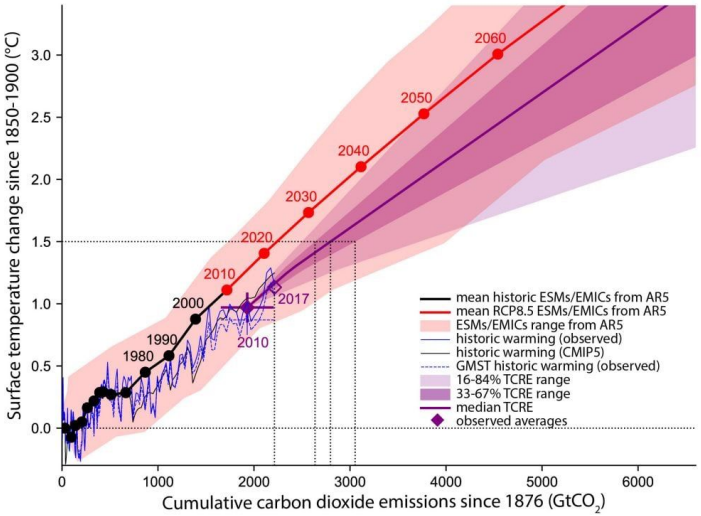
Kokonaisvaltainen ilmasto- ja ympäristövaikutusten arviointi

Otso Peräkylä ja Tuukka Petäjä
Helsingin yliopisto, Ilmakehätieteiden keskus INAR
29.11.2024

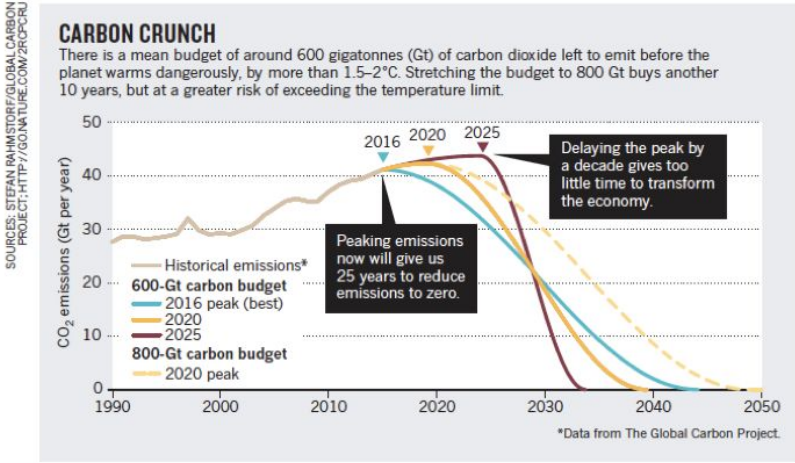
Myös: Laura Riuttanen, Janne Salovaara, Ville Leinonen, Henri Jokinen ja Markku Kulmala

“Luonnontieteellinen osa”

Päästövähennyksillä on kiire



IPCC 1.5 asteen raportti: jokainen päästetty hiilitonni aiheuttaa lisäkuumenemista



Figueres et al. (2017) Three years to safeguard our climate, Nature 546, 593-595.

Jos haluttaisiin pysyä 1.5 asteen kuumenemisessa, päästöjä olisi vähennettävä äärimmäisen nopeasti

