Sustainability

What is Sustainability?

Sustainability was first mentioned in (Hannß Carl von Carlowitz, 1713) in the context of forestry and discussing sustainable forest management in his seminal book *Sylvicultura oeconomica*. The field is known today as *sustainable yield* of *natural capital* required to maintain *ecosystem services* (Peter Kareiva et al., 2011). Aldo Leopold proposed the idea of *land ethics* as *"[a] thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise"* in his seminal book A Sand County Almanac(Leopold, 1972). The 1987 United Nations' Brundtland Report (Our Common Future) defined sustainable development as *"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (World Commission on Environment and Development, 1987).

- planetary health https://unfccc.int/climate-action/un-global-climate-action-awards/planetary-health

- Wardani et al. (2023) "long-term human well-being is dependent on the well-being of the planet, including both biotic and abiotic systems. It recognizes interlinkages across environmental sustainability, public health, and socioeconomic development.""

Biodiversty Loss

Protecting biodiversity

Table 1: Biodiversity loss data from (Bradshaw et al., 2021).

What Happened?	How Much?
Vertebrate species population average decline	68% over the last 50 years
Land surface altered by humans	70% of Earth
Vertebrate species extinct	700 in 500 years
Plant species extinct	600 in 500 years
Species under threat of extinction	1 million

- The current environmental upheaval, led by Gen-Z and Millennials, and the business adaptation (or lack thereof) to sustainable economic models, taking into account the hidden social and environmental costs we didn't calculate in our pricing before.
- We also need to consider environmental effects (E in ESG). We haven't taken into account the whole cost of production, leading to the wrong pricing information. To achieve this, we need expert governance (G).

Consumer lifestyle contributes to environmental destruction. According to Ellen MacArthur Foundation, Material Economics (2019)'s models show 45% of CO_2 equivalent emissions come from our shopping; produced by companies to make the products we consume. A large scale study by Anthony Leiserowitz et al. (2022) on Meta's Facebook (n=108946) reported people in Spain (65%), Sweden (61%), and Taiwan (60%) believe "climate change is mostly caused by human activities". An even larger survey (n=1.2 million) by the United Nations across 50 countries, distributed through mobile game ads, showed the majority of people agreeing climate change is an "emergency" UNDP (2021). While people express eco-conscious ideas, it's non-trivial to practice sustainability in daily life. Deyan Georgiev (2023) reports only 30% of people in the Gen-Z age group believe technology can solve all problems.

Table 2: "Climate change is an emergency" UNDP (2021).

Age Group	Agree	Neutral or Disagree
18-35	65%	35%
36-59	66%	34%
Over 69	58%	42%

Ecological Indicators of the Biosphere

Sustainability can be measured using a variety of **_ecological indicators_**.

Dinerstein et al. (2017) identifies 846 terrestrial ecoregions.

- Svalbard Seed Vault
- Jackson (1996) _preventive environmental management_
- Jackson (2017) limits to growth update
- Ecological Indicators (I like the name Ecomarkers) for Earth are like Biomarkers in human health.

Some argue sustainability is not enough and we should work on regeneration of natural habitats.

The Climate

The Price of Climate Change

Long term cost is more than short-term gains.

Climate Data Vizualisation

Climate data visualization has a long history, starting with **Alexander von Humboldt,** the founder of climatology, who revolutionized cartography by inventing the first *isothermal maps* around the year 1816; these maps showed areas with similar temperature, variations in altitude and seasons in different colors (Honton, 2022). Humboldt's isotherms are now available as 3D computer models in (Anon., 2023a).

Earth's physical systems are very sensitive to small changes in temperature, which was not understood until 30 years ago (McKibben, 2006).

- Industrial revolution: : "transition to a low carbon economy presents challenges and potential economic benefits that are comparable to those of previous industrial revolutions" (Pearson and Foxon, 2012).
- Tragedy of the commons: (Murase and Baek, 2018; Lopez, Pastén and Gutiérrez Cubillos, 2022; Meisinger, 2022).

Figure 1: Humboldt's Naturgemälde, early data visualization of ecology, rain, temperature, elevation, etc

Earth System Models from the first calculation by Svante Arrhenius and Guy Stewart Callendar to today's complex models that integrate the various Earth systems and cycles ran on supercomputers Anderson, Hawkins and Jones (2016)

Climatech

How are large corporations responding to the climate crisis?

Lack of leadership. Capgemini (2022): "Many business leaders see sustainability as costly obligation rather than investment in the future". Hoikkala (2019): for example the CEO of the Swedish clothing producer H&M, one of the largest fast-fashion in the world, recognizes the potential impact of conscious consumers as a threat.

Many large businesses have tried to find solutions by launching climate-focused funding. (Korosec, 2021) reports that Amazon's 2B USD to a Climate Pledge Fund earmarked to fix climate problems is invested in energy, logistics, and packaging startups, which will reduce material waste. "Good intentions don't work, mechanisms do," Amazon's founder Bezos is quoted as saying in (Clifford, 2022). Walmart is taking a similar approach, having launched a project in 2017 to set CO_2 reduction targets in collaboration with its suppliers Walmart (2023). These examples underlines how money marketed as climate funding by retail conglomerates means focus on reducing operational cost of running their business through automation and material savings.

Large corporations such as Nestle and Coca Cola support the biodiversity law to have a level playing field for business (Greens EFA, 2023).

