System Design for Sustainability

July-October 2023

Week 1

TA: Arti Agarwal

What is Sustainability, why we need to care, characterizing sustainability, examples of designs, systems thinking, intro to PSS design.

What *is* “sustainability”?

“Meeting the needs of the present without compromising the ability of future generations to meet their own needs."

What is unsustainable?

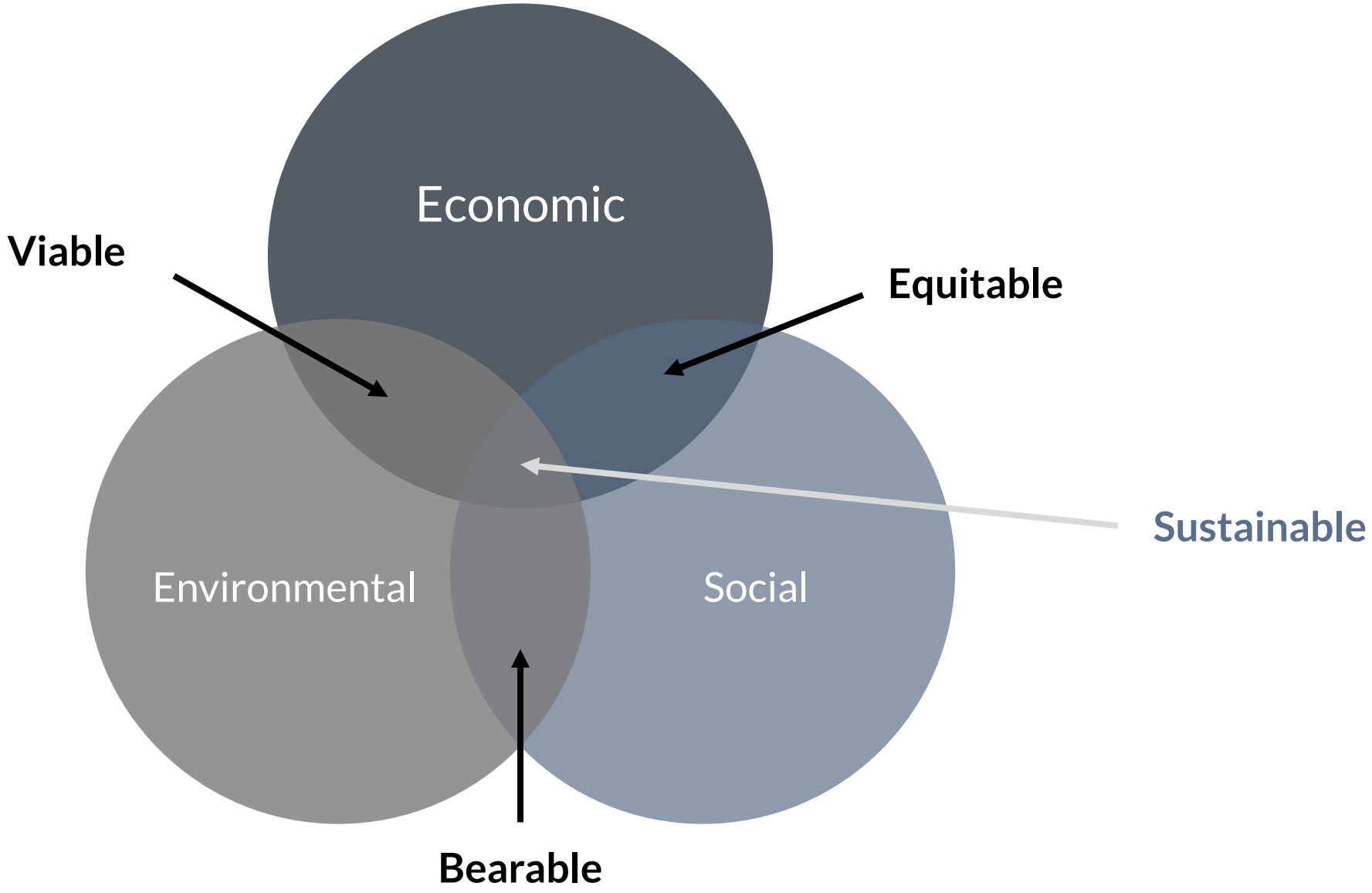
Why do you think designers need to care about sustainability?

The process of design—of a product, say—looks very scrambled and complex, when the question of sustainability arises.

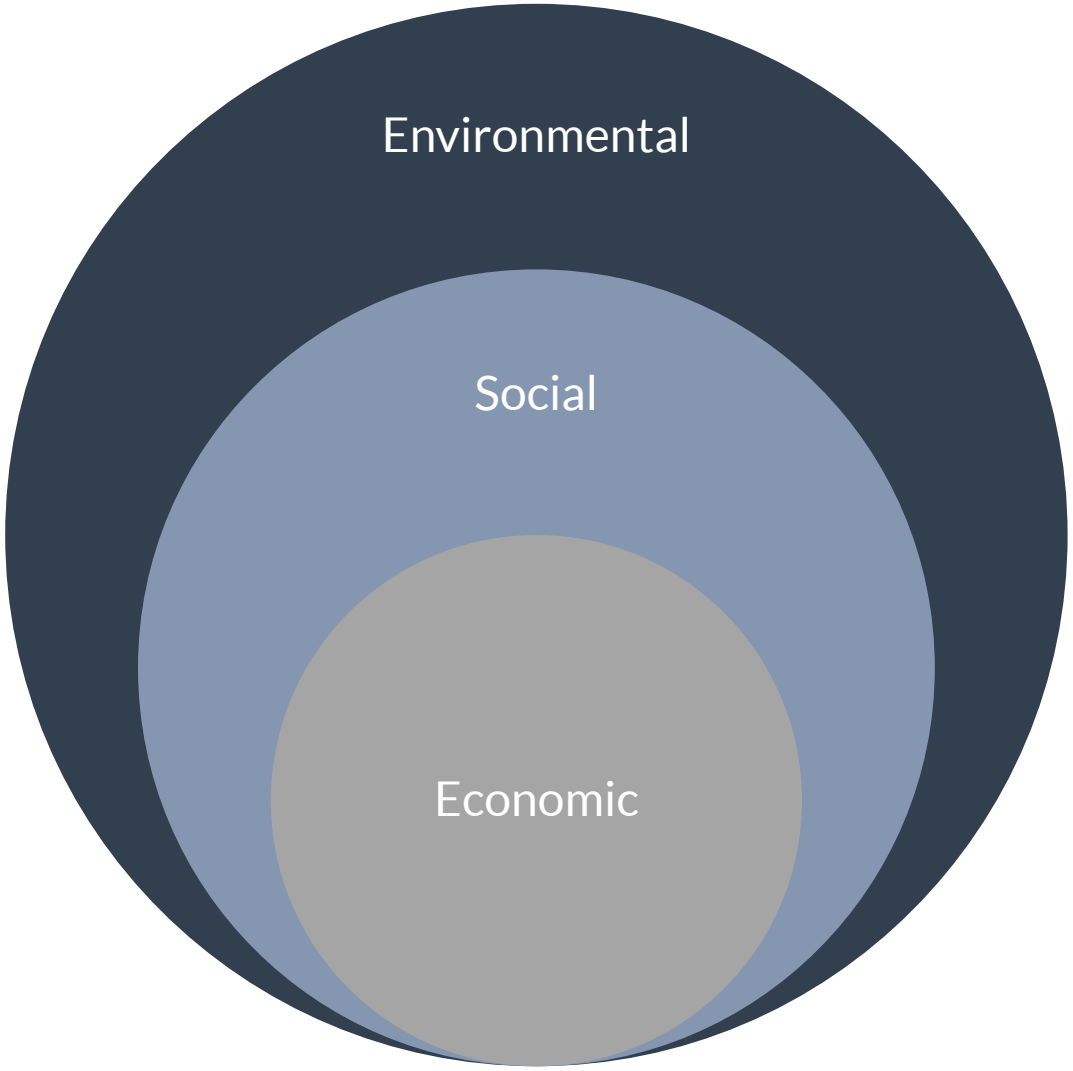
In this course, we learn different methods to "unscramble" the process of design for sustainability.