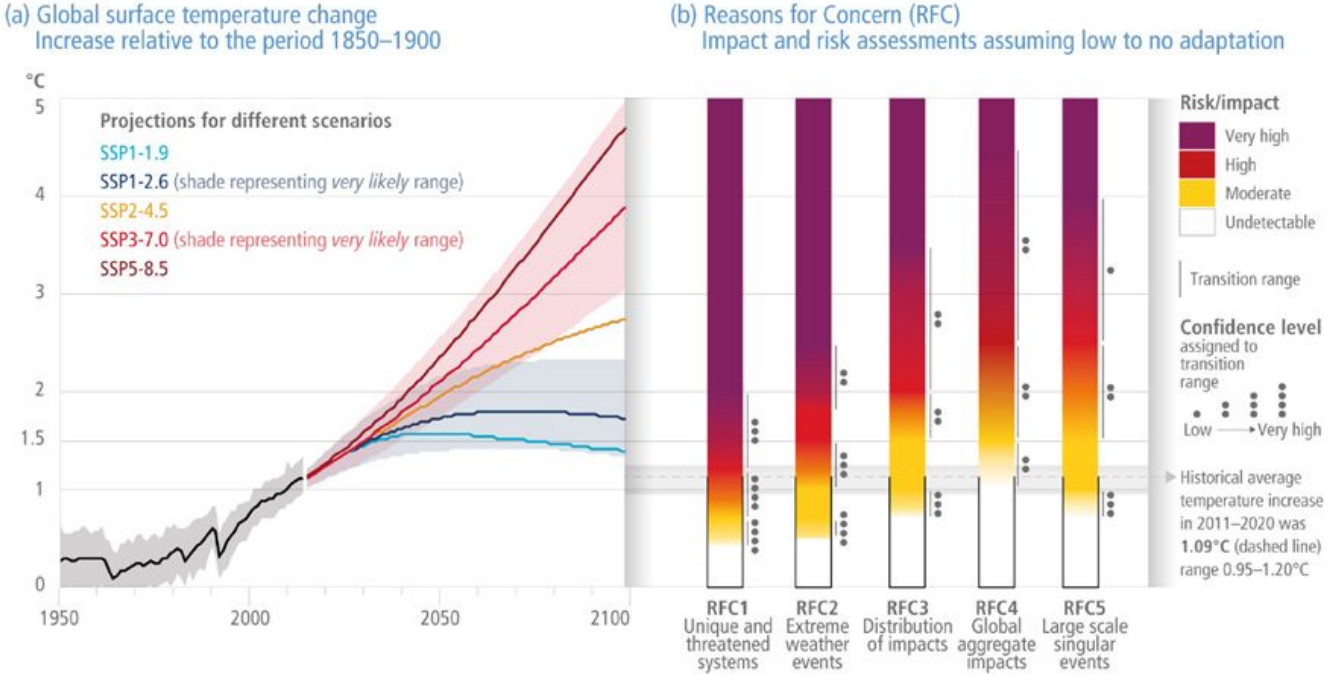
Actions required across the society:

