quaternary

Article

The Climate Fluctuation of the 8.2 ka BP Cooling Event and the Transition into Neolithic Lifeways in North China

Chao Zhao [1,2,3]

[1] School of Cultural Heritage, Northwest University, Xi'an 710069, China; chz63@pitt.edu
[2] Department of Anthropology, University of Pittsburgh, Pittsburgh, PA 15260, USA
[3] The Louis Frieberg Center for East Asian Studies, Hebrew University of Jerusalem, Jerusalem 91905, Israel

Received: 22 May 2020; Accepted: 13 July 2020; Published: 4 August 2020

Abstract: Early Neolithic lifeways in North China, which are marked by a low-level food production economy, population aggregation, and sedentism, thrived just after the period of a climatic cooling event at 8.2 ka. Instead of simply regarding this climate fluctuation as a cause for the significant socio-economic transition, this paper attempts to explore the interplay between people's choices of coping strategies with climate change as a perspective to learn how people respond to this climate fluctuation and how such responses generated the interlocked socio-economic transitions. This analysis indicates that pre-existing changes in human adaptive behaviors prior to the cooling events were sufficient to enable people in certain areas to apply the intensification of food procurement in circumscribed territories as a strategy to cope with the climate fluctuations of the 8.2 ka BP cooling event. The application of such a coping strategy facilitated the economic and sociopolitical transition into Neolithic lifeways and led to the flourishing development of Neolithic cultures after 8 ka BP in North China.

Keywords: climate fluctuation; 8.2 ka BP cooling event; transitional sites; Early Neolithic; adaptive strategy; North China

1. Introduction

The development of Neolithic culture occurred right after the eighth millennium BP in North China, which is marked as one of the most dramatic economic, social, and cultural changes in Chinese history. For hundreds of thousands of years in North China, human beings lived in mobile hunting–gathering lifeways in simple and small groups. Then, during the early Holocene (approx.: 12–7 ka BP), significant changes happened and facilitated the multi-faceted transformations of people's lifeways in terms of economic practice, sociopolitical organization, and cultural identity. By contrast with Paleolithic lifeways, people in the Neolithic period were integrated into larger social communities, lived in sedentary or semi-sedentary villages, developed new types of art forms and beliefs, and carefully treated the dead to increase inter-personal social and cultural connections [1]. Rather than seasonally exploiting food resources in a large range of territories, people began to intensively use the local resources in the circumscribed environment, firstly by the combined reliance on intensified hunting–gathering and low-level primitive farming and then by further developed agriculture [2,3]. Such lifeways stimulated the booming of the population and fundamentally changed the pattern of interactions between humans and the environment [4].

It is widely assumed the Holocene climatic optimum facilitated the prevalence of Neolithic lifeways since it provided an affluent environment of food resources and provided suitable climate conditions for farming [5]. However, a finer-scale examination of the climatic change suggests that there are multiple rounds of climate fluctuations in post-glacial periods, reflected as the oscillations between the warmer–wetter and colder–drier periods [6–8]. The 8.2 ka BP cooling event is such a climate fluctuation and was expressed as a drop in temperature during the general trend towards the warmer and wetter climate in Early Holocene. This cooling event occurred at around 8.2 ka BP and lasted for two to four centuries (some records detected that the decrease in temperature was initiated as early as 8.4 ka BP) [9,10]. The archaeological records in North China indicate a dramatic increase in site numbers and the thriving development of Neolithic culture after 8–7.8 ka BP, implying that the all-round and widespread transformation into Neolithic lifeways in North China happened soon after the 8.2 ka BP cooling event. Such a temporal correlation implies that the 8.2 ka BP cooling event might have played an important role in stimulating the significant cultural transition. However, rather than simply regarding this climate fluctuation as a cause of the cultural transition, I present how the interplay between humans and the environment across the 8.2 ka BP cooling event drove the cultural change.

Accumulative cultural preparation is an important focus of this study, since how people respond to climate change deeply relies upon their knowledge derived from long-term experience. One aspect of such cultural preparation is a suite of technological packages used to intensively exploit resources and massively store them for delayed consumption since sedentary lifeways and large group aggregation require sufficient food supplies in a confined area [11–13]. Another aspect of cultural preparation is organizational innovation, since the need to maintain large group aggregation and strengthen the sense of territoriality required more sophisticated sociopolitical organization and intensified social connections than ever before [14–16]. Such cultural preparations were formed and developed along with human coping strategies to deal with environmental changes. Some traits of such cultural preparations sporadically occurred as early as the Late Paleolithic but were significantly developed and deeply converged with other traits in the Early Neolithic period. Therefore, learning how people are technically and sociopolitically organized either to cope with challenges or take advantage of the favorable conditions of the environment over a long time span would be an insightful approach to explore how the human–environment interaction during the 8.2 ka BP cooling event generated the profound social and economic transition into the Neolithic lifeways.

2. Materials and Methods

2.1. The Study Area and the Research Approach

North China (about 33°–43° N, 100°–125° E) is a vast geographic region in East Asia that features a temperate semi-humid monsoon climate. It is separated from Central and South China by the Qinling mountains and Huai River to the south, bordered by the Mongolian Plateau and the Yinshan and Yanshan Mountains to the north, and bounded by the Yellow Sea and Bohai Sea to the east and the neighboring Gobi Desert region in the west. The Yanshan and Taihang Mountains divide North China into two regions. The area to the west and north is the Loess Plateau, which is comprised by loess-covered highland, mountains, hills, and basins. The area to the east is the North China plain, a flat landscape with large water bodies and sporadically distributed hills and low mountains. Influenced by the alternations of summer and winter monsoon, North China has hot and wet summers and cold dry winters. As for the intra-environmental variations across the sub-regions, the weather becomes drier moving from the southeast to the north and west, where the strength of the summer monsoon declines gradually. The climate becomes colder moving from lower elevation plains to the mountains and highlands [17].

North China is one of a few centers in the world where complex agricultural systems emerged independently. The most widely consumed staple grains in the Neolithic period of North China were two types of millet, namely foxtail millet (*Setaria* spp.) and broomcorn millet (*Panicum* spp.) (foxtail and broomcorn, *Setaria* and *Panicum* spp., respectively) [3], while people in the southern and eastern parts of North China also consumed domesticated rice (*Oryza* spp.) as a supplemental food resource [18].

The onset of flourishing Neolithic cultures in North China was once thought as the outcome of fully fledged millet agriculture [19]. However, recent studies have revealed that multiple factors of Neolithic lifeways, such as sedentism, large group aggregation, and cultural and technological sophistication, all came before the full establishment of the agricultural economy [5,20]. Thus, early Neolithic cultures were based upon a low-level food production economy characterized by the broad-spectrum use of wild resources and the incorporation of domesticates as auxiliary resources [2].

North China is an ideal area to investigate how the 8.2 ka BP cooling event impacted the patterns of human–environment interactions and facilitated the significant cultural transitions. This climatic event is well evident in the paleoclimate records of China. Furthermore, the growing body of archaeological discoveries provides sufficient evidence to learn how people respond culturally during climate fluctuation. In the following section, the manifestation of the 8.2 ka BP cooling event in China is presented under the general paleoclimate background during the Paleolithic–Neolithic transition in North China. It provides a better understanding of the nature of this climate fluctuation at the suitable regional scale focused on by this paper. Then, the range of the sites used for the studies are mapped out in a sequential chronological frame, and the charts of the sum probability of their radiocarbon dating results are compared with the charts of the paleoclimatic proxies to show the concurrence pattern between the climate fluctuation and the significant cultural transition. Finally, the possible modes of coping strategies under climate fluctuation are summarized according the previous anthropological studies and how they are reflected by archaeological evidence is discussed, shedding light on the range of evidence I collected and discuss in the following sections to learn what specific coping strategies people have applied, how their application was based on the previous cultural preparation, and how the application of such strategies impacted the subsequent cultural development.

2.2. Paleoclimate Fluctuation and the Paleolithic–Neolithic Transition in North China

The early and mid-Holocene are the key periods of significant social transformation into Neolithic lifeways. On average, increased humidity and temperature distinguish the early-mid Holocene "Anathermal" from the preceding Younger Dryas. At the peak of the wet/warm period, the average temperature was 2~3 °C higher than today's standard and the annual precipitation was 50~300 mm more than it is currently in North China [21,22]. However, the wet and warm periods were not consistent, but punctuated by periodical aridity and temperature decreases [23]. The 8.2 ka cooling event is an example of one period with noteworthy magnitude [24].

The 8.2 ka BP event is apparent in many climate records, particularly from the Northern Hemisphere. The event itself was most likely caused by meltwater escaping from Lake Agassiz-Ojibway into the Atlantic Ocean via the Hudson Bay, which altered thermohaline circulation [9,25,26]. The evidence of such a climate anomaly around 8.2 ka BP is clearly shown in ice cores from Greenland, where air temperatures dropped by 3 to 6 ± 2 °C [27]. The reinforced Northern Hemisphere cooling would have increased the temperature gradient between high and low latitudes, which caused the migration of the inter-tropical convergence zone southward. Such an effect would have led to the weakening of the East Asian monsoons and increased aridity [28].

The high resolution, well-dated paleoclimate proxies from East Asia can reflect the impact of this cooling event. The pollen records from Bigeum Island near the Korean Peninsula revealed a rapid drop in arboreal pollen frequency and a corresponding increase in fern spores, which implies that an abrupt dry and/or cold event significantly impacted the distribution of vegetation on the island [29]. The changing $\delta^{18}O$ values of the Guliya ice core in the Tibetan Plateau and stalagmites from Lianhua Cave in the Loess Plateau of North China, Heshang Cave in Central China, and Dongge Cave in South China all reflect an interval of weakening Asian monsoons during a certain period between 8.4 and 8.0 ka BP, coinciding within error with the 8.2 ka BP event reflected by the Greenland ice cores [30–33]. Furthermore, a 10-year moving average annual rainfall record in southwest China during the 8.2 ka BP event was reconstructed based on a central-scale model and the comparison of two high-resolution stalagmite $\delta^{18}O$ records from Dongge Cave and Heshang Cave. This reconstructed record reveals that the mean annual precipitation in southwest China during the central 8.2 ka BP event was less than that of the present (1950–1990) by ~200 mm and decreased by ~350 mm in ~70 years [34]. The stalagmite records of Shihua Cave and Nuanhe Cave in Northeast China indicate that the summer monsoon-dominated $\delta^{18}O$ record only weakly express the 8.2 ka event. Nonetheless, the variations of the winter-dominated proxies of $\delta^{13}C$ and Ba/Ca reflect a colder and drier climate initiated at 8.42 ka BP and centered at ~8.2 ka BP [35]. A clear drop in $\delta^{13}C$ at 8.6–8.1 ka BP can also be detected from the peat bog record of Hongyuan in the eastern Tibetan Plateau, indicating an obvious dry/cold period with decreased humidification [36].

A sharp increase in precipitation and temperature can also be detected by these paleoclimatic proxies after the 8.2 ka BP cooling event, which marks the onset of the mid-Holocene climatic optimum. The stalagmite record of Lianhua Cave shows a 2.5‰ $\delta^{18}O$ isotope depletion at 8.1 ka [33]. Such a magnitude of change is roughly similar to the transition from the Younger Dryas to the Early Holocene at 11.5 ka [5].

The cultural development and site distributions throughout the period from 11,500 to 7000 BP are presented in Figure 1. The comparison of climate fluctuation and cultural development (particularly referring to the occupation intensity of different types of sites) throughout this period is presented in Figure 2 (Supplementary Table S1). These two figures reflect the patterns of concurrence between climate and cultural changes, suggesting that the transitional sites occurred along with climate change into warmer and wetter conditions initiated from the beginning of Holocene (after 12 ka BP). These sites still share many features in common with the Upper Paleolithic sites in North China (45–12 ka BP) but, meanwhile, have shown the buds of the Neolithic cultural traits. During or even preceding the 8.2 ka BP cooling event, the Early Neolithic sites, characterized by settled inhabitation, large group aggregation, and intensive site use, emerged but were very rare and distributed only in limited areas of North China. With the onset of the climax of the Holocene climatic optimum (7.8–7 ka BP), the numbers of Early Neolithic sites soared and they were widely distributed across North China with sharply increased occupation intensity. In the following sections, the specific interplay between humans and the environment will be analyzed and discussed to learn the underlying mechanisms of this significant social change under climate fluctuations.