- Anon. (2013)
- Guidotti (2015)
- "Sustainability is important for many reasons including: Environmental Quality – In order to have healthy communities, we need clean air, natural resources, and a nontoxic environment."
- Low, S., Baum and Sovacool (2022) finds considerable uncertainty exists among experts which CO2 reduction methods among nature-based and technology-based are the most effective.
- Pathways to drawdown

Planetary Boundaries

- (Keeble, 1988) reported in April 1987 that *'residents in high-income countries lead lifestyles incompatible with planetary boundaries'*. While my home country Estonia at the time was considered low-income, a small nation in poverty behind the *Iron Curtain* occupation of the Soviet Occupy, we now in 2023, have indeed reached high-income status.
- De Balie (2018)
- Houdini (2018)
- Haeggman, Moberg and Sandin (2018)

Ecosystem Services

Gómez-Baggethun et al. (2010) the history of the valuation of nature's services goes back to the 18th century when David Ricardo and Jean Baptiste Say discussed nature's *work*, however both considered it should be free. In 1997 Daily (1997) proposed the idea of ecosystem services and Costanza et al. (1997) attempted to assess the amount of ecosystem services provided.

Le Provost et al. (2022) study shows *biodiversity* as one key factor to maintain delivery of ecosystem services. Noriega et al. (2018) attempts to quantify the ecosystem services (ES) provided by insects. While it can be assumed much of the flora and fauna are crucial for Earth's systems, science is still in the process of understanding and quantifying its contributions.

- Leverhulme Centre for Nature Recovery (2023) should we put a price on nature?
- Bousfield et al. (2022) reports there's evidence paying landowners for the ecosystem services their forests provide may reduce deforestation.
- Is it time to leave utilitarian environmentalism behind? Muradian and Gómez-Baggethun (2021)

Table 3: From Leverhulme Centre for Nature Recovery (2023)

9 Steps
Identify ecosystem functions
Quantify ecosystem functions
Identify ecosystem services
Quantify ecosystem services
Quantify financial value of ecosystem services
Assign property rights
Create ecosystem service markets
Commodify nature

There are 2 approaches to protecting nature

Economics of Nature Commodification	Economics of the Sacred
Measure and assign value to nature	Say nature is sacred, such as Churches, and can't be touched. Eisenstein (2011); Eisenstein (2018)

- Han and Chen (2022) identifies nature-based solutions "land re-naturalization (such as afforestation and wetland restoration)"

Table 5: From Han and Chen (2022)

Non-Exhaustive list of
Afforestation
Wetland restoration

- Meanwhile the destruction pressure on ecosystems is rapidly increasing (cite A B C).

- Espinosa and Bazairi (2023) marine ecosystem services **(need access)**

- Chen et al. (2023) Ecosystem vulnerability **(need access)**

- Zhang et al. (2023) Integrating ecosystem services conservation into urban planning **(need access)**

- Li et al. (2023) tourism is a large industrial sector which relies on ecosystem services. In Taiwan, (Lee, Jan and Liu, 2021) developed a framework of indicators to assess sustainable tourism.

Environmental Degradation

Growing Population

Earth's population reached 8 Billion people In November 2022 and population projections by predict 8.5B people by 2030 and 9.7B by 2050 (The Economic Times, 2022; United Nations Department of Economic and Social Affairs, Population Division, 2022).

(Hassoun et al., 2023) forecasts increase of global food demand by 62% including impact of climate change.

- While population growth puts higher pressure on Earth's resources, some research proposes the effect is more from wasteful lifestyles than the raw number of people (Cardinale et al., 2012).

- Bowler et al. (2020) Anthropogenic Threat Complexes (ATCs):

Wellbeing Economy Governments

- Finland, Iceland, New Zealand, Scotland, Wales, Canada https://weall.org/wego

Marine Heatwaves

- Smale et al. (2019)
- Gelles and Andreoni (2023)

Slavery

In 2023, an estimated 50 million people are still in slavery around the world; lack of supply chain visibility hides forced labor and exploitation of undocumented migrants in agricultural work; 71% of enslaved people are estimated to be women. (Borrelli et al., 2023; Kunz et al., 2023).

The UN SDG target 8.7 targets to eliminate all forms of slavery.

Slavery is connected to environmental degradation and climate change (Decker Sparks et al., 2021). Enslaved people are used in environmental crimes such as 40% of deforestation globally. Cobalt used in technological products is in risk of being produced under forced labor in the D.R. Congo (Sovacool, 2021). In India and Pakistan, forced labor in brick kiln farms is possible to capture remotely from satellite images (Boyd et al., 2018). In effect, the need for cheap labor turns slavery into a *subsidy* keeping environmental degradation happening.

- Christ and V Helliar (2021) estimates 20 million people are stuck inside corporate blockchains. The Global Slavery Index measures the ***Import Risk*** of having slavery inside its imports Walk Free (2023).

- Hans van Leeuwen (2023) slavery affects industries from fashion to technology, including sustainability enablers such as solar panels.

- "commodification of human beings"

- Anand Chandrasekhar and Andreas Gefe (2021): Trading commodities "Switzerland has a hand in over 50% of the global trade in coffee and vegetable oils like palm oil as well as 35% of the global volume of cocoa, according to government estimates." Can traders have more scrutiny over what they trade?

- Modern Slavery Act.

Overpopulation

- "Overpopulation is a major cause of biodiversity loss and smaller human populations are necessary to preserve what is left" Cafaro, Hansson and Götmark (2022).

