 1a obviously show that the episode at ~4000 cal. y BP (with a relatively broad range from 4300 to 3800 cal. y BP) was an episode of frequent extreme flooding within and around the Qin River Basin. Except for five selected sites located in the low-lying floodplain area (no. 4, 8, 10, 12, and 13 in Figure 1a), the remaining eight selected sites are situated in highlands or in the transitional zone between highlands and lowlands (Figure 1a). In particular, four sites (no. 1–4 in Figure 1a) were distributed in the middle and lower Qin River reaches. Consequently, the episode at ~4000 cal. y BP was indeed an extremely flood-rich episode in the Qin River Basin.

4.3. Subsistence Strategy and Its Varieties around the Qin River Basin

To uncover the subsistence strategies in the upper and middle Qin River reaches, the archaeobotanical data from the southern Shanxi and northern Henan regions were used in this study (Figure 1a) due to these regions exhibiting much communication on archaeological cultures during the Longshan and Erlitou periods [55–58]. The selected archaeobotanical data include 13 records during the Longshan period and 8 records during the Erlitou period (Table 2), and the percentages of their counts are summarized in Figure 5. During the Longshan and Erlitou periods, although there were five main types of crops around the Qin River Basin, namely, foxtail millet (*Setaria italica*), broomcorn millet (*Panicum miliaceum*), rice

(*Oryza sativa*), wheat (*Triticum aestivum*), and soybean (*Glycine max*), foxtail and broomcorn millets were the two mainly cultivated crops (Table 2, Figure 5). Isotopic data from human bone remains in southern Shanxi and northern Henan regions also suggest that humans primarily relied on millet-based agriculture during the Longshan and Erlitou periods [77–80]. However, obvious differences in cropping structures existed between the Longshan and Erlitou periods. Specifically, during the Longshan period, the average proportions of foxtail millet and broomcorn millet were 86.52% and 11.87%, respectively. The average proportion of foxtail (broomcorn) millet had increased (decreased) to 94.52% (5.21%) during the Erlitou period, clearly suggesting the further improvement of the dominant role of foxtail millet in cropping structures of human subsistence strategy (Figure 5).

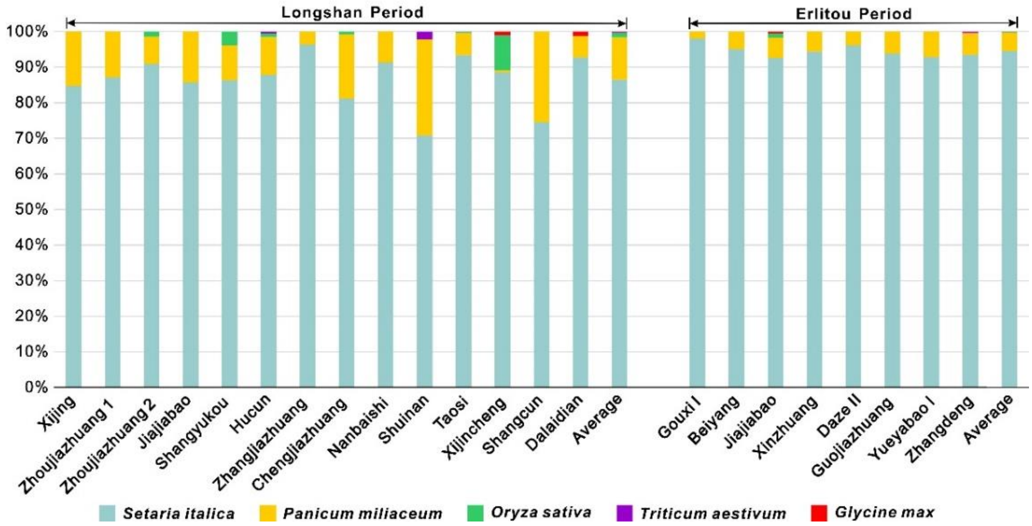

Figure 5. Abundance ratio of corps from the flotation results around the Qin River Basin during the Longshan and Erlitou periods.