Sustainability can be assessed on a scale, in a context

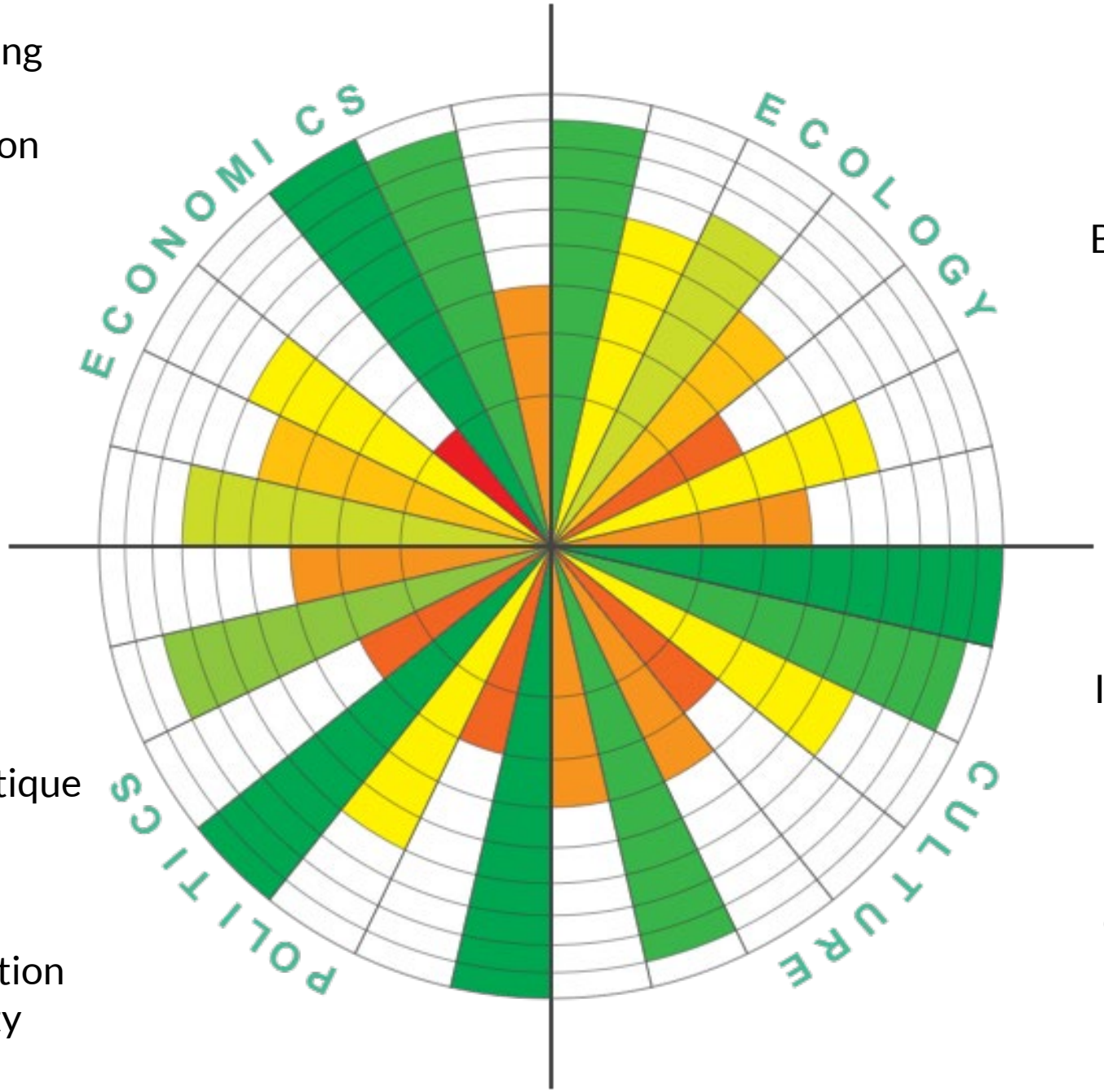
Characterizing sustainability


Economic
Viable
Equitable
Environmental
Social
Sustainable
Bearable

Why does “social” sustainability matter? To whom does it matter?



Production and Resourcing
Exchange and Transfer
Accounting and Regulation
Consumption and Use
Labour and Welfare
Technology and Infrastructure
Wealth and Distribution



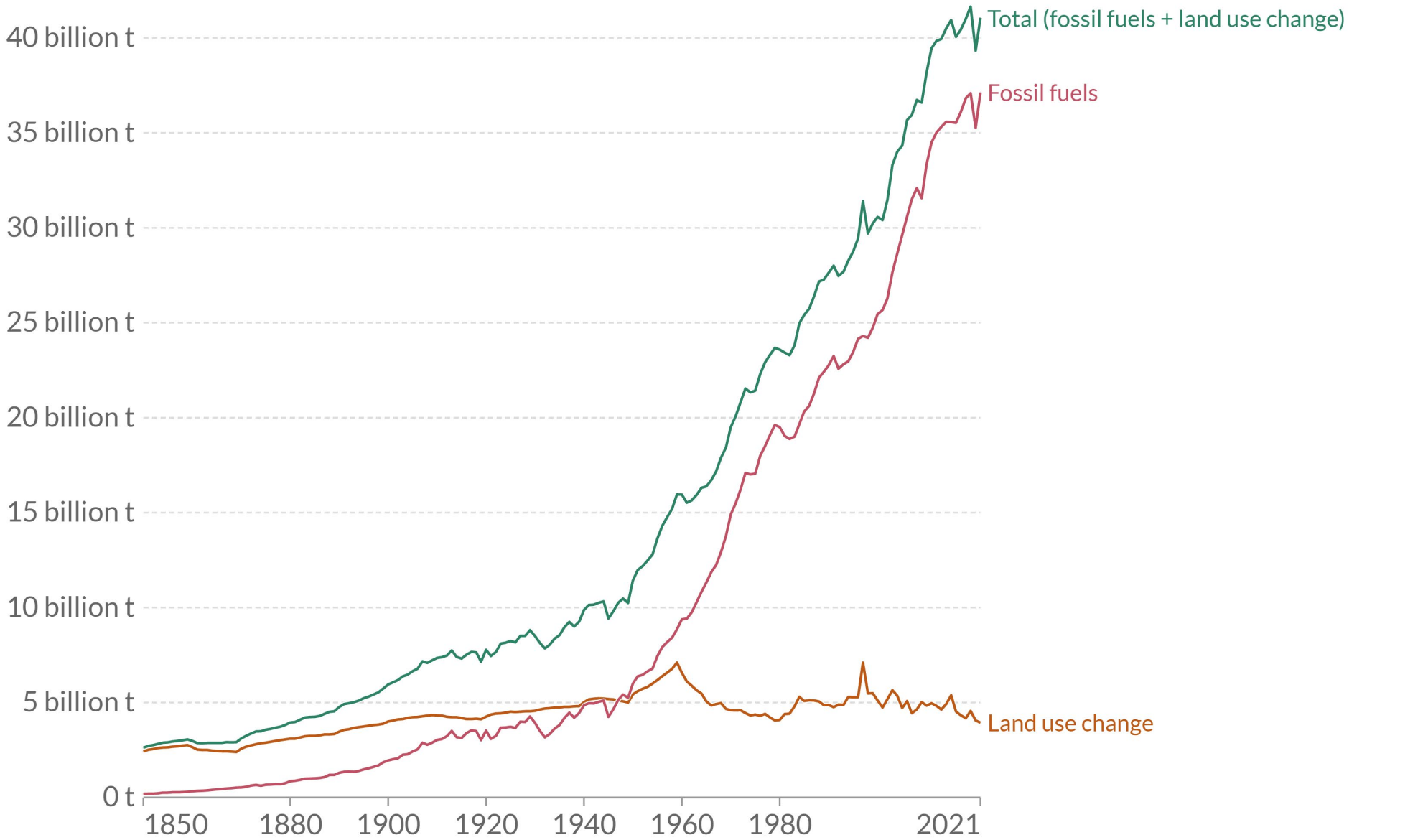
Materials and Energy
Water and Air
Flora and Fauna
Habitat and Settlements
Built-Form and Transport
Embodiment and Sustenance
Emission and Waste

Organization and Governance
Law and Justice
Communication and Critique
Representation and Negotiation
Security and Accord
Dialogue and Reconciliation
Ethics and Accountability

Identity and Engagement
Creativity and Recreation
Memory and Projection
Beliefs and Ideas
Gender and Generations
Enquiry and Learning
Wellbeing and Health

Why do we need to care about sustainability *now*?

