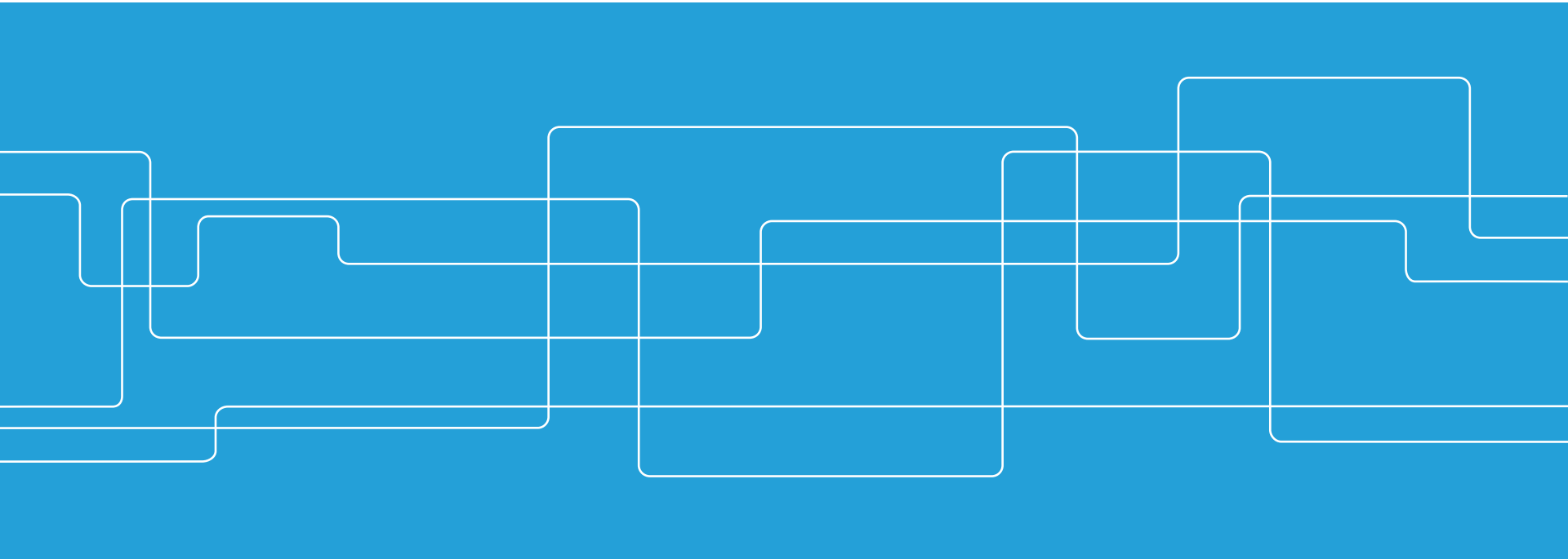




Engineering for a Sustainable Society

Part 2

Christophe Duwig





- What is footprint?

