With the support of the Erasmus+ Programme of the European Union

Our Planet at Risk

CHAPTER 2

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SEPTEMBER 2021 | LET'S ACT ERASMUS PLUS PROJECT

2. Our Planet at Risk

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Introduction

The planet is at risk of becoming less and less inhabitable because of modern industrialisation and consumer capitalism. As a result, global environmental threats loom, such as climate change, pollution of the atmosphere, acidification of the seas and rising sea levels, desertification, land degradation and loss of biodiversity.

Human behaviour stands at the root of many of these threats, and it also holds the keys for reversing the trend. Action includes a combination of change in individual and collective behaviour, changed policy and governance as well as scientific and technological developments which combined can open promising opportunities for a better life. Adoption of new materials and sources of energy, global communication and clean mobility may allow people in the future to enjoy better lives than any time in the past, all while being part of a global sustainable community.

Contrasting scenarios can be, and are indeed, being built. At the root of the difference between doom and hope stands human action (or inaction) at all levels. Public and corporate action count, as does citizens action backed by knowledge, understanding, awareness and engagement. Only together can we make the difference needed. For some, the impact of climate change is already a reality in everyday lives, for others it is somewhat removed. However, sooner or later it will affect us all directly.

2.1 Humanity at a crossroad between Holocene and Anthropocene

The Holocene is the name given to the geological epoch which started at the end of the last glacial period and has lasted for approximately 12.000 years. The Holocene has observed a slightly warmer and stable climate than previous periods which has allowed for human civilization, as we know it today, to thrive and develop.

Without pressure from humans, the Holocene was expected to continue for at least several thousands of years. However, some scientists believe we are finding ourselves at a crossroad between the Holocene and a new age, usually referred to as the Anthropocene.

Anthropos is the Greek word for human, and the Anthropocene refers to the beginning of a new geological epoch, an epoch where human exploitation has reached such a magnitude that it has a dominant impact on the natural geology of Earth.

In this chapter we will explore how and why the favourable conditions of the Holocene are under threat from human exploitation, and what must be done to reverse such threats to assure humanity's long-term goal of "meeting the human rights of every person within the means of our life-giving planet"[1].

Modern civilizations flourished during the Holocene

Earth has experienced substantial variations in the climate over the past millions of years moving between glacial periods (ice-age) and interglacial periods (Fig 1). However, over the past 12.000 years, Earth has experienced an unusually stable and slightly warmer environment than the previous 110.000 years, which allowed human civilizations rise, develop, and thrive[2]. This period is called the Holocene. The unprecedented stability of the environment of the Holocene (+- 1c°) is the result of the particularly circular orbit that Earth is currently making around the sun[3] combined with many

[1] Kate Raworth, Doughnut Economics, 2017
[2] Johan Rockström et al, A safe operating space for humanity, 2009
[3] Berger, A. & Loutre, An Exceptionally Long Interglacial Ahead?, 2002

interdependent natural systems that help regulate the climate including the rainforests and temperate forests, oceans, the large permafrost regions, and the savannahs[4].

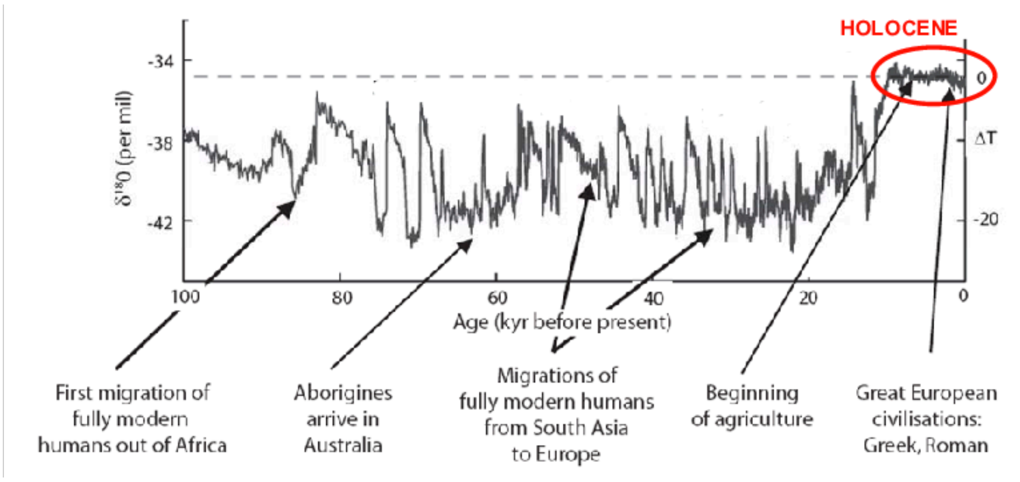

Fig 1: The last glacial cycle (indicator of temperature) and selected events in human history. The Holocene is the last 10,000 years. Adapted from Young and Steffen (2009), Principles of Ecosystem Stewardship, New York, Springer[5]

During the Holocene, primary resources such as water, land or fossil-fuels have been plentiful, and the world's ecosystems have been able to absorb the waste of human activity resulting in stable and predictable temperatures, freshwater availability and biogeochemical flows all stayed within a relatively narrow range which allowed for a stable environment that provided optimal conditions for human development.

Anthropocene

Since the industrial revolution, especially since the post war boom from the 1950s onwards, human activity has had a dramatic impact on earth. Human exploitation of natural resources in the quest of increased production and consumption powered by fossil fuels has led to a massive increase in the emission of Greenhouse Gasses (GHGs), while intensive forms of agricultural farming facilitated by chemical fertilizers and land-use conversion, to feed an ever-growing and increasingly affluent global population, have been putting massive pressure on the environment and the many interconnected systems that assure the stable environment of the Holocene.

The impacts of human activities have led to the loss of biodiversity, imbalance of ecosystems and climate change, all of which enhanced each other, resulting in associated systems being more unstable. The impact has reached such levels that could damage the systems that keep Earth in the desirable equilibrium state and the result could be detrimental, even irreversible in some cases, leading to abrupt environmental change and a new state less conducive to human development[6].