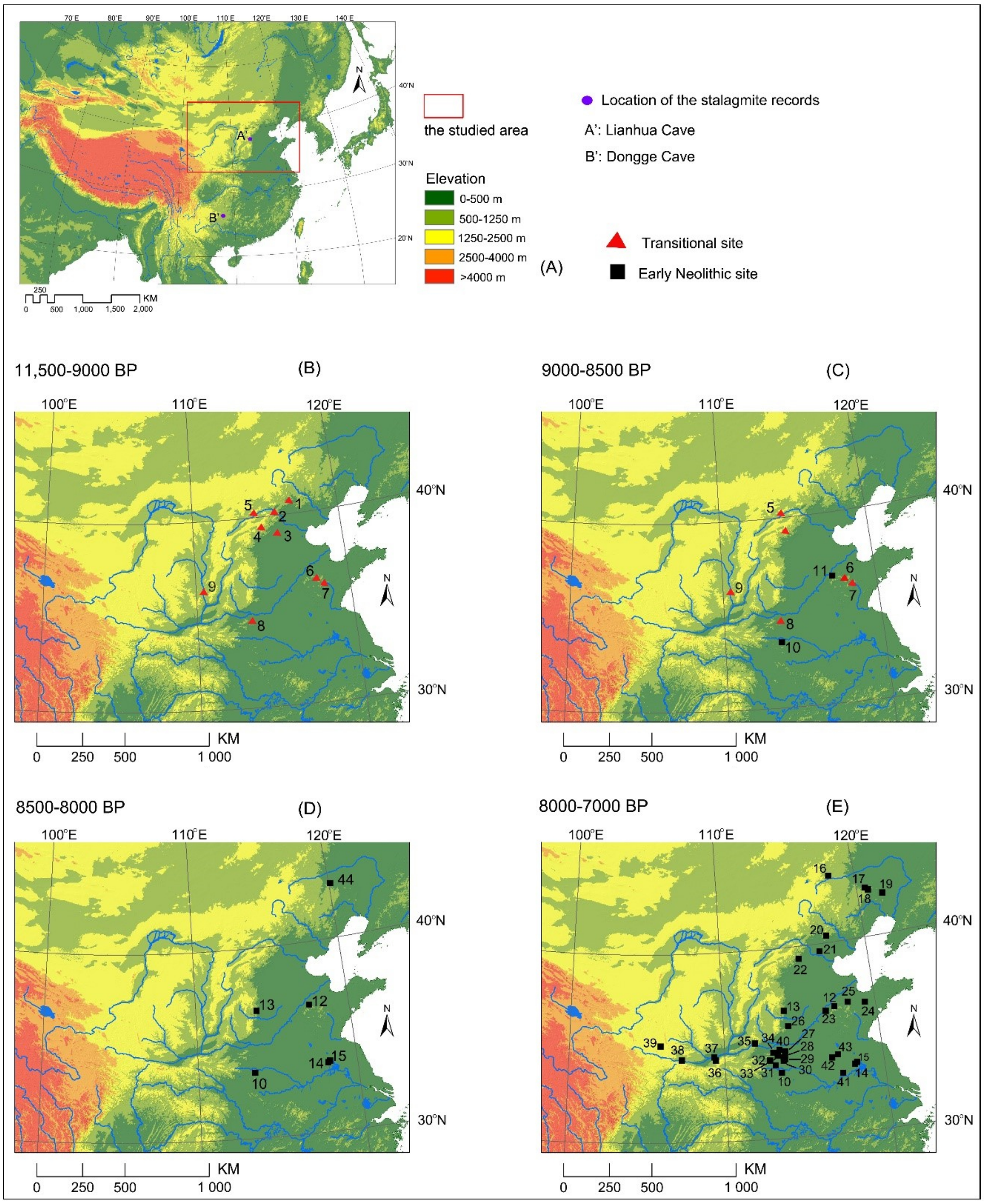

Figure 1. The distributions of the archaeological sites from 11,500 to 7000 cal BP. (**A**). Studied area; (**B**). The distributions of the archaeological sites from 11,500 to 9000 cal BP; (**C**). The distributions of the archaeological sites from 9000 to 8500 cal BP; (**D**). The distributions of the archaeological sites from 8500 to 8000 cal BP; (**E**). The distributions of the archaeological sites from 8000 to 7000 cal BP (The name of the sites: 1: Zhuannian [37]; 2: Donghulin [38]; 3: Nanzhuangtou [39]; 4: Ximiao [40]; 5: Yujiagou [41]; 6: Huangya [42]; 7: Bianbiandong [43]; 8: Lijiagou [44]; 9: Shizitan S9 and 12G [45,46]; 10: Jiahu [47]; 11: Zhangmatun [48]; 12: Xihe [49]; 13: Cishan [50]; 14: Shunshanji [51]; 15: Hanjing [52]; 16: Baiyinchanghan [53]; 17: Xinglonggou [54]; 18: Xinglongwa [55]; 19: Chahai [56]; 20: Shangzhai [57]; 21: Beiwang [58]; 22: Beifudi [59]; 23: Yuezhuang [60]; 24: Qianbuxia [61]; 25: Houli [61]; 26: Huawo [62]; 27: Shawoli [63]; 28: Peiligang [64]; 29: Tanghu [65]; 30: Shigu [66]; 31: Shuiquan [67]; 32: Zhongshanzhai [68]; 33: Egou [69]; 34: Tieshenggou [70]; 35: Bancun [71]; 36: Beiliu [72]; 37: Baijia [73]; 38: Beishouling [74]; 39: Dadiwan [75]; 40: Malianggou [76]; 41: Shuangdun [77]; 42: Shishanzi [78]; 43: Xiaoshankou [79]; 44: Xiaohexi [80]).

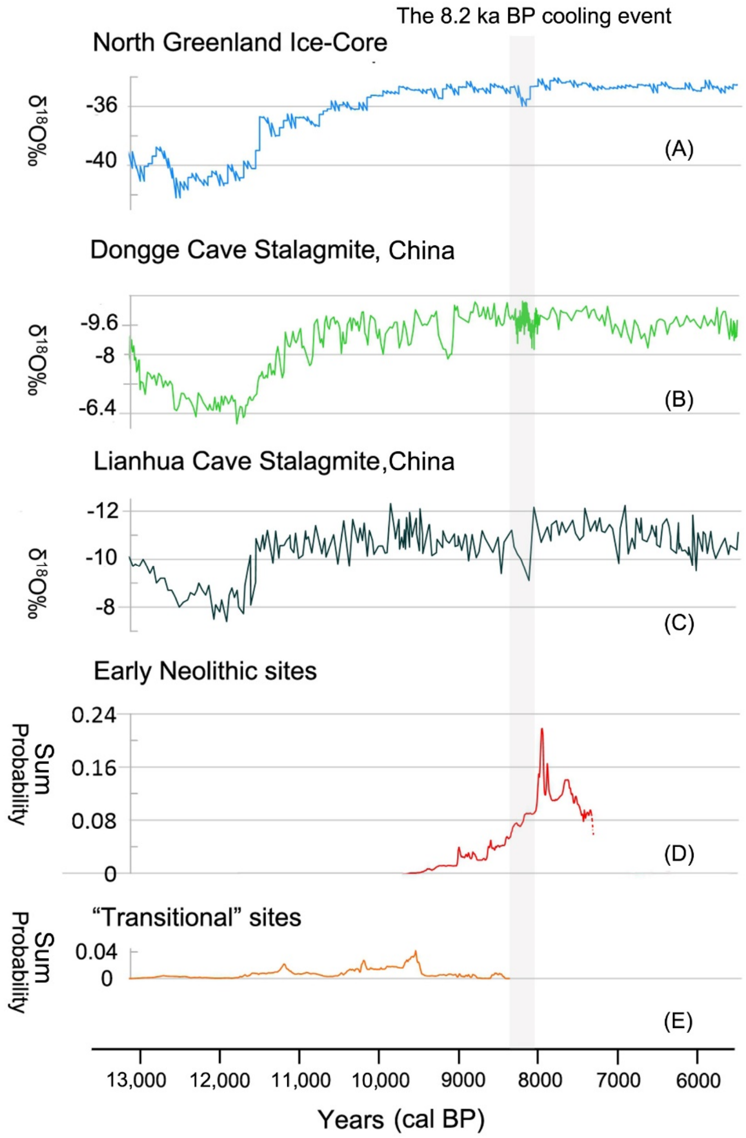

Figure 2. Graphic comparison of human occupation intensity and climate fluctuation. The shaded gray bar shows the time span of the 8.2 ka BP cooling event. The curve (**A**) represents hemispheric changes in precipitation and temperature recorded in the North Greenland ice core [81]. Higher $\delta^{18}O$ values indicate warmer temperatures and higher humidity. The curve (**B**) represents a proxy for monsoon intensity in South China from the Dongge Cave stalagmite records [31]. Higher $\delta^{18}O$ values indicate strong winter monsoons (cold/dry) and lower $\delta^{18}O$ values indicate stronger summer monsoons (warm/wet). The curve (**C**) represents a proxy for monsoon intensity in North China from the Lianhua Cave stalagmite records [33,82]. Higher $\delta^{18}O$ values indicate strong winter monsoons (cold/dry) and lower $\delta^{18}O$ values indicate stronger summer monsoons (warm/wet). The curves in (**D**,**E**) respectively indicate the relative occupation intensity of the Early Neolithic and the transitional sites across North China based on the sum probability of radiocarbon age estimates. The basic information of the radiocarbon dates (including the dataset of the radiocarbon dating and the explanation of how the sum probability distribution model was built) is presented in the supplementary data.

2.3. Human Responses to the Impacts of Climatic Change

How climate change impacts on the development of human society has long been a hot topic attracting broad academic attention. Nowadays, environmental determinism is already obsolete and few scholars would regard environmental change as the decisive force leading to social changes.

The influences of climate change on human society are now evaluated under the complex patterns of the interplay between humans and the environment since we realized that human beings are able to flexibly handle the situations caused by environmental changes in various ways [83]. Facing similar natural challenges caused by environmental deterioration, different human communities might come up with varied coping strategies to deal with them. Such divergent strategies would have different impacts on the trajectory of local social and cultural development [84–86]. The choice of coping strategy is usually the result of previously held beliefs, social–political organization, technological bases, and historical interaction with neighboring societies [87,88]. Moreover, the potential advantageous conditions due to climatic amelioration may only benefit people and stimulate cultural fluorescence when people are fully prepared in cultural and social dimensions to sufficiently make use of such conditions [11,89].

The change into a colder and drier climate in historic and present day North China is often considered as climate deterioration because: (1) it would lead to the reduction of total biomass and therefore cause a decrease in resource affluency and the sizes of rich resource patches [90]; (2) it will also shorten the growing season, leading to the extension of the lean season for food resources [91,92]; (3) it will lead to unfavorable conditions for farming activity, at least in some parts of North China, due to the threat of disasters like drought and frost [93,94]. The sharp climatic change from a warm/wet period into a cold/dry period could also increase the risks of subsistence practice and force people to adjust their coping strategies, since the past experience of subsistence strategy might no longer fit well with the changing environment situation [95].

Based on an anthropological view, the ancient foragers might have had several options to handle the situation of such climate deterioration, as listed below:

(1) To increase mobility: This can be achieved as either expanding the foray distance or increasing the frequency of movement, or both [96]. Such a coping strategy could have enabled foragers to use a larger range of territory to procure resources and make up the deficiency of food resources in any confined areas, or reduce the resource pressures of any circumscribed regions [90,96].
(2) To actively intensify the yields of food resources in the circumscribed area where the resources are relatively abundant or have a suitable environment for food production [87]: The surplus of the food resources usually went into storage and could be consumed later in lean seasons [97,98]. A substantial amount of effort and/or prerequisites are required to fulfill such a strategy, such as technological improvements, new inventions, part-time cultivation, and improved methods and investments for resource management [13,99,100]. Such requirements call for intensified investment in the circumscribed area and therefore people must have settled down and developed effective ways to defend the resources within their immediate territory [14].
(3) To make long-distance migrations: Since environmental deterioration exerts impacts to varying degrees in different places, some areas might be less severely affected by climate change and might serve as destinations for migration [101]. Differing from the two strategies mentioned above, the migration strategy might have not necessarily required people to modify their adaption strategies since people could have still relied on past coping strategy by moving into the places where their past experience of subsistence strategy still fulfilled their needs [102]. However, since these destinations are usually not "empty", the long-distance migration might have caused changes in social and cultural interaction, either reflected by inter-group conflict or amalgamation [103].
(4) To develop social alliances and increase the intensity of social exchanges: This can increase reciprocal ties and buffer against subsistence risks [104]. This strategy is especially suitable in more heterogenous environments where the neighboring people may have relied on different subsistence bases and could have mutually complemented each other's strategies through exchange [11].

