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Article

Climate Change and Classic Maya Water Management

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Abstract: The critical importance of water is undeniable. It is particularly vital in semitropical regions with noticeable wet and dry seasons, such as the southern Maya lowlands. Not enough rain results in decreasing water supply and quality, failed crops, and famine. Too much water results in flooding, destruction, poor water quality, and famine. We show not only how Classic Maya (ca. A.D. 250–950) society dealt with the annual seasonal extremes, but also how kings and farmers responded differently in the face of a series of droughts in the Terminal Classic period (ca. A.D. 800–950). Maya farmers are still around today; kings, however, disappeared over 1,000 years ago. There is a lesson here on how people and water managers responded to long-term climate change, something our own society faces at present. The basis for royal power rested in what kings provided their subjects materially—that is, water during annual drought via massive artificial reservoirs, and spiritually—that is, public ceremonies, games, festivals, feasts, and other integrative activities. In the face of rulers losing their powers due to drought, people left. Without their labor, support and services, the foundation of royal power crumbled; it was too inflexible and little suited to adapting to change.

Keywords: climate change; water management; Maya; reservoirs; political systems

1. Introduction

1.1. Those Who do not Learn From the Past are Condemned to Repeat It—George Santayana

The critical importance of water is undeniable—it is the stuff of life. In the forward of a United Nations/World Water Assessment Programme report, former United Nations Secretary General Kofi Annan states, "The centrality of freshwater in our lives cannot be overestimated. Water has been a major factor in the rise and fall of civilizations" [1]. People minimally need 2–3 liters of water per day for drinking alone [2]; the amount increases to 20–50 liters when one takes into account cooking, cleaning, bathing, production needs, and other activities [1]. Some of the largest consumers of water are food and agriculture [1].

Rainfall patterns and water supplies are influenced by several factors, including "the amount, form, seasonality, and event characteristics of precipitation, as well as temperature, solar radiation and wind that affect evaporative loss" [3]. Cultural factors and decisions revolving around water include dealing with potable water supplies during annual drought, allocating water, repairing water or agricultural systems damaged by annual flooding and tropical storms, and supplying food in times of scarcity. Not enough rain results in decreasing water supply and quality, failed crops, and famine. Too much water results in flooding, destruction, poor water quality, and famine. One only has to think of the recent catastrophic Hurricane Katrina and floods in Pakistan. These extremes are exacerbated by global climate change and concomitant problems, which will only worsen, as the recent cholera outbreak in flood-stricken Pakistan has shown. Interestingly, and until relatively recently, studies on the impacts of climate change on water quality (vs. quantity) have been noticeably few [4].

The issue of water is particularly relevant in semitropical regions with their noticeable wet and dry seasons, such as the southern Maya lowlands in northern Central America and southeastern Mexico (Figure 1). In this paper, we show not only how Classic Maya (ca. A.D. 250–950) society dealt with the annual seasonal extremes, but also how kings and farmers responded differently in the face of a series of droughts in the Terminal Classic period (ca. A.D. 800–950). Maya farmers are still around today; kings, however, disappeared over 1,000 years ago. There is a lesson here on how people and water managers responded to long-term climate change, something our own society faces at present.

Since history can repeat itself, it is becoming increasingly important that policy makers, politicians and others realize, as the International Council for Science notes, that "Archives from the past—e.g., ice cores, coral cores, tree rings, archaeological records—must be studied more vigorously to provide paths of change, baseline conditions, insights into past societal resilience or fragility and perspectives on projection of future change" [5]. We illustrate this point through a discussion of Classic Maya water systems, particularly between ca. A.D. 550 and 850. Such cases as the Maya focus on the human side of the story regarding climatic change, which serves two purposes: one, it provides lessons from the past from which we can learn; and two, it humanizes problems resulting from climate change, making it more palatable to the general populace.

