Digital technology and AI : what are the social and environmental issues?

Nicolas Burger

May 1st 2026

Curriculum

Nicolas Burger

UTT – Université de Technologie Troyes

2015 – Systems, Networks and Telecommunications Engineer

2015 – Master in Information Systems Security

2020 – PhD in Systems Optimization and Safety

Portraits 2 Passages

2016 – Today – Co-founder

utt+ alumni

2022 – 2025 – Head of the association

Optimistik

2020 – Today – R&D Engineer

IESF – Société des Ingénieurs et Scientifiques de France

2024 – Today – Head of the doctoral committee

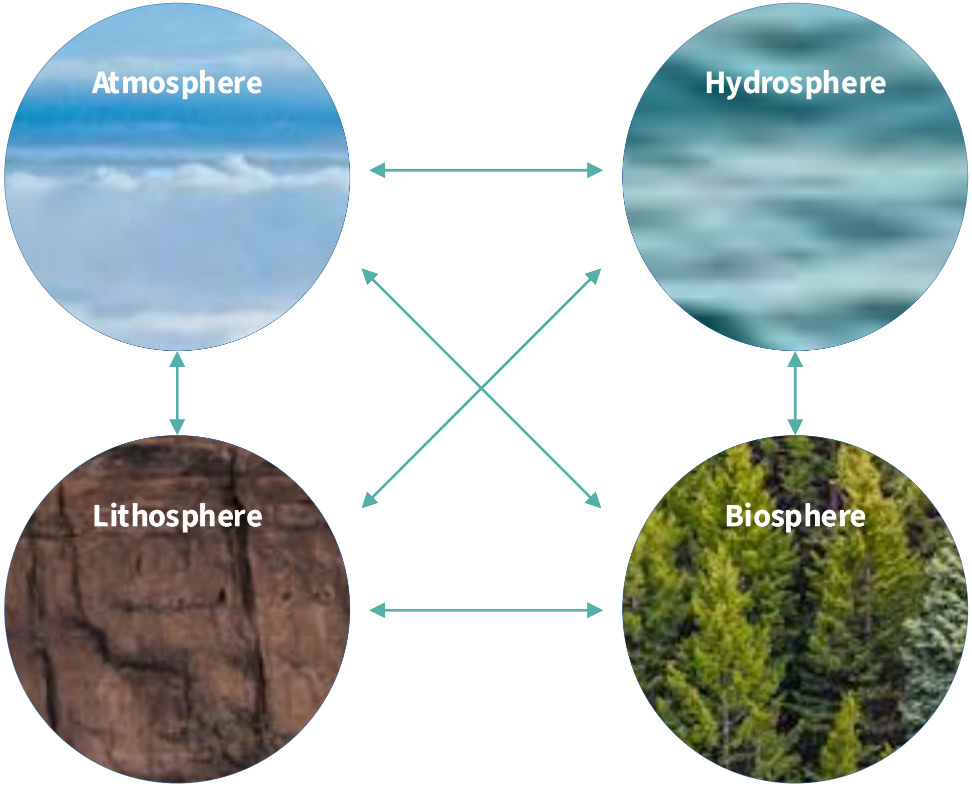
2024 – 2026 – Citizen Assembly on Science - Society

Contents

Earth system

Earth system

Dinitrogen (78%)
Dioxygen (20%)
Argon (0,93%)
Carbon dioxyde (0,041 %)

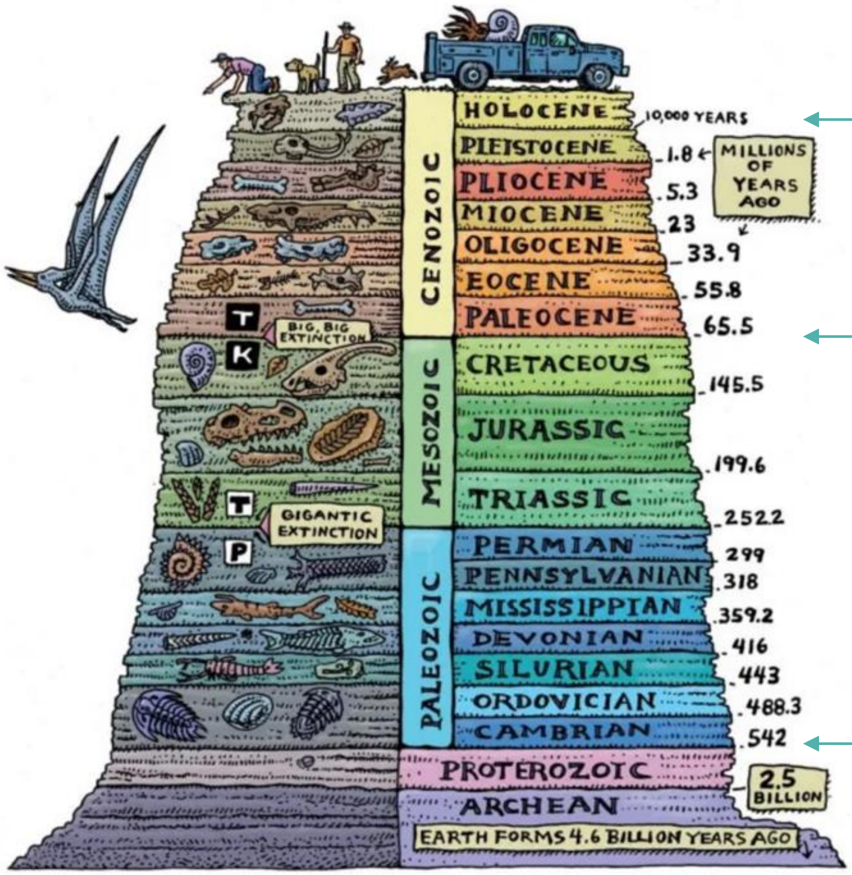


Oceans, **rivers**, **water tables**
Glaciers, ice floes, eternal snows
Water vapor

Earth crust
Upper mantle

Living organisms : Plants, animals, insects, marine life…

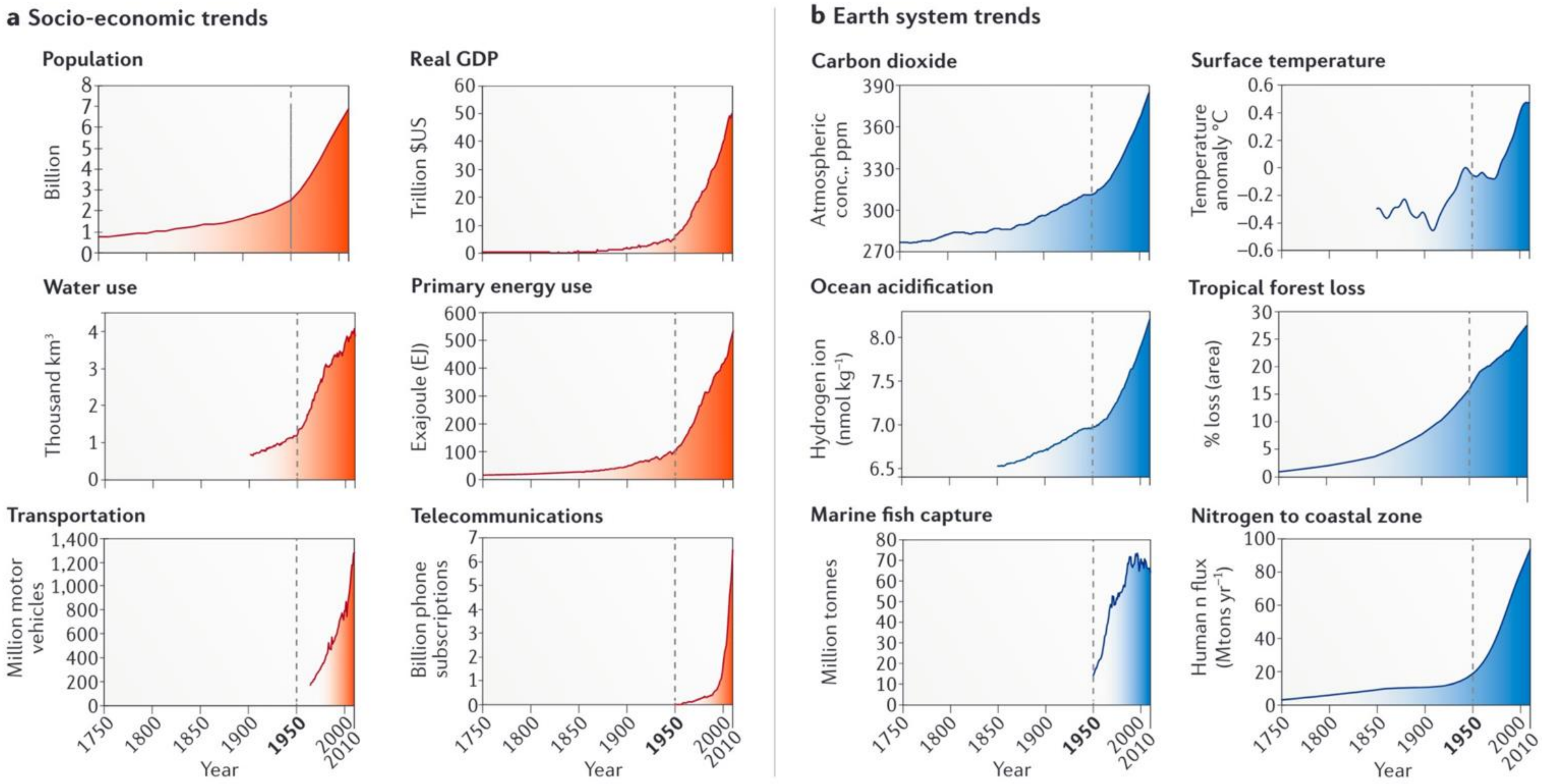
An evolving system



Temperate climate, proliferation of the human species

Dominance of mammals and birds, milder, drier climate

Early fossils, insects, complex plants



SOURCE

The emergence and evolution of Earth System Science, Steffen et al (2020)

When does the Anthropocene begin?

1492 - 1800 : old and new worlds collide

1760 - Today : industrial revolution

1945 - Today : atomic detonations

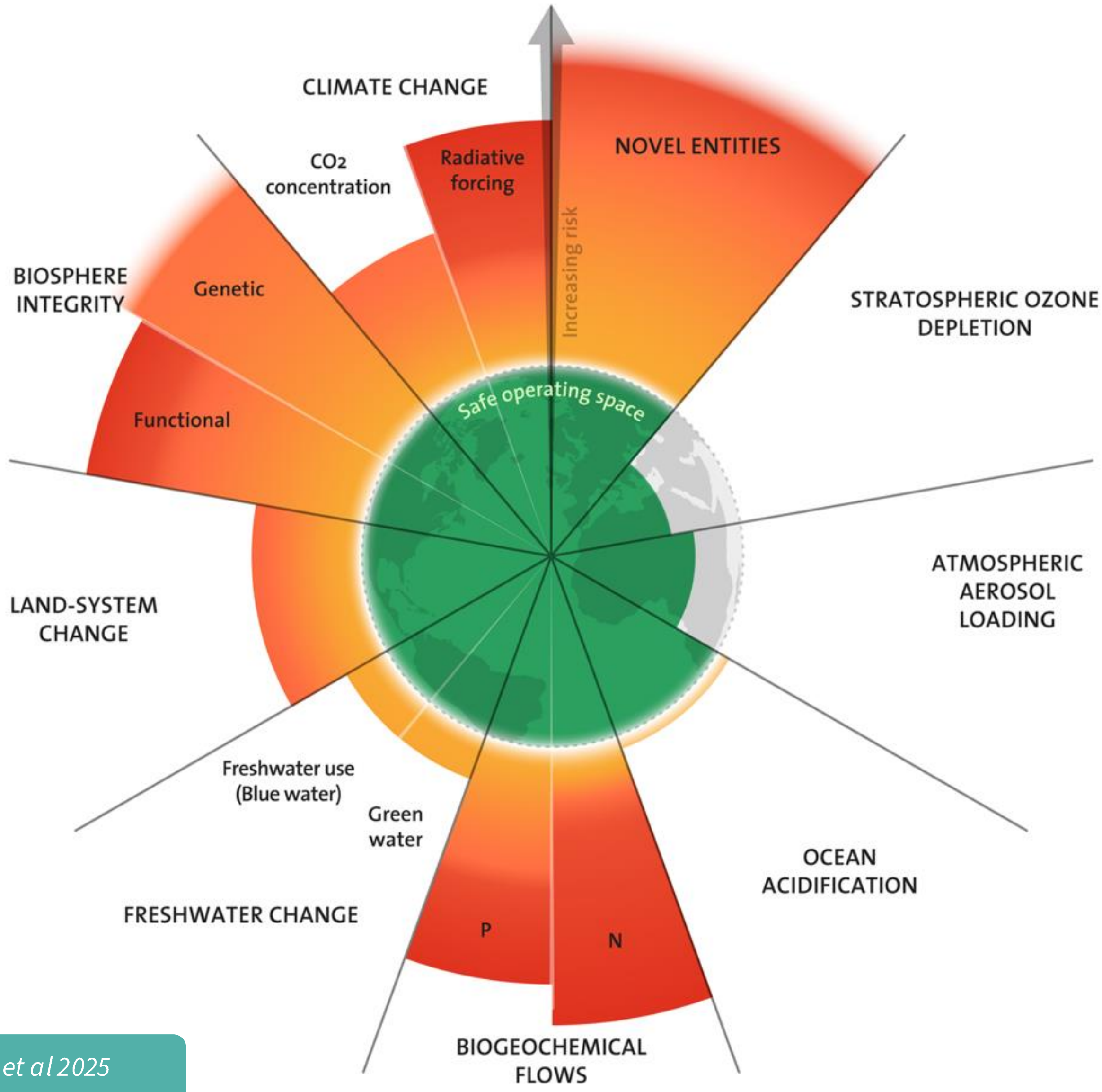
1950 - Today : industrial chemicals

SOURCE

Defining the Anthropocene, Lewis and Maslin (2015)