Overconsumption

Overconsumption is one of the main drivers of climate change." Around 2/3 of global GHG emissions are directly and indirectly linked to household consumption, with a global average of about 6 tonnes CO_2 equivalent per capita." (Ivanova et al., 2020; Renee Cho, 2020)

Overconsumption is also one of the root causes of plastic pollution. Ford et al. (2022) and Lavers, Bond and Rolsky (2022) find strong linkage of climate change and marine plastic pollution "along with other stressors that threaten the resilience of species and habitats sensitive to both climate change and plastic pollution".

- Lavers, Bond and Rolsky (2022) plastic pollution is pervasive around the Earth and is fundamentally linked to climate change

While the number on overconsumption are clear, the debate on overconsumption is so polarized, it's difficult to have a meaningful discussion of the topic (Ianole and Cornescu, 2013).

- Overconsumption and underinvestment.

- Cities are responsible for 80% of the emissions Rosales Carreón and Worrell (2018)

- Moberg et al. (2019) reports daily human activities emission contribution on average in four European countries (France, Germany, Norway and Sweden).

Table 6: Daily human activities emission contribution on average in France, Germany, Norway and Sweden from Moberg et al. (2019).

Emission Share	Category
21%	Housing
30%	Food
34%	Mobility
15%	Other

- Eesti Vabariigi Valitsus (2022) Estonian Green Deal Action Plan (Eesti Rohepöörde Tegevusplaan).
- Armstrong McKay et al. (2022) discusses tipping points.

SDGs

- SDGs need to discussed in their totality Popkova et al. (2022).

Planetary Boundaries

- As long as humanity is a mono-planetary species, we have to come to terms with the limitations of our home, Earth.

Earth System Law

- Du Toit and Kotzé (2022)

- Williams and Joshi (2013) higher CO_2 concrentrations in the air can cause more turbulence for flights.

- Warmer climate helps viruses and fungi spread Press (2023)

Biodiversity

Almond, R.E.A. et al. (2022) reports, the number of species killed, mass destruction of nature. "69% decline in the relative abundance of monitored wildlife populations around the world between 1970 and 2018. Latin America shows the greatest regional decline in average population abundance (94%), while freshwater species populations have seen the greatest overall global decline (83%)."

Biodiversity loss is linked to overconsumption, weak legislation and lack of oversight. (Crenna, Sinkko and Sala, 2019) recounts European Union consumers' negative impact on biodiversity in countries where it imports food. WWF (2022) case study highlights how 4 biodiverse regions Cerrado in Brazil, Chaco in Argentina, Sumatra in Indonesia, and the Cuvette Centrale in Democratic Republic of Congo are experiencing rapid destruction due to consumer demand in the European Union. While the European Union (EU) has recently become a leader in sustainability legislation, biodiversity protection measures among private companies is very low Marco-Fondevila and Álvarez-Etxeberría (2023).

Meanwhile, there is some progress in biodiversity conservation. UEBT (2022) reports "Biodiversity awareness is now at 72% or higher in all countries sampled, compared to only 29% or higher across countries sampled in 2009."

Similarly to climate protection, the UN has taken a leadership role in biodiversity protection. Unit (2023): The history of the United Nations Convention on Biodiversity goes back to 1988, when the working group was founded. UNEP (Tue, 12/20/2022 - 07:44): The Convention on Biodiversity 2022 (COP15) adopted the first global biodiversity framework to accompany climate goals.

Biodiversity Indicators

Cutting edge research uses AI for listening to nature, assessing biodiversity based on species' sounds in the forest. Millions of detections of different species with machine learning passive acoustic AI models, can also assess species response to climate change (AI for Good, 2023; Guerrero et al., 2023).

May (2011) argues biodiversity loss is a concern for 3 points of views:

Table 7: From May (2011).

View	
Narrowly Utilitarian	Biodiversity is a resource of genetic novelties for the biotech industry.
Broadly Utilitarian	Humans depend upon biodiverse ecosystems.
Ethical	Humans have a responsibility to future generations to pass down a rich natural world.

Forest and Deforestion

Around 27% of Earth's land area is still covered by forests yet deforestation is widespread all around the world; highest rates of deforestation happened in the tropical rainforests of South America and Africa, mainly caused by agricultural cropland expansion (50% of all deforestation) and grazing land for farm animals to produce meat (38,5%), totaling close to 90% of global deforestation (Anon., 2022a). Forests are a crucial part of Earth's carbon cycle and the main natural CO_2 capture system; due to deforestation, Europe rapidly losing its forest carbon sink (Frédéric Simon, 2022).

Afforestation is different from reforestation, which takes into account biodiversity.

- 1 billion tree project (Bastin et al., 2019; Anon., 2020; Greenfield and @pgreenfielduk, 2021)
- Burning of biomass undermines carbon capture.

Water

- Clean water and water pollution
- Koch (2022) (**Need access!**)

Air

Air pollution is widespread around the planet, with 99% of Earth's human population being affected by bad air quality that does not meet WHO air quality guidelines, leading to health problems linked to 6.7 million premature deaths every year World Health Organization (2022). Grounbreaking research by Lim et al. (2022) analyzed over 400000 individuals in England, South Korea and Taiwan establishes exposure to 2.5 m PM (PM2.5) air pollution as a cause for lung cancer. Bouscasse et al. (2022) finds strong health and economic benefits across the board from air pollution reduction in France. In Hannah Devlin (2022), prof Tony Mok, of the Chinese University of Hong Kong: "We have known about the link between pollution and lung cancer for a long time, and we now have a possible explanation for it. As consumption of fossil fuels goes hand in hand with pollution and carbon emissions, we have a strong mandate for tackling these issues – for both environmental and health reasons".

