From ocean to ozone, the limits of our planet

The population of vertebrate species on Earth in the wild saw a dramatic fall of about 30% between 1970 and 2006, with the worst effects being in the tropics and in freshwater ecosystems. Destruction of species' habitats by pollutants and land-use change are obliterating flora and fauna at unprecedented rates. In fact, the ecological footprint of humanity — the natural habitats, such as water and land, transformed or destroyed as a result of human activity — far exceeds the biological capacity of the earth.

In an attempt to understand the natural world, its relationships with human societies and limits, in 2009, Johan Rockström and others from the Stockholm Environment Institute described elements of the biophysical world that link us together. Often regarded as a "safe operating space for humanity", these planetary boundaries include loss of biodiversity, land-use change, changes to nitrogen and phosphorus cycles, ocean acidification, atmospheric aerosols loading, ozone depletion, chemical production, freshwater use and, of course, climate change.

In the course of 12,000 or so years after the last ice age, the Holocene epoch has offered a stable climate, a period of grace for humanity to grow and to flourish, with settlements, agriculture and, more recently, economic and population expansion. This epoch has since given way to the Anthropocene, the exact beginnings of which are debated, but which has led to over-reliance on fossil fuels, industrial agriculture, pollution in water, soils and air, loss of species and so on, which are devastating for many life forms and connected ecosystems throughout the planet.

Many of these conditions respond in a non-linear manner to changes. This means, for instance, that ecosystems that are stressed by their exposure to pollutants may not recover once the pollutants are removed. Or, some systems may collapse precipitously under conditions referred to as thresholds. We understand many of these thresholds and how they interact with each other, but not all.

When ecological thresholds or tipping points are crossed, significant large-scale changes may occur, such as breakdown of glaciers in Greenland and the Antarctica, the dieback of rainforests in the Amazon, or failure of the Indian monsoons. Since these boundaries interact with one another and cause changes across scales, crossing a threshold in one domain can speed up or undermine processes in another subsystem. For instance, greenhouse gas (GHG) emissions increase ocean acidification, land-use change often increases GHG emissions, and increasing nitrogen and phosphorus deplete species biodiversity and freshwater resources and increase warming from climate change.

According to Mr. Rockström and others, we are already at critical levels of concern for climate change, fresh water, species biodiversity and changes to nitrogen and phosphorus cycles, which are reaching tipping points. For example, GHG emissions have led to average atmospheric carbon dioxide concentrations being about 410 ppm. This is well above the 350 ppm level considered a 'safe' limit, and the earth is already about a degree Celsius warmer than average pre-industrial temperatures.

Since publication of these studies by Mr. Rockstrom and others, there has been plenty of discussion, even strong disagreement, regarding the boundaries. Some scientists, such as Kate Raworth, have expanded them to reflect and include several social dimensions such as equity and gender justice that were subsequently placed in the centre of a schematic representation of the boundaries as a circle with a hole or as a doughnut.

One may regard planetary boundaries as support systems for life on Earth or view them as expressing “carrying capacity” and defining “limits to growth”. The latter is a thesis that was originally published nearly half a century ago by the Club of Rome as a book in 1972. It described the situation we would find ourselves in with exponential population and economic growth. While the “limits to growth” argument was challenged for good analytical reasons, it still provided a lens through which to view the changing world of the 21st century. It also offered the idea of thinking about a system as a whole — systems thinking — not just as separate parts and feedback mechanisms as valuable processes in considering long-term change.

The idea of sustainability has been embedded in the human imagination for a very long time and is expressed through our ideas of nature, society, economy, environment and future generations. But it became formally a part of international agreements and discourse when it was recognised at the Earth Summit of 1992 in Rio de Janeiro.

This systems view and the recognition of interlinkages among the social, environmental, and economic pillars of sustainability, and between biophysical planetary boundaries and social conditions, are essential to have a chance of keeping the world safe for future generations. It is telling that scholars who work on planetary boundaries regard climate change as one of the easiest to manage and contain.

In thinking about these planetary limits then, researchers and policymakers should reflect on multiple systems and the linkages among them, and whether step-by-step or transformative changes must be considered to keep the planet safe for the future.

Sujatha Byravan is a scientist who studies science, technology and policy

The new U.S. Fed Chairman is unlikely to opt for policies that might upset the President’s plan

END