Sustainability – history og theory

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Content

Sustainability – history og theory

The future

- Absolute sustainability
- Two utopic possibilities

Be serious

76 – slides

You can download slide show + my notes on:
https://molgard.com/sustainability/

Sustainability – history og theory

Three hundred years : 1700 – 2022

From philosophy to business

Philosophy – research – institutionalize - business

1713 – 1968 Sustainable history

Nachhaltigkeit

Hans Carl von Carlowitz

1713

Thomas Malthus

David Ricardo

An Essay on the Principle of Population

1798

Alexander von Humboldt

Views of Nature

1802

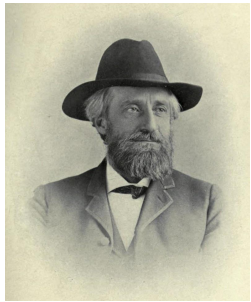
George Perkins Marsh

Man and Nature

1864

Nathaniel Southgate Shaler

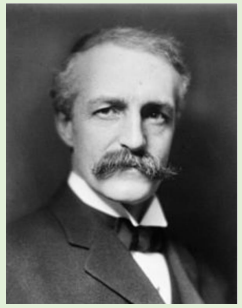
Nature and Man in America



1891

Gifford Pinchot

The Fight for Conservation



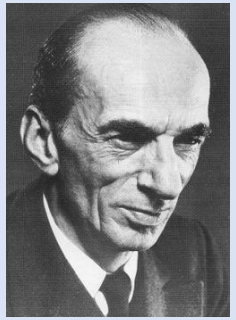
1910

William Vogt

Road to Survival

Henry Fairfield Osborn Jr.

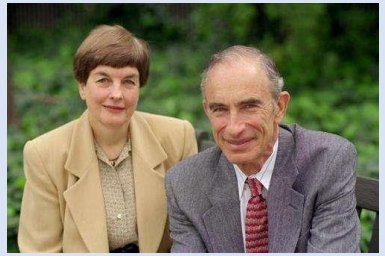
Our Plundered Planet



1948

Anne and Paul Ehrlich

The Population Bomb



1968

1713 – Forestry and mining

Nachhaltigkeit (restraint??)

Hans Carl von Carlowitz was a tax auditor, forester and managed mining operations.

Sylvicultura oeconomica oder haußwirthliche Nachricht und Naturmäßige Anweisung zur wilden Baum-Zucht, 1713

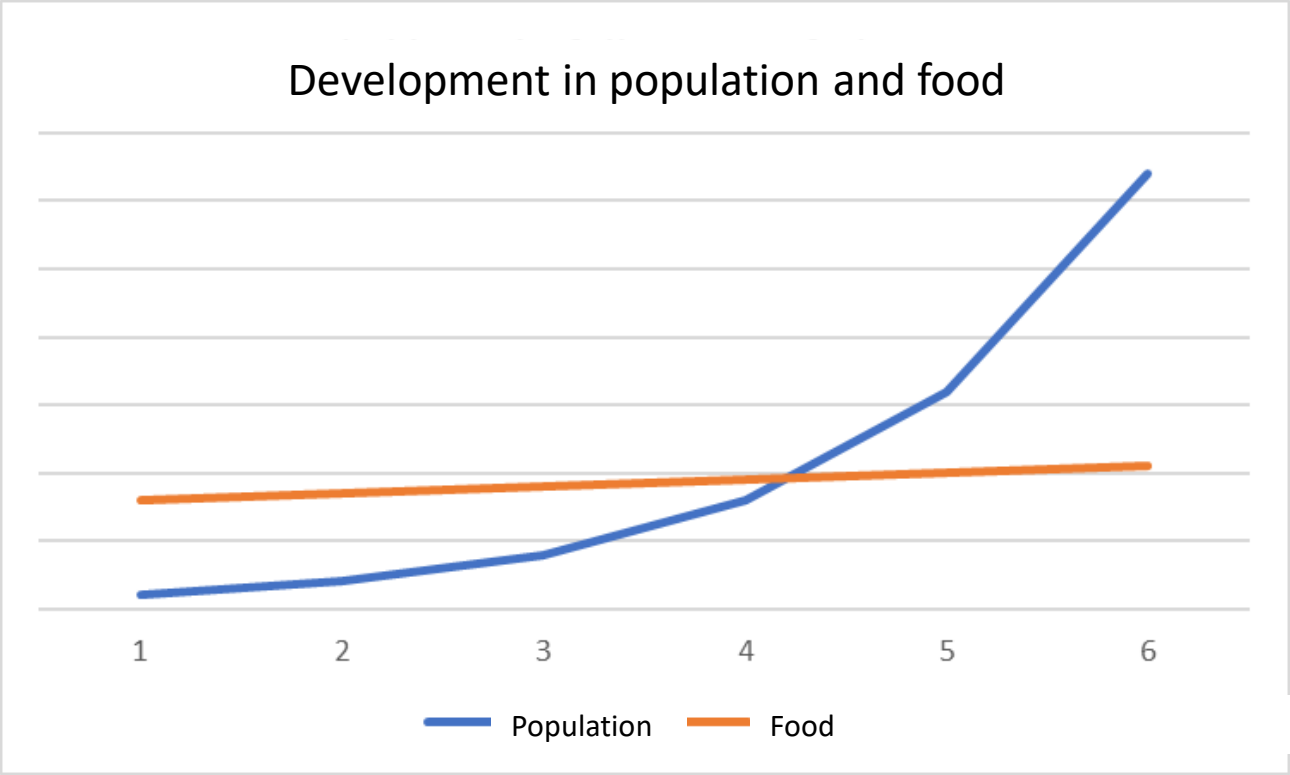
(… or Domestic Notice and Natural Instruction for Wild Tree Breeding…)


Mit Gott!
SYLVICVLTVRA OECONOMICA,
Oder
Haußwirthliche Nachricht und Naturmäßige
Anweisung
Zur
Wilden Baum-Zucht,
Nebst
Gründlicher Darstellung/
Wie zuförderst durch Göttliches Benedeyen dem allenthalben und insgemein einreissenden
Grossen Holtz-Mangel/
Vermittelst Säe-Pflantz- und Versetzung vielerhand Bäume zu prospiciren/
Alles zu nothdürftiger Versorgung des Hauß- Bau- Berg- und Schmelz-Wesens/
Worbey zugleich eine gründliche Nachricht von den in Churfl. Sächs. Landen
Gefundenen Torff
Dessen Natürliche Beschaffenheit/ grossen Nutzen/ Gebrauch und nützlichen Verkohlung.
Hannß Carl von Carlowitz/
Mit Königl. Pohl. und Churfl. Sächs. allergnädigsten PRIVILEGIO.
LEIPZIG/
verlegts Johann Friedrich Braun 1713.

1798 - Economists- Population growth

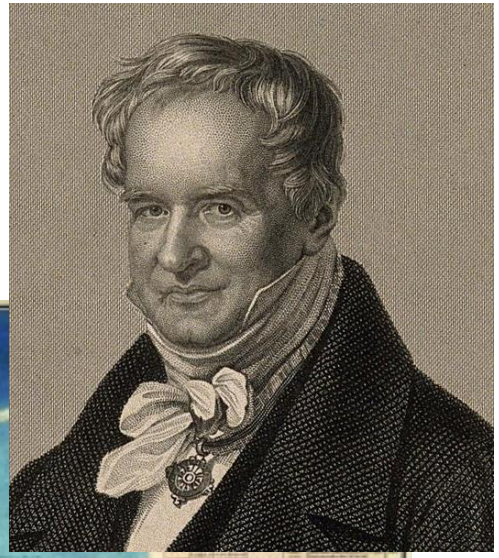
Thomas Malthus and David Ricardo

An Essay on the Principle of Population, 1798



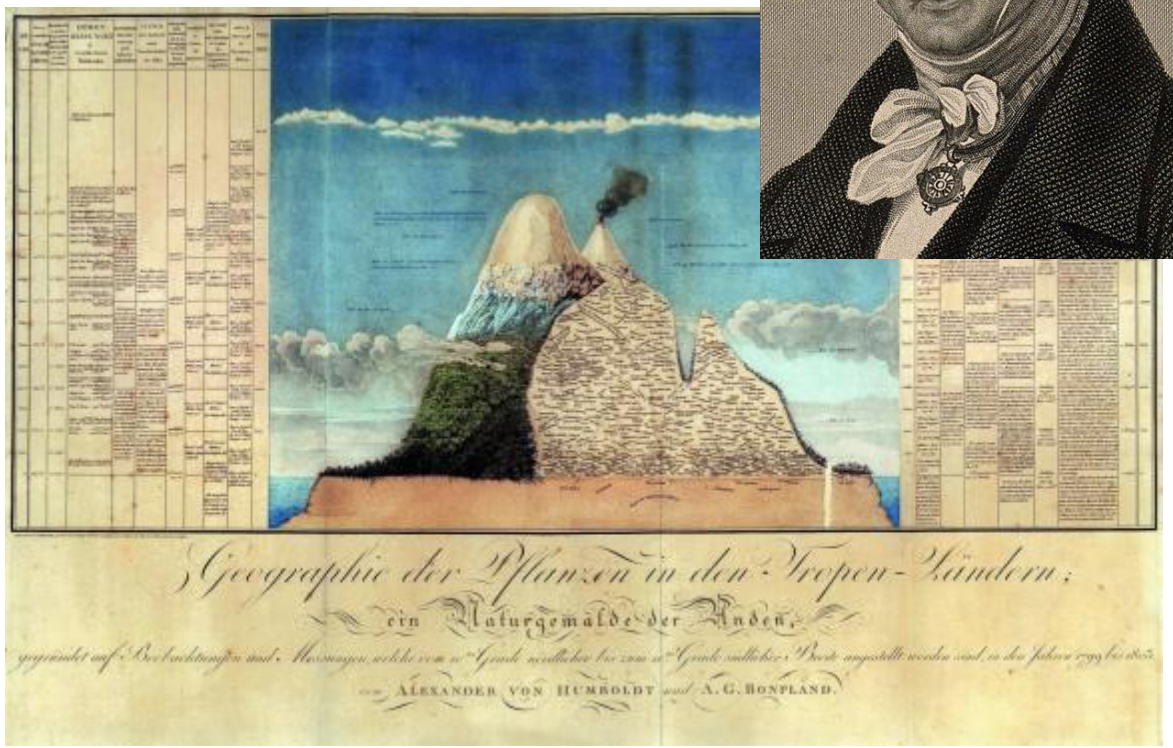
1802 – A German ”invent” the nature

Alexander von Humboldt, who by some is considered to be "inventor" of the nature, was a German scientist, explorer and, not least, a romantic.



Humboldt describes nature as a net where everything is connected, including humans.

He was supposed to have predicted climate change in the 19th century.



Views of Nature, 1808

1864 – American environmentalist

The philology George Perkins Marsh, who some consider to be America's first environmentalist.

Marsh believed that man created the earth (not as a god) - the first thoughts about the Anthropocene age.

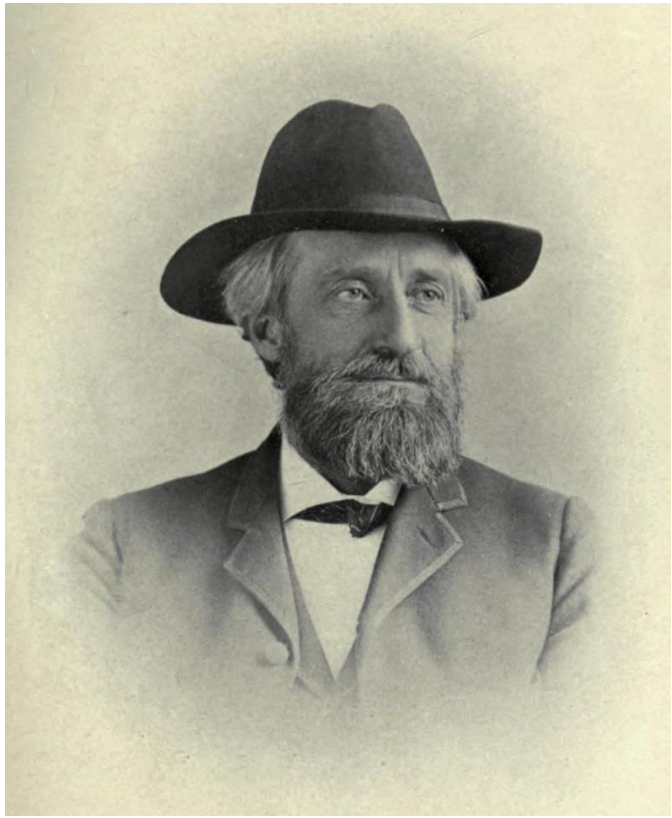
Man and Nature, 1864

1891 – American environmentalist

The paleontologist and geologist Nathaniel Southgate Shaler

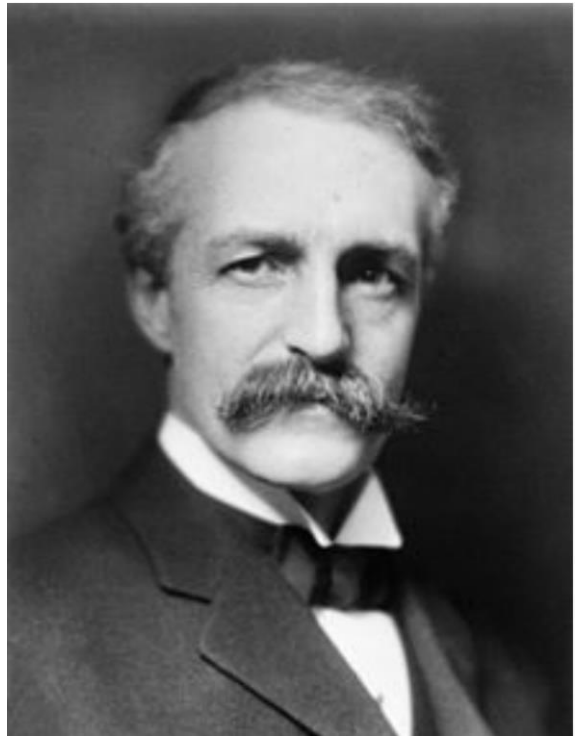
Flooded areas in the eastern part of United States and dry areas in the western part of United States led to thoughts about human influence on the earth.

Nature and Man in America, 1891.



1910 – Sustainability defined for the first time

Gifford Pinchot – American Forester and politician



The central thing for which Conservation stands is to make this country the best possible place to live in, both for us and for our descendants.

The Fight for Conservation, 1910.

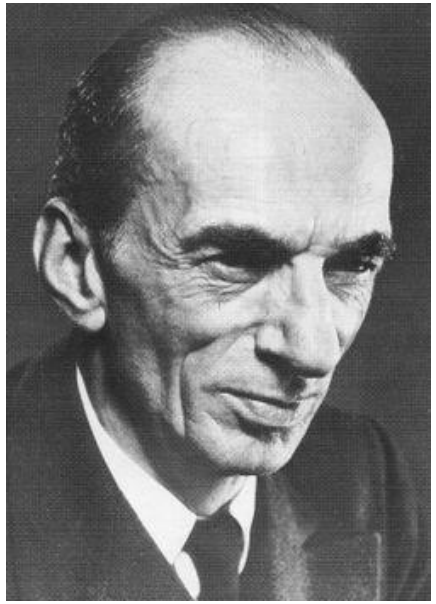
1948 – Population growth

The ecologist and zoologist William Vogt, who was director of the Planned Parenthood association

Road to Survival, 1948

The conservationist Henry Fairfield Osborn Jr.

Our Plundered Planet, 1948



Both Vogt and Osborn believed that the size of the population should stay within a sustainable size and that the problems could not be solved with technological solutions.

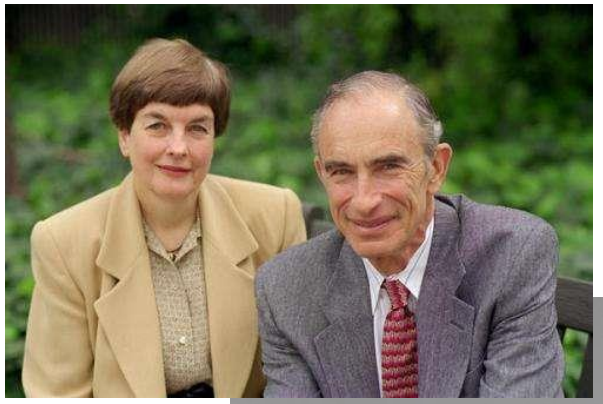
1968 – Population growth

Anne and Paul Ehrlich, Stanford professor

The Population Bomb, 1968

1971 – The IPAT model

Paul Ehrlich, John Holdren og Barry Commoner agree on the IPAT formula:



$$I = P \cdot A \cdot T$$

I: Environmental impact

P: Size of population

A: Affluence (consumption)

T: Technology

1972 – Club of Rome

D.H. Meadows, D.L. Meadows, J. Randers, og W. W. Behrens III from MIT model **World3** (dynamic system analysis)

The Limits to Growth, 1972

$$\mathbf{I = P \cdot A \cdot T}$$

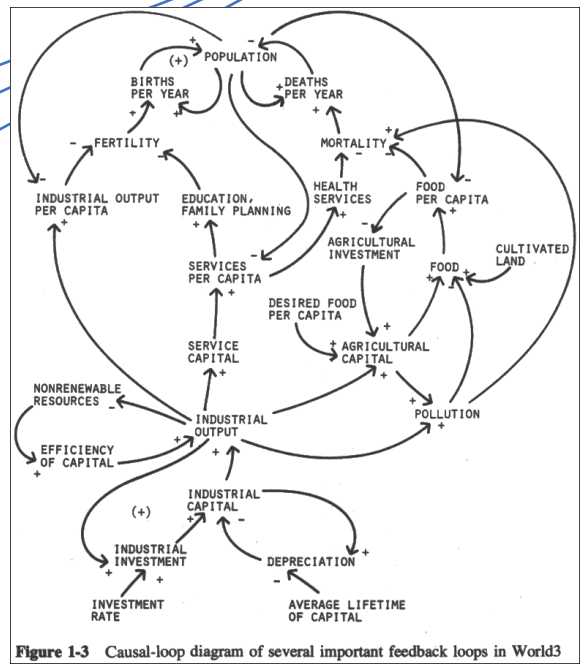
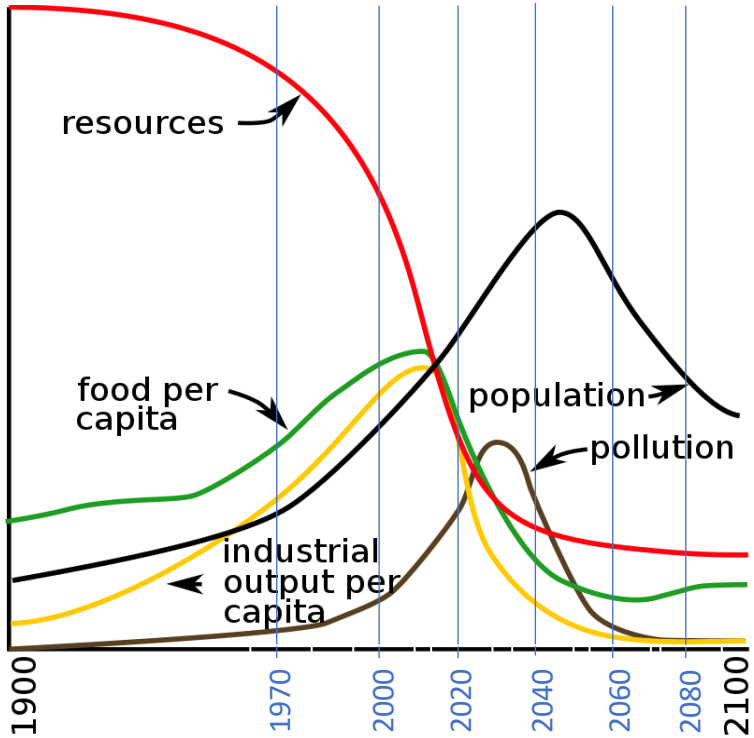


Figure 1-3 Causal-loop diagram of several important feedback loops in World3



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1972 - UN Stockholm Conference

Aren't poverty and need the most important pollutions? How can we talk to villagers and slum-dwellers of the need to protect the air, the ocean and rivers when their own life is contaminated?

The environment cannot be improved in conditions of poverty.

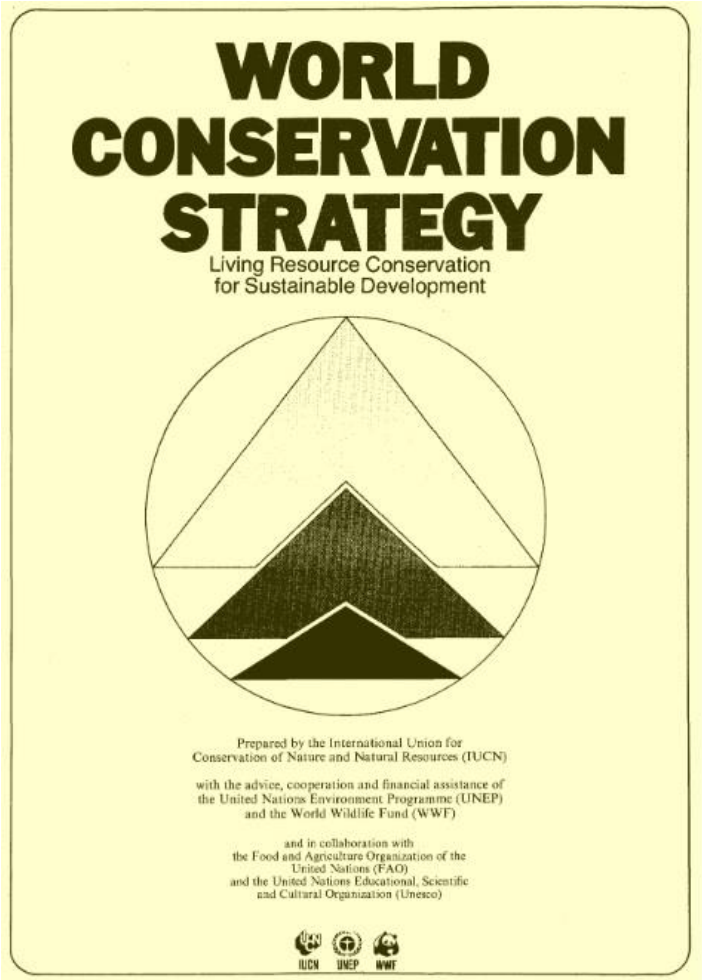
Indira Gandhi

1980 World Conversation Strategy

World Conservation Union, FN og WWF

For the first time in a written report, we come across sustainable development, the purpose of which is to promote social and economic welfare.