5. Discussion

5.1. Relationship between Human Settlement Distribution and Subsistence Strategy

Archaeobotanical studies over the past two decades have revealed that sedentary agriculture dominated the subsistence strategy between ~6000 and ~5000 cal. y BP in the Central Plains and the surrounding areas, and agriculture occupied a more prominent position in local human subsistence strategy during the following Longshan and Erlitou periods [81,82]. This is consistent with the selected archaeobotanical results around the Qin River Basin (Figure 5). Consequently, during the Longshan and Erlitou periods, local ancient people would have preferred to reside in the areas suitable for farming. As aforementioned, the terrain in the study area inclines from north to south, with elevation dropping from ~2500 m asl to ~200 m asl (Figure 2), and only the valleys of the Qin River are relatively wide, flat, and conducive to the growth of crops [61]. As a result, most human settlements of the Longshan and Erlitou periods in the study area were located close to rivers (Figure 3), with settlement slopes concentrating within the 0–15° range (Table 4). In other words, these human settlements were concentrated in the valley plains. However, it should be noted that, in comparison with the Longshan period, the average proportion of foxtail (broomcorn) millet increased (decreased) from a previous 86.52% (11.87%) to 94.52% (5.21%) during the Erlitou period (Figure 5). Related studies found that foxtail millet requires higher soil fertility and water requirements, as well as a longer growing period than broomcorn millet [83,84]. As a result, the proportion of broomcorn millet in contemporaneous cropping structures was higher in areas north of the study area [85,86]. In the study area, mean annual precipitation presents a decreasing trend from south to north [61], and the middle Qin River reaches are mainly composed of valley plains with a lower slope gradient (Figure 3). Thus, the middle reaches of the Qin River are more suitable for foxtail millet cultivation than the upper reaches, likely causing more human settlements to be distributed in the middle reaches during the Erlitou period (Figure 2).

5.2. Relationship between Human Settlement Distribution and Extreme Floods at ~4000 cal. y BP

The collected geological evidence in this study unquestionably indicates that the episode at ~4000 cal. y BP was indeed an extreme-flood-rich episode within and around the Qin River Basin (Figure 1a; Table 1). This flood-rich episode at ~4000 cal. y BP in the study area is relatively well corroborated by the statistically summed flood occurrence frequency with a bin of 400 years in the Yellow River Basin [76]. Although the cause of frequent extreme flooding occurrence at ~4000 cal. y BP in the Yellow River Basin remains unclear, most studies thought it was associated with the abrupt climatic change event occurring at ~4000 cal. y BP [40–49,65–67]. As stated earlier, the distances of most human settlements and river courses were less than 1000 m during both the Longshan and Erlitou periods (Table 5), suggesting that human settlements in the upper and middle Qin River reaches were extremely vulnerable to floods. Thus, frequent extreme flooding occurrences at ~4000 cal. y BP would inevitably influence the people dwelling near the river. As a result, between the Longshan and Erlitou periods, both the number and spatial distribution patterns of human settlements presented significant changes (Figure 2). Obvious changes in spatial distribution patterns of human settlements between the Longshan and Erlitou periods most likely were local human responses to the extreme-flood-rich episode at ~4000 cal. y BP.

5.3. Possible Impact of Human Cultural Factors on Human Settlement Pattern Variation

Archaeological surveys and excavations of past decades have demonstrated that remarkable sociopolitical variations existed during the transitional stage (i.e., at ~4000 cal. y BP) from the Longshan period to the following Erlitou period in China [50,51,87,88]. In this context, a large population likely migrated from the area north of the study area and triggered intergroup conflict during the late Longshan period [89–93]. Through the contrast of unearthed ceramic assemblages, archaeologists in China have speculated that a large population had migrated from the northern Shanxi and Shaanxi regions to southern Shanxi and northern Henan regions and then likely caused conflict with local groups [90,91]. This speculation is supported by the evidence of violence observed at the Taosi site (no. 10 in Figure 1a, green triangle) [92] and sudden increase in the number of weapons and walled sites around the study area during the late Longshan period [51,91–94]. Consequently, extensive human immigration and subsequent intergroup conflict could possibly also cause settlement number decreases and the obvious spatial pattern variation in human settlements between the Longshan and Erlitou periods in the upper and middle Qin reaches.

6. Conclusions

By comparing the spatiotemporal changes in human settlement, a variety of subsistence strategies during the Longshan and Erlitou periods, and extreme floods at ~4000 cal. y BP in the upper and middle Qin River reaches, the following conclusions can be drawn.

(1) Human settlement distribution patterns between the Longshan (from ~4400 to ~4000 cal. y BP) and Erlitou (from ~3800 to ~3500 cal. y BP) periods were significantly different. The Longshan settlements were ubiquitously spread across the study area, while the Erlitou settlements were concentrated in the valley plains of the middle Qin River reaches, and the number of human settlements decreased significantly during the Erlitou period.

(2) The collected geological evidence containing well-age-constrained extreme flooding unquestionably indicates that the episode at ~4000 cal. y BP was an extreme-flood-rich episode within and around the Qin River Basin.

(3) Foxtail and broomcorn millets were the two mainly cultivated crops during the Longshan and Erlitou periods in the study area. However, there were distinct differences in the cropping structures of human subsistence strategy, presenting a higher (lower)

proportion of foxtail (broomcorn) millet during the Erlitou period than during the Longshan period.