Health and sustainability are inextricably linked. "Human health is central to all sustainability efforts.", "All of these (food, housing, power, and health care), and the stress that the lack of them generate, play a huge role in our health" (Sarah Ludwig Rausch and Neha Pathak, 2021).

The main way to combat air pollution is through policy interventions. MARIA LUÍS FERNANDES (2023) EU has legislation in progress to curb industrial emissions. If legislation is in place, causing bad air quality can become bad for business. Gu et al. (2023) links air

pollution to credit interest rates for business loans in China; companies with low environmetal awareness and a history of environmental penalties pay 12 percent higher interest rates.

Clean air is a requirement.

Climate Change Disasters

Environmental activists have been calling attention to global warming for decades, yet the world has been slow to act (McKibben, 1989).

Global warming increases the risk of disasters and extreme weather events. As extreme temperatures are increasingly commonplace, there's increased risk of wildfires (Volkova, Roxburgh and Weston, 2021). Summers of 2022 and 2023 were the hottest on record so far, with extreme heat waves recorded in places around the world (Douglas, 2023; Falconer, 2023; National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, 2023; NOAA National Centers for Environmental Information, 2023; Serrano-Notivoli et al., 2023; Venturelli et al., 2023). As temperatures rise, certain cities may become uninhabitable for humans CBC Radio (2021). The summer of 2023 saw extensive wildfires in Spain, Canada, and elsewhere; rapidly moving fires destroyed the whole city of Lāhainā in Hawaii [CITE]. The part of Earth where the *human climate niche* is becoming smaller (McKibben, 2023). Some parts of South America have seen summer heat in the winter, with heatwaves with temperatures as high as 38 degrees (Livingston, 2023).

- Observed changes in heatwaves (Perkins-Kirkpatrick and Green, 2023).

Climate-related disasters can spur action as extreme weather becomes visible to everyone. After large floods in South Korea in July 2023 with many victims, president Joon promised to begin taking global warming seriously and steer the country towards climate action Web (2023); AFP (2023); Al Jazeera (2023). South Korea has a partnership with the European Union European Commission (2023a).

The fossil energy production that's a large part of global CO2 emissions has caused several high-profile pollution events. Large ones that got international news coverage include Exxon Valdez and Deepwater Horizon.

- Chernobyl and Fukushima
- the Great Pacific Garbage Patch
- Lenton et al. (2023) quantifying human cost of global warming.
- EJAtlas tracks environmental justice cases around the world Scheidel et al. (2020).
- Disputes in Eerola (2022).

Carbon Accounting

- Watershed

- The legislation has created an industry of CO_2 accounting with many companies like Greenly, Sustaxo, etc.

- Quatrini (2021) sustainability assessments are complex and may give flawed results.

- Nonetheles, CO_2 emission reduction has the added positive effect of boosting corporate morale (Cao, Li and Hasan, 2023).

Agroforestry & Permaculture

Agroforestry plays an active role in achieving Sustainable Development Goals (SDGs) (Ruba and Talucder, 2023);

- Food forests for regenerative food systems.

- Irwin et al. (2023)

- Yadav et al. (2023)

- Low, G., Dalhaus and Meuwissen (2023)

- Ollinaho and Kröger (2023) "bioeconomy is not inherently sustainable and may pose considerable risks to biodiversity."

- De Queiroz-Stein and Siegel (2023)

- Gamage et al. (2023) "Organic food and drink sales in 2019 totaled more than 106 billion euros worldwide."

- "Would you rather buy a DogeCoin or a regenerative food forest token?" Curve Labs founder Pat Rawson quotes Shiller (2019) in ReFi podcast about Kolektivo. ReFi DAO (2022) (Use as a question for the survey?)

Biodesign

MIT is a source of many fantastic innovations.

- Neri Oxman, biomaterials MIT media lab, 15. sept. 2020

- Neri Oxman's expressions: "ecology-indifferent", "naturing", "mother naturing", "design is a practice of letting go of all that is unnecessary", "nature should be our single client".

- Use imagination

- Societal movements change things: implication for design: build a community

- Processes sustain things: implication for design: built an app

Quality of Life

- Kaklauskas et al. (2023)
- Rieger et al. (2023) Integrated science of wellbeing
- Fabris and Luburić (2022)
- Sustainability is part of product quality. If a product is hurting the environment, it's a low quality product.

Restoration Ecology

- Bioswales
- Fischer et al. (2021) UN announced 2021–2030 the Decade on Ecosystem Restoration

Digital Twins

- We can use all the data being recorded to provide a Digital Twin of the planet, nature, ecosystems and human actions to help us change our behavior and optimize for planetary wellbeing.
- The EU is developing a digital twin of Earth to help sustainability prediction and planning, integrating Earth's various systems such as climate, hydrology, ecology, etc, into a single model Anon. (2023b).
- EU releases strategic foresight reports since 2020 European Commission (2023b)

Mitigation & Adaption

Cap & Trade

The share of CO_2 emissions among people around the world is highly unequal across the world (referred to as ***Carbon Inequality***). Chancel (2022) reports "while one-tenth of the global population is responsible for nearly half of all emissions, half of the population emits less than 12%".

