Humanity at crossroads of dignity and decent life for all on a stable planet

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It is now two centuries since Jean-Baptiste Joseph Fourier recognised that the radiative forcing of the atmospheric gases keeps the Earth warm and thus habitable. It was three decades later that John Tyndall discovered that water vapour and carbon dioxide are the major greenhouse gases that trap heat (Fleming 1998). Curiously, just a few years later concerns about 'running out of coal' took hold, and fears intensified following the publication of Stanley Jevons's book "The Coal Question" in 1865 with a scenario of long-lasting coal scarcity (Jevons 2017). This made it more complicated to put aside the fears of shortage while in reality coal is an abundant resource worldwide.

About the same time, in 1859 crude oil was discovered by (Colonel) Edwin Drake on behalf of the Seneca Oil Company, at first mostly as a replacement of whale oil in lamps (Sherman 2002). The real disruptive change of motor vehicles replacing horses and carriages was initiated three decades later partially also because of the negative environmental externality of the horse economy that filled streets with manure. Just about the same time, before the turn of the century 1896, later Nobel Laureate Svante Arrhenius published the famous paper indicating that emissions of carbon dioxide from coal combustion may eventually result in enhanced global warming (Arrhenius 1896). He anticipated a 5 to 6°C global mean temperature increase from a possible doubling of atmospheric carbon dioxide due to human activities. At that time, it was inconceivable that crude oil would replace coal as the dominant energy source half a century later.

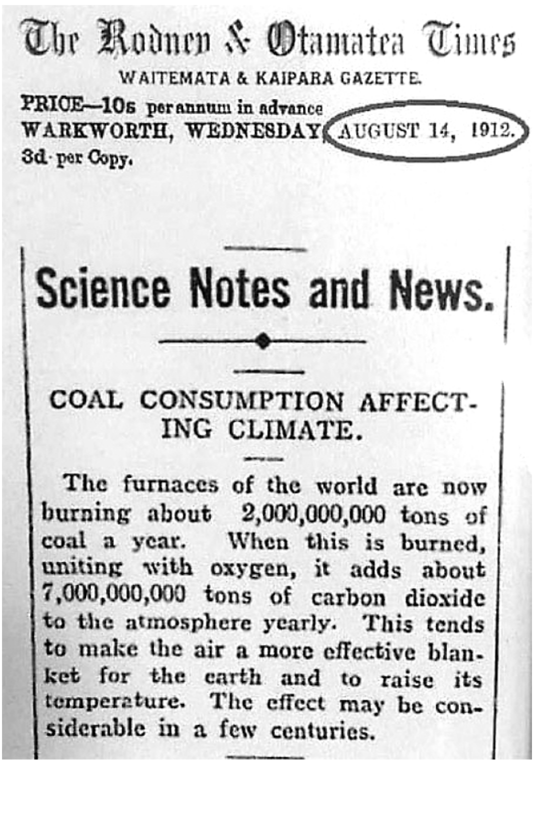
Figure 1. Easter parade in New York City on 5th Avenue in 1900 and 1915. Source: Adapted from Campanale, Carbontracker. 1900: National Archives and Records Administration, Records of the Bureau of Public Roads. Image 30-N-18827, from https://www.archives.gov/exhibits/picturing_the_century/newcent/newcent_img1.html. Photographer unknown. 1915: Library of Congress, LC-B2- 2529-9, Washington, D.C. 20540 USA, hdl.loc.gov/loc.pnp/pp.print.

This all illustrates the nature of disruptive change through innovation diffusion and the replacement of dominant systems because of perceived limits including their ever larger environmental and other negative externalities. The confluence of multiple crises and saturation of the old, dominant systems leads to a dynamic process of evolutionary changes and a growing perception that a better and more prosperous future is possible.

The great coal-or-manure-in-the-streets questions were there for decades before that disruptive and transformational change occurred. These are some of the key crossroads in human development expressed through new technologies and changing economics, behaviours and regulatory systems.