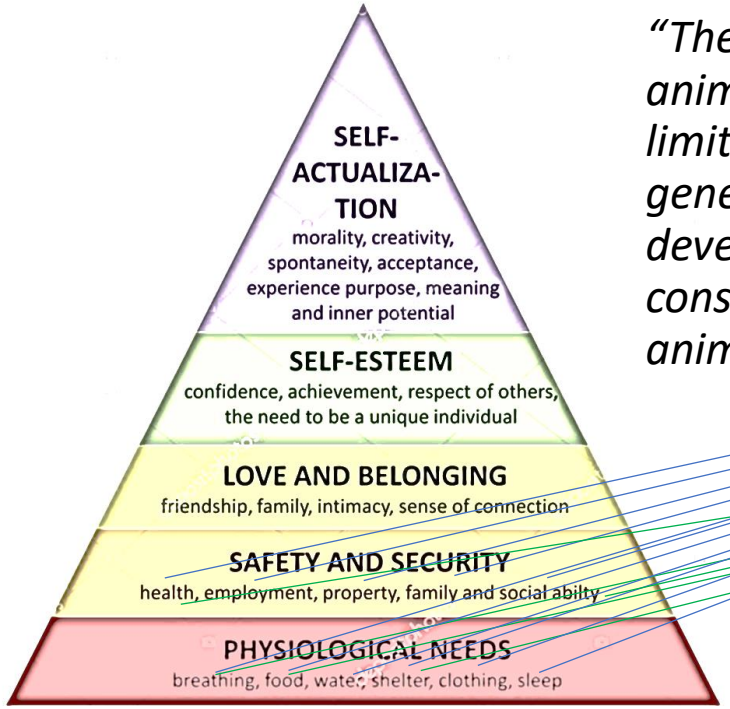
Human beings, in their quest for economic development and enjoyment of the riches of nature, must come to terms with the reality of resource limitation· and the carrying capacities of ecosystems, and must take account of the needs of future generations.



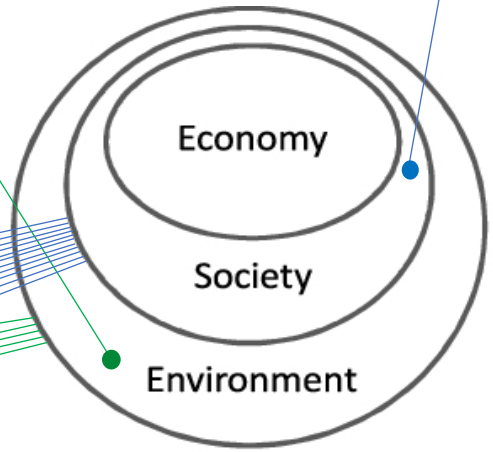
1987 – Brundtland Report and the 3 pillars

" Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

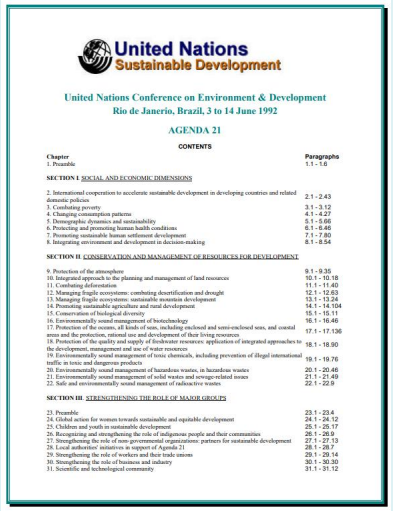
Our Common Future, 1987



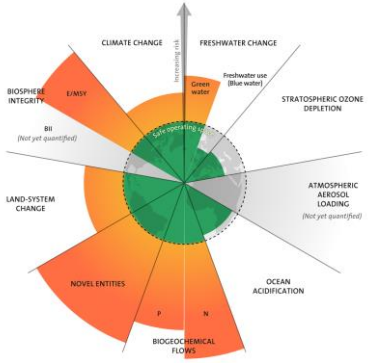
"The loss of plant and animal species can greatly limit the options of future generations; so sustainable development requires the conservation of plant and animal species."



1992 – 2022 - Sustainable history



ISO 14001

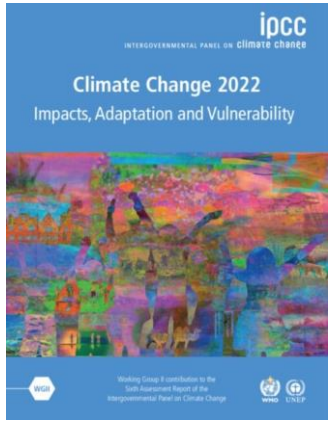


Certified B Corporation

EU Taxonomy Regulations

E S G
ENVIRONMENT SOCIAL GOVERNANCE

EAT



cradletocradle

Future-Fit Business

GREENHOUSE GAS PROTOCOL

SCIENCE BASED TARGETS
DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

DTU CENTRE FOR ABSOLUTE SUSTAINABILITY

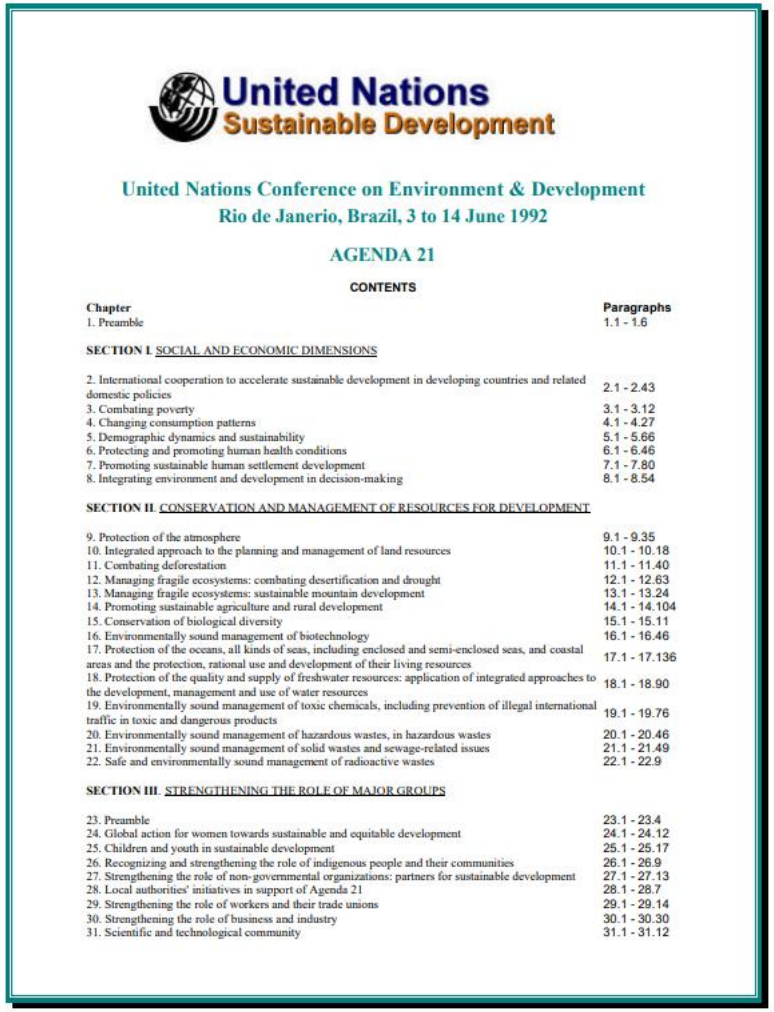
1992 1995 1996 2000 2002 2009 2010 2015 2016 2017 2018 2020 2022

1992 - Rio Conference - Agenda 21

Agenda 21 a non-binding action plan for sustainable development.

300 pages in which it is described how sustainable development can be obtained in the det 21st century.

The report is very technical and did not appeal to ordinary people.



United Nations
Sustainable Development

United Nations Conference on Environment & Development
Rio de Janerio, Brazil, 3 to 14 June 1992

AGENDA 21

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4. Changing consumption patterns	4.1 - 4.27
5. Demographic dynamics and sustainability	5.1 - 5.66
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7. Promoting sustainable human settlement development	7.1 - 7.80
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30. Strengthening the role of business and industry	30.1 - 30.30
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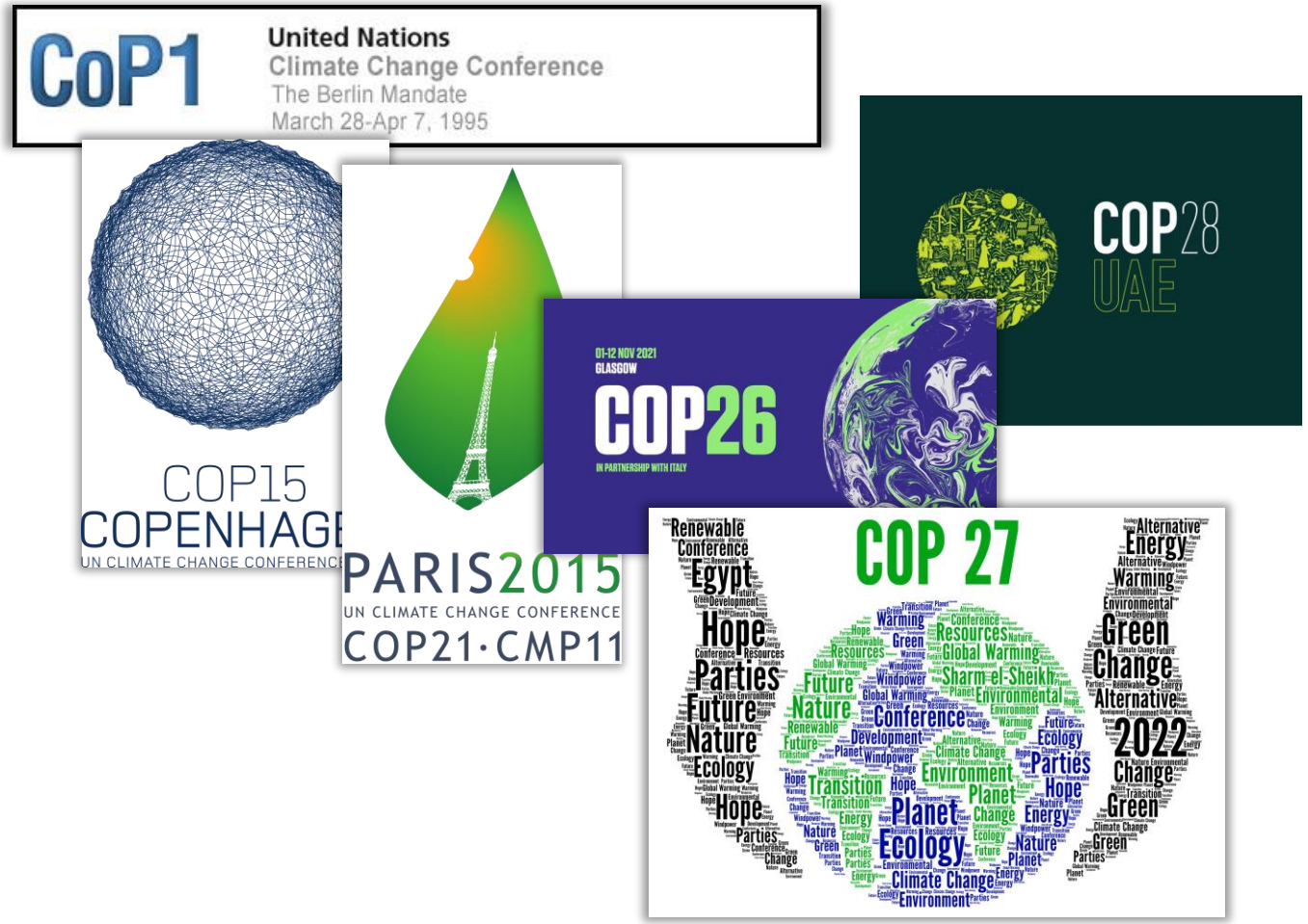
1995 – 2023 – COPxx

The United Nations Climate Change Conferences.

The conferences serve as the formal meeting of the UNFCCC parties (Conference of the Parties, COP) to assess progress in dealing with climate change.

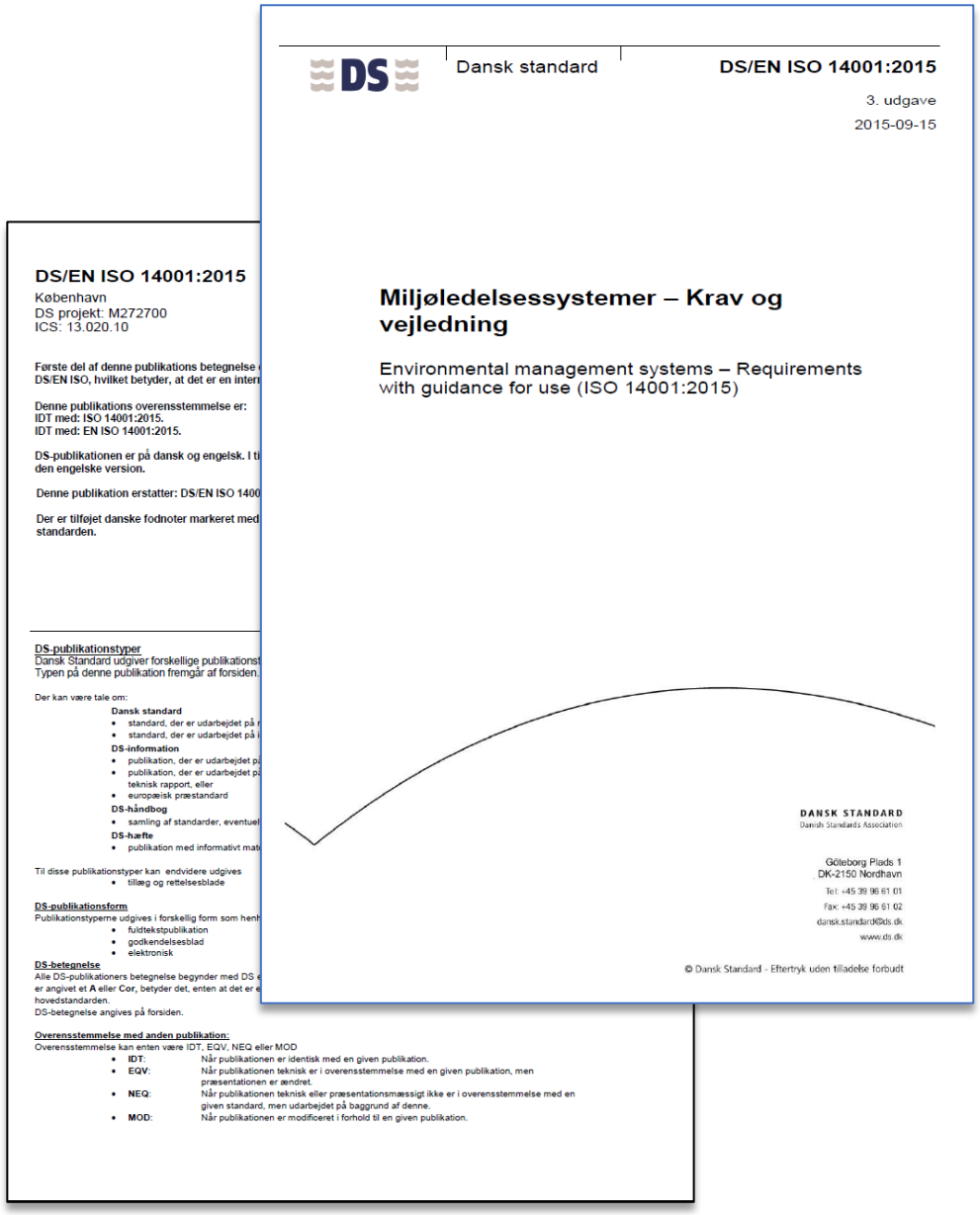


1996 – ISO 14001

Standard for environmental management system

No environmental requirements, only regulatory requirements.

Requirements for documentation



DS/EN ISO 14001:2015
København
DS projekt: M272700
ICS: 13.020.10

Første del af denne publikations betegnelse
DS/EN ISO, hvilket betyder, at det er en intern

Denne publikations overensstemmelse er:
IDT med: ISO 14001:2015.
IDT med: EN ISO 14001:2015.

DS-publikationen er på dansk og engelsk. I ti
den engelske version.

Denne publikation erstatter: DS/EN ISO 1400

Der er tilføjet danske fodnoter markeret med
standarden.

DS-publikationstyper
Dansk Standard udgiver forskellige publikationst
Typen på denne publikation fremgår af forsiden.

Der kan være tale om:

Dansk standard
- standard, der er udarbejdet på
- standard, der er udarbejdet på

DS-information
- publikation, der er udarbejdet p
- publikation, der er udarbejdet p teknisk rapport, eller
- europæisk præstandard

DS-håndbog
- samling af standarder, eventuel

DS-hæfte
- publikation med informativt mat

Til disse publikationstyper kan endvidere udgives
- tillæg og rettelsesblade

DS-publikationsform
Publikationstyperne udgives i forskellig form som henh
- fuldtekstpublikation
- godkendelsesblad
- elektronisk

DS-betegnelse
Alle DS-publikationers betegnelse begynder med DS
er angivet et **A** eller **Cor**, betyder det, enten at det er
hovedstandarden.
DS-betegnelse angives på forsiden.

Overensstemmelse med anden publikation:
Overensstemmelse kan enten være IDT, EQV, NEQ eller MOD
- **IDT**: Når publikationen er identisk med en given publikation.
- **EQV**: Når publikationen teknisk er i overensstemmelse med en given publikation, men præsentationen er ændret.
- **NEQ**: Når publikationen teknisk eller præsentationsmæssigt ikke er i overensstemmelse med en given standard, men udarbejdet på baggrund af denne.
- **MOD**: Når publikationen er modificeret i forhold til en given publikation.

DS Dansk standard DS/EN ISO 14001:2015
3. udgave
2015-09-15

Miljøledelsessystemer – Krav og vejledning

Environmental management systems – Requirements with guidance for use (ISO 14001:2015)

DANSK STANDARD
Danish Standards Association

Göteborg Plads 1
DK-2150 Nordhavn
Tel: +45 39 96 61 01
Fax: +45 39 96 61 02
dansk.standard@ds.dk
www.ds.dk

2000 - UN 2015 goals

2001 – Greenhouse Gas Protocol

GREENHOUSE GAS PROTOCOL

GHG Protocol establishes comprehensive global standardized frameworks to measure and manage GHG emissions from private and public sector operations, value chains and mitigation actions.

GREENHOUSE GAS PROTOCOL

Global Warming Potential Values

The following table includes the 100-year time horizon global warming potentials (GWP) relative to CO_2. This table is adapted from the IPCC Fifth Assessment Report, 2014 (AR5)[i]. The AR5 values are the most recent, but the second assessment report (1995) and fourth assessment report (2007) values are also listed because they are sometimes used for inventory and reporting purposes. For more information, please see the IPCC website (www.ipcc.ch). The use of the latest (AR5) values is recommended. Please note that the GWP values provided here from the AR5 for non-CO_2 gases do not include climate-carbon feedbacks.

Global warming potential (GWP) values relative to CO_2

Industrial designation or common name	Chemical formula	GWP values for 100-year time horizon		
		Second Assessment Report (SAR)	Fourth Assessment Report (AR4)	Fifth Assessment Report (AR5)
Carbon dioxide	CO_2	1	1	1
Methane	CH_4	21	25	28
Nitrous oxide	N_2O	310	298	265
Substances controlled by the Montreal Protocol				
CFC-11	CCl_3F	3,800	4,750	4,660
CFC-12	CCl_2F_2	8,100	10,900	10,200

2002 - Cradle to Cradle

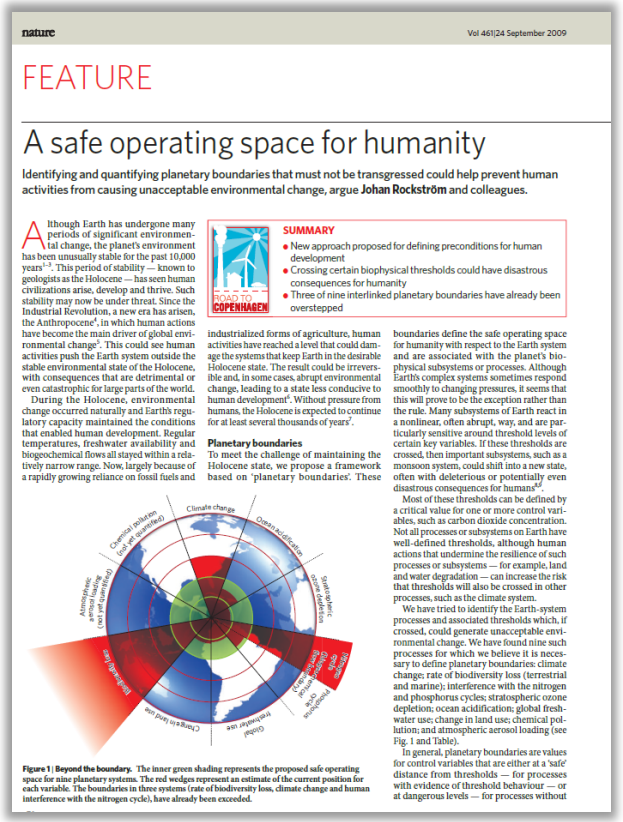
The German chemist Michael Braungart and the American architect William McDonough establish Cradle to Cradle

cradletocradle

2009 Planetary boundaries

Johan Rockstrøm, et al.,

Stockholm Resilience Centre



nature Vol 461|24 September 2009

FEATURE

A safe operating space for humanity

Identifying and quantifying planetary boundaries that must not be transgressed could help prevent human activities from causing unacceptable environmental change, argue Johan Rockström and colleagues.

ROAD TO COPENHAGEN

SUMMARY

- New approach proposed for defining preconditions for human development
- Crossing certain biophysical thresholds could have disastrous consequences for humanity
- Three of nine interlinked planetary boundaries have already been overstepped

Although Earth has undergone many periods of significant environmental change, the planet's environment has been unusually stable for the past 10,000 years[1–3]. This period of stability — known to geologists as the Holocene — has seen human civilizations arise, develop and thrive. Such stability may now be under threat. Since the Industrial Revolution, a new era has arisen, the Anthropocene[4], in which human actions have become the main driver of global environmental change[5]. This could see human activities push the Earth system outside the stable environmental state of the Holocene, with consequences that are detrimental or even catastrophic for large parts of the world.

During the Holocene, environmental change occurred naturally and Earth's regulatory capacity maintained the conditions that enabled human development. Regular temperatures, freshwater availability and biogeochemical flows all stayed within a relatively narrow range. Now, largely because of a rapidly growing reliance on fossil fuels and industrialized forms of agriculture, human activities have reached a level that could damage the systems that keep Earth in the desirable Holocene state. The result could be irreversible and, in some cases, abrupt environmental change, leading to a state less conducive to human development[6]. Without pressure from humans, the Holocene is expected to continue for at least several thousands of years[7].