To offset the impact of long-term global change in Latin America, the Intergovernmental Panel on Climate Change [6] recommends expanding "rainwater harvesting," practicing "water storage and conservation techniques; water re-use; desalination," and increase the efficiency of water-use and irrigation [6]. To accomplish this goal, it is necessary to coordinate national water policies and integrate water resources and water-related hazards management to create flexible and adaptive systems [7]. How can this seemingly insurmountable goal be achieved? History provides clues.

Figure 1. Map of the Maya area with sites and centers mentioned in text [8].

For one, inflexible systems frequently fail as the Moche case of Peru shows [9]; in this case, an inflexible government and subsistence technology lessened farmers' ability to survive long-term droughts, torrential rains, and destructive floods. A series of El Niño events damaged the large-scale irrigation systems repeatedly in the late A.D. 600's, eventually resulting in the demise of Moche political power. There are many other cases, and Fagan concludes with a cautionary note and highlights recent instances where the lack of foresight and articulation between institutions, resources, and changing rainfall patterns have had devastating results. Fagan [10] also highlights how short-term or immediate responses, for example, using depleted resources to supplicate the gods, can make societies more vulnerable in the long run—a lesson with which we are increasingly becoming familiar. He has continued his call to arms [11] by making the point through several case studies from around the world indicating that our inability to efficiently respond to climate change in the long term has drastic and unforeseen consequences.

2. Classic Maya Water Management

Tropical areas such as the southern Maya lowlands in northeastern Chiapas, eastern Tabasco, southern Campeche and Yucatan Peninsula of Mexico, north and central Guatemala, Belize, and western Honduras have some of the most diverse and complex ecosystems in the world. A critical concept to keep in mind regarding the Maya, however, and most other tropical societies, is that all aspects of Maya life, past and present, were rainfall-dependent. The noticeable wet and dry seasons impacted agricultural schedules, where and how people lived, water quality, political power, exchange systems, transportation, and so on. The dry season, usually from January through May or June, is a period when it does not rain at all for four months and temperatures and humidity noticeably climb [12,13]. The dry season is also the time for non-agricultural activities (e.g., building programs, participating in public ceremonies, feasts and markets, *etc.*) and the quest for reliable sources of clean water. Since the southern lowlands become a green desert for four to six months each year, this need was more noticeable in areas without permanent water sources, such as those containing the largest and most powerful Classic Maya centers like Tikal, Calakmul, Naranjo, and Caracol [2,14,15], which were located in regions with fertile soils and along lucrative trade corridors. Powerful kings attracted thirsty farmers in the dry season—the agricultural downtime; in the rainy season farmers were busy in their fields dotted across the landscape mirroring the mosaic distribution of fertile soils [16-20].

Further challenges in this rainfall dependent society, given that they lacked large formal irrigation systems, included predicting the end of the dry season and the beginning of the rainy season. This is a crucial factor since maximum productivity required farmers to plant the major staples of maize, beans and squash immediately before the rains began. And the beginning of the rainy season can vary up to five months in any given area, as well as the amount of rainfall per year, which can range from 1,350 to 3,700 mm [2,12,21]. An additional draw on water supplies was maize, the major staple in Mesoamerica. It is a relatively thirsty plant compared to millet, sorghum and manioc, for example [22]. And to make matters worse, “two fungus species produce aflatoxin in…maize…if the crop is stressed by drought or stored improperly,” a dangerous chemical that is “by far the worst liver carcinogen known” [23]. This setting and these conditions only bring home the fact that the Classic Maya (ca. A.D. 250–950) exemplify adaptability. Not only did they adapt, they flourished and accomplished all of the feats for which they are famous without beasts of burden, wheeled vehicles, major road systems, and metal implements. Maya kings, however, did face challenges in acquiring and maintaining their hold over their relatively dispersed subjects.

