CHAPTER 1

Environmental Issues

In the mid-2020s, the state of the environment is marked by myriad challenges across multiple ecological systems. The systemic nature of environmental issues means that addressing one problem can influence another, making it imperative to appreciate these connections—on a global scale. From rising global temperatures and deforestation to lost biodiversity and ocean acidification, the long list of issues challenges us to think holistically about our relationship with the environment.

CLIMATE CHANGE AND GLOBAL WARMING

At the core of climate change is the accumulation of greenhouse gases (GHGs) like carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These gases trap heat in Earth's atmosphere, creating what scientists call the "greenhouse effect." This effect is essential for maintaining temperatures that support life, and natural occurrences, such as volcanic and sunspot activity, lead to variation in temperatures over time, e.g., periods of much colder temperatures lead to the ice ages. More recently, however, GHG concentrations have risen far beyond observable historical levels, leading scientists to conclude[1] that human activity, such as burning fossil fuels, deforestation, and industrial agriculture, are the major drivers.

The resulting rise in global average temperatures—already exceeding 1.1°C above pre-industrial levels—is affecting our climate.[2] Extreme events, like hurricanes, droughts, increased precipitation, heatwaves, and wildfires, are becoming more frequent and severe, affecting millions of people and costing billions of dollars in damages across the world. At the same time, increases in average temperatures contribute to the melting of glaciers and polar icecaps, leading to sea-level change that threatens coastal cities and many island nations. Some forecasts suggest that by the end of the century, sea level may rise at least 0.3 meters above year 2000 levels,[3] endangering hundreds of millions of people living in coastal regions.

It should be noted that complex interrelationships across the climate system make it difficult to forecast what the future climate will look like

under different scenarios. For example, temperature rise leads to melting of the Arctic permafrost which releases methane, a very potent GHG, which further increases GHG concentration in the atmosphere. This is a positive feedback loop since it accelerates the underlying process. Actions may have unforeseen negative relationships as well. For example, large segments of the maritime shipping industry burn an oil product called bunker fuel which is both very polluting and contributes meaningfully to GHG emissions. A recent initiative by the International Maritime Organization (IMO) not only reduced GHG emissions but also reduced sulfur, which is known to contribute to cloud formation. Scientists estimate that the effort to reduce GHG emissions contributed to a net increase in global warming once the cooling effect of cloud cover was taken into account.[4]

POLLUTION

The byproducts of human enterprise may have a polluting effect on the air, ground, and water that we depend on for life. Air pollution, primarily driven by industrial emissions, vehicle exhaust, and the burning of fossil fuels—colloquially referred to as smog—is a severe public health challenge in many emerging economies (e.g., China, India, Mexico). In these urban centers, the concentration of toxic pollutants and fine particulate matter ($PM_{2.5}$) often far exceeds safe thresholds.

Burning biomass, like wood and leaves, can also create harmful air pollution that affects more than just the immediate area where the burning takes place. For example, palm-oil farmers in Southeast Asia sometimes use "slash and burn" techniques to clear land for replanting, releasing so much smoke and particulate matter into the air in 2010–2015 that the "haze" conditions in nearby Singapore led authorities to restrict much outdoor activity.[5]

The economic and social impacts of air pollution are vast in the forms of loss of labor productivity and incidence of respiratory and cardiovascular diseases. Some studies estimate that exposure to outdoor air pollution contributes to 4.2 million premature deaths worldwide every year.[6] This does not include fatalities from less frequent but more alarming releases of airborne toxic chemicals such as the 1984 Union Carbide incident in Bhopal, India, which killed an estimated 3,800 people immediately and up to 10,000 in total during the first few days.[7]