1) Energy
2) Infrastructure
3) Transport
4) Land use
5) Industry
6) Finance

1.5 astetta ei ole maaginen raja

Riskit kasvavat kullakin asteen kymmenyksen lisäkuumenemisella

→ Kaikki päästövähennykset ovat hyödyllisiä



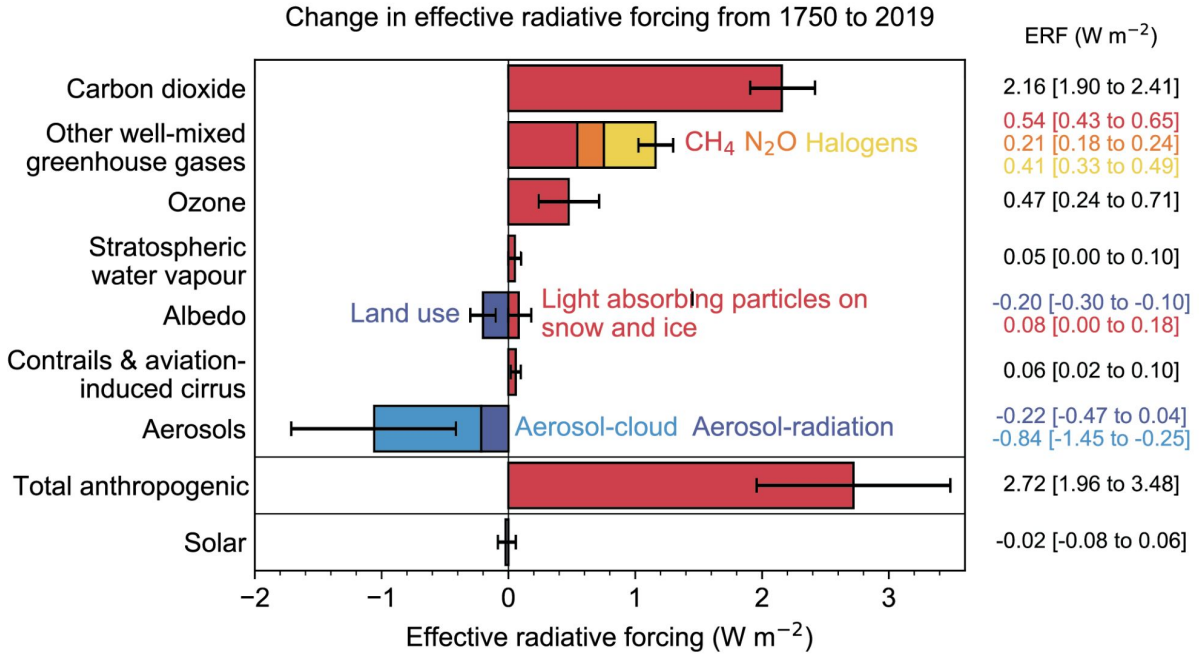
IPCC AR6

Hiilidioksidi ei ole ainoa syy kuumenemiseen

… mutta se on tärkein syy

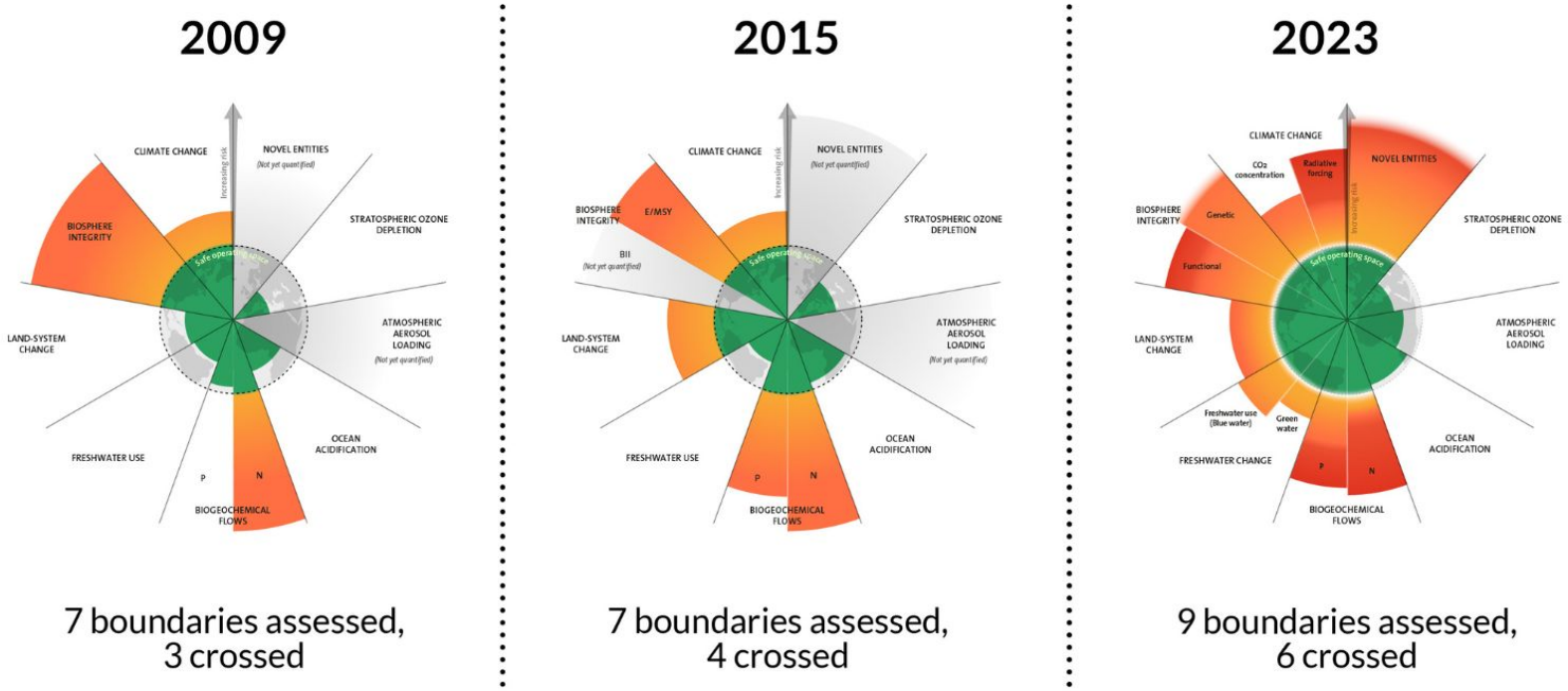
Esim. metaanipäästöjä vähentämällä voidaan vaikuttaa erityisesti lähitulevaisuuden lämpenemiseen

Eri yhdisteillä hyvin erilainen vaikutus ilmastoon



IPCC AR6

Eikä ilmasto ole ainoa ongelma



Planetaariset rajat: kuusi yhdeksästä rajasta ylitetty

www.stockholmresilience.org/research/planetary-boundaries

Ongelmien tarkastelu erillään johtaa huonoihin tuloksiin

ATMOSPHERIC SCIENCE

Clean the Air, Heat the Planet?

Almut Arneth,[1,2*] Nadine Unger,[3] Markku Kulmala,[2] Meinrat O. Andreae[4]

Science, 2009

Example:

Control measures to improve air quality can reduce the amount of cooling sulfate aerosols.

Good for the health, bad for the climate.

Ministeriö hautasi tilaamansa raportin tuulivoiman haitoista

Tuulivoima | Päätös syntyi sen jälkeen, kun Metsähallituksen tuulivoimakehittäjät olivat arvostelleet selvitystä.

