Study on the Relationship Between Societal Collapse and Environmental Factors

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Abstract: The correlation between societal collapse and environmental factors is worth researching since it provides us with insights on to what extent environmental factors can impact society. In the essay, we choose Holocene collapses and more recent collapses (or rapid decreasing of populations) examples, including the 4.2aBP event, 3.2kaBP event, the Ming dynasty, India, Darfur, Syria, and the United States, to seek into the correlation. We found that climate, especially the megadrought, does lay an important foundation and has a large impact on agriculture, given the cases of the Ming Dynasty, India, Darfur, Syria and the United States. During a climate change, especially a drought, the agricultural products of a given society may decline significantly, leading to famines which cause conflicts and reduction of population. In modern societies, however, such as the United States, governments may have macroeconomic control over production of agriculture, and thus the severity of the result of climate change may be lessened. In this article, we study the result of climate change by researching cases of societal collapse. In conclusion, we find that reduction of agricultural production caused by climate change is an important cause for the collapse of societies. Nevertheless, in recent days, the government's responses have begun to play a role in the result of climate change.

1. Introduction

Societal collapse happens often over history. It can contain many different processes under different times and geological areas and is thus difficult to define. Tainter (1988), Renfrew (1984), and Diamond (2005) all correlated the definition of collapse with the concept of sociopolitical complexity of the society [1][2]. However, when considering the political and social implication of the decline of a modern city like Detroit [3], the definition can be better understood as “the fragmentation or dis-articulation of a particular political apparatus” [4][5]. Overall, both social and political aspects are important in the definition of societal collapse.

The causes of societal collapses have been debated fiercely over time, without a definite conclusion. Weiss (2017) emphasized on the environmental factor, especially megadrought, as the mono-cause for societal collapses, while Tainter (1988) analyzed the collapse of societies with the law of diminishing returns. Additional inputs cause a declining rate of productivity [1]. In Butzer’s analysis (1980) of the causes of societal collapses, he mentioned that “the very multiplicity of systemic components increases the probability of a chance concatenation of negative inputs” [6]. Though debated, Diamond (2015) always mentions five causes of societal collapses, which includes climate change, hostile neighbors, collapse of essential trading partners, environmental problems, and societies’ response to the four causes above [7].

It is significant to explore the causes of societal collapse and especially its relationship with environmental factors. As climate warming becomes an essential problem for today’s society, it is even more important to analyze the extent of environmental factors it can have on society. In this essay, we took both Holocene and more recent examples of societal collapse which involve environmental problems as part of the cause of the societal collapse. These societies vary in complexity, development degree, and economic prosperity. We hope to see the combined effect of

both environmental and social factors on the collapses of society, and to what extent environmental factors can affect societies overtime. By exploring the possible impact that environmental factors can have on societal collapse, we can have a deeper understanding on how climate warming can affect our society.

2. 4.2kaBP and 3.2kaBP Holocene Collapse

Over the Holocene period, two series of collapses are widely studied. The first series of collapses were synchronous with the 4.2kaBP (around 2200 BC) abrupt climate change. It includes the collapse of the Akkadian Empire in the Mesopotamia area around 2240-2196BC, evidenced by the abandoned clay ball and a large storage vessel, an unfinished building, and a disappeared settlement around 2200 BC [8]. The collapse also happened in Egypt, which marks the end of the Old Kingdom, shown by having no pyramids during the First Intermediate Period [9]. Another series of collapses were the Late Bronze Age Collapse around 3.2kaBP, marked by the massive habitat-tracking of populations moving from Greece to the southern Mediterranean [10].

For the causes of 4.2kaBP events, environmental factors lay an important foundation. According to Weiss (2019), high-resolution proxy data in different areas all showed a sudden cooling and aridification happening around 4.2kaBP [11].

In the Mesopotamia area, the effect of environmental factors eliminated dry-farming cereal cultivation across north Mesopotamian. It also led to a 30 – 50 percent reduction in Tigris-Euphrates flow in southern Akkadian agriculture which then reduced the Akkadian yields [8]. The existing dust, marine, and terrestrial records all indicate that there is no significant difference at decadal level between the 4.2kaBP climate change and the timing of North Mesopotamia settlement abandonment. This furthermore reveals striking similarity between the total duration of the second dust event and settlement abandonment [12]. In regions that depend on rain-fed agriculture, the adaptive societal response linked with abandonment was habitat-tracking. Regional settlement surveys suggest that the populations leaving and abandoning the rain-fed plains of southwestern Turkey, western Syria and northern Mesopotamia settled along the banks of the Euphrates River and the karst-spring fed Orontes River [13]. In Egypt, because of the reduction in the Indian summer monsoon caused by the megadrought[14], the Nile flow was retracted [15]. The source of the Blue Nile, Lake Tana, also manifests a drier phase, leading to a reduction in Nile flow during the same period [16]. The reduced flow directly impacted marshland vegetation [17]. In addition, the flow also caused severe famine [18][19] which further led to the abandonment of sites in North Egypt [20].