Global CO_2 emissions from fossil fuels and land use change, World

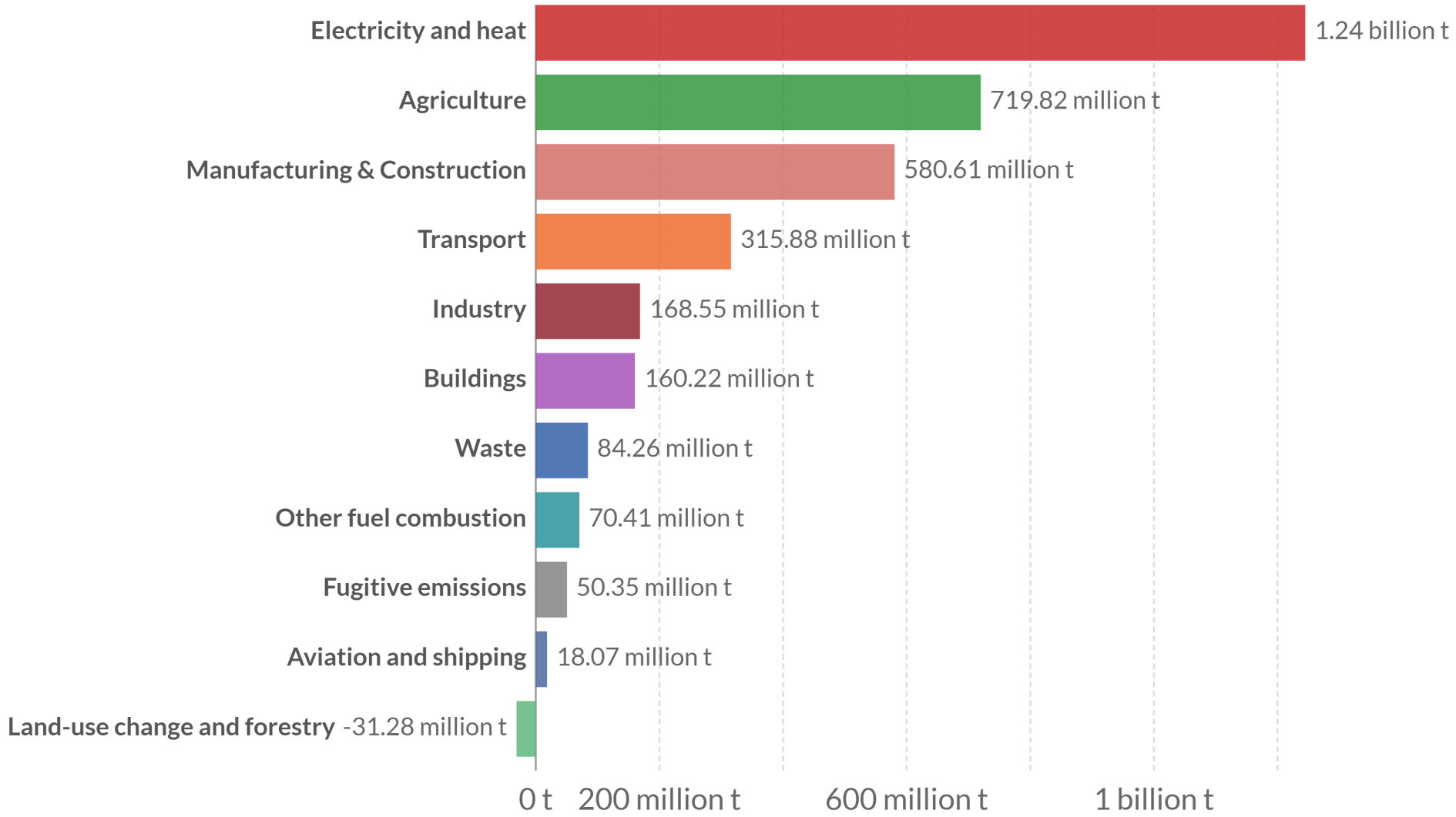


Source: Our World in Data based on the Global Carbon Project (2022)

OurWorldInData.org/co2-and-other-greenhouse-gas-emissions • CC BY

Greenhouse gas emissions by sector, India, 2019

Emissions are measured in carbon dioxide equivalents (CO2eq). This means non-CO2 gases are weighted by the amount of warming they cause over a 100-year timescale.

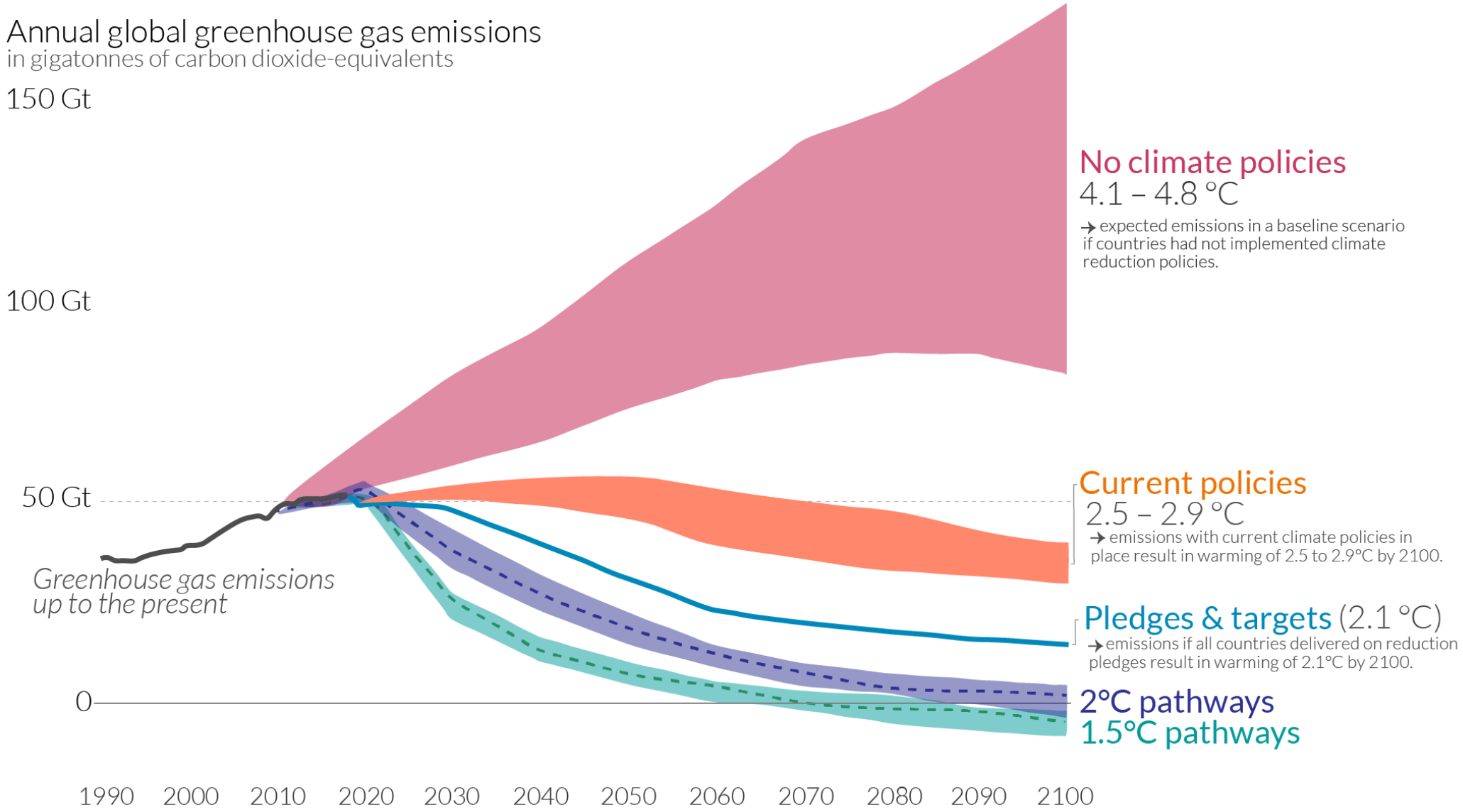


Source: Our World in Data based on Climate Analysis Indicators Tool (CAIT).
OurWorldInData.org/co2-and-other-greenhouse-gas-emissions • CC BY

Global greenhouse gas emissions and warming scenarios

Our World in Data

– Each pathway comes with uncertainty, marked by the shading from low to high emissions under each scenario.
– Warming refers to the expected global temperature rise by 2100, relative to pre-industrial temperatures.

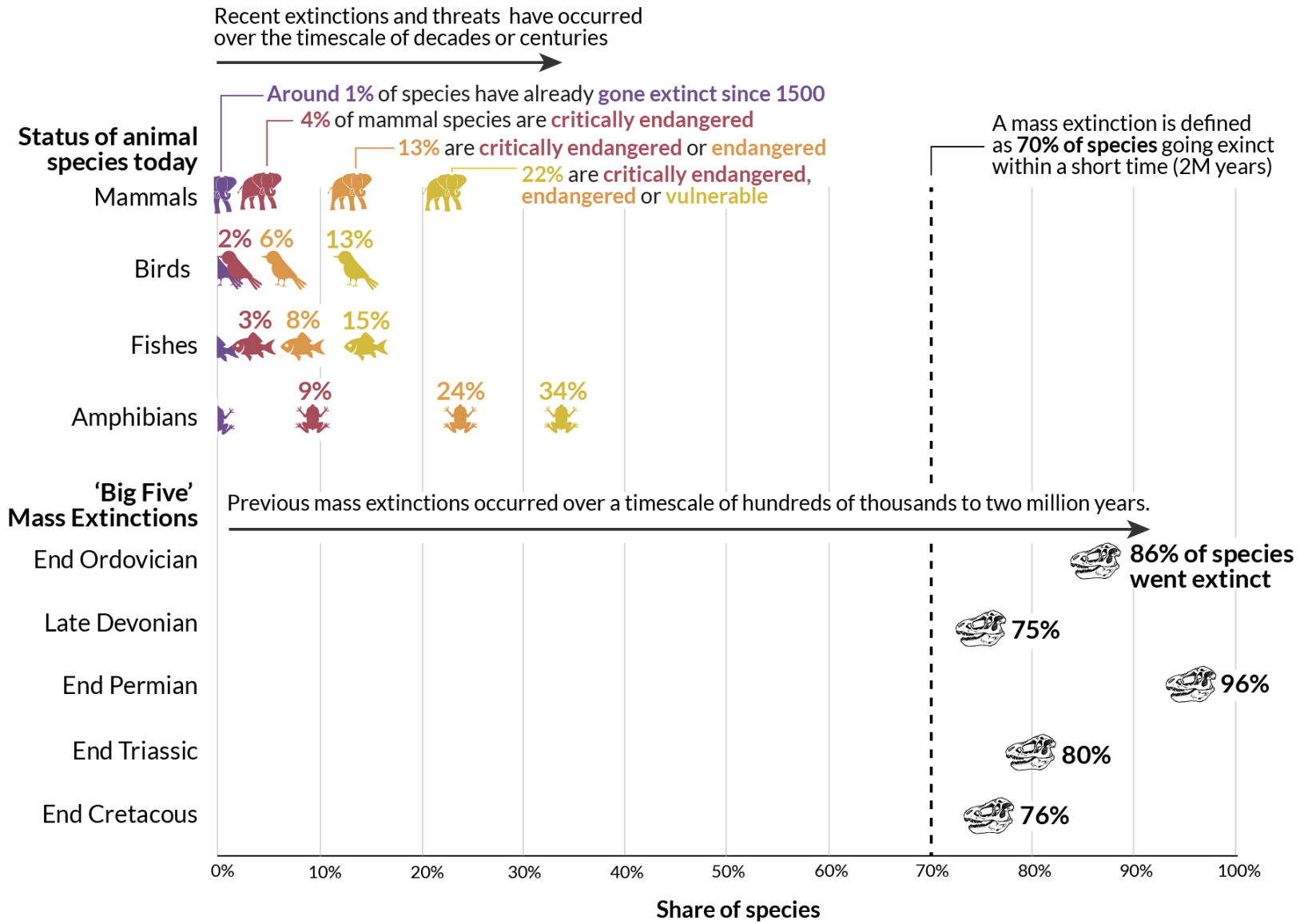


Data source: Climate Action Tracker (based on national policies and pledges as of November 2021).
OurWorldinData.org – Research and data to make progress against the world's largest problems.