Planetary boundaries

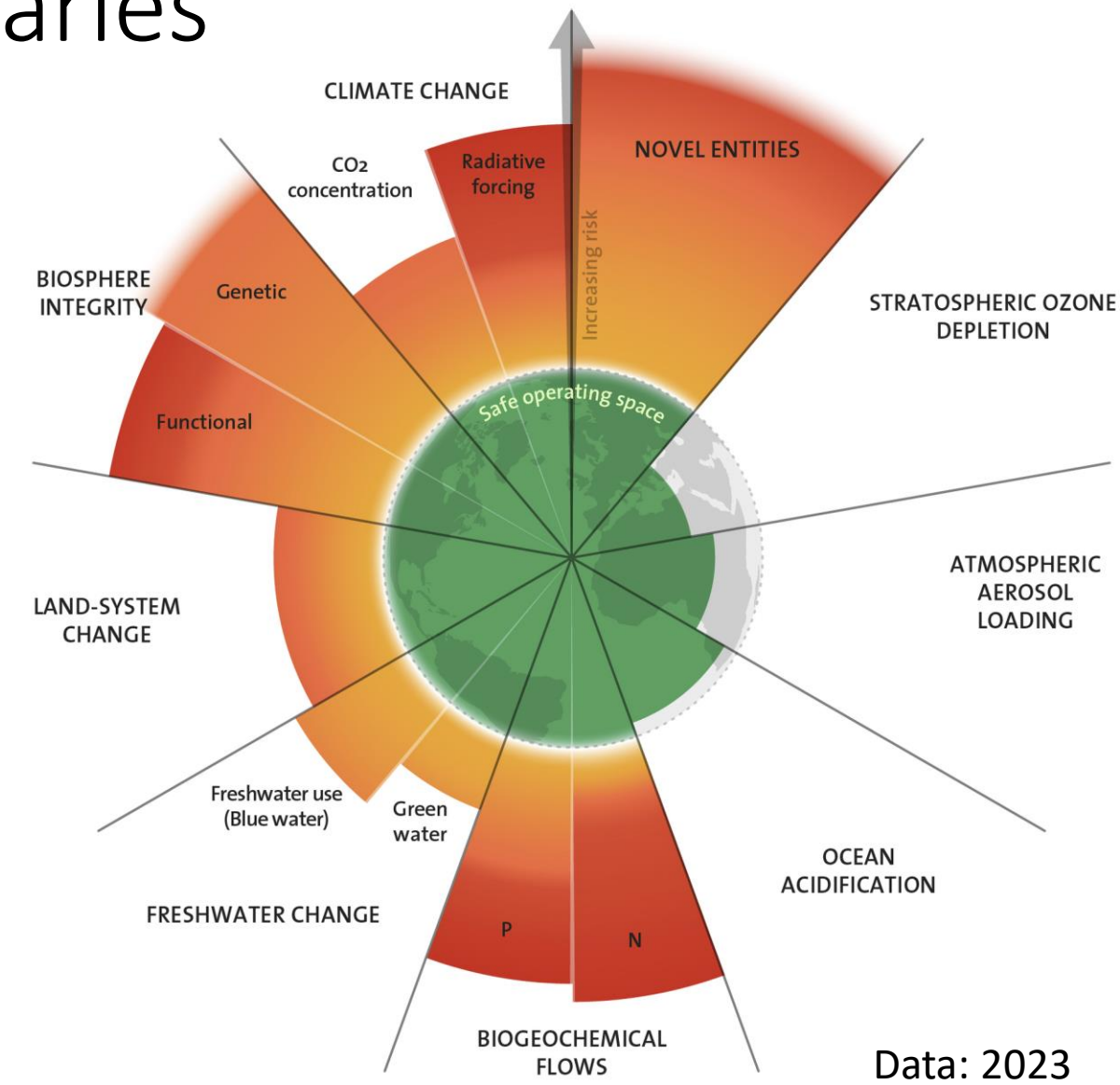
To meet the challenge of maintaining the Holocene state, we propose a framework based on 'planetary boundaries'. These boundaries define the safe operating space for humanity with respect to the Earth system and are associated with the planet's biophysical subsystems or processes. Although Earth's complex systems sometimes respond smoothly to changing pressures, it seems that this will prove to be the exception rather than the rule. Many subsystems of Earth react in a nonlinear, often abrupt, way, and are particularly sensitive around threshold levels of certain key variables. If these thresholds are crossed, then important subsystems, such as a monsoon system, could shift into a new state, often with deleterious or potentially even disastrous consequences for humans[8,9].

Most of these thresholds can be defined by a critical value for one or more control variables, such as carbon dioxide concentration. Not all processes or subsystems on Earth have well-defined thresholds, although human actions that undermine the resilience of such processes or subsystems — for example, land and water degradation — can increase the risk that thresholds will also be crossed in other processes, such as the climate system.

We have tried to identify the Earth-system processes and associated thresholds which, if crossed, could generate unacceptable environmental change. We have found nine such processes for which we believe it is necessary to define planetary boundaries: climate change; rate of biodiversity loss (terrestrial and marine); interference with the nitrogen and phosphorus cycles; stratospheric ozone depletion; ocean acidification; global freshwater use; change in land use; chemical pollution; and atmospheric aerosol loading (see Fig. 1 and Table).

In general, planetary boundaries are values for control variables that are either at a 'safe' distance from thresholds — for processes with evidence of threshold behaviour — or at dangerous levels — for processes without

Figure 1 | Beyond the boundary. The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded.



Data: 2023

2010 – Cirkular economy

Ellen MacArthur Foundation

ELLEN MACARTHUR FOUNDATION
Rethink the future

2015

1 TOWARDS THE CIRCULAR ECONOMY

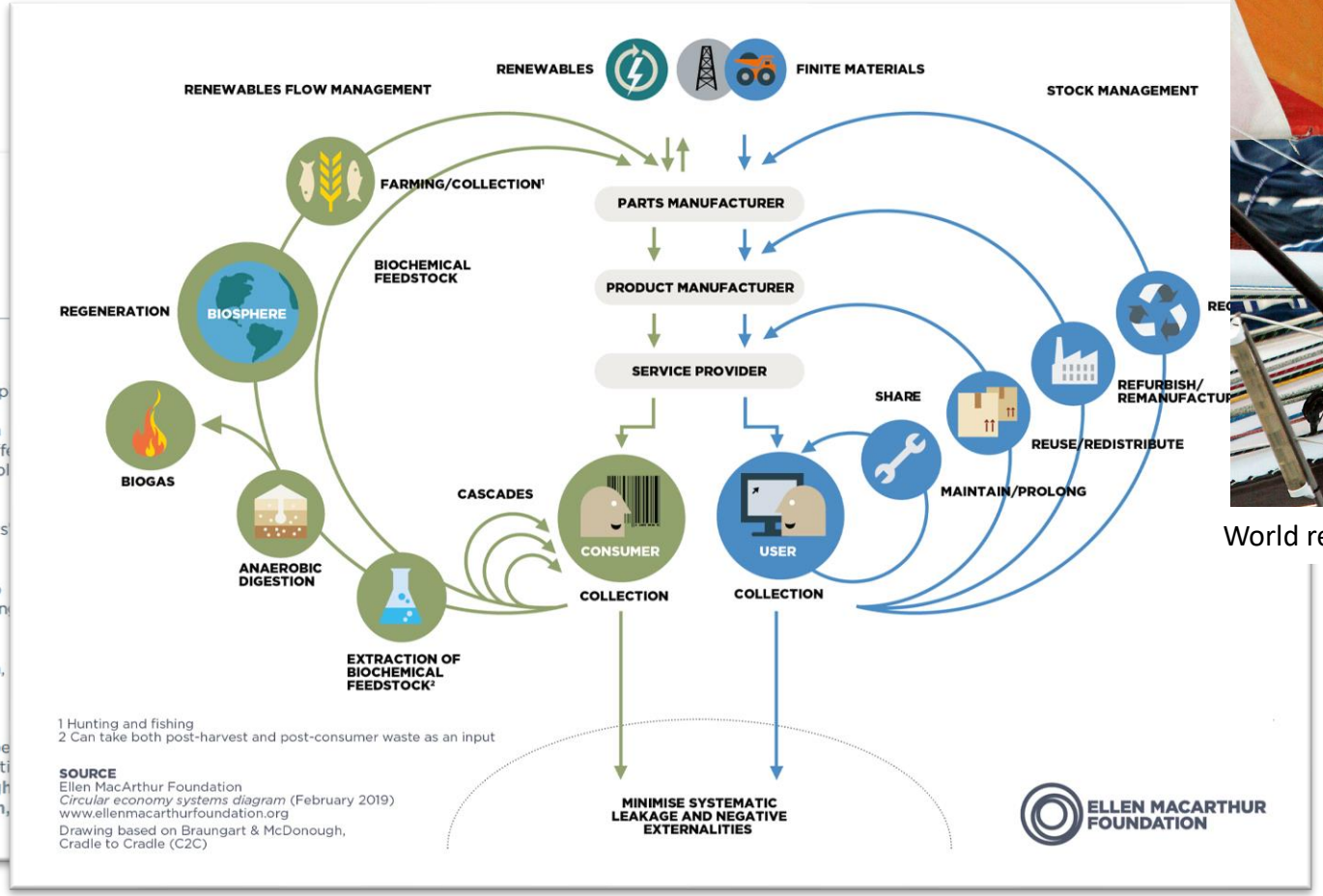
Acknowledgements

The Ellen MacArthur Foundation was formed in 2010 to insp
a generation to rethink, redesign and build a positive future.
The Foundation believes that the circular economy provides a
coherent framework for systems level redesign and as such off
us an opportunity to harness innovation and creativity to enabl
positive, restorative economy.

The Foundation is supported by a group of 'Founding Partners'
B&Q, BT, Cisco, National Grid and Renault. Each of these
organisations has been instrumental in the initial formation of
the Foundation, the instigation of this report and continues to
support its activities in education, communications and workin
as a business catalyst.

McKinsey & Company, a global management consulting firm,
provided the overall project management, developed the fact
base and delivered the analytics for the report.

In addition to a number of leading academic and industry expe
an extended group of organisations provided input and experti
They included **Caterpillar, Cyberpac, Desso, EPEA, Foresigh
Group, ISE, Marks & Spencer, Product-Life Institute, Ricoh,
Turntoo, and Vestas.**



World record around the world, 2005

2013 Most expensive TV commercial - SodaStream

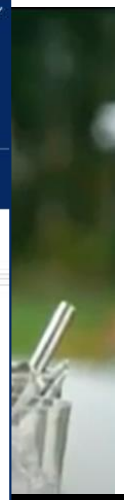
3. Feb. Superbowl

30 sec. ≈ 3,3 millions USD

5. Feb. The Guardian

Low sale for a long time

put our own house in order



2014 – Absolute Sustainability

Anders Bjørn og Michael Hauschild, DTU

Int J Life Cycle Assess
DOI 10.1007/s11367-015-0899-2

LIFE CYCLE SUSTAINABILITY ASSESSMENT

Introducing carrying capacity-based normalisation in LCA: framework and development of references at midpoint level

Anders Bjørn[1] · Michael Zwicky Hauschild[1]

Received: 18 November 2014 / Accepted: 30 April 2015

Abstract
Purpose There is currently a weak or no link between the indicator scores quantified in life cycle assessment (LCA) and the carrying capacity of the affected ecosystems. Such a link must be established if LCA is to support assessments of environmental sustainability and it may be done by developing carrying capacity-based normalisation references. The purpose of this ar-

Results and discussion The developed references can be applied to indicator results obtained using commonly applied characterisation models in LCIA. The European NR are generally lower than the global NR, mainly due to a relatively high population density in Europe. The NR were compared to conventional normalisation references (NR′) which represent the aggregated interventions for Europe or the world in a recent reference year.

2015 - Science Based Targets initiative

SCIENCE BASED TARGETS

DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

CDP DISCLOSURE INSIGHT ACTION · UN GLOBAL COMPACT · WORLD RESOURCES INSTITUTE · WWF

Near term | Long term | Net-zero | Location | Region | Company × | Sector | Date

COMPANY/FINANCIAL INSTITUTION	TARGETS		
	NEAR TERM	LONG TERM	NET-ZERO
Ørsted Denmark, Europe	1.5°C	1.5°C	2040
Scan Global Logistics A/S Denmark, Europe	COMMITTED	-	COMMITTED
NREP Denmark, Europe	COMMITTED	-	COMMITTED
STARK Group Denmark, Europe	1.5°C	-	COMMITTED
NKT Cables Group A/S Denmark, Europe	COMMITTED	-	COMMITTED
GN Store Nord A/S Denmark, Europe	COMMITTED	-	COMMITTED
Kvadrat A/S Denmark, Europe	COMMITTED	-	COMMITTED
Norican Group Denmark, Europe	COMMITTED	-	COMMITTED
Royal Unibrew Denmark, Europe	COMMITTED	-	COMMITTED
Stryhns AS Denmark, Europe	1.5°C	-	COMMITTED

2015 - UN 17 Sustainable Development Goals

2015 (2006) – B Corp

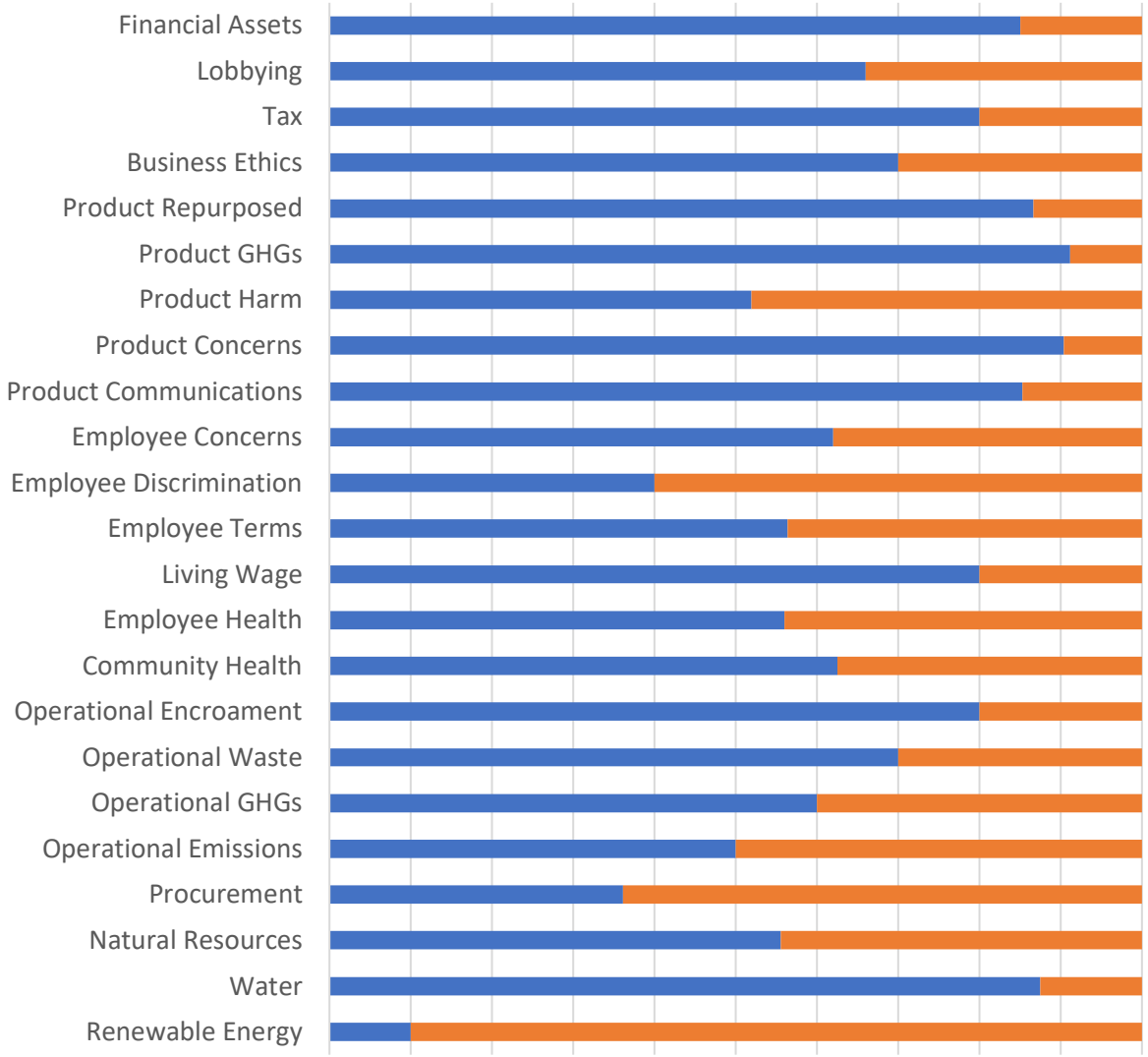
A global movement of companies with a common goal to redefine what makes a company successful.

Companies are certified according to environmental and social responsibilities.

September 2022, 5.697 certified

Grading system: minimum score 80 of 100

2016 (2013) – Future-Fit



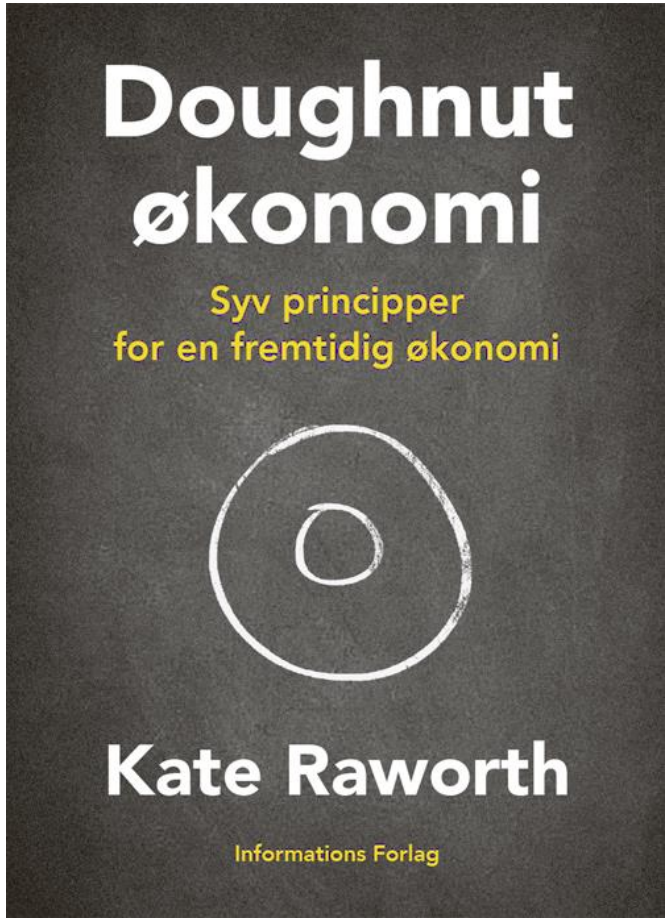
Future-Fit Business

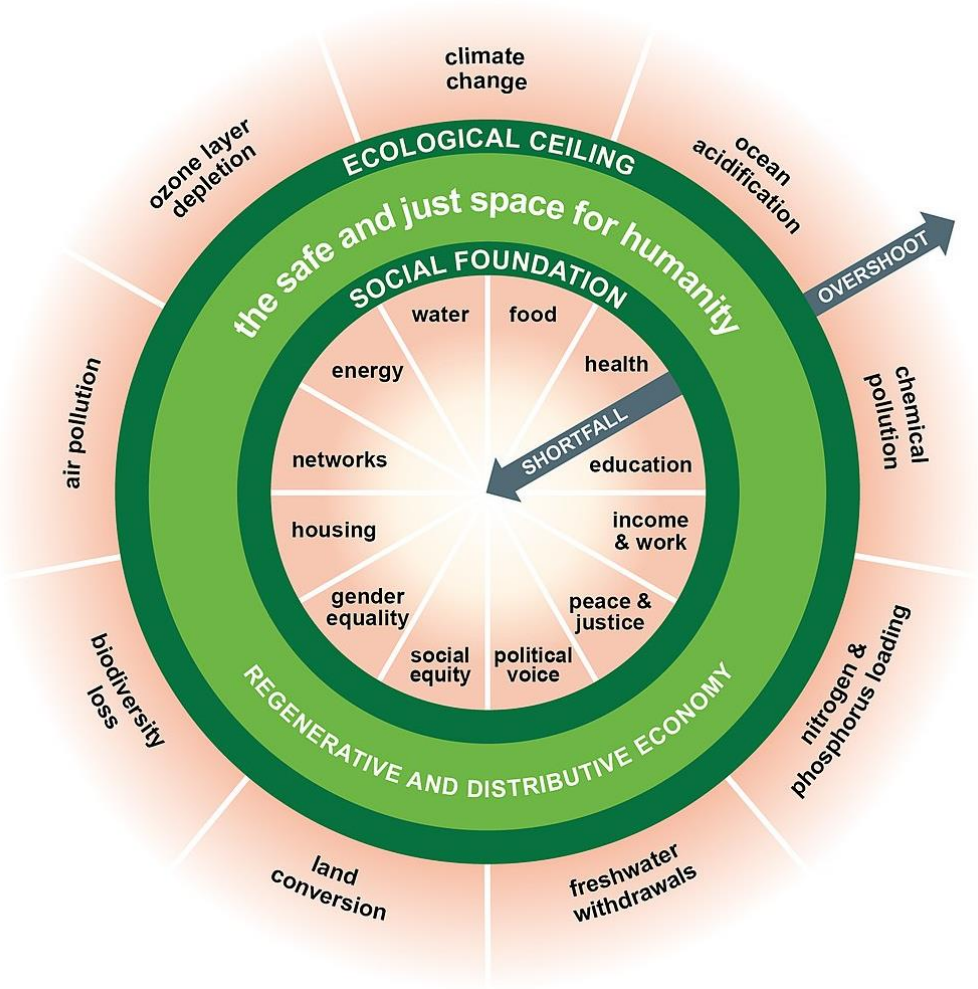
Open-source tool

Strategic tool

A member society

2017 – Doughnut economy





2017 (2004) - ESG

2004 - “Who Cares Wins“, was a joint initiative of financial institutions at the invitation of UN.

2017 – Nasdaq initially introduce a guide Nasdaq’s Nordic and Baltic markets.

