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Navigating Climate Catastrophe

This is Part 1 of an exploration of the current state of the climate crisis.

Part 1: The Predicament

People have widely varying beliefs about climate change. A surprising number still think that it's a hoax, or that it's a trivial problem. At the other end of the opinion spectrum, some say it signals the end of the world and there's nothing we can do to stop it. Between those extremes are lots of folks who believe climate change is a serious dilemma, but we can deal with it by installing solar panels, nuclear power, solar radiation management technologies, and/or machines to remove carbon dioxide (CO_2) from the atmosphere, after which we will continue to live mostly the way we do today.

This confusion about climate change arises partly because of the political polarization and subjectivity that has overtaken many media outlets. It partly reflects the fact that climate science is unsettled, due to the complexity of Earth's climate system. It also derives from the fact that people don't like to think that the way they are currently living cannot be sustained.

In this article we will dive far beneath superficial beliefs about the climate crisis. We'll explore what scientific studies tell us about why Earth's climate is changing, as well as the consequences we can expect throughout the remainder of this century. We'll also look at what can realistically be done to minimize those impacts and to adapt to warming that's already in the pipeline.

We will examine the difference between incremental climate warming and runaway climate change driven by self-reinforcing feedbacks. And we'll note the indicators of whether we are nearing tipping points for runaway climate heating.

Crucially, we will view climate change from a perspective that includes the mosaic of developing global threats that will likely shape and limit our collective response to global warming. As we'll see, failure to take this big-picture view of the situation can lead to unrealistic assumptions about industrial society's ability to "solve" climate change using technology.

This is a complex, disturbing, and highly important topic, so buckle up.

It's Complicated

Scientists have needed decades to grasp the ways in which the components of Earth's climate interact, and there is still much that is poorly understood. Here is a brief overview of what researchers now mostly agree on.

Over millions of years, the main factors influencing Earth's climate have been changing solar output, colliding tectonic plates, volcanoes, comet and asteroid collisions, and variations in our planetary orbit. However, none of these can explain the 1.5 degrees Celsius spike in surface temperatures that we've seen so far. And this warming appears to be accelerating. Something new is happening. And quickly.

Since long-term climate factors don't appear to be responsible for the warming, short-term "forcings" are the most likely culprits. These include changes to the gas composition of the atmosphere, to the planet's albedo (i.e., the proportion of sunlight it reflects), or to the amounts of particulate matter in the air preventing sunlight from reaching the surface.

Atmospheric gases whose molecules are comprised of more than two atoms tend to trap heat rather than letting it radiate into space; for this reason, they are known as greenhouse gases. The main ones are water vapor (H_2O), carbon dioxide (CO_2), and methane (CH_4). Water vapor's impact is largely self-canceling: while it traps heat, clouds (which are water vapor) also reflect sunlight. More significantly, the burning of billions of tons of coal, oil, and gas during the last century or so has released enormous amounts of carbon dioxide into the atmosphere, whose CO_2 concentration has increased from 280 parts per million (ppm) in pre-industrial times to over 425 ppm today. The amount of methane in the atmosphere is also rising, again due to human activities. The consensus of climate scientists is that human-caused greenhouse gas emissions are the main reason for the observed average planetary surface warming.

However, the other two short-term climate forcings also play a role. Earth's albedo, or reflectivity, is shifting. Glaciers and sea ice are melting, exposing darker water and rock, which absorb more heat from sunlight. People are cutting down forests and planting row crops, and land surface is being paved, all on an unprecedented scale; these activities increase how much heat the land absorbs from sunlight. The highly reflective planetary cloud cover is also changing, again in response to human activities. Some of these cloud changes, including ones induced by the heat and smoke of larger and more frequent wildfires, are indirectly due to human action (they're responses to global warming, which is human-caused). On a net basis, planetary reflectivity is declining, so the Earth is absorbing more heat from the sunlight that hits its surface.

The third forcing, particulate matter in the atmosphere, has a cooling effect because it reflects sunlight; but it also has a warming effect when it settles on (and darkens) patches of ice and snow. On a net basis, smoke and other particulates released directly from human activity (burning coal and oil) and indirectly from human activity (from the increased frequency and intensity of wildfires that result from greenhouse gas-induced global warming) tend to reduce the warming that would otherwise be happening due to greenhouse gas accumulation in the atmosphere.