Tilaajille

Muuttava nuori maakotka kuvattiin Nokialla lauantaina 5. lokakuuta. Maakotkien määrä kasvaa hitaasti, koska maakotkat aloittavat pesinnät vasta neljä- tai viisivuotiaina eivätkä yleensä pesi joka vuosi. Kuva: Raimo Innanmaa

Petja Pelli HS
14.10. 7:00

YMPÄRISTÖMINISTERIÖ jätti julkaisematta lähes valmiin selvityksen, jossa kerrottiin tuulivoimarakentamisen haitoista maakotkille.

Miten toimijoiden päästöjä arvioidaan?

GREENHOUSE GAS PROTOCOL

GHG Protocol: Scope 1-2-3

Scope 1: Direct Emissions

- e.g. company vehicles, process emissions, “fugitive emissions”

Scope 2: Indirect Emissions from Purchased Energy

- e.g. electricity bought from a utility company

Scope 3: Other Indirect Emissions (Value Chain)

- e.g. indirect emissions resulting from the organisation’s value chain— upstream = emissions from suppliers, raw material extraction, employee commuting, business travel… and; downstream = emissions from product use, end-of-life disposal, distribution logistics...

https://ghgprotocol.org/

Päästöjen lisäksi: hiilikädenjälki

Measuring the positive environmental impact an organisation's products, services, etc. have by reducing emissions or other environmental burdens for "users" or "customers"

- Direct carbon savings: emission reductions achieved through the use of a product or service compared to an alternative, e.g. more energy-efficient appliance
- Indirect carbon savings: emissions avoided across the value chain due to efforts or innovations, e.g. supply chain optimized
- Scaling Positive Impact: how widely the organisation's solution can be adopted to multiply benefits

Key Metrics:

- Reductions in energy or material use during product use
- Reduced emissions over the lifecycle of the product or service
- Avoided emissions from waste minimization or circular economy initiatives

E.g. VTT/LUT 2021, https://www.sitra.fi/en/dictionary/carbon-handprint/

Current (European) legislative initiatives related to corporation reporting

Laws to harmonize ESG reporting across Europe, reduce greenwashing, and ensure organisations contribute to the EU Green Deal's sustainability objectives. Such as:

Corporate Sustainability Reporting Directive (CSRD) — implementation by 2028:

- Expands on the earlier Non-Financial Reporting Directive (NFRD), covering all large EU companies and non-EU companies listed on EU-regulated markets.
- Companies must report on: ESG impacts; GHG Scope 1, 2, and 3; resilience to climate risks with scenario analysis; business practices alignment with Paris Agreement target
- Reports must follow the European Sustainability Reporting Standards (ESRS), with mandatory third-party assurance

EU Taxonomy Regulation

- Economic activities to guide investments towards a net-zero economy by 2050
- Financial disclosures for aligning taxonomy criteria on e.g. renewable energy and circular economy initiatives

EU Deforestation Regulation (EUDR) — by end of 2024

- Combats deforestation by requiring due diligence for companies handling commodities such as cocoa, coffee, and soy.

Focus on Materiality:

- Under CSRD, companies assess impacts using "double materiality," covering both financial impacts on the business and broader environmental/social impacts of the business itself

Future Additions:

- Sector-specific standards for high-impact industries (e.g. agriculture, energy, mining…) in development
- Reporting standards for small and medium enterprises (SMEs) are also expected (for example: for listed SMEs CSRD will apply starting in 2026, with first reports published in 2027…)

https://corpgov.law.harvard.edu/

ESG Reporting (by Global Reporting Initiative)

Standardised framework for reporting organisation's:

- Environmental (E) performance:
  - Energy use, GHG emissions, and climate-related risks
  - Water withdrawal, consumption, and discharge
  - Biodiversity impacts, waste management, and pollution prevention
- Social (S) performance:
  - Labor practices: wages, working conditions, health and safety
  - Human rights: non-discrimination, freedom of association, child/forced labor
  - Community engagement: stakeholder inclusiveness, contributions to local development
- Governance (G) performance:
  - Corporate governance structures, decision-making, and compliance
  - Anti-corruption measures and ethical business practices
  - Risk management and adherence to regulations

https://www.globalreporting.org/standards/

Integrated Reporting Framework

Holistic view of how an organisation creates value over time by assessing multiple forms of capital and the relationships between them, assessing:

- Natural Capital: Environmental resources and ecosystem services used by the organisation
- Human Capital: Employees' competencies, knowledge, and wellbeing
- Social and Relationship Capital: Stakeholder relationships, community engagement, and trust
- Intellectual Capital: Organizational knowledge, innovation, and intangible assets
- Financial Capital: Economic resources, including profits and investments
- Manufactured Capital: Physical assets like infrastructure and technology

Focusing on:

- Interdependencies between financial performance and non-financial factors
- Long-term value creation, beyond short-term profit
- Governance, risk management, and strategic responses to external factors (e.g., climate change, societal expectations)
- How changes in policies and practices affect the organisation's ability to sustain value creation across all capitals

https://integratedreporting.ifrs.org/resource/international-ir-framework/

Future-fit Business Benchmark

Guide organizations toward becoming “future-fit” by aligning their operations with societal and planetary needs. Evaluates not just outcomes (e.g., emissions) but systemic practices, policies, and innovation driving sustainable transformation.