(4) Both extreme floods at ~4000 cal. y BP and the variety of subsistence strategies influenced human settlement distribution patterns in the upper and middle Qin River reaches. Millet-based agriculture dominated local subsistence strategy during the Longshan and Erlitou periods; thus, the valley plains suitable for agricultural cultivation hosted most Longshan and Erlitou settlements. However, frequent extreme floods and intergroup conflicts due to a large amount of human immigration at ~4000 cal. y BP that occurred within and around the Qin River Basin are likely to have jointly caused significant settlement number reduction and spatial range shrinking of settlement distribution. After ~4000 cal. y BP, owing to increasing proportion of higher-water-requirement foxtail millet in cropping structures of human subsistence strategy, more Erlitou settlements were distributed in the wetter middle Qin River reaches.

Author Contributions: Conceptualization, W.G., K.L. and P.Z.; methodology, K.L., W.G. and W.H.; software, H.H., P.G., W.J. and X.L.; writing—original draft preparation, W.G. and K.L.; writing—review and editing, W.G., K.L., P.Z. and W.H.; funding acquisition, K.L. and W.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research was jointly supported by the grants from the National Key Research and Development Program of China (No. 2020YFC1521605), the MOE Youth Foundation of Humanities and Social Sciences, China (No. 17YJCZH046), the Natural Science Foundation of Henan Province, China (No. 222300420420), the Foundation of Humanities and Social Sciences of the Department of Education, Henan Province, China (No. 2018-ZZJH-086), and the Yellow River Laboratory of Henan Province (for Henan University).

Data Availability Statement: All data used during the study appear in the article.

Acknowledgments: We are grateful to academic editors and two anonymous reviewers for their constructive comments and suggestions, and are thankful for data support from "National Earth System Science Data Center, National Science & Technology Infrastructure of China (http://www.geodata.cn, accessed on 20 May 2022)".

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Ortloff, C.R.; Kolata, A.L. Climate and collapse: Agro-ecological perspectives on the decline of the Tiwanaku State. *J. Archaeol. Sci.* **1993**, *20*, 195–221. [CrossRef]
2. Binford, M.W.; Kolata, A.L.; Brenner, M.; Janusek, J.W.; Abbott, M.; Curtis, J.H. Climate variation and the rise and fall of an Andean civilization. *Quat. Res.* **1997**, *47*, 235–248. [CrossRef]
3. DeMenocal, P.B. Cultural responses to climate change during the late Holocene. *Science* **2001**, *292*, 667–673. [CrossRef] [PubMed]
4. Li, K.F.; Gao, W.H.; Wu, L.; Hu, H.N.; Gong, P.P.; Li, S.Y.; Jin, R.; Si, Y. Spatial expansion of Human settlement during the Longshan period (~4.5–~3.9 ka BP) and its hydroclimatic contexts in the lower Yellow River floodplain, Eastern China. *Land* **2021**, *10*, 712. [CrossRef]
5. Butzer, K.W. Collapse, environment, and society. *Proc. Natl. Acad. Sci. USA* **2012**, *109*, 3632–3639. [CrossRef]
6. Wu, L.; Lu, S.G.; Zhu, C.; Ma, C.M.; Sun, X.L.; Li, X.X.; Li, C.C.; Guo, Q.C. Holocene environmental archaeology of the Yangtze River Valley in China: A review. *Land* **2021**, *10*, 302. [CrossRef]
7. Büntgen, U.; Myglan, V.S.; Ljungqvist, F.C.; McCormick, M.; Cosmo, N.D.; Sigl, M.; Jungclaus, J.; Wagner, S.; Krusic, P.J.; Esper, J.; et al. Cooling and societal change during the Late Antique Little Ice Age from 536 to around 660 AD. *Nat. Geosci.* **2016**, *9*, 231–236. [CrossRef]
8. Li, K.F.; Zhu, C.; Jiang, F.Q.; Li, B.; Wang, X.H.; Cao, B.; Zhao, X.F. Archaeological sites distribution and its physical environmental settings between ca 260–2.2 ka BP in Guizhou Province, Southwest China. *J. Geogr. Sci.* **2014**, *24*, 526–538. [CrossRef]
9. Dong, G.H.; Li, R.; Lu, M.X.; Zhang, D.J.; James, N. Evolution of human-environmental interactions in China from the Late Paleolithic to the Bronze Age. *Prog. Phys. Geogr.* **2020**, *44*, 233–250. [CrossRef]
10. Li, K.F.; Gao, W.H. Holocene climate change in Henan area: A synthesis of proxy records. *Quat. Int.* **2019**, *521*, 185–193. [CrossRef]
11. Weninger, B.; Alram-Stern, E.; Bauer, E.; Clare, L.; Danzeglocker, U.; Joris, O.; Claudia, K.E.; Gary, R.F.; Todorova, H.; Andel, T. Climate forcing due to the 8200 cal yr BP event observed at Early Neolithic sites in the eastern Mediterranean. *Quat. Int.* **2006**, *66*, 401–430. [CrossRef]
12. Anderson, D.G.; Maasch, K.A.; Sandweiss, D.H. *Climate Change and Cultural Dynamics: A Global Perspective on Mid-Holocene Transitions*; Academic Press: London, UK, 2007.