Planetary boundaries

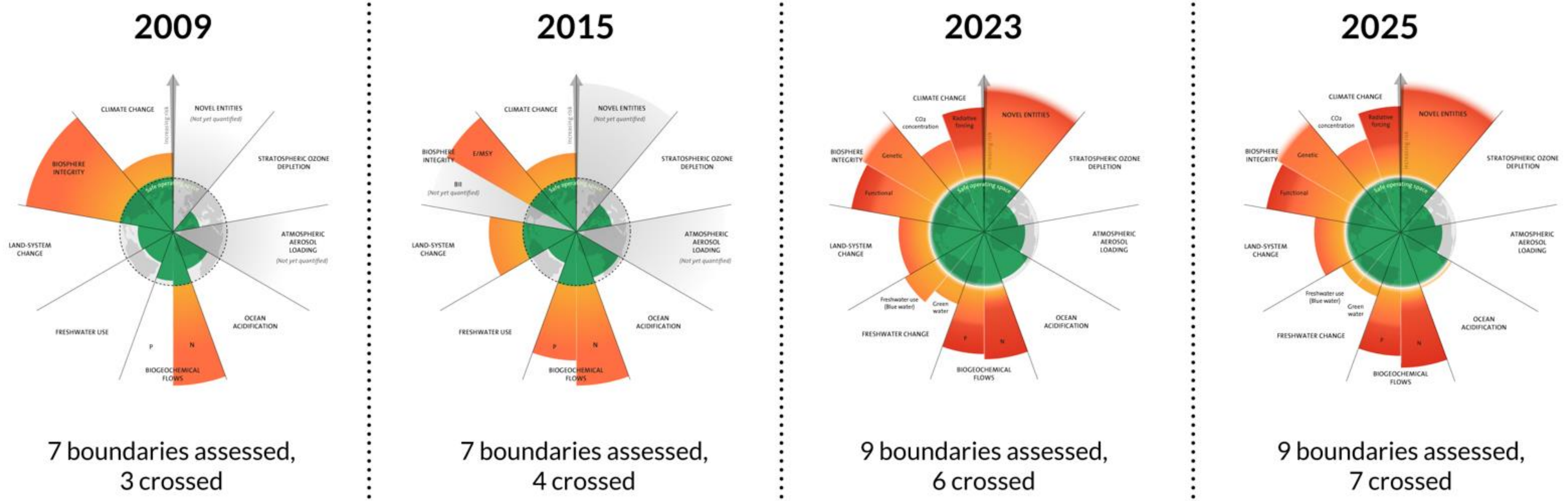
Planetary boundaries



SOURCE

Azote for Stockholm Resilience Centre, based on analysis in Richardson et al 2025

Planetary boundaries



SOURCE

Azote for Stockholm Resilience Centre, based on analysis in Richardson et al 2025

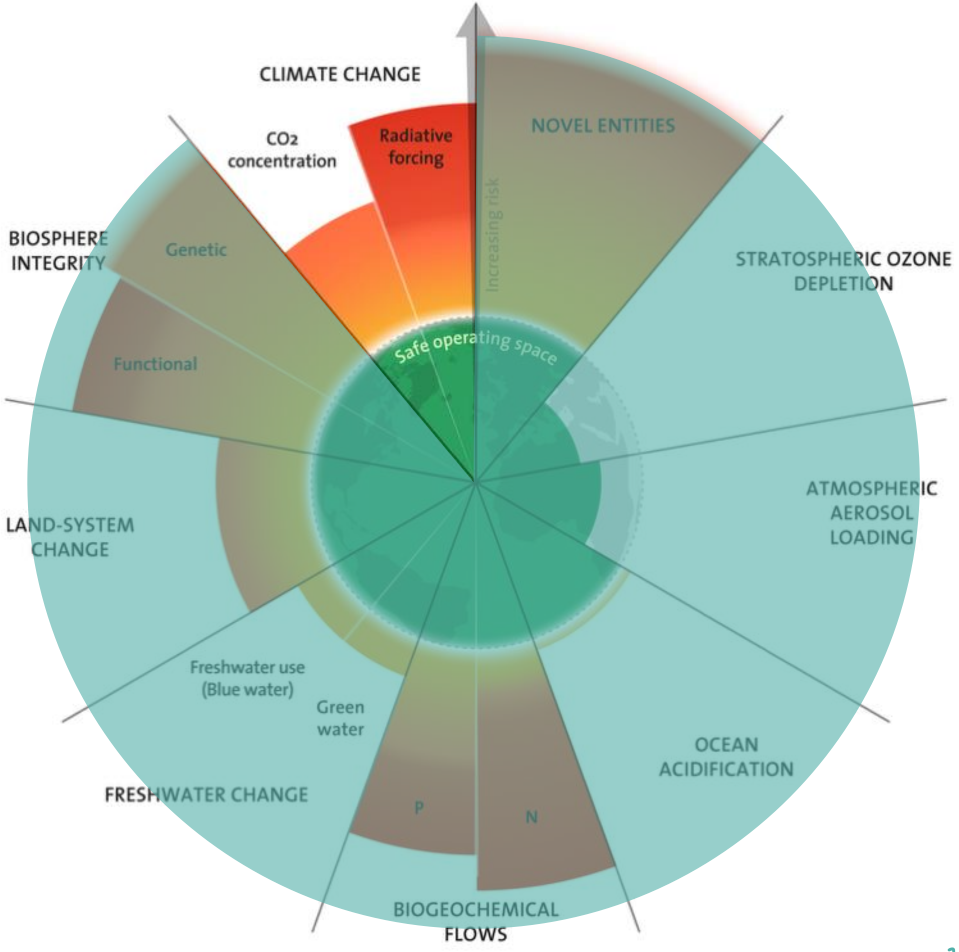
Climate change

CO_2 concentration

Boundary: 350 ppm
Pre-industrial: 280 ppm
Current: **417 ppm**

Radiative forcing

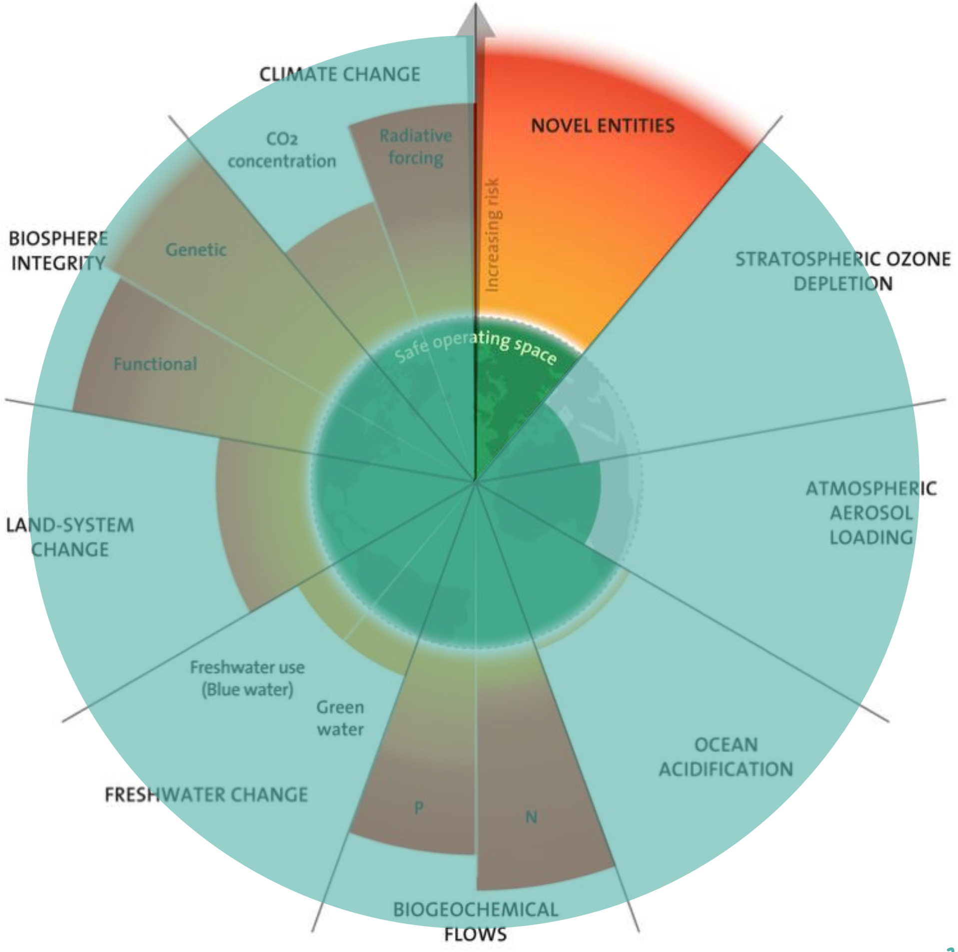
Boundary : 1 W/m^2
Pre-industrial (reference): 0 W/m^2
Current: **3,22 W/m^2**



Novel entities

Measurement
Diffusion of synthetic entities in the environment (quantity and impact)

- Plastic
- Alloys
- Nuclear wastes
- Endocrine disruptors
- …



Biogeochemical flows

Phosphorus (P) cycle

Boundary: 11 Tg/an

Pre-industrial: 0 Tg/an

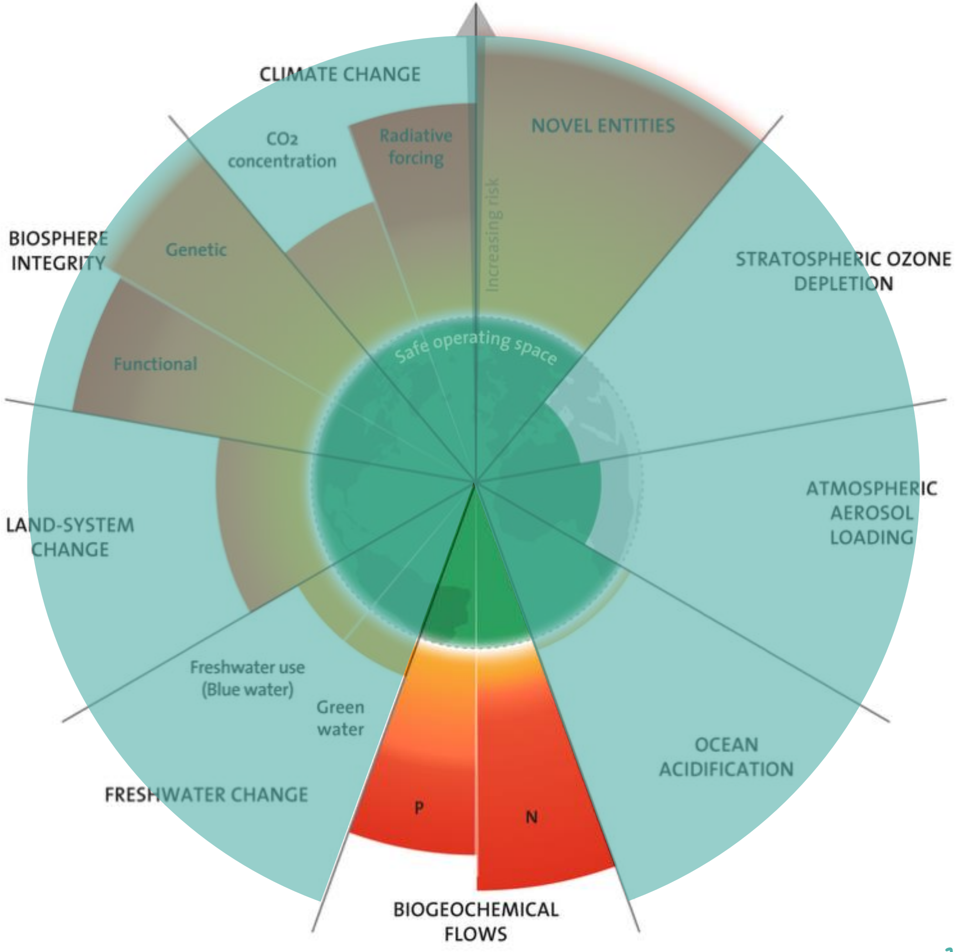
Current: **22 Tg/an**

Nitrogen (N) cycle

Boundary: 62 Tg/an

Pre-industrial: 0 Tg/an

Current: **190 Tg/an**



Biosphere integrity

Genetic diversity (number of extinctions per million species per year)