- One example is the ICT sector.
- Bajarin (n.d.) Over 300 million PCs sold in 2022

- Anon. (2021a) Estonian company "sustainable lifecycle management of IT equipment"
- Ärileht (23.09.2022, 12:53) Recycle your phone, FoxWay and Circular economy for PCs.
- Zhou et al. (2022) ICT is an example of inequality, while emerging economies bear 82% of the emissions, developed countries gain 58% of value.

Emissions' Data

Data about green house gas emissions.

Table 8: Comparing highest per capita CO_2 emissions (mostly from oil producers) vs regional average per capita CO_2 emissions vs total CO_2 emissions(Ivanova et al., 2020; World Resources Institute, 2020; European Commission. Joint Research Centre., 2022; **crippaCO2EmissionsAll2022?**).

Regional Avergage Per Capita Emissions (2020)	Highest Per Capita Emissions (2021)	Highest Total Emissions (2021)
North America 13.4 CO_2e tonnes	Palau	China
Europe 7.5 CO_2e tonnes	Qatar	United States
Global Average 4.1 CO_2e tonnes	Kuwait	European Union
Africa and the Middle East 1.7 CO_2e tonnes	Bahrain	India
	Trinidad and Tobago	Russia
	New Caledonia	Japan
	United Arab Emirates	Iran
	Gibraltar	Germany
	Falkland Islands	South Korea
	Oman	Indonesia
	Saudi Arabia	Saudi Arabia
	Brunei Darussalam	Canada
	Canada	Brazil
	Australia	Turkey
	United States	South Africa

"The world's top 1% of emitters produce over 1000 times more CO2 than the bottom 1%" IEA (2023)

(**crippaCO2EmissionsAll2022?**) reports latest figures from the EU's Emissions Database for Global Atmospheric Research (EDGAR)

The EU Copernicus satellite system reveals new greenhouse emissions previously undetected (Daniel Värjö, 2022).

Emissions Trading Schemes

From Carbon Offsets to Carbon Credits

Retiring CO_2 allowances

- Facilitating citizens' access to CO_2 emissions trading may be an efficient method to organize large-scale CO_2 retiring Rousse (2008)
- "A carbon credit represents one tonne of carbon dioxide that has been prevented from entering or has been removed from the atmosphere" (Anna Watson, 2022, 2023).

As of 2023 there isn't a single global CO_2 trading market but rather several local markets as described in the table below Anon. (n.d.a).

Table 9: CO_2 credit trading markets around the world from Anon. (n.d.a).

CO_2 Market	Launch Date	Comments
European Union	2005	EU: Araújo et al. (2020)
South Korea	2015	
China	2021	China's national emissions trading scheme (ETS) started in 2021 priced at 48 yuan per tonne of CO_2, averaged at 58 yuan in 2022 (Liu, H., 2021; Ivy Yin, 2023).
United States of America	2013	No country-wide market; local CO_2 markets in California, Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont
New Zealand	2008	New Zealand Rontard and Reyes Hernández (2022) (need access)
Canada	2013	

Most of the world is not part of a CO_2 market.

- (Sipthorpe et al., 2022) compares traditional and blockchain-based solutions to carbon trading.

- (United Nations Environment Programme (UNEP), 2021) report. "The Emissions Gap Report (EGR) 2021: The Heat Is On shows that new national climate pledges combined with other mitigation measures put the world on track for a global temperature rise of 2.7°C by the end of the century. That is well above the goals of the Paris climate agreement and would lead to catastrophic changes in the Earth's climate. To keep global warming below 1.5°C this century, the aspirational goal of the Paris Agreement, the world needs to halve annual greenhouse gas emissions in the next eight years.
- (United Nations Environment Programme (UNEP), 2021) report "If implemented effectively, net-zero emissions pledges could limit warming to 2.2°C, closer to the well-below 2°C goal of the Paris Agreement. However, many national climate plans delay action until after 2030. The reduction of methane emissions from the fossil fuel, waste and agriculture sectors could help close the emissions gap and reduce warming in the short term, the report finds. Carbon markets could also help slash emissions. But that would only happen if rules are clearly defined and target actual reductions in emissions, while being supported by arrangements to track progress and provide transparency."
- (United Nations Environment Programme, 2022) 2022 Emissions Gap report.

Carbon Markets

For the individual person, there's no direct access to CO_2 markets, however there are different types of brokers who buy large amounts of carbon credits and resell them in smaller quantities to retail investors. "Carbon pricing is not there to punish people," says Lion Hirth Lion Hirth (n.d.). "It's there to remind us, when we take travel, heating, consumption decisions that the true cost of fossil fuels comprises not only mining and processing, but also the damage done by the CO_2 they release."

The Price of CO_2

Stern (2022) reports carbon-neutral economy needs higher CO_2 prices. Rennert et al. (2022): Carbon price should be 3,6x higher that it is currently. Ritz (2022) argues optimal CO_2 prices could be highly asymmetric, low in some countries and high (above the social cost of CO_2) in countries where production is very polluting.

- iGenius (2020)

Compliance Markets

Table 10: Compliance market CO_2 prices on August 12, 2023; data from (CarbonCredits, 2023; Ember, 2023; Trading Economics, 2023).

Compliance Markets	Price (Tonne of CO_2)
EU	83 EUR
UK	40 Pounds
US (California)	29 USD
Australia	32 USD
New Zealand	50 USD
South Korea	5.84 USD
China	8.29 USD

Voluntary Carbon Markets

Voluntary Carbon Markets (VCM) lack standardization and transparency Ela Khodai (2023)

Carbon Credits are useful for private companies who wish to claim *carbon neutrality, climate positivity*, or other related claim, which might be viewed in good light by their clients or allow the companies to adhere to certain legislative requirements.