13. Boyd, W.E. Social change in late Holocene mainland SE Asia: A response to gradual climate change or a critical climatic event? *Quat. Int.* **2008**, *184*, 11–23. [CrossRef]
14. Dong, G.H.; Wang, L.; Cui, Y.F.; Elston, R.; Chen, F.H. The spatiotemporal pattern of the Majiayao cultural evolution and its relation to climate change and variety of subsistence strategy during late Neolithic period in Gansu and Qinghai Provinces, northwest China. *Quat. Int.* **2013**, *316*, 155–161. [CrossRef]
15. Lespez, L.; Glais, A.; Lopez-Saez, J.; Drezen, Y.L.; Tsirtsoni, Z.; Davidson, R.; Biree, L.; Malamidou, D. Middle Holocene rapid environmental changes and human adaptation in Greece. *Quat. Res.* **2016**, *85*, 227–244. [CrossRef]
16. Liu, L.; Chen, X.C.; Wright, H.; Xu, H.; Li, Y.; Chen, G.; Zhao, H.; Kim, H.; Lee, G. Rise and fall of complex societies in the Yiluo region, North China: The spatial and temporal changes. *Quat. Int.* **2019**, *521*, 4–15. [CrossRef]
17. Park, J.; Park, J.; Yi, S.; Kim, J.C.; Lee, E.; Choi, J. Abrupt Holocene climate shifts in coastal East Asia, including the 8.2 ka, 4.2 ka, and 2.8 ka BP events, and societal responses on the Korean peninsula. *Sci. Rep.* **2019**, *9*, 10806. [CrossRef] [PubMed]
18. Mayewski, P.A.; Rohling, E.E.; Stager, J.C.; Karlén, W.; Maasch, K.A.; Meeker, L.D.; Meyerson, E.A.; Gasse, F.; van Kreveld, S.; Holmgren, K.; et al. Holocene climate variability. *Quat. Res.* **2004**, *62*, 243–255. [CrossRef]
19. Railsback, L.B.; Liang, F.Y.; Brook, G.A.; Voarintsoa, N.R.G.; Sletten, H.R.; Marais, E.; Hardt, B.; Cheng, H.; Edwards, R.L. The timing, two-pulsed nature, and variable climatic expression of the 4.2 ka event: A review and new high-resolution stalagmite data from Namibia. *Quat. Sci. Rev.* **2018**, *186*, 78–90. [CrossRef]
20. Zhang, H.W.; Cheng, H.; Cai, Y.J.; Spötl, C.; Kathayat, G.; Sinha, A.; Edwards, R.L.; Tan, L.C. Hydroclimatic variations in southeastern China during the 4.2 ka event reflected by stalagmite records. *Clim. Past* **2018**, *14*, 1805–1817. [CrossRef]
21. Wiener, M.H. The interaction of climate change and agency in the collapse of civilizations ca. 2300–2000 BC. *Radiocarbon* **2014**, *56*, 1–16. [CrossRef]
22. Ran, M.; Chen, L. The 4.2 ka BP climatic event and its cultural responses. *Quat. Int.* **2019**, *521*, 158–167. [CrossRef]
23. Stanley, J.D.; Krom, M.D.; Cliff, R.A.; Woodward, J.C. Nile flow failure at the end of the Old Kingdom, Egypt: Strontium isotopic and petrologic evidence. *Geoarchaeology* **2003**, *18*, 395–402. [CrossRef]
24. Marshall, M.H.; Lamb, H.F.; Huws, D.; Davies, S.J.; Bates, R.; Bloemendal, J.; Boyle, J.; Leng, M.J.; Umer, M.; Bryant, C. Late Pleistocene and Holocene drought events at Lake Tana, the source of the Blue Nile. *Glob. Planet. Chang.* **2011**, *78*, 147–161. [CrossRef]
25. Staubwasser, M.; Sirocko, F.; Grootes, P.M.; Segl, M. Climate change at the 4.2 ka BP termination of the Indus valley civilization and Holocene south Asian monsoon variability. *Geophys. Res. Lett.* **2003**, *30*, 1425. [CrossRef]