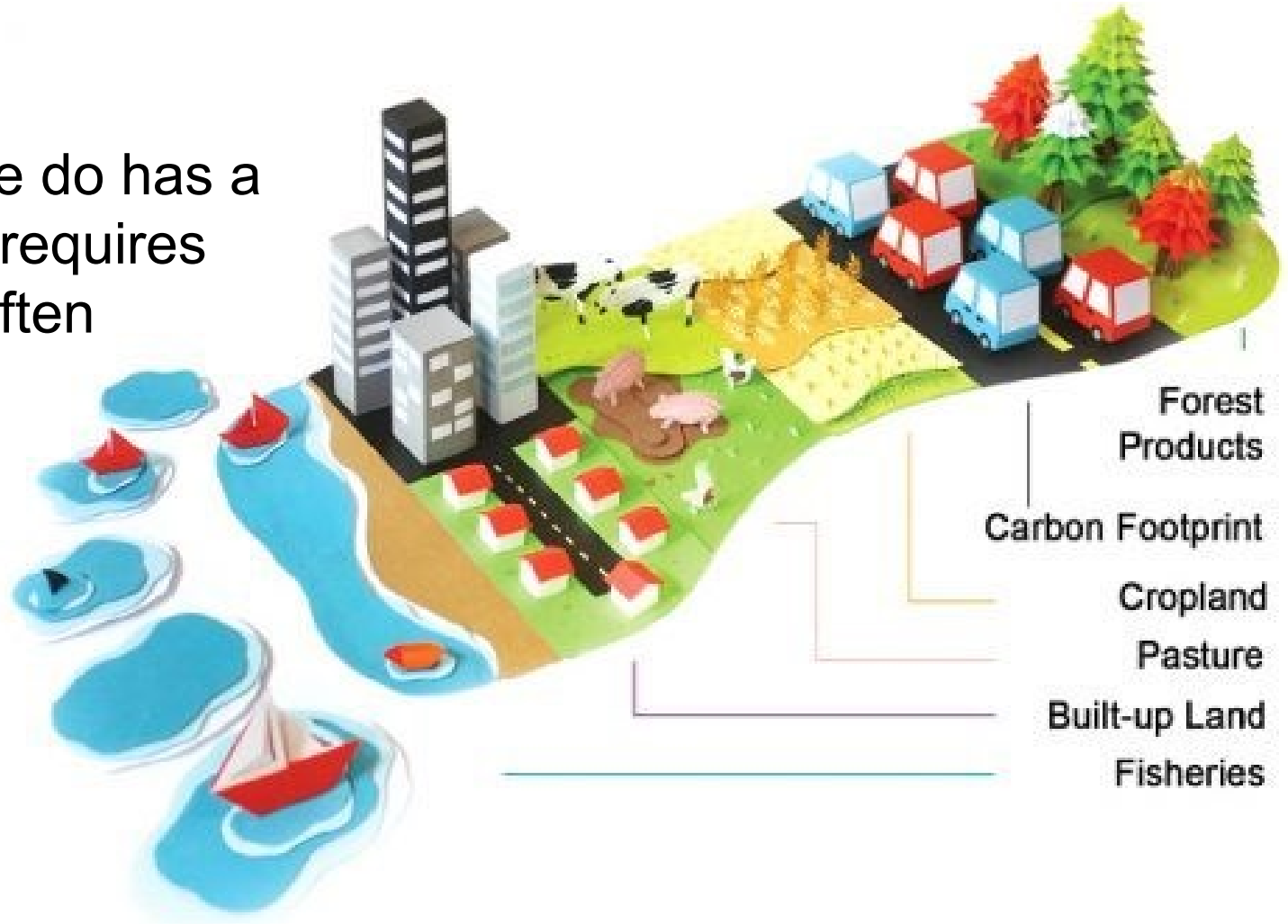
A measure of the resource we are using

- How do we make it?

Everything we do

• Footprint

Everything we do has a footprint and requires energy and often material





Measuring over-consumption

Difficult task since value chain are global and production is invisible

People are material and energy blind

It is a complex problem calling for comprehensive LCA

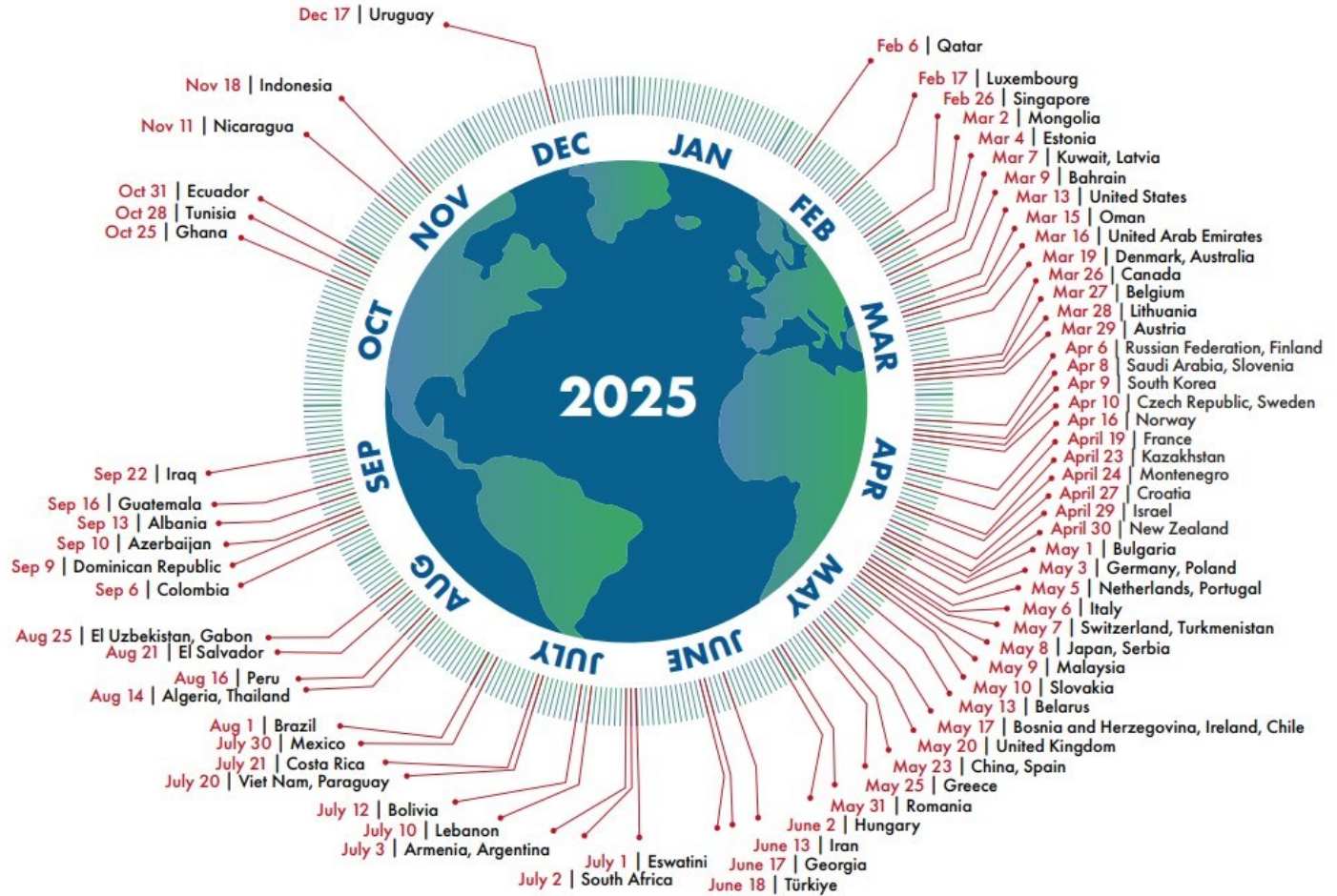
For emissions, there is Scope 1, Scope 2 and Scope 3. Nothing for material, biodiversity, ...



A measure of over-consumption

Country Overshoot Days 2025

When Earth Overshoot Day would land if all the people around the world lived like...