How far are we from a sixth mass extinction?

Shown is the share of assessed animal species that have gone extinct or are threatened with extinction today, relative to the share of species that went extinct in previous mass extinction events.
This is only shown for species in vertebrate groups where more than 80% of known species have been assessed for their extinction risk.

Our World in Data

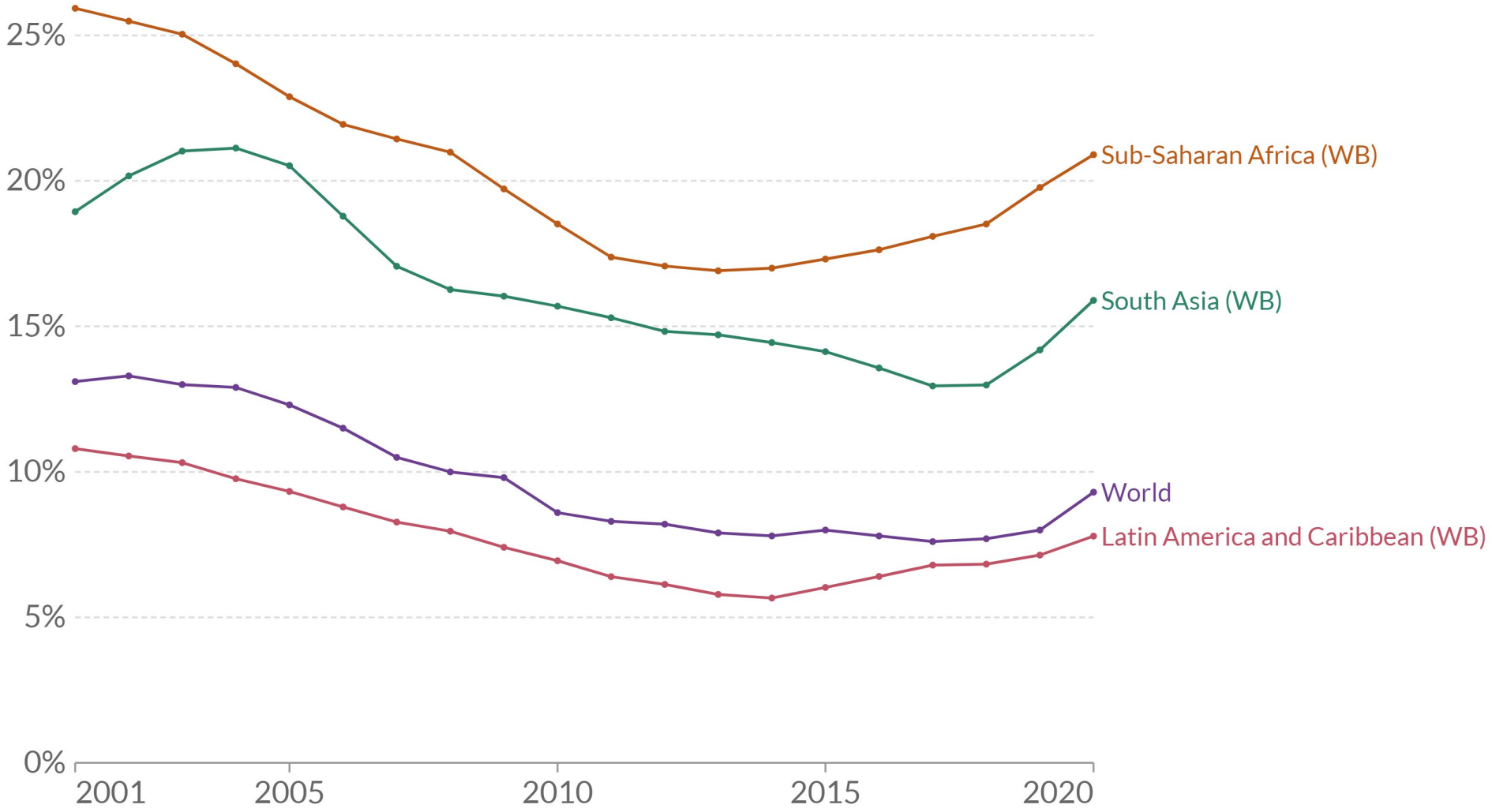


Data Sources: Barnosky et al. (2011). Has the Earth's sixth mass extinction already arrived? *Nature*. Threatened species from IUCN Red List (2021). Images sourced from Noun Project.

Share of the population that is undernourished

Share of individuals that have a daily food intake that is insufficient to provide the amount of dietary energy required to maintain a normal, active, and healthy life.

Our World in Data

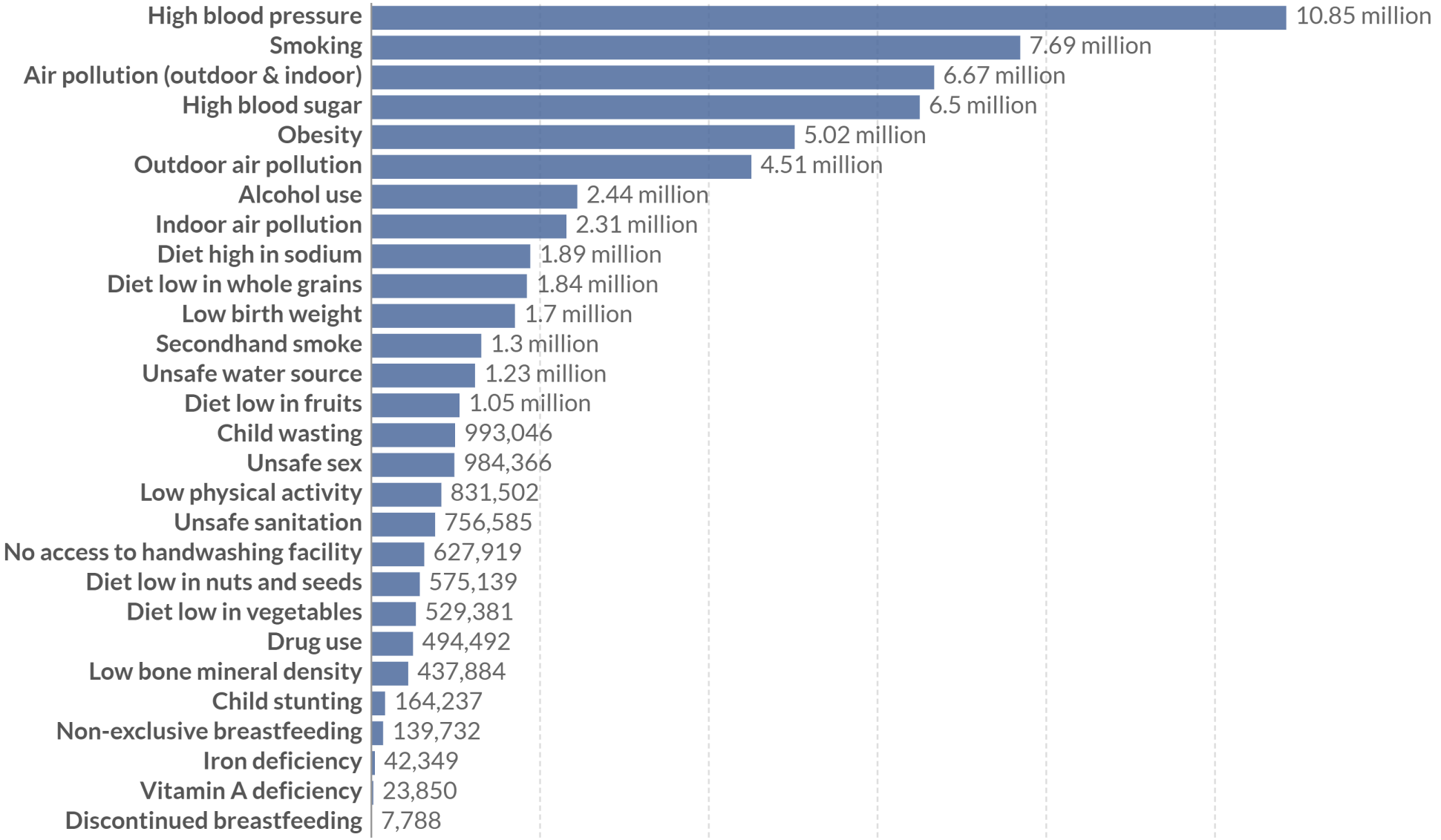


Source: Food and Agriculture Organization of the United Nations (via World Bank)
Note: Countries and regions with rates below 2.5% are coded as "2.5%" in the FAO dataset.
OurWorldInData.org/hunger-and-undernourishment • CC BY

Number of deaths by risk factor, World, 2019

The estimated number of deaths caused by each risk factor.