Arguably, the world has been at crossroads during the last decades. In the aftermath of the oil crisis of the 1970s, the disadvantages of the oil economy became obvious, including multiple environmental concerns of the fossil-intensive development path. The great climate question was on the agenda with more importance than ever because of the much better scientific understanding of the radiative forcing resulting from the accumulation of the anthropogenic greenhouse gases in the atmosphere. Several publications indicated that, if unabated, anthropogenic climate change is likely to lead the world to some 5°C warming or so and that 1°C would be reached by now (see Broecker 1975; Häfele et al. 1981), which is what happened because of a lack of determined measures and policies to reduce the greenhouse gas (GHG) emissions. The latest IPCC WG1 report (IPCC 2021) indicates that the actual global mean-temperature increase is now 1.1°C.

Figure 2. An article from over a century ago pointing to the global warming as the result of coal combustion, indicating that the effects may be considerable in the future. Source: Waitemata and Kaipara Gazette, August 14, 1912.



The Rodney & Otamatea Times

WAITEMATA & KAIPARA GAZETTE.

PRICE—10s per annum in advance
WARKWORTH, WEDNESDAY, AUGUST 14, 1912.
3d per Copy.

Science Notes and News.

COAL CONSUMPTION AFFECTING CLIMATE.

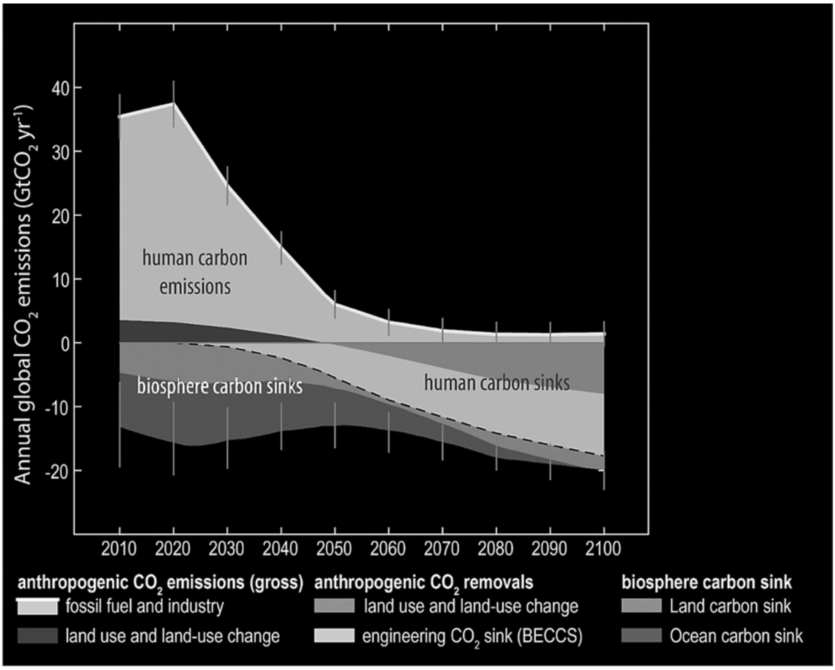
The furnaces of the world are now burning about 2,000,000,000 tons of coal a year. When this is burned, uniting with oxygen, it adds about 7,000,000,000 tons of carbon dioxide to the atmosphere yearly. This tends to make the air a more effective blanket for the earth and to raise its temperature. The effect may be considerable in a few centuries.

This global temperature increase is not too far from the Paris Climate Change Agreement that calls for reduction below 2°C and, if possible, down to 1.5°C (UNFCCC 2015). At the Conference of the Parties in 2021, the 1.5°C target has been approved, thus requiring vigorous emissions mitigation (UNFCCC 2021). It is, however, almost certain that 1.5°C warming will be achieved by 2040 even if vigorous mitigation measures are initiated. In other words, global mean temperature would go beyond the Paris target before it comes down again toward the end of the century through so-called net-negative emissions. These include nature-based solutions such as afforestation and sustainable land use. Other measures would include combustion of sustainably grown biomass in conjunction with carbon capture and storage. In principle, this is possible but would still require scale-up and measures to make sure that this does not endanger other Earth-systems such as biodiversity and nutrient cycles.

This overshoot of global temperature will be exceedingly difficult to avoid. However, there are a few pathways in the literature that show that in principle this could be achieved if immediate and determined action will be assumed by all toward radical decarbonisation worldwide (Grubler et al. 2018). This transformative pathway foresees huge changes throughout the whole energy system over the next three decades, including radical change of behaviours.