This new state, also called the Anthropocene, represents a globalised phase of environmental change, as local environmental changes can no longer be separated from the global. Activities in one place of the Earth can influence far-removed places on Earth as well as have an effect on global scale[7]. Think of the melting ice sheet in Greenland or the deforestation of the Amazon Forest.
This new globalised phase of environmental change is having an increasing effect on our climate, often with a dramatic increase in natural disasters such as hurricanes, flooding, drought, forest fires

[4] Johan Rockström et al, A safe operating space for humanity, 2009
[5] https://www.researchgate.net/figure/The-last-glacial-cycle-of-18O-an-indicator-of-temperature-and-selected-events-in-human_fig1_42766179
[6] Steffen, W. et al. Global Change and the Earth System: A Planet Under Pressure, 2004
[7] Steffen, W., Crutzen, P. J. & McNeill, J. R., The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature?, 2007

and other natural events, which in turn can have a significant impact on economic and human development everywhere in the world, especially in the poorer regions. If not addressed adequately, this could see human activities push the earth system outside the stable environmental state of the Holocene, with consequences that can be detrimental or even catastrophic for large parts of the world[8].

Without pressure from humans (CO2 emission, loss of biodiversity and imbalance of ecosystems, pollution and more), the Holocene would have continued for at least several thousands of years[9]. According to Johan Rockström and colleagues, there is now sufficient scientific evidence to document that humanity stands at a crossroad: one road takes us further into disequilibrium and loss of stable living conditions in large areas, and the other can largely save the stable state of the Holocene. Precaution should be the guiding principle at this crossroad, and actions towards sustainable development is paramount on this voyage.

To help us steer in the right direction, striving for Holocene like conditions, it is important to understand two fundamental elements:

1. Which are the rising human pressures on ecosystems and the planetary system that are putting the Earth at risk,
2. How does nature and the Earth system respond to such pressures (Earth resilience and tipping points).

Only then do we have the knowledge needed to be able to start identifying the solutions and technologies that are adequate, and only then can we design economic instruments and global governance systems that are fit for the task and identify the individual actions needed by all.

The Great Acceleration

Why have we landed in this unprecedented situation standing at such an important crossroad for humanity? According to many scientists[10] [11], planet Earth is being squeezed on multiple fronts simultaneously, a squeeze which has been significantly amplified in the last 50 years, exemplified by the exponential rise in terms of welfare and development, from population and economic growth to paper and water consumption and telephone use, as well as mass tourism and production of motor vehicles[12] (Fig 2).

What evidence do we have to suggest we have entered the Anthropocene? The Great Acceleration graphs (Fig 2) helps document how human activity, predominantly the global economic system, is now the prime driver of change in the Earth System, including its geology and ecosystems. While the Great Acceleration graphs start around the Industrial Revolution, the acceleration only really begins in the post-war are of the 1950s and continues thereafter.

The Great Acceleration graphs trace the evolution of socio-economic trends, like population growth, GDP and primary energy use, as well as linked Earth System trends, like carbon dioxide, surface temperature and ocean acidification, and suggests these are in fact interlinked and together putting increased pressure on planet Earth.

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[8] Johan Rockström et al, A safe operating space for humanity, 2009
[9] Berger, A. & Loutre, An Exceptionally Long Interglacial Ahead?, 2002
[10] Steffen, W. et al. Global Change and the Earth System: A Planet Under Pressure, 2004
[11] Steffen, W. et al, The Anthropocene: From Global Change to Planetary Stewardship, 2011
[12] Steffen, W., Crutzen, P. J. & McNeill, J. R., The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature?, 2007

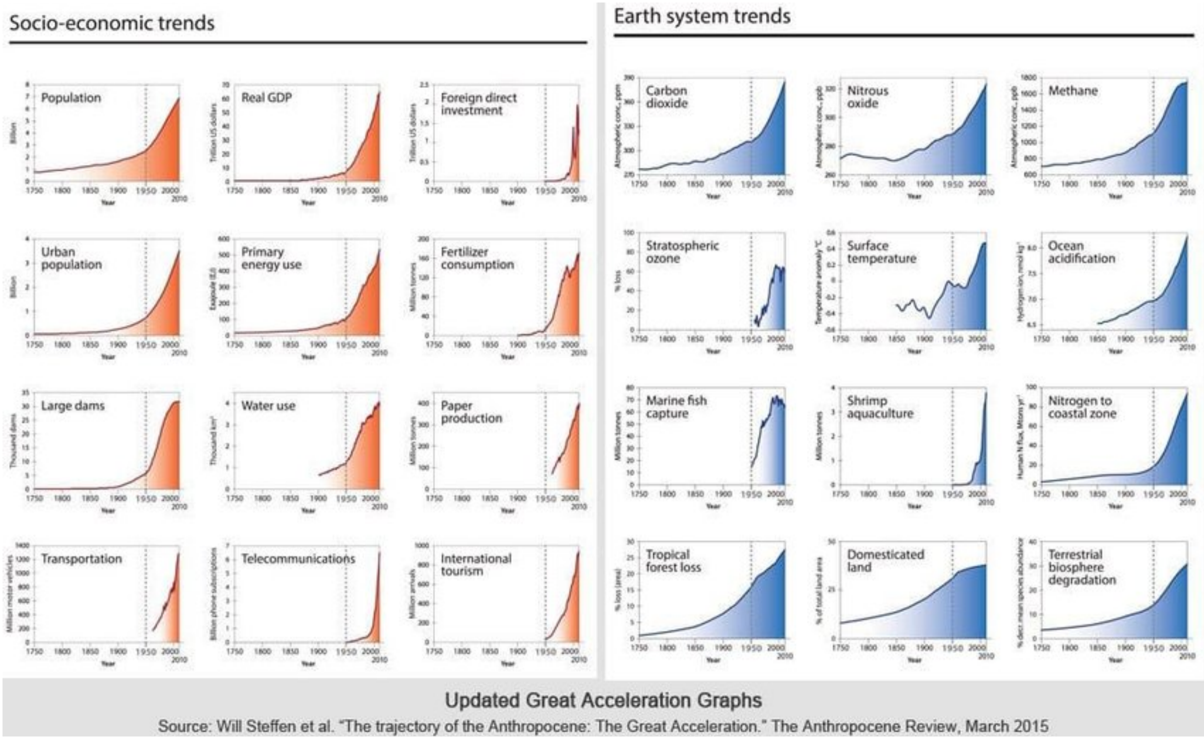

Fig 2: Great Acceleration, Will Steffen et al., The trajectory of the Anthropocene, The Anthropocene Review, 2015[13]