Different coping strategies can be reflected by a range of archaeological evidence listed in Table 1. In the following section, the multiple lines of evidence from the sites will be analyzed to learn the specific coping strategies people relied on to deal with the climate fluctuation in North China. The sites include both the ones during the time span of the 8.2 ka BP cooling event and prior to this climate fluctuation. Since the choice of coping strategy is closely based on the cultural preparedness that evolved from prior subsistence practices, the incorporation of the earlier sites strategies provides us an important cultural context to evaluate how and why people chose certain strategies to cope with the climate fluctuation of the 8.2 ka BP cooling event.

Table 1. Different coping strategies under climatic deterioration and their corresponding material implications reflected by archaeological evidence.

Coping strategy under climatic deterioration	Archaeological manifestation
Increase mobility	Scarcity of the sites; lack of the permanent site structure; thin cultural deposits; portable toolkits.
Intensify the resource exploitation of the circumscribed affluent area	Toolkits used for intensive resource extraction; traces of intensified site occupation (thick cultural layer, permanent site structure, etc.); faunal and floral evidence showing the intensified resource use; traces of increased social integration (enlargement of the site, non-utilitarian goods); traces of territoriality (cemetery, defense structure).
Long-distance migration	Evidence of cultural transmission; the sharp decline in site numbers contrasted by the dramatic increase in site numbers in another area.
Alliance and trans-regional exchange	The presence of exotic goods, mutual cultural influences; stylish cultural markers showing the presence of reciprocal ties.

3. Results

3.1. The "Transitional Remains" of the Early Holocene (11.5–8.5 ka BP)

In China, "Paleolithic" and "Neolithic" are short-hand terms for Pleistocene foragers and primitive Holocene farmers [4]. The differences between the two temporal/cultural entities are so pronounced that their shared heritage and genealogy are largely unexplored [4]. In past studies, some scholars have drawn attention to the lack of information connecting terminal Pleistocene foragers to the Early Neolithic farmers (or low-level food producers) and cited a "gap" in the archaeological record of North China from about 11,500 to 9000 BP [105,106]. However, although the evidence is still scarce, transitional sites that emerged in the Early Holocene prior to the full appearance of "Neolithic packages" have been found in different regions of North China. The names of the distributions of these sites are listed in maps "B" and "C" in Figure 1.

People were probably not sedentary and were organized as relatively small groups in this period. This inference is made from the evidence that: (1) no permanent dwelling structures have ever been found across the sites; (2) the site size is usually smaller than that of village-like settlements, except for the Nanzhuangtou site (which is estimated to be as large as 2 ha, but the precision of the estimation is still debated) [39]. The open-air site Donghulin is as large as 0.3 ha, smaller than most of the Neolithic sites found in a later period [38]. The Bianbiandong and Huangya sites are rock shelter sites, with only narrow spaces for daily activities [42]. The Lijiagou and Shizitan Locality 9/Locality12 G sites are deeply buried under the earth, so it is hard to make a reliable estimation of the site area. However, according to the exposure of the lithic remains on the profile, the site areas are probably not large [45,46,107].

Nonetheless, other lines of evidence suggest that people might have put more investment in site construction than in earlier periods. Burned earthen surfaces have been found in both Donghulin and Bianbiandong sites [38,43]. These are in an irregular oval shape and are harder than the surrounding depositions, which is inferred as living floors [38,43]. Decayed wooden poles have been found in the Nanzhuangtou site, which are suggested to have been used for constructing simple dwellings [39]. The hearths identified in the Donghulin site are in a more complex structure than the ones found in the Upper Paleolithic period (45–12 ka BP). The lower level of the hearths was arranged neatly by placing rocks in a circle. They are about 0.5–1 m in diameter and 0.2–0.3 m in depth, which is thicker than most of those found in the earlier period, showing the more intensive and perhaps persistent use of them [38]. Piles of rocks in semi-circular shapes have been found in the Lijiagou site. Such rock crescents might be correlated with dwelling construction and indicate more labor investment for inhabitation [107].

The occurrence of secondary burial in the Donghulin and Bianbiandong sites also implies that people had relatively permanent settlements at this time, to which the dead were brought back for ritual burials [108].

The faunal and floral remains found during this period indicate that people relied on a wide range of wild resources for their subsistence base. Some r-selected species (referring to the ones that quickly and massively produce short-lived “cheap” offspring), which are abundant in nature and hard to deplete in a short time, were intensively exploited, such as acorns in the mountainous regions and water caltrop in wetland environments [109]. Meanwhile, the earliest evidence of millet domestication was identified from the flotation results of the Donghulin site and starch analysis from the Zhuannian and Nanzhuangtou sites. The morphological studies of these millet remains show a combination of both wild and domesticated features, indicating that millet was still undergoing domestication [110,111]. Even though flotation results show that the broomcorn and foxtail millet make up only a tiny proportion of the charred seeds, morphological changes from the wild versions suggest that people had begun to carry out intensive intervention and management of the growth and reproduction of millet [111].

Corresponding technologies related to resource intensification are widely found in this period. Except for Shizitan Loc 9/Loc 12 G, pottery sherds have been discovered in all other sites [112]. Pottery provided people with innovative cooking techniques, which facilitated a more thorough intake of nutrients from food resources, like the grease from animal bones and hard-to-digest plant resources such as millet [92,113]. However, pottery is breakable and not suited transport over long distances, therefore it does not fit well in highly mobile lifeways [114]. The pottery found in this period is simple in form, crude, coarse-grained, and fired at low temperatures. The quantities are small in comparison with later period sites [115]. Such evidence indicates that even though the pottery and accompanying new cooking methods were widely adopted by foragers, vessels were not as intensively used as by the subsequent Neolithic farmers. The mobile lifeways and the limited levels of resource intensification might have confined the extent of people’s reliance on pottery use [113].

Like pottery, grinding stone tools are also used for the intensive exploitation of food resources. They can process a wide range of foods, like nuts, tubers, bulbs, roots, and grass seeds, grinding them into powders that facilitate storage and consumption [116]. The grinding stones can be found in all of the abovementioned sites, except for Shizitan S12G [112]. However, most of the grinding stones found in this period are less regular in shape, with narrower grinding surfaces in comparison with those found in Early Neolithic sites after 8 ka BP [117] (the grinding slabs shown in Figure 3 and Figure 5 can provide an intuitive comparison). Moreover, grinding slabs make up only a small proportion of the lithic tool assemblage in each site except Nanzhuangtou, where only very limited number of lithic remains have been found [39]. In the Donghulin site, the grinding tools only comprise 11.05% of the tool assemblage [118]. In the Lijiagou site, they are only 13% of the tool assemblage in its upper cultural layer (approx. ~10.5–10 ka BP) [44]. Chipped stone tools still dominate the lithic assemblages in these sites. Such a pattern indicates that, even though grinding stones were widely adopted by people as auxiliary tools for food processing, they were not yet expected to play an important role in massively processing food resources at the unprecedented levels seen in the Early Neolithic period (about 8.5–7 ka BP).

To sum up, the features of the transitional sites, on the one hand, more closely resemble the preceding Upper Paleolithic sites in terms of the lack of permanent dwelling structures, small site size, chipped stone-dominated tool assemblage, and thin cultural depositional layers. Such similarities indicate that people in the Early Holocene at least partially inherited the socio-economic organization and land-use strategies from terminal Pleistocene foragers. However, the techniques necessary for the intensive exploitation of resources that were prevalent in the subsequent Neolithic period had already appeared and were widely adopted during this period [112]. The presence of domesticated millet also indicates that the knowledge of intensive resource management for certain species, and even cultivation, was developed in this period [111].

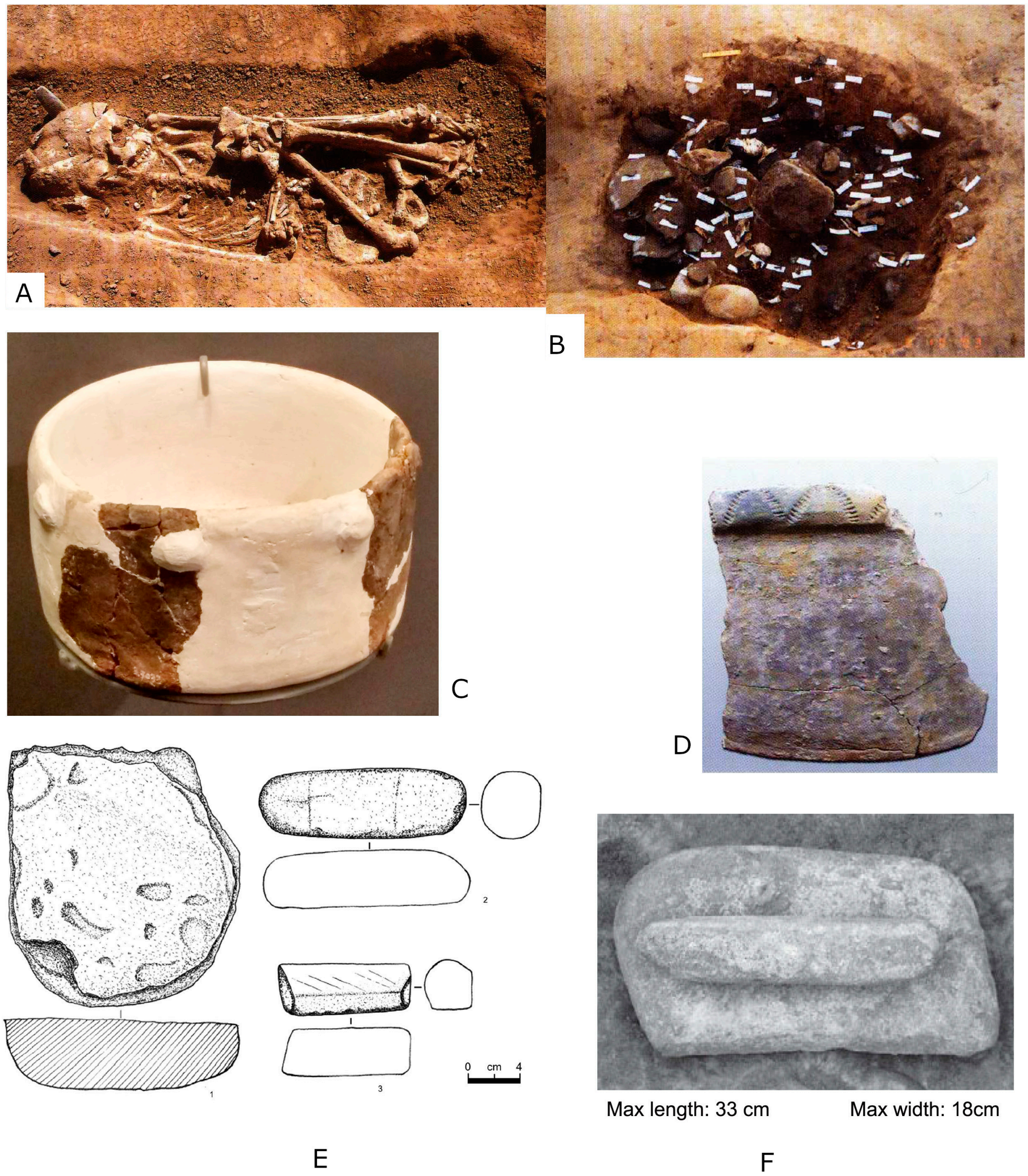

Figure 3. Features and artifacts found from transitional sites (11.5–8.5 ka BP) which show the innovative cultural traits that herald the "Neolithic package" and differ from typical Paleolithic remains ((**A**): sedentary burial, Donghulin site (2 in Figure 1); (**B**): stone-lined hearth, Donghulin site (2 in Figure 1); (**C**): Pottery bowl, Zhuannian site (1 in Figure 1); (**D**): pottery sherd with decorations on the rim, Donghulin site (2 in Figure 1); (**E**): stone slab and rollers Bianbiandong site (7 in Figure 1); (**F**): stone slab and roller, Donghulin site (2 in Figure 1), the maximum length and width are marked in the graph, after [37,38,43]).

Though these techniques and knowledge were still in their primary stage of development and had not yet became prevalent, they did stimulate subtle behavioral modifications and provided cultural preparedness for further social and economic transformation. For instance, such techniques and knowledge enabled people to fully exploit certain kinds of food resources that thrived due to climate amelioration at the beginning of Early Holocene, such as acorns and water caltrop. The paleoclimate data indicate that the beginning of the Early Holocene (which started at around 12 ka BP) was a warmer and wetter period in comparison with the Terminate Pleistocene period [31,82]. The warm and wet climate facilitated the recovery of forests in the mountainous region of North China and may have increased the distribution of nut-bearing trees, like oaks. The wet climate also expanded wetland areas and facilitated the growth of highly productive wetland food resources [109]. Even though sedentary lifeways had not yet been formed, the enhanced food resource supplies or the need to intensively exploit food resources in certain areas might have led people to stay for longer durations, making more intensive and regular use of certain sites within their land-use system.