Boundary: <10

Pre-industrial: 1

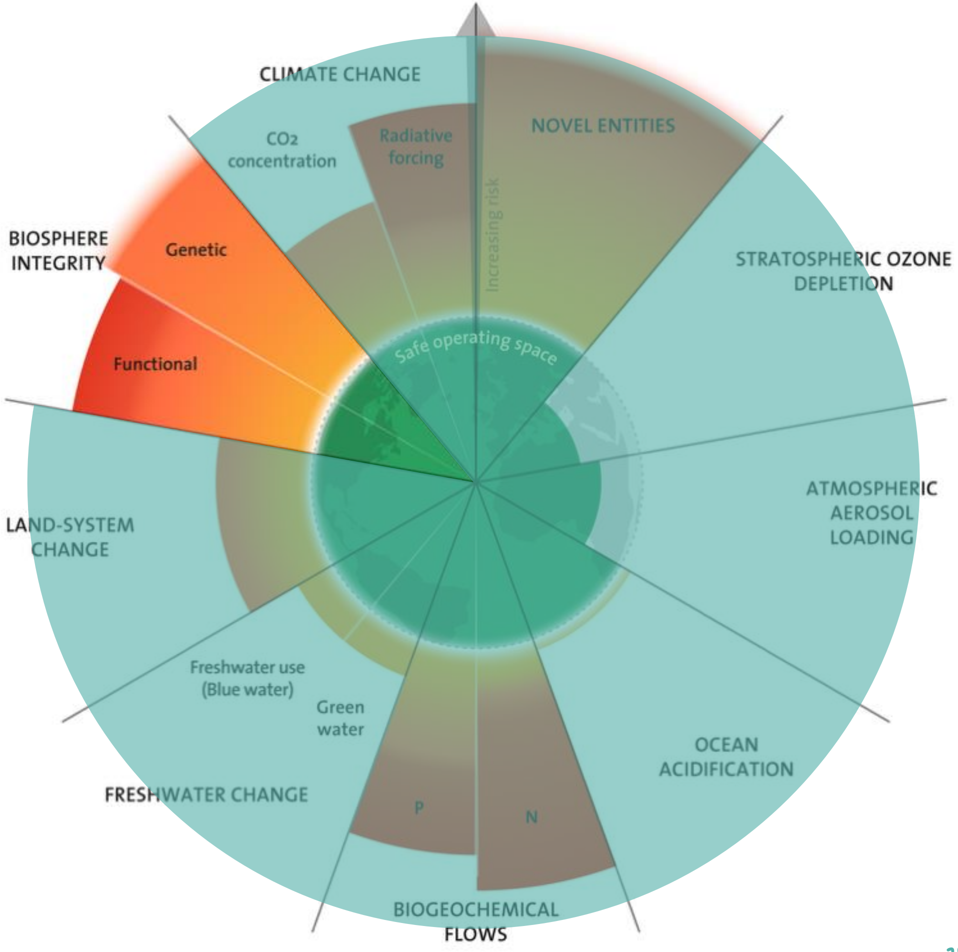
Current: **> 100**

Functional diversity

Boundary: < 10%

Pre-industrial: 1,9%

Current: **> 30%**



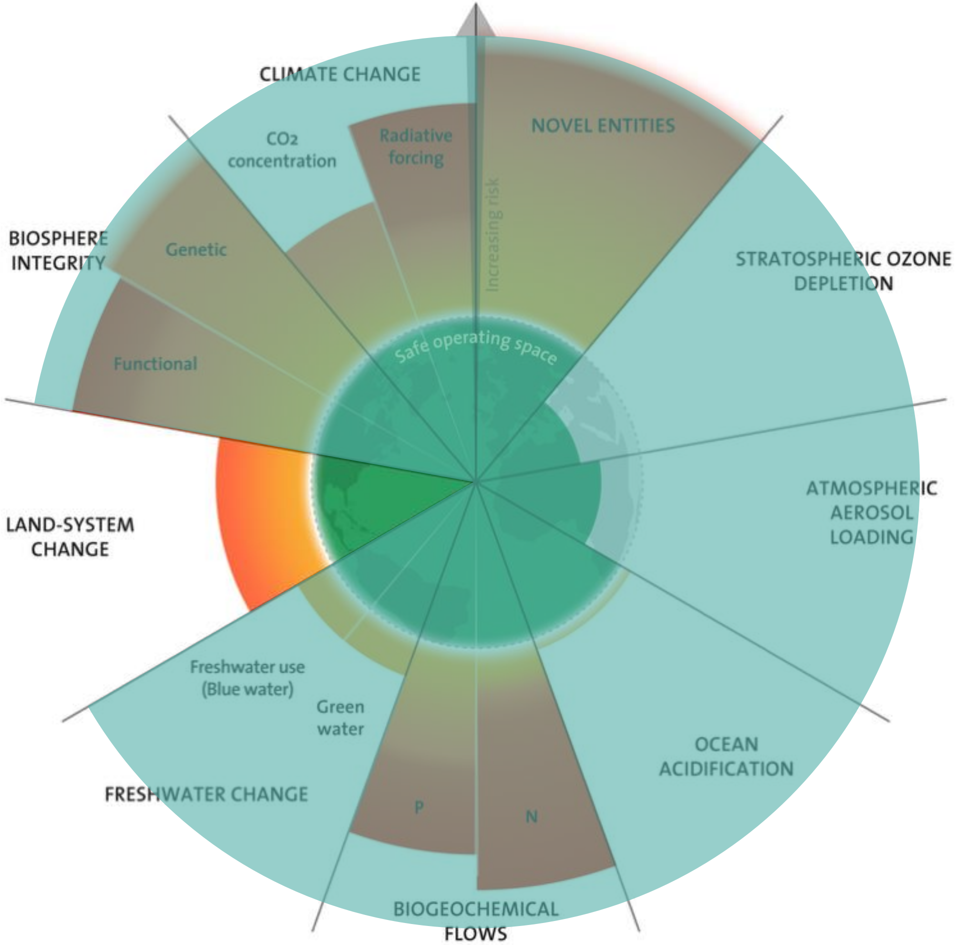
Land-system change

Part of the original forest

Boundary: 75%

Pre-industrial: 100%

Current: **62%**



Freshwater change

Blue water (disruption of drinking water flow)

Boundary: 10,2%

Pre-industrial: 9,4%

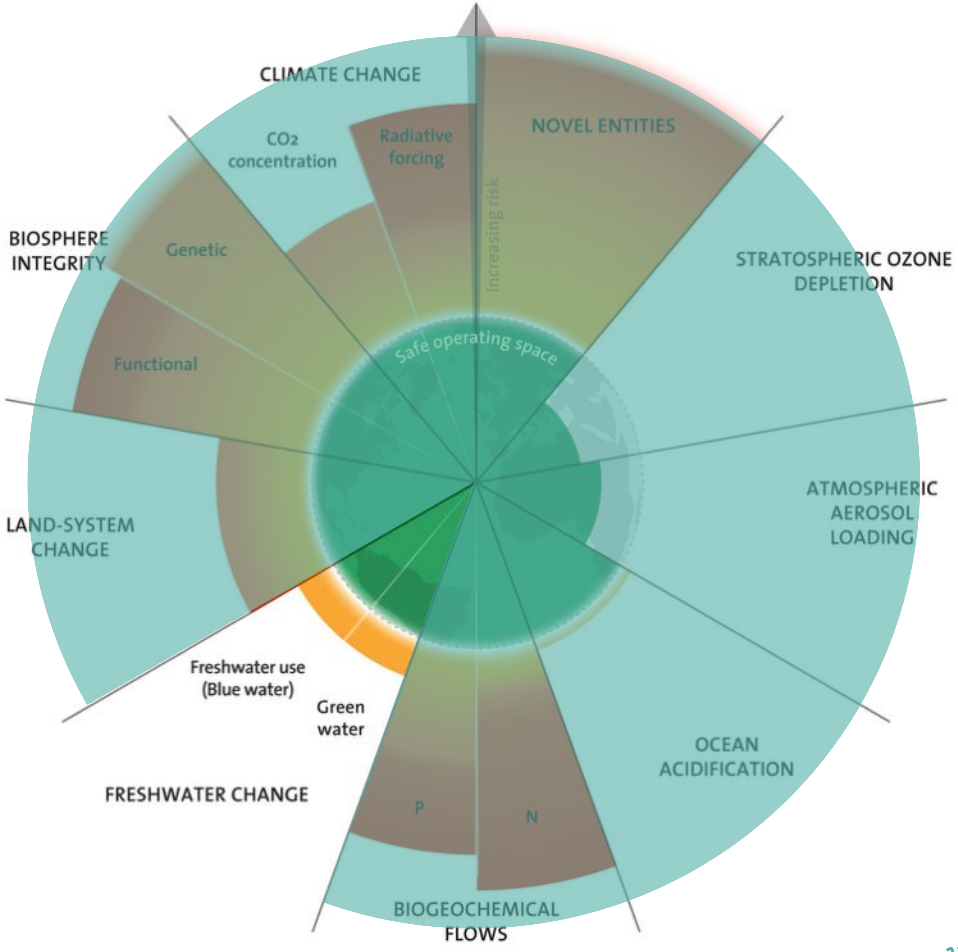
Current: **18,2%**

Green water (disruption of water flow to vegetation)