26. Dixit, Y.; Hodell, D.A.; Petrie, C.A. Abrupt weakening of the summer monsoon in northwest India ~4100 yr ago. *Geology* **2014**, *42*, 339–342. [CrossRef]
27. Weiss, H.; Courty, M.A.; Wetterstrom, W.; Guichard, F.; Senior, L.; Meadow, R.; Crunow, A. The genesis and collapse of third millennium north Mesopotamian civilization. *Science* **1993**, *261*, 995–1004. [CrossRef]
28. Carolin, S.A.; Walker, R.T.; Day, C.C.; Ersek, V.; Sloan, R.A.; Dee, M.W.; Talebian, M.; Henderson, G.M. Precise timing of abrupt increase in dust activity in the Middle East coincident with 4.2 ka social change. *Proc. Natl. Acad. Sci. USA* **2019**, *116*, 67–72. [CrossRef]
29. Nicoll, K.; Zerboni, A. Is the past key to the present? Observations of cultural continuity and resilience reconstructed from geoarchaeological records. *Quat. Int.* **2020**, *545*, 119–127. [CrossRef]
30. Degroot, D.; Anchukaitis, K.; Bauch, M.; Burnham, J.; Carnegy, F.; Cui, J.; Luna, K.; Guzowski, P.; Hambrecht, G.; Huhtamaa, H.; et al. Towards a rigorous understanding of societal response to climate change. *Nature* **2021**, *591*, 539–550. [CrossRef]
31. Jia, X.; Dong, G.H.; Li, H.; Brunson, K.; Chen, F.H.; Ma, M.M.; Wang, H.; An, C.B.; Zhang, K.R. The development of agriculture and its impact on cultural expansion during the late Neolithic in the Western Loess Plateau, China. *Holocene* **2013**, *23*, 85–92. [CrossRef]
32. Pokharia, A.K.; Agnihotri, R.; Sharma, S.; Bajpai, S.; Nath, J.; Kumaran, R.N.; Negi, B.C. Altered cropping pattern and cultural continuation with declined prosperity following abrupt and extreme arid event at similar to 4200 yrs BP: Evidence from an Indus archaeological site Khirsara, Gujarat, western India. *PLoS ONE* **2017**, *12*, e0185684. [CrossRef]
33. Li, K.F.; Gong, P.P.; Hu, H.N.; Jia, W.Y.; Liu, X.L.; Gao, W.H. Spatial variability of human subsistence strategies during the Longshan period (~4.6–~3.9 ka BP) and its possible physical environmental contexts in the Yellow-Huai River area, East China. *Sci. Cult.* **2021**, *7*, 105–116.
34. Liu, F.G.; Feng, Z.D. A dramatic climatic transition at ~4000 cal. yr BP and its cultural responses in Chinese cultural domains. *Holocene* **2012**, *22*, 1181–1197. [CrossRef]
35. Sun, Q.L.; Liu, Y.; Wünnemann, B.; Peng, Y.J.; Jiang, X.Z.; Deng, L.J.; Chen, J.; Li, M.T.; Chen, Z.Y. Climate as a factor for Neolithic cultural collapses approximately 4000 years BP in China. *Earth-Sci. Rev.* **2019**, *197*, 102915. [CrossRef]
36. An, C.B.; Tang, L.Y.; Barton, L.; Chen, F.H. Climate change and cultural response around 4000 cal yr B.P. in the western part of Chinese Loess Plateau. *Quat. Res.* **2005**, *63*, 347–352. [CrossRef]
37. Cui, J.X.; Sun, Z.Y.; Burr, G.S.; Shao, J.; Chang, H. The great cultural divergence and environmental background of Northern Shaanxi and its adjacent regions during the late Neolithic. *Archaeol. Res. Asia* **2019**, *20*, 100164. [CrossRef]
38. Xiao, J.L.; Zhang, S.R.; Fan, J.W.; Wen, R.L.; Xu, Q.H.; Yoshio, I.; Toshio, N. The 4.2 ka event and its resulting cultural interruption in the Daihai Lake basin at the East Asian summer monsoon margin. *Quat. Int.* **2019**, *527*, 87–93. [CrossRef]

