Adaptation or Decline? Consequences of Climate Change in Iran

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1. Introduction

Human health, subsistence, and culture have always been influenced by climate change, from hunter-gatherer communities in the Pleistocene to food producer societies in the Holocene (DeMenocal, 2001; Prentice, 2009; Weiss, 2000). Climatic conditions have been constantly fluctuating at different temporal and spatial scales for a variety of reasons (Berger, 2013; Clark et al., 2002; Shindell et al., 2003). Abrupt climatic changes have caused severe tensions and pressures on the nature and subsistence patterns of human societies and played an important role in the cultural transitions (Anderson et al., 2007; Dalfes et al., 2013; Danti, 2010; Gupta, 2004; Staubwasser and Weiss, 2006; Weiss, 1997). Thus, the adaptation or decline of human societies is directly dependent on the extent of the vulnerability, the public's perception of the importance of climate change, and the effective actions of statesmen to mitigate this phenomenon (Semenza et al., 2008).

The intensification of global warming and increasing extreme weather events, especially floods and droughts, have imposed heavy losses and damages to the industrial and agricultural sectors in Iran over the past fifteen years. Two major problems in Iran are the concentration of power in Tehran (located in North Central Iran) and the ignorance/denial of many officials about the possible consequences of climate change. This led us to recount the Holocene climatic events and their effects on human societies from the Neolithic to the Iron Age (with a case study of the North Central Iran region), as well as propose some possible methods of adaptation and resilience to climate change. The main question is, if this situation continues, to what extent will Iran be able to withstand the consequences of climate change? This country, due to its historical and archeological background, and as one of the most vulnerable countries in the world in terms of environmental conditions and water resources, needs to take greater steps to adapt to the current global warming; otherwise it will soon face severe social and political risks (Madani, 2014).

2. Climate change

Although the general temperature trend in the late Holocene epoch, according to the paleoclimate research of a Greenland ice core (GISP2), indicates cooling (Alley, 2004), due to intense human activities and population growth over the last two hundred years, Earth's temperature has been rising at an accelerating rate. The effects of this climate change on nature include the rising and acidification of ocean water, the melting of glaciers, the rise of El Niño events, and extreme weather events such as heat waves, cold spells, severe storms, flooding, droughts, dust storms, and wildfires which disrupt the life of several species. These effects can also have devastating consequences for human health, not only as direct threats to human lives, but also as a cause of internal and external social conflicts (especially water wars), widespread migrations, the spread of fatal diseases, and increased mortality (Pachauri et al., 2014). While the global warming crisis is on the rise, the increasing population will undoubtedly increase the risks.

3. Holocene Climate Change in the Middle East

Climatic archives around the world show that during the Holocene, abrupt climate change has occurred repeatedly (Alley et al., 2003; Bond et al., 1997; Mayewski et al., 2004). Climate change has had devastating effects on many human cultures and civilizations. For example, during the 8.2 ka BP climatic event, a severe cooling period (less severe than Younger Dryas) occurred in the northern hemisphere, which caused severe droughts in the Middle East by weakening Indian monsoons and the Mediterranean and Sudanese precipitation systems (Alley and Ágústsdóttir, 2005; Dixit et al., 2014; Rohling and Pälike, 2005). Most Neolithic cultures in southwest Asia were disrupted in the second half of the 7th millennium BC. The event also triggered the spread of early farmers, by different routes, out of West Asia and the Near East into Greece and Bulgaria (Budja, 2007; Weninger et al., 2006). Historical studies of the last two thousand years show that cooling periods have been directly related to the prevalence of fatal infectious