Our World in Data

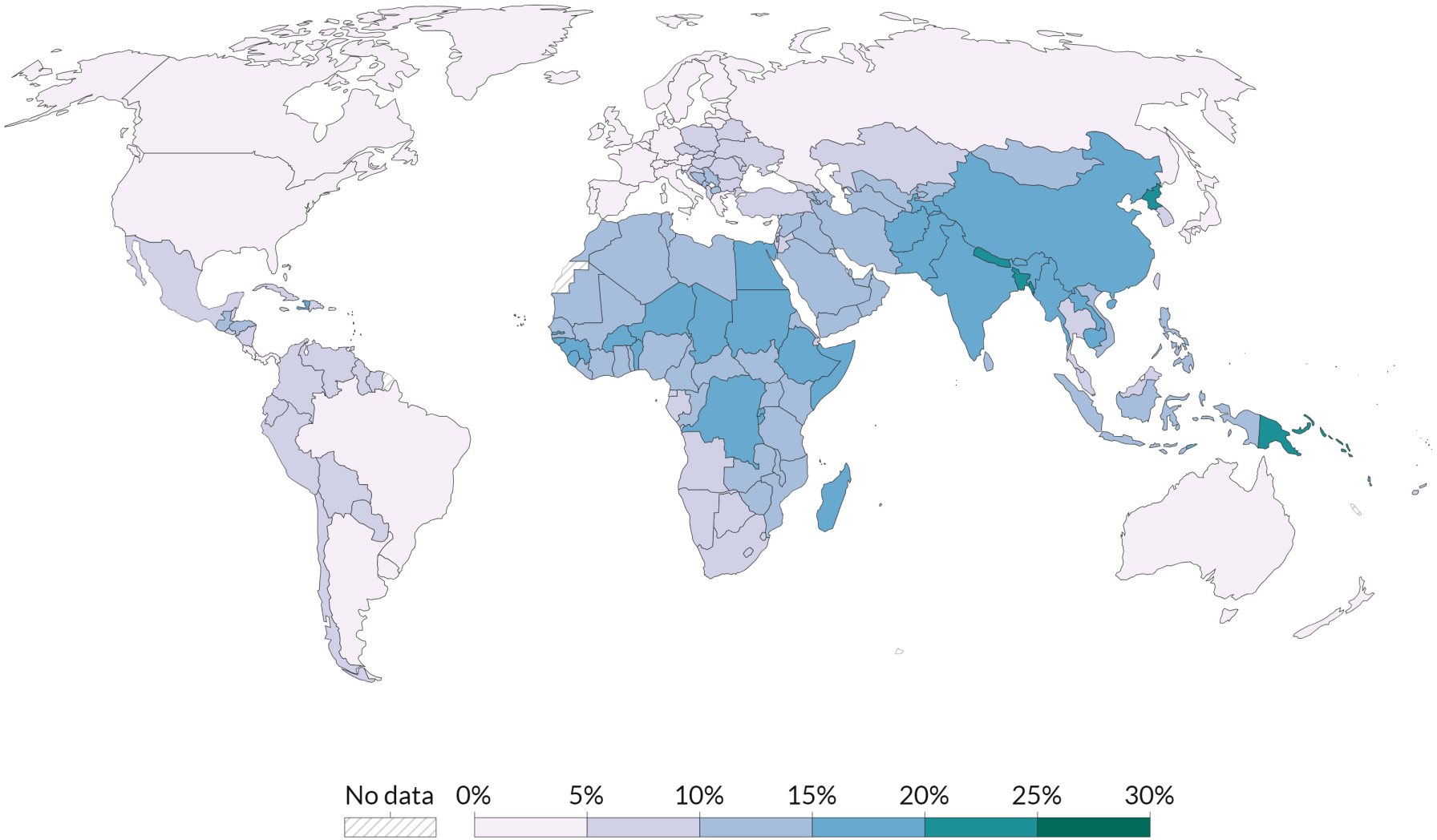


Source: IHME, Global Burden of Disease (2019)

Share of deaths attributed to air pollution, 2019

Share of deaths, from any cause, which are attributed to air pollution – from outdoor and indoor sources – as a risk factor.

Our World in Data

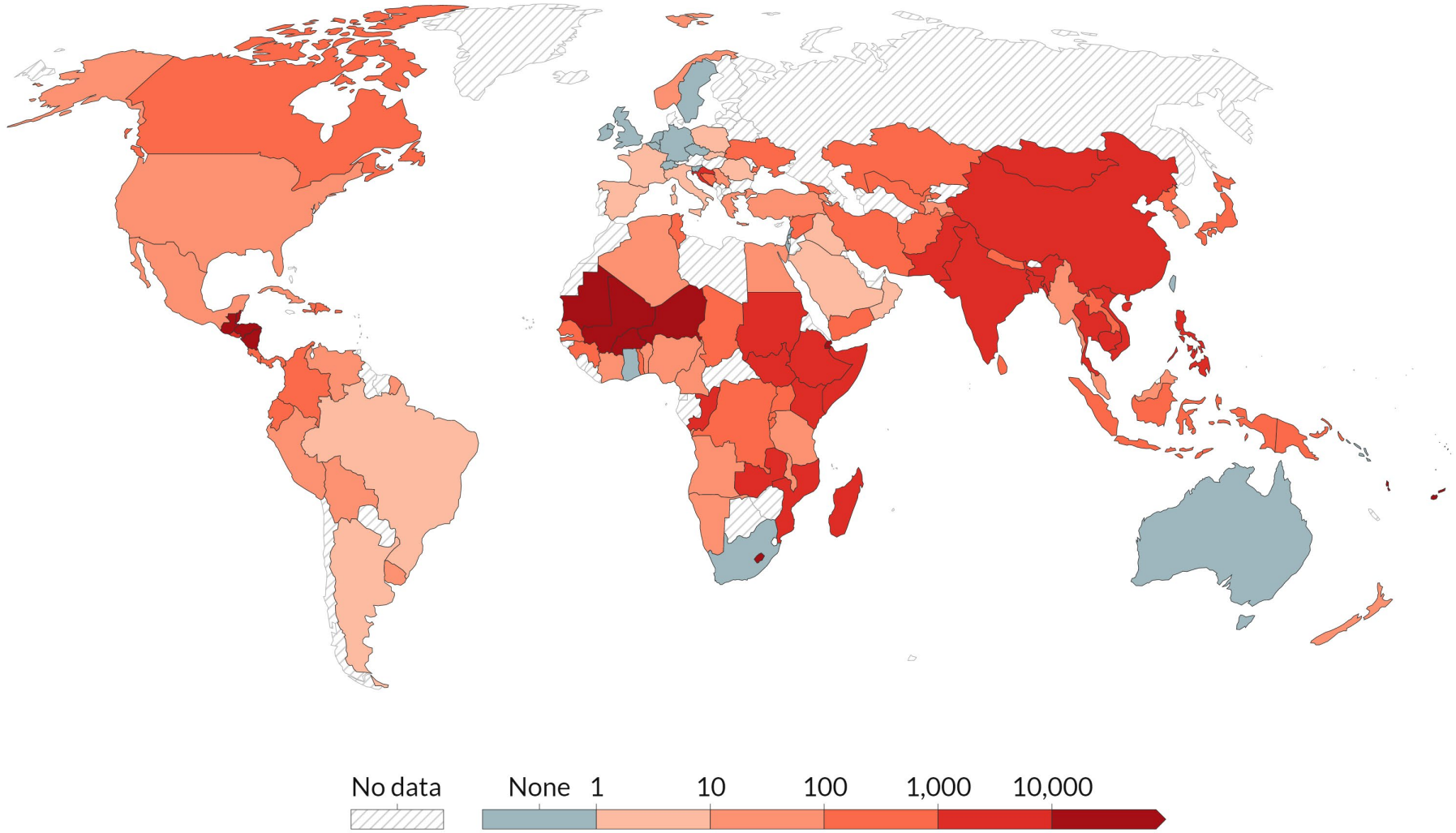


Source: IHME, Global Burden of Disease (2019)

Number of people affected by disasters per 100,000, 2020

Our World in Data

Disasters include all geophysical, meteorological and climate events including earthquakes, volcanic activity, landslides, drought, wildfires, storms, and flooding. People affected are those requiring immediate assistance during an emergency situation.



Source: Our World in Data based on EM-DAT, CRED / UCLouvain, Brussels, Belgium – www.emdat.be (D. Guha-Sapir)