During 3.2kaBP, a complex abrupt climate change was detected in the North Atlantic atmospheric and oceanic circulation patterns [8]. Weiss (2017) believes that it is “this climate shift caused crop failures and famine, which precipitated or hastened socio-economic crises and forced eventful regional human migrations in the Aegean and Eastern Mediterranean” [8].

From the two major collapses over the Holocene periods, part of the reason for societal collapse lay on the abrupt megadrought happening over both 4.2kaBP and 3.2kaBP. The happening of the megadrought further impacted agriculture production which is essential to sedentary societies like Akkadian Empire and Egypt. These societies lost the fundamental living necessities without enough agriculture production. With the reduction of agriculture in rain-fed areas, populations are forced to move to other areas which depend on precipitation. Overall, megadrought has an essential impact on societal collapse for both 4.2kaBP events and 3.2kaBP events.

3. More recent collapse

3.1. Ming Dynasty

Climate change in the 17th century had significantly affected turmoil, wars, population migration, and the replacement of dynasties. In the 15th century, the climate of ancient China entered a Little Ice Age due to monsoon failure, with a cooling rate of about 0.4 ℃/100 year during the 1550-1650

s. High-resolution temperature reconstructions of the Northern Hemisphere [21][22][23][24][25][26] suggested that it was the coldest period of the Little Ice Age from the late 16th century to the end of the 17th century, which was also the coldest century during the past 1000, or even 2000 years [27].

This cooling in climate shortened the crop growing season and reduced farmland area, which greatly affected agricultural production by reducing land carry capacity [28], which was related to the heavy dependence on agriculture and the low level of agricultural production technology [29]. The study also suggests that the climate turned dry rapidly during the periods of 1610-1640 s, typically during the periods of 1630-1640s [27], which aggravated crop failures. Meanwhile, locusts that flew and jumped to many regions also worsened the condition of agriculture.

Some scholars [30][31][32][33][34][35][36] suggested that the weakened agro-ecosystem and decreased pastoral resources that triggered the invasion of the Manchu people started in 1619 was caused by a rapid cooling period occurred in the ending of the Ming Dynasty. The eastern monsoon area which experienced annual droughts, and according to locusts disasters, was sensitive to climate change [37][38]. Thus, in north China, especially in the north China plain, there were a large number of areas of crop failure which led to a severe decline in agricultural production, and thus famines occurred [39][40][41]. The peasants were completely plagued by famines and the corresponding taxation.

The Serious Drought of the Chongzhen Years from 1637 to 1643 AD was the most severe drought, which lasted the longest and spread in 23 provinces [27]. The extreme drought may be caused by large volcanic eruptions and amplified both by volcanic activities and El Niño events[42]. According to The History of Ming, in the summer of the 10th year of Chongzhen, the capital and the southwest of Shanxi did not have any rain; In the 11th year, two capitals, Shandong, Shanxi, and Shaanxi, suffered from drought; In the 12th year, Hebei, Shandong, Henan, and Shanxi experienced drought; In the 13th year, two capitals of the Ming Dynasty suffered from drought; In the 14th year, the two capitals, and the other four provinces experienced drought; In May of the 16th year, the people devoutly prayed for rain. In 1640, drought and locust disasters were the most serious, accounting for approximately half of the crops that were not harvested [27].

In conclusion, disasters, especially drought events, were obviously present in both the north and the south, and they developed rapidly in 1638 and 1639. Intensively breaking out in 1640, disasters differentiated the south and north again and gradually decreased. This drought directly resulted in grain shortages, soaring rice prices, and famine, and it simultaneously triggered turbulence and fiscal crashes indirectly. At that time, the social system had lost its self-recovery function and worsened its ecosystem significantly, and the Ming Dynasty could not bear these great social changes. All of these external pressures pushed the undeveloped agricultural society to adjust, and an optional path forward was the structural transformation of human society to adapt to the alteration of the external environment, meaning that the Ming Dynasty had to develop resilience. Unfortunately, the Ming Dynasty was finally destroyed by natural disasters and wars including internal rebellions and external invasions.