It is useful to highlight three particular categories that have put significant pressures on Earth

1. human population pressure: growth and affluence,
2. human caused climate change,
3. ecosystem crises and regime shifts

1. Population Growth and Increased Affluence

The first pressure refers to the fact that over the last 120 years the world population has exploded, growing from 1,6 billion in 1900 to 3 billion in the 1950s, 7.7 billion in 2019 and with the UN predictions for 2050 being 9.7 billion with a continued increase and reaching a peak of around 10.4 billion at the end of the century[14].

The increase in population, living standards and affluence has resulted in an exponential increase in consumption and production which has and continues to put an increased strain on primary resources. This, in turn, has put an increased strain on Earth's climate and ecosystems.

The "hockey stick" graph (Fig 3) documents the increase of the world population over the past 12.000 years. The population on Earth was relatively stable until the 15th century, after which it started to grow at unprecedented rates, reaching just under one billion in 1800 and then growing at exponential rates until today and is expected to peak at 10.4 billion by the end of the century.

[13] https://www.researchgate.net/figure/The-Great-Acceleration-Steffen-et-al-2015b_fig5_326295135
[14] UN, World Population Prospects, 2019

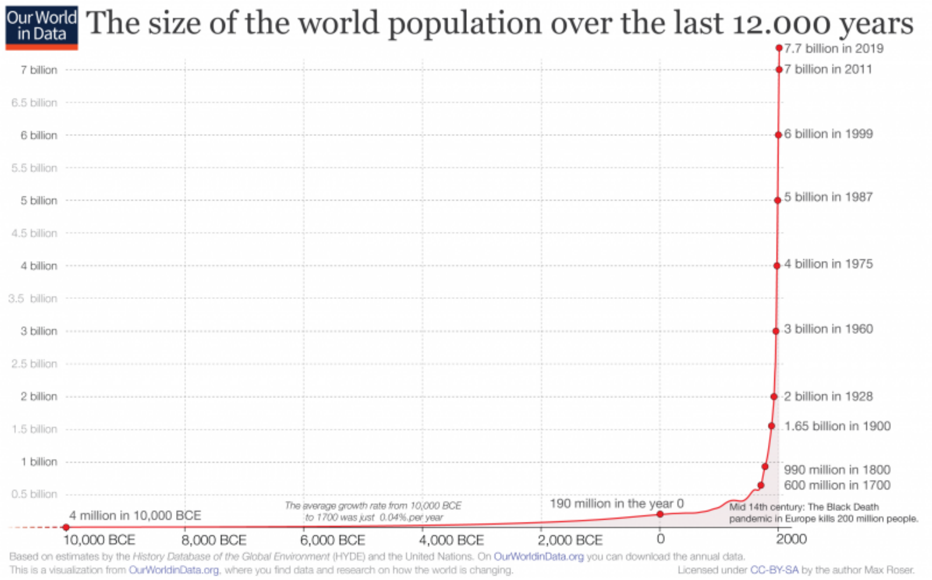

Fig 3: The Size of the world population over the last 12.000 years, Our World in Data[15]

Population growth is, however, a temporary phenomenon. It is the result of being in the middle of a demographic transition. This is where better living conditions lead to lower mortality rates while fertility rates remain high. Eventually, the fertility rates also come down, and population growth will stabilise again. In some of the first industrialised countries, the demographic transition took around 100 years, however some newly industrialised countries have achieved stable demographic growth in as little as ten years. Explore the five stages of the demographic transition (Fig 4) to visualise the demographic transition and why population growth is a temporary phenomenon.

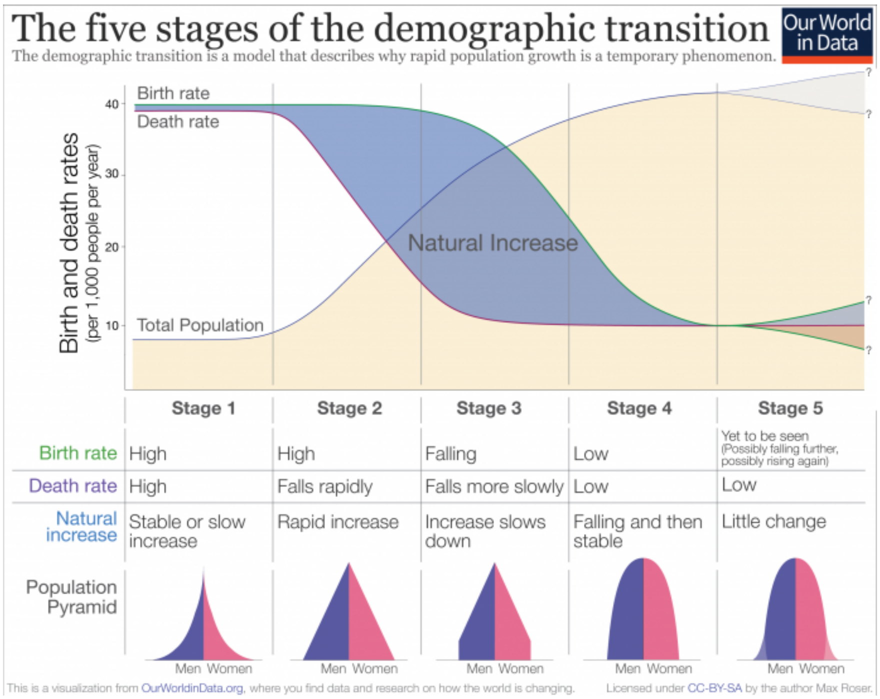

Fig 4: The five stages of demographic transition, Our World in Data[16]

The UN expects the global population to peak at around 10.4 billion people at the end of the century. After this, it will start declining. Predictions about population growth are dependent on the

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[15] https://ourworldindata.org/uploads/2018/11/Annual-World-Population-since-10-thousand-BCE-for-OWID-800x498.png
[16] https://ourworldindata.org/world-population-growth

speed of the demographic transition, which depends on 1. individual choices, 2. level of education, 3. culture and policies, 4. availability of adequate healthcare services to meet individual choices.