There are many companies which facilitate buy carbon credits as well as a few organizations focused on carbon credit verification.

- In Estonia, startups Arbonic and Single.Earth are trialing this approach in several forests.
- Carbon Credit Retirement?
- Methodologies: Anon. (2022b)
- KlimaDAO (2023) call for an open standard

Table 11: Voluntary market CO_2 prices on August 12, 2023; data from (CarbonCredits, 2023).

Voluntary Markets	Price (Tonne of CO_2)
Aviation Industry Offset	$0.93
Nature Based Offset	$1.80
Tech Based Offset	$0.77

Fossil Fuels

Fossil fuels are what powers humanity as well as the largest source of CO_2 emissions. IEA (2022) reports "Global CO_2 emissions from energy combustion and industrial processes rebounded in 2021 to reach their highest ever annual level. A 6% increase from 2020 pushed emissions to 36.3 gigatonnes". As on June 2023, fossil fuel based energy makes up 82% of energy and is

still growing Institute (2023). The 425 largest fossil fuel projects represent a total of over 1 gigatons in CO_2 emissions, 40% of which were new projects Kühne et al. (2022). Tilsted et al. (2023) expects the fossil fuel industry to continue grow even faster. In July 2023, the U.K. granted hundreds of new oil and gas of project licenses in the North Sea (Anon., 2023c).

Renewable Energy

There's ample evidence from several countries suggesting moving to renewal energy brings environmental benefits:

- Amin et al. (2022) suggests "removing fossil fuel subsidies and intra-sectoral electricity price distortions coupled with carbon taxes provides the highest benefits" for both the economy and the environment in Bangladesh.

- Luo et al. (2022) suggests using reinforcement learning to reduce energy use in cooling systems.

- The true cost of products is hidden. The work is hidden.

- Montreal protocol eradicates CfCs and the ozone holes became whole again.

Emission Scopes

The U.S. National Public Utilities Council (NPUC) decarbonization report provides a useful categorization of ***emission scopes*** applicable to companies and for organizing emission reduction schemes (National Public Utilities Council, 2022). For example, for consumers in Australian states and territories in 2018, 83% of the GHG emissions are Scope 3, meaning indirect emissions in the value chain Goodwin et al. (2023).

Table 12: From National Public Utilities Council (2022).

Emission Scope	Emission Source
Scope 1	Direct emissions
Scope 2	Indirect electricity emissions
Scope 3	Value chain emissions

One's scope 3 emissions are someone else's scope 1 emissions.

- Mapping pollution sources in China Xie et al. (2021)

Carbon Capture

Many technology startups focused on climate solutions (often referred to as climatech by the media), have proposed a range of approaches to CO_2 reduction in the atmosphere.

- Vitillo et al. (2022) illustrates how direct air capture of CO_2 is difficult because of low concentration and CO_2 capture at the source of the emissions is more feasible.

- Gaure and Golombek (2022) simulate a CO_2 free electricity generation system in the European Union where "98% of total electricity production is generated by wind power and solar; the remainder is covered by a backup technology.". The authors stipulate it's possible to power the EU without producing CO_2 emissions.

- **Important: "creating sustainability trust in companies in realtime"**

- Howard et al. (2017) argues Oceans play crucial role in carbon capture.

Social Cost of Carbon

Sustainability is filled with complexities, where CO_2 emission is compounded by biodiversity loss, child labor, slavery, poverty, prostitution, dangerous chemicals, and many other issues become intertwined (TEDx Talks, 2020). One attempt to measure these complexities, is the Social Cost of Carbon (SCC) which is defined as "additional damage caused by an extra unit of emissions" (Zhen, Tian and Ye, 2018; Kornek et al., 2021). For example the cost of damages caused by "one extra ton of carbon dioxide emissions" (Stanford University, 2021). SCC variations exists between countries (Tol, 2019) and regions (Wang, Y., Ma and Wang, 2022).

- As shown in the Phillipines by Cheng and Han (2022), with increasing extreme weather events, "businesses are more likely to emerge in areas where infrastructure is resilient to climate hazards". Jerrett, Jina and Marlier (2022) says, In California, "Wildfires are the second most important source of emissions in 2020" and "Wildfires in 2020 negate reductions in greenhouse gas emissions from other sectors."

- Lin et al. (2022) says, apart from CO_2, reduction of other atmospheric pollutants, such as non-CO_2 greenhouse gases (GHGs) and short-lived climate pollutants (SLCPs) is required for climate stability.

- Wang, T.-P. and Teng (2022): Quantifying climate damage proposes scenarios of climate damage.

Nationally Determined Contributions

- UNFCCC. Secretariat (2022) The State of Nationally Determined Contributions

While most countries have not reached their Nationally Determined Contributions, the Climate Action Tracker data portal allows to compare countries (Climate Analytics and NewClimate Institute, 2023).

Table 13: Climate Action Tracker's country comparison of the 10 top polluters' climate action.

Country or Region	NDC target
China	Highly insufficient
Indonesia	Highly insufficient
Russia	Critically insufficient
EU	Insufficient
USA	Insufficient
United Arab Emirates	Highly insufficient
Japan	Insufficient
South Korea	Highly insufficient
Iran	Critically insufficient
Saudi Arabia	Highly insufficient

- Fransen et al. (2022) notes that the majority of Nationally Determined Contributions (NDCs) are dependent on financial assistance from the international community.

