



## **The Journal of Population and Sustainability**

ISSN 2398-5496

Article title: On sustainability, vulnerability, climate and conflict

Author(s): Colin Kelley

Vol. 1, No. 1, (Autumn 2016), pp.35-44.

doi: 10.3197/jps.2016.1.1.35  
Open Access – CC BY 4.0

---

# On Sustainability, Vulnerability, Climate and Conflict

COLIN KELLEY

---

*Dr Kelley is a climate scientist focusing on climate variability and change, particularly drought, in semiarid and arid regions that are especially vulnerable. He is an Associate Research Scientist with Columbia University's International Research Institute for Climate and Society and a Senior Research Fellow with the Center for Climate and Security in Washington, DC.*

---

## **Introduction: vulnerability and resilience**

The human population of the Earth is over 7.4 billion and growing.<sup>1</sup> Population growth inherently increases demand for resources, such as humans' most basic needs, water and food. In 1798 Thomas Robert Malthus (1798) introduced the theory that, if left unchecked, the population of our planet will, at some point, outgrow its resources, exceeding the planet's carrying capacity. Malthus's theory did not foresee technological advances in food production (Green Revolution)<sup>2</sup> and it is similarly difficult for us to envision what the future holds with respect to the relationship between resource supply and demand. It is fair to say, however, that the Earth is on an unsustainable trajectory. Now, over 200 years after Malthus introduced the theory, the world's population growth is still outpacing the growth in food production.

One characterization of a nation's sustainability lies in the balance between the supply and demand of its resources. Changes in demand, due to population growth for example, or supply, such as declining access to food and water, act to increase the strain on existing vulnerability. Every region and nation comprises

---

1 <http://www.worldometers.info/world-population/>

2 See Evenson and Gollin (2003)

a unique combination of population, geography, governance, economy, access to natural resources, social and religious structure/diversity, climate and other characteristics. The interdependence between these many factors is distinctive and often quite complex, on both spatial and temporal scales. Each nation varies with respect to its inherent vulnerability, or alternately its fundamental lack of resilience to change, and therefore in its capacity to adapt.

Many nations/regions are disproportionately vulnerable to changes, particularly abrupt changes (or 'shocks'), due to inherently limited access to water or other resources, for instance. Semi-arid and arid regions certainly fall in this category. When such changes occur, these nations are more likely to exceed their thresholds of resilience, sometimes leading to conflict, ranging from small-scale land and water disputes to full-scale war. This is not to suggest a climate determinism however, as there are also examples where extreme climatic changes have resulted in increased cooperation rather than violence (Subramanian et al., 2015). When large-scale conflicts do occur they further compound existing difficulties, sometimes leading to forced migration internally and perhaps even spilling over national boundaries when people seek refuge elsewhere, further increasing the strain on resources in those host countries, and so on.

A society's climate has a central influence on its ability to succeed and flourish or conversely to suffer and fail. Climate change is thought by many to be the greatest challenge facing our planet and its inhabitants (not only humans) now and for the remainder of this century (and perhaps much longer). When the climate changes, particularly in abrupt or extreme ways, it can directly impact access to water and food. Water is of course vital for human consumption and for cultivation of agriculture and livestock. Hence a society's vulnerability is, and has always been, directly linked to changes in climate.

### **Climate and civilisation in history**

Links between the rise and decline of ancient civilizations and changes in their climatic conditions have long been theorized. Such changes are directly associated with access to water and, by extension, agricultural potential. The collapse of the highly developed Akkadian Empire that ruled in Mesopotamia roughly four millennia ago was attributed to a sudden shift to more arid conditions. Similar collapses occurred in Egypt and in India during the same period (Cullen, 2000).

The Mayan civilization flourished during a period of wetter than normal conditions over two centuries and then collapsed after an ensuing period of declining rainfall that lasted three centuries. This climate change triggered a fragmentation of society and governance and an increase in warfare, and was followed by an extended drought and a population collapse (Kennett et al., 2012).