39. Wu, W.X.; Liu, T.S. Possible role of the "Holocene event 3" on the collapse of Neolithic cultures around the central plain of China. *Quat. Int.* **2004**, *117*, 153–166.
40. Wang, W. Discussion on the large-scale cultural changes at ~2000 BC in China. *Archaeology* **2004**, *1*, 67–77. (In Chinese)
41. Yu, S.Y.; Hou, Z.F.; Chen, X.X.; Wang, Y.X.; Song, Y.G.; Gao, M.K.; Pan, J.R.; Sun, M.; Fang, H.; Han, J.Y.; et al. Extreme flooding of the lower Yellow River near the Northgrippian-Meghalayan boundary: Evidence from the Shilipu archaeological site in southwestern Shandong Province, China. *Geomorphology* **2020**, *350*, 106878. [CrossRef]
42. Zhang, H.W.; Cheng, H.; Sinha, A.; Spötl, C.; Cai, Y.J.; Liu, B.; Kathayat, G.; Li, H.Y.; Tian, Y.; Li, Y.W.; et al. Collapse of the Liangzhu and other Neolithic cultures in the lower Yangtze region in response to climate change. *Sci. Adv.* **2021**, *7*, eabi9275. [CrossRef]
43. Wu, Q.L.; Zhao, Z.J.; Liu, L.; Granger, D.E.; Wang, H.; Cohen, D.J.; Wu, X.H.; Ye, M.L.; Bar-Yosef, O.; Lu, B.; et al. Outburst flood at 1920 BCE supports historicity of China's Great Flood and the Xia dynasty. *Science* **2016**, *353*, 579–582. [CrossRef]
44. Wu, L.; Zhu, C.; Ma, C.M.; Li, F.; Meng, H.P.; Liu, H.; Li, L.Y.; Wang, X.C.; Sun, W.; Song, Y.G. Mid-Holocene palaeoflood events recorded at the Zhongqiao Neolithic cultural site in the Jianghan Plain, middle Yangtze River Valley, China. *Quat. Sci. Rev.* **2017**, *173*, 145–160. [CrossRef]
45. Zhang, J.N.; Xia, Z.K. Deposition evidences of the 4 ka BP flood events in central China plains. *Acta Geogr. Sin.* **2011**, *66*, 685–697, (In Chinese with English Abstract).
46. Tan, L.C.; Shen, C.C.; Cai, Y.J.; Cheng, H.; Edwards, R.L. Great flood in the middle-lower Yellow River reaches at 4000 a BP inferred from accurately-dated stalagmite records. *Sci. Bull.* **2018**, *63*, 206–208. [CrossRef]
47. Huang, C.C.; Pang, J.L.; Zha, X.C.; Su, H.X.; Jia, Y.F. Extraordinary floods related to the climatic event at 4200 a BP on the Qishuihe River, middle reaches of the Yellow River, China. *Quat. Sci. Rev.* **2011**, *30*, 460–468. [CrossRef]
48. Huang, C.C.; Pang, J.L.; Zha, X.C.; Zhou, Y.L.; Su, H.X.; Li, Y.Q. Extraordinary floods of 4100–4000 a BP recorded at the late Neolithic ruins in the Jinghe River Gorges, middle reach of the Yellow River, China. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **2010**, *289*, 1–9. [CrossRef]
49. Zhang, Y.Z.; Huang, C.C.; Tan, Z.H.; Chen, Y.L.; Qin, H.J.; Huang, C.; Li, Y.Q.; Zhang, Y.X.; Li, X.G.; Shulmeister, J.; et al. Prehistoric and historic overbank floods in the Luoyang Basin along the Luohe River, middle Yellow River basin, China. *Quat. Int.* **2019**, *521*, 118–128. [CrossRef]
50. Liu, L.; Chen, X.C. *The archaeology of China: From the Late Paleolithic to the Early Bronze Age*; Cambridge University Press: Cambridge, UK, 2012.
51. Liu, L. *The Chinese Neolithic: Trajectories to Early States*; Cambridge University Press: Cambridge, UK, 2004.
52. Rosen, A.M. The impact of environmental change and human land use on alluvial valleys in the Loess Plateau of China during the Middle Holocene. *Geomorphology* **2008**, *101*, 298–307. [CrossRef]
53. Lu, P.; Lü, J.Q.; Zhuang, Y.J.; Chen, P.P.; Wang, H.; Tian, Y.; Mo, D.W.; Xu, J.J.; Gu, W.F.; Hu, Y.Y.; et al. Evolution of Holocene alluvial landscapes in the northeastern Songshan region, Central China: Chronology, models and socio-economic impact. *Catena* **2021**, *197*, 104956. [CrossRef]
54. Li, K.F.; Gao, W.H. Human settlement distribution patterns during the Longshan and Xinzhai-Erlitou periods and their hydrogeomorphic contexts in the Central Plains, China. *Catena* **2021**, *204*, 105433. [CrossRef]
55. Liu, Y.; Zhang, G.H.; Cheng, Y.; An, J.F. Excavation report of Hecun Site in Zezhou County, Shanxi Province. *J. Natl. Mus. China* **2014**, *4*, 44–58. (In Chinese)
56. National Museum of China; Shanxi Provincial Institute of Archaeology; Changzhi Municipal Bureau of Cultural Relics and Tourism. *Survey Report of Early Archaeological Cultures in the Upper Reaches of the Zhuozhang River*; Science Press: Beijing, China, 2015. (In Chinese)
57. Shanxi Provincial Institute of Archaeology. Investigation report of Xilimen Site in Gaoping County, Shanxi Province. *Huaxia Archaeol.* **2021**, *5*, 3–9. (In Chinese)
58. Bureau of National Cultural Relics. *Atlas of Chinese Cultural Relics—Shanxi Volume*; SinoMaps Press: Beijing, China, 2006. (In Chinese)
59. Hosner, D.; Wagner, M.; Tarasov, P.E.; Chen, X.; Leipe, C. Spatiotemporal distribution patterns of archaeological sites in China during the Neolithic and Bronze Age: An overview. *Holocene* **2016**, *26*, 1576–1593. [CrossRef]
60. Li, J.C.; Han, L.Y.; Zhang, G.M.; Su, Z.Z.; Zhao, Y.F. Temporal-spatial variations of human settlements in relation to environment change during the Longshan culture and Xia-Shang periods in Shanxi Province, China. *Quat. Int.* **2017**, *436*, 129–137. [CrossRef]
61. Yellow River Jiaozuo Bureau. *Annals of Qin River*; The Yellow River Water Conservancy Press: Zhengzhou, China, 2009. (In Chinese)
62. Fu, P. Design Flood Calculation of the Qin River Based on Paleoflood Method. Master's Thesis, Hohai University, Nanjing, China, 2005. (In Chinese with English Abstract).
63. Guo, Y.Q. Study on the Rare Paleofloods Discharge Restoration at Ten-Millennium Scale from Several Rivers in Monsoonal Areas of China. Doctor's Thesis, Shaanxi Normal University, Xi'an, China, 2017. (In Chinese with English Abstract).
64. Li, Y.Q.; Huang, C.C.; Ngo, H.H.; Yin, S.Y.; Dong, Z.B.; Zhang, Y.Z.; Chen, Y.L.; Lu, Y.J.; Guo, W.S. Analysis of event stratigraphy and hydrological reconstruction of low-frequency flooding: A case study on the Fenhe River, China. *J. Hydrol.* **2021**, *603*, 127083. [CrossRef]