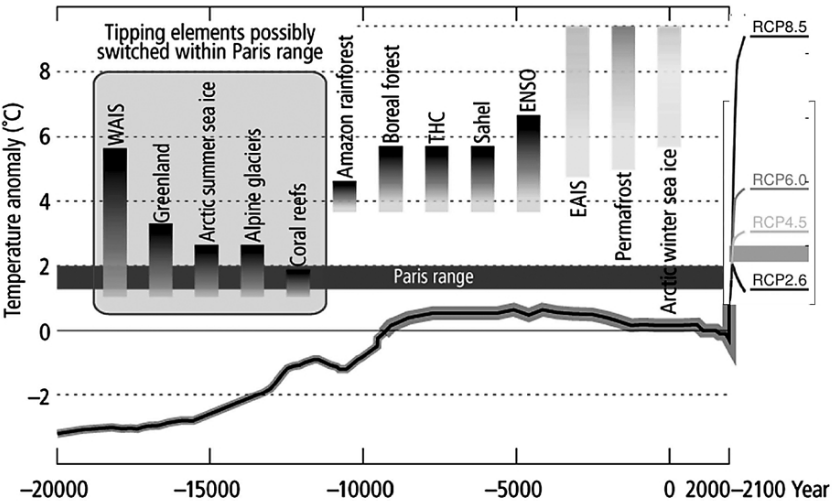
The climate science is clear: stabilising climate at any given level requires global GHG emissions to be zero at some point. The longer this takes, the higher would be the ultimate global mean temperature increase. The reason is that the temperature change is in the zero-approximation a linear function of cumulative emissions. This is the 'carbon law' (Rockström et al. 2017). For the target of 1.5°C, this needs to occur by mid-century. This means that the emissions need to be halved every decade starting immediately from some 40GtC per year to about 20 GtC per year by 2030, followed by 10 GtC per year by 2040 and then zero by mid-century. The good news is that these kinds of disruptive transformational changes did occur before, as mentioned above, these three decades have passed.

Figure 3. Illustration of the 'carbon law' indicating that emissions need to be halved every decade toward zero by mid-century, accompanied by the carbon removal from the atmosphere and preservations of the land and ocean carbon sinks. Source: Rockström et al., 2017.



Climate is not the only planetary challenge. Humanity is putting ever greater pressure on Earth systems that support life as we know it. This includes thawing of the permafrost and glaciers around the world as well as ice sheets, loss of biodiversity and destruction of whole ecosystems, pollution of oceans and so on. The greatest danger might be around the corner with the possibility of tipping elements in many of these systems that may be triggered by the current pressures such as the massive dying of coral reefs. Tipping refers to a change in the functioning of systems due to external forcing. An example would be desertification of previously fertile lands or nutrients that cause overgrowth of algae and plants in the water bodies, a process defined as eutrophication. An even more extreme example is the destruction of the rain forest and its entire ecosystems in the Amazon, which would have global implications.

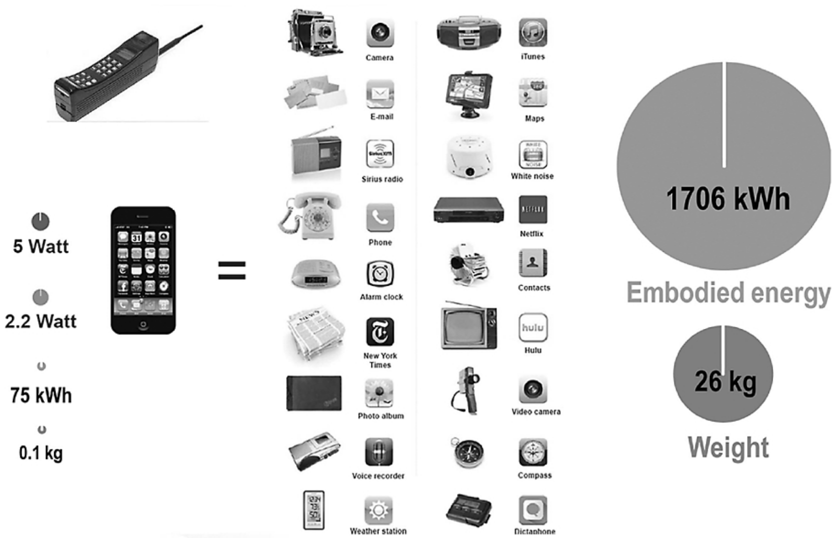
Figure 4. Tipping elements in relation to the global mean temperature since the last glacial maximum and through the Holocene. Also shown are future pathways (RCPs) indicating that Paris range can be achieved assuming immediate and rapid reduction of emissions. Source: Schellnhuber et al., 2016.