Eg: Blue Economy

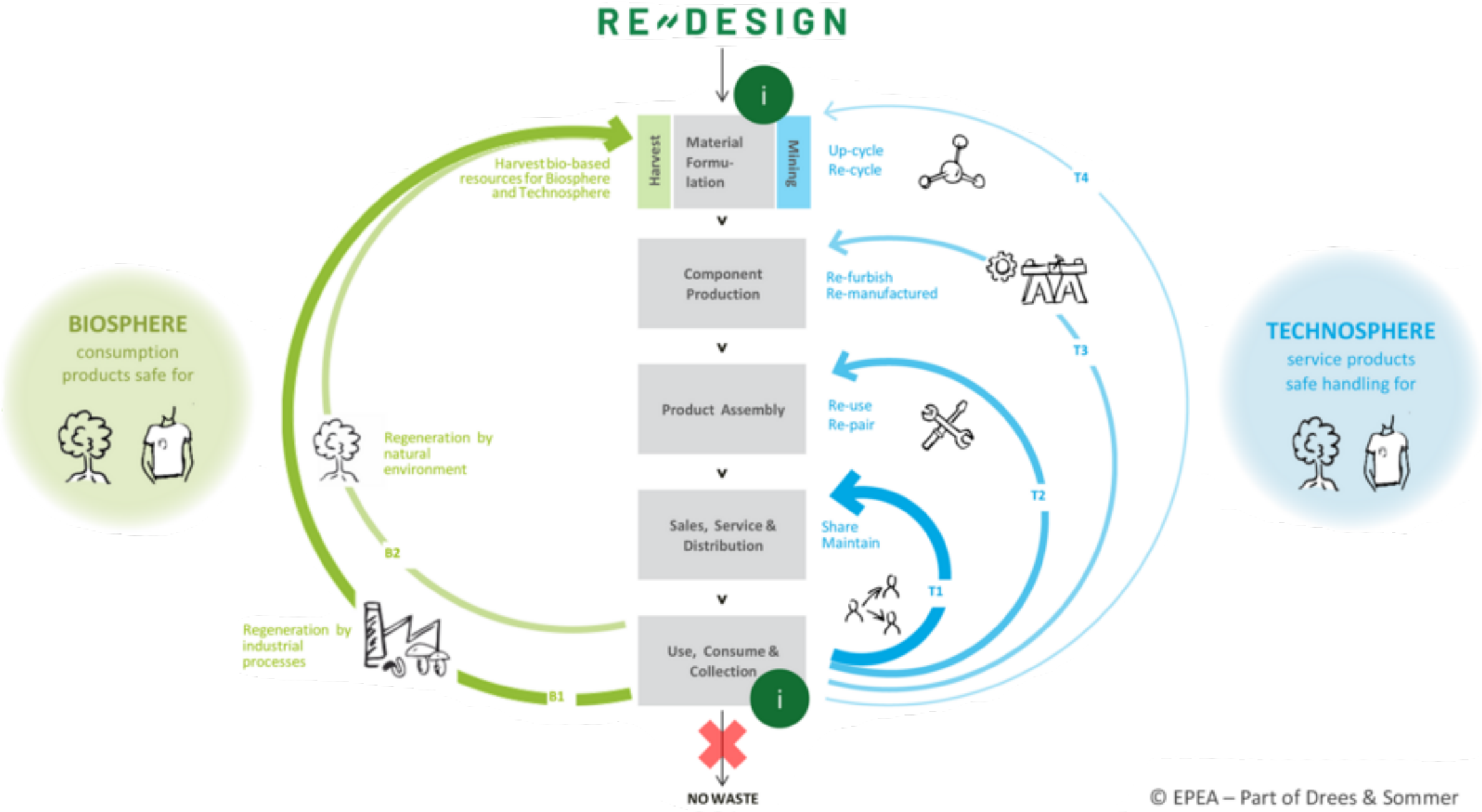
Cradle to Cradle Design

Cradle to Cradle Design is a sustainable design philosophy that aims to create products that can be continuously reused and recycled without any loss of quality.

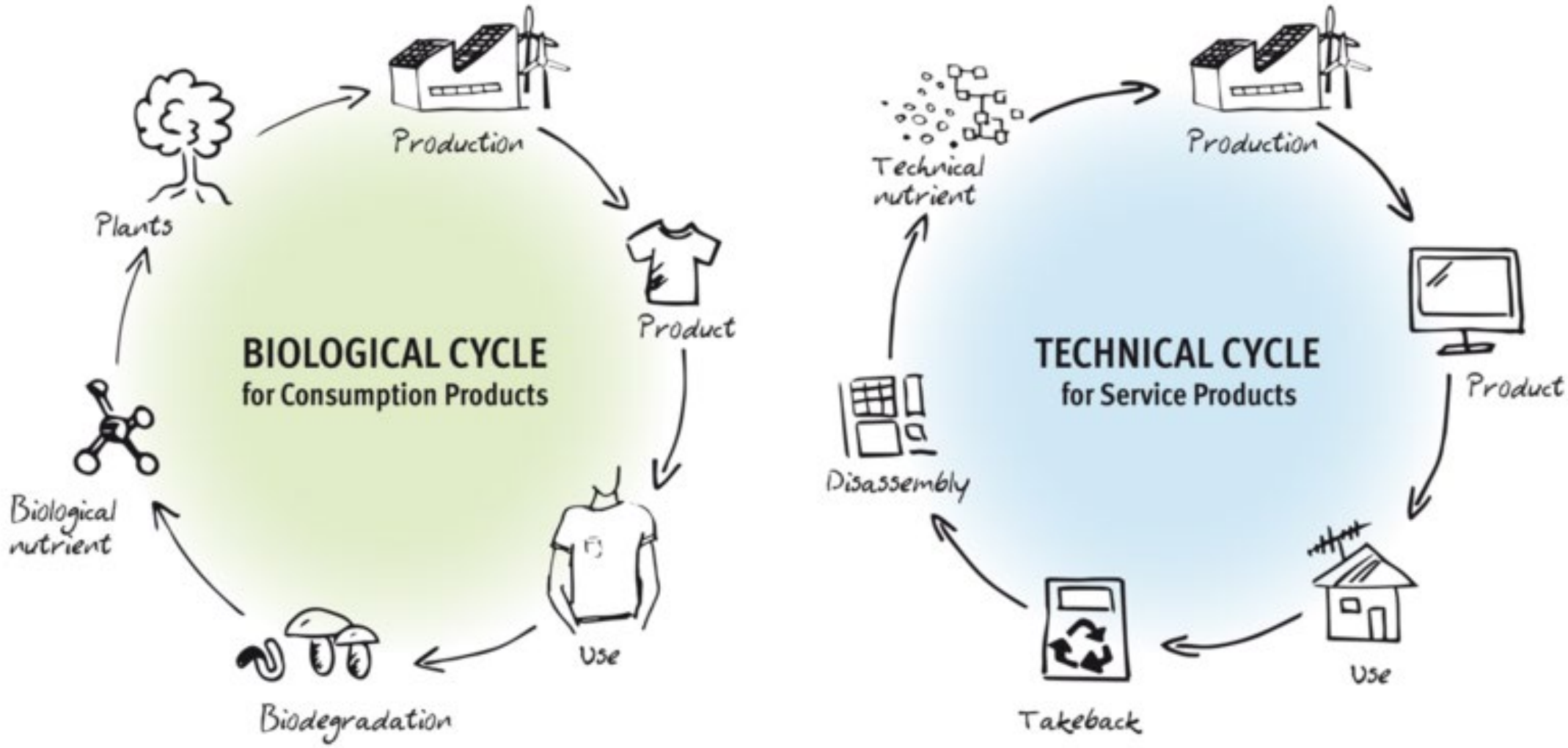
Cradle to Cradle Design

It mimics nature’s ways (biomimetic) and tries to replicate them in design.

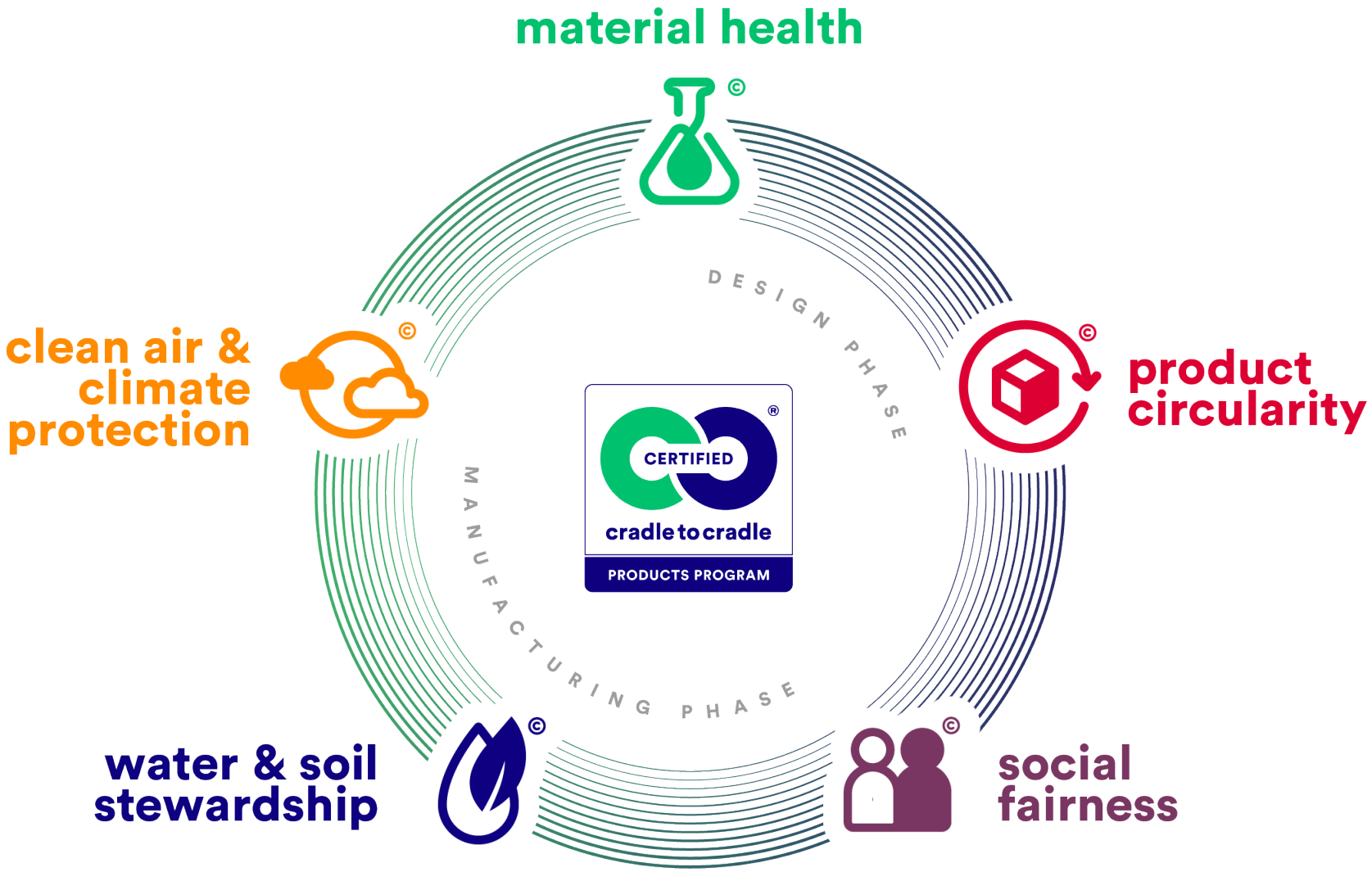
- Cradle to Cradle describes the safe and potentially infinite circulation of materials and nutrients in cycles.
- Consumables like natural fibres, cleaning agents or biodegradable packaging circulate in a biological cycle to which they can be safely reintroduced after use.
- Consumer goods such as electronic items or flooring circulate in a technical cycle.