Performance data

		A.P. Moller - Maersk		
		2021	2020	2019
1. Social performance				
Our employees				
1.1	Number of employees (FTEs)	85,375	83,624	86,279
1.2	Gender - female/total (% based on headcount)	31%	28%	28%
1.3	Women in management (JL 4+ - % based on headcount)	33%	31%	31%
1.4	Women in leadership (JL 6+ - % based on headcount)	22%	21%	20%
1.5	Target nationalities/total (% based on headcount)	72%	72%	71%
1.6	Target nationalities in executive leadership (JL 8 & 9 -% based on headcount)	15%	12%	13%
1.7	Fatalities (headcount)	4	1	5
1.8	Lost-time injury frequency (based on exposure hours)	0.93	1.22*	1.16
2. Environmental performance				
Energy consumption				
2.1	Energy consumption (total, TJ)	473,188	432,767	463,815
2.1	Fuel oil (1,000 tonnes)	11,083	10,368	11,173
2.1	Gas fuels (1,000 tonnes)	28	11	10
2.1	Other fuels (1,000 tonnes) - excluding biofuel	307	120	130
2.1	Biofuels (1,000 tonnes)	82	32	8
2.2	Renewable technologies (1,000 MWh)	165	66	-
2.2	Electricity (1,000 MWh)	731	664	656

JL: Job Level

*Restated based on improved reporting processes and the inclusion of exposure hours from contractors in Terminals and Logistics and Services that was not report
The numbers of the performance indicators correspond to the numbered sections in the Performance data accounting policies

Performance dat

Greenhouse gas (GHG) emissions (1,000 tonnes CO_2 eq)		
2.3	Direct GHG emissions (scope 1 GHG Protocol)	
2.4	Indirect GHG emissions (scope 2 GHG Protocol) – loca based	
2.5	Indirect GHG emissions (scope 2 GHG Protocol) - market based	
2.6	Value chain emissions (scope 3 GHG Protocol)	
2.7	Total GHG emissions (scope 1, 2 - location-based - an	
2.8	Relative CO_2 reduction (percentage vs 2008 baseline)	
Other air emissions		
2.9	SOx (1,000 tonnes)	
2.9	NOx (1,000 tonnes)	
Other resource consumption		
2.10	Waste (1,000 tonnes)	
2.11	Water (1,000 m^3)	
Spills (hydrocarbon)		
2.12	>10 m^3 (number of spills)	
3. Economic performance (USD million)		
3.1	Revenue	
3.2	Profit/loss before financial items (EBIT)	
3.3	CAPEX	
3.4	Tax for the year	

*Restated based on the implementation of an improved scope 3 methodology. Read more on p. 25.
Numbers of the performance indicators correspond to the numbered section in the Performance data accounting policies

2018 - Greta Thunberg

What Greta say:

Hey adults, will you be kind and listen to what the scientists tells us.

2019 – EAT–Lancet Commission

To Achieve Planetary Health Diets for nearly 10 Billion People by 2050.

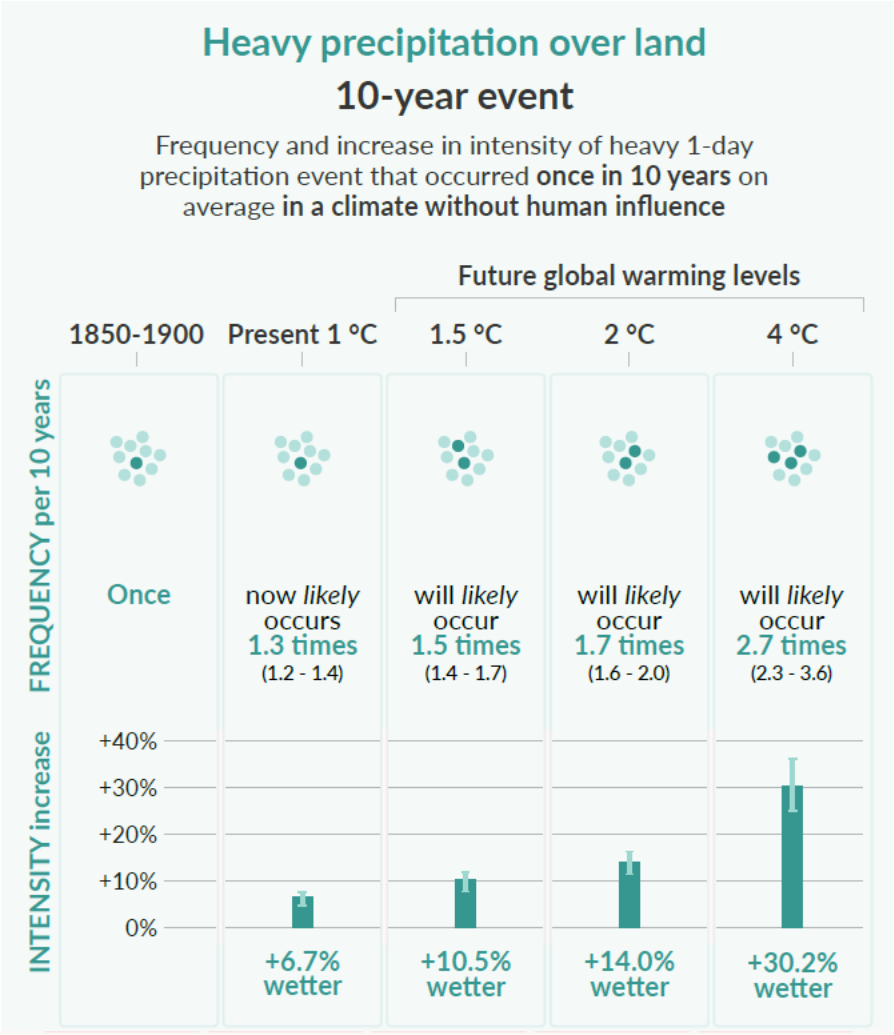
2020 - EU taxonomy

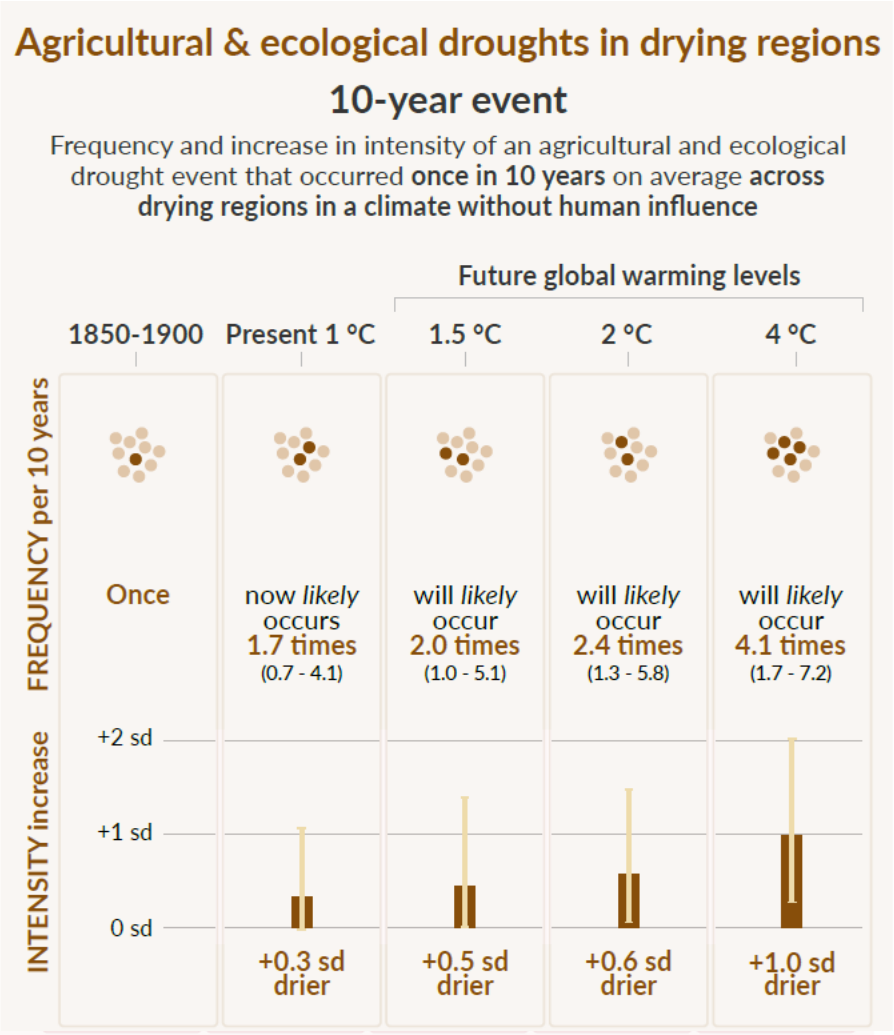
A part of ”Green deal”.

A classification system established to clarify which investments are environmentally sustainable.

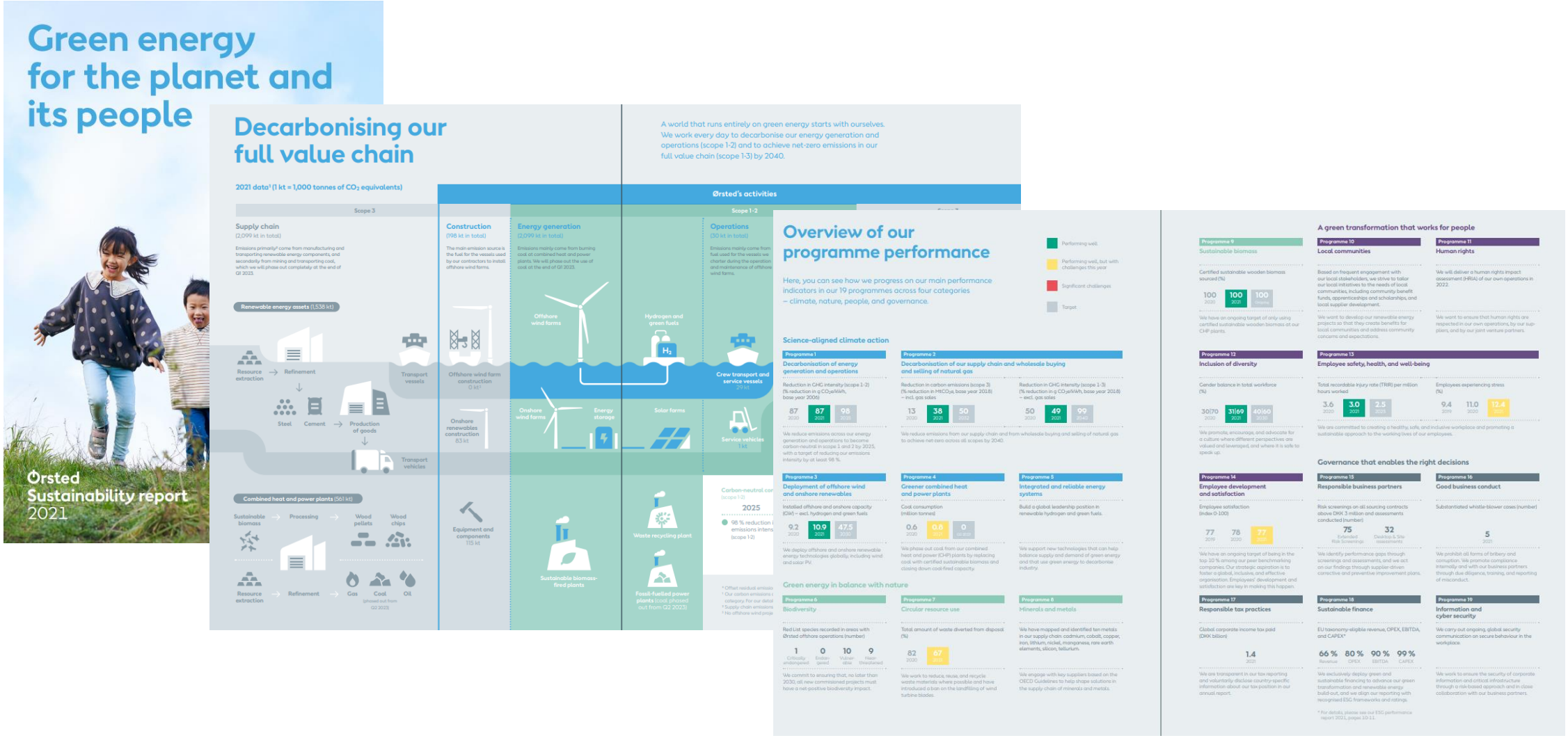
The aim of the taxonomy is to prevent greenwashing and to help investors make greener choices.

2022 - IPCC – Sixth Assessment Report





2022 – Large companies take responsibility



2022 - Large companies takes responsibility

A.P. Moller - Maersk ESG strategy

	Environment		Social			Governance		
Commitments	**We will take leadership in the decarbonisation of logistics**		**We will ensure that our people thrive at work by providing a safe and inspiring workplace**			**We operate based on responsible business practices**		
	We will deliver on our customer commitment to decarbonise their supply chains in time and our societal commitment to act and have impact in this decade		We create an engaging environment for all colleagues	We facilitate diversity of thought	We ensure everyone gets home safe by preventing fatal and life-altering incidents	We live our Code of Conduct	We procure sustainably	We protect and treat data with respect
Strategic targets *All targets are for end of year*	**2040**: • Net zero across the business • 100% green solutions to customers	**2030**: • Aligned with the Science Based Targets initiative 1.5°C pathway • Industry-leading green customer offerings across the supply chain	**2025**: Top quartile score on engagement survey	**2025**: >40% women in management >30% diverse nationality of executives	**2023**: • 100% of High Potential Incidents trigger frontline Learning Teams • Global Leadership (Top 900) upskilled in Maersk safety and security principles	**2023**: 100% of employees trained in the Maersk Code of Conduct	**2024**: 100% of suppliers committed to the Supplier Code of Conduct	**2023**: 100% of employees trained on data ethics
Overview of all ESG categories	Climate change Environment and ecosystems (incl. ship recycling)		Employee relations and labour rights - Safety & security - Human capital Sustainable and inclusive trade - Diversity, equity and inclusion - Human rights			Business ethics - Governance - Responsible tax Sustainable procurement - Data ethics - Citizenship		

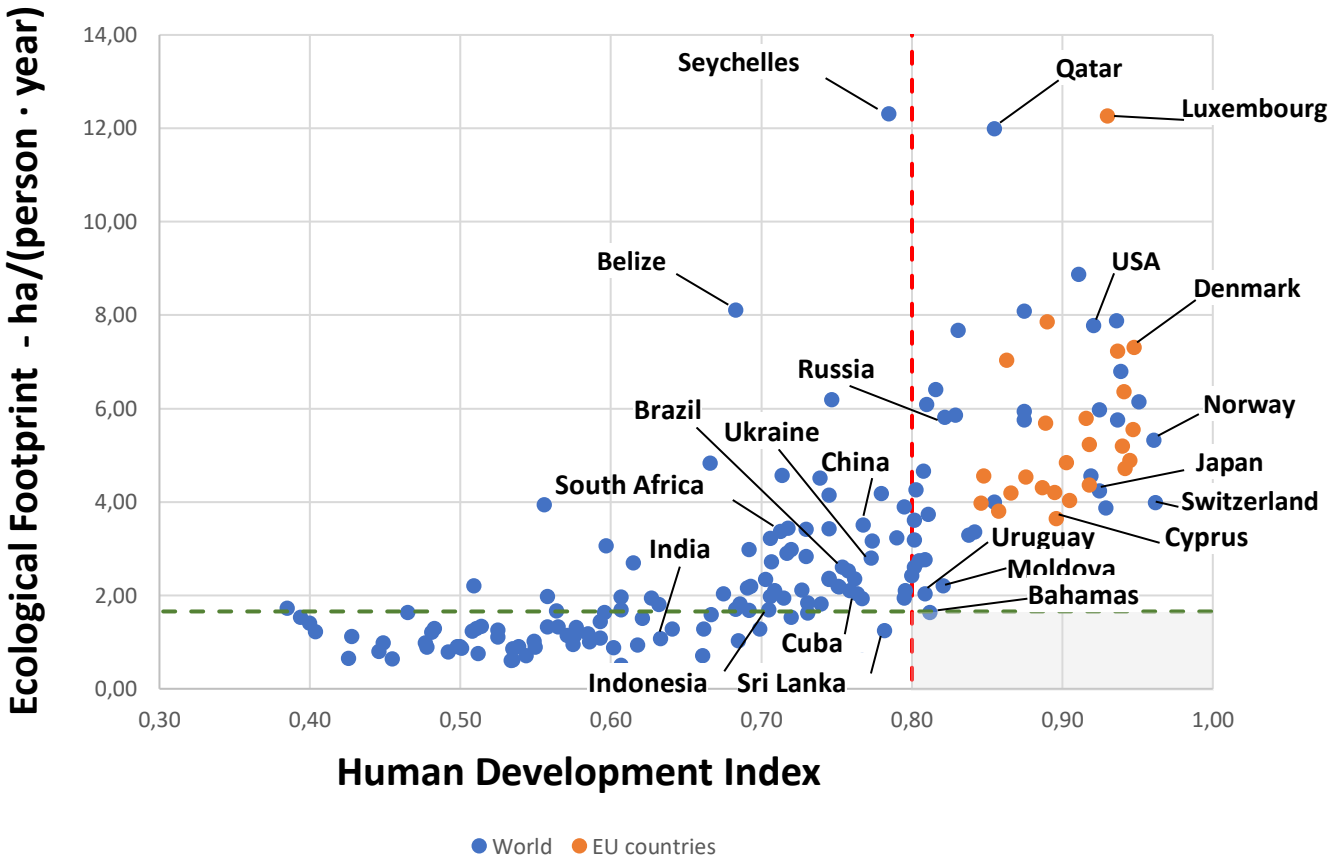
2022 – Centre for Absolute Sustainability

The future - Absolute sustainability

Climate, earth and consumption

2022 (2013) – Center for Absolute Sustainability

Human Development / Ecological Footprint



Human Development Index: $HDI = \sqrt[3]{LEI \; x \; EI \; x \; II}$

Life Expectancy Index: $LEI = \frac{LE - 20}{85 - 20}$

Education Index: $EI = \frac{\frac{MYS}{15} + \frac{EYS}{18}}{2}$

Income Index: $II = \frac{ln(GNIpc) - ln(100)}{ln(75000) - ln(100)}$

Ecological Footprint: $EF = \Sigma T_i / Y_w \, x \, EQF_i$

T_i: tons of each product i consumed in the nation in a year

Y_w: yearly world-average yield for producing each product i

EQF_i: equivalence factor for each product i

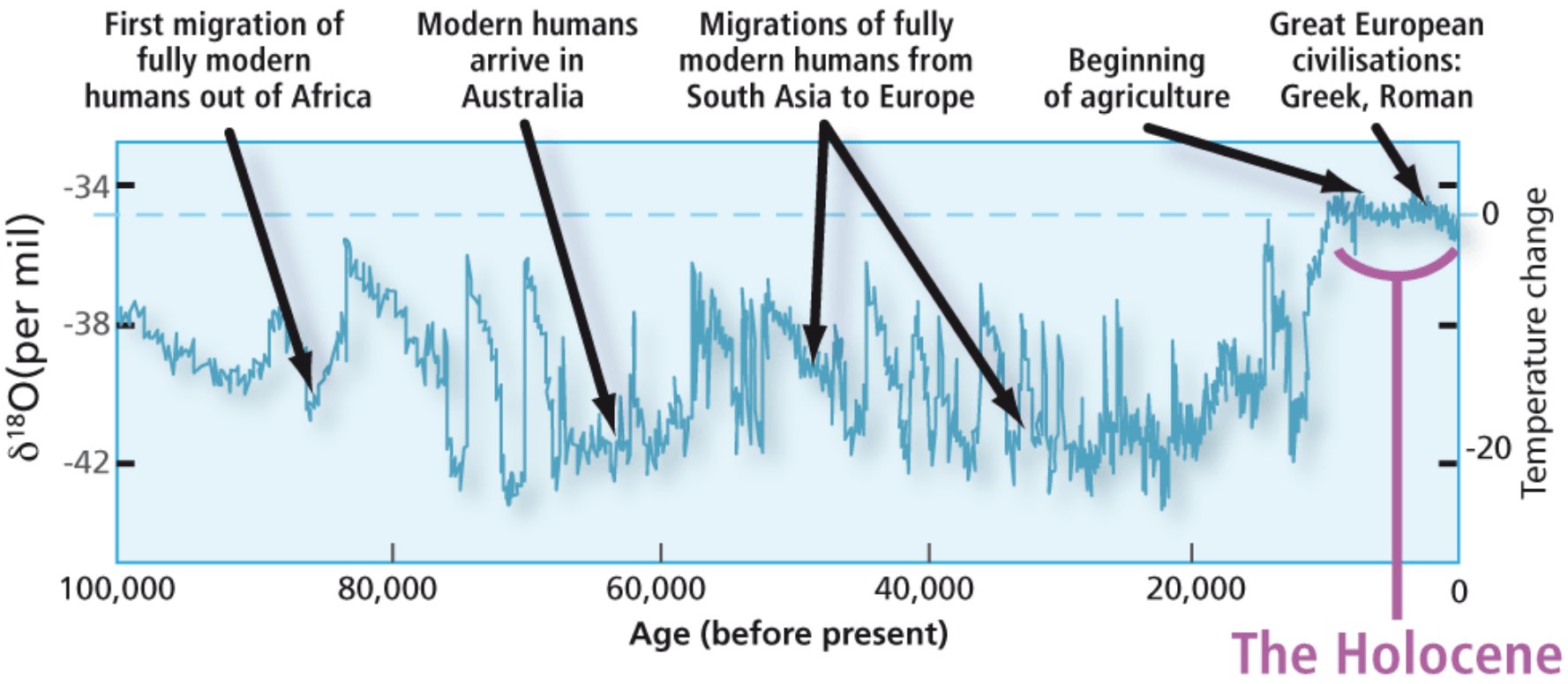
Sources:

UN, Human Development Index (HDI), 2021

Global Footprint Network, Ecological Footprint , 2019

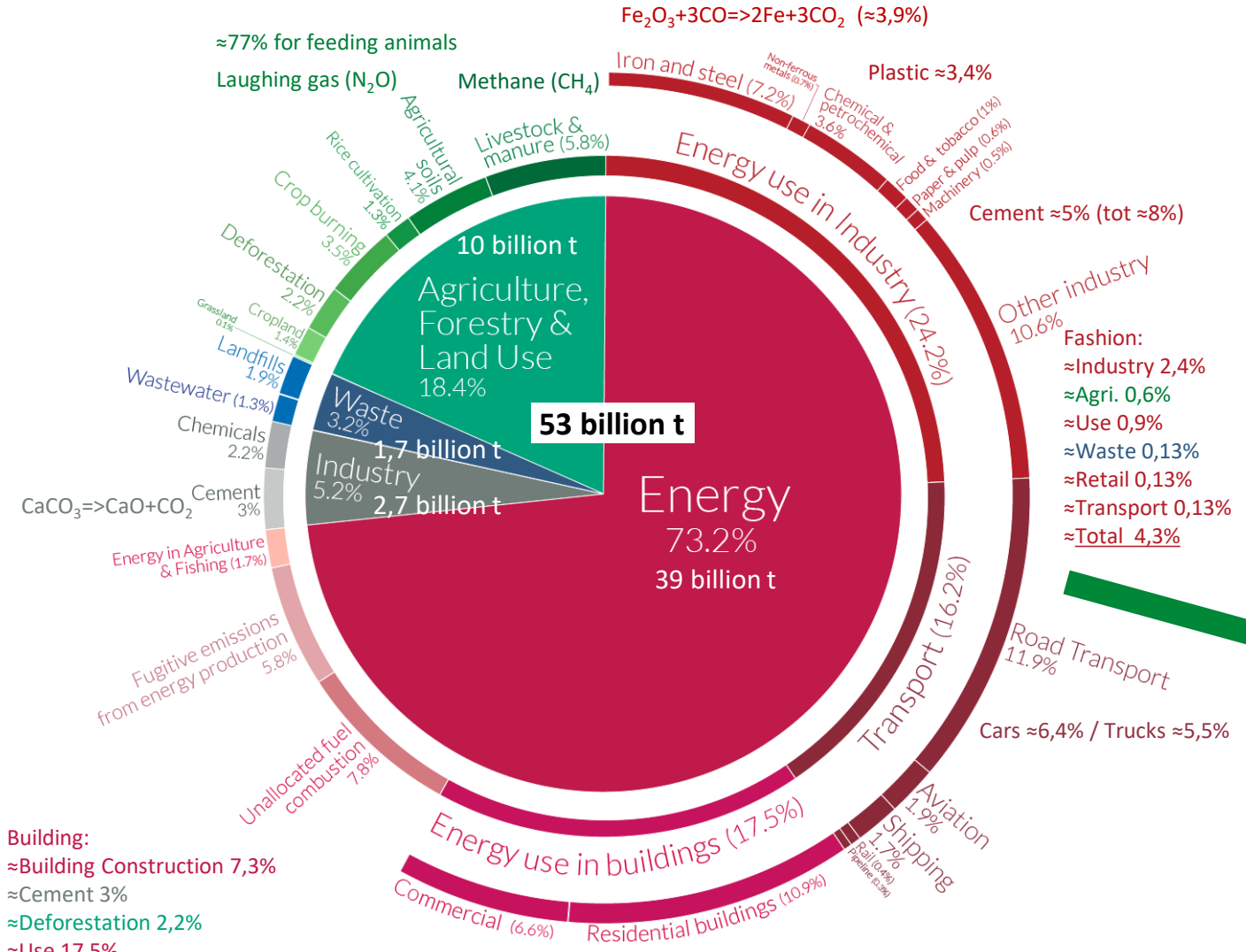
The stable Holocene time period

How will the Anthropocene epoch change the temperature on earth?

