Editorial

Future Earth and Sustainable Developments

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Our planet has been undergoing continuous warming since the industrial revolution (1850 CE), such that its mean temperature has risen ~1°C, and continues to rise to the present day. This is mainly due to human activity, particularly CO_2 emissions, resulting in far-reaching and mostly irreversible consequences to the Earth's systems. These include dominant negative changes in the atmosphere, hydrosphere, lithosphere, cryosphere, and biosphere. Since human influence has now overwhelmingly exceeded natural forces on a globe scale, some Earth scientists have proposed a geological epoch called the “Anthropocene”: a new epoch in the history of our planet, named after the significant influences of humanity on the globe.[1] Indeed, our planet's climate is changing rapidly in the Anthropocene, and so climate change will become the defining challenge of our time, and its impacts will affect generations to come.

To address the most pressing sustainability challenges posed by global climate change, it is essential to focus on the operation of all of the Earth’s systems, as well as the integration of natural and social sciences. This will allow the delivery of transdisciplinary research results, new research tools, critical knowledge, apposite strategies, and practical solutions for sustainable global developments. In 2012, the International Council for Science and the International Social Science Council, together with a large number of other agencies, jointly launched a 10-year (2014–2023) international scientific research program, called “Future Earth,” at the UN Conference on Sustainable Development (Rio+20). Built on more than three decades of research into global environmental change, Future Earth aims to strengthen the interface between science and policy, using principles of co-design, co-production, and co-delivery. It highlights cross-cutting capabilities on observing systems, data systems, Earth system modeling, theory development, scoping and synthesis, communication and engagement, capacity development and education, and science-policy interface activities. The program defined three research themes: (1) dynamic planet, (2) global development, and (3) transitions toward sustainability, with the goals of further understanding complex Earth systems and human dynamics across different disciplines, and seeking systems-based approaches to underpin evidence-based policies and strategies for sustainable development. Future Earth is now a knowledge-action network bringing together academia from natural and social sciences, policy, business, civil society, and more, with a common goal of transformations toward sustainability.

Over the past several years, Future Earth and The Earth League, two major international organizations representing networks of global sustainability scientists, have collated and assessed the most up-to-date Earth system science, and as a result have underscored a number of important advances in our knowledge of observational facts, underlying drivers/mechanisms, and impacts of climate change, as well as societal effects and strategies/solutions for mitigations/adaptations, including the following.[2–6]

(1) Climate change is faster and more intense than expected, including persistent global warming, accelerating sea level rise and acidification, and the retreat of mountain glaciers and polar ice sheets. (2) The world is not on track to reach the Paris Agreement for stabilizing the climate at 2°C–1.5°C above the pre-industrialization level(before 1850 CE): emissions must peak as soon as possible and decline sharply until 2050 (Figure 1). Despite rapid growth in renewable energy, the overall size of the fossil fuel industry continues to increase, and thus time is almost running out if the increase in global temperature is to be limited to well below 2°C, although technically it remains possible. (3) Every half degree matters: the impacts of 1.5°C versus 2°C of warming will be substantially different for human health, living conditions, and natural ecosystems, and thus limiting global warming to 1.5°C instead of 2°C is now considered as a strongly preferable goal. (4) At least a 50% reduction in emissions by 2030 is needed to meet the 1.5°C target (Figure 1), and this calls for major and urgent socio-technical transformations across all sectors and scales. (5) Options for large-scale removal CO_2 from the atmosphere remain economically and/or technically limited. (6) Forests are under threat by deforestation, increase in temperature, and anthropogenic forest fires. (7) Weather extremes will become a “new normal” and more severe, and these are now clearly attributable to climate change. (8) Rapid terrestrial and marine biodiversity and ecosystem losses are evident (Are we in the midst of the sixth mass extinction on our planet?). (9) Climate change puts additional pressure on land and ocean, and thus the food/water security and health/wellbeing of hundreds of millions of people. At the same time, an appropriate transformation of agriculture and food/water/vegetation systems is needed for both global health benefits and reduction of greenhouse gas emissions. (10) The most vulnerable and poor are hardest hit by climate change. (11) Stronger and more comprehensive policy measures would reduce climate risks. (12) Equity and equality are pivotal to successful climate change mitigation and adaptation. (13) Critical tipping points may occur with increasing climate impacts on the planet, which, if crossed, may lead to either far-reaching and/or irreversible consequences for the stability of life on Earth, or a large jump to another hydroclimatic state at various regional scales. (14) Managing plants and soil becomes a critical prerequisite for limiting CO_2 emissions to meet the Paris Agreement. (15) The time may have come for social tipping points on climate action. (16) Sustainability research can and must support a systems-based (including social-human behaviors) approach to managing global public health risks that are potentially devastating to communities and economies globally, such as the COVID-19 crisis. (17) It is likely that climate impacts are hitting harder and sooner than the most of the climate assessments suggest.