65. Zhang, Y.Z.; Huang, C.C.; Pang, J.L.; Zha, X.C.; Zhou, Y.L.; Wang, X.Q. Holocene palaeoflood events recorded by slackwater deposits along the middle Beiluohe River valley, middle Yellow River basin, China. *Boreas* **2015**, *44*, 127–138. [CrossRef]
66. Huang, C.C.; Pang, J.L.; Zha, X.C.; Zhou, Y.L.; Su, H.X.; Zhang, Y.Z.; Wang, H.S.; Gu, H.L. Holocene palaeoflood events recorded by slackwater deposits along the lower Jinghe River valley, middle Yellow River basin, China. *J. Quat. Sci.* **2012**, *27*, 485–493. [CrossRef]
67. Yuan, G.K. The reason for the ruin of the Longshan city-site at Mengzhuang. *Archaeology* **2000**, *3*, 39–44. (In Chinese)
68. Song, J.X.; Wang, L.Z.; Fuller, D.Q. A regional case in the development of agriculture and crop processing in northern China from the Neolithic to Bronze Age: Archaeobotanical evidence from the Sushui River survey, Shanxi province. *Archaeol. Anthropol. Sci.* **2019**, *11*, 667–682. [CrossRef]
69. Jiang, Y.C.; Dai, X.M.; Wang, L.Z.; Wang, X.Y.; Qin, L. Plant macro-remains reveals the agricultural pattern and regional variation of Shanxi Plateau during Longshan Period. *Quat. Sci.* **2019**, *39*, 123–131, (In Chinese with English Abstract).
70. Zhao, Z.J.; He, N. Flotation results and analysis at Taosi site in 2002. *Archaeology* **2006**, *5*, 77–86. (In Chinese)
71. Chen, X.X.; Wang, L.Z.; Wang, Q. Analysis of floatation results from the 2006–2007 excavation of Xijincheng site in Bo'ai County, Henan Province. *Huaxia Archaeol.* **2010**, *3*, 67–76. (In Chinese)
72. Liu, Z.; Li, H.M.; Zhang, Z.Q.; Guo, Q.; Li, H.; Jia, X. Utilization of plant resources in Longshan Period in the Central China: Take Shangcun site in Xinxiang City Henan Province as an example. *Agric. Hist. China* **2021**, *1*, 13–21, (In Chinese with English Abstract).
73. Wu, X.; Guo, M.J.; Wang, R.; Guo, R.Z.; Jin, G.Y. Analysis of plant remains of Longshan period at Dalaidian site in Hebi City, Henan Province. *East Asia Archaeol.* **2017**, *14*, 184–201. (In Chinese)
74. Liu, H.; Song, G.D.; Li, S.T. Analysis of carbonized macroremains from the Zhangdeng site, Henan. *Acta Anthropol. Sin.* **2021**, *40*, 1063–1071, (In Chinese with English Abstract).
75. Shanxi Cultural Relics Bureau. *Selected Important New Discoveries in the Third Cultural Relics Census in Shanxi Province*; Science Press: Beijing, China, 2010. (In Chinese)
76. Wang, H.Y.; Jia, Y.N.; Zhang, Y.Z.; Wang, N.L.; Luo, P.P.; Qiu, H.J.; Ayidina, S.; Xiao, Q.L.; Chen, D. Research progress of paleoflood events in the Yellow River Basin since the last deglaciation. *Prog. Geogr.* **2021**, *40*, 1220–1234, (In Chinese with English Abstract). [CrossRef]
77. Zhang, X.L.; Qiu, S.H.; Bo, G.C.; Wang, J.X.; Zhong, J. Stable carbon and nitrogen analysis of human bones from the Erlitou and Taosi sites. In *Science for Archaeology (Volume 2)*; Archaeological Science and Technology Center, Institute of Archaeology, Chinese Academy of Social Sciences, Eds.; Science Press: Beijing, China, 2007; pp. 41–48. (In Chinese)
78. Ling, X.; Chen, L.; Xue, X.M.; Zhao, C.C. Stable isotopic analysis of human bones from the Qingliang temple graveyard, Ruicheng County, Shanxi Province. *Quat. Sci.* **2010**, *30*, 415–421, (In Chinese with English Abstract).