The demise of Angkor in the Khmer empire in Cambodia has been attributed to the combination of drought and intense monsoonal rainfall that impacted the city's water supply and agricultural productivity and damaged its water control infrastructure (Buckley et al., 2010).

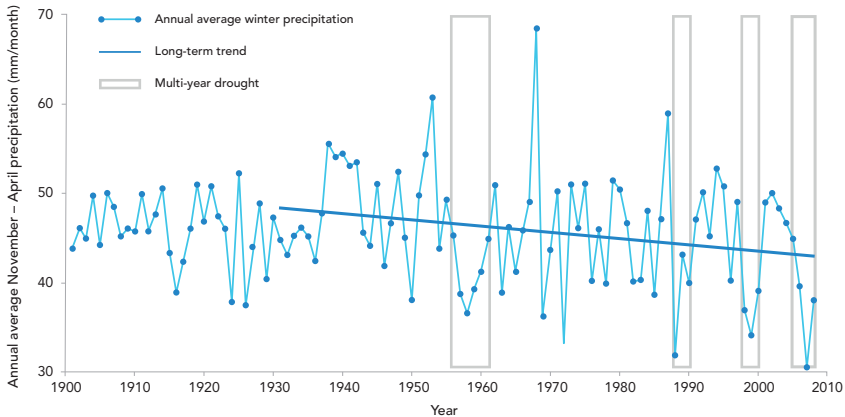
The Roman Empire rose during a period of stable and favorable climatic conditions, and then fell into crisis during the Empire's third century under deteriorating climatic conditions. The Empire recovered in a second, briefer period of favorable conditions, after which regional differences in climate conditions coincided with the diverging fates of the eastern and western Empires in subsequent centuries. Additionally, climate conditions beyond the Empire's boundaries played an important role by affecting food production in the Nile River valley, and by encouraging two major migrations and invasions of pastoral peoples from Central Asia (McCormick et al., 2012).

These are merely examples and are not listed here to imply that climate is the single determining factor in a civilization's relative success or lack thereof. As mentioned above, the relationship between the many important factors is quite complex; but it is reasonable to conclude that climatic factors have often played an important role. This applies to modern times as well.

### **Climate change and violence today**

There have been a number of studies linking climate to violence in the modern era (Cane et al., 2014; Hsiang and Burke, 2014), but other studies downplay the importance of such links. Although this body of literature has at times been contentious (Hsiang and Meng, 2014), climate can play a role, whether small or large, in a society's ability to flourish or even succeed. Abrupt changes in climate can often push a society's resilience beyond its ability to effectively adapt.

This leads to the example of Syria. The Fertile Crescent, where agriculture and herding began over ten thousand years ago, receives most of its yearly rainfall during the winter months, from late October to early April. A study conducted by myself and others and published in the Proceedings of the National Academy of Sciences (PNAS) in early 2015 (Kelley et al., 2015), found that from 2006–2010 the region experienced its worst multi-year winter drought in the observed record.

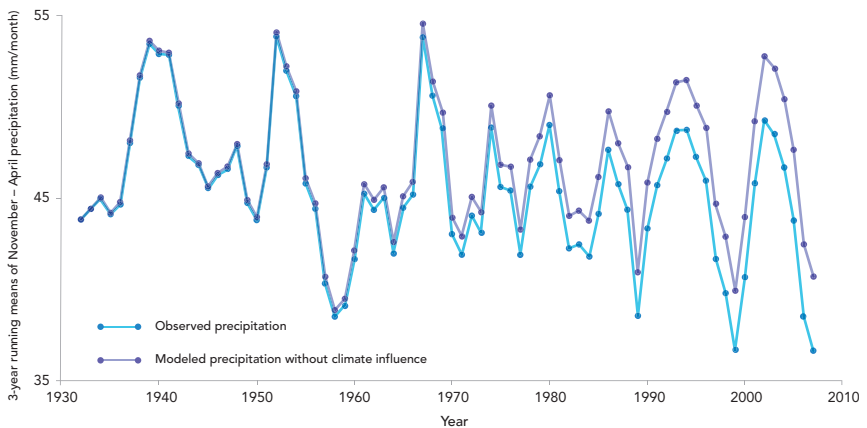


GRAPHIC BASED UPON LA FOND (2016)