3.2. Pioneering Changes in Coping Strategies Across the 8.2 ka BP Cooling Event in North China

Dating results for the transitional sites in the Early Holocene reveal that most of them are concentrated between 11.5 and 8.5 ka BP, suggesting that the main occupational phase of these sites is before the 8.2 ka BP cooling event. There are large "empty" areas where no archaeological sites have been discovered during the 8.2 ka BP cooling event except for a few "pioneering" sites found in specific regions which provided rich and diversified food resources. These sites show similar features to those thriving Early Neolithic settlements that appeared after 8 ka BP. This pattern implies significant modifications to human coping strategies in the period of the 8.2 ka BP cooling event.

The appearance of the "pioneering sites", characterized by larger-scale population amalgamation, sedentary lifeways, intensive site use, and rich material remains, suggests that people in some areas adopted the strategy of staying put in resource-rich areas and investing in ways to increase the local food supply as a means to adapt to climatic deterioration. Several sites have reflected the adoption of such a strategy, as discussed below.

3.2.1. The Jiahu Site

The Jiahu site (shown as 10 on maps "D" and "E" in Figure 1), is located in the Huai River Valley on the southeast edge of the Huanghuai alluvial plain in Wuyang County, Henan Province. Based on radiocarbon dates and cultural features, the Jiahu site was occupied from 9000 to 7600 BP, and can be divided into three phases: (1) 9000–8500 BP; (2) 8500–8000 BP; (3) 8000–7600 BP [119]. The total area of the site is about 5.5 ha and more than 2900 m^2 have been excavated over eight seasons of excavation from 1983 to 2013 [120,121]. Phase 1 of the Jiahu site was before the appearance of the 8.2 ka BP cooling event and was contemporary with some "transitional remains", such as the upper layer of the Lijiagou site and the lower layer of Shizitan Locality 9. Certain features of cultural remains in Jiahu Phase 1 differ pronouncedly from the "transitional remains" for various aspects. One crucial difference is the complexity of the site structures. Fifteen houses have been discovered, which are widely distributed from the west to east zone of the site and can be divided into five clusters. Fifty-one burials are laid close to the pit houses. In addition, two kilns and numerous pit structures have been found within the excavation zone. The pit structures were used as storage facilities or midden deposits [47]. Such complexity of site structure implies that people were sociopolitically organized in different ways and occupied the sites with more stable residency. The clustered distribution of houses probably reveals the amalgamation of different groups (which might have family ties) rather than the natural growth of a small band [122]. More investment for dwelling construction, storage facilities, and garbage disposal indicate a pattern of relatively stable habitation rather than ephemeral site use [123]. Moreover, pottery was used far more frequently in the Jiahu site [47]. The forms of pottery were more diversified than those found in the transitional sites, and they were made in more regularized shapes and fired at higher temperatures. The grinding stones were also made in more regular shapes [124].

Phase 2 of Jiahu had temporal overlap with the 8.2 ka BP cooling event. In this period, the settlement was further developed and became prosperous. The increasing number of artifacts, as well as houses, burials, and pit structures, indicates that people made more intensified use of the site during this period [47]. The houses were still distributed in clusters (the Jiahu report divides them into six clusters). The increase in burial numbers from 51 to 348 between Phase 1 and Phase 2 suggests a sharp increase in population size [119,121]. Unlike Phase 1, when burials and houses were mixed together, concentrated cemetery zones appeared. The distributional pattern indicates that, while they were spatially separated from the houses, each of the cemetery zones roughly corresponded with one house cluster. Analysis of the strontium isotopes of human bones from the cemetery indicates that, beginning in Phase 2, a few people from other regions migrated into the Jiahu site [125]. Some special items, such as turtle shells with gravel, a bone flute, and other carved bone "folk-shaped" items, have been found in a few of the burials [47]. Such items (seen as Figure 4) probably served as ritual paraphernalia and the appearance of them implies the elaboration of ritual activity during this period.

Figure 4. The items possibly used as ritual paraphernalia in the Jiahu site ((**A**) turtle shell with gravel, found in burial M363; (**B**) bone folk-shaped item; **1**: found in burial M395, **2**: found in burial M363. (**C**) bone flute; **1**: found in burial M57, **2**: found in burial M68; after [47]).

How could the Jiahu community have become prosperous during the general background of climatic deterioration? This could well be closely related to people's strategical exploitation of rich resource patches during the period of climate deterioration. The Jiahu site is located on the low-lying alluvial plain and near the confluence area of the ancient Hui and Sha rivers. Based on the study of geomorphology and sedimentology, Jiahu is situated on a hillock slightly higher than the surrounding area and faces large marshes and waterbodies to the east. Such a location offered easy access to different ecozones for procuring food resources within a circumscribed area. The marsh to the east of the site provides highly productive wetland food resources and is an ideal place for rice cultivation. To the east, a zone with rich aquatic resources provides habitat for freshwater fishes and shellfish. To the west of the site is a vast plain with terrestrial resources like deer, tree nuts, and fruit [47]. The Jiahu tool assemblages (seen as Figure 5) indicate that, through all three occupational phases, people were equipped with complex techniques to procure various resources from different ecozones: specially designed bone harpoons in varying sizes were used for gathering fish, and bone arrowheads were used for hunting. The grinding tools were enlarged and produced in more formal shapes, making up higher proportions within the lithic tool assemblages (30% of the lithic tools in Jiahu Phase 2) in comparison with those of "transitional remains" [125]. Such changes reflect that specialized technologies were used intensively for the bulk processing of plant resources. The stone hoes and sickles may have been used as tilling and harvesting tools relevant to farming activity [124]. The flotation results and faunal remains also indicate that people extracted a broad spectrum of wild plant and animal species from different ecozones and incorporated domesticated rice and pigs as supplemental food resources [126,127].

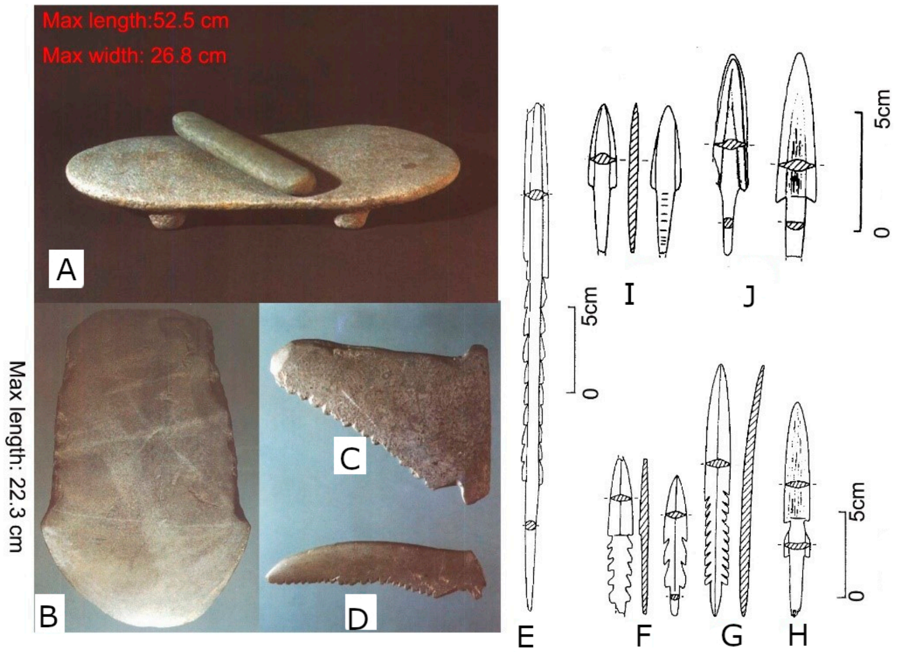

Figure 5. Toolkits of the Jiahu site which show the intensity of the techniques of food acquisition ((**A**): stone slab and roller, the size of the stone slab is marked in the figure; (**B**): stone hoe; (**C**,**D**): stone sickle; (**E**–**H**): bone harpoon; (**I**,**J**): arrowhead, after [47]).

The climatic deterioration and sophistication of the techniques for resource acquisition increased the value of specific rich resource patches, like the area around the Jiahu site. For one thing, climate deterioration resulted in a "patchy" distribution of freshwater resources that effectively constrained the distribution of the plants and animals that depended on them. This would concentrate the distributions of rich resource patches into smaller areas and increase the inter-patch distance [90]. Additionally, food resources in such rich patches could be fully exploited by human beings with the assistance of complex techniques. Under such circumstances, people would likely be tethered to such constrained areas instead of making a long-distance movement. This would facilitate the growth of local populations and even attract people from less affluent areas. The enlargement of the community size required more food supplies and therefore stimulated further resource intensification. Besides, increasing population density would have led to scalar stress among community members and might even have cause social conflict, which called for innovative sociopolitical solutions to cope [128]. The elaboration of ritual activities, the division and management of cemeteries, and perhaps even the construction of ditches at the boundary of the settlement at Phase 2 were likely used as a cultural means for the Jiahu community to enhance social integration. The intensification of ritual activities, as ethnographic evidence indicates, could also potentially have been used as a means to deal with subsistence stresses and risks, which often appear when factors like population growth, social interaction, environmental change, and climate fluctuation have broken up the pre-existing balance between humans and the environment [86,129].

3.2.2. Shunshanji and Hanjing

Shunshanji and Hanjing are two adjacent sites located in the low-lying hills of the lower Huai River drainage area in the eastern part of Huanghuai Plain, which is the transitional zone between North and Central China (respectively shown as 14 and 15 in maps "D" and "E" of Figure 1).

The cultural remains of Shunshanji can be divided into three phases. Radiocarbon dates indicate that Phase 1 and Phase 2 lasted from 8.5–8 ka BP (the boundary between Phases 1 and 2 is estimated to be at 8.3~8.2 ka BP), while Phase 3 is estimated as the period of 8–7 ka BP. The size of Shunshanji is 17.5 ha, which is the largest ever found before 8 ka BP in North China. An area of 2750 m^2 has been excavated in total over three field seasons. The settlement has a ditch that encircles an area of nearly 7.5 ha. The cultural remains were found both within and outside of the ditch, including houses, pit structures, and burials [51].

Phytoliths from the ditch profile reflect the impact of the 8.2 ka BP cooling event at the beginning of Phase 2, with types indicating the cold climate significantly increasing during this period [130]. Yet like the Jiahu site, the Shunshanji cultural remains suggest that the settlement became prosperous during Phase 2. During this period, the ditch was constructed and a cemetery appeared to the northwest of the ditch. The distribution of cultural remains expanded and a richer amount of artifacts and relics was deposited [51]. Such a pattern indicates more intensified occupation of the site. According to the presence of a large quantity of deer, boar, fish, and turtle bones and the features of lithic types [51,131], the subsistence base of the settlement was still based on the intensive exploitation of wild resources. Rice phytoliths have also been found, and interestingly, the amount of them in Phase 2 is higher than those from both Phases 1 and 3, which may suggest that people intensified the cultivation of rice to some extent during the cooling period and decreased the level of intensification when the climate returned to a warmer and wetter pattern [130]. Whether or not people applied institutionalized rituals to enhance social integration at Shunshanji is still not clear. But the placement of small animal- or human-shaped pottery figurines in the ditch might be correlated with specific rituals or sacrifices [132].

The Hanjing site is 4 km west of Shuishanji and radiocarbon dates indicate that the main occupational phase was contemporaneous with Shuishanji [52]. The Hanjing site is about 5 ha and a 3 ha area of the site was encircled by a ditch. The ditch was infilled with numerous types of garbage, like broken ceramics and animal bones. The evidence shows that the ditch was filled and the roads and activity zones were formed on top of it during the late occupational phase, suggesting the expansion of the site [52]. Besides the ditches, houses, and pit structure, a section of paddy field has been found, directly indicating intentional rice cultivation [131].

3.2.3. Zhangmatun and Xihe

Zhangmatun and Xihe are two adjacent sites (slightly more than 20 km apart) located in the transitional zone between the hills/low mountains of the Taiyi Mountain range and the North China alluvial plain in Shandong Province in eastern North China (respectively shown as 11 and 12 on maps "C", "D", and "E" of Figure 1). The Zhangmatun site is estimated to be as large as 0.7 ha, and 600 m^2 have been excavated. One pit house and one pit structure have been identified, along with a rich amount of faunal and floral remains. Dating results show that this site was occupied from 9 to 8.5 ka BP [48]. Although the limited excavation area does not allow us to explore the site's layout features, the appearance of a pit house and associated rich food remains resemble the site features of Jiahu Phase 1. Though the site size is smaller than Jiahu, it is larger than most of the sites classified as "transitional remains". Such evidence suggests that the transition into Neolithic lifeways, as indicated by growing residential stability, increasing levels of resource intensification, and the enlargement of group size, appeared prior to the 8.2 ka BP cooling event in this region.