79. Hou, L.L.; Hu, Y.W.; Zhao, X.P.; Li, S.T.; Wei, D.; Hou, Y.F.; Hu, B.H.; Lv, P.; Li, T.; Song, G.D.; et al. Human subsistence strategy at Liuzhuang site, Henan, China during the proto-Shang culture (~2000–1600 BC) by stable isotopic analysis. *J. Archaeol. Sci.* **2013**, *40*, 2344–2351. [CrossRef]
80. Yang, F.; Wang, Q.; Wang, F. Stable carbon and nitrogen isotope evidence of human and animal diets at the Xijincheng site, Bo'ai County of Henan Province. *Quat. Sci.* **2020**, *40*, 418–427, (In Chinese with English Abstract).
81. Zhao, Z.J. The process of origin of agriculture in China: Archaeological evidence from flotation results. *Quat. Sci.* **2014**, *34*, 73–84, (In Chinese with English Abstract).
82. Yuan, J. *Research on Subsistence from the Neolithic to the Bronze Age in China*; Fudan University Press: Shanghai, China, 2021. (In Chinese)
83. Chai, Y. *Common Millet*; China Agricultural Press: Beijing, China, 1999; pp. 56–101. (In Chinese)
84. Guedes, J.D.; Butler, E.E. Modeling constraints on the spread of agriculture to Southwest China with thermal niche models. *Quat. Int.* **2014**, *349*, 29–41. [CrossRef]
85. Sheng, P.F.; Shang, X.; Zhou, X.Y.; Storozum, M.; Yang, L.P.; Guo, X.N.; Zhang, P.C.; Sun, Z.W.; Hu, S.M.; Sun, Z.Y.; et al. Feeding Shimao: Archaeobotanical and isotopic investigation into early urbanism (4200–3000 BP) on the northern Loess Plateau, China. *Environ. Archaeol.* **2021**, 1–15. [CrossRef]
86. Li, H.M.; Cui, Y.F.; James, N.; Ritchey, M.; Liu, F.W.; Zhang, J.N.; Ma, M.M.; Dong, G.H. Spatiotemporal variation of agricultural patterns in different geomorphologic and climatic environments in the eastern Loess Plateau, north-central China during the late Neolithic and Bronze Ages. *Sci. China Earth Sci.* **2022**, *65*, 934–948. [CrossRef]
87. The Institute of Archaeology in Chinese Academy of Social Sciences. *Chinese Archaeology: Neolithic*; China Social Science Press: Beijing, China, 2010. (In Chinese)
88. Zhang, C.; Pollard, A.M.; Rawson, J.; Huan, L.M.; Liu, R.L.; Tang, X.J. China's major Late Neolithic centres and the rise of Erlitou. *Antiquity* **2019**, *93*, 588–603. [CrossRef]
89. Liu, X. *Selected Essays on the Archaeology of Xia, Shang and Zhou*; Science Press: Beijing, China, 2014; pp. 3–41. (In Chinese)
90. Han, J.Y. The expansion and influence of the Laohushan Culture. *Cult. Relics Cent. China* **2007**, *1*, 20–26. (In Chinese)
91. Han, J.Y. Violent cultural changes in Longshan period and tribal warfare in Chinese legendary Era. *J. Soc. Sci.* **2020**, *1*, 152–163, (In Chinese with English Abstract).

92. Shanxi Archaeological Team of The Institute of Archaeology in Chinese Academy of Social Sciences; Shanxi Provincial Institute of Archaeology; Linfen Municipal Bureau of Culture. Excavation on the city-site at Taosi, Xiangfen, Shanxi, in 2002. *Acta Archaeol. Sin.* **2005**, *3*, 307–346, (In Chinese with English Abstract).
93. Sun, Z.Y.; Shao, J.; Di, N. A synthesis of the archaeological discovery and research on the Shimao site. *Cult. Relics Cent. China* **2020**, *1*, 39–62. (In Chinese)
94. Wei, X.T. Discussion on the age of the Longshan city sites in the Central Plains and the reasons for their rise and fall. *Huaxia Archaeol.* **2010**, *1*, 49–60. (In Chinese)