For more information, visit:

<https://overshootday.org/newsroom/country-overshoot-days/>

Source: National Footprint and Biocapacity Accounts, preliminary 2025 Edition
York University, FoDaFo, Global Footprint Network, data.footprintnetwork.org





Visualizing how much resource we use and the impact of activity

Concept of planetary boundaries – not only CO₂

Introduce tipping-points / irreversible boundaries

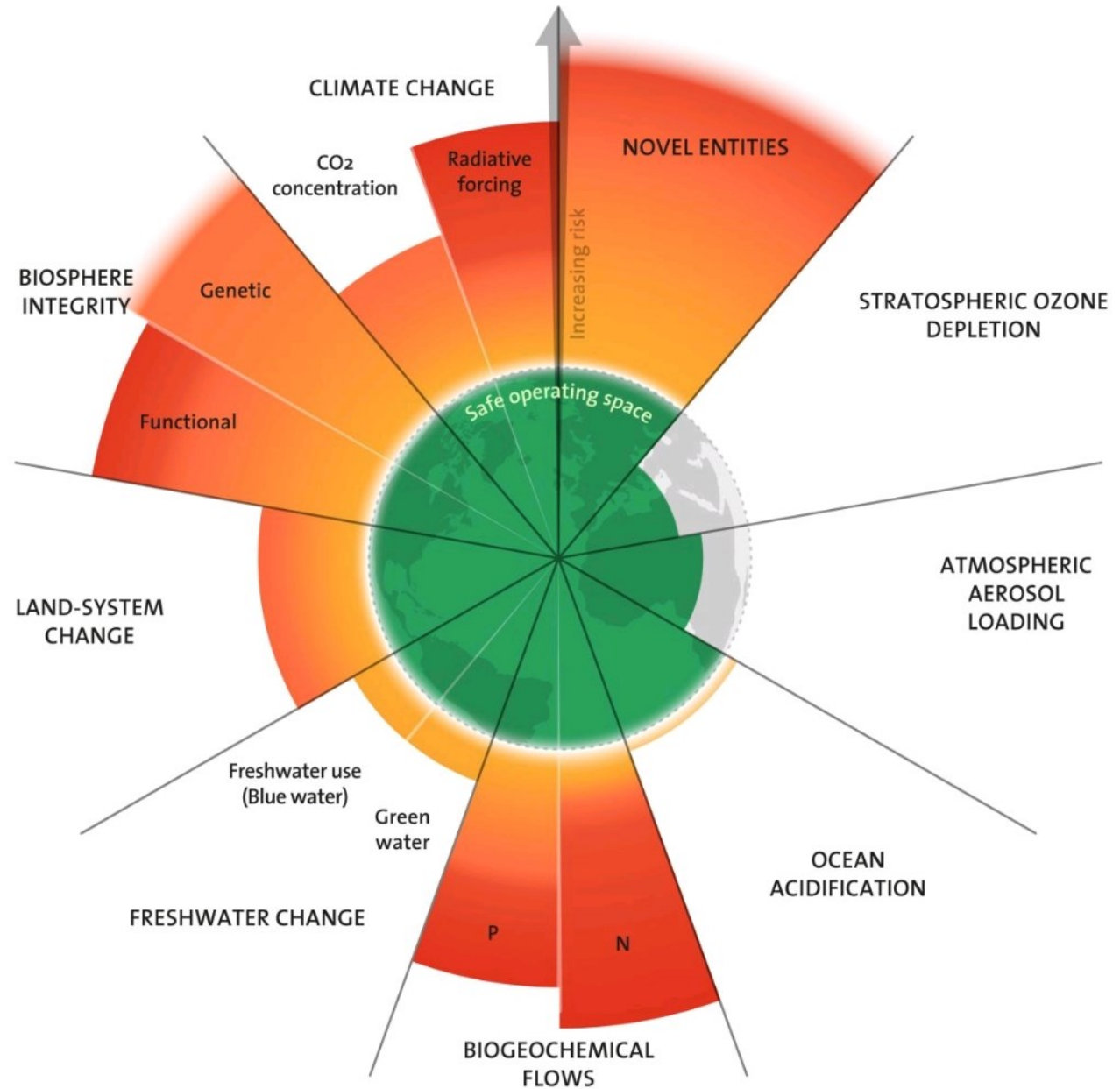
A serie of few indicators that are worldwide

Difficult to be actionable at company or region level



Quantifying footprint and impact on the planet

The nine planetary boundaries





The 9 boundaries - 1-4

- Stratospheric ozone depletion

If this layer decreases, increasing amounts of UV radiation will reach ground level. This can cause a higher incidence of skin cancer in humans as well as damage to terrestrial and marine biological systems. Fortunately, the result of the Montreal Protocol appears to be on the path that will allow us to stay within this boundary.

- Loss of biosphere integrity (Genetic diversity Extinction rate and Functional Diversity)

Changes to ecosystems due to human activities were more rapid in the past 50 years than at any time in human history, increasing the risks of abrupt and irreversible changes. The main drivers of change are the demand for food, water, and natural resources, causing severe biodiversity loss and leading to changes in ecosystem services.

- Chemical pollution and the release of novel entities

Emissions of toxic and long-lived substances such as synthetic organic pollutants, heavy metal compounds and radioactive materials represent some of the key human-driven changes to the planetary environment. These compounds can have potentially irreversible effects on living organisms and on the physical environment.

- Climate Change

Recent evidence suggests that the Earth, now passing 420 ppmv CO₂ in the atmosphere, has already transgressed the planetary boundary and is approaching several Earth system thresholds.