**Figure 1. Rainfall (1901–2008):** Precipitation patterns are changing in the Fertile Crescent. Rainfall from November through April, when most of it occurs, has decreased 13% since 1931. The gray boxes represent multi-year droughts, which are defined as three or more consecutive years when precipitation is below the century-long average.

This unusually severe drought directly preceded Syria’s Arab Spring uprising (in early 2011). The severity and duration of the drought caused an agricultural collapse and a subsequent mass migration of farmers and their families to the urban areas in Syria’s west. The influx of internally displaced people into the cities after the prior arrival of Iraqi refugees and on top of robust natural population growth, led to overcrowding, a lack of employment and resources, a sharp increase in crime in the urban peripheries and, perhaps most importantly, little or no relief from the government. The Syria conflict escalated into a prolonged and bloody civil war that led to Syrians fleeing the country for their safety and causing a global refugee crisis.

Governance is perhaps chief among the factors that led to Syria's instability. The Syrian government had for decades encouraged wheat and even water-intensive cotton production, and Syria had succeeded in becoming a net exporter of wheat, to the point that it reached 25% of their total GDP. When the drought occurred Syria abruptly went from a net exporter to a net importer of wheat, which put them at the mercy of global food prices, high at the time. Another example of poor governance is the clear failure by the Assad regime to address the suffering of the displaced rural population.



GRAPHIC BASED UPON LA FOND (2016)

**Figure 2. Separating the influence of climate change (1932–2007):** Using measurements of carbon dioxide concentrations in the atmosphere coupled with climate models and statistical analysis, scientists were able to estimate what rainfall in the Fertile Crescent would have looked like without the influence of climate change.

The Syrian government's strong dependence on agriculture, which was initially implemented in the interest of national security, ironically depended not only on the rain that typically falls in Syria, but also the water that flows in through the Tigris and Euphrates rivers, and perhaps most importantly on groundwater. Groundwater, in semi-arid and arid regions in particular, has long been a vital complement to rainfall for irrigation purposes. Exponential population growth was responsible for a dramatic increase in the extraction of groundwater. In 1950, Syria's population was roughly 5 million and has since grown to nearly 25 million. This increased stress alone put Syria in an untenable position. Declining

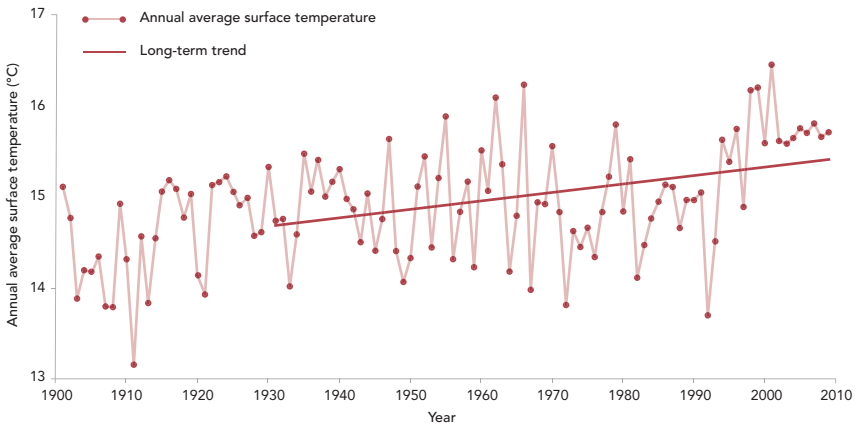
groundwater in the Fertile Crescent is merely an example of a systemic problem globally, one that is a very real threat to sustainability even before the deleterious effects of climate change are considered.

