

The Journey from Consumer to Investor: Designing a Financial AI Companion for Young Adults to Help With Sustainable Shopping, Saving, and Investing

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Measuring Sustainability

“Nachhaltigkeit” - meaning *sustainability* in German - was likely the first use of the concept of preserving natural resources, conceived by a tax accountant Hannß Carl von Carlowitz in 1713 in his seminal book on forestry - *Sylvicultura oeconomica* -, referring to the goal of achieving prudent forest management practices in his native Saxony in Southeastern Germany, which at the time was under severe deforestation pressure from mining, ship-building and agricultural production (Hannß Carl von Carlowitz, 1713; Gottschlich and Friedrich, 2014). This particular field of sustainability study is now known as *sustainable yield of natural capital* - the principal of a natural resource, such as in fishing and forestry shouldn't be over-harvested in order to maintain *ecosystem services* - a contemporary term from the theory of *natural capital*, referring to benefits humans receive from the stock of world's natural resources (Peter Kareiva et al., 2011). Perhaps more poetically, the American wildlife ecologist Aldo Leopold proposed the idea of **land ethics** in 1972 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 landmark work *A Sand County Almanac* (Leopold, 1972). In a similar vein, the 1987 United Nations' Brundtland Report titled “*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). Given these varied ideas, it could be said people have been concerned with our planet's natural environment and its preservation already for centuries. Yet it is only in the last century that human activities have begun to affect Earth's systems on a previously unseen scale, necessitating a deeper understanding of human – nature interactions, such as in the case of climate change.

Measuring Climate Change

Just as with sustainability, studies of Earth's climate go back for a long time. Already in 1896, the Nobel Prize winner Svante Arrhenius first calculated how an increase in CO₂ levels could have a warming effect on our global climate (Anderson, Hawkins and Jones, 2016; Wulff, 2020). 120 years later, the Paris Climate Agreement came into effect, with countries agreeing on non-binding targets on how to keep CO₂ levels 1.5 °C below pre-industrial levels (United Nations, 2016). While awareness of Earth's warming climate was growing, the CO₂ emissions kept rising too. The hockey-stick growth of CO₂ concentration since the industrial revolution is clear in the data from 1958 onward, following a steady annual increase, called the *Keeling Curve* (Keeling and Keeling, 2017). Written records of global temperature measurements are available starting from the 1880s when documentation of temperatures become available in ship records (Brohan et al., 2012). Temperature estimations from tree-trunks allow some temperature comparisons with the climate as far back as 2000 years ago (Rubino et al., 2019).

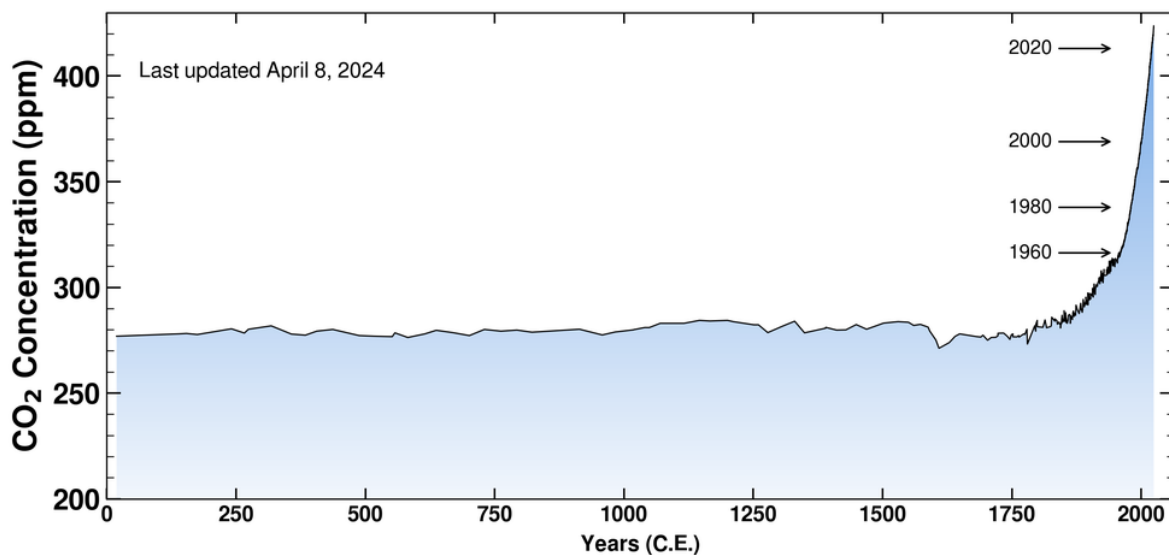


Figure 1: CO₂ concentration in the atmosphere as of Ap. Image Credit: Scripps Institution of Oceanography at UC San Diego.