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epidemics, such as plague and cholera (McMichael, 2012). Therefore, the presence of cooling events has likely led to population decline during this period. Also, during the 5.2, 4.2, and 3.2 ka BP events, the occurrence of severe droughts (in the Northern Hemisphere) caused the decline of many Middle Eastern cultures and civilizations through famine, war, mass migration, sand and dust storms, and possibly the spread of epidemics. The collapse of the developed Uruk culture in Mesopotamia is likely to be justified by the 5.2 ka BP dry event (Danti, 2010; Postgate, 1986; Weiss, 2003), and the 4.2 ka BP Megadrought event appears to be the root cause of the decline for almost all Middle East civilizations of that time: the collapse of the Akkad dynasty, the First Intermediate period in Egypt, and the post-urbanization period in the Indus Valley (Hassan, 1997; Possehl, 1997; Staubwasser et al., 2003; Weiss et al., 1993; Weiss, 2016; Welc and Marks, 2014). Also, the period of wars, civil conflicts, migrations, and the collapse of powerful civilizations such as the Kassites (the Middle Babylonian dynasty in Mesopotamia), the Hittites (in Anatolia), Ugarit (in Syria), and the weakening of the Egyptian kingdom between 1200 and 900 BC has been synchronous with the 3.2 ka BP drought event (Kaniewski et al., 2015, 2019).

4. Iran's vulnerability to climate change

Iran lies between latitudes 24° and 40° N and longitudes 44° and 64° E, and due to its proximity to the subtropical region, generally has a semi-arid to arid climate and desert nature. Therefore, the country has been severely vulnerable to drought periods. For example, during the severe drought of the years 1870 to 1872, over one million people across Iran died from famine and starvation (Melville, 1988; Okazaki, 1986). Furthermore, Iran is not easily able to supply the water needed for 83 million people in the agricultural, industrial, and domestic sectors because of limited water reserves and inefficient management of water resources. Therefore, population growth (more than 100 million people by 2050) in parallel with global warming, without the necessary infrastructure and facilities, can have adverse consequences for the livelihood of the people and the security of the country.

Drought periods damage the agricultural and industrial sectors, which can lead to increased unemployment, poverty, public discontent, and, consequently, civil conflicts. Given that several industrialized and densely populated provinces of Iran such as Tehran (the capital city with 10 million inhabitants), Qazvin, Alborz, and Markazi are located in the semi-arid parts of North Central Iran, the occurrence of insecurity (as a result of drought) in this key region can have extremely risky consequences for the whole country. Besides, prolonged droughts lead to the drying up of lakes, wetlands, and the abandonment of agricultural lands, turning them into dust hotspots. Not only is this a threat to people's health, but it also disrupts their daily activities. This phenomenon has created a critical situation in recent years, especially in the Elam, Khuzestan, Sistan, and Baluchistan provinces.

Another important climatic hazard in Iran is flooding. The floods in March 2019 caused heavy damage in the western, southwestern, and northern parts of Iran. The main causes of these tragic events were torrential rains, inefficient urban management, and lack of coordination between academics and government officials (Abbasi et al., 2017; Kardan et al., 2017; Manavipour et al., 2017; Mehdinasab et al., 2014; Roknoddin Eftekhari et al., 2010). Many people were killed and displaced in these events.

5. Impacts of Holocene dry events in North Central Iran

As mentioned, North Central Iran is currently an important region in the country. Therefore, mentioning the effects of Holocene climatic events on the ancient communities of this region can be useful in clarifying the potential consequences of current climate change in Iran.