A newly released study, using tree-ring data from throughout the greater Mediterranean, characterized the natural rainfall variability over the last 900 years (Cook et al., 2016). Much of the region's weather is linked to atmospheric variability over the North Atlantic. This natural variability ranges from very short to much longer time scales. The latter manifests itself in consecutive decades of drier or wetter than normal conditions over Europe. The greater Mediterranean region has experienced a significant decrease in winter rainfall over recent decades, and at least part of the drying is due to climate change (Kelley et al., 2011). In the eastern Mediterranean, Fertile Crescent/Levant region, the longer-term natural variability over the North Atlantic holds less sway and the climate change signal is therefore more distinct (Kelley et al., 2011). Thus the increase in the frequency and the severity of multi-year droughts in this region over recent decades is believed to be due to human-induced climate change. Droughts such as the most severe one that occurred just prior to Syria's collapse were estimated to be two to three times more likely due to the climate change influence (Kelley et al., 2015). The new tree ring study provides compelling convergent evidence that the recent drying in the Levant/Fertile Crescent is well outside the range of natural variability over the last 900 years and is therefore very likely to be human-induced.

Yemen, another Arab Spring nation, is one of the poorest and most food insecure nations in the world and has been for some time. Yemen and Syria are similar in a number of ways. They have faced nearly identical population increases since 1950, both are highly agrarian societies and both depend strongly on groundwater, which has declined rapidly. Again, these are factors associated with high vulnerability before the effects of climate change are even considered. Most of Yemen's population resides in its west, near the mountains that run parallel to the Red Sea coast. Although this region does not receive an abundance of rainfall it is easily the wettest in all of the Arabian Peninsula. As such, western Yemen has the capacity for fairly diverse agriculture; but Qat, the mild narcotic that has been grown for many generations, has begun to supplant food crops due to its more regular yield and high profitability. Clearly, for a nation that is poor and food insecure, the decline in food crops is alarming. Worse, however, is that Qat

is highly water dependent, much more so than food crops, and is increasing the strain on Yemen's rapidly declining groundwater.

It has been suggested by some that Yemen's capital city of Sanaa may be the world's first to run out of water. Unlike Syria, Yemen has not seen a significant decline in rainfall over the last 40 years, although both nations, like much of the greater Middle East, have experienced a strong increase in surface temperature.



GRAPHIC BASED UPON LA FOND (2016)

**Figure 3. Temperature (1901–2009):** Temperature has shown a long-term increasing trend in the Fertile Crescent. Every year from 1994 through 2009 was warmer than the century-long average for the region.

This is important because higher temperatures, among other factors, cause more water to evaporate from the soil. The enhanced drying of the soil during the dry months has a cumulative effect, inhibiting groundwater recharge. Although Yemen did not experience a climate 'shock' similar to the extreme drought in Syria, in early 2015 it too collapsed into large-scale conflict.

As with Syria, it is important to reiterate that Yemen's conflict owes its existence to many important factors, not only to conditions made worse by climate change. Again, each nation is distinct in not only its response to climate change, but in the relationship between the many factors that combine to produce vulnerability. There



are numerous other examples of nations experiencing climate change in one form or another and how it has added to their existing vulnerabilities and heightened the overall water and resource stress, with differing outcomes. To accurately assess each country's (or region's) threshold of resilience, with an eye toward building the capacity to predict when that threshold may be crossed, is a tremendous challenge.

As of this writing, tentative ceasefires have been agreed upon for Syria and Yemen. The future of these two nations is far from clear. What is clear, however, is that Syria's civil war has had a profound effect on the rest of the world. Thus, it stands as a primary example of how climate change can combine with other key factors to exacerbate existing food and water security and social challenges and to push a vulnerable region beyond its resilience. As such, the security communities, including Department of Defense (2014), have taken climate change very seriously for some time now.