The most urgent mission now lies in turning knowledge into action to address the world's most serious sustainability challenges resulting from CO_2 emissions. To achieve this goal, substantial efforts are required, including (1) consistently promoting Earth system science research across different disciplines, thus continuing to generate high-impact and cutting-edge results to further understand complex Earth systems and human dynamics, as well as connections between environmental, social, and economic systems. (2) Use the improvements in knowledge to underpin evidence-based, and thereby increasingly accurate and effective solutions and strategies for sustainable development. (3) A civil movement for urgent action and/or worldwide transformation toward decarbonization is very important. As a result of increasing evidence of the risks involved with

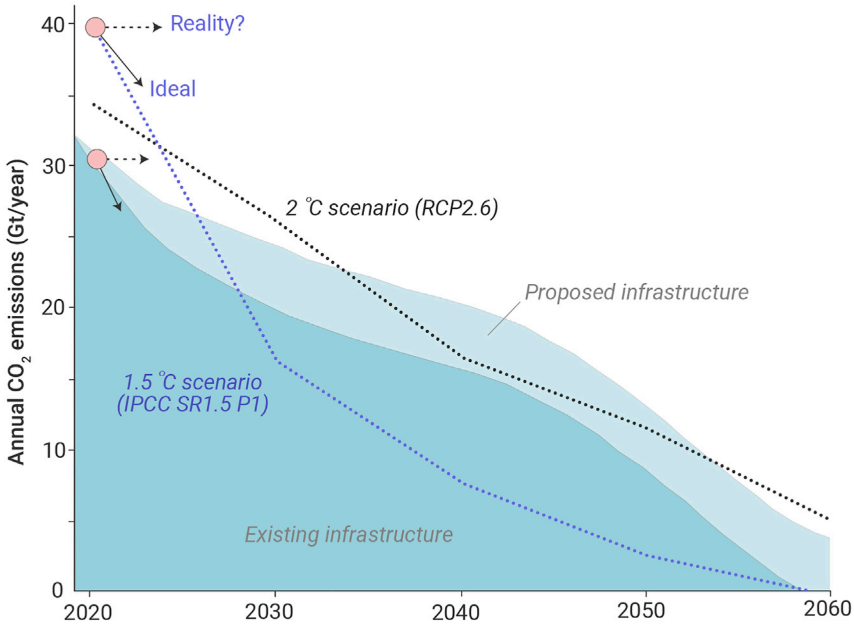

Figure 1. Existing and Proposed CO_2 Emissions from Fossil Fuel Infrastructure Compared with Pathways to 1.5°C (IPCC SR1.5 P1, Blue dotted Line) and 2°C (RCP2.6, Black dotted Line) Scenarios The emissions exclude some of the current CO_2 sources, such as land use change and cement manufacturing, and thus the 1.5°C and 2°C scenarios start at higher levels. Modified from Pihl et al.[2] The clear gap between reality (dotted arrows) and ideal (solid arrows) calls for immediate action, the two sets of arrows indicate the current actions under 1.5°C and fossil fuel infrastructure scenarios.

global climate change, more citizens worldwide are now seriously concerned about climate change, and thus a threshold of 20% of the population may have already been reached, who will enact significant system-level changes through changes in their personal behavior. (4) Limiting temperature increases to 2°C–1.5°C above the pre-industrial level will largely depend on rapid, dramatic reductions in greenhouse gas (CO_2) emissions, primarily from reduction in fossil fuel use (Figure 1). The roadmap has never been as clear as it is now, because of the advances in our understanding of Earth system science. However, moving forward along the roadmap has never been as complicated, albeit as critical, as it is today, mainly due to the large gap between commitments to decarbonization and the reality of increasing carbon consumption. The United States, one of the nations with major emissions, withdrew a few years ago from the Paris Agreement, which represented a major setback. As a result, more convincing scientific results, more effective resulting solutions/strategies, together with stronger civil movements, all become critical to push countries, governments at all levels, business and civic leaders, and policy makers into taking necessary actions to achieve the goals of the Paris Agreement. Time is running out, and we are indeed facing a "make-or-break" moment.

Based on historical data, we can see that increases in greenhouse gases (mainly CO_2) and global temperature are indeed accelerating, following on from the industrial revolution to the present day. A prospect for limiting global temperature increase to well below 2°C, aiming for 1.5°C, is emerging with a concrete, science-based strategy. We say "emerging," for there is much still to be done at the forefront of Earth Future for a global decision-making at a crossroads.

REFERENCES

1. Waters, C.N., Zalasiewicz, J., Summerhayes, C., et al. (2016). The Anthropocene is functionally and stratigraphically distinct from the Holocene. Science ***351***, 137.
2. Pihl, E., Martin, M.A., Blome, T., et al. (2019). 10 New Insights in Climate Science 2019 (Future Earth & The Earth League). https://futureearth.org/publications/science-insights/10-new-insights-in-climate-science-2019/.
3. Independent Group of Scientists appointed by the Secretary-General (2019). Global Sustainable Development Report 2019: The Future Is Now—Science for Achieving Sustainable Development (United Nations). https://sustainabledevelopment.un.org/gsdr2019.
4. World Meteorological Organization (compiled) (2019). United in science: high-level synthesis report of latest climate science information convened by the Science Advisory Group of the UN Climate Action Summit. https://public.wmo.int/en/resources/united_in_science.
5. Future Earth (2020). Our Future on Earth. http://www.futureearth.org/publications/our-future-on-earth.
6. Jeppesen, E., Beklioğlu, M., Özkan, K., and Akyürek, Z. (2020). Salinization increase due to climate change will have substantial negative effects on inland waters: a call for multifaceted research at the local and global scale. The Innovation ***1***, 100030.