- Core Principles:
  - Organizations should contribute positively to societal and environmental well-being
  - Actions should align with achieving a sustainable future for all
- Environmental Goals:
  - Eliminate greenhouse gas emissions (Scopes 1, 2, and 3)
  - Transition to renewable energy and sustainable resource use
  - Avoid harm to ecosystems and biodiversity
- Social and Ethical Goals:
  - Fair labor practices, diversity, and community wellbeing
  - Transparent and ethical business operations
- Systemic Issues:
  - Address root causes of unsustainable practices (e.g., overconsumption, waste)

https://futurefitbusiness.org/benchmark/

The Natural Step Framework

Provides a scientifically grounded framework for sustainable development, helping organisations identify and eliminate unsustainable practices while fostering alignment with ecological and social systems.

- Four Sustainability Principles Assessed (used to identify harmful practices):
  - avoid systematic increases in substances from the earth's crust
  - avoid systematic increases in substances produced by society
  - avoid degradation of ecosystems
  - avoid undermining social systems
- Key Focus Areas
  - backcasting methodology: envision a sustainable future and work backward to identify actionable steps today
  - systemic change: organisational behaviour, supply chains, and product/service designs contribute to sustainability
  - strategic decision-making: use sustainability principles to guide decisions at all levels—long-term to day-to-day
- Broader Perspective
  - emphasises ecological and social systems as interconnected
  - aims to shift organisational culture toward systems thinking and proactive sustainability

https://thenaturalstep.org/approach/

Core concept

Multi-disciplinary and multi-stakeholder approach

Science + stakeholders in a co-design process

1) Utilize the fundamental natural science expertise regarding climate change and different processes influencing the rate of global change
2) Utilize the scientific expertise in social sciences / behavioral science to initiate the change
3) Utilize the expertise of the stakeholders in their field of work and detailed understanding on the needs / possibilities

→ a concept for assessing comprehensive impacts of jointly selected activity in climate change (keeping in mind the other grand challenges)


OUR ACTIONS
What can we concretely do?
CAUSAL ACTIONS
What can we help/affect/teach/develop/etc with and for others?
F-F: Ecosystems
F-F: Systemic issues
Natural Step: Earth materials
CarbonSink+
Muun kuin GHGn/ positiivisten ympäristövaikutusten arviointi?
Kuluttajakampanjointi/ koulutus ylikulutuksen vähentämisestä?
SYSTEMIC EFFECT
Natural Step: Systemic Changes
Natural Step: Social resources
F-F: Biodiversity
ENVIRONMENTAL IMPACTS
SOCIETAL IMPACTS
IRF: Manufactured capital
GHG Scope 3
Natural Step: Future-cast/ Long-term planning
New legislations
ATMOSPHERIC IMPACTS
INDIRECT EFFECT
IRF: Social capital
IRF: Natural capital
ECONOMIC IMPACTS
IRF: Human capital
ESG: Environmental
ESG: Social
GHG Scope 2
Uusien resurssiviisaiden yhteistyöverkostojen perustaminen?
ESG: Governance
Kestävä sijoittaminen, hankinta, omaisuudenhallinta…
DIRECT EFFECT
Natural Step: Organisational Culture
IRF: Financial capital
F-F: Energy
F-F: Labour
GHG Scope 1

Model for climate impact evaluation

Carbon footprint (Scope 1, 2, 3)

Effect of land use and additional sink (CarbonSink+)

Quantitative

Other effects on climate

- New action
- New action plans
- Change in values
- Change in behaviour
- New leadership structures
- New collaboration
- New information
- Change in system structures

Qualitative

Other effects

- Air quality
- Biodiversity
- Social sustainability
- Economic sustainability

Tutkimuksen esittely

Pienryhmissä työstettyjä aineistoja käytetään tutkimuksessa. Tutkimuksen tarkoitus on yhteiskehittää kokonaisvaltaita ilmastovaikutusten arviointia sekä alueellista ilmastotoimintaa. Tutkimusta johtaa Helsingin yliopiston Ilmakehätieteiden keskus.

Tutkimusaineisto: pienryhmien tuotokset, osallistujien taustatahot, tutkimuskysely

Tutkimuskysely ja tietosuojakirjaus:
https://www.acccflagship.fi/ilmastotoimintakeskus/alkukartoitus/

Tutkimukseen osallistuminen on vapaaehtoista.