Just like all individual countries will go through this transition, so will the world as a whole go through this transition.

Global fertility has more than halved in the last 50 years. In the 1960s, women had, on average, five children. Today this global average is below 2.5. This means that the world is well into the demographic transition, and the global population growth rate peaked half a century ago. As can be observed in Fig 5, the global demographic transition that the world entered more than two centuries ago is then coming to an end. A new balance will prevail, where low mortality rates will be accompanied by low fertility rates resulting in population changes.

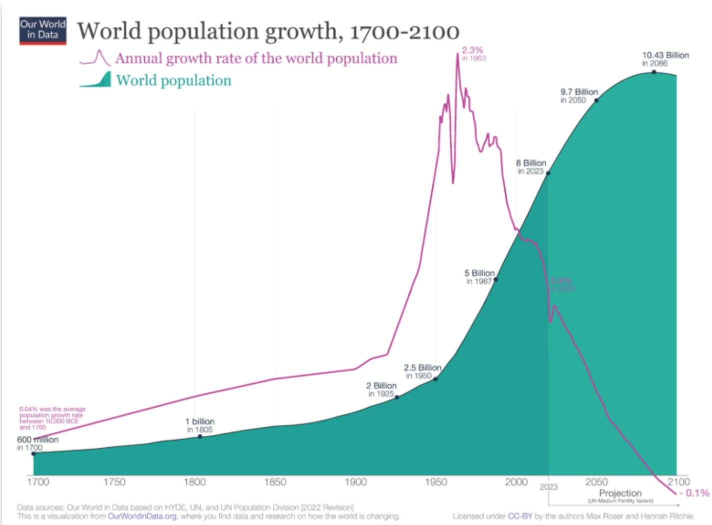

Fig 5: World population growth, 1700-2100, Our World in Data[17]

What are the changes expected for the future? As can be observed in Fig 6 Asia has experienced rapid population growth over the past 50 years. Today, its population stands at around 4.7 billion and is expected to rise to 5.3 billion by 2050. After that we find a significant shift as it is expected to fall in the latter half of the century, and by 2100 is projected to fall almost back to levels we see today.

Where the most significant population growth will occur over the coming years is in Africa. Today, its population is around 1.4 billion and by 2100 it is projected to reach just under 4 billion. As can be observed in Fig 6, today, Africa has today around 18% of the global population and by 2100 this is projected to rise to 38%. In contrast, today Asia has around 60% of the global population which will fall to around 45% in 2100.

At the end of the century, more than 8 out of every 10 people in the world will live in Asia or Africa.

[17] https://ourworldindata.org/future-population-growth#:~:text=Towards%20the%20end%20of%20the,the%20population%20dynamics%20beyond%202100.

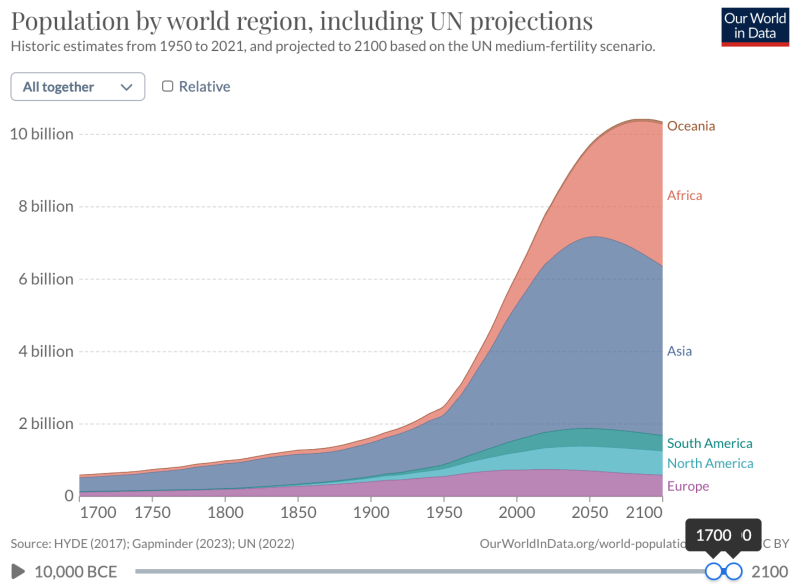

Fig 6: Population by world region, including UN projections, Our World in Data[18]

The increase in number of people on the planet has been accompanied by a necessary increase in the production of food which certainly has had an important impact on ecosystems around the world as many wild habitats have been converted to agricultural land. However, the more substantial impact on Earth only materialized in the very recent past, when large segments of the world population, especially in South-East Asia (Fig 7), entered the middle-class, where they are experiencing fast economic and human development, and with that join the increasing group of mass-consumers[19].

Mass-consumers do not only demand sufficient food every day, which can often be provided by local traditional agriculture, but also want the same elaborate foods, goods, services, and experiences as people in other more developed nations (transport, consumption, housing, tourism etc), following habits proposed by worldwide advertising, and with that have much higher ecological footprints on Earth. Rapid urbanisation is the result of all segments society striving for improved jobs and lifestyles. More than half the world's population today live in cities, and another 2.5 billion people are expected to join them by 2050. Urban centres worldwide, especially in developing countries, often have characteristics that make them and their inhabitants especially vulnerable to the adverse impacts of climate change and other natural and anthropogenic hazards and need specific risk reduction strategies[20].