Analysis by James Hansen and colleagues suggests that atmospheric aerosols (including particulates) produced by burning fuels and forests, and activities like jet travel and oceanic shipping, have offset some of the warming that would otherwise have been caused by the CO_2 we've emitted. If humanity stops burning fossil fuels, those particulates and aerosols will be reduced, and so will their cooling effect. Hansen writes: ". . . aerosol cooling is a Faustian bargain because payment in enhanced global warming will come due once we can no longer tolerate the air pollution." Some scientists attribute a recent spike in North Atlantic surface temperatures in part to the implementation of limits on particulate matter from shipping.

There are some climate scientists who argue that much more attention should be paid to human disruption of water cycles. The destruction of topsoil by industrial agriculture releases carbon into the atmosphere, but also reduces the land's ability to retain water and stay cool. Likewise, deforestation reduces evapotranspiration and disrupts cooling water cycles. So, while greenhouse gases trap heat from sunlight, the processes of urbanization, deforestation, and industrial agriculture make the land surface hotter, meaning there is more heat to trap; they also reduce the cooling circulation of water through natural cycles involving soil, plant growth, transpiration, and rain.

Perhaps you can already appreciate how complicated climate science is. But we've only sampled the list of problems that keep researchers awake at night. Here's another big one: the oceans absorb over 90 percent of the added heat from the greenhouse effect and also absorb most human-generated CO_2. However, oceans may lose at least some of their ability to continue doing this due to shifts in deep currents and the fact that warmer waters absorb less carbon dioxide.

The components of Earth's climate system interact to enhance or inhibit temperature change. Systems scientists call these interactions feedbacks—which can be either negative (balancing) or positive (self-reinforcing). Negative feedbacks stabilize the climate; positive feedbacks destabilize it. We're already seeing positive climate feedback from melting glaciers and sea ice, which lower the Earth's albedo, leading to surface warming and therefore even more melting. Climate scientists worry that melting permafrost could add enormous amounts of carbon dioxide and methane to the atmosphere, and that warming oceans could eventually release billions of tons of methane from sea beds. In a worst-case scenario, self-reinforcing feedbacks could lead to runaway climate change, in which the planet's response to the CO_2 we emit would not be linear and incremental, but faster, more extreme, and harder to predict. As we'll see below, this has happened before in Earth history (though not as a result of human action, because it took place long before there were any humans).

All of these factors have to be accounted for when climate scientists try to assess climate sensitivity, which is the amount of warming we should expect from a doubling of atmospheric CO_2 compared to pre-industrial times. Scientists have struggled to agree on an answer. Their current best guess is a 1.5 to 4.5 degree Celsius increase in average surface temperature. That's a wide range. So, understandably, climate sensitivity is the subject of intense ongoing research and debate.

James Hansen argues that the lower estimates of climate sensitivity are unrealistic. In a recent paper, he and his co-authors concluded that, even if we stop burning fossil fuels today, there is more warming already in the pipeline: "Eventual global warming due to today's GHG forcing alone—after slow feedbacks operate—is about 10°C." We should all hope that Hansen is wrong (I'm sure he does too), because that much warming would be utterly horrific.

Feedbacks and tipping points will largely determine whether we experience runaway climate change, to which it will be extremely difficult to adapt. The other main factor that will decide our fate is what we humans do over the next ten or twenty years.

Climate Change in Context

We know what's causing the climate to change—deforestation, urbanization, industrial agriculture, and the burning of fossil fuels. So why don't we just stop?

Answering that question requires knowledge of energy history. People began using fire hundreds of thousands of years ago, and started using domesticated animals for agriculture and transportation at least 10,000 years ago. These innovations gave our species access to energy beyond what was contained in our food—as well as giving us more food. (By the way: there's evidence to suggest that fire and agriculture began changing Earth's climate several thousand years ago; without them, the planet's surface would likely have cooled by up to 5 degrees Celsius. See Steven Earle's *A Brief History of the Earth's Climate*, pages 117-119.)