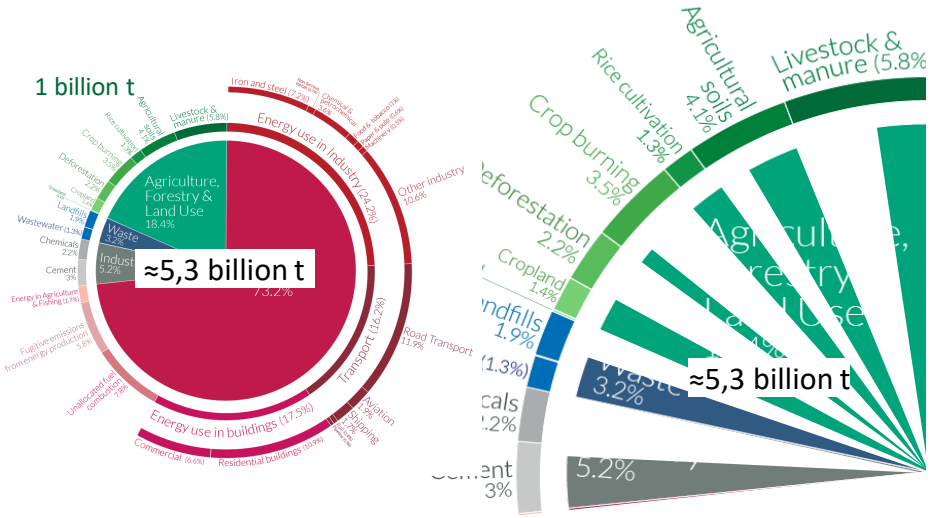


Source: Global IGBP Change

Greenhouse gasses (CO_2-e) by sectors (2016)



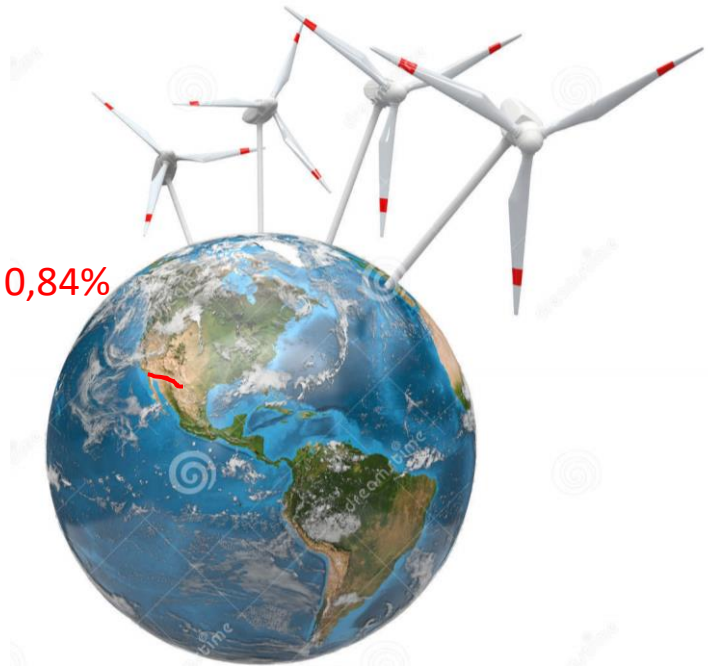
Absolute sustainability - factor > 8



Sources:
Our World in Data

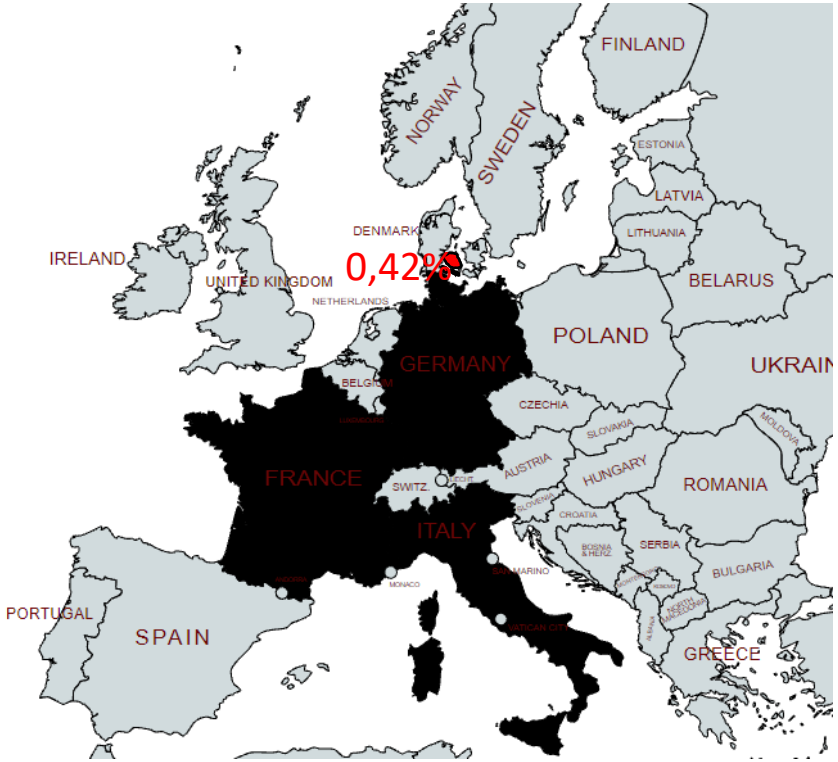
Renewable energy - 604 EJ (Exajoule) in 2019

4,6 mill. Offshore wind turbines



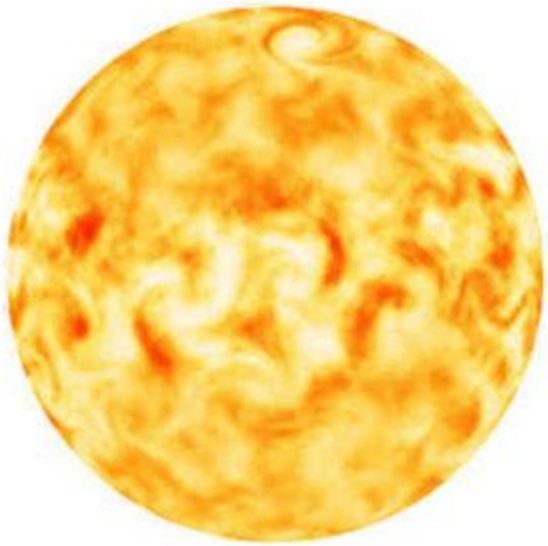
19 x around the world

1,1 mill. km^2 solar panels



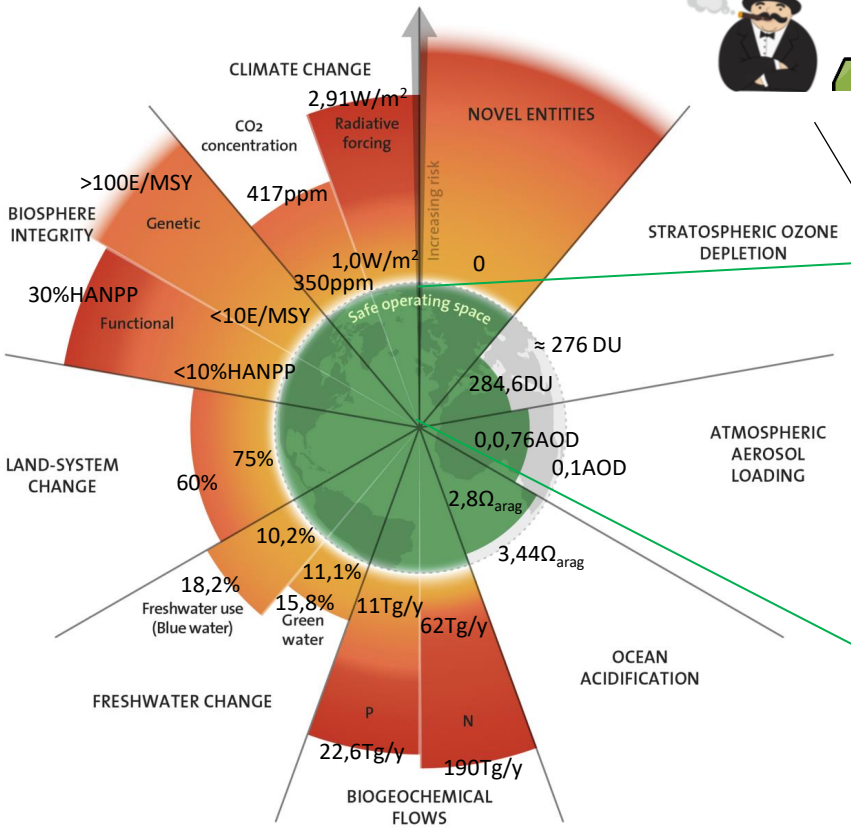
0,87% of the surface of the Earth

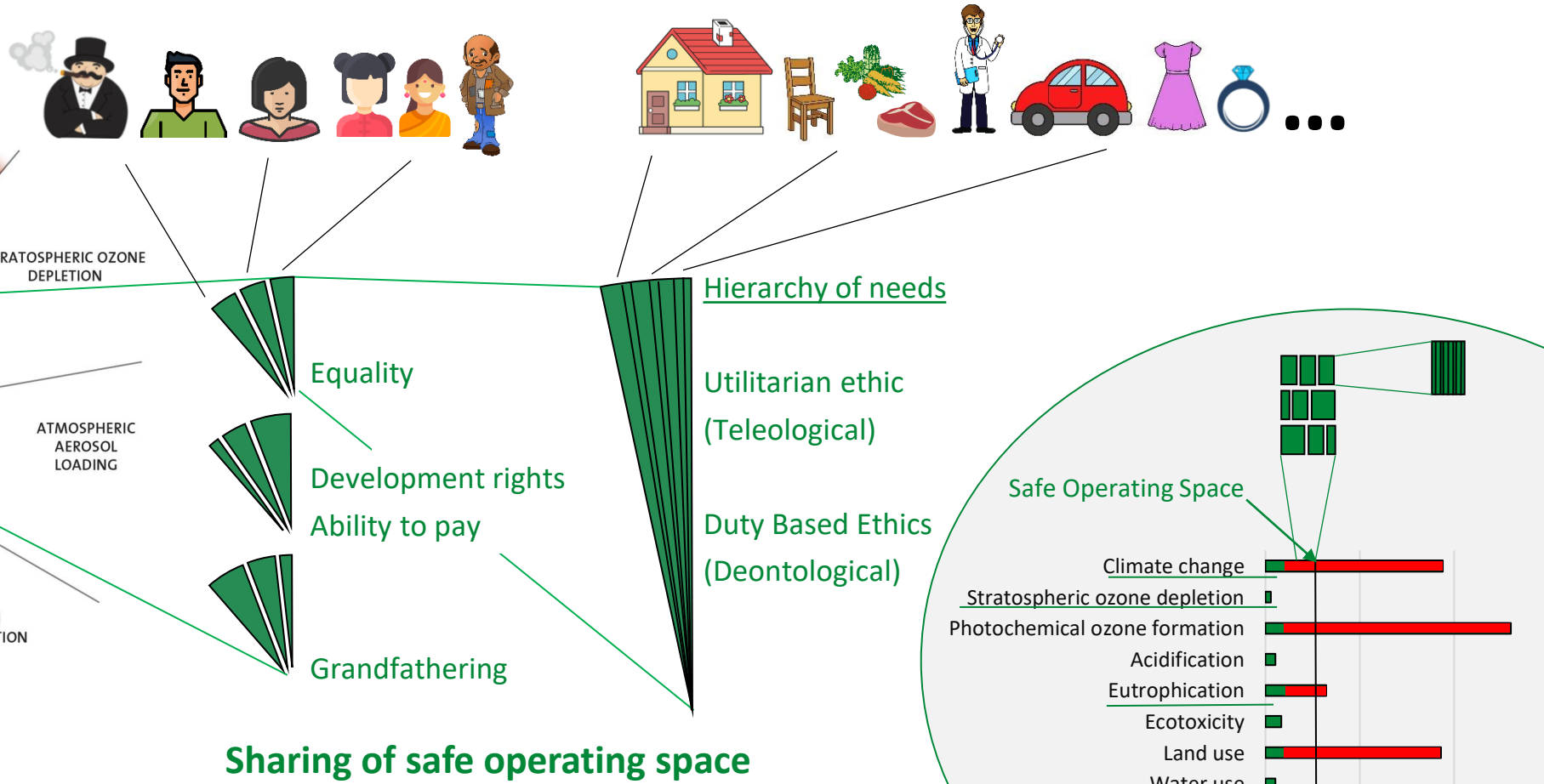
Incoming solar energy

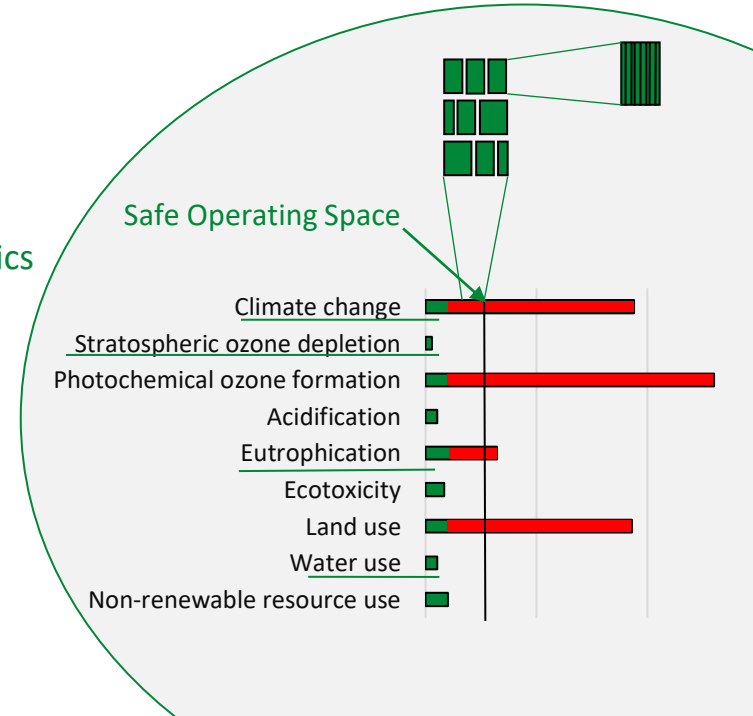


5.000 x our consumption

Absolute Sustainability







Planetary boundaries – Safe Operating Space

Example Climate

ppm CO_2 or W/m^2

kg CO_2-eq per per

Impact category	World	Europe	Unit (per person year)
Climate change	985	985	kg CO_2-eq
	522	522	kg CO_2-eq
Ozone depletion	0.078	0.078	kg CFC-11-eq
Photochemical ozone formation	3.8	2.5	kg NMVOC-eq
Terrestrial acidification	2.3×10^3	1.4×10^3	mole H^+ eq
Terrestrial eutrophication	2.8×10^3	1.8×10^3	mole N eq
Freshwater eutrophication	0.84	0.46	kg P eq
Marine eutrophication	29	31	kg N eq
Freshwater ecotoxicity	1.9×10^4	1.0×10^4	$[PAF]\times m^3\times day$
Land use, soil erosion	1.8	1.2	tons eroded soil
Land use, biodiversity	1.5×10^4	9.5×10^3	$m^2\times year$
Water depletion	306	490	m^3

Absolute Sustainability – Sharing principles

Grandfathering (GF):

$$pb_{c,r,GF} = \frac{e_{c,r,t=2010}}{E_{r,t=2010}} * PB_r$$

Per capita allocation (IEPC):

$$pb_{c,r,IEPC} = \frac{pop_{c,t}}{POP_t} * PB_r$$

Equal cumulative per capita allocation (ECPC):

$$pb_{c,r,ECPC} = \frac{\sum_{t=2010}^{t\_end} pop_{c,t}}{\sum_{t=2010}^{t\_end} POP_t} * PB_r$$

Ability to pay (AP):

$$pb_{c,r,AP} = e_{c,r,t=2010} - \left(\frac{e_{c,r,t=2010} \cdot \sqrt[3]{\frac{gdp_{pc_{c,t}}}{GDP_{PC_t}}}}{\sum_c^{NC} e_{c,r,t=2010} \cdot \sqrt[3]{\frac{gdp_{pc_{c,t}}}{GDP_{PC_t}}}} \cdot (E_{r,t=2010} - PB_r) \right)$$

Development Rights (DR):

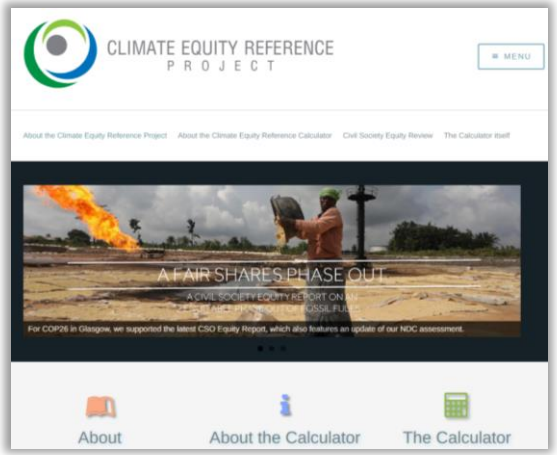
$$pb_{c,r,DR} = e_{c,r,t=2010} - \left(\frac{rci_{c,t=2010}}{RCI_{t=2010}} \cdot (E_{r,t=2010} - PB_r) \right)$$

Resource efficiency (RE):

$$pb_{c,r,RE} = e_{c,r,t=2010} - \left(\frac{e_{c,r,t=2010} \cdot \frac{re_{c,t=2010}}{RE_{t=2010}}}{\sum_c^{NC} e_{c,r,t=2010} \cdot \frac{re_{c,t=2010}}{RE_{t=2010}}} \cdot (E_{r,t=2010} - PB_r) \right)$$

Sharing the safe operating space - ethics

PB = planetary boundary level
e = country-level environmental pressure
E = global environmental pressure
pop = country-level population
POP = global population
gdp_{pc} = country-level per capita GDP
GDP_{pc} = global per capita GDP
rci = country-level responsibility capability index
RCI = responsibility capability index summed over all countries
re = country-level resource efficiency
RE = global resource efficiency
c = country
r = planetary boundary
t = year

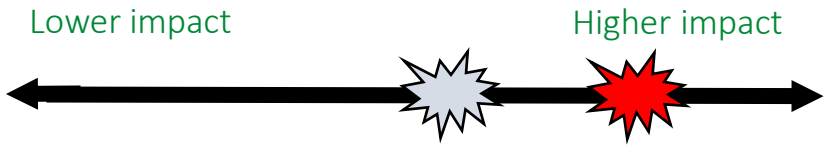


Absolute Sustainability

Past

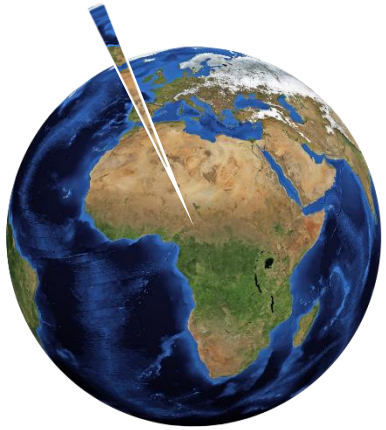
VS

Which one is best?



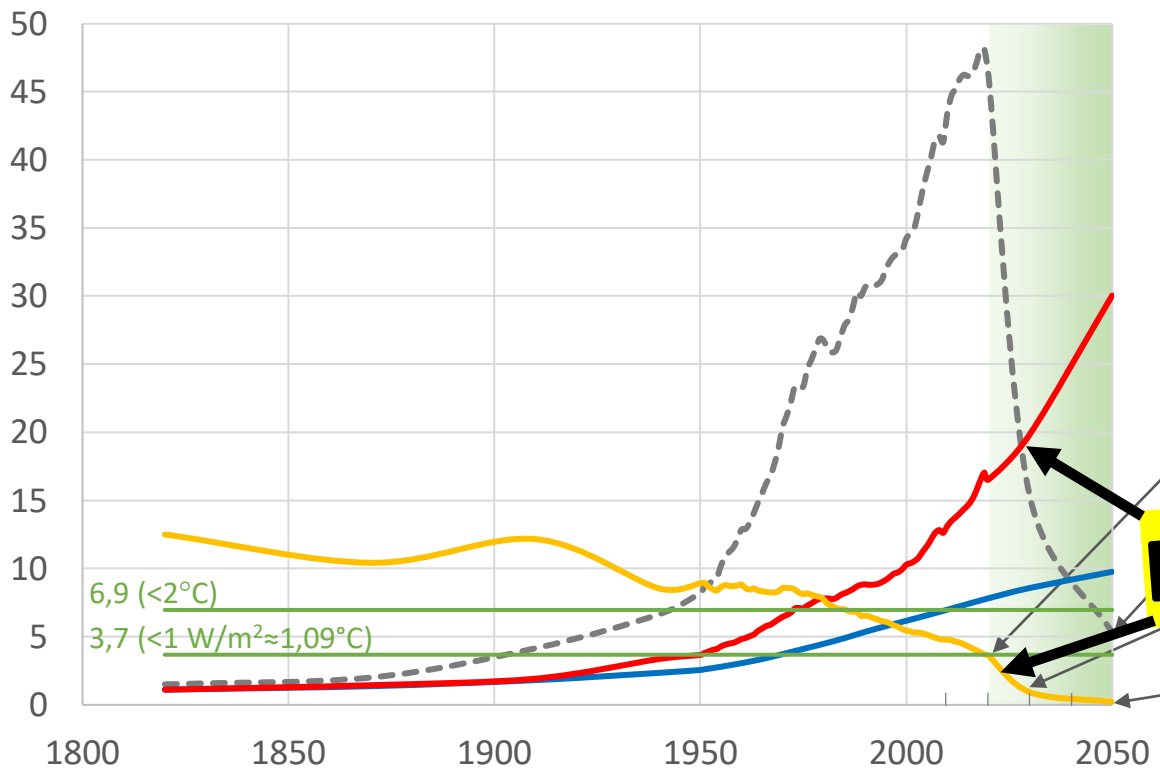
Future

VS



Is it good enough?