Pollution is not limited to the air we breathe. Ground and water pollution can be deadly for ecosystems and people in the surrounding area. Examples may be related to improper disposal of industrial waste—see the Hinkley groundwater contamination case in California which inspired the

movie *Erin Brockovich*[8]—or use of chemicals before their negative effects are fully understood. DDT, or dichloro-diphenyl-trichloroethane, was a popular synthetic insecticide in the United States between the 1940s and the early 1970s. Seeping into the groundwater, this chemical made its way into river fish, which are an important food source for bald eagles. Consumption of elevated levels of DDT was found to cause bald eagles to lay eggs with shells that were too thin to survive and the population of bald eagles plummeted.[9]

GARBAGE

Garbage, in all its forms, is slightly different from pollution in that many countries have formal systems for the collection and disposal of garbage. Large public companies, like Veolia and WMI, provide these services to hundreds of millions of people around the world and have rich market capitalizations as a result.[10] But the modern world creates hundreds of millions of tons of waste each year, with many potentially negative consequences. Two industries receiving particular attention in the 2020s include plastics and apparel.

The modern world generates over 450 million metric tons of plastic each year.[11] Plastics are derived from fossil fuels; there are many different types of plastic which vary in the degree to which they biodegrade over time—some in years or decades, others are expected to persist for centuries. Plastic pollution affects marine and terrestrial ecosystems alike; well-publicized examples include the "Great Pacific Garbage Patch" and countless images of marine species caught with plastic in their stomachs or killed by plastic wrapped around their necks.[12] We now know that microplastics—fragments less than 5 millimeters in size[13]—are found all around the world and in the human bloodstream, with as yet unknown consequences.

Apparel waste is another increasingly important issue. For most of human history clothing was made by hand from natural materials. Like so many other industries, apparel manufacturing has evolved with the advent of steam and electricity, specialized machinery, and especially synthetic fabrics. These were combined in the 2000s to great effect in the development of "fast fashion," exemplified by H&M and Inditex (better known to many by its brands, including Zara), whereby inexpensive clothing is produced rapidly by mass-market retailers in response to the latest trends. The 2020s brought "ultra-fast fashion" in the form of Chinese brands like Shein and Temu. In all cases, the firms offer consumers an almost irresistible combination of rapidly changing styles available at super-cheap prices, leading to increased consumption.

As opposed to more durable (or expensive) clothing for which mending is an attractive option, cheap clothes are more likely to be discarded. When clothes are donated or recycled in developed countries like Canada and the United States, that often means items are shipped to places like Accra, Ghana, where as much as 40% end up in mountains of textile waste or clogging up the beach.[14] Although secondhand is more affordable than new clothing, the volume of cheap clothing verges on overwhelming.

The above examples are transparently negative views on these two industries, but a word of balance is appropriate here. Plastics have revolutionized many industries, making items more accessible and affordable to millions and improving many lives as a result. Where we used to use paper bags for our groceries, made from trees, cheap plastic bags seemed like a better choice. Today, the push is to bring reusable bags for your purchases, but cloth bags require energy to produce and distribute too. Which type of bag appears to be more environmentally friendly depends on the calculus you use, something we will explore again later in the book. Advocates for the apparel industry might point out the positive social and economic effects of more comfortable and affordable clothing for consumers at the base of the economic pyramid. Recycling would seem to be a solution to both problems. However, recycling rates for plastics and apparel are at most 10–15% globally, with considerable variation by country[15]—which doesn't mean that we shouldn't recycle, but that it's not (yet) a meaningful solution. Like much in the field of sustainability, multiple perspectives must be considered when evaluating the impact of these industries.

LAND HEALTH

Deforestation remains rampant around the world, with an annual loss of approximately 10 million hectares of forest and jungle. This widespread tree loss is mainly driven by the expansion of agriculture, logging for timber, and urban development. One impact of deforestation concerns carbon sequestration. Trees naturally absorb carbon dioxide, so cutting down trees leads to an increase in atmospheric GHGs, accelerating climate change. Additionally, deforestation causes soil erosion and loss of habitat for the species that live there. Of course, the initial wave of deforestation occurred hundreds of years ago when mankind cut down trees for building and fuel across much of Europe and North America; this is not a new phenomenon. What is new this time, however, is that GHG concentration is rising at a time when we have fewer trees to help sequester the extra carbon dioxide.

