SUSTAINABILITY IN THE FACE OF UNCERTAINTY: THE CHALLENGE OF A RAPIDLY CHANGING PLANET

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Aiming for sustainability of the current state of humanity in the face of an uncertain future through the implementation of small steps in the right direction may not be a sufficient strategy. What we don't know is likely to be more important and consequential for our future than what we know. Unexpected rare, high-impact events and changes in society, economy and, increasingly, also the environment are likely the ones determining our path on a rapidly changing planet. Building resilience to these events and changes may be key for the survival of our civilization.

Sustainability is a characteristic of a process that can be maintained indefinitely. The sustainability of systems depends on the nature of the system and can change over time. Systems can be in a state where the future is determined by minor changes over a long time, while at other times, minor changes can lead to extreme high-impact events rendering the current state unsustainable.

For human societies on Earth, sustainability depends on the state and developments in society, economy and the environment. While we are well aware of the importance of rare, high-impact (RHI) events in society (e.g., wars, revolutions, pandemics) and economy (e.g., depressions, bubbles), we are less aware of similar events in the environment. Disasters caused by natural and anthropogenic hazards have a large impact, but in recent centuries, even the biggest of these disasters were small compared to the RHI events in society and economy. With increasing human numbers, technological capabilities, and economic connectivity, the scale of social and economic RHI is likely to increase a lot. Given the accumulating evidence of anthropogenic impact we have to ask whether these developments also increase the probability of environmental RHI events.

Humanity has re-engineered the planet, with significant changes in chemical and physical processes, land surface conditions, and composition of the biosphere. It has become a globally connected, dominating factor in the Earth system, indicating that we have entered the Anthropocene. The assumed stewardship of humanity for planet Earth is a challenge: while we are able to create beautiful landscapes, architecture, and settlements, astonishing art and technology, and to maintain prosperous societies over long periods, we have also shown that we are able to enter into dysfunctional periods and inflict great disasters on ourselves and the environment. Technology has boosted the impact of the dysfunctional enormously.

Moreover, paleo-records show that the Earth system can produce much larger environmental RHI events than those known to us from recent history. Over the last several millenniums, Earth has been in an exceptionally stable period with only mediocre changes in, e.g., climate, water and energy cycle, and sea level, with no RHI events occurring. A re-engineered Earth may well be on a path out of this relatively long stable state and entering a period with unpredictable future trajectories. Paleo-records can be used to assess the natural range of extreme variations in climate, sea level, atmosphere and ocean circulation, biodiversity, etc., but a re-engineered Earth reduces the value of past experience as a basis for assessing future trajectories of the Earth system.

Most studies of potential environmental changes over the next centuries are based on models calibrated on the basis of past experience. Predictions show smooth changes over time, and few of the current models are able to predict or even simulate RHI events. This results in a potentially false impression that the future can be simulated based on past experience. It is clear that the unknown may be far more important and consequential then the known, thus limiting the value of these empirical models. While studying the outliers in the past may be an important complementary activity towards indicating what the outliers in the future might be, the responsibility of science is to inform society about the portfolio of the possible RHI events to enable us to build the "early warning systems" needed to mitigate their full impact.

What does sustainability mean in the face of an uncertain and to a large extent unpredictable future? It is doubtful that humanity will be able to mitigate its impact sufficiently to maintain the current system state with relatively minor adaptations. The possibility of significant rapid diversions from the current state requires resilience to RHI events and creates an insurance problem: how much do we want to invest and adapt to make us resilient to RHI events and to make sure we have the lifeboats we might need?