RE-DESIGN
BIOSPHERE
consumption
products safe for
TECHNOSPHERE
service products
safe handling for
Harvest
Material
Formu-
lation
Mining
Component
Production
Product Assembly
Sales, Service &
Distribution
Use, Consume &
Collection
Harvest bio-based
resources for Biosphere
and Technosphere
Regeneration by
natural
environment
Regeneration by
industrial
processes
B2
B1
Up-cycle
Re-cycle
Re-furbish
Re-manufactured
Re-use
Re-pair
Share
Maintain
T4
T3
T2
T1
NO WASTE
© EPEA – Part of Drees & Sommer

Cradle to Cradle Design



Cradle to Cradle Design Certification Standards



Systems Thinking

"Systems thinking is an approach that designers use to analyze problems in an appropriate context. By looking beyond apparent problems to consider a system as a whole, designers can expose root causes and avoid merely treating symptoms. They can then tackle deeper problems and be more likely to find effective solutions."---***Interaction Design Foundation***

Origins of Systems Thinking

- Developed by Prof Jay Forrester at MIT in 1950s.
- Has its origins in the control theory.
- Has wide applications in every field.
- Since designers solve complex problems which are inherently embedded in systems, it makes sense to use systems thinking for design.

What is a “System”?

"A system is a set of **interdependent parts** sharing a common **purpose.**

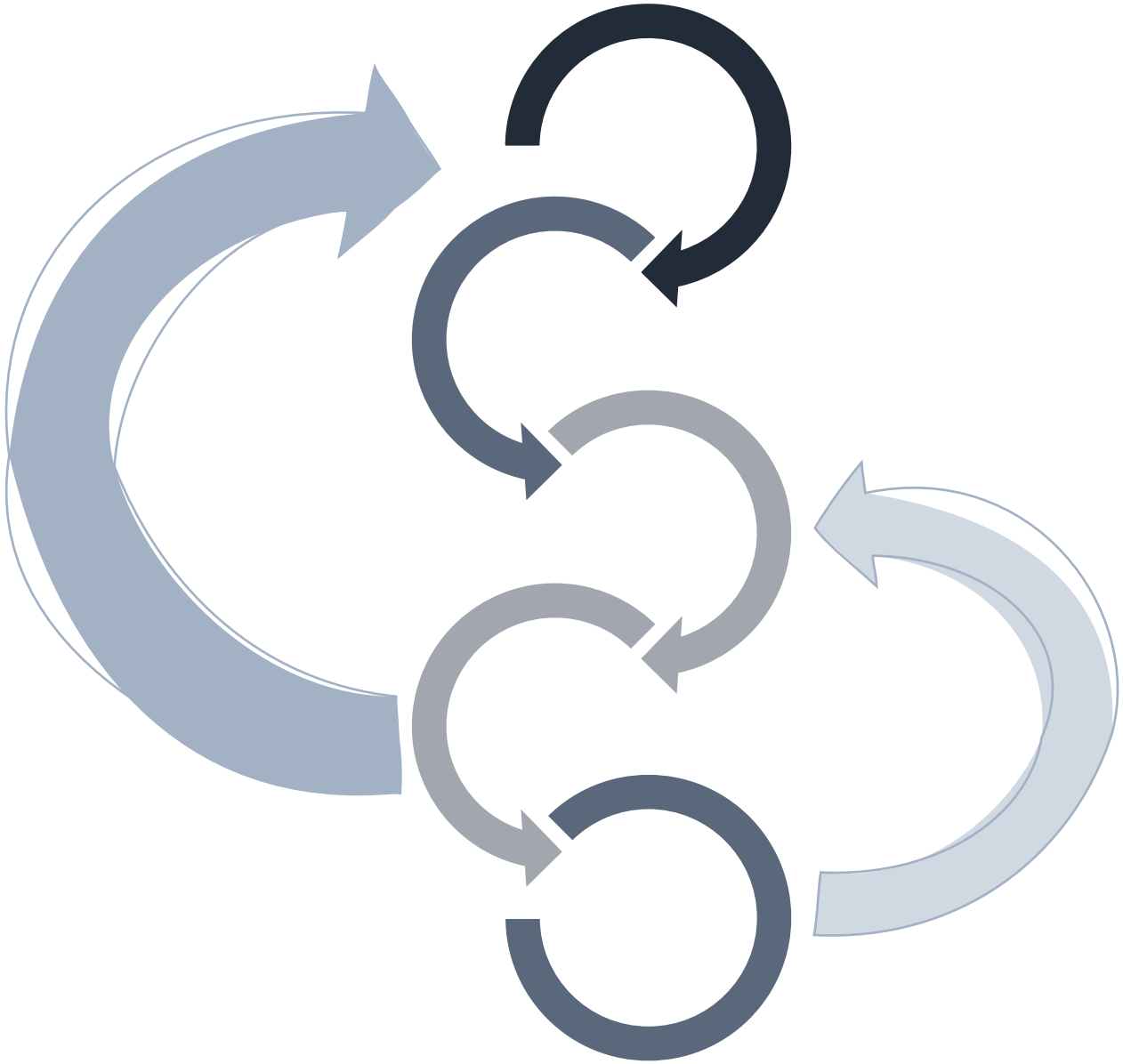
The performance of the whole is affected by each and every one of its parts.”—Prof James Paine, MIT.

Features of a System

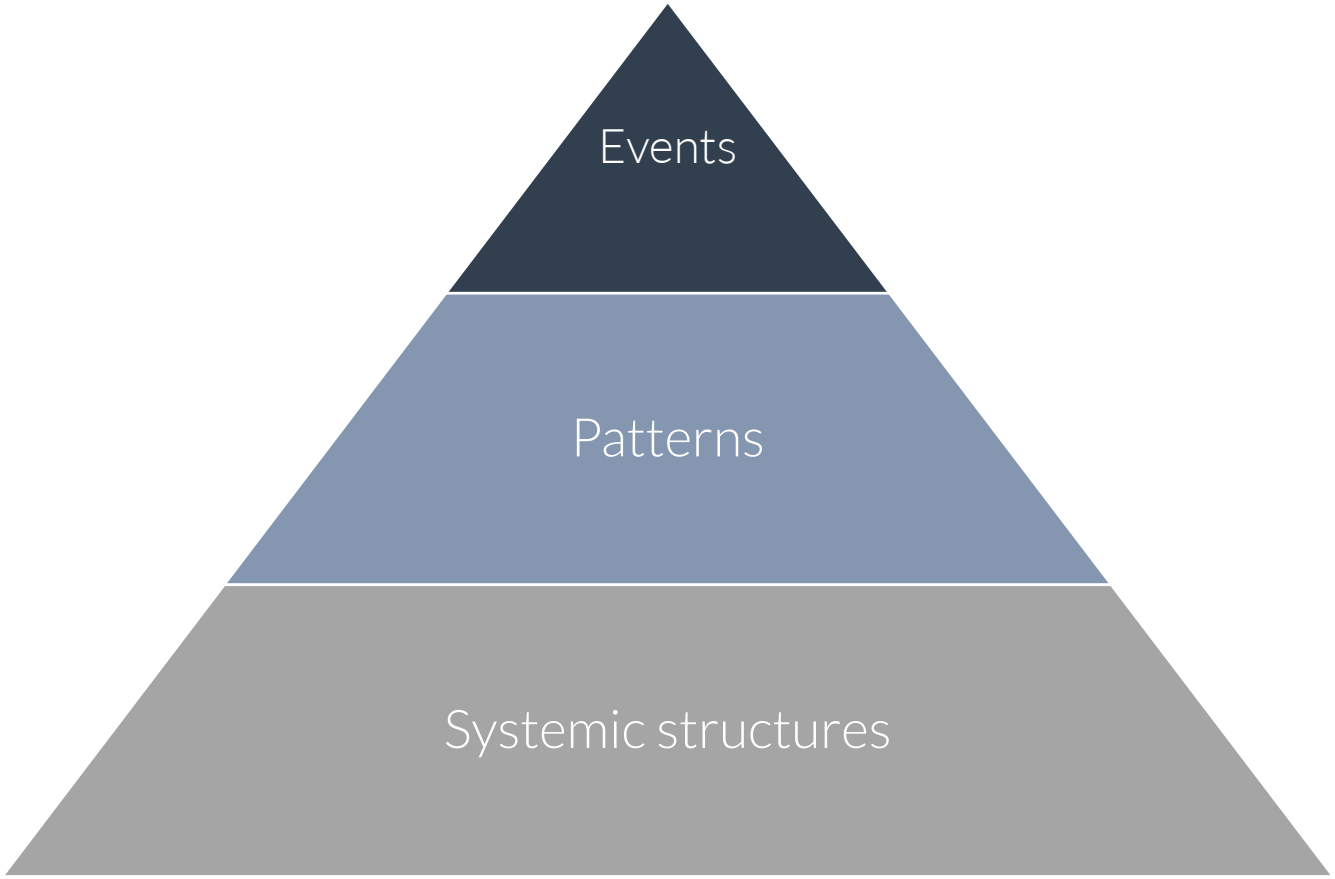
Not every collection of parts is a "system." Systems have some defining characteristics:

- Systems have a purpose.
- All parts must be inter-related and inter-dependent.
- All parts must be present for the system to function.
- The order of the parts of the system matters for its function.
- Systems attempt to maintain stability through feedback.