The 9 boundaries - 5-7

- Ocean acidification

Around a quarter of the CO₂ that humanity emits into the atmosphere is ultimately dissolved in the oceans. Here it forms carbonic acid, altering ocean chemistry and decreasing the pH of the surface water. This increased acidity reduces the amount of available carbonate ions, an essential 'building block' used by many marine species for shell and skeleton formation. Acidity leads to the losses of these species and in turn could potentially lead to drastic reductions in fish stocks.

- Freshwater consumption (Blue) and the global hydrological cycle (Green)

The freshwater cycle is strongly affected by climate change and its boundary is closely linked to the climate boundary, yet human pressure is now the dominant driving force determining the functioning and distribution of global freshwater systems. The consequences of human modification of water bodies include both global-scale river flow changes and shifts in vapour flows arising from land use change. These shifts in the hydrological system can be abrupt and irreversible. Water is becoming increasingly scarce - by 2050 about half a billion people are likely to be subject to water-stress, increasing the pressure to intervene in water systems.

- Land system change

Forests, grasslands, wetlands and other vegetation types have primarily been converted to agricultural land. This land-use change is one driving force behind the serious reductions in biodiversity, and it has impacts on water flows and on the biogeochemical cycling of carbon, nitrogen and phosphorus and other important elements.

While each incident of land cover change occurs on a local scale, the aggregated impacts can have consequences for Earth system processes on a global scale.



The 9 boundaries - 8-9

- Nitrogen and phosphorus flows to the biosphere and oceans

The biogeochemical cycles of nitrogen and phosphorus have been radically changed by humans as a result of many industrial and agricultural processes. Nitrogen and phosphorus are both essential elements for plant growth.

Human activities now convert more atmospheric nitrogen into reactive forms than all of the Earth's terrestrial processes combined. Much of this new reactive nitrogen is released to the atmosphere (N) or aquatic system (N, P) rather than taken up by crops. A significant fraction of N and P makes its way to the sea, and can push marine and aquatic systems across ecological thresholds of their own.

- Atmospheric aerosol loading and influence on Earth's climate system.

aerosols play a critically important role in the hydrological cycle affecting cloud formation and global-scale and regional patterns of atmospheric circulation. They also have a direct effect on climate, by changing how much solar radiation is reflected or absorbed in the atmosphere.

Humans change the aerosol loading by emitting atmospheric pollution (many pollutant gases condense into droplets and particles), and also through land-use change that increases the release of dust and smoke into the air. Shifts in climate regimes have already been seen in highly polluted environments, giving a quantifiable regional measure for an aerosol boundary.



How do we use the boundaries & associated dilemma

- Recent tool, popularized 2021 by Netflix documentary
- Focus in on the planet (maybe difficult for most people)
- Introduces the concept of tipping points
- Some boundaries were crossed to save lives, system, N and P
- Some take away for engineers:
 - Ozone layer was saved by politicians and engineers
 - Electrification requires metals and mines that impact (at least) Land Use, Fresh Water and Biosphere
 - Non fossil chemicals impact Land Use, Novel entities, Fresh water, Biosphere, ...
 - Climate change is about changing our energy system
 - **It is a complex system, and we need to work with other people**



Using the planetary boundaries

Doughnut Economics

First published in 2012 in an [Oxfam report](#) by Kate Raworth – recent attempt to use the planetary boundaries in sustainable development economics.

Broad interest UN General Assembly to Extinction Rebellion.

Kate Raworth's 2017 book, Doughnut Economics: seven ways to think like a 21st century economist.

Doughnut Economic Action Lab community (DEAL) is very active with a diverse toolbox <https://doughnuteconomics.org/tools>

