Global Change

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Introduction

"We are living on this planet as if ours was the only generation that mattered"
Carl Sagan, Cosmos (1980)

This section of the Earth Systems and Environmental Sciences module focuses on Global Change. Whether on a daily basis, as in the changing weather, or on millennial time scales, as in slow-moving geological forces, we bear witness to a changing world all around us. The predominant global change force today is the human species as we transform the environment on a planetary scale and at rates that exceed historic bounds. The insidious drivers of such prodigious change are rapid population growth and consumption of natural resources with impacts that accumulate in space and time.

As if in a blink of an eye, our numbers doubled in the past five decades to 7.2 billion. Another doubling to 14 billion is just 60 years away, based on current annual population increases of 1.2%. To put this into perspective, imagine that in the time it takes to read this article (~10 min) over 17 million new-born babies will have taken their first breath; 250 million more will be added by the end of your day (24 h). To feed, clothe, and shelter this sea of humanity, ecosystems everywhere are being rapidly terraformed. The speed and magnitude with which such global change is occurring has prompted scientists to refer to this period as the Great Acceleration or the Anthropocene (Age of Humanity). Population growth and consumption levels are explored in the Society section under Demographics.

Humans as the Planet’s Ecological Bigfoot – as population increases, our ecological footprint is readily visible all around us (see Society, energy subsection and Figures 1 and 2). Witness the degradation of 60% of the world’s essential ecosystem services (15 of 24 services) as evaluated by the Millennium Ecosystem Assessment (2005), including freshwater, fisheries, air and water purification, and regulation of regional and local climates. Similarly, in order to meet rising wood fiber demands, forests have been destroyed at an alarming rate of ~25 ha every minute of every day, the equivalent of some 13 million ha globally deforested each year during the past decade or 88000 US football fields each day over this period, based on Food and Agriculture Organization (FAO) (2010) statistics. Deforestation rates and the loss of over 40% of the world’s forests are discussed in the forestry subsection of Bioscience.

The situation is no better in the marine environment, where 40% of coral reefs – the wellspring of marine ecosystems – have declined or been destroyed in the last few decades (Food and Agriculture Organization, FAO, 2010). And the same is true for mangroves and coastal wetlands, nurseries for the world’s fisheries, which are in rapid decline. Such dramatic changes and their implications for people and wildlife are explored in Oceans (coral reefs subsection), Atmospheric Sciences (air pollution subsection), Bioscience (fisheries subsection), and Freshwater Hydrology (water supply subsection).

In sum, humanity is playing a dangerous game of roulette with the planet’s life-giving systems and especially the biosphere. Such human-caused environmental degradation has elevated species extinction rates to ~1000 times the background level as estimated from the fossil record. Presently more than 5000 species of vertebrates and 8000 species of vascular plants are at the brink of extinction and some estimates project up to 40–70% of taxa assessed (Intergovernmental Panel on Climate Change, IPCC, 2007) could be gone by century’s end with climate change now the “elephant in the room.” In this module, we explore humanity’s footprint through limits to growth (Society, conservation of resources subsection) and extinction rates (Bioscience, extirpation and extinction subsection).

Climate Change – since the beginning of the industrial revolution some 150 years ago, we have had a fossil-fuel economy. To meet transportation needs, run countless electrical gadgets, heat or cool homes, and supply global economies with energy, our burning of prodigious amounts of fossil fuels comes with a substantial cost to the climate. In fact, the build up of carbon dioxide in the atmosphere is now poised to change the very climate that birthed agro-economies at the dawn of the Holocene climatic optimum some 10000 years ago. Despite well-financed efforts to deny it and to prevent much needed policies, climate change (also known as climate chaos, climate disruptions, global warming), the consequence of fossil-fuel emissions, is unequivocally real and predominately caused by human activities (Intergovernmental Panel on Climate Change, IPCC, 2007). We now live in a world with rapidly melting glaciers, rising seas (Ocean, sea level subsection), intense floods and droughts (see Freshwater Hydrology, floods and drought subsection), and mega-storms (see Atmospheric Sciences, extreme weather subsection), in addition to other related climatic changes (Society, climate change impacts subsection).
Figure 1  Global human footprint analysis showing levels of low human impacts (green) to high (purple) impacts. Source: http://earthobservatory.nasa.gov/Features/footprint/Images/fullres_footprint.gif