Boundary: 11,1%

Pre-industrial: 9,8%

Current: **15,8%**



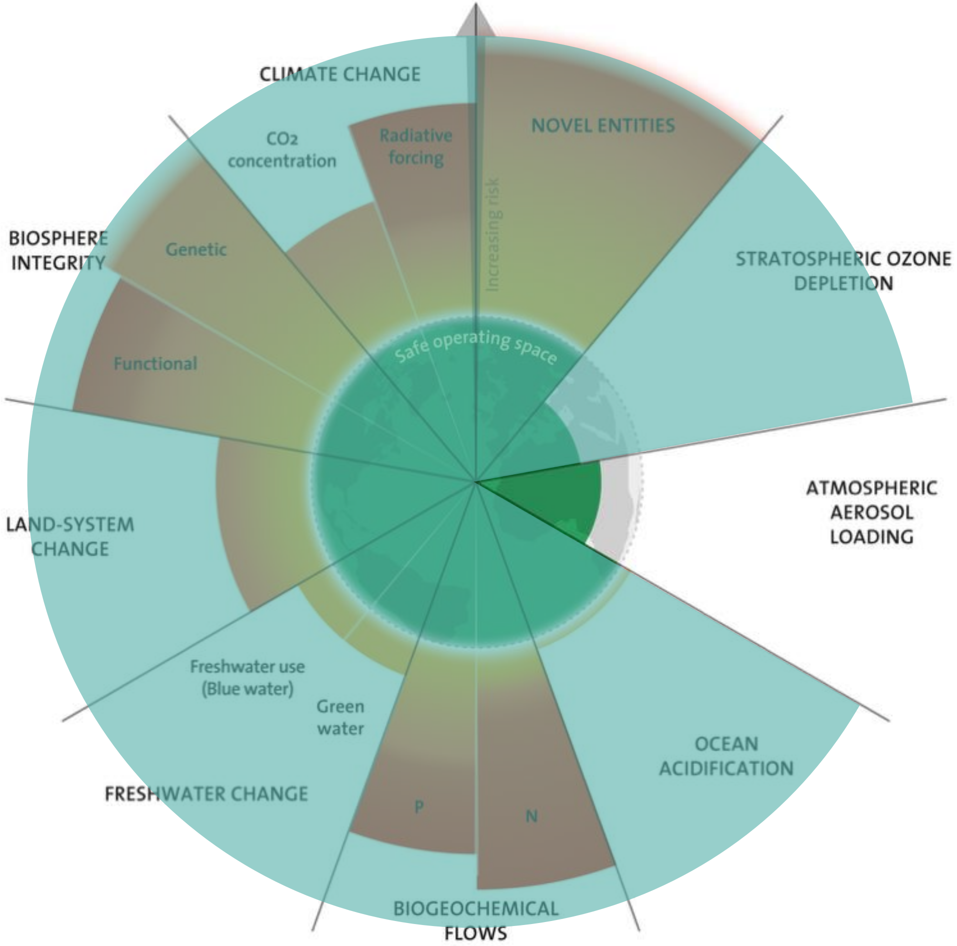
Atmospheric aerosol loading

Aerosol optical thickness

Boundary: 0,1

Pre-industrial: 0,03

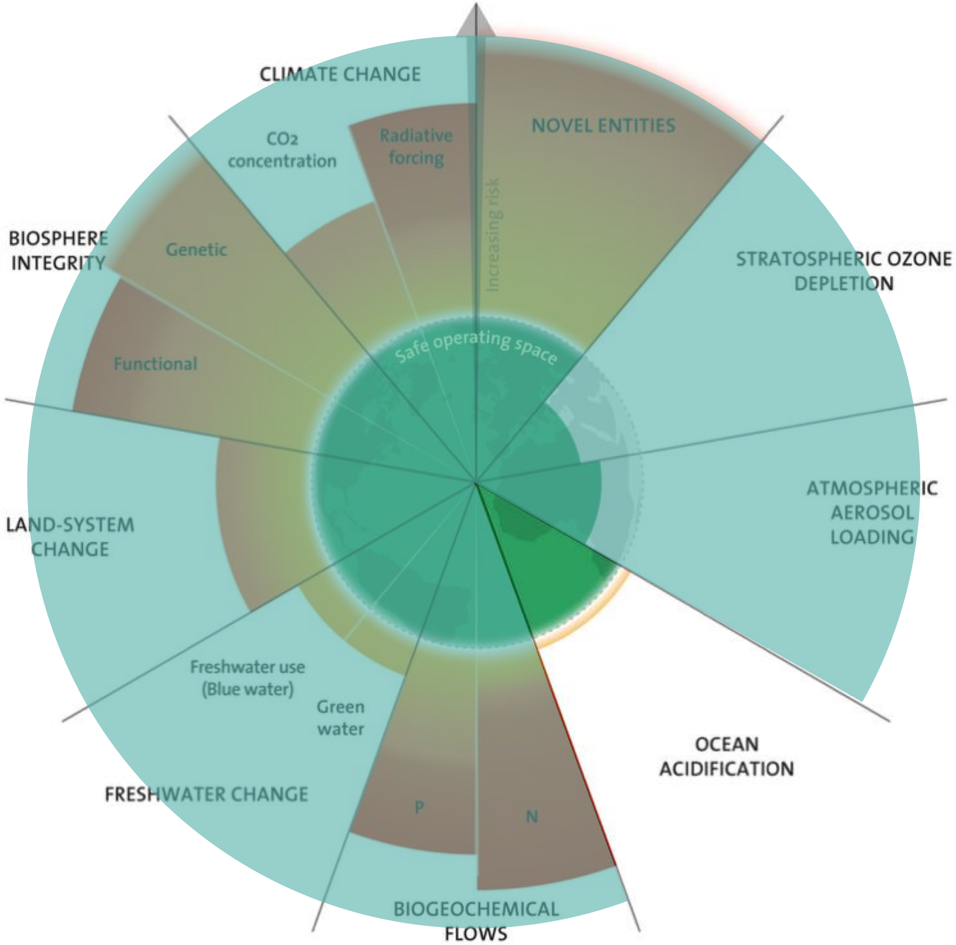
Current: **0,076**



Ocean acidification

Global average saturation rate of aragonite in surface water

Boundary: 2,75
Pre-industrial: 3,44
Current: **2,8**



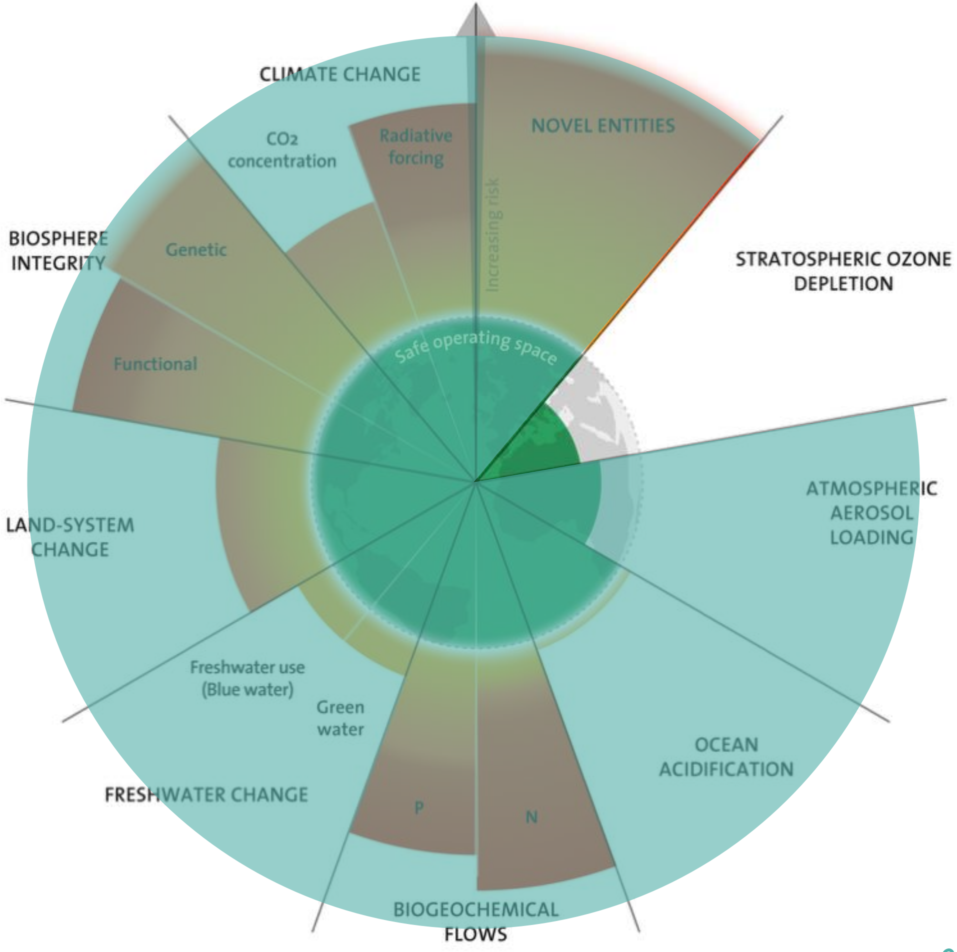
Stratospheric ozone depletion

Stratospheric ozone concentration (Dobson unit)

Boundary: 276

Pre-industrial: 290

Current: **284,6**



Doughnut Theory

Doughnut theory (Kate Raworth)

What **level of use of biophysical resources**

is associated with

satisfying **people's basic needs**

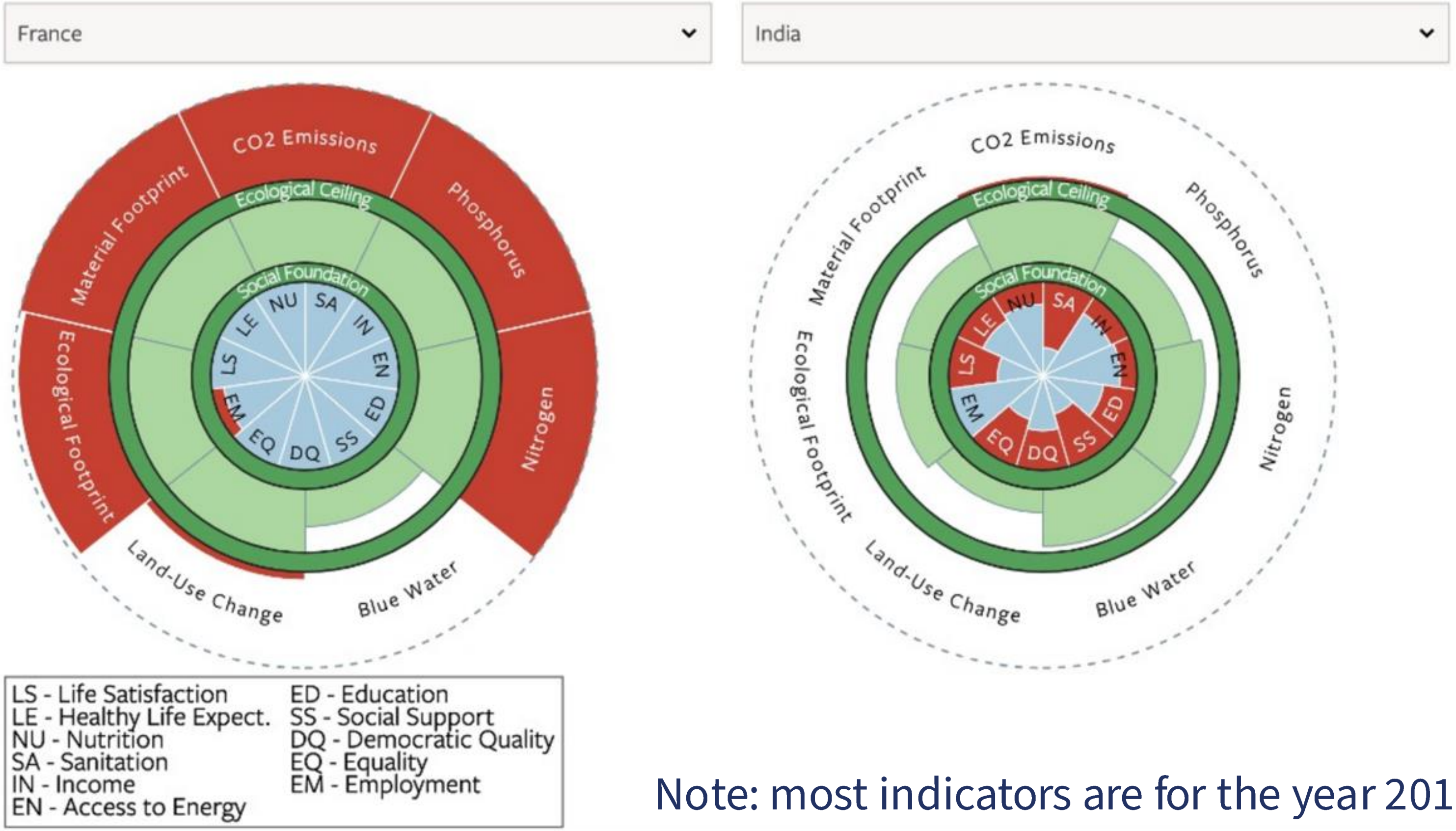
and can this level of resource use be extended to all populations

without exceeding the planet's critical limits?

SOURCE

A good life for all within planetary boundaries, O'Neill et al (2018)

Doughnut theory (Kate Raworth)

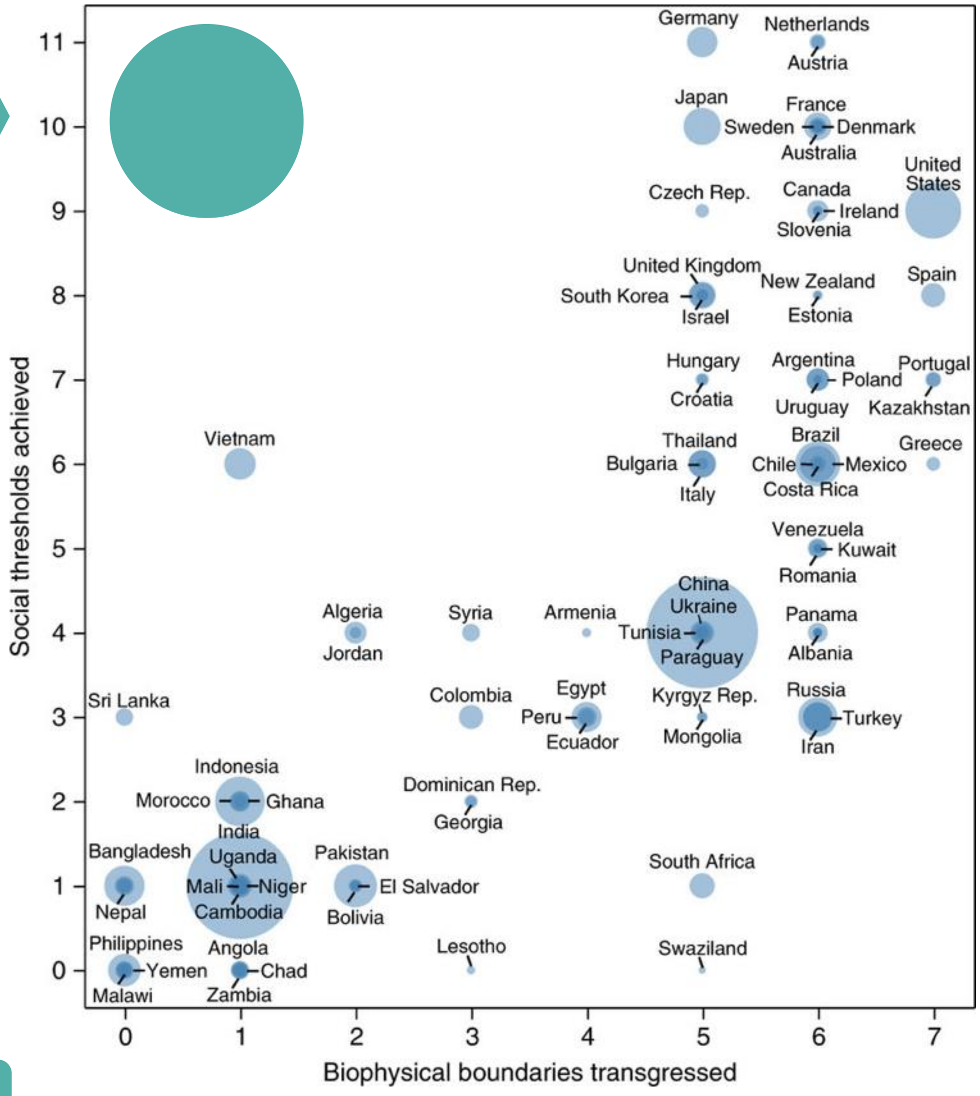


Note: most indicators are for the year 2011

SOURCE

A Good Life For All Within Planetary Boundaries

We're aiming for this area!