Popular as a Grass Root initiative, not a mainstream way to see economics

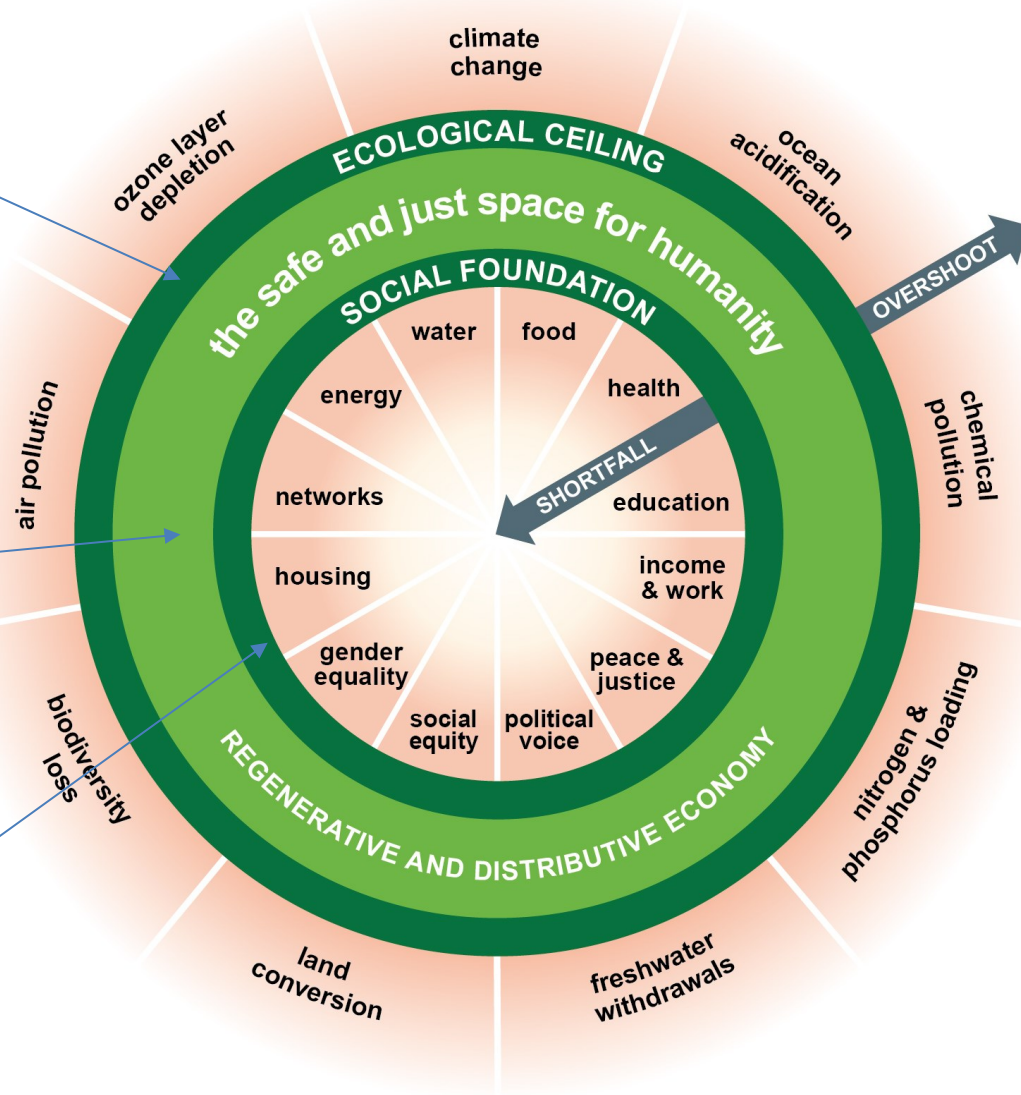


Doughnut Economics: meet the basic needs and stay on the safe operating zone

Outer zone is limited by the planetary boundaries

Where we want to be!

Inner region is about meeting all needs of the humanity, connects to the SDGs



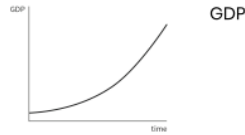
Seven ways to think like a 21st century economist

Seven Ways to Think:

From 20th-Century Economics

To 21st-Century Economics

1. Change the Goal



the Doughnut

2. See the Big Picture



embedded economy

3. Nurture Human Nature



rational economic man



social adaptable humans

4. Get Savvy with Systems

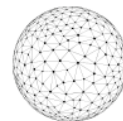


dynamic complexity

5. Design to Distribute



growth will even it up again

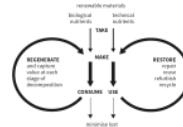


distributive by design

6. Create to Regenerate

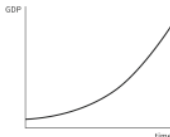


growth will clean it up again

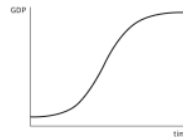


regenerative by design

7. Be Agnostic about Growth



growth addicted

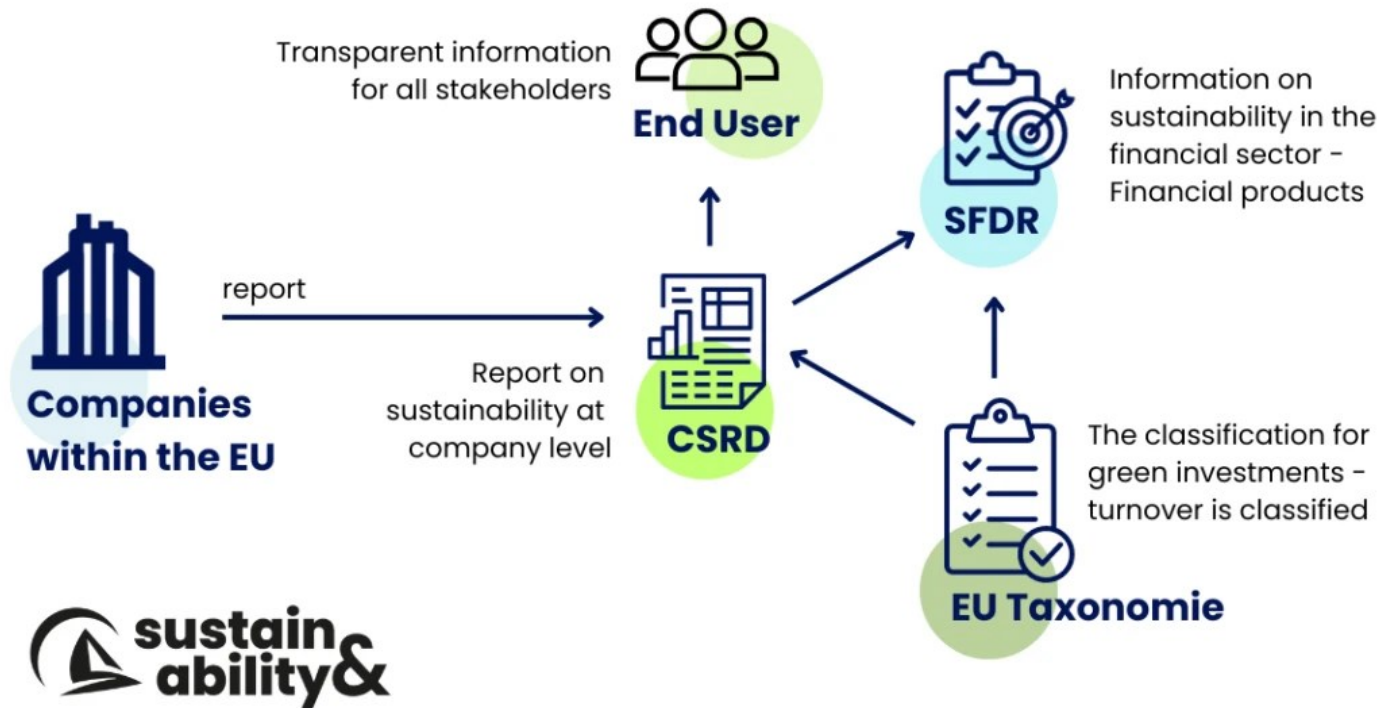


growth agnostic

Some principles of system thinking as opposed to main stream 20th century economics

New regulations for addressing the impact of what we do

EU Action plan





The Sustainable Finance Disclosure Regulation (SFDR) 2021

What is SFDR?