Yhteystiedot: Laura Riuttanen, laura.riuttanen@helsinki.fi, puh. 050 4154746

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Urbaani ilmanlaatu 2.0

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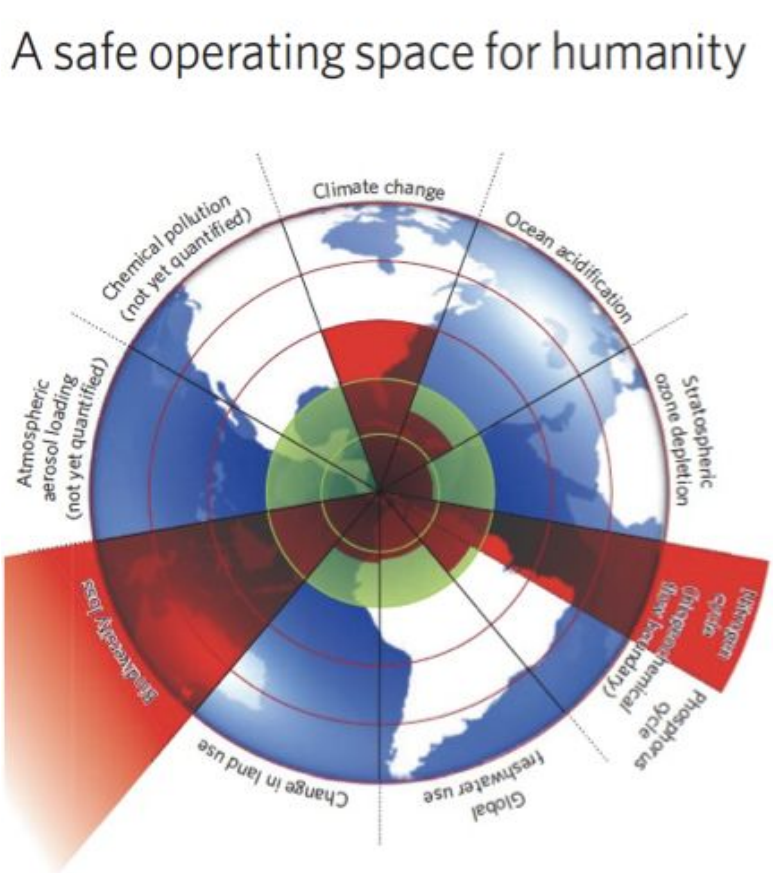
How to address other environmental hazards?



Rockström et al. (2009) A safe operating space for humanity, Nature 461, 472-475.

Table 1 | SDG Index 2016: score and ranking.

Rank	Country	Score
1	Sweden	84.5
2	Denmark	83.9
3	Norway	82.3
4	Finland	81.0
5	Switzerland	80.9
110	India	48.4
115	Pakistan	45.7
118	Bangladesh	44.4
141	Nigeria	36.1
145	Chad	31.8
146	Niger	31.4
147	Congo, Dem. Rep.	31.3
148	Liberia	30.5
149	Central African Republic	26.1

Schmidt-Traub et al. (2017) National baselines for the Sustainable Development Goals assessed in the SDG Index and Dashboards. *Nature Geosci* **10,** 547–555

Salvia et al. (2019) Assessing research trends related to Sustainable Development Goals: local and global issues, J Cleaner Prod. 208, 841-849.

Challenges

Differences in efficiency to trap long-wave radiation

Differences in atmospheric lifetimes

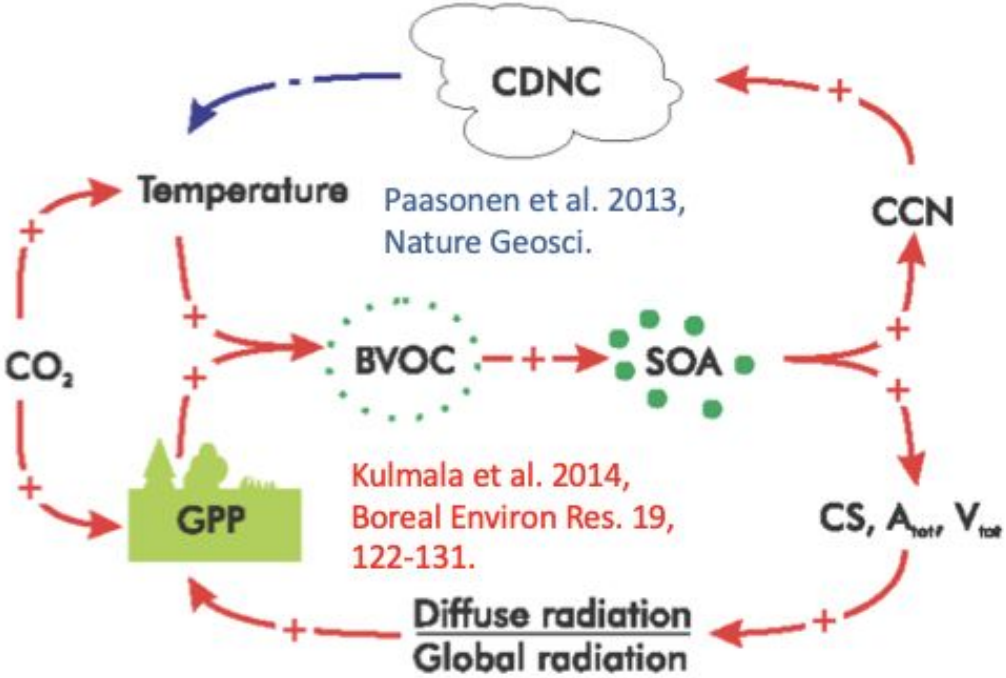
Different compounds are relevant with different time scales