CO_2-e = Population · Affluence · Technology



I = P · A · T

CO_2-e = **Population** · **GDP pr inhabitant** · **Technology**

358g / $ (2020)

41g / $ (2020) = absolute sustainability

5,3 Billion ton CO2-e

18g / $ (2050

Be aware of rebound effects

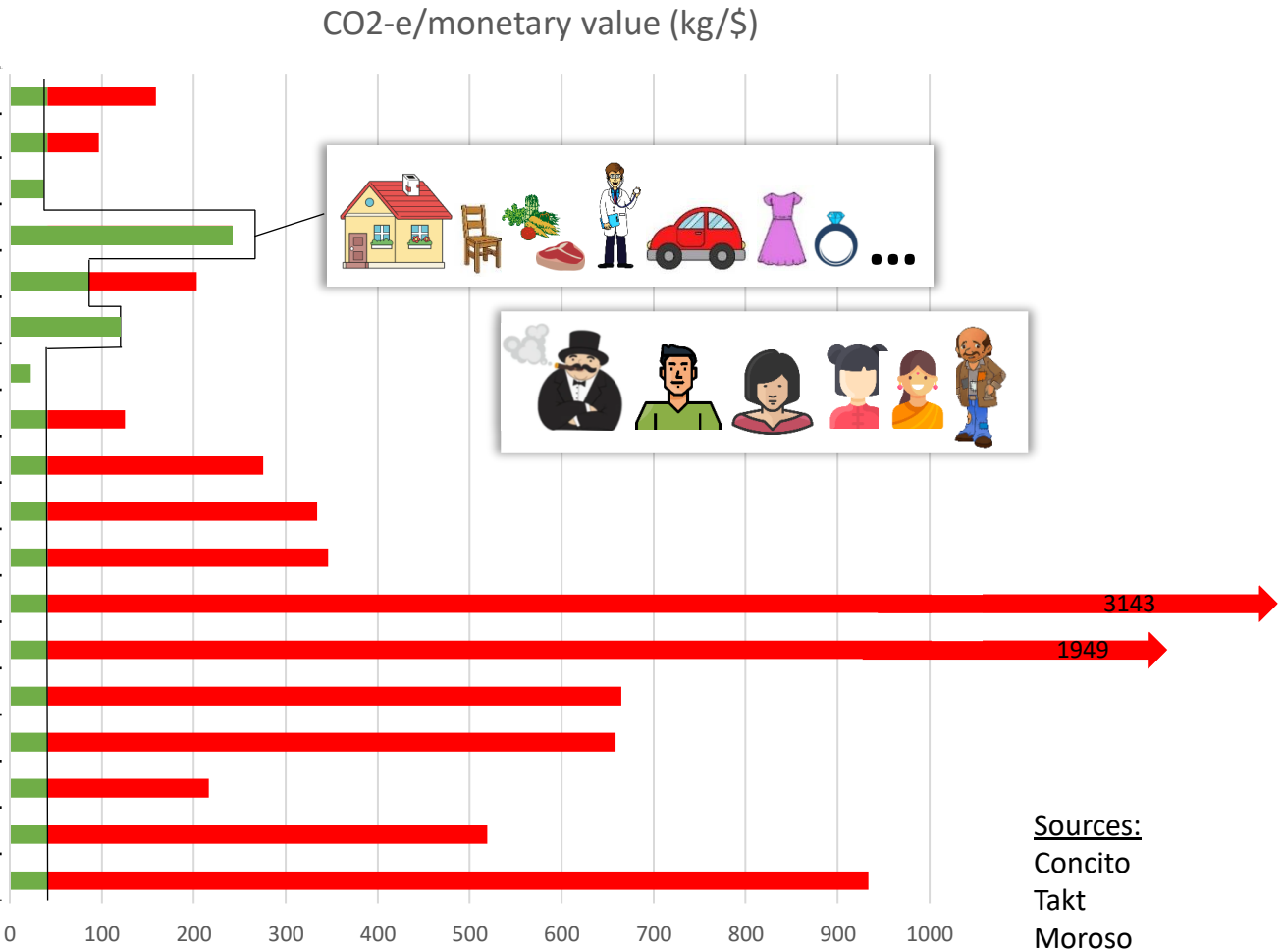
decouple

CO2-e (Billion ton CO2-e)
Population (Billion inhabitants)
GDP per inhabitant (Thousand $ / inhabitants)
Technology (100g C02 / $)
Planetary boundary (Billion ton CO2-e)

Sources:
The World Bank: Population, CO2 emissions, GHG emission, GDP.
PWC: The World in 2050.
Bjørn & Hauschild: Introducing carrying capacity-based normalisation in LCA.

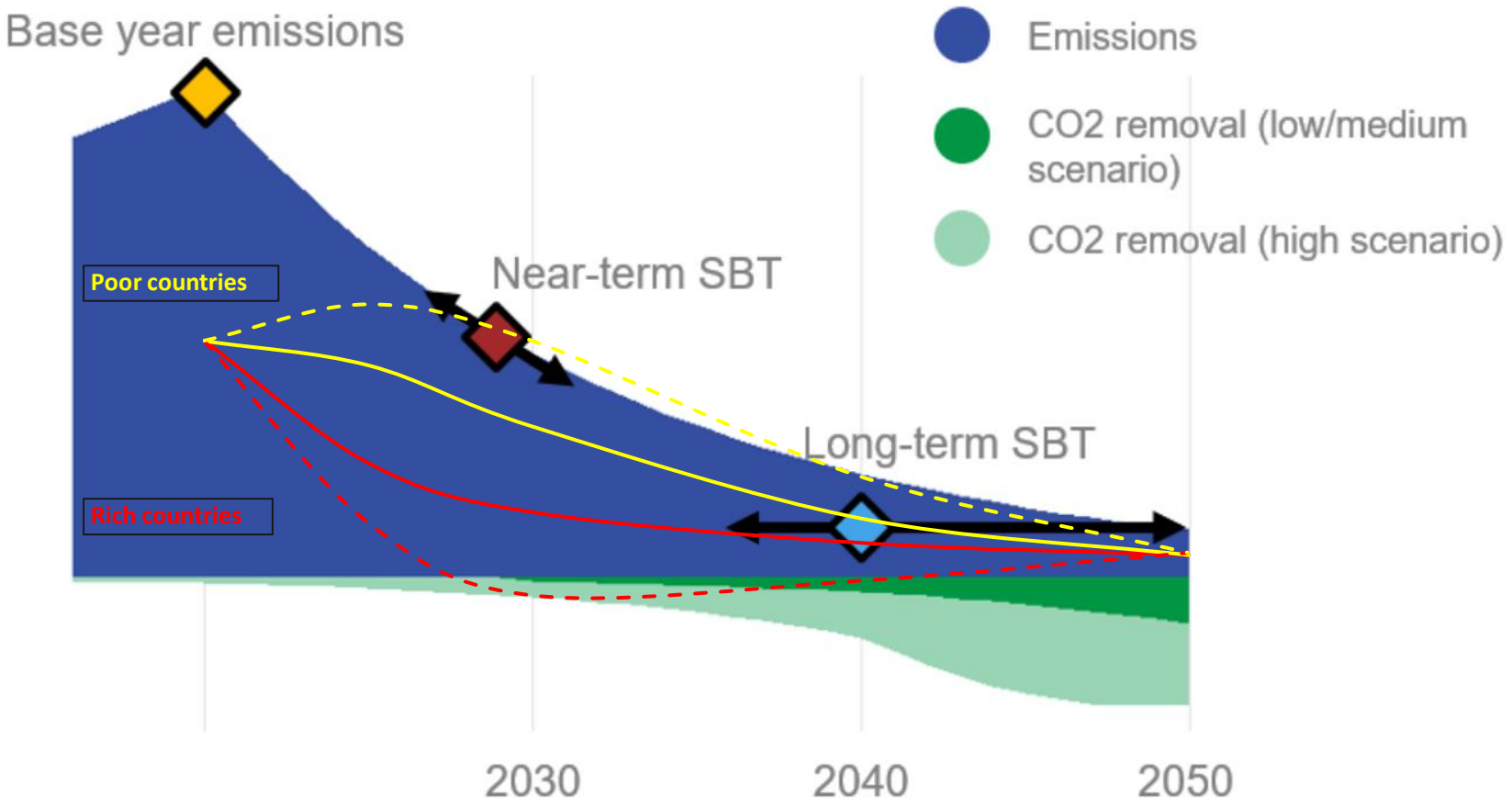
CO_2-e = Population · Affluence · <u>Technology</u>

	CO2-e	Price	CO2-e/$
	kg/(kg km part)	$/(kg km part)	g/$
Plastic chair	24,6	$155	159
Wood chair with steel base	22,9	$236	97
Wood chair	13,8	$369	37
Cabbage, white, raw	0,25	$1,03	242
Pasta	1,2	$5,91	203
Potatos	0,36	$3,69	97
Mulle	0,22	$9,60	23
Milk oak	0,37	$2,95	125
Milk cow	0,61	$2,22	275
Chicken	2,22	$6,65	334
Pork meat	3,58	$10,34	346
Beef meat	32,5	$10,34	3143
Gasolin	4,03	$2,07	1949
Car - Petrol	0,215	$0,32	665
Car - Diesel	0,213	$0,32	658
Car - Electrical - renewable	0,07	$0,32	216
Car - Electrical - EU mix	0,168	$0,32	519
Car - Electrical - 100 coal	0,302	$0,32	934

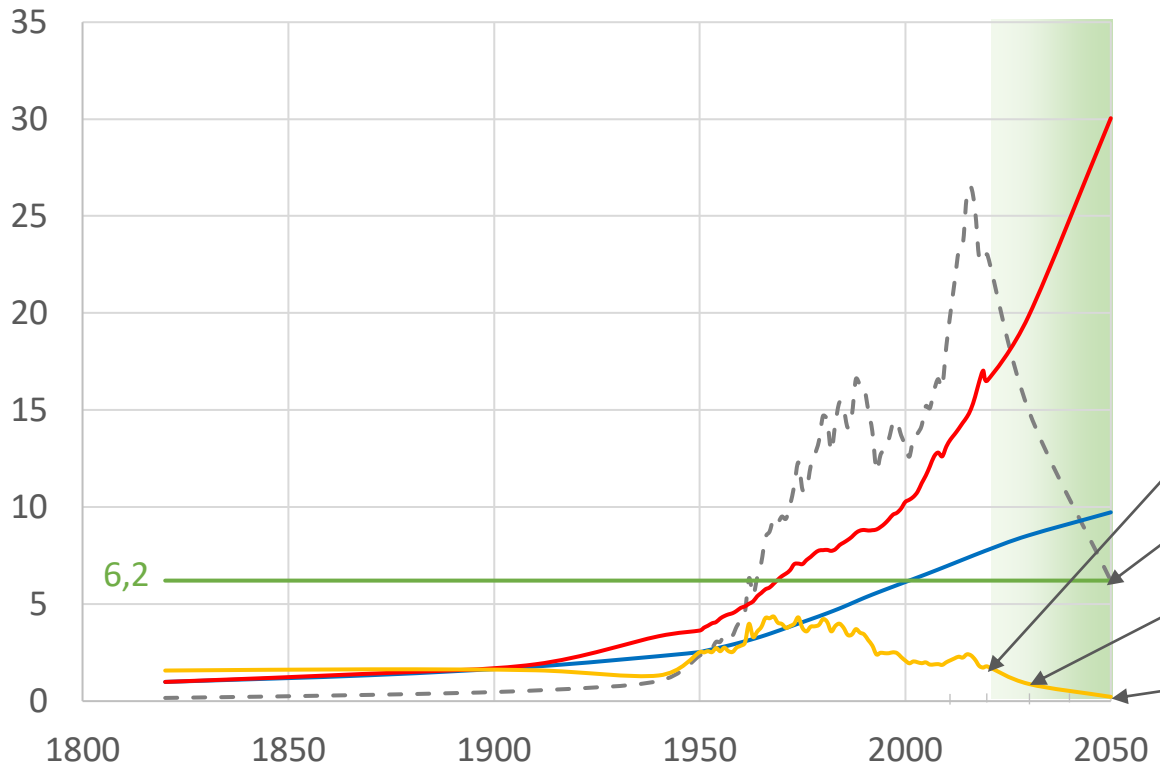


<u>Sources:</u>
Concito
Takt
Moroso
European Environmental Agency

Science Based Target (SBTi) - pathway



Phosphate = Population · Affluence · Technology



I = P · A · T

Phosphate = Population · GDP pr inhabitant · Technology

178mg / $ (2020)

48mg / $ (2020) = absolute sustainability

6,2 Million ton

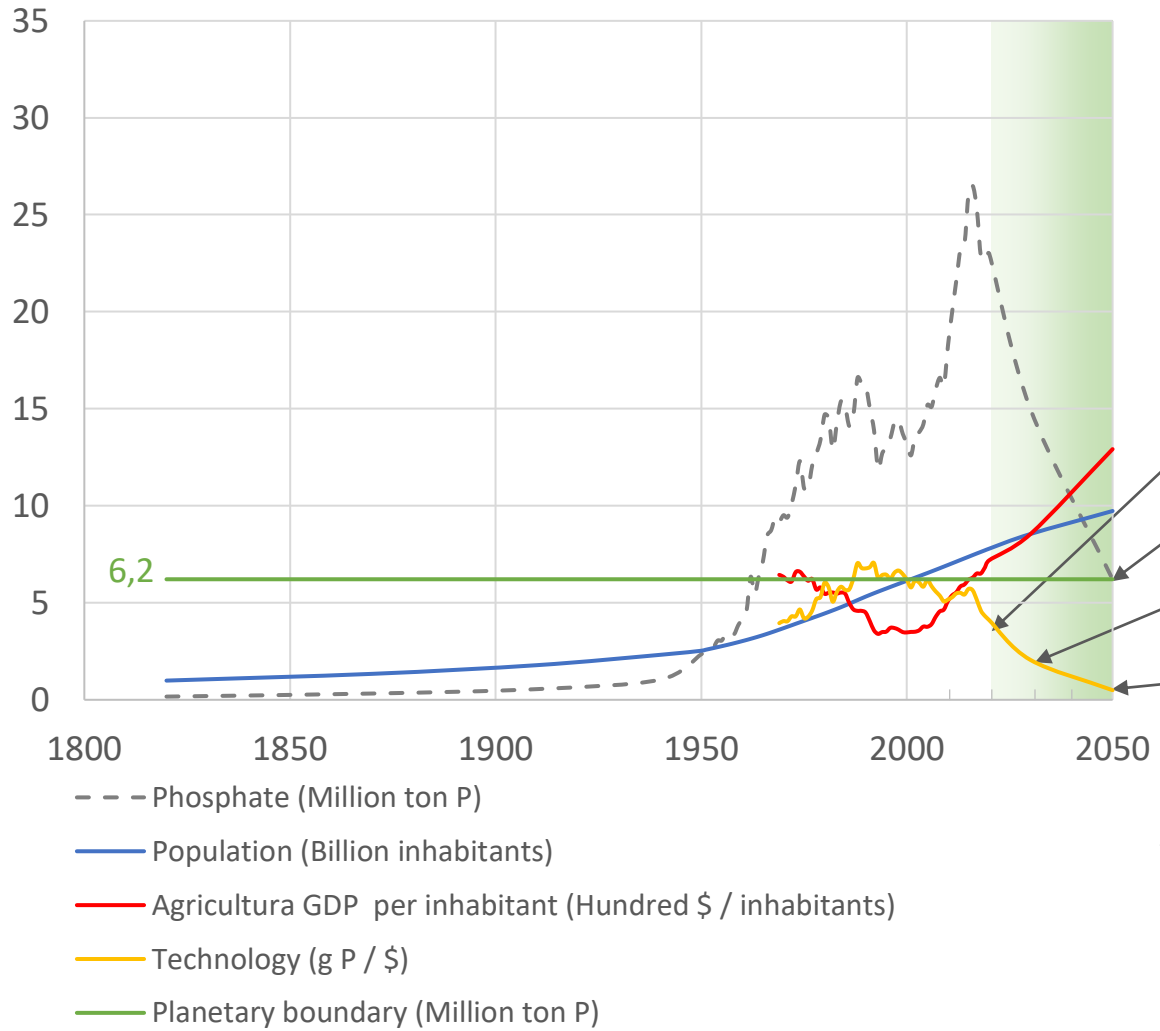
88mg / $ (2030)

21,2mg / $ (2050) = absolute sustainability

- Phosphate (Million ton P)
- Population (Billion inhabitants)
- GDP per inhabitant (Thousand $ / inhabitants)
- Technology (100mg P / $)
- Planetary boundary (Million ton P)

Sources:
The World Bank: Population, GDP.
USGS: Phosphate Rock - Historical Statistics.
PWC: The World in 2050.
Bjørn & Hauschild: Introducing carrying capacity-based normalisation in LCA.
Steffen et al: Planetary boundaries: Guiding human development on a changing planet.

Phosphate = Population · Affluence · Technology



I = P · A · T

Phosphate = Population · Agri. GDP pr inhabitant · Technology

4,1g / $ (2020)

1,1g / $ (2020) = absolute sustainability

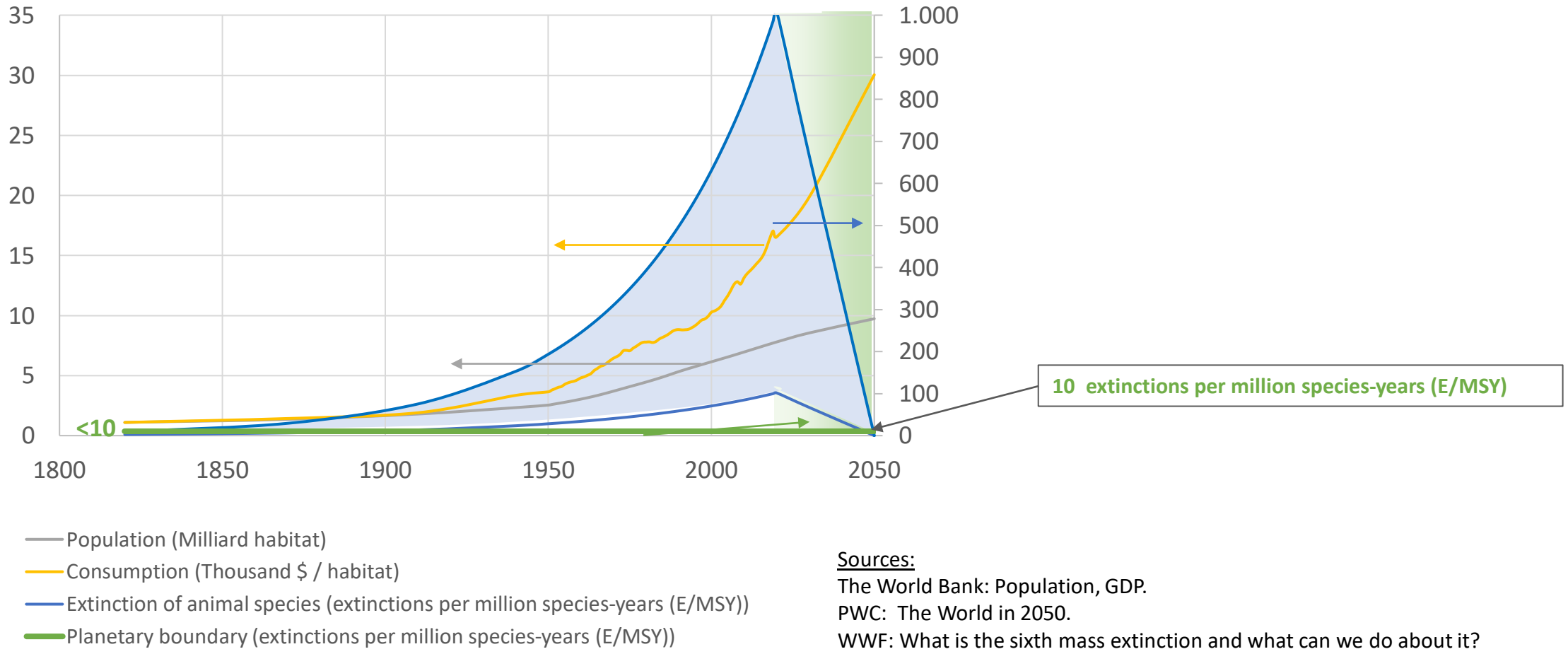
6,2 Million ton

2,1g / $ (2030)

0,5g / $ (2050) = absolute sustainability

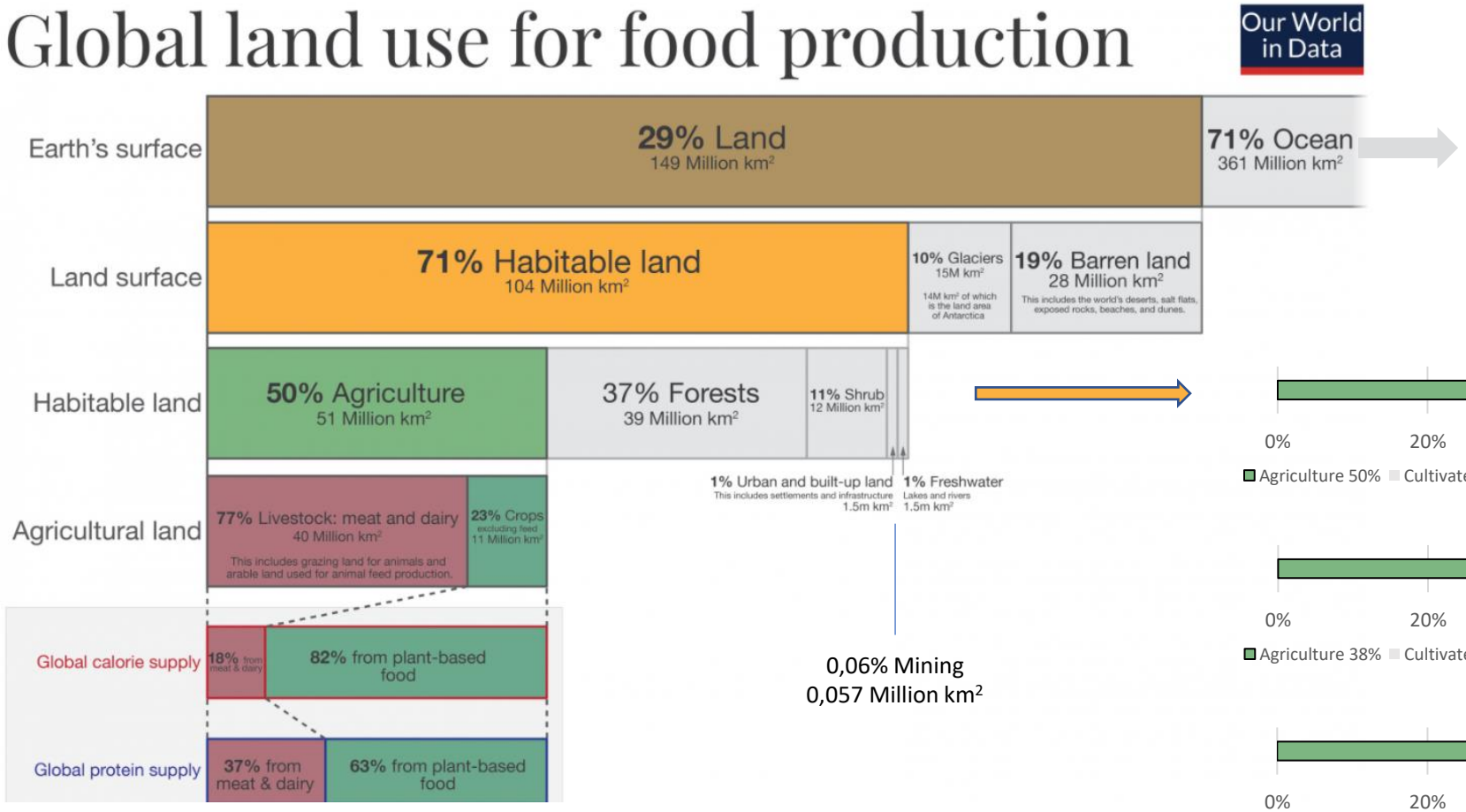
Sources:
The World Bank: Population, GDP.
USGS: Phosphate Rock - Historical Statistics.
PWC: The World in 2050.
Bjørn & Hauschild: Introducing carrying capacity-based normalisation in LCA.
Steffen et al: Planetary boundaries: Guiding human development on a changing planet.