3.2. India

The Great Famine of 1876 – 1878 was a famine which affected the South and Southwestern part of India. It was part of a larger pattern of drought and crop failure across India, China, South America and parts of Africa caused by an interplay between a strong El Niño and an active Indian Ocean Dipole Marshall [43]. Sontakke et l. also attribute also attribute the famine to the reduction in Indian summer monsoon rainfall in 1877. The famine began in 1876 after an intense drought resulted in crop failure in the Deccan Plateau [44]. According to the estimates, about 40% of irrigated land went unirrigated [45] which affected an area of 670,000 square kilometers (257,000 sq mi) and caused distress to a population totalling 58,500,000 (Imperial Gazetteer of India vol. III (1907), The Indian Empire, Economic (Chapter X: Famine, pp. 475 - 502, Published under the authority of His Majesty's Secretary of State for India in Council, Oxford at the Clarendon Press. Pp. xxx, 1 map, 552.).

Governmental actions did play a role in the famine. For example, the provincial government of Madras increased the ration halfway towards Cornish's recommendations, to 570 grams (1.25 lb) of grain and 43 grams (1.5 oz) of protein in the form of daal [46]. However, even with ration, many more people had succumbed to the famine (Imperial Gazetteer of India vol. III (1907), The Indian Empire, Economic (Chapter X: Famine, pp. 475 – 502, Published under the authority of His Majesty's Secretary of State for India in Council, Oxford at the Clarendon Press. Pp. xxx, 1 map, 552.).

3.3. Darfur

The Darfur Crisis began in February of 2003, marking it with anti-government militant activity, and aggravated further conflicts. This crisis came against the backdrop of repeated droughts in the region of the Sahel, Sudan which is located on the verge of the southern Sahara Desert, situated in the transition zone of the tropical desert to tropical savanna. The precipitation in the very region was continuously below the mean precipitation in historical data since the 1960s, which caused regional droughts and was reinforced by human activity. The severity of the drought reached its peak in 1972 and declined in 1973. However, another drought, which was much more severe than the latter one, occurred in 1983, leading to a southward drift of the Sahara Desert. In the 1990s, with the vegetation recovery, precipitation in Darfur increased, but, after the 2000s, a drought occurred again [41].

El Nino in the Pacific has a strong influence on Atlantic climate fluctuations in the northern equatorial region and is prone to drought in North Africa, including Darfur in Sudan if it coincides with strong tidal cycles [47]. The long-term environmental risks which existed for decades brought by climate change had been a serious challenge to agriculture and livestock production in Darfur. Meanwhile, the restriction of the geographical conditions of the ecotone also accelerated the occurrence of the Darfur Crisis. Darfur region had maintained the characteristics of a typical agro-pastoral ecotone, where the environment was fragile and changeable. In addition to the environmental risks, human economic life also affected the change of natural vegetation, which led to the north-south displacement of agro-pastoral ecotone. The outbreak of the Darfur Crisis was inseparable from the geographic character of the region. Sudan was located between the equator and the Tropic of Cancer, the boundary of which climate was accordingly not obvious, and the basic distribution of east-west belts. Precipitation increased from less than 25mm annually in the northernmost part to more than 2000mm annually in the southernmost part, and the corresponding natural belt transitioned from tropical desert to tropical grassland and tropical forest in the south [48]. Under such climate conditions, agricultural and animal husbandry production was subject to severe geographical limitations.

Economic activities in Darfur were constrained by differences in rainfall, and farmers and herdsmen had formed relatively fixed and intersecting living spaces, showing a clear regional pattern. In terms of the regional economy in Darfur, the self-reliance of the three groups balanced the limited trade with each other. Community structures with strong historical inertia were often too rigid to cope with new changes [49]. To some extent, climate change has become an external force that overturns the geographical distribution pattern of traditional agriculture and animal husbandry in Darfur. The impact of the continuous drought on the north-south swing of the agro-pastoral interlace had forced the population to concentrate in the narrow farming area in the middle, and the living space of farmers and herdsmen was greatly overlapped. Surging population densities were likely to push the environmental load beyond its fragile carrying limit, further exacerbating resource pressure and environmental degradation, and more likely to fuel societal collapse, including damage caused by civil war and refugees that account for 19% of the total population in the southern Darfur [41].

In conclusion, in the second half of the 20th century, due to the abnormal temperature of the tropical ocean surface, the climate fluctuations in the region of Sahel frequently fluctuated, causing catastrophic results to the agricultural and animal husbandry production that rely on the natural environment in this area. Due to the continued less precipitation, the production of crops in Darfur's

farming zone decreased significantly. During the same period, the edge of the Sahara Desert moved southward, forcing herders to move south to enter the farming production land belt.