Common name (chemical formula)	Lifetime (years)	GWP			GTP		
		20-year	100-year	500-year	20-year	100-year	500-year
Carbon dioxide (CO_2)	150†	1	1	1	1	1	1
Methane (CH_4)	12	72	25	7.6	57	12	4
Nitrous oxide (N_2O)	114	289	298	153	303	322	265
Sulphur hexafluoride (SF_6)	3200	16,300	22,800	32,600	17,500	23,400	28,000
Black carbon	0.020	1600	460	140	470	77	64

Lifetimes and metric values are taken from Table 2.14 of [4], and [5].
†CO_2 lifetime is representative and cannot be expressed by a single estimate because of the multiple timescales on which CO_2 is removed. (e.g., [26]).
GTP: Global Temperature Change Potential; GWP: Global Warming Potential; IPCC: Intergovernmental Panel on Climate Change.

Feedbacks

Quantification of natural feedback mechanisms slowing down climate change providing the society time to reduce the emissions of CO2.



In boreal forest environment

CarbonSink+

Max impact 1.8 times the CO2 sink

- Kulmala et al. (Boreal Environ Res) based on 18 years of SMEAR II data from Hyytiälä
- Paasonen et al. (Nature Geosci) based on global aerosol data and cloud albedo parameterization, feedback strength varies from location to location. The highest gain in clean boreal environments.
- Petäjä et al. (Nature Geosci) quantified the upper loop including CDNC with direct observations
- Yli-Juuti et al. (Nature Comm) quantified the upper loop with in-situ and satellite data

Feedbacks and interactions can slow down (negative) the change, or enhance it (positive).

These need to be verified against observations and monitored in a continuous, systematic manner.

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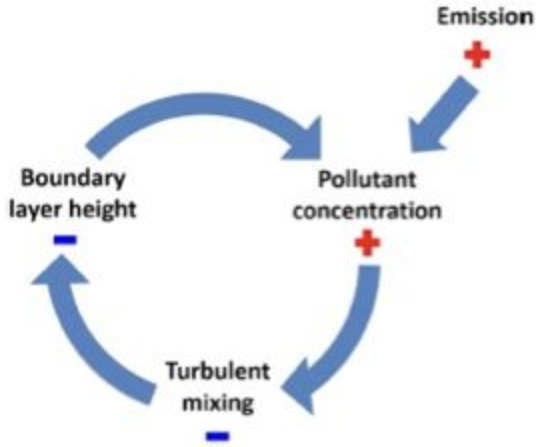
Science, 2009

SCIENTIFIC REPORTS

Enhanced air pollution via aerosol-boundary layer feedback in China

T. Petäjä[1,2], L. Järvi[1], V.-M. Kerminen[1], A.J. Ding[2], J.N. Sun[2], W. Nie[1,2], J. Kujansuu[1], A. Virkkula[2,3], X.-Q. Yang[2], C.B. Fu[2], S. Zilitinkevich[1,3,4,5,6] & M. Kulmala[1]



Example:

Control measures to improve air quality can reduce the amount of cooling sulfate aerosols.

Good for the health, bad for the climate.

Poor air quality episodes are amplified by the feedback mechanisms!

Way forward?