In 1938, Guy Stewart Callendar was the first scientist to demonstrate the warming of Earth's land surface as well as linking the production of fossil fuels to increased CO₂ and changing climate (Hawkins and Jones, 2013). By the latest data from 2022, the current world population of 8 Billion people emitted 37.5 gigatonnes of CO₂ per year, the highest emissions recorded in history (Statista, 2023). To limit global warming to 1.5 °C as agreed by the world nations in Paris, removal of 5-20 gigatons of CO₂ per year would be needed according to reduction pathways calculated by the Intergovernmental Panel on Climate Change (IPCC) (Wade et al., 2023). Yet, most countries are missing the mark [MISSING CITATION]. Given this model of climate change, the G7 countries (Canada, France, Germany, Italy, Japan, United Kingdom, United States) are heading for 2.7 °C of warming by 2050 (CDP, 2022). The monumental task of removing several gigatons of CO₂ from the atmosphere requires massive policy shifts and collaboration across countries and industries (Mackler, Fishman and Broberg, 2021).

News reports saying quoting the “The European Union’s Copernicus Climate Change Service (C3S)” 1.5 has already been breached (Anon., 2024a; Anon., 2024b).

In 1948, the International Union for Conservation of Nature (IUCN) was founded, which in LULUCF “Land Use, Land-Use Change, and Forestry” can be a source of greenhouse gas emissions or a carbon sink (removing CO₂ from the atmosphere)

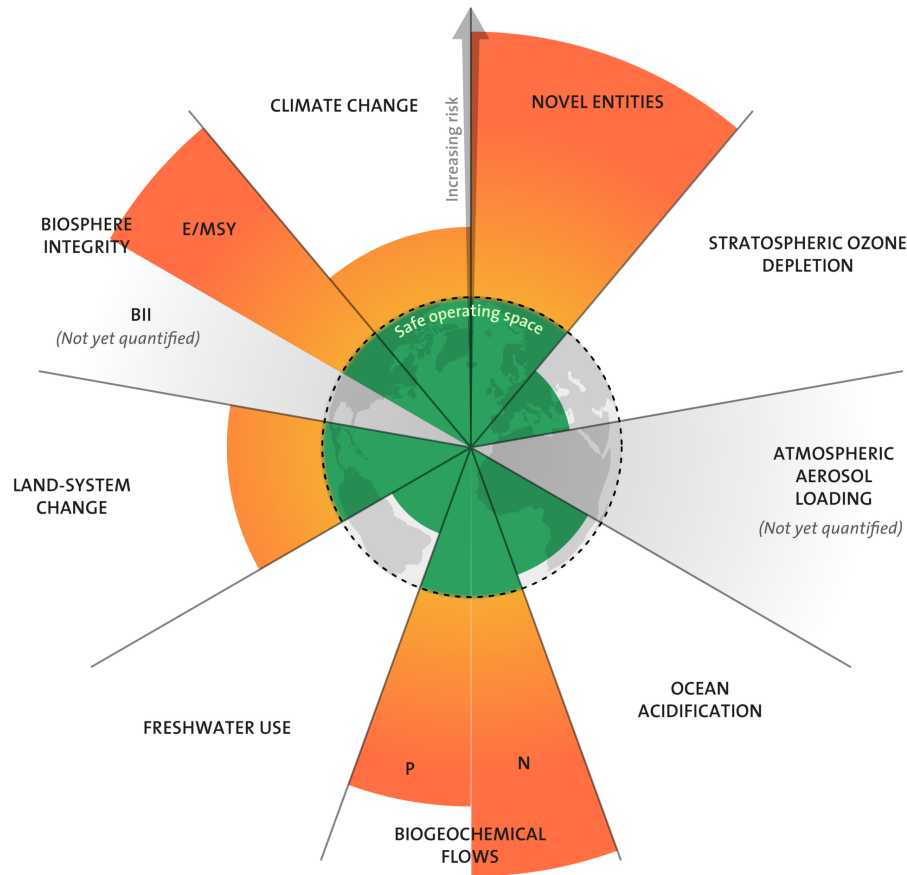


Figure 2: Planetary Boundaries. J. Lokrantz/Azote based on Steffen et al. 2015

In addition the enormity of emissions, humanity is facing other massive problems. The Stockholm Resilience Centre reports we have already breached 4 out of our 9 planetary boundaries: in addition to climate change, biodiversity loss (Extinctions per Million Species per Year aka E/MSY), land-system change (deforestation, land degradation, etc), and biogeochemical flows (cycles of carbon, nitrogen, phosphorus, etc); on a positive side, the challenges of fresh water use, ocean acidification and stratospheric ozone depletion are still within planetary limits (Persson et al., 2022).

Atmospheric aerosol loading and the biodiversity intactness index (BII) were quantified recently (ADD CITATION)

- (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)

Planetary Boundaries

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

Evolving Measurements from Planetary Boundaries to Planetary Health

Planetary Health

- 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.”*

Biodiversity 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 CO₂ 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%

AI is being used to map icebergs and measure the change in size European Space Agency (2023)

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 3: 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 CO₂ 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

Ecosystem Services Enable Life on Earth

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, 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 (ADD CITATION A B C).
- Espinosa and Bazairi (2023) marine ecosystem services (**need access, ncku doesn't sub**)

- 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 Is Cir

Growing Population and Overpopulation

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

Marine Heatwaves

- Gelles and Andreoni (2023) describe how marine heatwaves threaten global biodiversity.

Slavery Still Exists

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 Helliard (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.

Overconsumption Drive Climate Change

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 CO₂ 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).