SOURCE

A Good Life For All Within Planetary Boundaries

DOUGHNUT ECONOMICS ACTION LAB

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Amsterdam City Doughnut

Downscaling the global concept of the Doughnut to turn it into a tool for transformative action in the City of Amsterdam

Posted by Amsterdam Donut Coalition & the DEAL Team July, 07, 2020 46 likes

Amsterdam, Noord-Holland, The Netherlands

Strategy for 100% circular development by 2050

SOURCE

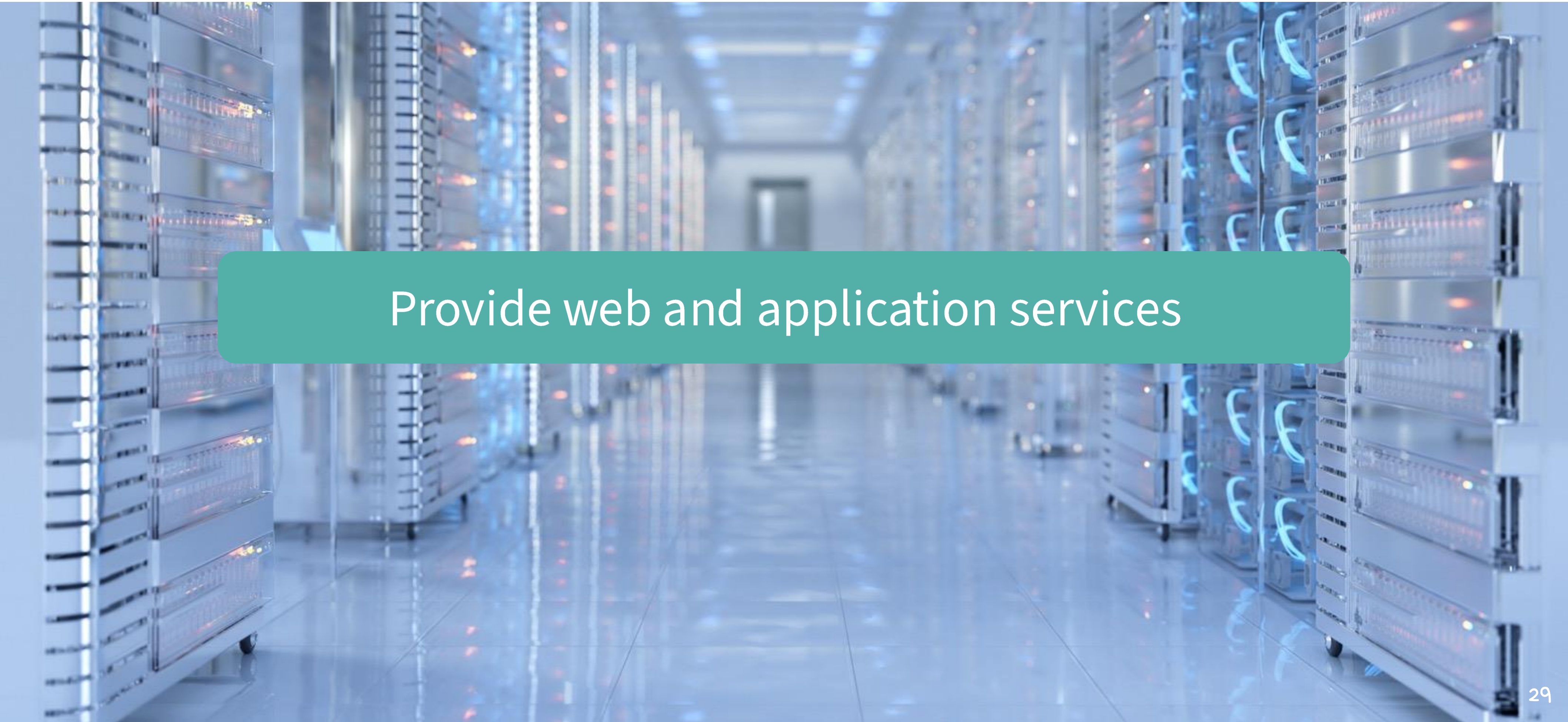
[Doughnut Economics Action Lab (DEAL)](#)

Digital technology and its footprint

User terminals

Computers	• Desktop PC, Laptop…
Smartphones	• iPhone, Samsung Galaxy, Google Pixel
Tablets & E-readers	• iPad, Samsung Tab, Microsoft Surface, Kindle, Kobo
Smartwatches	• Apple Watch, Garmin, Fitbit
AR/VR Headsets	• Meta Quest, Apple Vision Pro, Microsoft HoloLens
Gaming Consoles	• PlayStation, Xbox, Nintendo Switch
Smart TVs	• Android TV, Apple TV
Smart Speakers	• Amazon Echo, Google Home, Apple HomePod

Servers



Provide web and application services

Network equipment

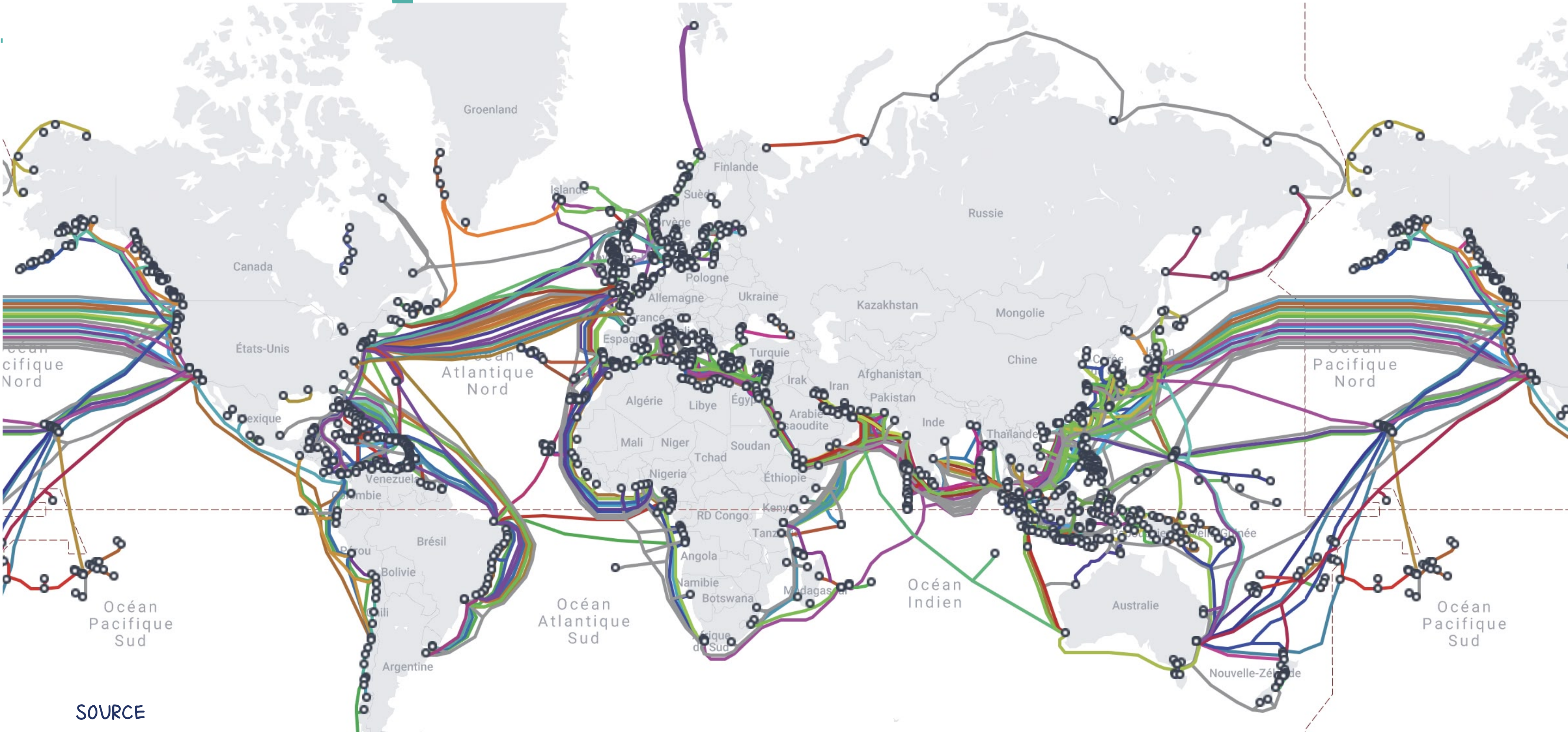
Routers & Switch

Antennas

Cables

Satellites

World map of submarine cables

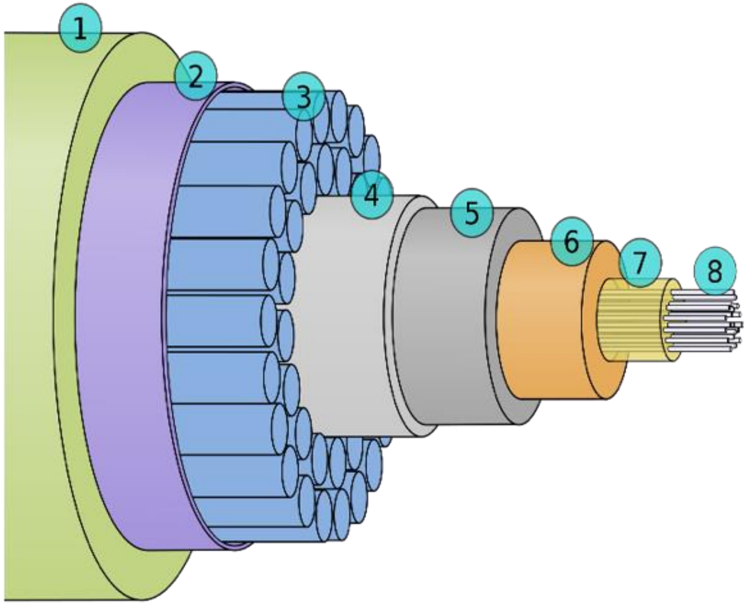


SOURCE

Image : Submarine Cable Map (site consulté en avril 2024)
Données : TeleGeography

1,400,000 kms of active cable

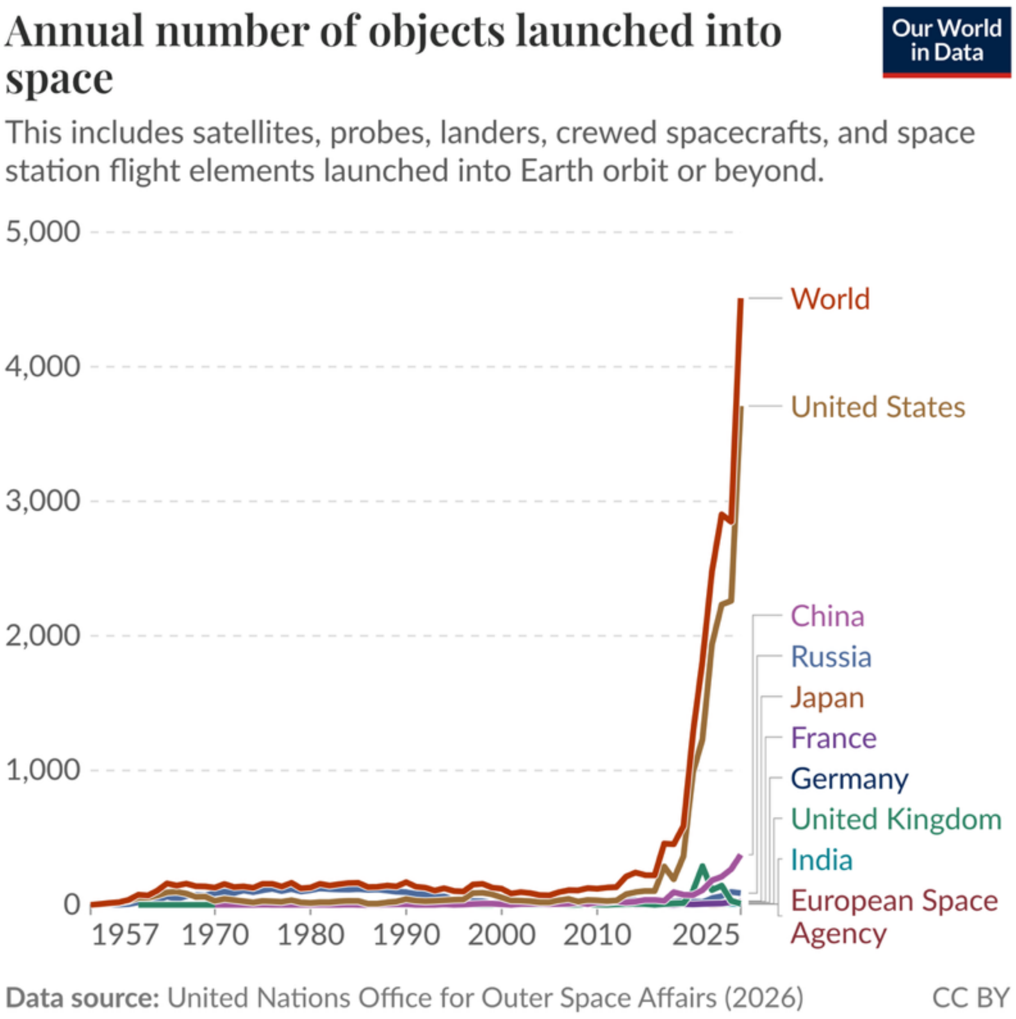
Composition of a submarine cable



1. Polyethylene
2. Mylar tape
3. Steel tensioners
4. Aluminium protection for waterproofing
5. Polycarbonate
6. Copper tube
7. Petroleum jelly
8. Optical fibers