- Part of the EU Action Plan to improve transparency in sustainable finance.
- Purpose: Ensures financial market participants and advisors disclose:
 - How they manage *sustainability risks* (e.g., environmental/societal impacts on investments).
 - The *negative impacts* of investments on society and the environment.

Principal Adverse Impact (PAI) Indicators

Goal: Standardize reporting on adverse sustainability impacts.

64 PAI Indicators defined to measure impacts in areas like:

- Greenhouse gas emissions
- Biodiversity
- Water and waste management
- Social and employee matters



How SFDR works

SFDR Product-Level Disclosures

Three Categories of Financial Products:

1. Article 9: Products with sustainable investment as their objective.
2. Article 8: Products that promote environmental/social characteristics.
3. Article 6: All other products (must explain if sustainability risks are not considered).

Why SFDR Matters

- Objective: Increase transparency in sustainable finance.
- Impact: Helps investors make informed decisions about sustainability risks and impacts.
- Broader Goal: Aligns with the *EU's three major objectives* for sustainable finance.



Understanding the Corporate Sustainability Reporting Directive (CSRD)

What is CSRD?

CSRD: Corporate Sustainability Reporting Directive

Enacted: January 2023

Applicable: Financial year 2024, reporting starts in 2025

Scope: ~50,000 EU companies (large firms, listed SMEs, and non-EU companies with significant EU operations)

Why Was CSRD Introduced?

Goal: Make Europe the world's first climate-neutral continent by 2050

Purpose: Ensure transparency on companies' environmental and social impacts

Focus: Align business activities with sustainability goals



How does CSRD work?

Who Must Report & When?

Who: Large EU companies, listed SMEs, non-EU companies with €150M+ EU revenue

When: Phased implementation starting in 2025

Why: Provide stakeholders with ESG impact data

Double Materiality Concept

Definition: Companies must assess:

How sustainability issues affect financial performance

How business activities impact society and the environment

Core of CSRD: Ensures holistic reporting

ESRS & Compliance Challenges

ESRS: European Sustainability Reporting Standards (12 ESG disclosure areas)

Challenges: Data quality, compliance timelines, double materiality assessment



All indices from Better Life (more of less) scale with wealth and energy and material footprint



Example of the fashion industry

About 0% of global CO₂ emissions – more than international flights and maritime shipping combined. Purchases in the EU in 2020 generated about 270 kg of CO₂ emissions per person.

3rd largest source of water degradation and land use in 2020. 9 m³ of water, 400 m² of land and 391 kilogrammes (kg) of raw materials to provide clothes and shoes for each EU citizen

About 20% of global clean water pollution from dyeing and finishing products. A single laundry load of polyester clothes can discharge 700,000 microplastic fibres that can end up in the food chain.

Textile waste in landfills and low recycling rates < 50% are collected for reuse or recycling, and only 1% of used clothes are recycled into new clothes.

