Scientific and Spiritual Dimensions of Climate Change

Unit 8 – Part 1
Prospects for the Future

This first part of Unit 8 contains more science for those who are interested in learning more. It is optional to study it as a group.

Planet Earth will continue to exist despite climate change, although in an impoverished state, as there will be much fewer species of plants and animals. In the course of many thousands of years, a rich biodiversity will probably evolve again on the Earth and the climate return to its natural cycles. The only question is how and whether human civilization will survive. Currently we are on a direct course to self-destruction.

"Our global economy is outgrowing the capacity of the Earth to support it, moving our early twenty-first century civilization ever closer to decline and possible collapse. ... We are consuming renewable resources faster than they can regenerate. Forests are shrinking, grasslands are deteriorating, water tables are falling, fisheries are collapsing, and soils are eroding. … And we are discharging greenhouse gases into the atmosphere faster than nature can absorb them, setting the stage for a rise in the earth's temperature well above any since agriculture began."[1]

As mentioned previously, global temperatures of the last 10,000 years have been about the most stable in the Earth's history which allowed humans to develop a civilization built on agriculture. We are in one of the naturally occurring warm interglacial periods. The Earth did experience warmer temperatures than now, but the last time temperatures were warmer than at present was about 125,000 years ago, at a time when humans survived as hunter-gatherers.

The extremely high concentration of greenhouse gases in the atmosphere, however, is unprecedented in all human history. In its 6th Assessment Report, the IPCC stated that carbon concentrations have not been as high as they are today for at least 2 million years!

Section 1: Future Threats

Current estimates for temperature rise by the end of this century is 4°C (7.2°F), if we continue with business as usual. If the Paris Agreement is implemented in a timely manner, the Earth would warm 2.7 – 3.1°C (4.9 – 5.6°F). Scientist James Hansen describes how our world could potentially look like with 2.8°C warming:

"Our best information comes from the Earth's history. The last time that the Earth was 2.8°C (5°F) warmer was three million years ago, when sea level was about 24m (80 feet) higher. Twenty-four meters (eighty feet)! In that case, the United States would lose most East Coast cities: Boston, New York, Philadelphia, Washington, and Miami; indeed, practically the entire state of Florida would be under water. Fifty million people in the US live below that sea level. Other places would fare worse. China

would have 250 million displaced persons. Bangladesh would produce 120 million refugees, practically the entire nation. India would lose the land of 150 million people.

“A rise in sea level, necessarily, begins slowly. Massive ice sheets must be softened and weakened before rapid disintegration and melting occurs and the sea level rises. It may require as much as a few centuries to produce most of the long-term response. But the inertia of ice sheets is not our ally against the effects of global warming. The Earth’s history reveals cases in which sea level, once ice sheets began to collapse, rose one meter (3.3 feet) every twenty years for centuries. That would be a calamity for hundreds of cities around the world, most of them far larger than New Orleans. Devastation from a rising sea occurs as the result of local storms which can be expected to cause repeated retreats from transitory shorelines and rebuilding away from them.”[2]

As if this was not enough, there are several issues that should prompt us to quick and effective actions:

- The projected sea-level rise scenario as described in the previous two paragraphs is based on a 2.8°C (5°F) warming. “Present emission trends put the world plausibly on a path toward 4°C (7.2°F) warming within the century. Such a warming level and associated sea-level rise of 0.5 to 1 meter, or more, by 2100 would not be the end point: a further warming to levels over 6°C (10.8°F), with several meters of sea-level rise, would likely occur over the following centuries.”[3] More recent scientific research projects significantly larger sea-level rise by the end of the century.

- Inertia of the Climate System: Even if we could keep carbon dioxide levels stable at today's levels, the planet would continue to warm for decades. It takes a long time for the oceans to warm. As long as they are still in the process of warming, the atmosphere cannot reach equilibrium. Unfortunately, we are not even on a path to stabilize CO_2 levels. On the contrary, CO_2 concentrations are continuing to rise every year.

- The Limit of Carbon Sinks:
  Almost half of the CO_2 which humanity has emitted since the industrial revolution has been absorbed by plants during photosynthesis, especially by trees, and by the water and phytoplankton in the oceans. Without this absorption, the warming we have already experienced would have been stronger. However, this process has already started to change because there is a limit to this carbon sink. Due to warmer temperatures, some old growth forests are now releasing more CO_2 than absorbing. The oceans used to be a huge carbon sink as well, but some show signs that they are close to reaching their capacity to absorb CO_2.
  (In addition, the absorption of CO_2 into the oceans makes the water more acidic. See Unit 3 Section 13)

- Aerosol Pollution:
  The burning of fossil fuels not only emits greenhouse gases, but also toxic air pollutants, especially sulfate aerosols. (In this context, aerosols are not spray cans, but tiny atmospheric particles.) These aerosols are a serious health hazard (lung disease) and cause acid rain and crop losses. Ironically, they have a slight cooling effect on the local climate as they reflect some of the sun’s rays back into space. Of course, we cannot consider them a “solution” to

the climate crisis because of their negative effects. Also, they remain in the lower atmosphere for only several weeks while greenhouse gases stay many decades and centuries. Cleaning up our air pollution will have some warming effect on the climate.