Archaeological data shows that the region was almost uninhabited during the 8.2 ka BP cold event between ca. 6500 and 6000 BC (Shaikh Baikloo et al., 2018). This event coincides with the end of the Pre-Pottery Neolithic. Evidence of the 8.2 ka BP event can be observed in high-resolution climate proxies in Iran (Fig. 1). It seems that the dry climatic conditions in the continuation of this event lasted until about 5400 BC. Since then, irrigation agriculture in the Near East has flourished. The end of the Pottery Neolithic coincided with the 6.2 ka BP dry event, which occurred between about 4300 and 4000 BC (Shaikh Baikloo et al., 2019). During the Chalcolithic period (4300 – 3000 BC) several dry periods occurred and evidence of the occurrence of floods belonging to the middle and late of this millennium has been found from some ancient sites in North Central Iran; floods that caused long-term abandonment of some areas (Chaychi Amirkhiz and Shaikh Baikloo, 2020). Finally, under the influence of the 5.2 ka BP dry event, this period was also over. Many people in the region appear to have perished during the 5.2 ka BP event due to drought and famine and some communities have also migrated to the southeastern plains of the Caspian Sea through passages of the Alborz mountains in North Semnan to survive. At that time, this area has been a good place for rural communities due to the more favorable climate (Shaikh Baikloo et al., 2020). The Bronze Age in North Central Iran is considered a period of cultural decline because the number of settlements has decreased significantly (Shaikh Baikloo et al., 2016). Probably the main cause was the 4.2 ka BP dry event and other droughts during the third millennium BC. Paleoclimate studies of Gol-e-Zard (Yellow Flower) Cave in the northeast of Tehran province show two very dry periods in 4.51 – 4.4 and 4.26 – 3.97 ka BP (Carolin et al., 2019). The occurrence of these droughts can explain the sharp decline in population in this region during the third millennium BC. The unfavorable climatic and environmental conditions of this period may have changed the subsistence system of some farming communities in North Central Iran to pastoral-nomadism (Shaikh Baikloo and Chaychi Amirkhiz, 2020). The end of the Bronze Age overlapped with a dry period between ca. 1700 and 1600 BC. Then, in the early Iron Age, a humid climate prevailed, but the occurrence of the 3.2 ka BP dry event has brought intense tension to the Iranian plateau (Fig. 1). Most of the sites belonging to Iron Age I and II (1500 – 900 BC) are cemeteries without evidence of permanent settlement. This dry period has also caused an influx of nomadic groups from the north, whether via the Caucasus or Central Asia (Potts, 2014).

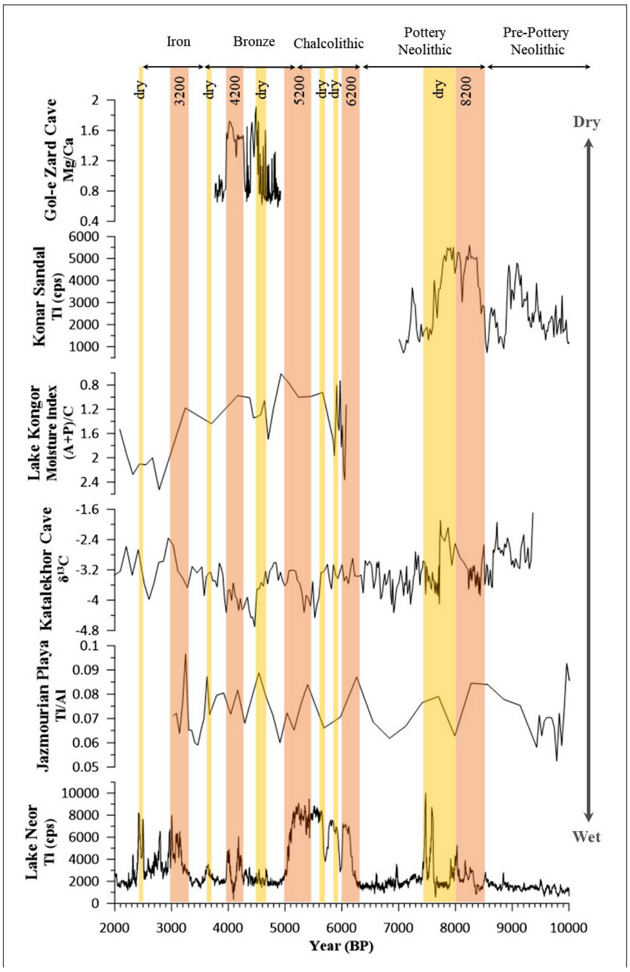

Figure 1: Dry events and dry periods in Iran from 10000 to 2000 BP. Red bands indicate dry events known in the paleoclimate literature (the 6200 BP event is introduced by the first author), and yellow bands illustrate dry climatic periods identified from the results of paleoclimate research in Iran. Lake Neor in Ardebil (Sharifi et al., 2015), Jazmourian Playa in Kerman (Vaezi et al., 2019), Katalekhor Cave in Zanjan (Andrews et al., 2020), Lake Kongor in Gorgan Plain (Shumilovskikh et al., 2016), Konar Sandal in Kerman (Safaierad et al., 2020) and Gol-e Zard Cave (Carolin et al., 2019).