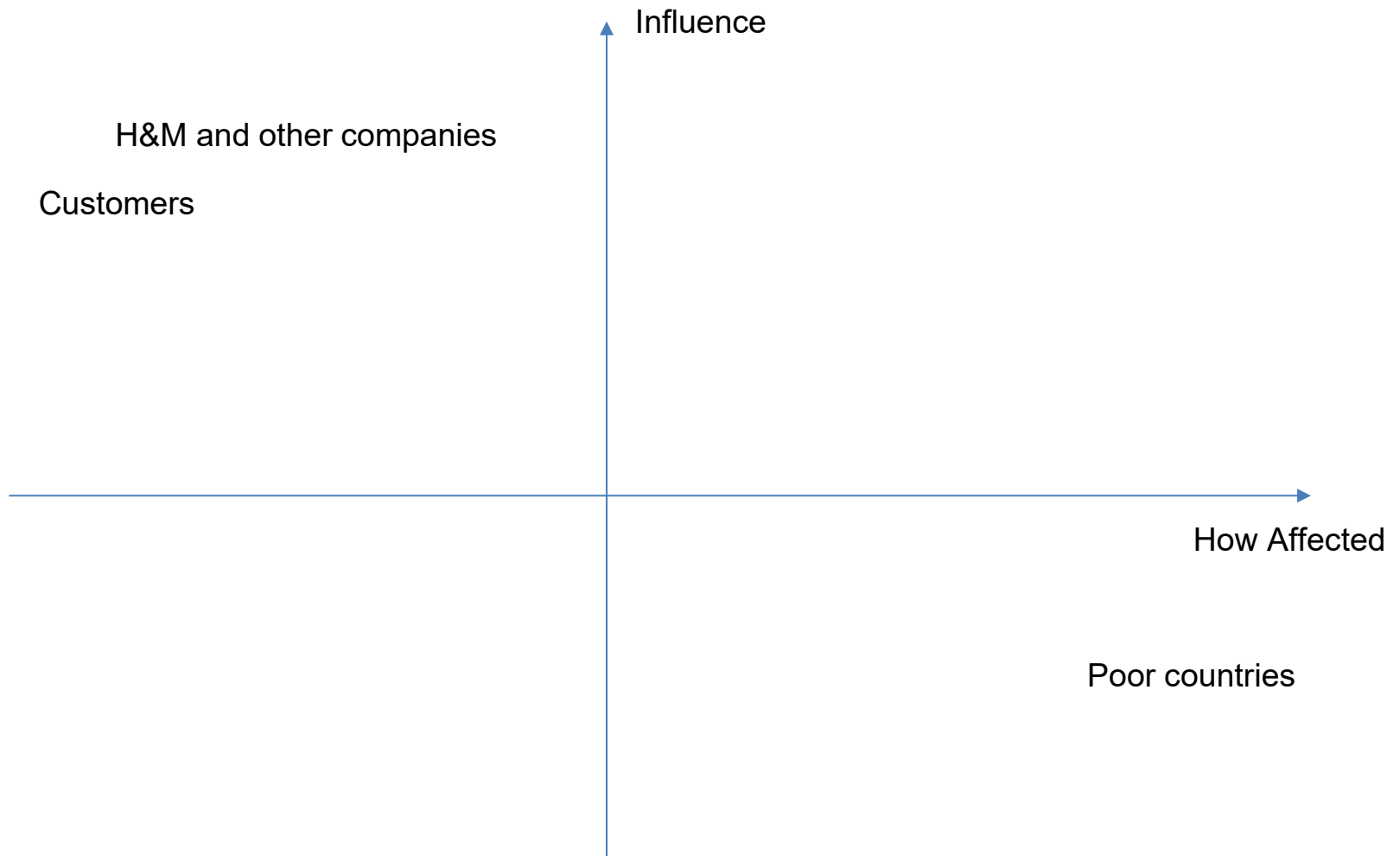


Just looking at cotton

- One needs 20 000 l water to produce 1 kg of cotton = 1 jeans + 1 T-Shirt
- certified organic cotton accounts for less than 1 per cent of global cotton supply
- What is the difference with organic cotton?
 - 46% reduced global warming
 - 26% reduced soil erosion
 - 62% reduced primary energy demand
 - 91% reduced blue water consumption
- Organic cotton farming sounds great!
- Recycling clothes is better!
- Buying less clothes is even better!



