Virtual Academy of Sustainability

Lecture 2: Global Change

Episode 2: Planetary Boundaries

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Overview of the Lecture

Episode 1: A Time of Accelerating Change

Episode 2: Planetary Boundaries

Episode 3: Interview

Learning Outcomes

- You will understand an Earth-system biophysical approach to help humanity deal with climate change and other global environmental threats.

Structure of Episode 2

1. Human Domination
2. Defining Planetary Boundaries
3. Conclusion

Human Domination

- In the last 200 years, humanity has transitioned into a new geological era – the "Anthropocene".
- An era defined by accelerating departure from the stable environmental conditions of the past 12,000 years.
- This period of stability – known as the Holocene – has seen human civilization arise, develop and thrive.
- Human enterprise has expanded rapidly since the Industrial Revolution threatening such stability.

Human Domination

- The environment is changing rapidly from the stable Holocene state to an unknown future state of significant different conditions.
- Humanity needs to change course, but in what direction and what principles should guide the journey?
- One way to address this challenge is to determine 'safe boundaries' based on fundamental characteristics of our planet and operate within them.

Planetary Boundaries

- To meet the challenge of maintaining the Holocene state, a group of 28 internationally renowned scientists proposed a framework based on 'planetary boundaries'.

- Planetary boundaries refer to safe biophysical boundaries, which, if crossed, could generate unacceptable environmental change for humanity.

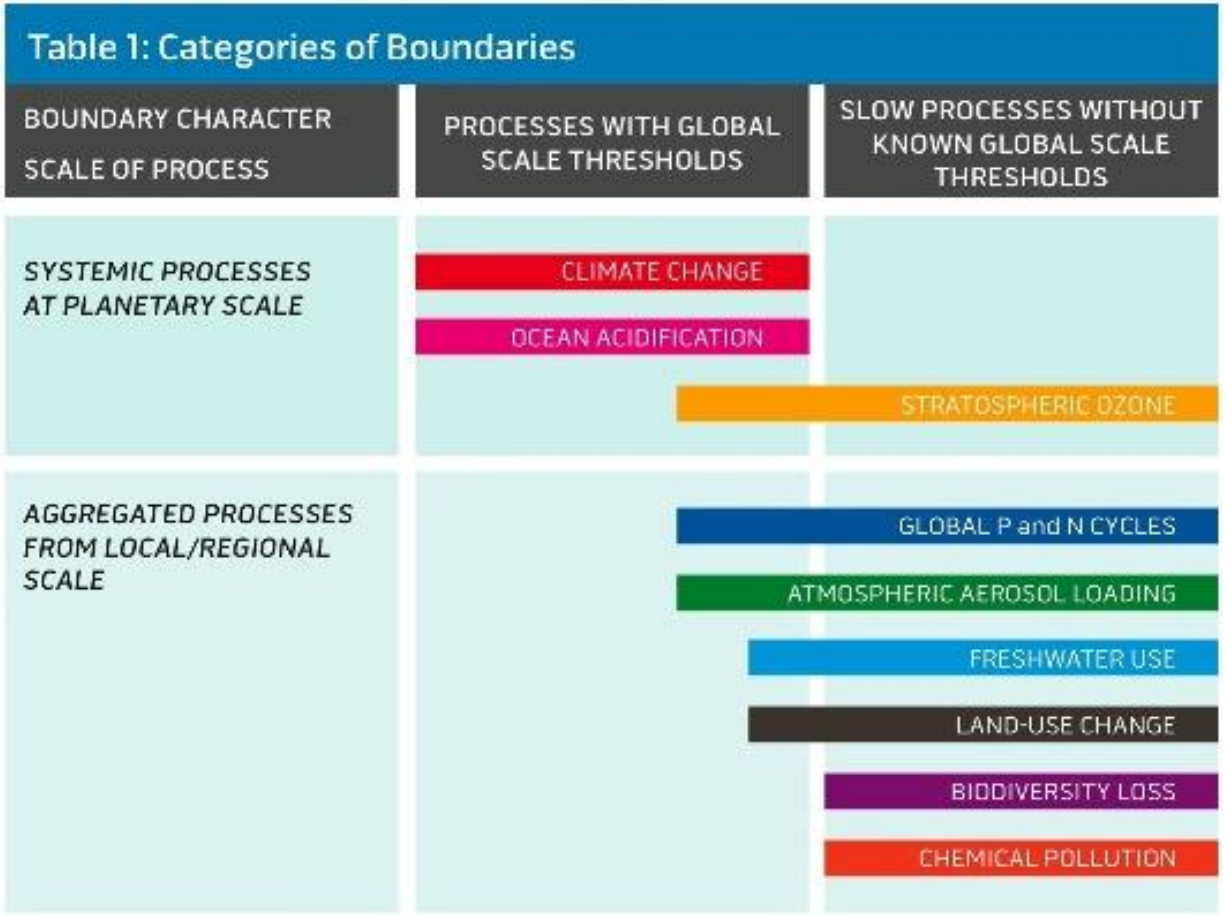
- Boundaries define the safe operating space for humanity with respect to the Earth system.