[18] https://ourworldindata.org/grapher/world-population-by-region-with-projections?time=1700..2100
[19] Our World in Data: Income inequality, 2016
[20] UN FCCC, 2017, Initiatives in the area of human settlements and adaptation

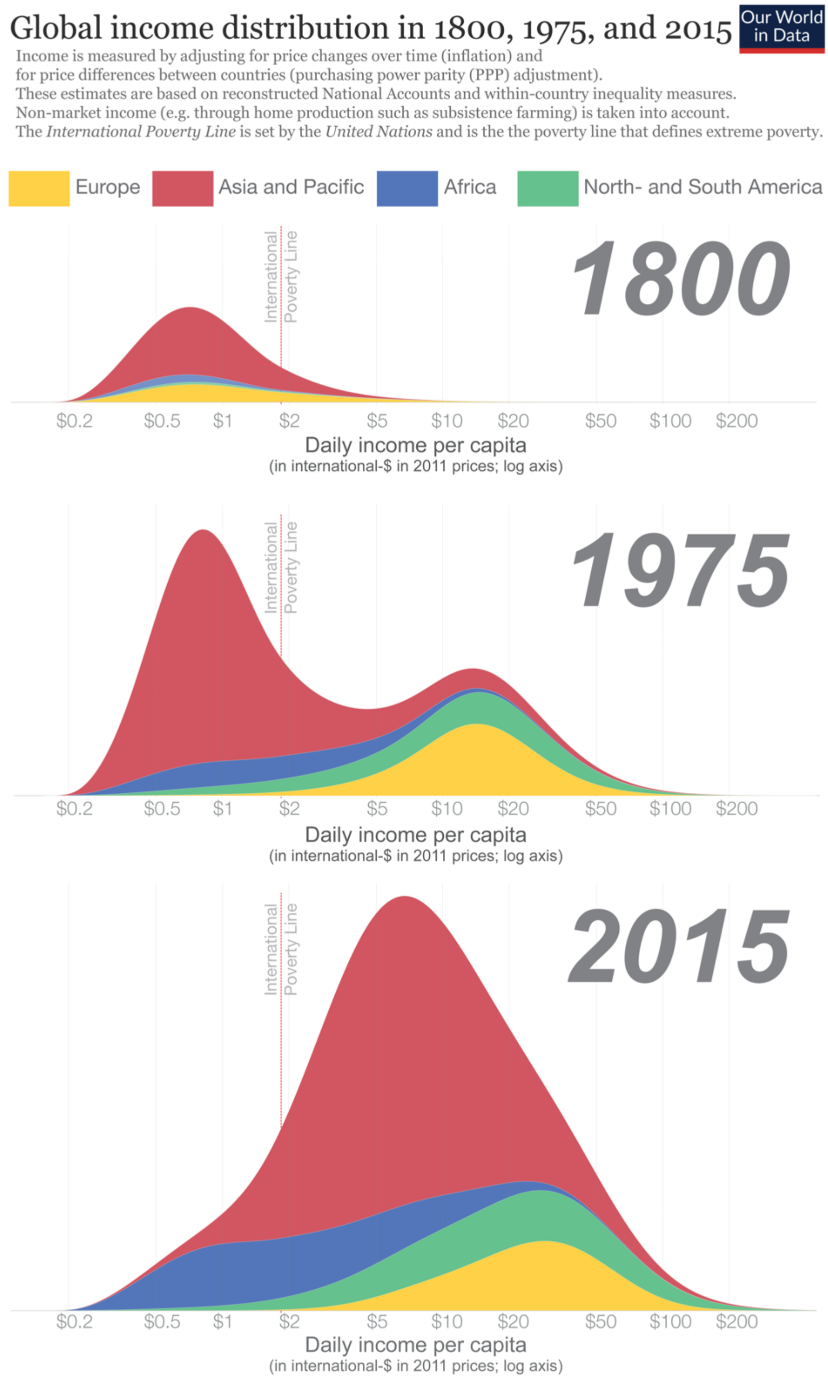

Fig 7: Global income distribution in 1800, 1975, and 2015, Our World in Data[21]

The global middle-class is expected to grow and reach 5.5 billion by 2030 and with that comes significant increase in middle-class spending, expected to account for one third of GDP growth mainly in emerging economies[22]. While the increase in economic and human development of the world's poorest populations is a phenomenon to be welcomed, as it will take millions out of poverty and give them the education, health, and job prospects that we all deserve, it also poses an enormous challenge if the growth and consumption of the entire middle-class and especially upper-class continues to be unsustainable[23].

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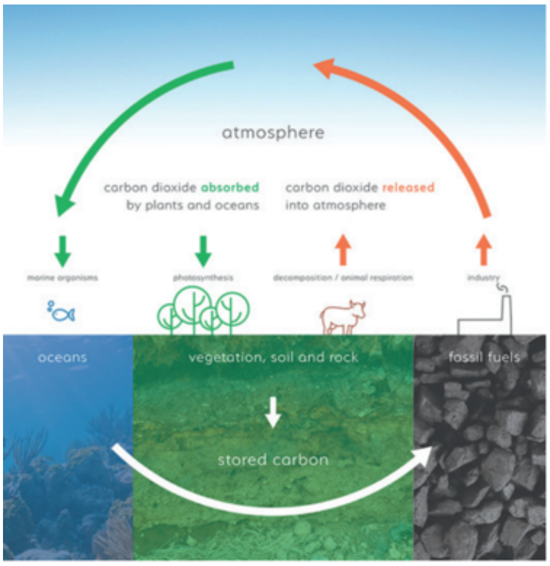
[21] https://ourworldindata.org/income-inequality
[22] European Commission, Developments and Forecasts of Growing Consumerism
[23] Our World in Data: World Population, 2019

2. Climate Change and Carbon Cycle

The second pressure is human-induced climate change, which is caused by an increased release of Carbon Dioxide (CO2) and other Green House Gasses (GHG) into the atmosphere.

Carbon is an essential element for all life forms on Earth. Carbon is used by plants to grow leaves and stems, which in turn are digested by animals to grow. Carbon is also stored in oceans and allow many types of marine organisms to form shells and skeletons. Most of the carbon on the planet is however contained within rocks, minerals, and other sediments buried beneath the surface of the planet. In the atmosphere, carbon is stored in the form of gases such as CO2 and when increasing in quantity, they accumulate to form an isolating layer which has a green-house effect on the planet.