The popular press often writes about cutting down trees in the Amazon, for example, but pays less attention to soil health. Intensive farming practices

and expanding use of chemical fertilizers can reduce soil quality, both for crop yield and for carbon sequestration. As some have pointed out, as a planet we produce more than enough food to feed the more than seven billion humans living today; we don't have a food production issue but rather a food distribution issue. That modern agricultural practices have dramatically increased crop yields is indisputable. The issue that may require more attention is the long-term effect of these practices. The United Nations Food and Agriculture Organization estimates that 25% of arable land may already be degraded,[16] with unknown consequences for future food security as the global population continues to expand.

BIODIVERSITY LOSS

Global biodiversity is in sharp decline; the Worldwide Fund for Nature estimates that populations of mammals, birds, fish, amphibians, and reptiles declined by an average of 73% between 1970 and 2020.[17] The loss extends to myriad plant and insect species as well. Some of this may seem a bit abstract—after all, the dodo and passenger pigeon went extinct more than 100 years ago without any meaningful impact on human progress. But once again, we should remember the complex system that exists in the natural world.

Aside from being, perhaps, the "right thing to do" to protect other living things, it can be hard to assign a monetary value to species reduction or disappearance. A case in point concerns pollinators, especially bees. A lack of bees to pollinate almond trees in California, for example, would almost certainly reduce agricultural yields and increase costs for environmental remediation efforts. As we will revisit later in the book, assigning a value to bees because of their link to crop values may be easier than valuing whales or white rhinos—but the fact that biodiversity is *difficult* to value doesn't mean that biodiversity is *without* value.

WATER: FRESH AND OCEANS

Fresh water constitutes a small fraction of the total water available on Earth, and only a fraction of that is accessible for human use. Access to clean fresh water is a critical issue for billions of people. Pressure comes from ever-growing populations and practices that take rivers and aquifers for granted. For example, we grow water-hungry crops, like those almonds in central California (Central Valley), under the assumption that mountain snowmelt

and local aquifers will always provide enough water for everyone. When fresh water is available, in many places it is poisoned by agricultural runoff, as well as discharge from companies and overburdened sanitation systems. Climate change alters precipitation patterns, adding further pressure to an already stressed resource.

Water issues are not limited to fresh water; climate change has a profound effect on ocean ecosystems. Ocean waters are already a critical carbon sink, and increased levels of carbon dioxide in the atmosphere cause them to absorb increasing amounts of carbon dioxide. This leads to acidification of the waters that harms shell-forming marine organisms. Ocean water temperatures are also rising, contributing to the bleaching of coral reefs that are home to 25% of marine life.[18] Collectively, these changes not only impact biodiversity but also lead to economic losses in the fishing and tourism sectors.

There is yet another change that should be of concern, particularly to island nations and those living in low-lying cities like Ho Chi Minh and Miami. The warming ocean waters lead to thermal expansion, further exacerbating sea-level rise.[19] Natural systems are intertwined, and changes in one part of the system may have impacts on other parts.

SUMMARY

Environmental challenges explored in this chapter—from climate change to other human-influenced degradation of the air, land, and water around us—are formidable and interconnected issues. Climate change serves as an overarching threat, reinforcing and magnifying the consequences of deforestation, biodiversity loss, and water scarcity, for example. Each problem, significant on its own, also carries significant weight that further contributes to systemic instabilities with natural and economic ramifications.

The combined effect of multiple environmental stressors means that changes in one area may have cascading consequences that are difficult to predict—and to counteract. Therefore, when taking steps to address any of these environmental issues, we should take care to consider potential linkages to other aspects of the system. As we shall see in Chapter 2, this extends beyond environmental issues to the impacts on people and society more broadly.