TODO

- "triple turn"
- lack of transparency
- Call for GOP contributors' transparency
- Renewable energy is a tool against tyranny by decentralizing the energy sources and production: Timchenko (2023)

Regenerative design

- dematerialize economies is not enough

Biomimicry

-

Eco-Design

Designing for Sustainability aka Circular Design or Eco-Design encompasses all human activities, making this pursuit an over-arching challenge across all industries also known as circular economy. Assuming that as individuals we want to act in a sustainable way, how exactly would be go about doing that?

- "Evolution of design for sustainability: From product design to design for system innovations and transitions"
- de Otazu et al. (2022) **Life Cycle Assessment and environmental impact analysis are needed to provide eco-design scenarios.**
- European Parliament (2022) proposal "On 30 March 2022, the European Commission put forward a proposal for a regulation establishing a general framework for setting eco-design requirements for sustainable products, repealing rules currently in force which concentrate on energy-related products only." Virginijus Sinkevičius, EU Commissioner for the Environment, Oceans and Fisheries, is quoted as describing eco-design "respects the boundaries of our planet" European Commission (2022a)

AI-Assisted Design

Gupta et al. (2023) argues software is key to building more sustainable products, already for decades. More recently, companies like AutoDesk are putting CO_2 calculations inside their design software.

- AI has the potential to provide the parameters for sustainability. Singh and Sarkar (2023) proposes an AI tool for deciding the suitable life cycle design parameters.
- Anon. (n.d.b): "Sustainability starts in the design process, and AI can help".

Circular Economy

Circular economy is a tiny part of the world economy. Circle Economy (2022) reports only 8.6% of world economy is circular and *100B tonnes of virgin materials* are sourced every year.

- McDonough and Braungart (2002) book
- McGinty (Thu, 08/06/2020 - 11:25): How to Build a Circular Economy
- Dull (2021) book
- Chapman (2009) argues in his seminal paper (and later in his book) for ***"Emotionally Durable Design"***, the simple idea that we hold to things we value and thus they are sustainable. We don't throw away a necklace gifted to us by mom, indeed this object might be passed down for centuries. Rose (2015) has a similar idea, where ***"Enchanted Objects"*** become so interlinked with us, we're unlikely to throw them away.
- Growing public understanding of how nature works and intersects with our use of money.

- Hedberg and Šipka (2021) argues digitization and data sharing is a requirement for building a circular economy.

Policy Context

The Policy Context in Europe From 2023 to 2030

We have an opportunity to re-imagine how every product can be an eco-product and how they circulate in our circular economy.

Timeline of the Policy Context:

- In 2019 by the von der Leyen commission adopted the European Union (EU) **Green Deal** strategy.

- In 2021 the Commision proposed a goal of reducing CO2e emissions by 55% by 2030 under the *Fit for 55* policy package consisting of a wide range of economic measures.

- In November 2022, the proposal was adopted by the EU Council and EU Parliament with an updated goal of 57% of CO2e reductions compared to 1990. This proposal is set to become a binding law for all EU member countries (European Commission (2019a); European Commission (2019b); Anon. (2022c); European Council (2022)).

- In March 2022, the EU Circular Economy Action Plan was adopted, looking to make sustainable products *the norm* in EU and *empowering consumers* as described in European Commission (2022b). Each product covered by the policy is required to have a ***Digital Product Passport*** which enables improved processing within the supply chain and includes detailed information to empower consumers to understand the environmental footprint of their purchases. It's safe to say the large majority of products available today do not meet these criteria.

European Green Deal

- Anon. (2021b)
- Switch2Green (2023)

It's up to legislators to provide sustainable products on our marketplace... but until we do, use the green filter.

- One of the EU goals is reducing consumption
- Tacking our consumption habits
- Europe is the hotbed of sustainability
- Iman Ghosh (2020)
- Lamoureux (2018) Florida sustainable companies

- MICHAEL HOULIHAN and BONNIE HARVEY (2018) customers prefer sustainable companies
- Rajagopalan and Landrigan (2023): In the US, the *Inflation Reduction Act* provides funding to development of decarbonizing technologies and includes plans to combat air pollution, reduce green house gases and address environmental injustices.

Ecodesign as Key Policy Tool

A large part of the proposal by Commission et al. (2014) is ***eco-design***, as a large part of product lifecycle environmental impact is defined in the design process.

Table 14: The framework proposes 9 values to strive for in high quality products.

Quality		
Durable	Reparable	Easy to recycle
Reusable	Easy to maintain	Energy efficient
Upgradable	Easy to refurbish	Resource efficient

Policy Around the World

Politics matters in sustainability.

In the European Union (EU), a wide range of legislative proposals, targets, organizations, and goals already exists across diverse countries. Upcoming laws aim to harmonize approaches to sustainability and raise standards for all members states, in turn influencing producers who wish to sell in the EU common market.

- In Brazil, deforestation fell 60% in 1 year, based on remote satellite reconnaissance, after the election of a more pro-environment leadership Watts (2023).

- Anon. (n.d.c) report: The EU has a ***taxonomy of environmentally sustainable economic activities*** published by the Technical Expert Group (TEG) on sustainable finance.

- The proposal for a Nature Restoration Law by the European Commission requiring member countries to restore 20% of EU's degraded ecosystems by 2030 and full restoration by 2050 has not yet passed Anon. (2023d) and is facing a backlash David Pinto (2023).