Water quantity and quality is a global concern—a critical factor in hot, humid environments where people require more water than their counterparts in temperate areas. Furthermore, water quality deteriorates during drought, flooding, and tropical storms. Other problems include endemic diseases (e.g., hepatic schistosomiasis) and pests, such as parasite-ridden flies and malaria-bearing mosquitoes that “flourish in environments disturbed by humans” [24]. In fact, intensive agricultural practices worsen the situation since land clearing results in open areas where stagnant water collects. This, in turn provides prime breeding grounds for water-borne parasites, pests and diseases to proliferate, such as diarrhea, as well as result in the build-up of noxious chemicals such as nitrogen [25]. Moreover, temperature changes throughout the year are not extreme enough to kill-off pests.

The Maya began migrating to the interior of the Yucatán Peninsula, especially the Petén in northern Guatemala, from riverine and coastal areas by ca. 1,000 B.C. [12,18]. Many of these areas had plentiful fertile soils, but they lacked lakes or rivers. Further adding to the challenge of living in these areas was low water tables in most parts of the southern lowlands, which meant that water did not percolate to the surface [26]. Tikal, Calakmul and several other centers without permanent water sources often are surrounded by *bajos*, or seasonally inundated swamps or other types of wetlands (40–60% in any given area; [28]), which in some instances provided additional agricultural land [29]. To compensate for the lack of permanent water sources, the Maya constructed water systems [12,30,31], including wetland reclamation (e.g., Cerros, Caracol [32]) and "passive" or concave macro-watershed systems where the Maya used gravity to divert and store water (e.g., El Mirador, Petén) [12,33]. While *aguadas*, or rain-fed natural depressions, are found throughout the landscape, water evaporation depleted water supplies as the dry season wore on. The Maya abandoned some of the earliest and largest centers by ca. A.D. 150 (e.g., El Mirador and Nakbe), perhaps due to problems with water systems (e.g., the silting up of reservoirs) [12,34], not to mention a multi-year drought [35]. The Maya learned from their mistakes and did not have to abandon another center until 700 to 800 years later.

Because more people migrated into the interior during the Early Classic period (ca. A.D. 250–550), they needed larger and more sophisticated artificial reservoirs to supply enough water (e.g., Tikal). Centers found along rivers also built reservoirs and other water control features (e.g., Copán, Río Azul [36,37]), the former due to disease-ridden rivers at the height of the dry season. Water systems increased in size and scope in the Late Classic period (ca. A.D. 550–850) when population and political power were at their zenith; the Maya built sophisticated reservoir systems epitomized by elevated convex macro-watershed systems where reservoirs, dams and channels were designed to capture and store rain water (e.g., Tikal, Caracol, Calakmul) [2,12,15,38,39].

Reservoirs provided for thousands of people. At Tikal, for example, Scarborough [2,15] shows that the reservoirs could hold more than 900,000 m^3 of water based on 1,500 mm of annual rainfall. The six central reservoirs alone contained from 100,000 to 250,000 m^3 of water. If each person consumed 4.8 liters of water daily for drinking, washing, making ceramics, cooking, and other uses [40], Tikal's reservoirs could easily have provided water for 45,000 [41] to 62,000 people [42] given "that 1 m^3 is equal to 1,000 liters, 45,000 to 62,000 people would require, for a period of six months, from 38,880,000 to 53,568,000 liters, or 38,880 to 53,568 m^3 of water" [43]. The Maya also used other, lower-lying reservoirs and *bajo*-margin reservoirs and *aguadas* for agriculture [15] and other uses (e.g., plaster manufacture, agriculture, and building projects).

Water collected in the reservoirs during the rainy season lasted through the dry season. However, a major concern would have been keeping drinking water clean, especially as the dry season wore on. After all, plentiful water only provides sustenance to people if it is free from dangerous toxins and water-borne diseases. The historic and archaeological records leave little doubt that the Classic Maya successfully survived the annual 'drought' for a millennium, and they maintained clean water stores to prevent standing water from becoming stagnant and a magnet for diseases and pests. They accomplished this feat through recognizing the significance of the wetland biosphere and applying its principles through maintaining a balance of hydrophytic and macrophytic plants and other organisms [44-46]—in other words, they transformed artificial reservoirs into wetland biospheres, which today are referred to as constructed wetlands [47]. Pondweeds, smaller plants, and their associated bacteria and algae all work together to purify water. For example, some bacteria act as 'living filters' and feed on the spores of parasites and also denitrify water [25,48]. In addition, all plants absorb nitrogen and phosphorus that build up in standing water [46].