The Xihe site dates to between 8.4 and 7.7 ka BP. The early occupational period of the site was contemporary with the 8.2 ka BP cooling event. More than 2400 m^2 of the site have been excavated, revealing over 30 houses and numerous surrounding pit structures. Houses were more densely distributed than in the Zhangmatun site. The largest house is more than 70 m^2 and most are as large as 25~50 m^2 [49]. The living floors and walls are more elaborately treated than the house found in Zhangmatun. The density of pottery in Xihe is also higher than in Zhangmatun, indicating that people used pottery far more frequently [133]. All these lines of evidence suggest that during the period of the cooling event, people were more stably settled in the circumscribed area, perhaps with a larger population aggregation and more intensified social integration (evidenced by the more compact distribution of houses and pit structures). However, the Xihe site is devoid of the elaborate expressions of ritual and symbolic affairs seen in the Jiahu site, indicating a less complex sociopolitical integration than at the Jiahu site.

The faunal and floral remains of Zhangmatun and Xihe indicate that people relied heavily on a wide range of wild resources and also incorporated domesticated crops and pigs as supplemental foods [20,134]. The domesticated crops in Zhangmatun were two types of millet (broomcorn and foxtail) [135]. The crops in Xihe were rice and foxtail millet [136]. The practice of rice cultivation, as well as a large amount of fish and bird bones found in both the Zhangmatun and Xihe sites, suggest that in addition to the exploitation of terrestrial resources, wetland and freshwater resources were intensively used [20].

3.2.4. Cishan

The Cishan site is located in the transitional zone between the Taihang Mountains and the North China plain (shown as 13 on maps "D" and "E" of Figure 1). Cishan has been dated between 8.4 and 7.6 ka BP. Three pit houses and 889 pit structures have been found within the 5519 m^2 excavation zone [137]. The site sits on a loess platform near a large river, and is not far from the forested piedmont zone. Such a location provides good opportunities for people to get resources from different environmental zones near the site [138].

The nature of the site is highly disputed. Given the facts that (1) millet and hackberry (*Celtis sinensis*) seeds have been found in some of the pit structures and (2) the majority of the remains are identified as pit structures instead of houses, some scholars have considered that the Cishan site was used as a specific place to store food resources and even hold sacrifice activities based on stored foods [139,140]. However, some scholars still insist that the Cishan was a residential site since it was excavated during the early period when the archaeologists still lacked the experience to distinguish large pit structures and small and simply built pit houses without interior hearths [141–143]. I agree with the inference that the Cishan site was a residential settlement for the following reasons: (1) some simply constructed houses could be mis-identified as large pit structures (i.e., middens or storage pits) and (2) the diversity of tools suggests that people were engaged in various activities besides the storage behaviors at Cishan, like woodworking, food processing, hunting, fishing, and cultivation [50]. The highly diversified faunal remains, such as migratory birds and deer with both dropped and undropped antlers, suggest multi-seasonal hunting [144]. Therefore, the Cishan community also shows a coping strategy of intensively using resources around the site and massively storing the food for delayed consumption in lean seasons. The large site area (estimated as roughly 10 ha) probably implies a large group aggregation as well.

However, the in situ distribution of about 140 suites of tool compounds reflects the behavior of intentionally preparing and leaving the tools for later use. This implies that people might have left the site temporarily and anticipated a later return [123]. Such combined evidence suggests that, on one the hand, Cishan communities stayed for a longer period of time in the site and repetitively used it based on a broad range of resources exploited from the surrounding environment. For another thing, the characteristics indicating sedentism were not yet stable.

3.2.5. Xiaohexi Remains

Prior to the flourishing development of Xinglongwa culture around 8~7.2 ka BP, a couple of newly discovered sites have been attributed to "Xiaohexi culture" in the west Liao River Valley in the northeast part of North China [145] (the type site, Xiaohexi, is marked as 16 on the maps "D" and

"E" of Figure 1). The Xiaohexi sites are usually located on slopes or high loess platforms along river valleys [146]. The age of these remains is mainly inferred from the stratigraphic evidence. The previous excavation of the Baiyinchanghan site revealed that a pit house of Xiaohexi culture was stratigraphically overlain by a pit house of early Xinglongwa culture [147], suggesting that at least part of the Xiaohexi remains might be even earlier than Xinglongwa culture, potentially with a time overlap with the 8.2 ka BP cooling event.

The Xiohexi sites are organized as hamlets or small villages. The appearance of pit houses and diversified toolkits indicates more settled lifeways with the intensive use of a wide range of surrounding resources near the site [80]. However, the Xiaohexi pottery is crude and simple in form [148]. The cultural deposits are thin and there are no complex overlaps of houses and pit structures built at different times, as seen in the Jiahu site [145]. Such patterns indicate that the degree of residential stability was lower than that of Jiahu.

3.2.6. Nucleated Sedentism and Resource Intensification: An Innovative Coping Strategy Occurred in Multiple Sites but in Different Expressions

All the sites I discussed above in this section (Section 3.2) point to increasing sedentism and resource intensification as a way to cope with environmental change—But expressed to varying degrees. The sedentism of the Jiahu site seems more stable since there is a complex pattern in which later houses or pit structures overlaid those built in earlier times. Corresponding sociopolitical practices to support the operation of the large and sedentary community of Jiahu were also more elaborate. The Shuishanji site is the largest site in this period, probably indicating the largest scale of population aggregation. The appearance of the cemetery and possible evidence of ritual or sacrifice activities also indicate intensified social integration. The fine-scale evaluation of the residential stability of Shuishanji is difficult since an only a very limited number of houses has been excavated. Yet according to the period of site occupation and relatively thick cultural deposition, we can at least infer that people inhabited and used this settlement with high levels of intensity.

As for the other sites, although they show tendencies of technological organization that are similar to Jiahu or Shunshanji/Hanjing, such as the increasing use of pottery and more sophisticated lithic and bone tool assemblages, they were less developed both in terms of the stability of sedentism or group aggregation and the elaboration of sociopolitical integration like those of Jiahu or Shuishanji. Such a pattern suggests that, even though people have attempted to rely on the increase in residential stability and resource intensification as a way to deal with environmental changes, the extent to which such a strategy can be fulfilled is still heavily influenced by the constraints of the local environment. The scale of the intensive use of wetland and aquatic resources in Jiahu, Shunshanji, and Hanjing seems larger than that of other sites mentioned above, indicating the importance of the exploitation of waterfront environments for the thriving development of Neolithic communities during the period of the 8.2 ka BP cooling event.

3.2.7. The Scarcity of the Archaeological Remains across North China and Its Implications

The distribution of the above-mentioned sites across multiple regions of North China suggest that the new coping strategy, applied to deal with the 8.2 ka BP cooling event, was not an occasionally occurring phenomenon confined to any specific region. Nonetheless, the site numbers are still scarce compared to those after 8 ka BP. There are vast gap areas distributed "in between" these sites which are devoid of any detachable sites. Though the absence of archaeological remains in these gap areas does not necessarily mean that people migrated out of such regions and left large portions of North China unoccupied, it is highly possible that people increased their mobility and left few visible remains for archaeologists since, as discussed in Section 2.3 of this article, increasing mobility could be an efficient coping strategy when used in an area with few or less rich resources to alleviate resource pressure and expand the area for resource exploitation [90]. Hence, the limited number of intensively occupied sites accompanied by vast "in between" areas devoid of any visible archaeological remains likely indicates that people might have adopted divergent ways to cope with environmental changes (nucleated sedentism, intensified resource exploitation vs. increase in mobility) across the area with varying degrees of resource affluency.

4. Discussion

4.1. Preexisting Cultural Preparations and the Path to the Neolithic Lifeway

The transitional remains of the Paleolithic to Neolithic disappeared during the period of the 8.2 ka BP cooling event. Such a change indicates that the land-use pattern, as reflected by the transitional sites, did not work well as an adaptive strategy for this climate fluctuation. People were either forced to return to more mobile lifeways to buffer against subsistence risks caused by the cooling event, or develop new forms of socioeconomic coping solutions.

The scarcity of archaeological remains probably indicates that people increased residential mobility in many regions of North China. However, a few sites, discussed in Section 3.2, like Jiahu, Shunshanji, Hanjing, Zhangmatun, Xihe, Cishan, and Xiaohexi, are quite distinctive since they show evidence for the initial formation of a "Neolithic package", indicating that people were economically and sociopolitically organized in new ways to pursue subsistence needs and interact with the environment. These groups were aggregated in larger communities and settled down in confined places based on the intensive resource exploitation of the surrounding area, combined with intensified hunting–gathering, part-time farming, and even small-scale animal husbandry. The locations of such settlements are usually in rich resource patches like the transitional zone between mountainous areas and plains, or between dryland and marshes and large water bodies. For one thing, some of these ecozones have certain types of highly productive food resources. For another, easy access to different ecozones provided people with diversified ranges of plant and animal resources to use [149].

People were able to fully exploit such "rich areas" partly based on the cultural preparations developed prior to the 8.2 ka BP cooling event. The onset of climate amelioration in the Early Holocene (12–8.5 ka BP) changed the resource distributional pattern and provided opportunities for people to experiment with new ways of resource exploitation and to modify their previous subsistence practices. Grinding stones and pottery became more widely adopted as part of the resource intensification techniques. Domesticated millet was incorporated for the first time into the diet, implying accumulated knowledge about plant domestication and cultivation. Such changes provided important technical and knowledge support for the further development of resource intensification. Accompanied by the modifications of subsistence practices, people began to stay for longer periods at certain sites and their mobility gradually decreased. Some even attempted to settle down in a few resource-rich areas with larger group sizes during 9~8.5 ka BP, as reflected by Jiahu Phase 1 and the Zhangmatun site.

Therefore, before the coming of the 8.2 ka BP cooling event, people in some regions of North China were fully prepared to intensify resource exploitation and increase sedentism as coping strategies to deal with climatic deterioration. However, since people's capabilities for food production were still low, and their subsistence basis was still heavily dependent on wild resources, the application of such a coping strategy only happened in the areas with rich resource patches, where people could take full advantage of extracting highly productive natural resources.

4.2. The Impact of Climate Change Coping Strategies on the Thriving Development of Neolithic Culture

Before the period of the 8.2 ka BP cooling event, sedentary settlements were only found sparsely in a few resource-affluent areas in North China. However, after the end of the 8.2 ka BP cooling event, sedentary settlements that embody distinctive Neolithic features thrived and became widely spread across different regions of North China (shown in Figure 1). Such a pattern indicates that the period around the 8.2 ka BP cooling event was a key time for the formation of Neolithic lifeways.

The specific interactive pattern between environmental change and the practice of coping strategies accounts for such significant social and cultural transitions. The drier and colder climate of the 8.2 ka BP cooling event reduced general resource affluence in North China and pushed the population in certain regions to aggregate in the constrained resource patches of relatively richer resource distributions than the surrounding areas. Under the general background of climatic deterioration, the values of such resource patches would have increased, which facilitated people to maintain long-term access to these places through more stable residency to ensure more persistent occupation and exclusive exploitation of such “sweet spots”. As a result, the land-use pattern became transformed from relatively extensive resource acquisition across broad regions into intensive resource exploitation in a circumscribed environment. Such a change created favorable conditions, as well as the stimulus, for the development and prevalence of techniques relevant to intensive resource exploitation, which contributed to the subsequent thriving development of Neolithic lifeways in two main aspects: first, it increased the levels of resource intensification and enabled people to acquire wild resources effectively and in substantial quantity in the circumscribed region during affluent seasons and store them for use during the lean season. On the other hand, as an important part of the resource intensification technique, the knowledge and skills of farming became further developed and people were able to use the benefits of the climatic amelioration after the end of the 8.2 ka BP cooling event to expand farming activity and increase the importance of domesticates as supplement food resources.