SOURCE

Image : Wikipédia [consulté en avril 2024]



4,510 objects were launched into space in 2025

US agencies and companies were responsible 82% of the global total

The vast majority of these American launches consist of small satellites deployed as part of large commercial "constellations"

Connected devices / IoT

Smart Appliances	• Smart fridges, washing machines, thermostats
Industrial IoT	• Sensors, actuators
Automotive	• Telematics systems, electric vehicle charging stations
Shared Terminals	• ATMs, airport check-in, fast-food ordering
Tracking systems	• RFID, GPS
Medical Devices	• Patient monitoring devices
Office Equipment	• Printers and copiers

A few orders of magnitude (world)

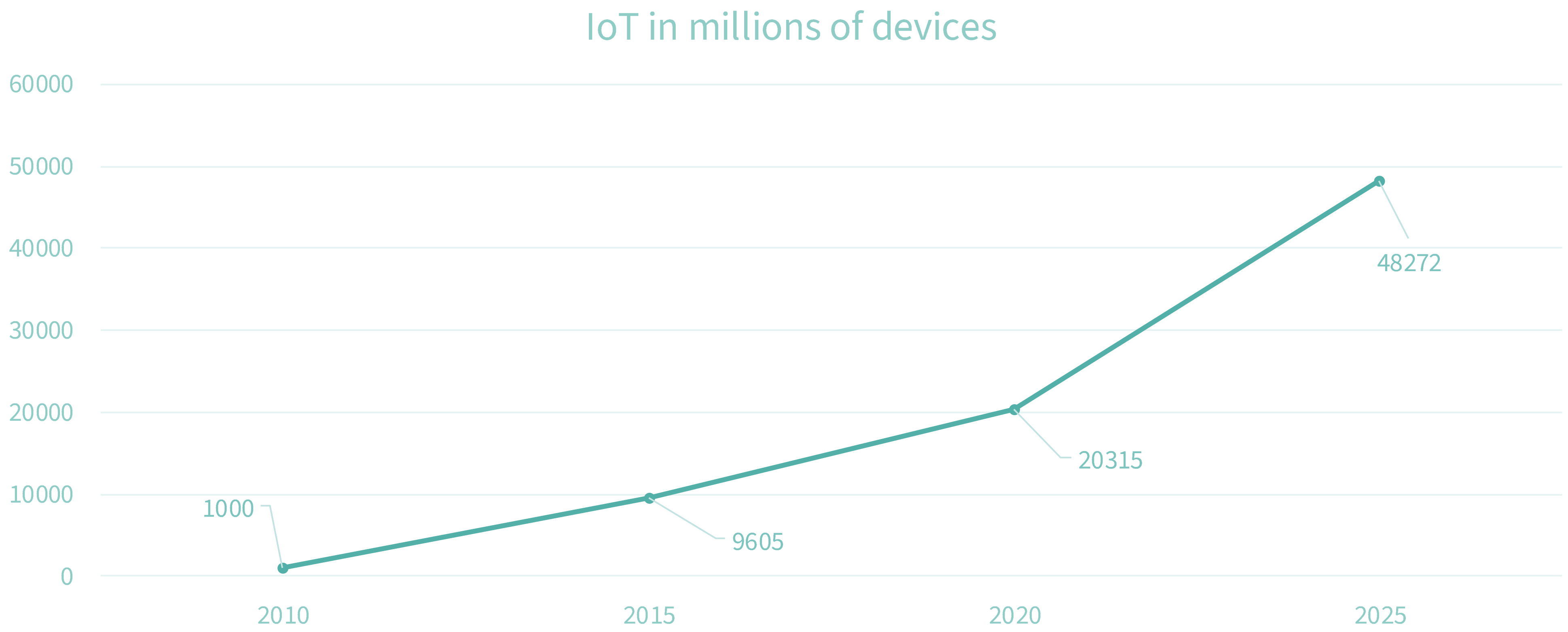
How many connected devices in 2025?

48,272 billion

SOURCE

Image : GreenIT.fr [consulté en avril 2025]

A few orders of magnitude (world)

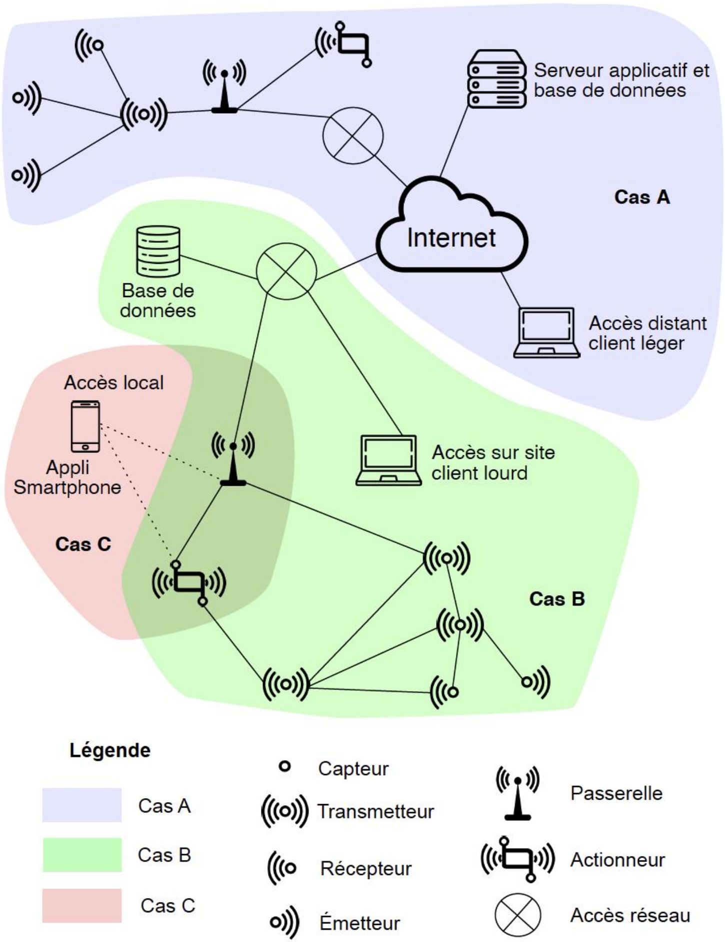


SOURCE

Image : GreenIT.fr [consulté en avril 2025]

Digital technology in industry

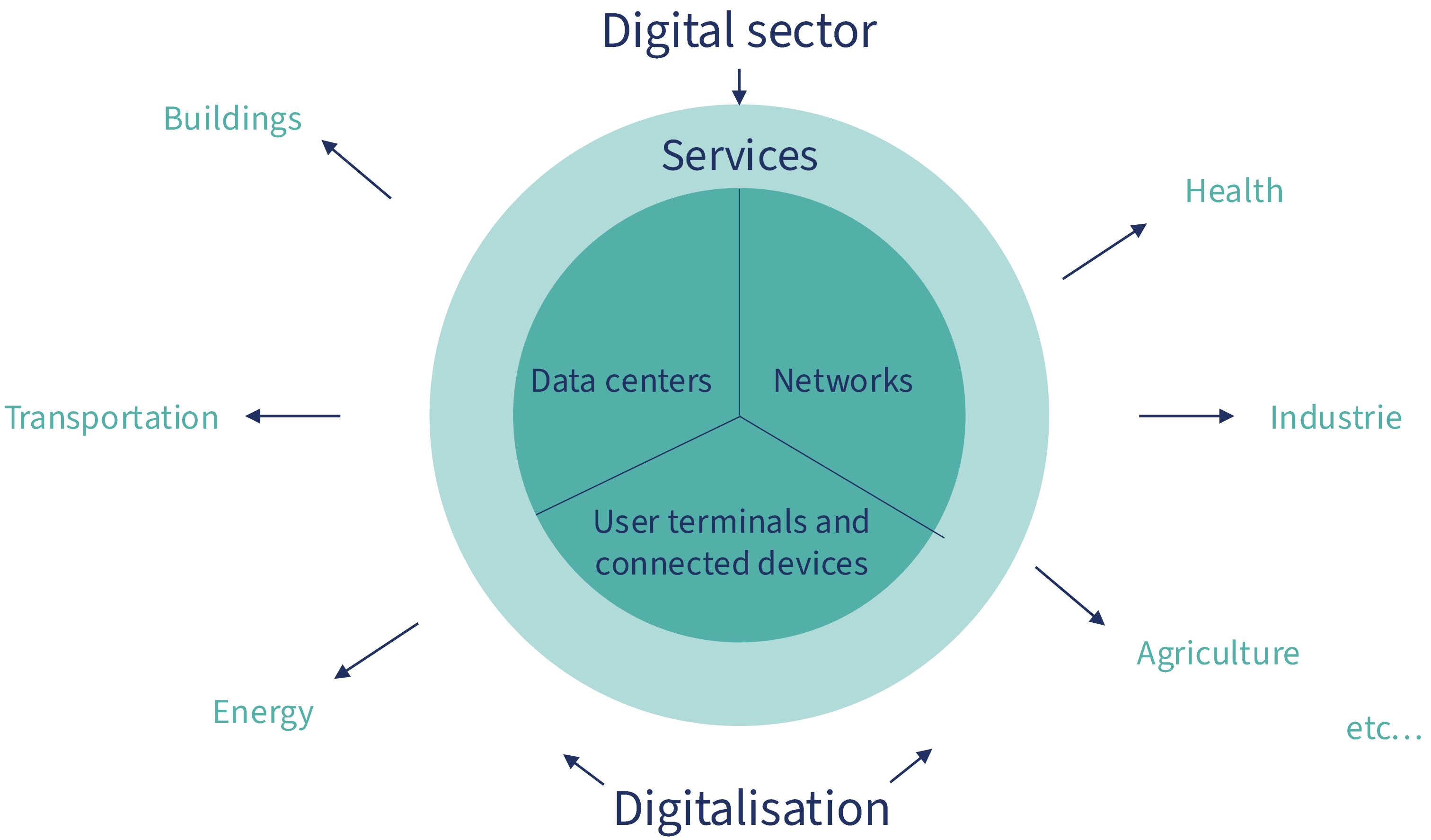
- Sensors (embedded systems)
- Industrial PCs
- PLCs
- User terminals
- Servers
- Infra network



SOURCE

Etude des compromis entre sécurité et disponibilité des systèmes embarqués communicants, 2020, Nicolas Burger

Defining digital technology



SOURCE

Est-ce que le secteur numérique existe ? (d'un point de vue environnemental), 2022, Gauthier Roussilhe [consulté en avril 2024]

L’atténuation du changement climatique sous contrainte de disponibilité des ressources minerales, 2025, Gaël Parpan

AI Impact – Data center usage

- Electricity used globally*: 165 TWh (2014) -> 420 TWh (2025)
- The acceleration is accelerating:
  - +7% per year over 2014-2019
  - +13% per year over 2019-2024

* excluding cryptocurrency

In current trends, data center global electricity consumption could reach 1500 TWh/year in 2030

SOURCE

Intelligence artificielle, données, calculs : quelles infrastructures dans un monde décarboné ?, Shift Project, 2025

The law is changing (loi n° 2021-1485 du 15/11/2021)

Goal

Reduce the environmental footprint of digital technology in France

- Make users aware of the environmental impact of digital technology
- Limit terminal replacement
- Encourage the emergence and development of ecologically virtuous uses of digital technology
- Promote data centers and networks that consume less energy
- Promote a responsible digital strategy in the regions

SOURCE

Légifrance [consulté en avril 2026]