A visible sign of clean water is water lilies, specifically *Nymphaea ampla*. Additionally, the bluish undersides of lily pads restrict the passage of light [49,50], thus preventing the build-up of too much algae, as well as inhibiting evaporation. Water lilies also provide food and cover for the natural predators of small flying pests such as dragonflies, as well as fish. Not surprisingly, the association of clean water, water lilies, and royal power is amply illustrated in the iconography [44,51]. Water lilies and associated elements are depicted on *stelae*, monumental architecture, murals, and portable items [52,53].

While water lilies, like all plants, absorb nitrogen through their roots, they are actually quite sensitive hydrophytic plants that can only grow in shallow (1–3 meter), clean, still water that does not have too much algae [54,55]. As a consequence, murky water will have few water lilies. The water lily also does not tolerate acidic conditions, nor water with too much calcium, such as limestone. Lining the reservoir with clay would counter calcium seeping into the water, as well as stabilize pH levels. Furthermore, if the sediment at bottom to which water lily roots attach contains too much organic matter such as decomposing plants, the gases released, including methane, ethylene and phenols, can be toxic to water lilies.

While certain amounts of bacteria can be beneficial in the cleansing process, it could also be a problem in certain circumstances [56]. For example, in the Mirador Basin, Hansen and his colleagues note that, "As the water recedes during the dry periods, the concentration of coliform and *Escherichia coli* become significant" [34]. The karstic topography upon which the Maya survived apparently does not effectively purify water; "typhoid bacilli, for example, are not effectively filtered" [57]. Basically, any bases or hydroxides, such as soda ash or potash, which are soluble in water, are capable of neutralizing acid. And as alluded to earlier, most *Nymphaea* species prefer water that is more neutral and slightly alkaline; few species can tolerate acidic conditions [49]. One could also use simple filtration techniques, such as a colander with sand and gravel through which water can pass, a suggestion now posited for Tikal for the ingress designs at some of the great reservoirs based on 2010 excavations by V. Scarborough and his colleagues.

Other associated issues concerning reservoirs are biting insect pests, such as mosquitoes, a concern perhaps ameliorated with the use of incense burners as insect repellents. Fish also devour pesky insects, and their feces, along with other bottom debris, serve as fertilizer [58]. The Maya also likely exploited certain artificial reservoirs "for protein and plant sources such as fish, snails, and fresh-water shellfish, reeds [for mats and baskets], as well as edible and medicinal plants…" [37]. Waterborne parasites likely were dealt with similar to what the Maya do at present, who kill off intestinal parasites by drinking the boiled bark of the copal tree (*Protium copal*) or leaves of the jackass bitter tree (*Neurolaena lobata*), or by drinking the juice of the Mexican wormseed fruit (*Chenopodium ambrosioides*) [59].

A significant potential contamination problem was human waste, given that "Sewage contains a much higher proportion of phosphates than does natural water, in which algal growth is usually limited by phosphorus shortage. Dense blooms of algae therefore grow in lakes polluted with sewage" [60]. Settlement maps, however, do not show residences at the edges of reservoirs. Even if human waste did pollute water sources, with time—just how much time is something on which civil engineers are working—the natural purification processes noted above could ameliorate this [61].

3. Classic Maya Kings, Water Managers, and Climate Change

The basis for royal power rested in what kings provided their subjects materially—that is, water during annual drought via massive artificial reservoirs [2], and spiritually—that is, public ceremonies, games, festivals, feasts, and other integrative activities [43,62]. Maya rulers organized the building and maintenance of reservoirs since it was not feasible to dig wells, as the water table is too deep in many parts of the southern lowlands—as archaeologists found out in the 1960s at Tikal when they were resigned to relying on ancient reservoirs after having drilled 180 meters without hitting water [57]. As mentioned, water collected in the reservoirs during the rainy season lasted through the dry season.