Besides consolidated economic bases, the maintenance of large group aggregation in the settled area also required sociopolitical innovations; otherwise, the population was inclined to split away and disperse when faced with increasing scalar stresses resulting from local population increases and densities [128]. Cemeteries, symbolic items, and ritual activities could have been effectively used to strengthen group identity and increase social integration [150,151]. The need to apply such sociopolitical innovations might at first have arisen in large aggregated communities that appeared around 8.5–8 ka BP, since the increased population was inclined to nucleate rather than split away under conditions when the environment outside the resource patches was less productive and there was a need for people to stay put in larger community sizes to facilitate perimeter defense. Among the sites found from around 8.5–8 ka BP, Jiahu, Shunshanji, and Hanjing show relatively large population aggregation and the most stable form of sedentism. The appearance of a cemetery in Jiahu and Shuishanji, as well as the emergence of ritual paraphernalia in Jiahu Phase 2, are ahead of the prevalent applications of such sociopolitical innovations during the prosperity of Neolithic culture after 8 ka BP [152]. Such a leading development of sociopolitical innovations might have provided the basis for future wide adoption by later societies.

Therefore, the application of resource intensification and increasing sedentism to deal with the climate fluctuation caused by the 8.2 ka BP cooling event provided favorable conditions for the convergence of the multiple “Neolithic traits” together, such as the sophistication of resource intensification techniques, sedentary inhabitation, the enlargement of group size, and the elaboration of social interaction. This combination generated new full-fledged forms of socioeconomic solutions to meet subsistence needs. Due to the environmental constraints around 8.2 ka BP, the appliance of such socioeconomic solutions was only possible in a few rich resource patches and was developed at different levels of prosperity in different regions. Nonetheless, after the 8.2 ka BP cooling event, the climate began to ameliorate and the warmer/wetter climate increased general resource affluence, creating more rich resource patches and decreasing the risks to food production. As a result, the practice of such new socioeconomic lifeways was less confined by environment constraints and was more widely adopted by people in different regions of North China.

5. Conclusions

As indicated by the material implications of the archaeological remains, certain types of “Neolithic traits” budded from the terminal Pleistocene to the early Holocene, accompanied by and partly as a consequence of climate amelioration. However, the dispersal of fully-fledged Neolithic lifeways across different regions of North China did not appear until the onset of the Holocene climate after 8–7.8 ka BP. The climate fluctuation caused by the 8.2 ka BP cooling event, which happened just before the coming of the climate optimum, exerted a significant impact on the development of the Neolithization process.

The occurrence of "pioneering" sites, with comprehensive Neolithic features during the period of 8.5–8 ka BP, suggests that changing environmental conditions required people to settle in relatively rich resource patches and form intensive interpersonal relationships, as well as between humans and resources. Such an intensive relationship required people to provide sufficient food supplies in the confined environment and develop more sophisticated socioeconomic mechanisms to reconcile social conflict and enhance the cohesion of the community. Therefore, as indicated by archaeological evidence, intensified techniques for resource acquisition were further developed based on the previous cultural accumulations. The innovative sociopolitical ways used to meet the social demand of nucleated sedentary societies also emerged during this period. The interplay of these two ever-evolving factors has fundamentally changed humans' land-use strategies and formed a new full-fledged sociopolitical practice for people to integrate their societies and interact with the environment. Taking favorable opportunities brought by climate amelioration after the period of the 8.2 ka BP cooling event, this Neolithic lifeway was widely adopted by people, it expanded into broader regions and was further developed, which was reflected in the thriving development of Early Neolithic cultures in North China.

Supplementary Materials: The following are available online at http://www.mdpi.com/2571-550X/3/3/23/s1, Table S1: The radiocarbon dates of the sites used for constructing the cumulative probability model of Figure 2 in the paper.

Funding: This research received no external funding.

Acknowledgments: Pei-Lin Yu from Boise State University contributed to the revision of the manuscript. Pu Yang from Nanjing University of Information Science and Technology provided important suggestions for the analysis of the Paleoclimate data. Yonaton Goldsmith from the Hebrew University of Jerusalem provided the important paleoclimatic dataset.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Shelach, G. The Development of Agriculture and Sedentary Life in North China. In *The Archaeology of Early China: From Prehistory to the Han Dynasty*; Shelach-Lavi, G., Ed.; Cambridge University Press: Cambridge, UK, 2015; pp. 68–102. [CrossRef]
2. Chen, S.; Yu, P.-L. Early "Neolithics" of China: Variation and evolutionary implications. *J. Anthropol. Res.* **2017**, *73*, 149–180. [CrossRef]
3. Zhao, Z. New Archaeobotanic Data for the Study of the Origins of Agriculture in China. *Curr. Anthropol.* **2011**, *52*, S295–S306. [CrossRef]
4. Barton, L.W. *Early Food Production in China's Western Loess Plateau*; University of California Davis: Davis, CA, USA, 2009.
5. Shelach-Lavi, G.; Teng, M.; Goldsmith, Y.; Wachtel, I.; Stevens, C.J.; Marder, O.; Wan, X.; Wu, X.; Tu, D.; Shavit, R.; et al. Sedentism and plant cultivation in northeast China emerged during affluent conditions. *PLoS ONE* **2019**, *14*, e0218751. [CrossRef] [PubMed]
6. Schettler, G.; Liu, Q.; Mingram, J.; Stebich, M.; Dulski, P. East-Asian monsoon variability between 15,000 and 2000 cal. yr BP recorded in varved sediments of Lake Sihailongwan (northeastern China, Long Gang volcanic field). *Holocene* **2006**, *16*, 1043–1057. [CrossRef]
7. Xu, Q.; Xiao, J.; Li, Y.; Tian, F.; Takeshi, N. Pollen-based quantitative reconstruction of Holocene climate changes in the Daihai Lake Area, Inner Mongolia, China. *J. Clim.* **2010**, *23*, 2856–2868. [CrossRef]
8. Wen, R.; Xiao, J.; Chang, Z.; Zhai, D.; Xu, Q.; Li, Y.; Itoh, S.; Lomtatidze, Z. Holocene climate changes in the mid-high-latitude-monsoon margin reflected by the pollen record from Hulun Lake, northeastern Inner Mongolia. *Quat. Res.* **2010**, *73*, 293–303. [CrossRef]
9. Alley, R.B.; Mayewski, P.A.; Sowers, T.; Stuiver, M.; Taylor, K.C.; Clark, P.U. Holocene climatic instability: A prominent, widespread event 8200 yr ago. *Geology* **1997**, *25*, 483. [CrossRef]
10. Rohling, E.J.; Pälike, H. Centennial-scale climate cooling with a sudden cold event around 8200 years ago. *Nature (London)* **2005**, *434*, 975–979. [CrossRef]

11. Chen, S. *The Prehistoric Modernization—An Ecological-based Exploration of the Process of Origin of Agriculture in China*; China Science Publishing: Beijing, China, 2013. (In Chinese)
12. Kelly, R.L. Mobility/Sedentism: Concepts, Archaeological Measures, and Effects. *Annu. Rev. Anthropol.* **1992**, *21*, 43–66. [CrossRef]
13. Cleland, C.E. The Focal-Diffuse model: An evoluntionary perspective on the prehistorical cultural adaptions of the eastern United States. *Midcont. J. Archaeol.* **1976**, *1*, 59–76.
14. Bar-Yosef, O.; Belfer-Cohen, A. The origins of sedentism and farming communities in the Levant. *J. World Prehistory* **1989**, *3*, 447–498. [CrossRef]
15. Bender, B. Gatherer-hunter to farmer: A social perspective. *World Archaeol.* **1978**, *10*, 204–222. [CrossRef]
16. Bandy, M.S.; Fox, J.R. Becoming Villagers: The Evolution of Early Village. In *Becoming Villagers: Comparing Early Village Societies*; Bandy, M.S., Fox, J.R., Eds.; The University of Arizona Press: Tucson, AZ, USA, 2010; pp. 1–16.
17. Ren, M. *The Compendium of Chinese Natural Geography*; The Commercial Press: Beijing, China, 1999; ISBN 9787100026277. (In Chinese)
18. Cohen, D.J. The beginnings of agriculture in China: A multiregional view. *Curr. Anthropol.* **2011**, *52*, S273–S293. [CrossRef]
19. Chen, W. The origin and development of the primitive agriculture. *Agricultural Archaeology* **2005**, *1*, 8–15. (In Chinese)
20. Wu, W. *Research on the Subsistence of Peiligang Period in North China*; Shandong University: Jinan, China, 2014. (In Chinese)
21. Fang, X.; Liu, C.; Hou, G. Reconstruction of precipitation pattern of China in the Holocene Megathermal. *Sci. Geogr. Sin.* **2011**, *31*, 1287–1292. (In Chinese)
22. Shi, Y.; Kong, Z.; Wang, S.; Tang, L.; Wang, F.; Yao, T.; Zhao, X.; Zhang, P.; Shi, S. Climate and environment of the Holocene megathermal maximum in China. *Sci. China Ser. B* **1993**, *27*, 481–493.
23. Shi, Y.; Kong, Z.; Wang, S.; Tang, L.; Wang, F.; Yao, T.; Zhao, X.; Zhang, P.; Shi, S. The climatic fluctuation and important event during the Holocene Megathermal in China. *Sci. China Ser. B* **1994**, *37*, 353–365.
24. Hai, C.; Fleitmann, D.; Edwards, L.R.; Wang, X.; Cruz, F.W.; Auler, A.S.; Mangini, A.; Wang, Y.; Kong, X.; Burns, S.J.; et al. Timing and structure of the 8.2 kyr B.P. event inferred from $\delta^{18}O$ records of stalagmites from China, Oman, and Brazil. *Geology* **2009**, *37*, 1007–1010.
25. Teller, J.T.; Leverington, D.W.; Mann, J.D. Freshwater outbursts to the oceans from glacial Lake Agassiz and their role in climate change during the last deglaciation. *Quat. Sci. Rev.* **2002**, *21*, 879–887. [CrossRef]
26. Cronin, T.M.; Vogt, P.R.; Willard, D.A.; Thunell, R.; Halka, J.; Berke, M.; Pohlman, J. Rapid sea level rise and ice sheet response to 8200-year climate event. *Geophys. Res. Lett.* **2007**, *34*. [CrossRef]
27. Kobashi, T.; Severinghaus, J.P.; Brook, E.J.; Barnola, J.-M.; Grachev, A.M. Precise timing and characterization of abrupt climate change 8200 years ago from air trapped in polar ice. *Quat. Sci. Rev.* **2007**, *26*, 1212–1222. [CrossRef]
28. Chiang, J.C.H.; Bitz, C.M. Influence of high latitude ice cover on the marine Intertropical Convergence Zone. *Clim. Dyn.* **2005**, *25*, 477–496. [CrossRef]
29. Park, J.; Park, J.; Yi, S.; Kim, J.C.; Lee, E.; Jin, Q. The 8.2 ka cooling event in coastal East Asia: High-resolution pollen evidence from southwestern Korea. *Sci. Rep.* **2018**, *8*, 12423. [CrossRef] [PubMed]
30. Wang, N.; Yao, T.; Thompson, L.G.; Henderson, K.A.; Davis, M.E. Evidence for cold events in the early Holocene from the Guliya ice core, Tibetan Plateau, China. *Chin. Sci. Bull.* **2002**, *47*, 1422–1427. [CrossRef]
31. Dykoski, C.A.; Edwards, R.L.; Cheng, H.; Yuan, D.; Cai, Y.; Zhang, M.; Lin, Y.; Qing, J.; An, Z.; Revenaugh, J. A high-resolution, absolute-dated Holocene and deglacial Asian monsoon record from Dongge Cave, China. *Earth Planet. Sci. Lett.* **2005**, *233*, 71–86. [CrossRef]
32. Li, X.; Hu, C.; Huang, J.; Xie, S.; Baker, A. A 9000-year carbon isotopic record of acid-soluble organic matter in a stalagmite from Heshang Cave, central China: Paleoclimate implications. *Chem. Geol.* **2014**, *388*, 71–77. [CrossRef]
33. Dong, J.; Shen, C.-C.; Kong, X.; Wang, H.-C.; Jiang, X. Reconciliation of hydroclimate sequences from the Chinese Loess Plateau and low-latitude East Asian Summer Monsoon regions over the past 14,500 years. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **2015**, *435*, 127–135. [CrossRef]
34. Liu, Y.; Hu, C. Quantification of southwest China rainfall during the 8.2 ka BP event with response to North Atlantic cooling. *Clim. Past* **2016**, *12*, 1583–1590. [CrossRef]