The inertia of the climate system, the carbon sinks, and aerosol pollution have so far clouded the effects of climate change. Without these factors, the warming we would have experienced so far would have been considerably greater. Now, with the climate system changing to new patterns, carbon sinks reaching their limits, and (hopefully) aerosol pollution diminishing (with pollution control and reduction of fossil fuel burning), the warming will accelerate, and its impacts become much more severe.

Section 2: Feedback Mechanisms

Many feedback mechanisms (self-reinforcing cycles) can accelerate the warming of the Earth. The following are the most important known feedbacks:

- *Ice - Albedo:* Snow and ice are the best reflectors of solar radiation. Water on the other hand is the worst reflector. It absorbs most of the heat. Expansive thawing of ice and snow, therefore, increases the absorption of solar energy. This ice - albedo feedback is believed to be the major reason why the Arctic is warming so rapidly. (See Unit 3, section 4, p. 3).
- *Melting of the Permafrost:* When permafrost melts, organic material that has been frozen for thousands, even millions of years, will break down, and in the process release CO_2 and methane. [4] Once permafrost starts to melt over extensive areas, for example in Alaska or Siberia, it initiates a feedback mechanism that intensifies the thaw. As the huge volume of thawed vegetation breaks down, it will release immense amounts of greenhouse gases. Once the process reaches this point of no return it will continually affect the global climate regardless of whether we reduce our carbon emissions or not.
- *Water Vapor:* The warmer the air, the more moisture it can hold. As the planet is warming up, there is more water vapor in the atmosphere. Water vapor is a powerful natural greenhouse gas, which magnifies the impact of man-made greenhouse gases.

Any of these and possibly other feedback mechanisms could bring the Earth's climate system to a *tipping point.* We don't know where that tipping point is. It's quite likely that the planet will cross over that threshold without humanity noticing. Once we will wake up to that reality, it will be too late because this is an irreversible process. Some scientists think that we are already close to that point. "Computer models of the Earth's climate suggest that a critical threshold is approaching. Crossing over it will be easy, crossing back quite likely impossible."[5]

Section 3: The Long-term Perspective

How long will human impact on the climate last? A very long time, because of the long lifespan of CO_2 in the atmosphere. This has to do with the carbon cycle.

"The excess CO_2 in the atmosphere is absorbed and transformed into carbon in trees, mucky soils, and dissolved in the ocean, and so the warming begins to subside. The oceans are a big player in this story, absorbing a majority of the CO_2 we release, on a timescale of centuries."[6]

Global mean temperature spikes for a few centuries, perhaps by as much as 5-8°C depending on the amount of carbon released. This is more warming than the IPCC forecast for the year 2100, because it takes a century or two for a full climate warming response to play out. It takes that long to warm the ocean. In the forecast for the year 2100, there is still excess warming "in the pipeline" which has been paid for, as excess CO_2 in the atmosphere, but not yet delivered.[7]

20 to 25% of fossil fuel CO_2 will still persist after a thousand years, and 10 to 12% will still remain in the atmosphere after ten thousand years.[8]

All prospects for the future are only estimates based on certain assumptions. We really don't know how exactly climate change will play out, how fast temperatures will rise or how specific geographical regions will be affected, although climate science has made much progress in the past years about regional climate-change impacts. The climate system is extremely complex.

The two main uncertainties are:

1. *The threshold of numerous feedbacks that will reinforce the warming, how these feedbacks will interact in the very complex climate system, and how sensitive the climate system will react.* The recent IPCC AR6 WG1 report though points to much scientific progress in estimating climate sensitivity. It is now believed to be around 3°C for a doubling of CO2.
2. *Human behavior: We don't know how much greenhouse gases humans will emit in the future. That's why climate models calculate different emissions scenarios.*

REFERENCES

[1] Lester R. Brown, *Plan B 2.0: Rescuing a Planet Under Stress and a Civilization in Trouble* (NY: W.W. Norton & Co., 2006), From Chapter 1. Entering a New World

[2] *The Threat to the Planet* by Jim Hansen, Director of the NASA Goddard Institute for Space Studies and Adjunct Professor of Earth and Environmental Sciences at Columbia University's Earth Institute. http://www.columbia.edu/~jeh1/2006/DukeEdin_complete_20061121.pdf

[3] *Turn Down the Heat: Why a 4° Warmer World Must be Avoided*, a Report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics, November 2012, p. xiii http://climatechange.worldbank.org/sites/default/files/Turn_Down_the_heat_Why_a_4_degree_centrigrade_warmer_world_must_be_avoided.pdf

[4] info from Field Notes from a Catastrophe, Elizabeth Kolbert p. 21

[5] Field Notes from a Catastrophe, Elizabeth Kolbert p.3

[6] *The Long Thaw,* David Archer, p. 4

[7] *The Long Thaw*, David Archer, p. 122

[8] *The Long Thaw,* David Archer, p. 123