The village of Pich in the state of Campeche, Mexico provides some insights into the character of Maya reservoirs and towns [63,64]. Before the federal government drilled a well in 1968, the village relied on a water system that has been active since at least the Late Classic period when a temple stood above the community. The Spanish razed the temple and used the rubble to construct a 17th century church, convent, and hacienda that still stand. The town surrounds an artificial reservoir with water lilies whose water is protected by massive overhanging Pich trees (thus the name of the town). Water was directed from a stream that was canalized from a stand of tropical forest upstream to purify the water and then diverted into the reservoir. The reservoir represented only a portion of the total water supply, as a line of hills choked the stream below the town allowing the capture of additional water. In the in-filled channel of the stream under the present surface is a perched water table; in the dry season, after the reservoir water was consumed, stone lined wells that were sunk in its bottom into the underlying perched water table were opened. The social organization of the town revolved in large part around maintaining the integrity of the reservoir, cleaning the reservoir and wells, guarding the water supply from animals and children, and cleaning the streets to ensure the sanitation of the water entering from the town. Citizens were required to participate if they drew more water than for basic subsistence needs. A similar organization likely existed in Classic Maya centers, with the addition of royal water managers.

Classic Maya kings performed the necessary ceremonies to the rain god, Chaak, royal ancestors, and other vital supernatural entities to ensure adequate rainfall and to maintain clean water supplies. Reservoirs thus served to integrate subjects during the dry season and provided the means for kings to collect tribute. Annual seasonal vagaries were challenging enough to deal with, such as finding enough water during annual drought, timing planting schedules, allocating water, repairing water or agricultural systems damaged by flooding and tropical storms, and finding food in times of scarcity. Thus, any changes in seasonal patterns lasting more than a few seasons would have been a challenge indeed.

Increasingly, evidence shows that a series of droughts struck the Maya lowlands during the latter part of the Classic period [65]. Specifically, oxygen isotope analysis of a stalagmite from a cave in the northwestern Yucatán Peninsula indicates at least eight Terminal Classic (ca. A.D. 800–950) droughts lasting from three to 18 years. The droughts peaked in the years 806, 829, 842, 857, 895, 909, 921, and 935 [66]. Significantly, the years between A.D. 804 and 938 show a 36% to 56% drop in precipitation. This series of droughts, depending on when they occurred and their severity, also helps explain why the ‘collapse’ extended over 100 years in the southern Maya lowlands—because the several droughts impacted centers differently depending on their particular social, environmental, and political circumstances [43].

With reference to comparing the Maya droughts to modern climate change, that the droughts were spaced a generation or less apart means they can be treated as a climate period or episode rather than a drought event in a moister climate—about 130 years of dry climate [21]. It would be the equivalent of our current global-scale culture facing 130 years of mostly hot global temperatures with many regions experiencing killer heat waves in the warm seasons. Other regions would experience teleconnected conditions appropriate to their local relations to ocean currents and airstreams. Whatever the local conditions are, it would be a matter of adapting to new conditions rather than surviving until previous climate patterns return.

During their 1,000 years of royal power, Maya engineers appear to have constrained the exodus of sediments from the interior while facilitating the removal of salts via terraces and related technologies. This engineered landscape prevented both salinization and loss of vital soil micronutrients [67]. Given this remarkable balance between environments and humans, it would take something drastic to bring it to an end. The seemingly incessant droughts set in motion a series of events that ultimately resulted in the demise of ***royal*** life. Rulers lost their power, some relatively quickly, and disappeared from the scene by the early 900's [68]; in contrast, rural population decreased at a slower pace [69]. In many cases, as was the case at Caracol, remnant groups of elites and commoners stayed on long after kings lost their right to rule [70]. Not surprisingly, populations decreased gradually; farmers adapted, kings did not. In some areas, well-adapted farmers continued to preserver into present times [71]—and free from royal tribute demands. This was due, in large part, to their expertise in managing their forest landscape [72,73]. They diversified subsistence strategies or migrated to feed families, but political institutions did not change their course of action and paid the ultimate price. Those who did not leave the southern lowlands re-organized at the community level and obtained water from lakes, rivers, *aguadas*, and former royal reservoirs [74].