A system is more than the sum of its parts.



Iceberg Principle of a System

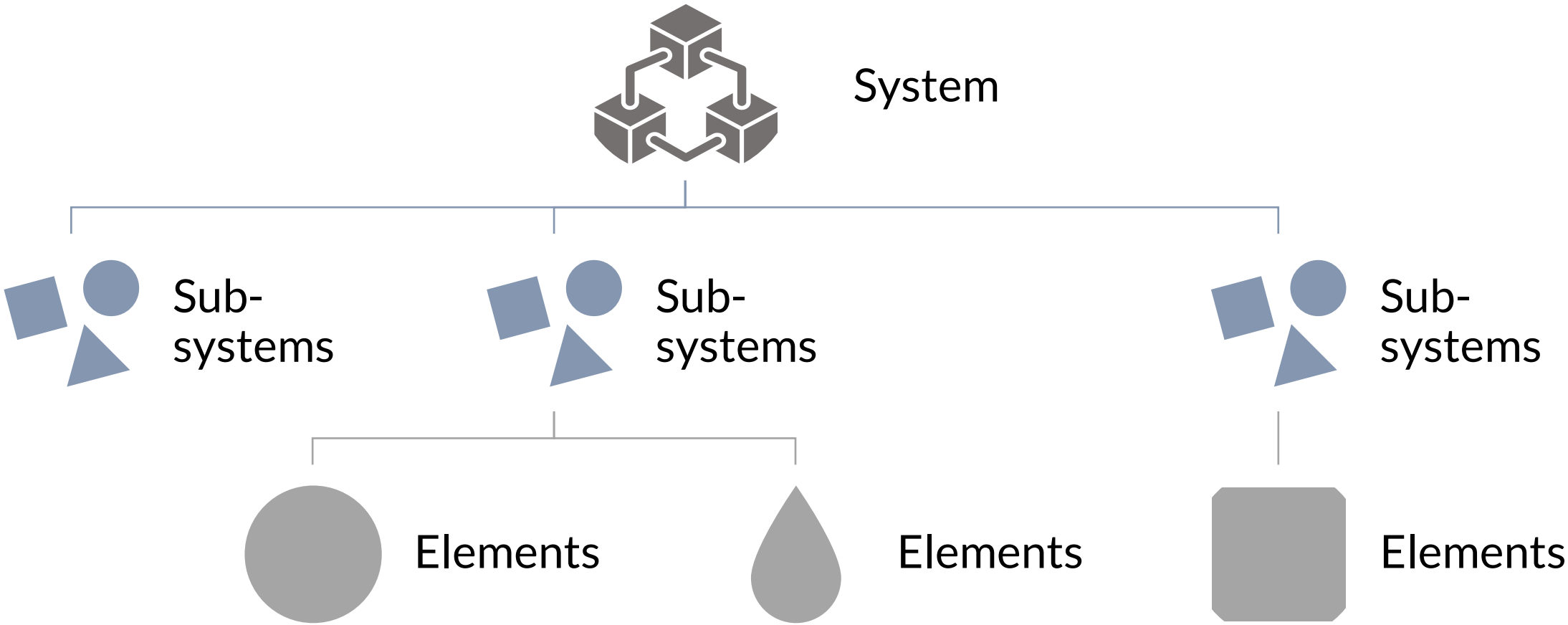


- Events are happenings we see every day.
- Patterns are accumulated "memories" of events.
- Systemic structures are ways in which parts of a system are organized.

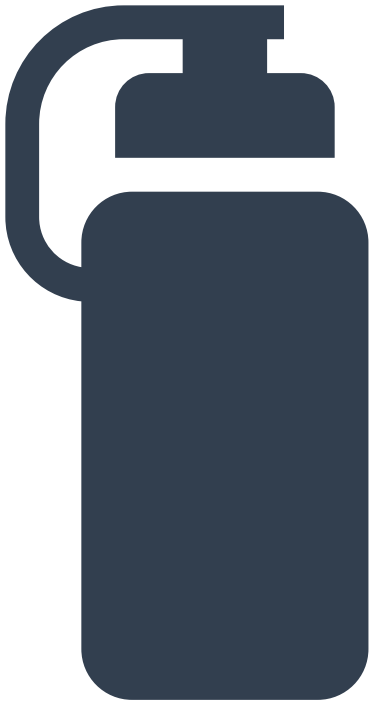
Types of Systems

- Natural Systems
- Environmental and Ecology Systems
- Organizational Systems
- Social Systems
- Engineered and Physical Systems
- Sociotechnical Systems
- Interactive Systems
- Information Systems

System Hierarchy

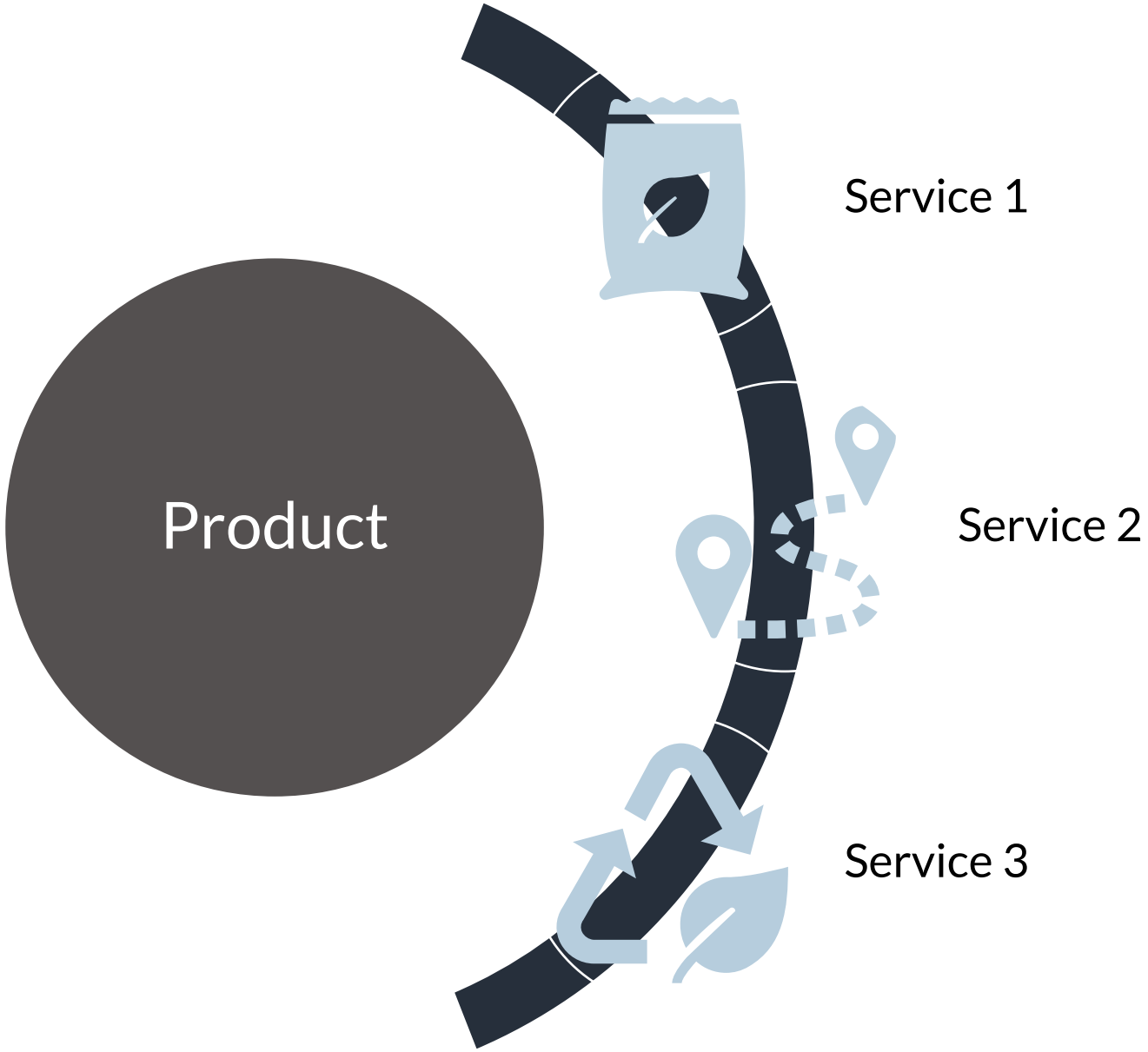


Hierarchy of An Insulated Water Bottle System



- System: the bottle
- Sub-systems:
  - **Cap**
    - Insulation ring
    - Sipper
    - Closing ring
  - **Body**
    - Outer wall
    - Inner wall
    - Insulating material
  - **Connector** (if any)

What Is a Product-Service System?


Product
Service 1
Service 2
Service 3

How can a Product-Service System be more sustainable?


OUR GOAL IS TO SHIP A MILLION UNITS THIS QUARTER.
DO WE HAVE ANY GOALS THAT INVOLVE MAKING CUSTOMERS HAPPY?
I'M TALKING ABOUT OUR GOALS, NOT THEIR GOALS.
TOTALLY DIFFERENT.
Dilbert.com DilbertCartoonist@gmail.com
3-25-14 ©2014 Scott Adams, Inc./Dist. by Universal Uclick

Systems Thinking applied to PSS