The amount of carbon in the system never changes as Earth is in a locked system, however it can and does constantly change location, also known as reservoirs, through a variety of processes including photosynthesis, burning of fossil fuels, and simply by breathing[24] - also known as the carbon cycle.



Source: Forest products commission, Western Australia

Fig 8: The carbon cycle, Forest products commission, Western Australia

In the Holocene, the natural carbon cycle has remained in balance, meaning that the amount of carbon naturally released from reservoirs has been equal to the amount that has been naturally absorbed by plants and oceans. This balance contributed to Earth's stable climate.

Industrialisation has been fuelled by the burning of fossil fuels which has released an exponential amount of otherwise trapped carbon into the atmosphere. This carbon release has been absorbed by other reservoirs, approximately 25% has been absorbed by plants and trees on earth and another 25% absorbed by oceans, leaving 50% to be released into the atmosphere[25] which has resulted in more CO2 in the atmosphere than usual (Fig 9). This additional carbon and other GHG gets trapped in the atmosphere, resulting in the planet heating up and causing the climate to change.

[24] National Geographic, ENCYCLOPEDIC ENTRY: The Carbon Cycle
[25] National Oceanic and Atmospheric Administration (NOAA)

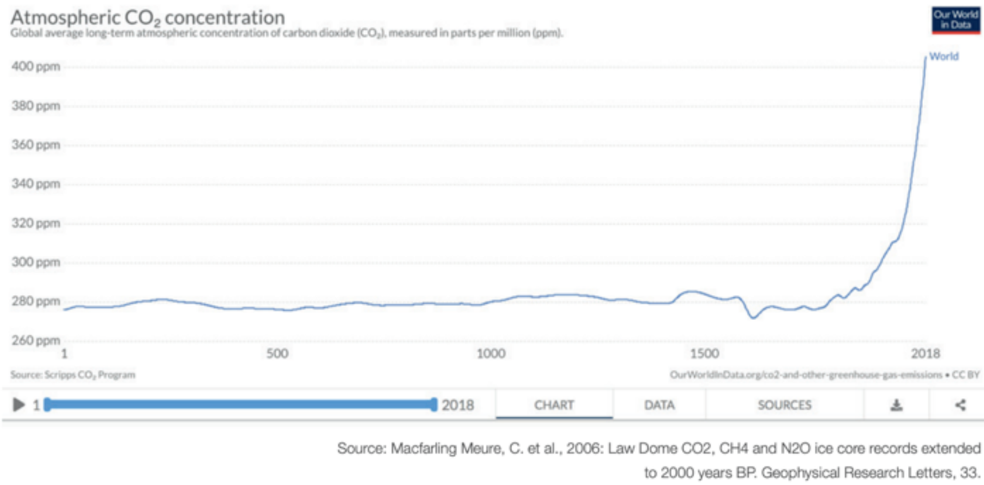


Fig 9: Atmospheric CO2 concentrations, Our World in Data

GHG emissions comes from several sources, including the production of electricity from fossil fuels (27%), transportation including passenger cars, aviation, and shipping (total 16%), agriculture including animal feedstock (19%), energy use in buildings including heating and cooling (7%), and manufacturing including production of cement and steel (31%)[26 27]. All sources must be reduced for us to be able to stabilise the temperature increase and associated climate change, the ways in which to do this will be further explored in Chapter 3.

3. Ecosystem crisis

The third pressure refers to the increasingly critical state of many of Earth's ecosystems. An ecosystem is a community or group of living organisms that live in and interact with each other in a specific environment, and they have an important role in Earth's overall capacity to regulate the climate and maintain the stable conditions that have enabled human development over the past 10.000 – 12.000 years. Increased agricultural production, deforestation, and land-use change account for significant GHG emissions[28] and are amongst the biggest drivers of biodiversity loss[29 30].

Many of the Earth's ecosystems are currently under great pressure due to increased human activity and domination. Marine ecosystems are increasingly at threat of pollution and CO2-induced acidification causing rapid extinction of hundreds if not thousands of species on a yearly basis; rainforests are at threat of deforestation from palm oil production, soybean farming, livestock farming, wood smuggling and legal and illegal mining as well as experiencing increased wildfires all of which is releasing tons of CO2 into the atmosphere rather than absorbing it. Temperate forests in the Northern Hemisphere are increasingly threatened by destruction caused by fungi, beetles, and fires as droughts are becoming more common; the Artic and Antarctic are increasingly warming up reversing their otherwise positive cooling effect on Earth[31].

Furthermore, the increased use of chemical fertilizers and pesticides to increase agricultural production has resulted in the degradation and pollution of soil and water and as a result both are suffering from becoming increasingly toxic to all living beings, also having a negative impact on many ecosystems.

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[26] Bill Gates, How to avoid a climate disaster, 2021
[27] https://ourworldindata.org/ghg-emissions-by-sector
[28] IPCC, 5th Assessment Report (AR5), Synthesis Report, 2014
[29] Andrew Hansen, Ruth S. Defries, Woody Turner; Land Use Change and Biodiversity, 2004
[30] Tim Newbold et al, A global model of the response of tropical and sub-tropical forest biodiversity to anthropogenic pressures, 2014
[31] Johan Rockström, SDG Academy, Planetary Boundaries and Human Opportunities, online course

While natural carbon sinks like the oceans, peatlands and forests can go some way in reducing overall global emissions, nature-based solutions, such as protecting and restoring forests, wetland, and coastal ecosystems, can also help humanity adapt and build resilience in the face of climate change, lead healthy and productive lives, and stimulate economic development. A transition to use land and other natural resources more sustainably is therefore vital and urgent.

Diminishing Earth's natural biodiversity and ecosystem functions and services, puts us all in an increased fragile situation and increases pressures on "ecosystem boundaries", also referred to as "tipping points", which when passed often lead to ecological regime shifts, from which it is difficult, often impossible, to return to the previous state[32].

