The Anthropocene and Planetary Boundaries

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Can we sustain economic growth?

• The world’s ability to combine long-term economic growth with environmental sustainability is the subject of wide debate

• One thing is certain: the current trajectory of human activity is unsustainable
  – If we continue on the current path, the environmental foundations of global well-being will collapse
  – Need to channel resources and knowledge into high sustainability technologies
Ecosystem services

• Human history is marked by patterns of migration and population growth

• The most deeply ingrained pattern however is the “appropriation of the Earth’s natural systems for human use…” (Jeffrey Sachs)
  – Nature provides us with the raw materials to support life – food, water, fuels, fiber
  – Human society harnesses these services to support population growth and rising levels of consumption, unaware of the long-term consequences
  – The consequences have so far been manageable: until recently: increasing population and increasing high-intensity activity
The Anthropocene

• The Anthropocene (Paul Crutzen). The term Anthropocene – from *Anthropo*, for “man” and *cene* for “new” – describes a new geological epoch in which humanity itself constitutes the largest driving force of change on Earth.

• Anthropocene has become an environmental key concept integrating different scientific disciplines and findings.
The Anthropocene

Agriculture – one of the breakthroughs in human history

– The shift to agriculture represented a qualitative change in the natural order; consequences of this are still being played out

– Human population soared with the onset of agriculture
  • Human society able to increase density wherever it was located
  • Opened the opportunity to expand the range of human habitats on a massive scale
The Anthropocene

• Industrial Revolution
  – The ability to tap into the coal, oil and natural gas allowed human societies to surpass the traditional limits on food, water, transport and shelter
  – Haber-Bosch process (for synthesizing nitrogen-based chemical fertilizers) made a massive expansion in agriculture possible

• The result of these technological advances?
  – Dramatic increase in population
  – The rapid rise of human productivity
  – The combination of these two factors resulted in an explosion of total economic activity
The Anthropocene

• Two centuries after the Industrial Revolution, we are confronting the benefits, but also the risks of our technological success
  – A tenfold increase in human population since 1750 plus a similar increase in production per person on the planet = a hundred fold increase in economic activity compared to the start of the industrial era

• This hundred fold increase corresponds to the human activities related to our use of the Earth’s resources and physical processes for human consumption
The Anthropocene

• The past 10,000 years, the Holocene period, was a period of stability. This stability may now be under threat.

• The scale of human activities is throwing fundamental, life-sustaining systems of the Earth off balance

• The work of Peter Vitousek et al. shows the extent to which humans now dominate the Earth’s systems
Human dominance or alteration of several components of the Earth system
Human dominance of Earth systems

1. Land transformation – clearing for agriculture; up to 50% of the Earth’s photosynthetic potential is directly appropriated for human use
2. Carbon Dioxide concentration – fossil fuels increasing the level of CO$_2$ in the atmosphere
3. Water use – human interference in the hydrological cycle (primarily to ensure water for food production)
4. Nitrogen fixation – Haber-Bosch process to increase the nitrogen fixation process
Human dominance of Earth systems

5. Plant invasions – introduction of foreign species (can have unpredictable consequences)
6. Bird extinctions – ¼ of all bird species have been driven to extinction by human activities
7. Marine fisheries – 2/3 of the world’s major marine fisheries are “fully exploited, overexploited or depleted)
The shift

• During the Holocene, environmental change was a natural process, and the planet’s regulatory capacity was able to maintain the conditions necessary for human development

• Due to a growing reliance on fossil fuels and on industrial agriculture, the systems that keep Earth in a desirable Holocene state are damaged
  – Results could be irreversible
  – In some cases, abrupt environmental change could lead to a state less conducive to development
Thresholds vs Boundaries

• Thresholds are defined as non-linear transitions in the functioning of coupled human–environmental systems
  – Example: retreat of Arctic sea ice due to anthropogenic global warming
  – Intrinsic feature of the system

• Boundaries are human determined values of the control variable set at a “safe” distance from a dangerous level or from the global threshold
  – Determining the “safe” distance involves normative judgements of how we choose to deal with risk and uncertainty
Human control variables and Earth response variables gives boundary

Control variable (e.g. ppm CO$_2$)

Response variable (e.g. extent of land ice)

Terrestrial carbon sequestration 9Mt yr$^{-1}$

Land use change (e.g. ecosystem to cropland)
Planetary Boundaries

• Concept developed to outline a safe operating space for humanity (Rockstrom et al 2009)
• Within this safe operating space, low likelihood of harming the Earth’s life support systems, such that they are able to continue to support growth & human development
• Effort is not to place a “cap” on development
• Rather, the boundaries provide a safe space for innovation, growth and development in the pursuit of human prosperity
9 boundaries, 3 forms/categories

• Categories

1. Boundaries defining a safe global level of depleting non-renewable fossil resources, such as energy and groundwater

2. Boundaries defining a safe global level of using the living biosphere, including exploitation of ecosystems, protection of biodiversity and consuming renewable resources

3. Boundaries providing a safe global level of Earth’s capacity to absorb and dissipate human waste flows
The boundaries

• Although the boundaries are described as individual boundaries and separate processes, they are tightly linked
  – Responses therefore cannot be concentrated on one boundary in isolation

• The approach rests on 3 branches of scientific enquiry
  1. scale of human action in relation to the capacity of Earth to sustain it
  2. the essential Earth processes and human action
  3. Resilience
Gaps

• Although the scientists present evidence that 3 of the boundaries have already been transgressed, there are still uncertainties
  – The seven boundaries are still tentatively quantified: the figures are still “best guesses”
  – Because the boundaries are linked, exceeding one will have implications on others – relationships that are not yet completely understood
  – Uncertainty, in terms of how long it takes to cause dangerous environmental change or trigger other feedback loops that reduce Earth’s ability to return to safe levels
Rockstrom et al: proposal for integrating Sustainable Development Goals with Planetary Boundaries
What have I got to say?...

• “We need a new way of thinking, a profound “mind-shift”. We urgently need to recognize that our societies are intimately connected to planet Earth.

• We cannot wave a magic wand to achieve a shift in human values.

• Awakening people to our connections with planet Earth will require efforts from science, culture, philosophy, and religion, guided by a moral compass of inter-generational responsibility and respect for nature.

Johan Rockström, 2013 *The Human Quest* with photographer Mattias Klum; Max Strom, Stockholm
"Still our best friend, the planet is doing all it can to remain in the stable equilibrium of the Holocene. And we should support it. We can drive us into a good Anthropocene – an era where we use our growing educational, scientific, and technological capacity to stay in Holocene-like conditions. In all aspects of life, society, and economy, we need to cooperate and co-act with nature.

Andreas Carlgerm, past- Minister for the Environment Sweden
How do we reach “safer living space”…?

• A transformative agenda must start with deeper insights.

• We believe that science, while important, is only one among many components required to recalibrate our values for the Anthropocene.

• We need to combine the latest scientific evidence, analyses, and observations with emotional, cultural, religious, and ethical dimensions of our experience.”

Johan Rockström, 2013 The Human Quest with photographer Mattias Klum; Max Strom, Stockholm
References

• Common Wealth: Economics for a Crowded Planet by Jeffrey Sachs

• A Safe Operating Space for Humanity by Johan Rockstrom et al., Nature Vol 461|24 September 2009


• Sustainable Development and Planetary Boundaries: Background Paper by Johan Rockstrom and Jeffrey Sachs with Marc C. Ohman and Guido Schmidt-Traub, May 2013