3.4. Syria

Syria has experienced a severe drought event which was caused by a long-term drying trend induced by climate change between 2006 and 2009, leading to the collapse of the regional agricultural and pastoral economy [50]. Some 1.3 million inhabitants of eastern Syria have been affected by this disaster, out of which 803,000 have lost almost all of their livelihoods and face extreme hardship [51], causing massive migration which finally led to the civil war and societal collapse.

Meanwhile, climate change was not the only reason for societal collapse. Government policies and regional positions had also an impact. Before the 21st century, the Syrian government implemented a policy to increase agricultural production, but excessively developed limited land and water resources [52]. In 2005, the government tried to restrict the mining of groundwater by opening a well-opened license, but this legislation was not implemented. In addition, the government transformed into a liberalized economy by cutting fuel and food subsidies, ignoring the demands of rural families, and thus massive populations were forced to migrate [53]. Moreover, the drought event did cause agricultural damage. Meanwhile, the government did not provide any subsidies or even not exacerbated the exploitation of agriculture, which further led to the inability of gaining reasonable development, leading to massive societal collapses in Syria.

In conclusion, the trend of climate change caused drought, which contributed to livelihood loss, leading to migration, and massive migration in Syria caused conflict, including societal collapse in regions. Although Syria faced a multi-decadal drying trend and the drought between 2006 and 2009 was unusually severe, comprehensive evidence through attribution studies of a link to climate change is still lacking. Whether the drought was a relevant cause of rural livelihood loss and whether this livelihood loss facilitated a significant migration to urban areas remains contested, although the majority of studies support these claims.

3.5. The United States

In modern societies, many of which have developed resilience to climate change, particularly droughts, in order to prevent the occurrence of societal collapse. The crops, livestock, and seafood produced in the United States contribute more than $300 billion to the economy each year, being an important sector of the U.S. economy, laying a foundation of regional and national economic system [54]. Changes in temperature, atmospheric carbon dioxide, and the frequency and intensity of extreme weather could have significant impacts on crop yields. Yields will decline if the higher temperature exceeds a crop's optimum temperature. As climate shifts, changes in productivity will drive farmers to change crops and move into new areas [55]. Transitions from extremes of drought to floods, in particular, increase nitrogen levels in rivers and lead to harmful algal blooms [56]. When facing climate change, corn and cotton show less sensitivity to extreme temperatures in the southern U.S., reflecting adaptation in seed varieties and farming practices to minimize losses. For wheat and barley, adaptation is dependent upon water availability, with higher sensitivity in dry regions. Some scholars assert that swaths in the southern U.S. will be unable to maintain any production of soy, wheat, corn, rice, barley, peanuts, and cotton [57].

In August 2021 more than 95% of the West was in states of severe drought, including reduction of precipitation and increasing temperature, conditions that are predicted to continue through at least October 2021, which is the most severe drought event in 122 years of observation. In order to reduce the significance of severe effects of droughts to agriculture, natural resource managers took steps to address these issues by increasing the diversity of trees and introducing species suitable for a changing climate [58]. Some farmers have torn out their highly valuable but water-intensive almond trees as well. Moreover, the reduction of meat production and consumption could be operated to fulfill the U.S.'s commitment to limiting global warming to less than 2 degrees Celsius [59]. Meanwhile, the U.S. government is considering shifting U.S. agriculture away from today's industrial overproduction and toward sustainable farming. Regarding the resilience to climate

change of U.S. agriculture, there is no sign that societal collapse may occur. Moreover, a systemic transformation toward sustainable agriculture and drastically reduced animal production is one of the most powerful interventions available today to both mitigate climate change and protect US food security in the decades ahead.

4. Conclusion

From the above societal collapses' examples overtime which involve the impact of environmental problems. We can see that:

1) The megadrought lay an important foundation for the collapses of these societies. Nearly all of the mentioned above societies are affected by climate and environment factors;

2) Megadrought or climate change caused most of the societies to have reduction on agriculture production, which is an important cause for the collapse of societies;

3) The importance of agriculture was previously thought to impact early societies more than more recent societies, since early societies had little connection with other civilizations and thus rely more on their own yield to sustain populations. However, from the above analysis, we find the importance of agriculture not only lay on early societies, but can also be applied to more recent society which is more loosely related to agriculture; and

4) As society developed and had larger complexity, government's responses began to play a role in the result of the megadrought.

However, according to Drake (2012), the effect of drought or famines may only lead to competition for limited resources, which are not enough for the collapse of a whole society. Other factors to societal collapse are also important and we should prevent environmental determinism. However, the analysis does provide us with a deeper understanding of the effect that environment and policies can have on societies.

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