6. Adaptation, resilience and mitigation strategies related to climate change

We propose some methods to deal with the consequences of climate change in Iran. Some of these methods are easily possible, but others require fundamental changes in the country's management strategies. First of all, it is recommended that government decisions are related to academic scientific outputs. One of the main tasks of both government and academia is to raise public awareness about climate change through mass media. This should be done regularly and frequently to institutionalize the culture of dealing with this phenomenon in society. Unfortunately, the majority of people and even the officials are still not aware of the depth of the tragedy.

The potential for renewable energy (solar, wind, and hydro) in Iran is widely available (Bahrami and Abbaszadeh, 2013; Hosseini et al., 2013). According to a study, constructing a solar power plant with an area of 2100 km^2 in the Lut desert (SE Iran) can supply electricity to the whole of Iran (Shaikh Baikloo and Sokhansefat, 2019). Changing the fuel of cars produced in Iran to non-fossil (such as electric and hybrid) can also be effective in the mitigation of global warming and reducing air pollution in large and industrial cities.

In Iran, only 35 to 40 % of water consumption is optimal. In the agricultural sector, mainly due to the use of traditional and inefficient methods of water transfer, more than 70 % of water either penetrates into the ground or evaporates (Haghiri and Karimkoshteh, 2004). Therefore, it is necessary to correct this situation as well.

Encouraging more non-meat foods can be one way to adapt to climate change. Global livestock production emits about 18 % of greenhouse gases (Moran and Wall, 2011). Also, 15.415 liters of water is used to produce one kilogram of beef and 8.763 liters for one kilogram of sheep/goat meat (Mekonnen and Hoekstra, 2012). In Iran, due to religious restrictions and general taste, there is no consumption of some foods, and in the current situation, it is necessary to make reforms in this regard.

Avoiding international tensions is of great importance for Iran. Over the past four decades, a series of sanctions imposed on Iran has put great pressure on the people's livelihood economy. Inflation and unemployment have risen to unprecedented levels, especially in the last decade (Islam, 2019). These conditions undoubtedly reduce the government's economic power to implement adaptation, resilience, and mitigation strategies related to climate change.

7. Conclusion

Archaeological and paleoclimate studies of Iran clearly show the impact of climatic events on human subsistence patterns. The current trend of anthropogenic global warming is not like the natural climate change in the past, which stopped and decreased after a while. The consequences of climate change for human societies can be migration, disease, unemployment, recession, civil unrest, war, and insecurity. Given the intensification of droughts and torrential rains due to increased global warming, it is necessary to implement adaptation, resilience, and mitigation strategies related to climate change in Iran (and the world). Apart from having an arid environment, Iran also suffers from numerous infrastructure and management (especially water) deficiencies that need to be reformed. Droughts can lead to regional desertification in large parts of Iran, and the occurrence of frequent floods causes heavy damage and losses. The combination of these consequences increases public dissatisfaction and has the potential for unrest and insecurity. Therefore, public understanding of climate change, optimal resource management, and the widespread use of renewable energy instead of fossil fuels in Iran is necessary to reduce the destructive effects of current global warming. Unfortunately, economic sanctions against Iran, in addition to the spread of unemployment and poverty, have led to a sharp decline in the government's economic ability to deal with climate change. Thus, Iran is at considerable risk of socio-economic collapse due to its high environmental vulnerability, inadequate infrastructure, dark international politics, severe economic weakness, and civil conflicts.

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