Explaining the disappearance of Classic Maya kings and the abandonment of centers in the southern Maya lowlands by A.D. 900 is complicated. It is complicated not so much because we are assessing hundreds of centers, each with their own distinct and long history, but because we are examining how millions of people dealt with a period of consistent droughts [75,52]. On the other side of the proverbial coin are centers without kings, such as the small centers of Barton Ramie and Saturday Creek along the Belize River in central Belize. Both were comprised of farmers of varying degrees of wealth and success who built their houses and planted their fields near rivers on rich alluvium beginning by c. 900 B.C. through ca. A.D. 1500 [76,77], dispersed around small temples, elite compounds, and sometimes ballcourts [43]. No major disruptions are evident in the Terminal Classic period when people elsewhere were abandoning kings and centers, which is not surprising given that these centers lacked royal trappings [78]. Elite and non-elite farmers did, however, have less access to exotics from the interior since long-distance networks were interrupted by collapsing political systems. The political system collapsed; the average Maya endured, and still do at present [79].

There were other complicating factors. First, there was the increasing number of rulers at secondary centers making claims for power (e.g., Tonina, Quiriguá, El Peru, to name a few). Second, a growing number of people needed dry-season water and capital; population numbers reached their height when Terminal Classic droughts struck, one after another. Finally, there was the increasing number of regional powerhouses attempting to extend their sphere of influence indicated by the rising number of 'battles' referenced in the inscriptions [80]. Outside influences also imposed constraints, such as the growing power of maritime trade [67]. In the face of all these stressors, the majority of Maya continued to do what they had done for millennia; farm their land, take care of their families, travel to local markets, and so on. Admittedly, these quotidian activities became more of a challenge in the face of increasing water problems. While there is little doubt that a series of droughts struck, and that rulers at each center tried to cope with them in their own way, no matter what they did failed to prevent their subjects, supporters, and laborers from leaving them. The question is, could they have done anything differently to preserve their water sources, that is, the basis for their power, from evaporating?

Increasing evidence suggests that kings at some centers intensified monumental building programs [80,81] and ceremonies [43], likely indicating their attempts to appease the rain god Chaak, the Maize god, ancestors, and others—an ancient Maya stimulus package, if you will. Could this labor have been better expended elsewhere? Would other short-term responses have been enough to stave off the impact of changing rainfall patterns? Since the foundation of the most powerful rulers at Tikal, Calakmul, Caracol and Naranjo consisted of reservoirs and their ability to attract dry-season laborers and subjects, their diminishing water supplies left them with nothing to keep their subjects. Furthermore, other indicators suggest rulers were starting to lose power; for example, at the end of the Late Classic period at Copán, some of Copán's elite adopted water symbolism (e.g., water lily headdresses), which was usually a royal prerogative [82,83]. This trend might explain why we see in the inscriptions at this time several uses of a new title, *k'ul ajaw*, or divine lord [84], perhaps indicating rulers' desperate attempts to claim even closer connections to the supernatural world in order to keep their subjects. In the end, this and their sponsorship of more ornate ceremonies and expensive building programs only highlighted their failure to bring forth the stuff of life—water.

In the face of rulers losing their powers, people left, period. Without their labor, support and services, the foundation of royal power crumbled. What once were kings became wealthy landowners, as their forebears had been. In the final years, we do not think that rulers could have done anything to save their kingdoms. The droughts impacted water supplies. If kings had relied earlier on a more diverse portfolio, so to speak, things might have been different. But they did not. Political decision making over the long run focused on water control; all the other things for which Maya royalty were so famous were an extension of their success as water managers.