Extinction of animal species

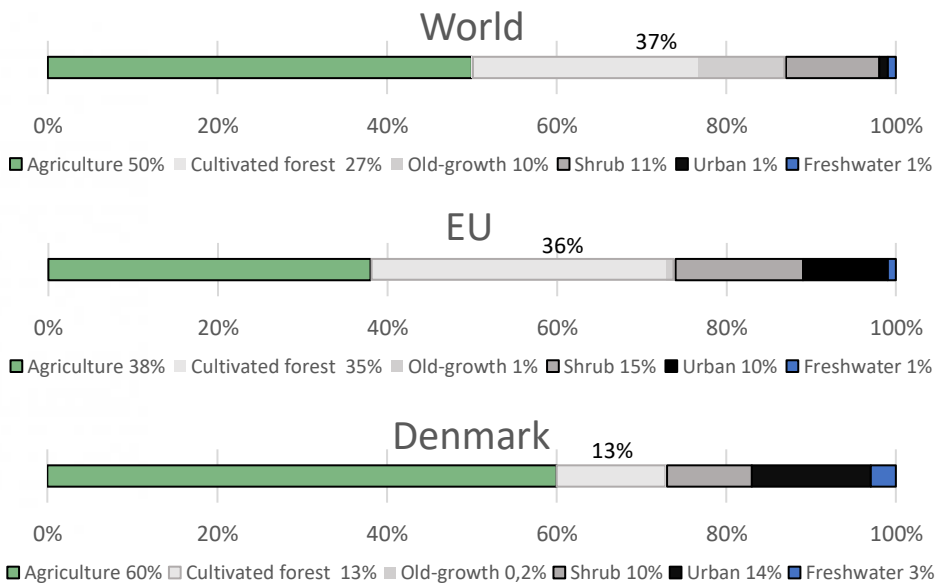


Sources:
The World Bank: Population, GDP.
PWC: The World in 2050.
WWF: What is the sixth mass extinction and what can we do about it?
Steffen et al: Planetary boundaries: Guiding human development on a changing planet.

Global use of land se (2019)



0,06% Mining
0,057 Million km²

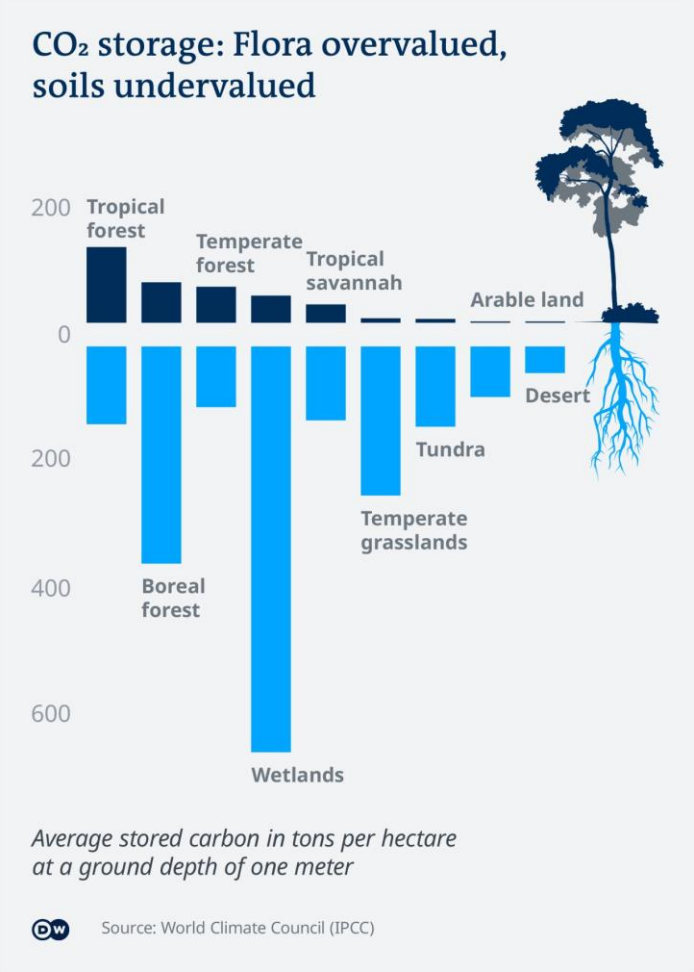


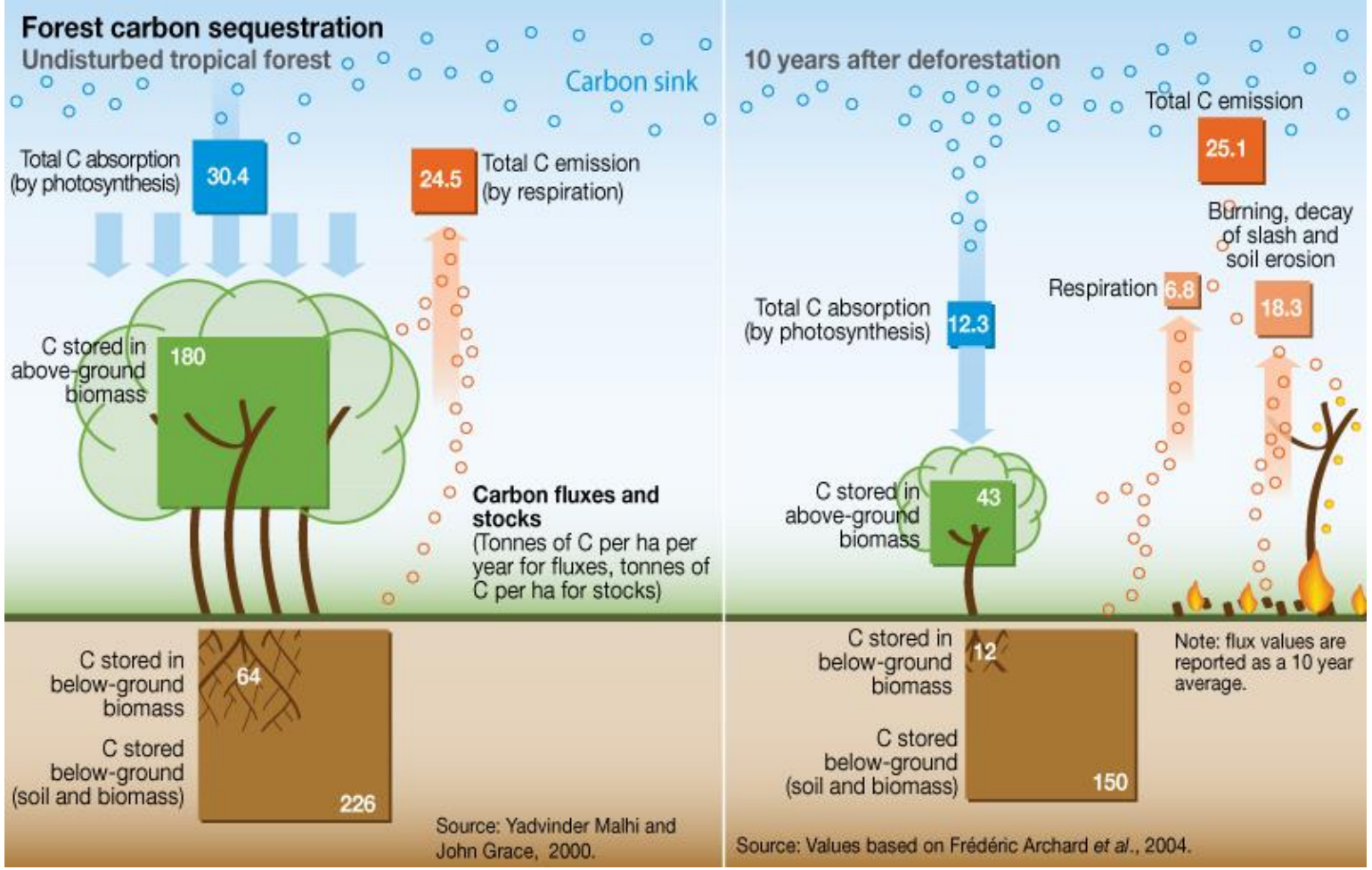
What about the nature?

Old growth forest

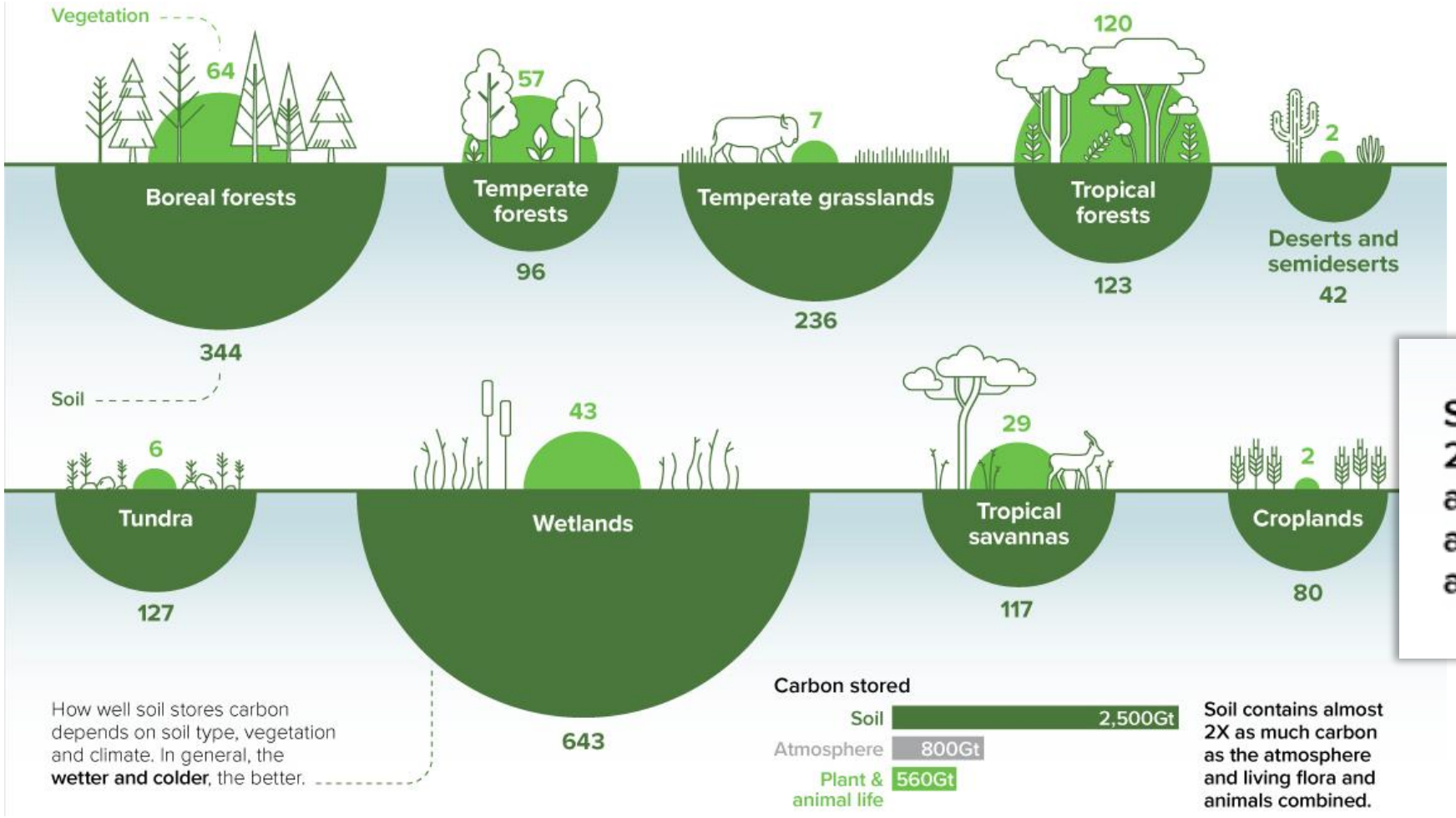
Cultivated forest

Where is the CO^2 absorbed in nature?



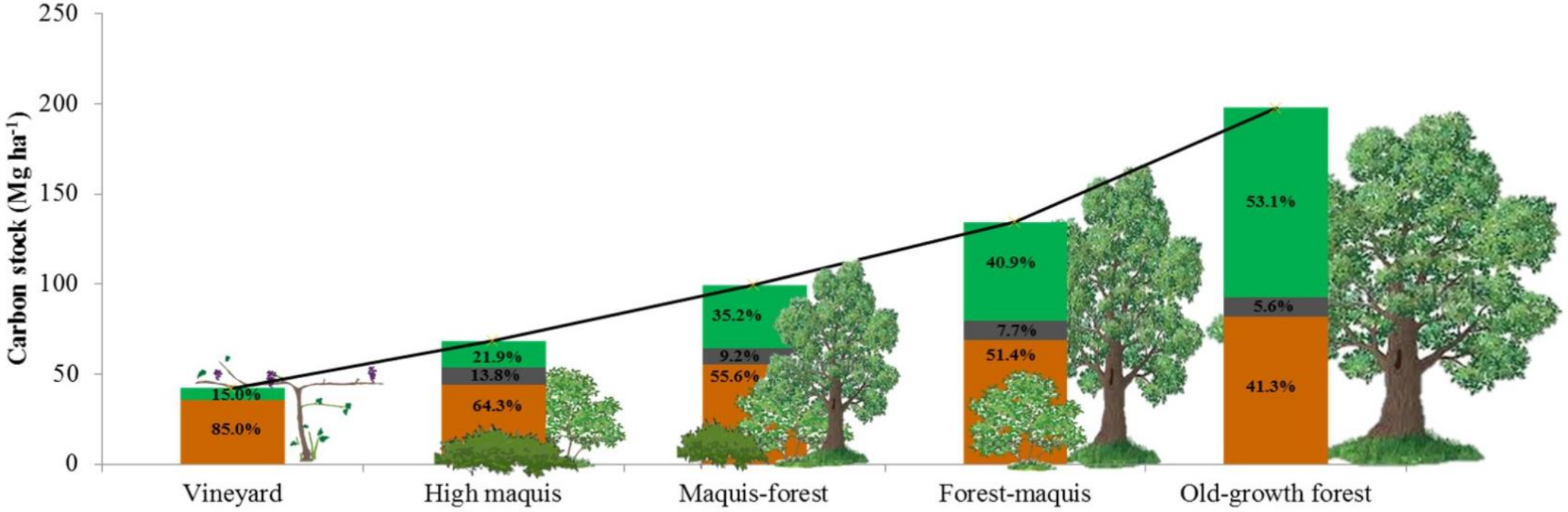


Where is the CO2 absorbed in nature?



Soil contains almost 2X as much carbon as the atmosphere and living flora and animals combined.

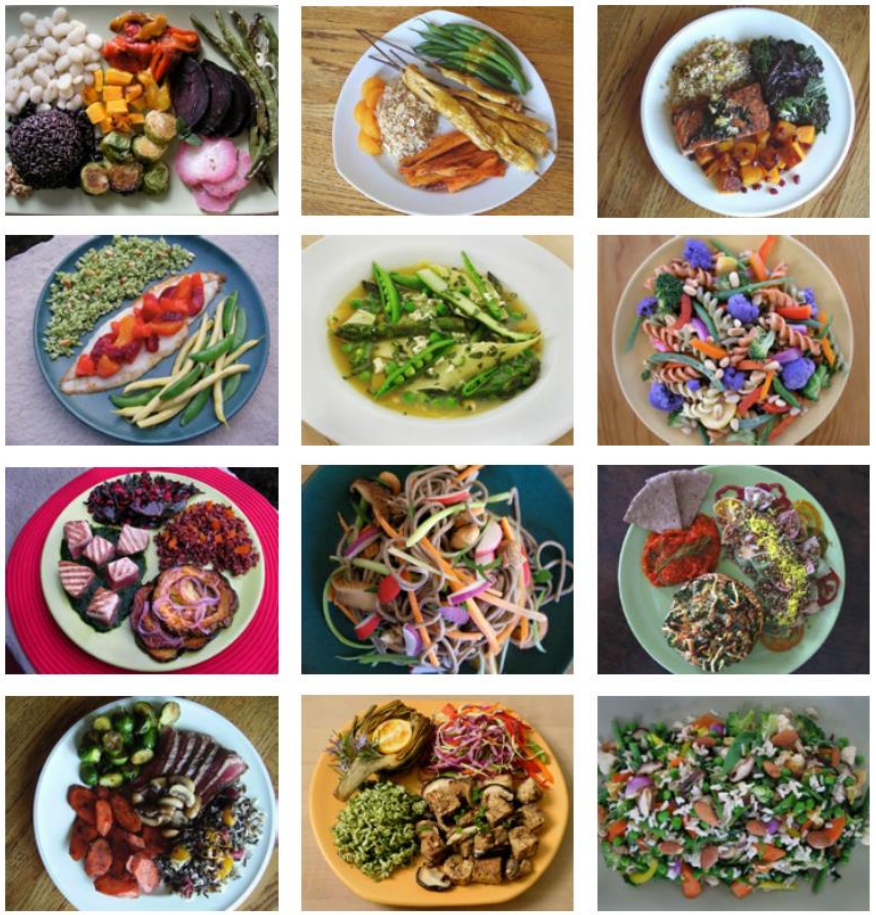
Where is the CO2 absorbed in nature?



Source: Emilio Badalamenti, et.al.: Carbon stock increases up to old growth forest along a secondary succession in Mediterranean island ecosystems

Healthy Diets From Sustainable Food Systems

	Macronutrient intake grams per day (possible range)	Caloric intake kcal per day
Whole grains		
Rice, wheat, corn and other	232	811
Tubers or starchy vegetables		
Potatoes and cassava	50 (0–100)	39
Vegetables		
All vegetables	300 (200–600)	78
Fruits		
All fruits	200 (100–300)	126
Dairy foods		
Whole milk or equivalents	250 (0–500)	153
Protein sources		
Beef, lamb and pork	14 (0–28)	30
Chicken and other poultry	29 (0–58)	62
Eggs	13 (0–25)	19
Fish	28 (0–100)	40
Legumes	75 (0–100)	284
Nuts	50 (0–75)	291
Added fats		
Unsaturated oils	40 (20–80)	354
Saturated oils	11.8 (0-11.8)	96
Added sugars		
All sugars	31 (0–31)	120



Source: The EAT-*Lancet* Commission, 2019

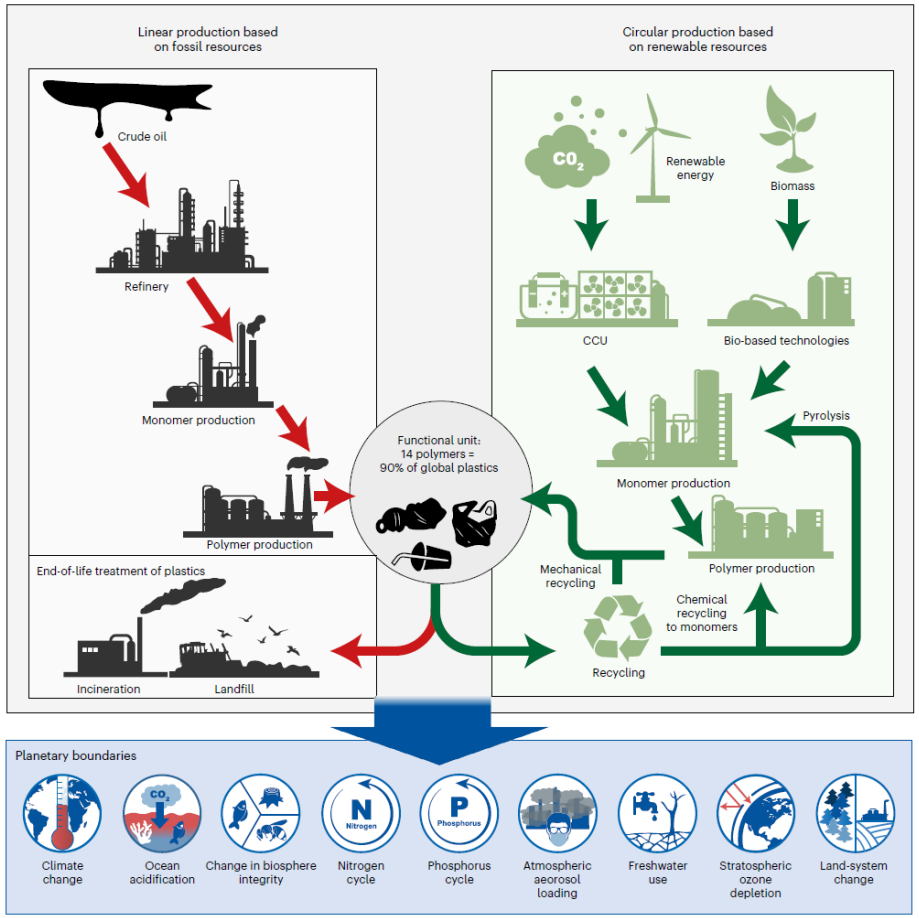
Healthy Diets from Sustainable Food Systems