It is evident that such changes would have catastrophic impacts also on human systems. The 'great acceleration' of the last three to five decades has brought benefits to many in the world but has also left many behind who are facing the greatest brunt from the erosion of the Earth-system's support and provisioning. In other words, Earth system and human systems are inseparable, which is clearly illustrated in the looming climate crisis. Explosive increase of GHG emissions is affecting tipping of the climate and other Earth systems, and this has consequences for possible tipping of human systems. When agriculture fails, social unrest and hunger are the consequences.

The coupling of Earth and human systems dynamics are not always negative. There are also important improvements. One of them is the rapid diffusion of mobile phones as an example of a resources-saving technological innovation that benefited the whole world. The first GSM phone was introduced exactly three decades ago, and today essentially everyone in the world has a mobile phone, ironically also close a billion people who do not have access to electricity! There are close to 10 billion phones for almost 8 billion people in the world. Significantly, the diffusion occurred essentially synchronously throughout the world, among the rich and the poor. In many important ways it is a leap-frogging technology as it provides new essential services. This is especially the case with smartphones that provide internet access, banking, billing and many other important services. At the same time smartphones need hundred times less energy compared to the devices they replace and about 25 times less materials. This is a very positive example of the great acceleration, especially as the diffusion occurred with minimal lag in the global North and South. All told, this results in a hundredfold decrease of greenhouse gases without even changing energy supply and can be seen as a 'positive tipping element'.

Figure 5. The rapid progress of information and telecommunication technologies could be an indication of the path-breaking potential of next-generation digital technologies and their clustering in new activities and associated behaviours. Devices that a smartphone replaces require hundred times more power and about 25 times more materials and embedded energy. Source: based on data in Grubler et al. (2018) and visualization of Tupy (2012), Graphic courtesy of Nuno Bento, cf. TWI2050 (2019, 2020).



Smartphones are a great example of the power of digital technologies and pervasive electrification. Coupled with zero-emission sources of electricity they could bring the needed transformative change. The disruptive nature of the digital revolution initiated by smartphones and the internet provides entirely new and enhanced capacities and thus serves as a major force in shaping both the systemic context of transformative change and of future solutions; at the same time, it potentially carries strong societal disruptive power, i.e. potential tipping elements, if not handled with caution, care and innovativeness. Thus, the direction of change is essential, as it is captured by the metaphor of the crossroads.

There are other examples of such breath-taking innovation diffusions, ranging from photovoltaics and windmills to laptops, tablets and, importantly, the Internet. What they have in common is 'granularity' rather than large 'unit size'. More granular innovations can be expected to have faster diffusion, lower investment risk, faster learning, more opportunities to escape lock-in, more equitable access, high job creation and larger social returns on innovation investment. In combination, these advantages enable rapid change (Grubler 1998; TWI2050 2020). This is highly relevant for the role of innovations in the context of transformative change. It indicates that for rapid transformation to occur investments should be directed toward innovations with high learning and diffusion potentials. So, while innovation processes are characterised by deep uncertainties, the strategy of supporting innovations that are inherently granular increases the likelihood of rapid diffusion and benefits for people and nature. To harness innovation for sustainability, the focus should be on efficiency and sufficiency in providing services to people, with a particular focus on consumption and production (TWI2050 2020). Smartphones are an example of these possibilities.

Despite the magnitude of the challenge and the unsustainable nature of the current trajectory, humanity has the knowledge, means and capacity at the crossroad ahead to move into a sustainable and resilient pathway. This challenge was the focus of the Crossroads Meeting held in Bonn on the occasion of the UNFCCC Conference of the Parties in 2017. There was ample evidence that transformations are beginning in some sectors and regions, but that much more is needed. Investing in high-quality education, well-functioning health systems, efficient and zero-carbon energy systems, environmental conservation and restoration, healthier and adequate food systems, more sustainable lifestyles, good governance and global cooperation initiatives would leverage implementation of the SDGs and support climate action (TWI2050 2020).