2.2 Planetary boundaries and tipping points

While we are increasingly altering life on Earth, we are also fundamentally dependent on life on Earth to supply us with food and water as well as a range of ecosystem services like pollination, recycling and the regulation of the climate with the help of marine systems and forests.

The globalised phase of environmental change is caused by humans and is not only having an impact on local and global environments, but also across various sectors, such as the economy, health, government, and are therefore influencing every aspect of human life from income and health to quality of life and safety.

It is important to understand how the ecosystem and climate crisis is threatening the Earths resilience. Exploring the planetary boundaries and tipping points will help us understand how we can navigate back to conditions that will keep supporting human flourishment.

Tipping points

Releasing an increased amount of GHG into the atmosphere while diminishing Earth's natural biodiversity and ecosystem functions and services, has put great pressure on Earth's resilience which puts us all in an increased fragile situation. This increased pressure on Earth's ecosystem boundaries is also referred to as "tipping points". Surpassing tipping points may lead to ecological regime shifts, from which it is difficult, often impossible, to return to the previous state[33].

Such shifts have important impact on the local environment and often also have an important and often permanent impact on humans living within these local environments. Example of a regime shift is when a rainforest turns into drylands or when a coral reef is bleached and dies off. Such changes have local as well as global implications, the extent of these are often difficult to quantify especially on the Global scale[34]. Healthy coral reefs have a rich fish population and the ability to sustain a series of income generating activities for the local population such as fishing and tourism and the reef also protect the coast from storms. Many of these coral reefs have sadly seen ecological regime shifts and the corals are now bleached and dead with a less diverse range of fish, often only much smaller fish, and only a limited community of plants and living organisms. Such change will have a big impact for both the ability of local people to continue to sustain themselves through fishing and tourism as well as a noteworthy impact on the conservation of nature.

The fact that humans are putting exponential pressure on Earth is unquestionable. There is no piece of nature left anywhere in the world that is not influenced by and interconnected with human

[32] Johan Rockström et al, A safe operating space for humanity, 2009
[33] Johan Rockström et al, A safe operating space for humanity, 2009
[34] Johan Rockström, SDG Academy, Planetary Boundaries and Human Opportunities, online course

activity. That is why many scientists no longer talk about environmental systems and social systems, but instead talk of social-ecological systems[35].

Acknowledging the impact human activity has on social-ecological systems is the first step needed for humanity to take responsibility of reversing current trends and restoring the safety of the Holocene like conditions.

Global social-ecological interconnection

To understand how the Earth responds to various pressures and how resilient it is, we must understand that we live in a totally interconnected social-ecological global system, where changes in the climate system affects ecosystems, which together influences human health, economics, and development at large. These effects have cross-scale interactions, i.e., how diminishing the forests in one part of the world will influence rainfall in another part of the world, and how the local, regional and global is interconnected.[36] In this hyper-connected world, we must perceive risks in a different way, as never before has environmental risks had such a direct impact on economic, social and human well-being and vice-versa[37].

One recent example of how interconnected humans and the ecosystems have become in the Anthropocene is the Covid-19 pandemic. The virus can likely be sourced to a wild animal and fish market in Wuhan, China, and as humans are globally interconnected, this virus emanating from some local ecosystem in China and yet resulted in a global pandemic with detrimental consequences for human health and the economy globally. As the global wildlife trade continues and development projects expand deeper into tropical forests, humans are increasing their exposure to wild animals and the diseases they may carry. 60% of known infectious diseases in humans and 75% of all emerging infectious diseases are zoonotic i.e., a type of disease that transmits between animals and humans[38], and while these appear in a local environment, they now have the potential of having a truly global effect.

Earth's Resilience

Resilience is the capacity to be able to deal with change, not only predictable incremental change but also sudden change such as shocks and crisis.

Earth's system is continuously regulating itself; this can be observed by the fact that much (approximately 50%) of the excess CO2 emitted over the past years have been absorbed by Earth's natural sinks such as the oceans and forests[39]. Earth is therefore continuously proving its resilience by adapting to new conditions.

However, the resilience of Earth's systems may become unstable when reaching its limits. Scientists have been mapping out the systems which are of key importance to Earth's resilience and if certain limits, or tipping points, are reached, they are likely to have detrimental effect on Earth as a whole[40]. We must try to predict the limits to ensure we do not surpass them. One example of a system that is being surpassed is the ice sheet in Greenland. Throughout the Holocene the Greenland ice sheet has been functioning as a permanent cooling element on Earth as the white ice sheets have reflected sun away from Earth. As Earth is warming, the ice in Greenland is increasingly melting, and the darker surface areas on the ice, resulting from dark pools of melted water as well as windblown dust

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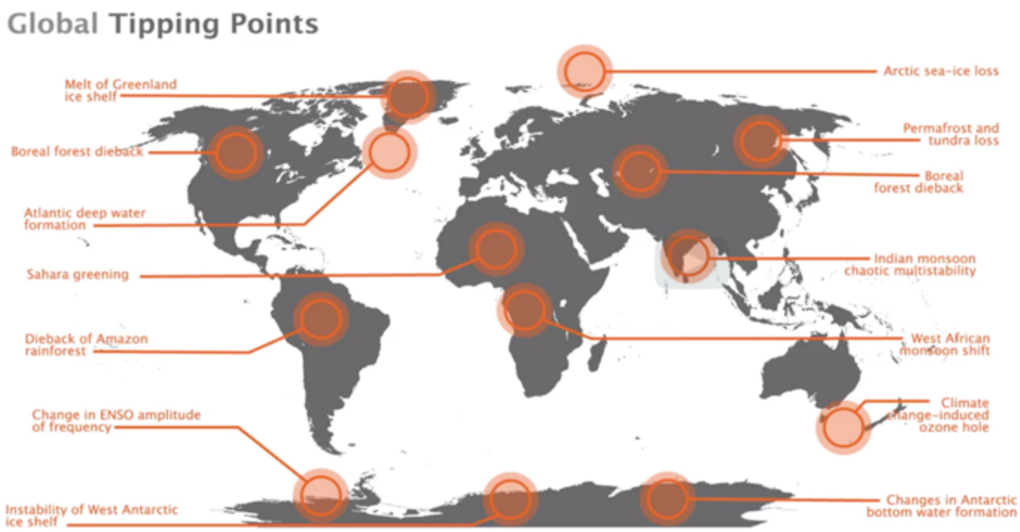
[35] Johan Rockström, SDG Academy, Planetary Boundaries and Human Opportunities, online course
[36] Will Steffen et al, The Anthropocene: From Global Change to Planetary Stewardship, 2011
[37] Johan Rockström et al, A safe operating space for humanity, 2009
[38] UNDP, Preventing the next Pandemic, 2020
[39] National Oceanic and Atmospheric Administration (NOAA)
[40] Johan Rockström, SDG Academy, Planetary Boundaries and Human Opportunities, online course