Planetary Boundaries

- Nine planetary boundaries were identified:
  - Climate change
  - Biodiversity loss
  - Nitrogen & phosphorus production
  - Stratospheric ozone depletion
  - Ocean acidification
  - Global freshwater consumption
  - Land use change for agriculture
  - Atmospheric (air) pollution
  - Chemical pollution

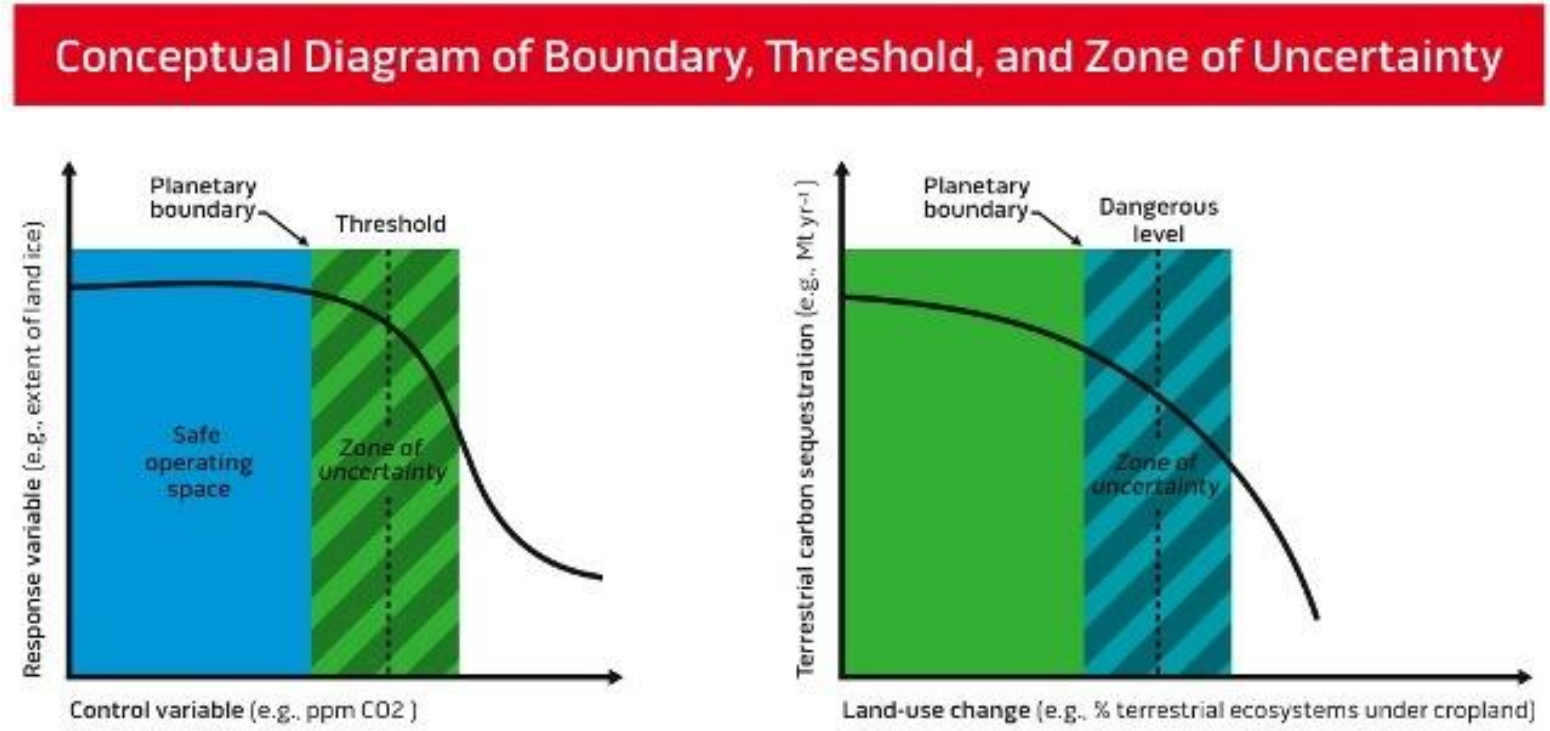
- Crossing one boundary may seriously threaten the ability to stay within safe levels of the others.