4. Discussion and Concluding Remarks

What lessons can we take from Classic Maya water management practices, especially in view of what is happening at present with global climate change, increasing population, and decreasing resources including water supplies? We can first assume, as elsewhere, that people make decisions to ensure the survival of their families. The political elite, however, also will do what they can to keep their power—like Maya rulers—all in an effort to maintain their right to exact control. When problems first develop, leaders initially rely on traditional means; if this strategy fails, political systems transform or fall apart. People, however, can adapt, like Maya farmers did. The Maya royal house of cards collapsed because it relied largely on water control. The foundation of their power was inflexible and little suited to adapting to major changes. The lesson here is that we need to rely on diverse and more flexible means of support.

Recently, evolutionary behavioralists assessing long-term change in society have proposed that conformist behaviors, versus innovation, have been a downfall for several societies [85]. In fact, modeling of social processes indicates that narrowing rather than broadening of options is characteristic of complex systems [86]. This point is a salient one for the Maya case—and many other societies. Maya kings used the same rituals that had served them in the past in the hope that conditions would change; they did not. The same is true for global climate change. We know global climate change will not end anytime soon, so it is up to individuals, families, and communities to act now and not wait for conditions to change.

Currently, however, in the face of worsening problems, responses increasingly are "trading up on the scale of vulnerability" [10]. We can avoid history repeating itself by informing the general populace, politicians, and policy makers about re-evaluating our short-term, short-sighted responses. Short-term responses have short-term benefits, often with unintended and detrimental consequences (e.g., expending precious resources in a futile attempt to prevent the inevitable; [9,11]). The long-term solutions and diverse portfolios that are necessary are difficult to appreciate by families concerned with the immediate future and politicians who are thinking about their political survival.

Common responses to drastic change in the past have included political collapse or transformation, migration, conflict, technological solutions, and adaptation [87-89]. Most of these options are no longer viable at present. Migration is less of an option due to protected or militarized borders and territorial issues. Conflict cannot allay problems because the crisis is no longer local, but global—though people will always fight over resources.

Political change, while viable, does not necessarily address the problems at hand; promises made during election campaigns are difficult to implement once in office if conditions are the same, not to mention technology and information flows. The majority of people are relying on technological innovations and inventions to save us since they have saved humankind in the past (e.g., increasing food production through use of plows, fertilizers, pesticides, *etc.*). An over-reliance on technology, however, can lead to an inability to adapt in the face of change, as seen at various times in the prehispanic southwest United States [90], at the end of the western Roman Empire [91], and in the Maya lowlands [81]. When political and subsistence systems are not flexible enough to adjust to changing conditions, they fail.

The only viable long-term option is adaptation—as Maya farmers did. Conditions are not going to change, so we must. We as a society need to greatly re-assess our way of thinking and living and change our behaviors [92,93]. The question is how to convince the people of the world to change their ways of thinking and living—that is, convince people of the necessity to adapt. This question is important because of the need for long-term solutions, which people typically avoid due to our aversion to change. As novelist D. H. Lawrence (1885–1930) once stated, "The world fears a new experience more than it fears anything, because a new experience displaces so many old experiences." But this is exactly the kind of change we need if we are going to avoid history repeating itself. Implementing incremental change would be a step in the right direction; but who will start this? Should it be the decision and actions of families and grass-root groups, or is it better left to higher-level institutions such as national legislators, transnational organizations, or the profit-motivated corporate world?

As the Classic Maya case has shown, it is the people, not politicians, who in the end resolve problems—at least after having given political leaders several opportunities to deal with the problems at hand. And since politicians sacrificing their careers for the long-term good is unlikely, people need to act. Herein lies the challenge—instituting culture change from the bottom up, and soon. One way to bring this home is to not only inform through lessons from the past, but by highlighting that humans are the same, and options for adaptation now quite finite. The more relevant stories we have to share, the greater chance our messages will be heard and have in reaching people about the critical importance of practicing sustainable ways of living.

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