Further innovations—including metallurgy, a heat engine, private ownership of natural resources, and legal protections for investors—made it possible and profitable to extract and burn coal, oil, and natural gas in enormous quantities. A vast and unprecedented energy subsidy from fossil fuels, in turn, enabled growth of both population and the economy. It made agriculture so efficient that a majority of people could leave farming behind and move to cities. The result, which Will Steffen and colleagues have called the Great Acceleration, has produced a host of benefits (longer lifespans, myriad technologies and consumer products, and instant communication), but also a plethora of problems, of which climate change is only one—though arguably the worst.

Gasoline-powered chainsaws have felled vast swathes of forest. People and their domesticated animals have proliferated to the point where they make up over 90 percent of Earth's mammalian biomass. Chickens now account for over 70 percent of global bird biomass. Altogether, wild nature is being pushed aside, and non-domesticated species are disappearing at roughly 1,000 times their normal extinction rate. Biodiversity loss worsens climate change.

Tens of thousands of chemicals are now made from or with fossil fuels. Some of these, including some pharmaceuticals, offer significant benefits. But only a tiny percentage have been tested for long-term environmental safety. Plastic particles are now everywhere—in oceans and streams, in the air, and in our bodies. Many chemicals mimic natural hormones and disrupt the endocrine systems of people and wildlife. Sperm counts in humans and wild animals, including insects, are plummeting.

Fossil fuels make it possible to extract natural resources at rates that are unsustainable over mere decades. For example, motorized fishing vessels enable fish to be harvested far faster than they can reproduce. Substances in Earth's crust, including minerals and fossil fuels, are extracted and often used in ways that make it practically impossible to reuse or recycle them.

Fossil fuels also produce immense amounts of wealth, as they are used to extract resources and transform them into goods. A socio-economic system that rewards competition and exploitation leads powerful people, countries, and institutions to capture unequal amounts of that wealth. Therefore, economic growth tends to increase economic inequality within and between nations. The effects of this wealth pump are blunted somewhat by government taxation and redistribution programs, but powerful people and corporations tend to capture governments by donating to the election campaigns of business-friendly politicians, who, in return, reduce taxes on the wealthy.

The result of the collision of all these problems is what's known as the polycrisis—a confluence of climate change with rising inequality, resource depletion, pollution, and the disappearance of wild nature, among other worsening dilemmas.

We can't know what to do about climate change unless we understand this big picture. Once we do, we see that many things we might do to "solve" climate change will have their own damaging impacts. For example, building renewable energy infrastructure or carbon removal technology at scale will require an enormous increase in energy usage and resource extraction. Further, many of the needed resources are in ecologically sensitive areas, or countries with a history of labor exploitation and steep income inequality. Also, all this resource extraction, energy usage, and manufacturing will produce its own pollution and environmental degradation. So, we might reduce carbon emissions, but we will just worsen other aspects of the polycrisis—which are also significant threats to our human future.

The polycrisis impacts our capacity for climate response. Political polarization, driven in part by increasing economic inequality, makes it harder for nations to make the tough choices required to reduce emissions. And the accelerating depletion of mineral resources threatens the build-out of alternative energy infrastructure.

Altogether, this bigger picture leads to the conclusion that there is no techno-fix. If we wish to avert the worst impacts of climate change, we will have to live differently.

This is a message that shows up surprisingly rarely in mainstream discussions of global warming. There's a reason for this: society has become dependent on continuing economic growth and population expansion in order to produce jobs, profits, and returns on investment. All politicians promise more growth, and voters demand it—in rich and poor countries alike.

This growth mania explains why carbon emissions haven't declined yet, despite decades of promises and commitments by governments, and despite enormous investments in renewable energy technologies. Even though solar and wind power generators are being installed at record rates, economic growth and population expansion feed the demand for even more energy—so, nations end up using more fossil fuels, rather than less. Solar panels just add to the energy from fossil fuels rather than displacing it. And, of course, we're still cutting down forests and building more cities.

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Now that we've explored the science and context of climate destabilization, we need to consider what's coming and how we can deal with the consequences. In Part 2, I will explain what we can expect as global heating continues and how we can respond in practical and wise ways. Read Part 2 here.