35. Wu, J.Y.; Wang, Y.J.; Cheng, H.; Kong, X.G.; Liu, D. Stable isotope and trace element investigation of two contemporaneous annually-laminated stalagmites from northeastern China surrounding the "8.2 ka event". *Clim. Past* **2012**, *8*, 1497–1507. [CrossRef]
36. Wang, H.; Hong, Y.; Lin, Q.; Hong, B.; Zhu, Y.; Wang, Y.; Xu, H. Response of humification degree to monsoon climate during the Holocene from the Hongyuan peat bog, eastern Tibetan Plateau. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **2010**, *286*, 171–177. [CrossRef]
37. Yu, J. The discovery of the Early Neolithic site Zhuannian, Beijing. *Beijing Wenbo* **1998**, *3*, 2–4. (In Chinese)
38. Zhao, C. The prehistoric Donghulin site in Mentougou district, Bejing City. *Kaogu* **2006**, *7*, 3–8. (In Chinese)
39. Li, J.; Qiao, Q.; Ren, X. The report of 1997's excavation of Nanzhuangtou site in Xushui, Hebei. *Acta Archaeol. Sin.* **2010**, *3*, 362–391. (In Chinese)
40. Yuan, S. AMS radiocarbon dating of Xinglong carved antler, Shiyu and Ximiao sites. *Acta Anthropol. Sin.* **1993**, *1*, 92–95. (In Chinese)
41. Mei, H. *The Transition from Paleolithic to Neolithic age in Nihewan Basin—The Discovery and Research of Yujiagou Site in Yangyuan*; Peking University: Beijing, China, 2007. (In Chinese)
42. Sun, B.; Cui, S. An exploration of the Early Neolithic remains in Shandong region. *Cultral Relics Cent. China* **2008**, *3*, 23–28. (In Chinese)
43. Sun, B.; Wagner, M.; Zhao, Z.; Li, G.; Wu, X.; Tarasov, P.E. Archaeological discovery and research at Bianbiandong early Neolithic cave site, Shandong, China. *Quat. Int.* **2014**, *348*, 169–182. [CrossRef]
44. Wang, Y.; Zhang, S.; Gu, W.; Wang, S.; He, J.; Wu, X.; Qu, T.; Zhao, J.; Chen, Y.; Bar-Yosef, O. Lijiagou and the earliest pottery in Henan Province, China. *Antiquity* **2015**, *89*, 273–291. [CrossRef]
45. Shi, J.; Song, Y. The excavation to Locality S9 of the Shizitan Site in Ji County, Shanxi. *Kaogu* **2010**, *10*, 7–17. (In Chinese)
46. Shi, J.; Chen, H.; Song, Y.; Shi, X.; Wei, X.; Li, L. Preliminary report on the excavation at the Locality S12G of the Shizitan site in Ji County, Shanxi Province. *Kaogu Yu Wenwu* **2013**, *3*, 3–8. (In Chinese)
47. Henan Antique Archaeology Institute. *Wuyang Jiahu*; China Science Publishing: Beijing, China, 1999. (In Chinese)
48. Wang, F.; Li, M. The Early Neolithic remains of Zhangmatun Site in Jinan City. *Kaogu* **2018**, *2*, 116–120. (In Chinese)
49. Liu, Y.; Wang, Z.; Zhang, K.; Li, S.; Wang, Z.; Zang, Z.; Sun, T.; Zhang, Z. The excavation report of the Xihe Site in Zhangqiu, 2008. *Haidai Kaogu* **2012**, *5*, 67–138. (In Chinese)
50. Sun, D.; Liu, Y.; Chen, G. The Cishan site in Wuan, Hebei. *Acta Anthropol. Sin.* **1981**, *3*, 303–338. (In Chinese)
51. Lin, L.; Gan, H.; Yan, L. The excavation of the Shunshanji site of Neolithic Age in Sihong County, Jiangsu. *Acta Anthropol. Sin.* **2014**, *4*, 519–562. (In Chinese)
52. Dai, X.; Zhuang, L.; Yu, H.; Lu, H.; Sun, Y.; Lu, J.; Shi, Y.; Fan, J.; Jiang, M.; Fang, D.; et al. 2014 excavational report of the Hanjing Site in Sihong, Jiangsu Province. *Culture of Southeast China* **2018**, *1*, 20–27. (In Chinese)
53. Inner Mongolia Antique Archaeology Institute. *Baiyinchanghan—The Excavation Report of the Neolithic Settlement*; China Science Publishing: Beijing, China, 2004. (In Chinese)
54. Liu, G.; Jia, X.; Zhao, M.; Tian, G.; Shao, G. The excavation of the Xinglonggou settlement in 2002–2003 season of the Chifeng city, Inner Mongolia. *Kaogu* **2004**, *7*, 3–8. (In Chinese)
55. Yang, H.; Zhu, Y.; Kong, Z.; Du, N. The preliminary report of the Xinglongwa site in Aohan Banner, Inner Mongolia. *Kaogu* **1985**, *10*, 865–874. (In Chinese)
56. Liaoning Antique Archaeology Institute. *Chahai: The Excavation Report of a Neolithic Settlement*; Antique Publishing House: Beijing, China, 2012. (In Chinese)
57. Yu, J.; Wang, Y. The preliminary report of the Shangzhai Neolithic site in Pinggu, Beijing. *Wenwu* **1989**, *8*, 1–8. (In Chinese)
58. Chen, Z.; Liu, H.; Zhang, X.; Yang, G.; Zheng, S.; Zhang, Y.; Yuan, Q.; Fu, Y.; Liu, H.; Zhou, S.; et al. The archaeoloigcal report of the Beiwang site, Langfang. *Wenwu Chunqiu* **2010**, *1*, 17–29. (In Chinese)
59. Duan, H. *Beifudi: The Prehistoric Site of Yi River Valley*; Cutural Relics Press: Beijing, China, 2007. (In Chinese)
60. He, D.; Xu, X. A preliminary exploration of Houli culture in Jinan region. *Shiqian Yanjiu* **2013**, *30*, 115–124. (In Chinese)
61. Sun, Q. *A Study of Houli Culture*; Shandong University: Jinan, China, 2014. (In Chinese)
62. Geng, Q. The trial excavation of the Huawo site in Qi county, Henan. *Kaogu* **1981**, *3*, 279–281. (In Chinese)
63. Wang, J. The Shawoli Neolithic site in Xinzheng, Henan. *Kaogu* **1983**, *12*, 1057–1065. (In Chinese)

64. Ren, W.; Wang, J.; Zheng, N. The report of the 1979-year excavation of the Peiligang site. *Acta Anthropol. Sin.* **1984**, *1*, 23–52. (In Chinese)
65. Xin, Y.; Hu, Y.; Zhang, Y.; Liu, Q. Excavation to the remains of Peiligang culture of the Tanghu site at Xinzheng City, Henan in 2007. *Kaogu* **2010**, *5*, 3–23. (In Chinese)
66. Guo, T.; Chen, J. The Archaeological report of Shigu site, Changge. *Huaxia Archaeol.* **1987**, *1*, 3–125. (In Chinese)
67. Zheng, N. The preliminary report of the excavation of the Shuiquan Neolithic site of Jia county, Henan. *Kaogu* **1992**, *10*, 865–874. (In Chinese)
68. Zheng, N. The preliminary report of the excavation of the Zhongshanzhai site in Linru, Henan. *Kaogu* **1986**, *7*, 577–585. (In Chinese)
69. Yang, Z. The preliminary report of the Egou Beigang Neolithic site in Mi county, Henan. *Wenwu* **1979**, *5*, 14–19. (In Chinese)
70. Li, Y. The preliminary report of the trial excavation of the Tieshenggou Early Neolithic site in Gong county, Henan. *Wenwu* **1980**, *5*, 16–19. (In Chinese)
71. Wang, J.; Zhang, X. A discussion on chronology of Yangshao culture remains at the Bancun site and the related issues. *Kaogu yu Wenwu* **2001**, *3*, 41–50. (In Chinese)
72. Zhang, R. The preliminary report of the second and third excavation of the Beiliu site in Weinan. *Shiqian Yanjiu* **1986**, *4*, 111–128. (In Chinese)
73. Chinese Academy of Social Sciences. *The Excavation Report of Baijia Cun Site in Lintong*; Bashu Publishing House: Chengdu, China, 1994. (In Chinese)
74. Chen, Y. A re-exmination of the Beishouling Early Neolithic site. *Huaxia Archaeol.* **1990**, *3*, 70–85. (In Chinese)
75. Gansu Antique Archaeology Institute. *Qinan Dadiwan—The Archaeological Report of the Neolithic Site*; Cultural Relics Publishing: Beijing, China, 2006. (In Chinese)
76. Li, Y. The survey and trial excavation of the Malianggou site in Mi county, Henan. *Kaogu* **1981**, *3*, 282–284. (In Chinese)
77. Anhui Antique Archaeology Institute; Bengbu Museum. *Bengbu Shuangdun—Neolithic Site Excavation Report*; China Science Publishing: Beijing, China, 2008. (In Chinese)
78. Jia, Q. Shishanzi Neolithic site in Suixi, Anhui. *Kaogu* **1992**, *3*, 193–203. (In Chinese)
79. Wang, J.; Wu, J.; Liang, Z. The preliminary report of the Xiaoshankou and Gutaisi sites in Su county, Anhui. *Kaogu* **1993**, *12*, 1062–1075. (In Chinese)
80. Yang, H.; Lin, X. The preliminary analysis of Xiaohexi Sites in Aohan Banner, Inner Mongolia. *Beifang Wenwu* **2009**, *2*, 3–6. (In Chinese)
81. Andersen, K.K.; Azuma, N.; Barnola, J.M.; Bigler, M.; Biscaye, P.; Caillon, N.; Chappellaz, J.; Clausen, H.B.; Dahl-Jensen, D.; Fischer, H.; et al. High-resolution record of Northern Hemisphere climate extending into the last interglacial period. *Nature* **2004**, *431*, 147–151. [CrossRef] [PubMed]
82. Dong, J.; Shen, C.-C.; Kong, X.; Wu, C.-C.; Hu, H.-M.; Ren, H.; Wang, Y. Rapid retreat of the East Asian summer monsoon in the middle Holocene and a millennial weak monsoon interval at 9 ka in northern China. *J. Asian Earth Sci.* **2018**, *151*, 31–39. [CrossRef]
83. Halstead, P.; O'Shea, J.O. Introduction: Cultural responses to risk and uncertainty. In *Bad Year Economics: Cultural Responses to Risk and Uncertainty*; Halstead, P., O'Shea, J.O., Eds.; Cambridge University Press: Cambridge, UK, 1989; pp. 1–7.
84. Rosen, A.M. *Civilizing Climate: Social Responses to Climate Change in the Ancient Near East*; Altamira: London, UK, 2007.
85. Steward, J.H. Ecological Aspects of Southwestern Society. *Anthropos* **1937**, *32*, 87–104.
86. O'Shea, J.O.; Halstead, P. *Conclusion: Bad year economics In Bad Year Economics: Cultural Responses to Risk and Uncertainty*; Halstead, P., O'Shea, J.O., Eds.; Cambridge University Press: Cambridge, UK, 1989; pp. 123–126.
87. Bar-Yosef, O. Climatic fluctuations and early farming in West and East Asia. *Curr. Anthropol.* **2011**, *52*, S175–S193. [CrossRef]
88. Minc, L.D.; Smith, K.P. The spirit of survival: Cultural responses to resource variability in North Alaska. In *Bad Year Economics: Cultural Responses to Risk and Uncertainty*; Halstead, P., O'Shea, J.O., Eds.; Cambridge University Press: Cambridge, UK, 1989; pp. 8–39.
89. Chen, S.; Yu, P.-L. Intensified foraging and the roots of farming in China. *J. Anthropol. Res.* **2017**, *73*, 381–412. [CrossRef]