Responsible design

Green In ICT*

Improving digital tools

Reduce impact

*ICT: Information and Communications Technology

Life Cycle Assessment (LCA)

- Comparisons of resource use, emissions, and waste across different products or services (functional unit)

- Standardized assessment method (ISO14040 and ISO14044)

- Multi-criteria environmental assessment
  - Ecological damage
  - Water footprint
  - Human toxicity
  - Resource depletion

LCA - Beginning of life

- Materials extraction
- Resource processing
- Assembly
- Supply chain

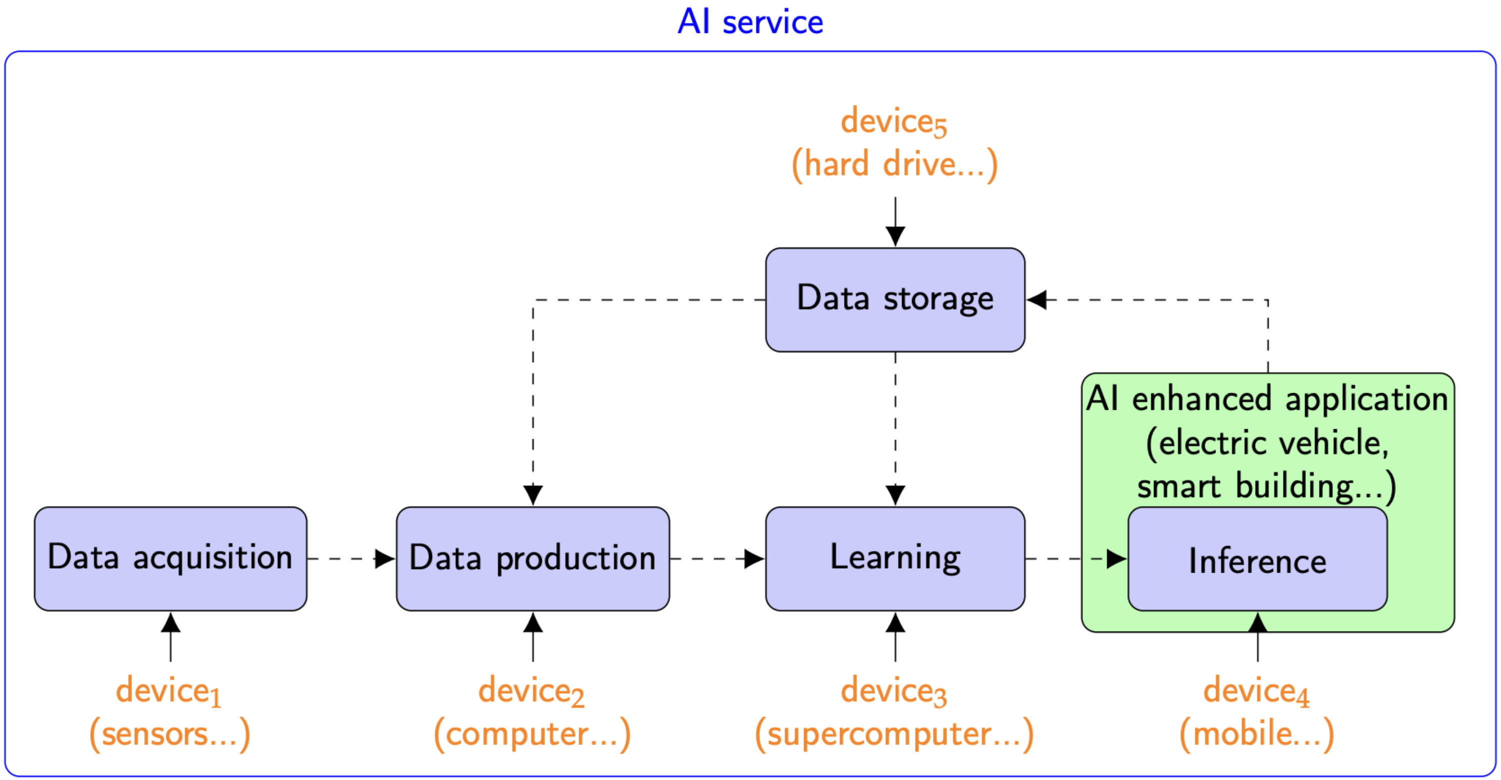
LCA – Middle of life

- Usage
- Repair
- Reuse

LCA - End of life

- Recycling
- Landfill
- Incineration

AI perimeter



SOURCE

Unraveling the Hidden Environmental Impacts of AI Solutions for Environment Life Cycle Assessment of AI Solutions, Anne-Laure Ligozat et al, 2022

Application sobriety – *Bundle**

Limit bundle size

Limit the number of bundles

Limit bundle generation resources
(compilation, download of dependencies...)

***Bundle**: Web application or final executable (scripts or binaries)

Application sobriety - Dependencies

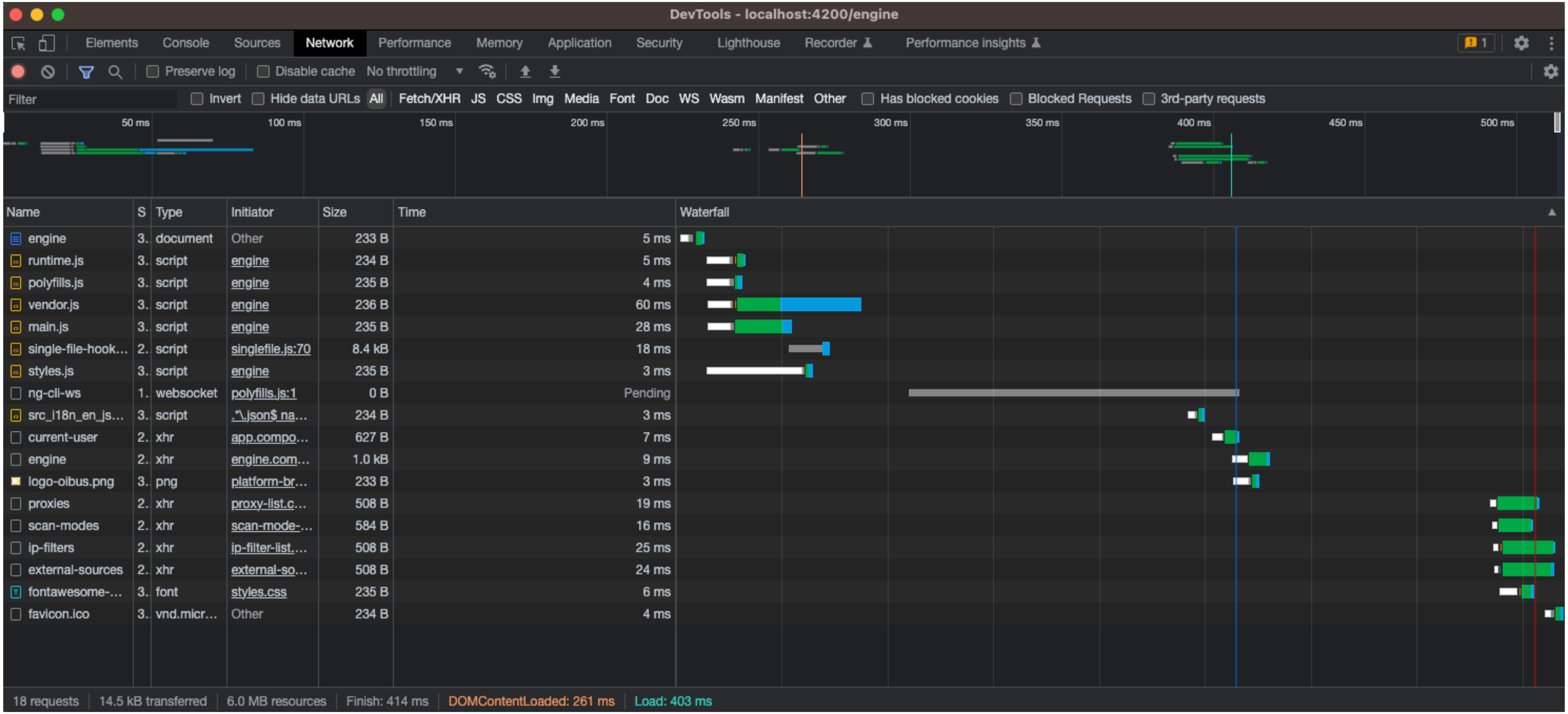
Library size

Maintainability

Security

Popularity

Application sobriety – HTTP requests



Application sobriety - Assets

Images

- Format
- Compression

Video

- Format / compression (720p, 1080p, 4K...)
- Gif instead of video?

Audio

- Compression (FLAC, MP3...)
- Bitrate (128 kbps, 192 kbps, 256 kbps...)

Filed

- Compression (*gz*, *zip*...)

Caching

Server side

- Avoid re-querying the database
- Allow another client to retrieve the same results
- How can I do this? RAM, Redis

Client side

- Avoid repeat requests (network load)
- How to use? Cookie (light client); file (heavy client)

Adapted databases

Time series

- InfluxDB, TimescaleDB

Geolocation data

- PostGIS

Relational data

- PostgreSQL, MSSQL, MySQL, SQLite

Assets (Images, video, audio)

- File systems, AWS S3, Azure Blob Storage

Data redundancy

- Database replication
  - Ensure service continuity in the event of an incident
  - Ensure disaster recovery

- Several adjustment variables
  - Delay between replications
  - Backup compression and storage

Shared servers

- Virtual machines
- Containers (Docker, LXC) and Volumes
- Managed databases (Mongo Atlas, Digital Ocean, AWS, Azure, OVH...)

Cold storage

- For which data?
  - Assets
  - Data replication (backup, archive)
  - Regulatory data (logs)

- What's in it for you?
  - Lower costs
  - More efficient compression
  - Longer storage life

Very cold storage

- Storage on disconnected media
- Very long-life media
  - CDS
  - Magnetic tapes
  - Paper archiving (several millennia)
- Exploratory: storage on DNA

Data archiving and obsolescence

- Resample data
  - Keep trends vs. all records

- Data filtering
  - Is it useful to keep all data? Ex: logs

- Expiration date
  - Keep data up to a regulatory limit

What about AI?

As a practitioner

- Reduce your I/O and redundant computation/data copying/storage
- Choose a low-carbon data center
- Avoid wasted resources by steering clear of grid search and by reusing or fine-tuning previously trained models
- Quantify and disclose your emissions

As an institution

- Deploy your computation in low-carbon regions
- Provide institutional tools for tracking emissions
- Cap computational usage
- Carry out awareness campaigns

SOURCE

Environmental Impact of Artificial Intelligence, Etienne Delort, Laura Riou, Anukriti Srivastava, *2023*

Green By ICT*

Using digital tools to support the ecological transition

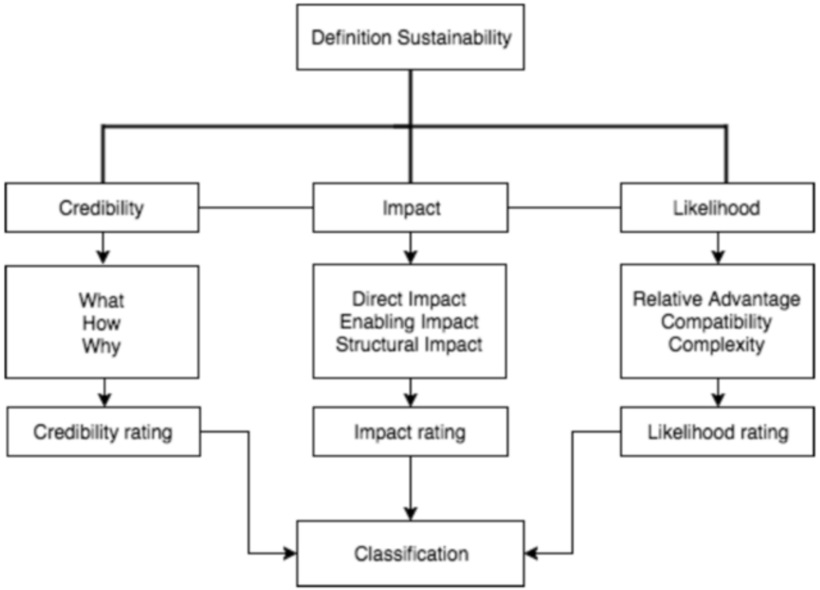
***ICT**: Information and Communications Technology

Optimizing and digitizing uses

- Use computing power to improve applications
  - Find process anomalies or improvements
  - Reduce material losses
  - Reduce waste discharge
  - Increase energy efficiency

- Other examples of digitization / usage optimization
  - Streaming platforms
  - E-readers
  - Email
  - Videoconferencing
  - …