The examples of Syria and Yemen perhaps beg the question of who will be next? Prior to its uprising, Syria was widely viewed by experts as stable and largely immune to the effects of the Arab Spring. According to a recent study (Werrell et al., 2015) certain popular indices of nation-state fragility (Fund for Peace's Fragile State Index, for instance) corroborated this belief; in hindsight it was not in fact the case. This leads to the conclusion that, while prediction of state failure or conflict is clearly a highly complex task involving numerous variables, there is strong reason to believe that closer examination of regional climate change and resource availability change could greatly improve existing state fragility indices, providing policy makers with better information with which to make informed decisions.

## References

Buckley, D. et al. (2010) Climate as a Contributing Factor in the Demise of Angkor, Cambodia. *Proceedings of the National Academy of Sciences*, Vol. 107 no. 15, pp. 6748–6752.

Cane, M.A. et al. (2014) Temperature and Violence. *Nature Climate Change*, 4, pp. 234–235.

Cook B et al. (2016) Spatiotemporal Drought Variability In The Mediterranean Over The Last 900 Years. *Journal of Geophysical Research-Atmospheres*, Vol. 121, Issue 5, pp. 2060–2074.

Cullen H et al. (2000) Climate Change and the Collapse of the Akkadian Empire: Evidence from the Deep Sea. *Geology*, Vol. 28; no. 4; pp. 379–382.

Department of Defense (2014) *Climate Change Adaptation Roadmap*. Office of the Deputy Under Secretary of Defense for Installations and Environment (Science & Technology Directorate), Alexandria, VA 22350–3605.

Evenson, R.E. and Gollin, D. (2003) Assessing the Impact of the Green Revolution, 1960 to 2000. *Science*, Vol. 300, Issue 5620, pp. 758–762.

Hoerling, M.P. et al. (2012) On The Increased Frequency of Mediterranean Drought. *Journal of Climate*, 25, pp. 2146–2161.

Hsiang, S.M. and Meng, K.C. (2014) Reconciling Disagreement Over Climate-Conflict Results In Africa. *PNAS*, Vol. 111 no. 6, pp. 2100–2103.

Hsiang, S. and Burke, M. (2014) Climate, Conflict, and Social Stability: What Does the Evidence Say? *Climatic Change*, Vol. 123, Issue 1, pp. 39–55.

Kelley, C. et al. (2011) The Relative Contributions of Radiative Forcing and Internal Climate Variability to the Late 20th Century Winter Drying of the Mediterranean Region. *Climate Dynamics*, Vol. 38, Issue 9, pp. 2001–2015.

Kelley, C. et al. (2015) Climate Change In The Fertile Crescent and Implications of the Recent Syrian Drought. *Proceedings of the National Academy of Sciences*, Vol. 112 no. 11 pp. 3241–3246.

Kennett, D. et al. (2012) Development and Disintegration of Maya Political Systems in Response to Climate Change. *Science*, Vol. 338, Issue 6108, pp. 788–791.

La Fond, K. (2016) Infographic: Syria Drought and Climate Change. *Circle of Blue*. Available at: <http://www.circleofblue.org/2016/middle-east/infographic/>

Malthus, T. R. ([1798] 2008) *An Essay on the Principle of Population*. Oxford, Oxford University Press.

McCormick, M. et al. (2012) Climate Change During and After The Roman Empire: Reconstructing The Past from Scientific and Historical Evidence. *The Journal of Interdisciplinary History*, 43 pp. 169–220.

Subramanian, A., Brown, B. and Wolf, A. (2012) *Reaching Across the Waters: Facing the Risks of Cooperation in International Waters*. Washington DC, The World Bank Press.

Werrell C., Femia F. and Sternberg T. (2015) Did We See It Coming?: State Fragility, Climate Vulnerability, and the Uprisings in Syria and Egypt. *SAIS Review of International Affairs*, Vol. 35, No 1, pp. 29–46.