90. Barton, L.; Brantingham, P.J.; Ji, D. Late Pleistocene climate change and Paleolithic cultural evolution in northern China: Implications from the Last Glacial Maximum. In *Developments in Quaternary Sciences*; Elsevier: Amsterdam, The Netherlands, 2007; Volume 9, pp. 105–128.
91. Ji, D.; Chen, F.; Bettinger, R.I.; Elston, R.; Geng, Z.; Barton, L.M.; Wang, H.; An, C.; Zhang, D. Human response to the Last Glacial Maximum: Evidence from North China. *Acta Anthropol. Sin.* **2005**, *4*, 270–282. (In Chinese)
92. Elston, R.G.; Guanghui, D.; Dongju, Z. Late Pleistocene intensification technologies in Northern China. *Quat. Int.* **2011**, *242*, 401–415. [CrossRef]
93. Fang, X.; Jiang, H.; Lian, P. Range and rate of abrupt change of precipitation around 3500 ka BP in the North China Farming-grazing transitional zone. *Earth Sci. Front.* **2002**, *1*, 163–167. (In Chinese)
94. Hou, G.; Liu, F.; Liu, C.; Fang, X. Prehistorical Cultural Transition Forced by Environmental Change in Mid-Holocene in Gansu-Qinghai Region. *Acta Anthropol. Sin.* **2009**, *1*, 53–58. (In Chinese)
95. Chen, S. The adaptative changes of the prehistoric cultures in the zones along Yanshan mountains and the Great Wall. *Acta Anthropol. Sin.* **2011**, *1*, 1–22. (In Chinese)
96. Kelly, R.L. Hunter-Gatherer mobility strategies. *J. Anthropol. Res.* **1983**, *39*, 277–306. [CrossRef]
97. Rowley-Conwy, P.A.; Zvelebil, M. Saving it for later: Storage by prehistoric hunter-gatherers in Europe. In *Bad Year Economics: Cultural Responses to Risk and Uncertainty*; Cambridge University Press: Cambridge, UK, 1989; pp. 40–56.
98. Testart, A.; Forbis, R.G.; Hayden, B.; Ingold, T.; Perlman, S.M.; Pokotylo, D.L.; Rowley-Conwy, P.; Stuart, D.E. The significance of food storage among Hunter-Gatherers: Residence patterns, population densities, and social inequalities. *Curr. Anthropol.* **1982**, *23*, 523–537. [CrossRef]
99. Hayden, B.; Bowdler, S.; Butzer, K.W.; Cohen, M.N.; Druss, M.; Dunnell, R.C.; Goodyear, A.C.; Hardesty, D.L.; Hassan, F.A.; Kamminga, J.; et al. Research and development in the stone age: Technological transitions among Hunter-Gatherers. *Curr. Anthropol.* **1981**, *22*, 519–548. [CrossRef]
100. Rowley-Conwy, P.; Layton, R. Foraging and farming as niche construction: Stable and unstable adaptations. *Philos. Trans. Biol. Sci.* **2011**, *366*, 849–862. [CrossRef]
101. Black, R.; Adger, W.N.; Arnell, N.W.; Dercon, S.; Geddes, A.; Thomas, D. The effect of environmental change on human migration. *Glob. Environ. Chang.* **2011**, *21*, S3–S11. [CrossRef]
102. Flohr, P.; Fleitmann, D.; Matthews, R.; Matthews, W.; Black, S. Evidence of resilience to past climate change in Southwest Asia: Early farming communities and the 9.2 and 8.2 ka events. *Quat. Sci. Rev.* **2016**, *136*, 23–39. [CrossRef]
103. Zvelebil, M. The mesolithic context of the transition to farming. In *Hunters in Transition: Mesolithic Societies of Temperate Eurasia and Their Transition to Farming*; Zvelebil, M., Ed.; Cambridge University Press: Cambridge, UK, 1986; pp. 5–15.
104. Weissner, P. Risk, Reciprocity and Social Influence in !Kung San Politics. In *Politics and History in Band Societies*; Leacock, E., Lee, R., Eds.; Cambridge University Press: Cambridge, UK, 1982; pp. 61–84.
105. Lu, T.L.D. *The Transition from Foraging to Farming and the Origin of Agriculture in China*; BAR International Series 774; British Archaeological Reports: Oxford, UK, 1999.
106. An, Z. Archaeological research on Neolithic China. *Curr. Anthropol.* **1988**, *29*, 753–759.
107. Wang, Y.; Zhang, S.; He, J.; Wang, S.; Zhao, J.; Qu, T.; Wang, J.; Gao, X. The excavation of the Lijiagou Site in Xinmi city, Henan. *Kaogu* **2011**, *4*, 3–9. (In Chinese)
108. Liu, L.; Chen, X. Neolithization: Sedentism and food production in the Early Neolithic (7000–5000 BC). In *The archaeology of China: From the Late Paleolithic to the Early Bronze Age*; Liu, L., Chen, X., Eds.; Cambridge University Press: Cambridge, UK, 2012; pp. 123–168.
109. Yang, X.; Ma, Z.; Li, J.; Yu, J.; Stevens, C.; Zhuang, Y. Comparing subsistence strategies in different landscapes of North China 10,000 years ago. *Holocene* **2015**, *25*, 1957–1964. [CrossRef]
110. Yang, X.; Wan, Z.; Perry, L.; Lu, H.; Wang, Q.; Zhao, C.; Li, J.; Xie, F.; Yu, J.; Cui, T.; et al. Early millet use in northern China. *Proc. Natl. Acad. Sci. USA* **2012**, *109*, 3726–3730. [CrossRef] [PubMed]
111. Zhao, Z. The process of origin of agriculture in China: Archaeological evidence from flotation results. *Quanternary Sci.* **2014**, *1*, 73–84. (In Chinese)
112. Chen, Y.; Qu, T. An Exploration of the complex phenomena of society in North China at around 10 ka B.P. *Zhongyuan Wenwu* **2012**, *3*, 20–26. (In Chinese)
113. Sturm, C.; Clark, J.K.; Barton, L. The Logic of Ceramic Technology in Marginal Environments: Implications for Mobile Life. *Am. Antiq.* **2016**, *81*, 645–663. [CrossRef]

114. Eerkens, J.W. Residential mobility and pottery sse in the western Great Basin. *Curr. Anthropol.* **2003**, *44*, 728–738. [CrossRef]
115. Shelach-Lavi, G.; Tu, D. Food, pots and socio-economic transformation: The beginning and intensification of pottery production in North China. *Archaeol. Res. Asia* **2017**, *12*, 1–10. [CrossRef]
116. Liu, L.; Field, J.; Fullagar, R.; Zhao, C.; Chen, X.; Yu, J. A functional analysis of grinding stones from an early holocene site at Donghulin, North China. *J. Archaeol. Sci.* **2010**, *37*, 2630–2639. [CrossRef]
117. Xiang, J. The Variations of the Origin of Grounding Stone between South and North China. *Nanfang Wenwu* **2014**, *2*, 101–109. (In Chinese)
118. Cui, T. *The Study of Donghulin Site's Lithic Assemblage—The Lithic Industry and Human Behavioral in the Process of Paleolithic to Neolithic Age*; Peking University: Beijing, China, 2010. (In Chinese)
119. Henan Antique Archaeology Institute; University of Science and Technology of China. *Wuyangjiahu II*; China Science Publishing: Beijing, China, 2015. (In Chinese)
120. Chi, Z.; Hung, H.-C. Jiahu 1: Earliest farmers beyond the Yangtze River. *Antiquity* **2013**, *87*, 46–63. [CrossRef]
121. Yang, Y.; Zhang, J.; Lan, W.; Cheng, Z.; Yuan, Z.; Zhu, Z. The Excavation of the Jiahu Site in Wuyang County, Henan in 2013. *Kaogu* **2017**, *12*, 3–20. (In Chinese)
122. Lin, Y. The key changes during the transition from Paleolithic to Neolithic Age in North China. *Wenwu Chunqiu* **2016**, *2*, 12–17. (In Chinese)
123. Li, B. *The Abandonment Process Research of Early Neolithic Sites in Northern China*; Jilin University: Changchun, China, 2018. (In Chinese)
124. Cui, Q. *The Lithics Analysis of Jiahu Site in Wuyang, Henan*; University of Science and Technology of China: Hefei, China, 2018. (In Chinese)
125. Lai, Y.; Zhang, J.; Yin, R. On instruments of production and economic structure of Jiahu site in Wuyang. *Zhongyuan Wenwu* **2009**, *2*, 22–28. (In Chinese)
126. Zhao, Z.; Zhang, J. Report on the analysis of the results of the 2001 flotation of the Jiahu site. *Kaogu* **2009**, *8*, 84–93. (In Chinese)
127. Cucchi, T.; Hulme-Beaman, A.; Yuan, J.; Dobney, K. Early Neolithic pig domestication at Jiahu, Henan Province, China: Clues from molar shape analyses using geometric morphometric approaches. *J. Archaeol. Sci.* **2011**, *38*, 11–22. [CrossRef]
128. Bandy, M.S. Fissioning, scalar stress, and social evolution in early village societies. *Am. Anthropol.* **2004**, *106*, 322–333. [CrossRef]
129. Bollig, M. *Risk Management in a Hazardous Environment—A Comparative Study of Two Pastoral Societies*; Springer: Berlin/Heidelberg, Germany, 2006.
130. Wu, W.; Lin, L.; Gan, H.; Jin, G. Environment and subsistence of the second phase of Shunshanji site: Evidence from phytolith analysis. *Zhongguo Nongshi* **2017**, *36*, 3–14. (In Chinese)
131. Zhuang, L.; Yu, H.; Qiu, Z.; Yan, L.; Liu, S.; Pan, M.; Ning, Z.; Jiang, M.; Fang, D.; Ma, G.; et al. 2015 and 2016 Excavational Report of the Hanjing Site in Sihong, Jiangsu Province. *Dongnan Wenhua* **2018**, *1*, 28–39. (In Chinese)
132. Lin, L.; Gan, H.; Yan, L.; Jiang, F. The Shunshanji site of the Neolithic age in Sihong County, Jiangsu. *Kaogu Xuebao* **2013**, *7*, 3–14. (In Chinese)
133. Liu, Y.; Lan, Y.; Tong, P. Excavation at the Neolithic Xihe site in Zhangqiu City, Shandong in 1997. *Kaogu* **2000**, *10*, 15–28. (In Chinese)
134. Song, Y. The comprehensive analysis of fauna remains of Houli cultural period in Jinan region. *Huaxia Kaogu* **2016**, *3*, 53–59. (In Chinese)
135. Wu, W.; Jin, G.; Wang, X. Plant cultivation and the subsistence of Houli Culture: Evidences from Zhangmatun site, Jinan city. *Zhongguo Nongshi* **2015**, *34*, 3–13. (In Chinese)
136. Wu, W.; Zhang, K.; Wang, Z.; Jin, G. The Analysis of the Plant Remains from Xihe Site, Zhangqiu (2008). *Dongfang Kaogu* **2013**, *10*, 373–390. (In Chinese)
137. Jin, J. A preliminary exploration of the "Tool Compounds" in late phase of the Cishan site. *Kaogu* **1995**, *3*, 231–237. (In Chinese)
138. Tong, W. The primary farming remains and the related issues of Cishan site. *Nongye Kaogu* **1984**, *1*, 194–207. (In Chinese)

139. Li, G. The transmission of millet and broomcorn millet around eight thousand years in North China and transfer characteristics of Cishan site in the east line of Taihang Mountain. *Nanfang Wenwu* **2018**, *1*, 229–251. (In Chinese)
140. Bu, G. The sacrificial site of Cishan and the related issues. *Wenwu* **1987**, *11*, 43–47. (In Chinese)
141. Luo, P. The houses of Cishan people. *Wenwu Chunqiu* **2006**, *1*, 1–2. (In Chinese)
142. Chen, S. *Adaptive Changes of Prehistoric Hunter—Gatherers during the Pleistocene-Holocene Transition in China*; Southern Methodist University: Dallas, TX, USA, 2004.
143. Yue, Q. An investigation of "Pit Structure" of the Cishan site. *Gujin Nongye* **1992**, *2*, 27–30. (In Chinese)
144. Zhou, B. The fauna remains of the Cishan site, Hebei. *Kaogu Xuebao* **1981**, *3*, 339–347. (In Chinese)
145. Suo, X. The preliminary analysis of Xiaohexi Culture. *Kaogu yu Wenwu* **2005**, *1*, 23–27. (In Chinese)
146. Wu, L. The micro-perspective analysis of the settlement of Xiaohexi culture in West Liao River Valley. *J. Chifeng Univ. Soc. Sci.* **2014**, *35*, 1–5. (In Chinese)
147. Suo, X.; Guo, Z. Xiaohexi Culture remains at the Baiyinchanghan Site. *Res. China's Front. Archaeol.* **2004**, *3*, 301–310. (In Chinese)
148. Shelach-Lavi, G.; Teng, M.; Goldsmith, Y.; Wachtel, I.; Ovadia, A.; Wan, X.; Marder, O. Human adaptation and socioeonomic change in northeast China: Results of the Fuxin regional survey. *J. Field Archaeol.* **2016**, *41*, 467–485. [CrossRef]
149. Janz, L. Fragmented landscapes and economies of abundance: The Broad-Spectrum revolution in Arid East Asia. *Curr. Anthropol.* **2016**, *57*, 537–564. [CrossRef]
150. Cohen, A.B. "Ritualization" in early village society: The case of the lake Titicaca Basin Formative. In *Becoming Villagers: Comparing Early Village Societies*; Bandy, M.S., Fox, J.R., Eds.; The University of Arizona Press: Tucson, AZ, USA, 2010; pp. 81–99.
151. Mantha, A. Territoriality, social boundaries and ancestor veneration in the central Andes of Peru. *J. Anthropol. Archaeol.* **2009**, *28*, 158–176. [CrossRef]
152. Chen, M. *A Study of the Cutlure and Society of Peiligang Period*; Fudan University: Shanghai, China, 2013. (In Chinese)