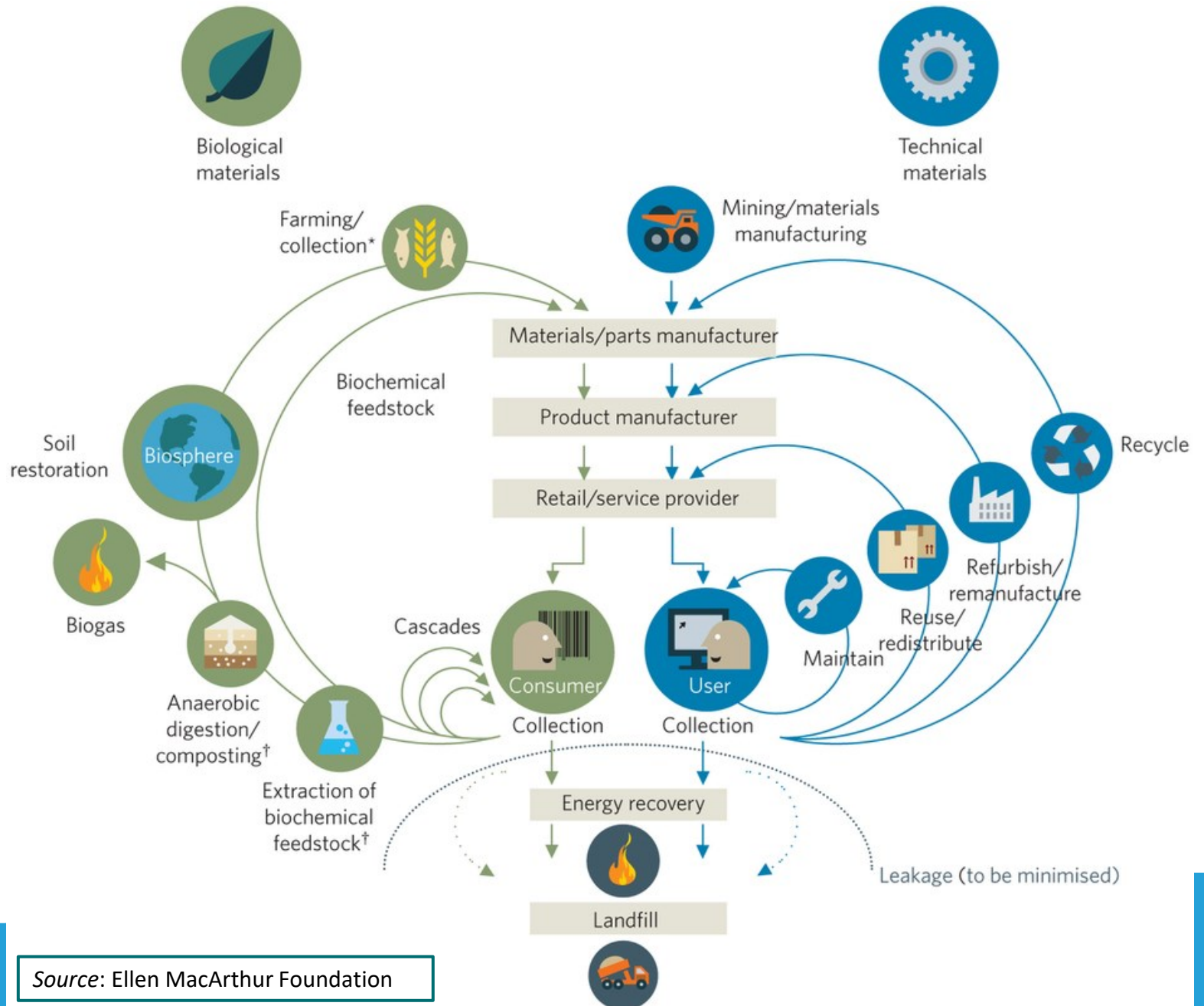
Stakeholder engagement map



Circularity for limiting extraction needs


























• Circularity



• Circular business model: the RESOLVE model

EXAMPLES

REGENERATE 	<ul style="list-style-type: none"> • Shift to renewable energy and materials • Reclaim, retain, and restore health of ecosystems • Return recovered biological resources to the biosphere 	    
SHARE 	<ul style="list-style-type: none"> • Share assets (e.g. cars, rooms, appliances) • Reuse/secondhand • Prolong life through maintenance, design for durability, upgradability, etc. 	    
OPTIMISE 	<ul style="list-style-type: none"> • Increase performance/efficiency of product • Remove waste in production and supply chain • Leverage big data, automation, remote sensing and steering 	    
LOOP 	<ul style="list-style-type: none"> • Remanufacture products or components • Recycle materials • Digest anaerobic • Extract biochemicals from organic waste 	       
VIRTUALISE 	<ul style="list-style-type: none"> • Books, music, travel, online shopping, autonomous vehicles etc. 	      
EXCHANGE 	<ul style="list-style-type: none"> • Replace old with advanced non-renewable materials • Apply new technologies (e.g. 3D printing) • Choose new product/service (e.g. multimodal transport) 	    



Exercise (10 min):

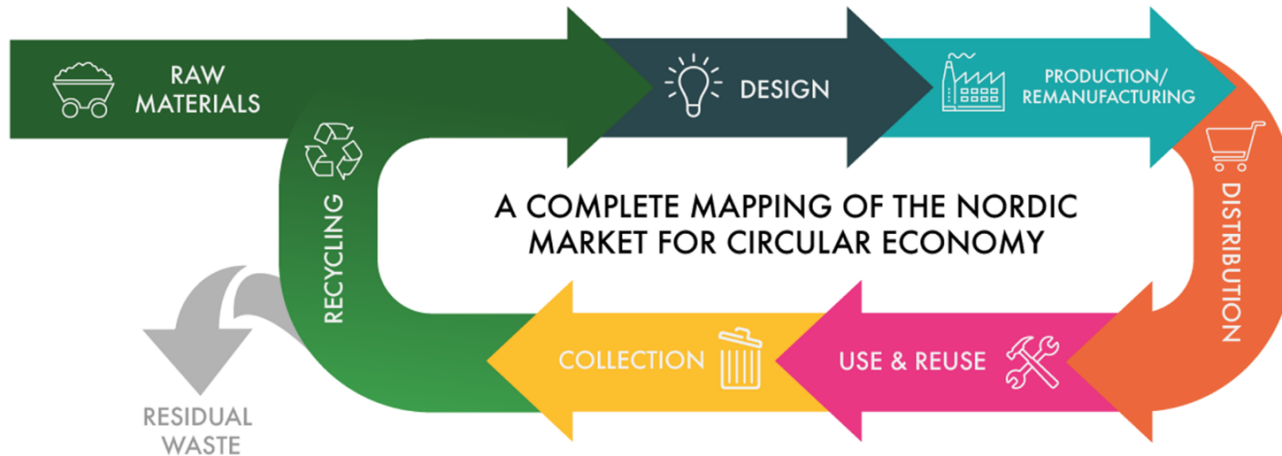
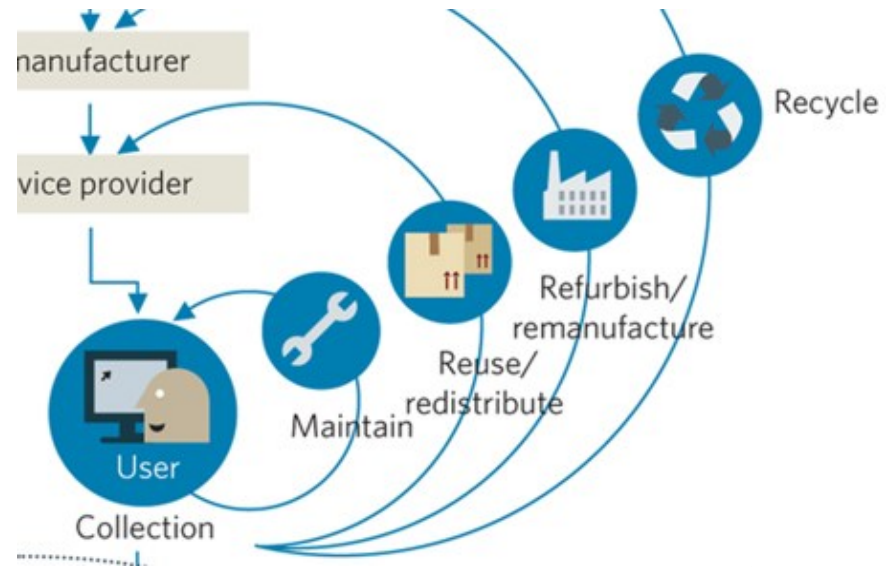
pick up an item for health care and make it circular

What is it made of?

What will you do?

How are you going to do it?

WHO will you work with?





Let's take a break