Planetary Boundaries



Source: Steffen et al (2011)

Planetary Boundaries



Source: Steffen et al (2011)

Planetary Boundaries

PLANETARY BOUNDARIES

Earth-system process	Parameters	Proposed boundary	Current status	Pre-industrial value
Climate change	(i) Atmospheric carbon dioxide concentration (parts per million by volume)	350	387	280
	(ii) Change in radiative forcing (watts per metre squared)	1	1.5	0
Rate of biodiversity loss	Extinction rate (number of species per million species per year)	10	>100	0.1–1
Nitrogen cycle (part of a boundary with the phosphorus cycle)	Amount of N_2 removed from the atmosphere for human use (millions of tonnes per year)	35	121	0
Phosphorus cycle (part of a boundary with the nitrogen cycle)	Quantity of P flowing into the oceans (millions of tonnes per year)	11	8.5–9.5	~1
Stratospheric ozone depletion	Concentration of ozone (Dobson unit)	276	283	290
Ocean acidification	Global mean saturation state of aragonite in surface sea water	2.75	2.90	3.44
Global freshwater use	Consumption of freshwater by humans (km^3 per year)	4,000	2,600	415
Change in land use	Percentage of global land cover converted to cropland	15	11.7	Low
Atmospheric aerosol loading	Overall particulate concentration in the atmosphere, on a regional basis		To be determined	
Chemical pollution	For example, amount emitted to, or concentration of persistent organic pollutants, plastics, endocrine disrupters, heavy metals and nuclear waste in, the global environment, or the effects on ecosystem and functioning of Earth system thereof		To be determined	

Boundaries for processes in red have been crossed. Data sources: ref. 10 and supplementary information

Source: Steffen et al (2011)

Planetary Boundaries

- Three boundaries (climate change, biodiversity loss, and phosphorus and nitrogen production) already transgressed.

- Transgressing climate change boundary can lead to:
  - melting of ice sheets,
  - rising sea levels,
  - abrupt shifts in forest and agricultural lands,
  - increasing intensity and frequency of extreme events (floods, wildfires, heat waves).

Planetary Boundaries

- Rate of biodiversity loss has skyrocketed in the postindustrial age (100-1000 times more than what could be considered natural).
- 30% of wildlife will come under the threat of extinction this century. (Steffen et al 2011)
- Excessive phosphorus and nitrogen (byproducts of agriculture) pollutes waterways and costal areas and adds harmful gases to the atmosphere.

Planetary Boundaries

- Even if the science is preliminary, the planetary boundaries approach is a credible attempt to quantify the limitations of our existence on Earth.
- The boundaries delineate a 'safe operating space' for human development and well-being.
- Although they are described in terms of individual quantities and separate processes, they are tightly coupled.
- If one boundary is transgressed, cascading impacts can put other boundaries under serious risk.

Planetary Boundaries

- Proposed numerical values, however, should not be seen as targets.
- Would risk the possibility that boundaries would be used to justify prolonged environmental degradation to the point of no return.
- Setting limits that are well within the bounds (safe operating space) might be wiser.

Conclusion

- Planetary boundaries approach raises important questions and opportunities for governance and institutions.
- Although some Earth-system processes (such as climate change and ocean acidification) are global in scale, others become global only when they aggregate from much smaller scales.
- Efforts to reduce pollution and limit and reverse ecosystem degradation at local and regional scales become important because of their larger-scale implications.
- There will also be a need for an institution (or institutions) operating with authority at the global level to ensure that the planetary boundaries are respected. (Steffen et al 2011)

Exercises for Self-Study

1. Describe the concept of planetary boundaries and their implications for governance.

2. What kind of institutional change is needed to establish and enforce these boundaries?

3. Why is remaining within the planetary boundaries a necessary – but not sufficient – condition for a bright future for humanity?

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