Figure 2  The magnitude and scale of human activities as illustrated by city lights and transportation corridors. Source: http://www.anthropocene.info/en/anthropocene
While natural systems are resilient to change if it occurs within their adaptive capacity, the combination of an expanding footprint and its causal effect on the climate is unprecedented. Such global change comes with consequences to food security (Bioscience, food security subsection), water supplies (Freshwater Hydrology, water supply), human health (Society, climate change impacts, climate policy), and to even world peace (Society, impacts of war).

Clearly, we are on a collision course with the natural world at a crucial moment in our evolution where the magnitude of global change threatens our own survival. Given the long residence times of carbon dioxide (decades to centuries) and nuclear waste (millennia), for instance, today’s civilizations are leaving behind byproducts of energy consumption that will impact the environment for generations to come (see articles in Society, energy subsection).

Age of Enlightenment or Downward Spiral – Human wellbeing is clearly dependent on the condition of the planet’s environment that affects everything we need to survive from local to global ecosystem services (e.g., clean air, clean water, fisheries). If carefully stewarded and used with restraint (see Society, conservation of resources), our natural resources will continue to sustain generations of people to come. Thus, it is in our own best interest to reach a sustainable relationship with the Earth as our health, emotional state, IQ level, food and water, spirituality (e.g., Biophilia, Gaia concept), children, and economic wellbeing depend on it.

Ecological sustainability – defined as the capacity of nature to sustain us along with the needs of countless species – is nonetheless a key goal for humanity to achieve while there is still time for such enlightened change. It is fundamental to preserving biodiversity and ecosystem services, but will we reach it in time? The keys to sustainability will depend on how quickly population growth levels off and, more urgently, declines, and whether consumption levels also drop precipitously – especially in developed countries that consume far more natural resources per capita than developing ones (Society, limits to growth).

Conclusions

This module on global change is a synopsis of the path humanity is currently on with respect to our interaction with the natural world, which has been anything but sustainable. Arguably, humanity faces no greater challenge but the need to proactively address the consequences of our expanding footprint while there is still time. Making the transition to sustainability hinges on a renewable energy economy enacted on a scale massive enough to arrest global climate change. While the ascent of civilization was a rapid one in our evolutionary timeline, the descent into unstable climates and rapacious natural resource consumption is far too quick for the planet’s life-giving systems to keep up. Even with a serious global commitment to sustainability, on the scale of the post-WWII Marshall Plan, for instance, repairing the damage to the planet’s systems – especially our fragile biosphere – will be slow going and risky business the longer we wait. For instance, if every reproductively fertile person alive today had no more than 2 children (China’s current birth policy), it would take over 70 years for population growth to level off (Society, demographics). The same can be said of climate change as if we stopped using fossil fuels right now, it would take decades for greenhouse gas concentrations to level off and even longer for ocean acidification to arrest.

With respect to climate change, our task is simply this – adapt or die, mitigate or fry! Climate adaptation solutions are presented in this module precisely to help ecosystems and people begin adapting to the inevitable consequences of climate change (see Society, adaptation and scenario planning). Mitigation will require bold and coordinated policies designed to substantially reduce our carbon footprint via renewable energy technologies expanded in a way so as to minimize their development footprint. The drive to energy independence (from fossil fuels) needs to work in concert with changes in forestry and agricultural practices to bring atmospheric CO2 levels back to within what some scientists believe are safe bounds (see 350.org). Land preservation and market-based solutions are urgently needed to reduce deforestation globally and, in doing so, to allow forests to sequester and store atmospheric carbon (Society, conservation of resources, DellaSala et al. 2012) for long periods, acting as carbon sinks. To do otherwise, would leave future generations with delinquent biological capital and a greatly impoverished and unsettling world.

References


Relevant Websites