A new wave of nationalism, populism, ethnic awareness and loss of ethical values is emerging in many countries. Wide segments of the global population feel threatened by accelerating change, often driven by globalisation processes, digitalisation, robotics and other social and cultural phenomena (TWI2050 2020). Even the suggested solutions connected to the sustainable development transformation itself (and its broad agenda) might be seen as threatening in many quarters, not dissimilar in style to the human reactions in earlier historical phases characterised by rapid change (e.g., the emergence of railways and the coal age or later the replacement of horses by cars).

Most recently, in 2020 these tendencies have been exacerbated by the COVID-19 pandemic, one of the greatest immediate threats to humanity. Despite the enormous success of science in developing many vaccines in an absolute record time, the failure to provide universal access and increasing reluctance to accept vaccination are huge barriers toward eradicating the pandemic. The closing of borders and increasing 'my country first' attitudes have further amplified the perceived threats, failures and lack of resilience in global economic, social and natural systems.

The challenge is to reduce the extent to which systemic risks like COVID-19 set back progress. Yet at the same time, the COVID-19 pandemic has brought out some of the best human characteristics: self-sacrifice in helping others; empathy and solidarity despite the need for social distancing. This has also provided an opportunity to build positive narratives oriented toward future, human-centred visions of society and economy on local, national and global levels. We need significant investments in social cohesion and robust transformative alliances to enable resilient sustainable development and to avoid societal backlashes driven by insecurity, injustice and disenfranchisement. It is even more important now to integrate social and economic goals with climate, water, oceans, biodiversity and other Earth systems so that sustainable development is not threatened in the long term (TWI2050 2020). This all illustrates that the world is at crossroads.

Digital technologies are examples of innovations with exceedingly rapid diffusion because they are granular, even though they are embedded in large and complex infrastructures and systems. They may catalyse the disruptive and transformational changes that need to be achieved within three decades. Artificial intelligence, connectivity (the Internet of Things), digitalisation of information, additive manufacturing (such as 3D printing), virtual or augmented reality, machine learning, blockchain, robotics, quantum computing and synthetic biology are all examples of granular innovations. Digital technologies have spread rapidly in much of the world. They can be a powerful influence in helping overcome social inequalities, but they are also characterised by inequalities themselves. Large disparities in access to, usage of and skills relevant for digital innovations exist, which are summarised as the 'digital divide'. Even more importantly, gaps also exist in the broader development benefits from using digital innovations. Digitalisation has often boosted growth, expanded opportunities and improved service delivery, yet the aggregate impact has fallen short of being inclusive and is thus unevenly distributed. Because of its generally granular nature and fast diffusion and learning rates, digitalisation is reshaping work, leisure, behaviour, education, health and governance, and it can facilitate the achievement of the SDGs.

However, initiating transformation is difficult due to institutional inertia by incumbent actors with vested interests and consumers/users with habits of following routines. In addition, the globalisation of economic and social activities that has occurred over past decades has created intricate webs of activities, making transformation a complex process. Furthermore, existing studies indicate that current policy instruments are either absent or ineffective for achieving the magnitude of transformation needed in the expected timeframe. This means that, unless there are substantially advantageous alternatives (simple, low cost, superior and universal) offered to individuals, achieving change will continue to be difficult.

The full unfolding of the 'Digital Revolution' will have even deeper impacts on our societies, creating a next generation of sustainability challenges. Moreover, the digital transformation may redefine our concept of us as humans. In the Anthropocene humans became the main drivers of Earth-systems changes. In the digital Anthropocene humans will also start to transform themselves, enhancing cognitive capacities into what can be called 'Homo digitalis'. This could be the next disruptive innovation to transform humanity by 2050 and beyond for the benefit of all and the nature.

The key question is whether humanity will have the political will to collectively achieve the essential transformation and avoid pitfalls of my-country-first or my-region-first logic that is spreading throughout the world. It is for us all to choose which direction to go, because a sustainable future for all is within reach if we act decisively and in unison. Time is a precious resource for achieving this disruptive and transformational change in just three decades by 2050.

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