Maybe:

1) Select a topic / activity that we know that has high carbon footprint

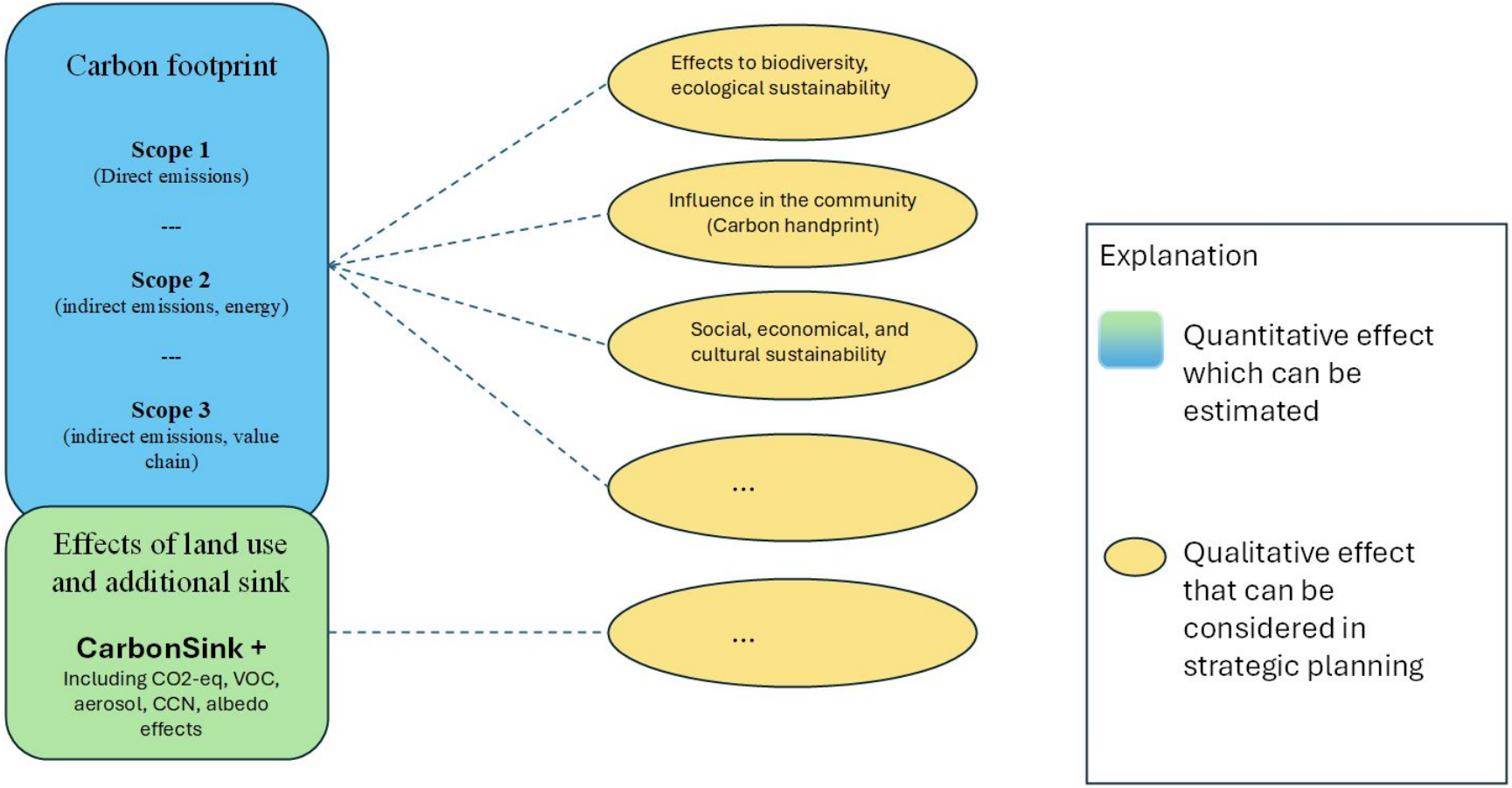
    Highest potential impact to reduce GHG emissions

2) Analyze other climate / environmental impacts of this topic / activity

    Include considerations from alternate ways to complete the action (life-cycle analysis)

    Include impacts to other climate relevant compounds, such as aerosols, albedo, etc

    Include analysis towards other environmental challenges (e.g., air quality / biodiversity)


Carbon footprint
Scope 1
(Direct emissions)

Scope 2
(indirect emissions, energy)

Scope 3
(indirect emissions, value chain)
Effects of land use and additional sink
CarbonSink +
Including CO2-eq, VOC, aerosol, CCN, albedo effects
Effects to biodiversity, ecological sustainability
Influence in the community (Carbon handprint)
Social, economical, and cultural sustainability
...
...
Explanation
Quantitative effect which can be estimated
Qualitative effect that can be considered in strategic planning

EU-säätely kestävyysasioissa

Corporate sustainability reporting directive (CSRD): isojen ja listattujen yritysten pitää 2025 alkaen raportoida kestävyysdataa

Sis. ilmastonmuutoksen vaikutukset/riskit yritykselle, mutta myös yrityksen ilmastovaikutukset. 2025 alkaen CSRD vaatii Pariisin sopimuksen kanssa yhteensopivan päästövähennystavoitteen

Sis. scopet 1, 2 ja 3