			GHG emissions	Cropland use	Water use	Nitrogen application	Phosphorus application	Biodiversity loss
Food production boundary			5.0 (4.7–5.4)	13 (11.0–15.0)	2.5 (1.0–4.0)	90 (65.0–140.0)	8 (6.0–16.0)	10 (1–80)
Baseline in 2010			5.2	12.6	1.8	131.8	17.9	100–1000
Production (2050)	Waste (2050)	Diet (2050)						
Busin. as usual	Full waste	**Busin. as usual**	9.8	21.1	3.0	199.5	27.5	1,043
Busin. as usual	Full waste	Dietary shift	5.0	21.1	3.0	191.4	25.5	1,270
Busin. as usual	Halve waste	**Busin. as usual**	9.2	18.2	2.6	171.0	23.2	684
Busin. as usual	Halve waste	Dietary shift	4.5	18.1	2.6	162.6	21.2	885
Impro. produc	Full waste	**Busin. as usual**	8.9	14.8	2.2	187.3	25.5	206
Impro. produc	Full waste	Dietary shift	4.5	14.8	2.2	179.5	24.1	351
Impro. produc	Halve waste	**Busin. as usual**	8.3	12.7	1.9	160.1	21.5	50
Impro. produc	Halve waste	Dietary shift	4.1	12.7	1.9	151.7	20.0	102
+Impro. produc	Full waste	**Busin. as usual**	8.7	13.1	2.2	147.6	16.5	37
+Impro. produc	Full waste	Dietary shift	4.4	12.8	2.1	140.8	15.4	34
+Impro. produc	Halve waste	**Busin. as usual**	8.1	11.3	1.9	128.2	14.2	21
+Impro. produc	Halve waste	Dietary shift	4.0	11.0	1.9	121.3	13.1	19

Control variable	Boundary (Uncertainty range)
GHG emissions	5 Gt CO_2-eq yr^{-1} (4.7 – 5.4 Gt CO2-eq yr^{-1})
Cropland use	13 M km^2 (11–15 M km^2)
Water use	2,500 km^3 yr^{-1} (1000–4000 km^3 yr^{-1})
N application	90 Tg N yr^{-1} (65–90 Tg N yr^{-1}) * (90–130 Tg N yr^{-1})**
P application	8 Tg P yr^{-1} (6–12 Tg P yr^{-1}) * (8–16 Tg P yr^{-1})**
Extinction rate	10 E/MSY (1–80 E/MSY)

Source: The EAT-*Lancet* Commission, 2019

Plastics within planetary boundaries



2030 Share of Operating Space

Scenarios

- Fossil-based
- Biomass
- Carbon Capture and Utilization (CCU) + mix*
- Carbon Capture and Utilization (CCU) + wind

Current recycling rate 23%

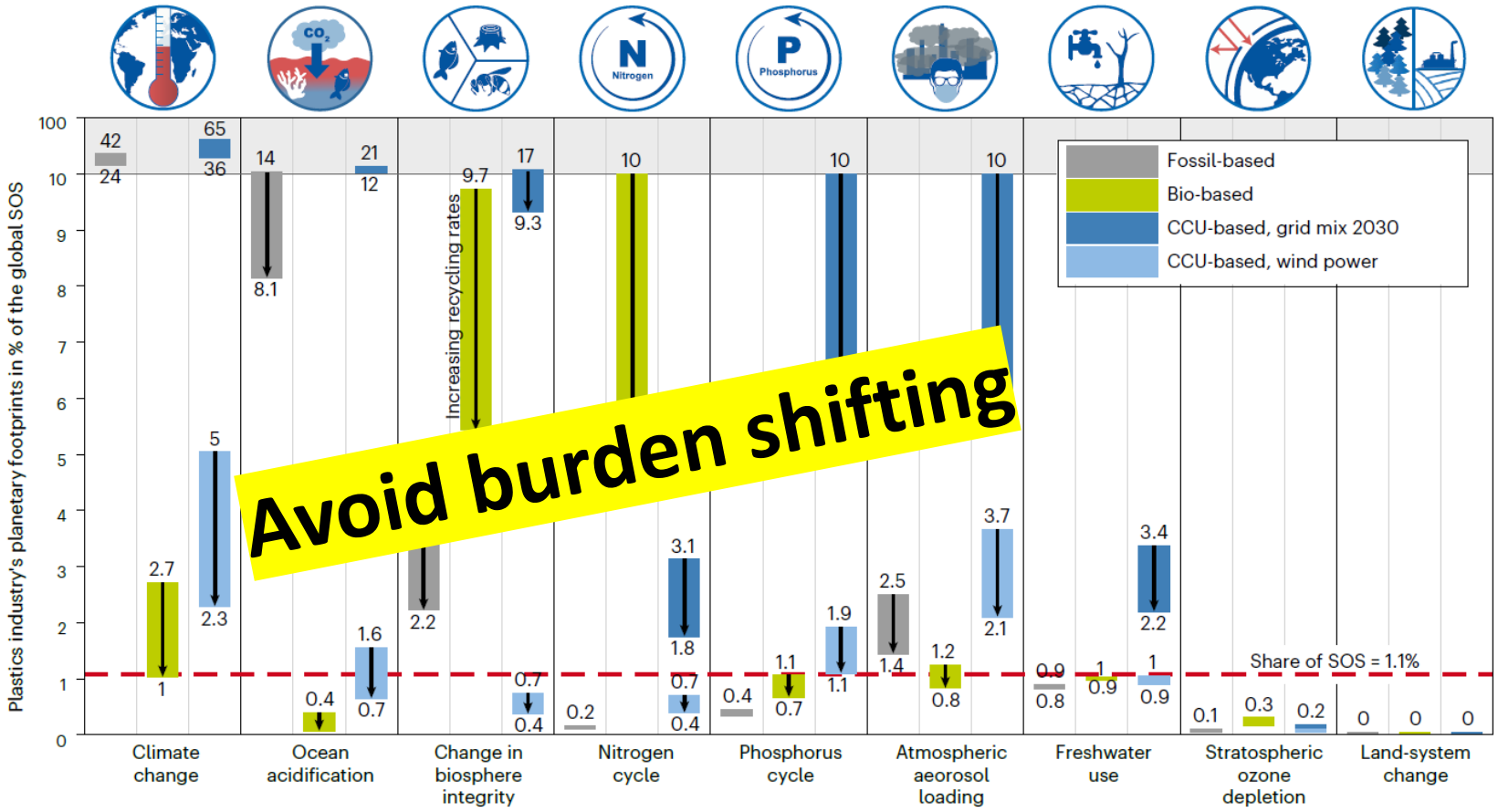
High recycling rate 94%

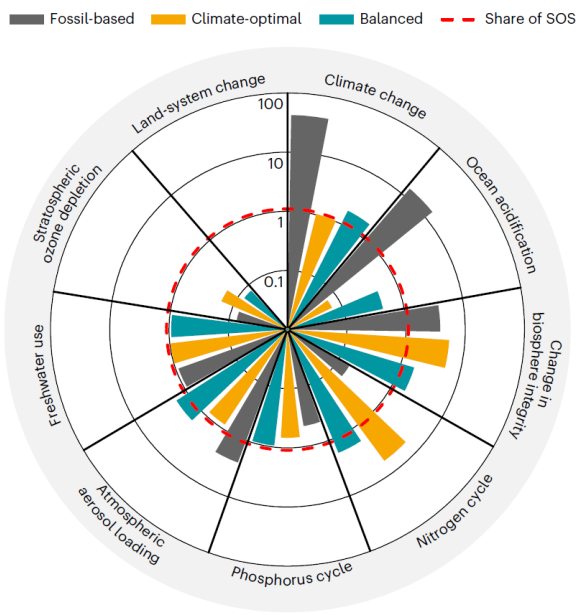
- Mechanical recycling of pure plastic 39%
- Chemical recycling of mixed plastics 55% (pyrolysis)

*Energy Agency Net Zero by 2050 scenario

Source: Marvin Bachmann. et.al, 2022

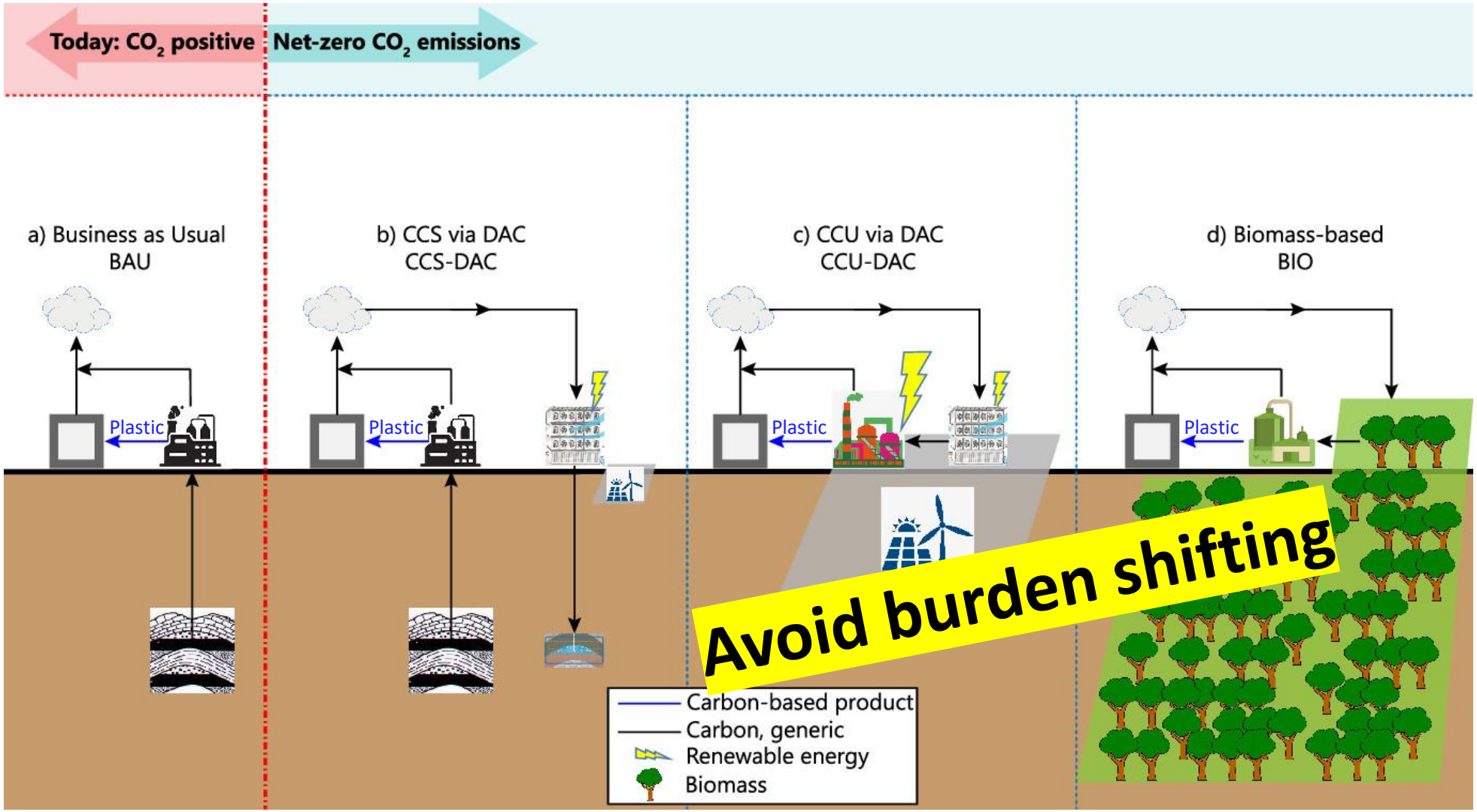
Plastics within planetary boundaries





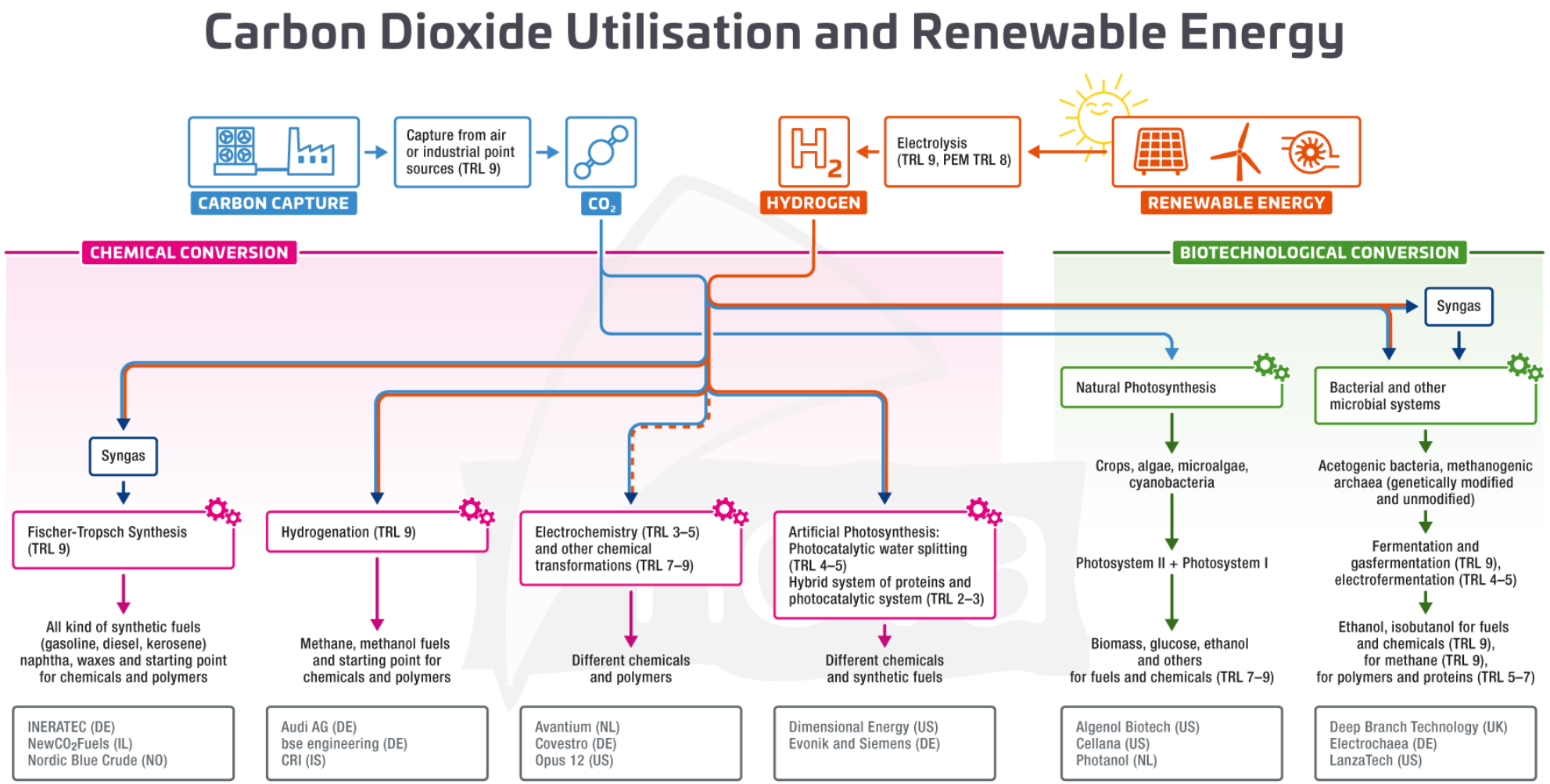
Source: Marvin Bachmann. et.al, 2022

Plastics within planetary boundaries



Source:
Paolo Gabrielli,

Plastics within planetary boundaries



Avoid burden shifting

The future - Two utopic possibilities

To live in harmony with the nature.

To live beside the nature.

To live in harmony with the nature

Hunter-gatherer societies

To live in harmony with the nature

Living remote

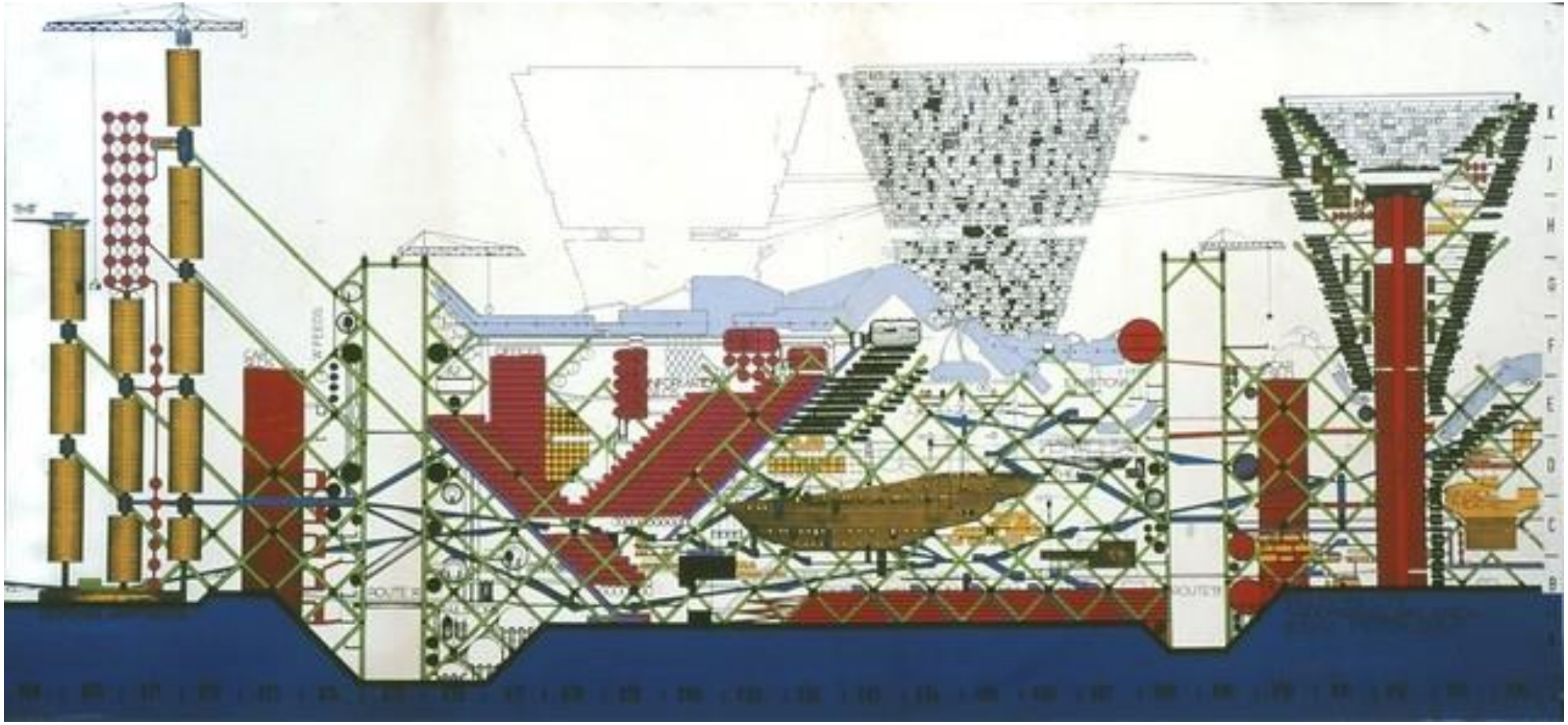
<u>What about?</u>

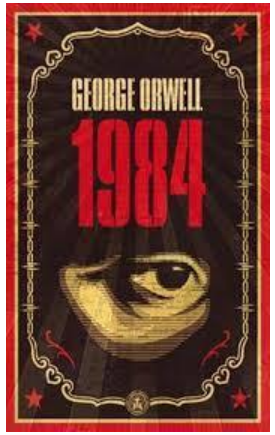
Transportation

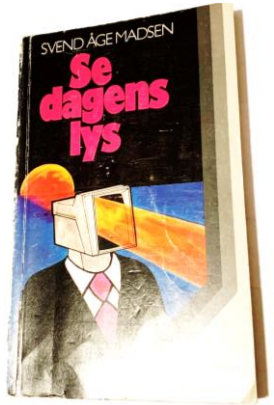
Energy

Sharing

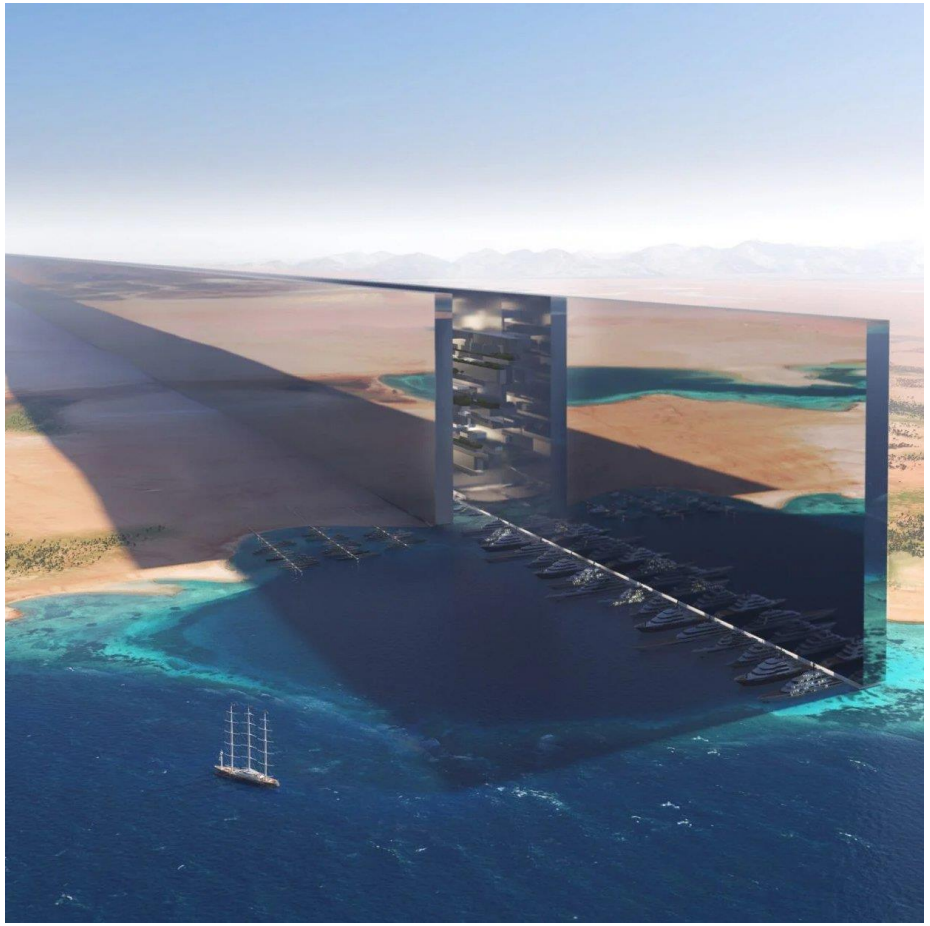
To live beside the nature – Plug in City







To live beside the nature – The Line



UN rights experts denounce planned Saudi executions of megacity opponents

Three members of Huwaitat tribe face execution, reportedly for opposition to Neom project

What about our food?

An estimate by Professor Dickson Despommier: by vertical farming it is possible to produce food for 50.000 person in a New York block (about 80x274m og 30 floors)

Is this indulgence?