- Manzardo et al. (2021) **(need access!)**

- Iñarra et al. (2022) **(need access!)**

- Munaro, Tavares and Bragança (2022) **(need access!)**

- Bassani et al. (2022) **(need access!)**

- Van Doorsselaer (2022) **(need access!)**

- Nuez, Ruiz-García and Osorio (2022) shows how electric vehicles may increase CO_2 emissions in some areas, such as Canary Islands, where electricity production is polluting.

- Rossi, Cappelletti and Germani (2022) shows how introducing sustainability early in the design process and providing scenarios where sustainability is a metric, it's possible to achieve more eco-friendly designs.

- Tiernan et al. (2022) microplastics are a real concern

- Arranz, Sena and Kwong (2022) developing circular economy is really complex

- Cheba et al. (2022)

- Ruiz-Pastor et al. (2022)

- Miyoshi et al. (2022) takes the example of ink toner bottles and shows in a case study how standardized compatibility between older and newer systems can save resources and results in sustainability savings.

- Finding green products and supporting companies making them

- Supporting legislative changes

- Track you consumption, saving, investing. Shift balance towards saving and investing.

- Nastaraan Vadoodi (2022)

- European Commission (2022c) Ecodesign for sustainable products

Waste Generation

Liu, K. et al. (2023) reports, e–waste is growing 3%–5% every year, globally. Thukral and Singh (2023) identifies several barriers to e-waste management among producers including lack of awareness and infrastructure, attitudinal barriers, existing *informal* e-waste sector, and the need for an e-waste license.

Extended Producer Responsibility

Extended Producer Responsibility (EPR) is a policy tool first proposed by Thomas Lindhqvist in Sweden in 1990 [CITE], aimed to encourage producers take responsibility for the entire life-cycle of their products, thus leading to more eco-friendly products. Nonetheless, EPR schemes do not guarantee circularity and may instead be designed around fees to finance waste management in linear economy models (Christiansen, Hasse and Tønder, 2021). The French EPR scheme was upgraded in 2020 to become more circular (Jacques Vernier, 2021).

In any case, strong consumer legislation (such as EPR) has a direct influence on producers' actions. For example, in HKTDC Research (2022), the Hong Kong Trade Development Council notified textile producers in July 2022 reminding factories to produce to French standards in order to be able enter the EU market. Peng, Shi and Tong (2023) finds that the ***Carbon Disclosure Project*** has been a crucial tool to empower ERP in Chinese auto-producers.

- The success of EPR can vary per type of product. For car tires, the EPR scheme in the Netherlands claims a 100% recovery rate Campbell-Johnston et al. (2020).

One type of legislation that works?

- Steenmans and Ulfbeck (2023) Argues for the need to engage companies through legislation and shift from waste-centered laws to product design regulations.

- In Europe, there's large variance between member states when in comes to textile recycling: while Estonia and France are the only EU countries where separate collection of textiles is required by law, in Estonia 100% of the textiles were burned in an incinerator in 2018 while in France textiles are covered by an Extended Producer Responsibility (EPR) scheme leading to higher recovery rates (Ibid).

Return, Repair, Reuse

- There's a growing number of companies providing re-use of existing items.
- Anon. (n.d.d) For example, Swap furniture in Estonia

Bring back your bottle and cup after use.

- Ruiz-Pastor and Mesa (2023) proposes a **product repairability index (PRI)**
- Formentini and Ramanujan (2023)
- Recycling (Lenovo, 08-29-22) "rethinking product design and inspiring consumers to expect more from their devices"
- "design is a tool to make complexity comprehensible" like the Helsinki chapel. there's either or a priest or a social worker. it's the perfect public service. "limit the barrier of entry for people to discover". elegant.
- Zeynep Falay von Flittner (n.d.)

Packaging

Packaging is a rapidly growing industry which generates large amounts of waste Ada et al. (2023). Bradley and Corsini (2023): "Over 161 million tonnes of plastic packaging is produced annually."

- Anon. (2022d)
- Anon. (2022e)
- Anon. (2010)
- Lerner (2019) Coca Cola plastic pollution
- Anon. (n.d.e)

Factories

- Transparency about the polluting factories where the products come from.. the product journey

- virtual factories

- Tracing emissions from factory pipes… what's the app?

- Factories should be local and make products that can be repaired.

- Carbon-neutral factories "made in carbon-neutral factory" list of products

- Stefan Klebert (2022)

- VDI Zentrum Ressourceneffizienz (2020)

- Anon. (n.d.f) and Anon. (n.d.g) CO_2 neutral factories?

- Anon. (n.d.h) CO_2 neutral websites https://ecograder.com/

- Eric fogg (2020) Lights-Out Manufacturing

- Mowbray (2018) "World's first free digital map of apparel factories"

- Anon. (n.d.i) Factory compliance - Fair Factories

- Planet Factory

- Anon. (n.d.j) Plastic waste makers index, sources of plastic waste

Design Implications

- In unison, the reviewed technologies and practices move us closer to enabling *realtime ESG*: up-do-date transparent information about how our product are produced. Realtime ESG is a building block to enable consumers and investors make more accurate, real-world purchase decisions.
- *People live in the polluted areas are so used to it. What app to wake them up? "You live in a highly polluted area. Here's the TOP 10 companies causing pollution. Here's what you can do."*
- Blood testing and biomarkers allow people to track their health. I'm introducing the concept of 'eco-markers' to follow the sustainability of human activities.
- Circular Economy

    – AI can help us make sense of the vast amounts of sustainability data generated daily.

- EPR

    – ERP and CDP data should be part of Green Filter.