Sustainable Computing Evaluation Framework

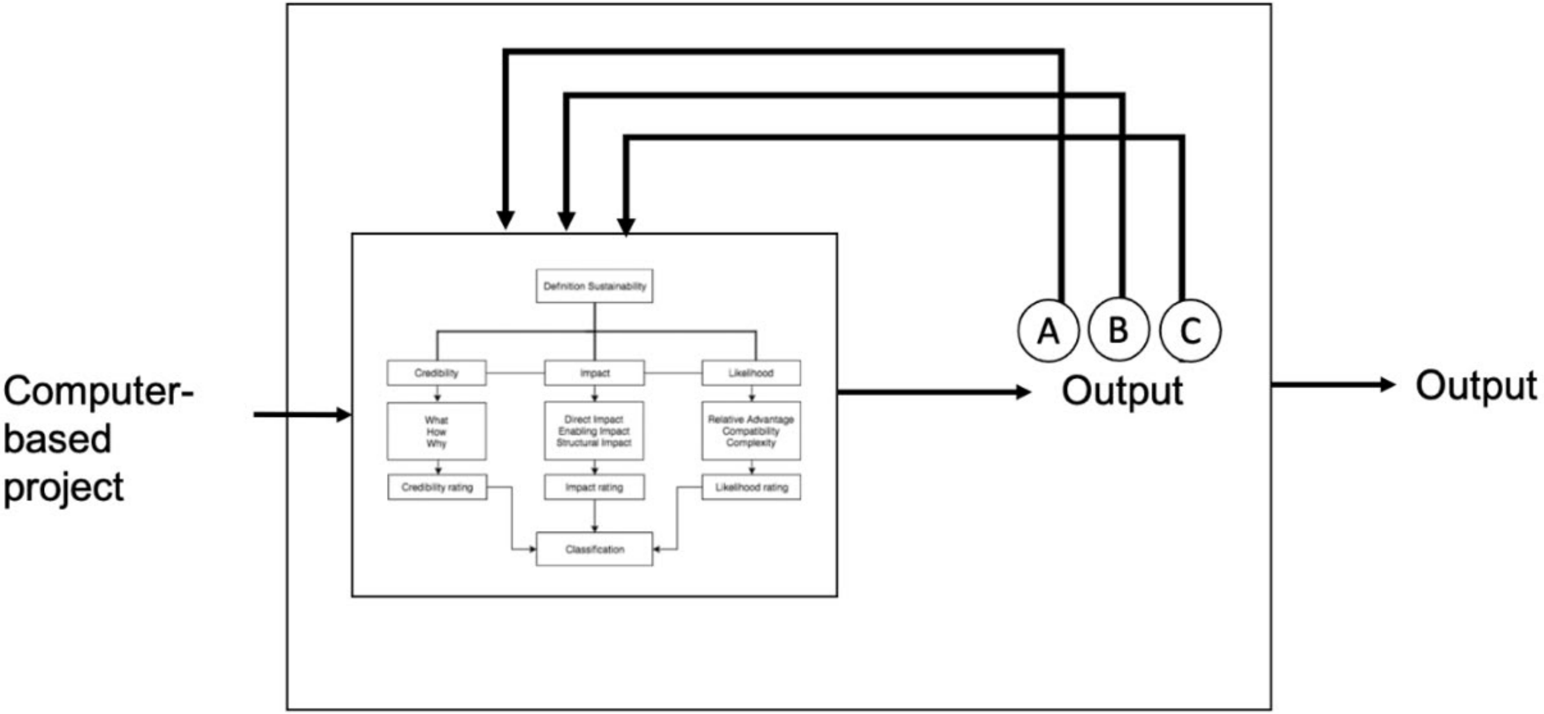


- Direct impacts:
  - Linked to LCA impacts
- Negative enabling impacts
  - Obsolescence
  - Induction (local rebound effects)
- Positive enabling impacts
  - Substitution
  - Optimization
- Negative structuring impacts
  - Rebound effects
  - Emerging risks
- Positive structuring impacts
  - Behavioral and cultural changes

SOURCE

Developing a Framework for Evaluating the Sustainability of Computing Projects, 2017, Anton Lundström et al
ICT for sustainability: an emerging research field, 2015, Lorenz Hilty and Bernard Aebischer

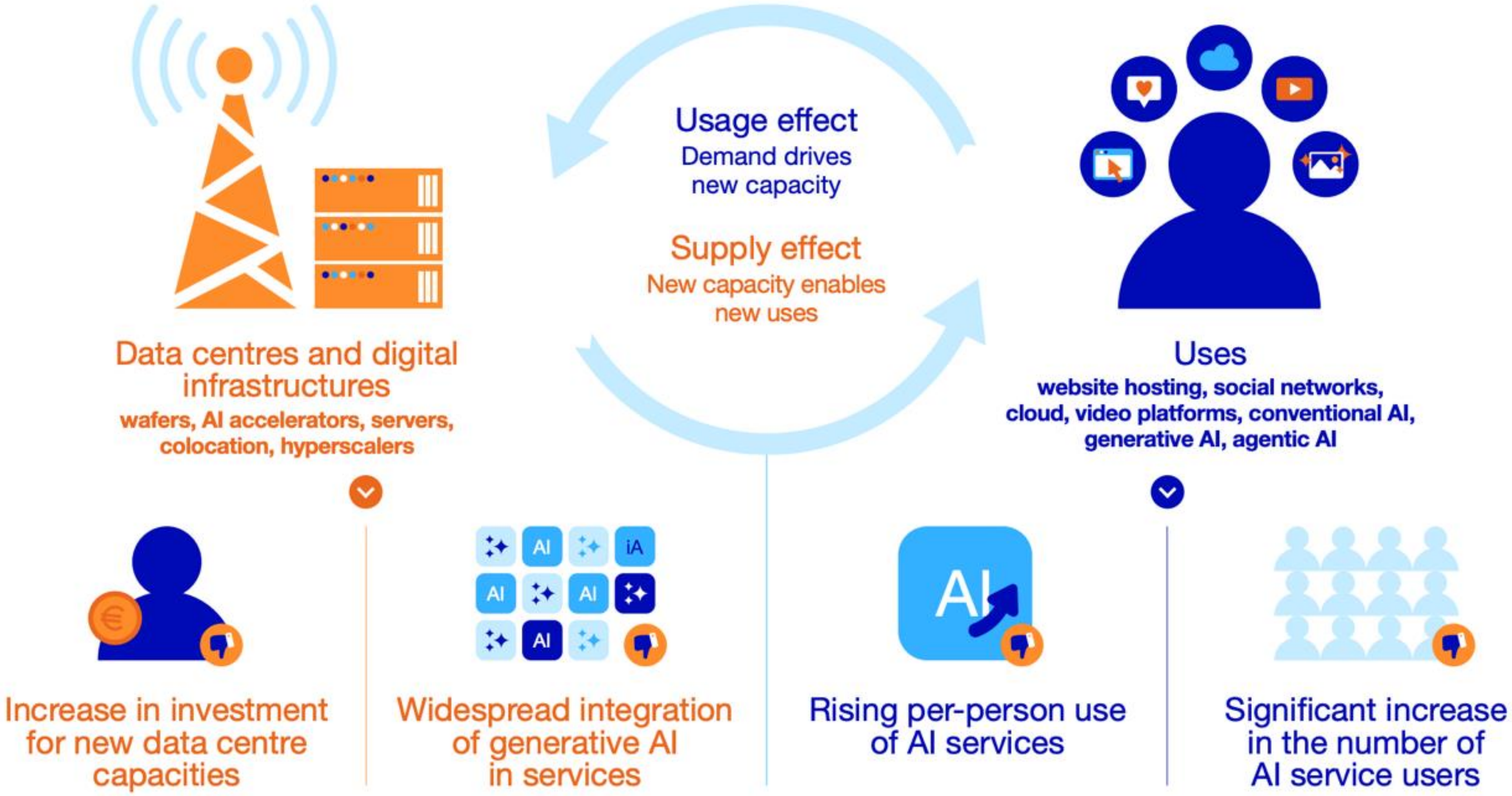
Sustainable Computing Evaluation Framework



SOURCE

Design of an interdisciplinary evaluation method for multi-scaled sustainability of computer-based projects. A work based on the Sustainable Computing Evaluation Framework, 2021, Lou Grimal et al

What about AI?



SOURCE

Intelligence artificielle, données, calculs : quelles infrastructures dans un monde décarboné ?, Shift Project, 2025

Rebound effects

Rebound effects

Energy or resource **savings**

initially anticipated by the use of a new technology

are partially or completely **compensated**

as a result of a **change in society's behavior**

Jevons' paradox

1. More efficient steam engine (James Watt)

2. More profitable coal

3. Widespread use

4. Increase in overall consumption

SOURCE

Sur la Question du Charbon, 1865, William Stanley Jevons

Rebound coefficient

Rebound coefficient	**Description**
R > 1	Backfire
R = 1	Total rebound
0 < R < 1	Partial rebound
R = 0	Zero rebound
R < 0	Super conservation

SOURCE

Exploring the limits for increasing energy efficiency in the residential sector of the European Union: Insights from the rebound effect, 2021, Baležentis et al.

Rebound effects on thermal insulation

Total rebound / backfire	Bulgaria, Czech Republic and Slovenia
Partial rebound	Austria, Croatia, Denmark, Estonia, France, Germany, Greece, Hungary, Latvia, Lithuania, Poland, Romania, Spain, Sweden and United Kingdom
Zero rebound / super-conservation	Belgium, Finland, Ireland, Luxembourg, Netherlands and Portugal

SOURCE

Exploring the limits for increasing energy efficiency in the residential sector of the European Union: Insights from the rebound effect, 2021, Baležentis et al.

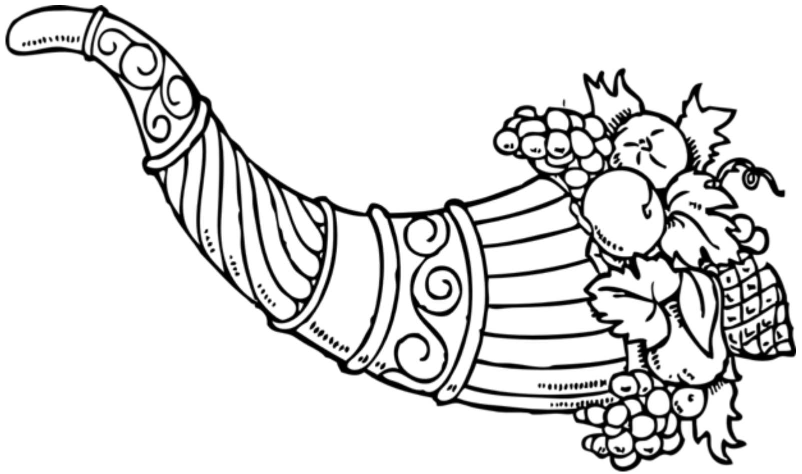
Mitigating the rebound effect

- Change management: education, communication, awareness-raising
- Measurement: supervision, data analysis
- Regulation and taxation: carbon tax, bans

Cornucopian paradigm

Cornucopian paradigm*

1. Personal
2. Variety
3. Instantaneous
4. Shareable
5. High quality
6. Pervasive
7. Continuous access
8. Eternal
9. Ephemeral
10. Cross-services and ubiquity



*From the Latin *cornu copiae* « horn of plenty »

SOURCE

Understanding and Mitigating the Effects of Device and Cloud Service Design Decisions on the Environmental Footprint of Digital Infrastructure, 2016, Chris Preist et al

Cornucopian paradigm (1/10)

Personal

Some services are necessarily personal, such as e-mail, but users increasingly expect **services traditionally shared** by groups of people (family TV, home audio system) **to be available on an individual basis**.

Cornucopian paradigm (2/10)

Variety

Users expect a **wide range of services** to be **available**.

Cornucopian paradigm (3/10)

Instantaneous

Users expect **immediate** service, with almost **no waiting**.

Cornucopian paradigm (4/10)

Shareable

Users want to create content that is **accessible to others** and **share it with them**.

Cornucopian paradigm (5/10)

High Quality

Users expect **ever-higher quality**, in the sense of audio, image and video resolution, and services respond by offering ever-higher **video resolution and sound quality**.

Cornucopian paradigm (6/10)

Pervasive

Users increasingly expect **every service** to be available **from any device**, seamlessly.

Cornucopian paradigm (7/10)

Continuous access

Users expect to be able to access services **anytime**, **anywhere**.

Cornucopian paradigm (8/10)

Eternal

Users expect **the content** they generate to be **always accessible and always available** (unless they decide otherwise) to themselves and to others.

Cornucopian paradigm (9/10)

Ephemeral

Users **create and save content** without worrying about whether they (or others) **will use it again**.

Cornucopian paradigm (10/10)

Cross-services and ubiquity

Users are increasingly looking for, and companies are encouraging, **a set of services** that **interact and support each other**, offering a richer overall experience.

Workshop / Discussion

1. Identify cornucopian paradigm on your practices / IT design
2. Offer a solution change the practice / design outside cornucopian paradigm

1. Personal
2. Variety
3. Instantaneous
4. Shareable
5. High quality
6. Pervasive
7. Continuous access
8. Eternal
9. Ephemeral
10. Cross-services and ubiquity

Time for discussion

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