and other particles darkening the bare ice, absorbs more sunlight and accelerates melting[41]. This process is reversing the cooling ability which increases the speed at which Earth as a whole is heating up.



Global Tipping Points

Fig 10: Identifies a number of earth systems that support the earth's resilience. As with the ice sheet in Greenland, it is fundamental that these systems do not surpass their tipping points and lead to ecological regime shift from which it is difficult, if not impossible, to return from.

Scientists have identified a number of key Earth systems that contribute to overall resilience of Earth. Changes in any of these systems will have a global impact and will not only affect other ecosystems on the planet, but will also impact human health, economics, and development at large (Fig 10). These effects have cross-scale interactions, i.e., how diminishing the forests in one part of the world will influence rainfall in another part of the world, and how the local, regional and global is interconnected.[42] In this hyper-connected world, we must perceive risks in a different way, as never before has environmental risks had such a direct impact on economic, social and human well-being and vice-versa[43].

We must connect the impact of local action on these systems on a planetary scale and acknowledge that we are collectively responsible and contributing to such system changes i.e., it is not the action of the Inuit people on Greenland that have caused the ice to melt, that is the result of accumulated Global GHG emissions especially by the more affluent middle-class population.

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[41] https://www.climate.gov/news-features/understanding-climate/greenland-ice-sheet-getting-darker
[42] Will Steffen et al, The Anthropocene: From Global Change to Planetary Stewardship, 2011
[43] Johan Rockström et al, A safe operating space for humanity, 2009

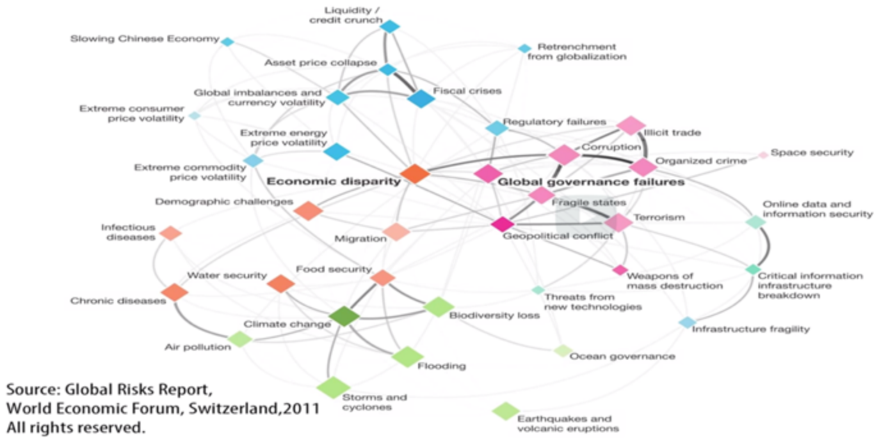

Fig 11: WEF 2011

We have explored ecological regime shifts and looked at how independent ecosystems, when put under certain external threats, may be pushed into a regime shift. We have also observed how interconnected the world is, and how the local environment and the changes that may occur within it, may have an impact on the regional and global environment and how it will also have an impact on many other parts of our lives such as health and economic well-being (Fig 11). Now we will explore how resilient Earth is to external pressures and identify the risks of pushing the entire earth system outside its stable state.

To be able to navigate sustainable development in the Anthropocene, we need to understand both the pressures and tipping points of systems, and together this allows us to explore the safe operating space for development.

Planetary boundaries

To avoid reaching global tipping points, and the risk of pushing the entire earth system outside of its current stability domain, we must identify the environmental processes, that have an impact on these systems.

Identifying these environmental processes has been the task of Johan Rockström and colleagues at the Stockholm Environmental Institute and the Potsdam Institute for Climate Impact Research, with support from the scientific community, in their framework based on 'planetary boundaries'. For the first time, scientists are identifying the environmental processes that are fundamental in regulating Earth's stable state and quantifying the safe limits outside of which the Earth system cannot continue to function in a stable, Holocene-like state, and as such define the safe operating space for humans[44]. The objective of the framework is to identify and deepen the understanding of the key environmental processes for Earth to stay in stable conditions. It is important to note that these are highly complex models that are continuously evolving as new scientific evidence is presented and knowledge gaps remain. As such the framework must be understood as a proposed step towards better understanding Earths carrying capacity, and not as complete and conclusive scientific evidence.

The framework defines nine independent, yet extremely interlinked, processes for which they believe it is possible to define planetary boundaries: climate change, biogeochemical flows (nitrogen and phosphorus), land-system change, freshwater use, aerosol loading, ozone depletion, ocean acidification, loss of biosphere integrity including biodiversity, and introductions of novel entities

[44] Johan Rockström, SDG Academy, Planetary Boundaries and Human Opportunities, online course

such as toxic chemicals and plastics.[45]. The analysis suggests that today, four of the Earth-system processes have already transgressed their boundaries: climate change, loss of biosphere integrity, land-system change, altered biogeochemical cycles. This does not mean they have crossed the tipping point, but that they are in a zone where there is potential for the tipping points to occur[46].

Fig 12: The nine Planetary Boundaries (graphic: J. Lokrantz/Azote based on Steffen et al. 2015)

The planetary boundaries system quantifies the limits and potential tipping points of Earth's systems independent of human activity. Once these limits have been quantified, human activity and ingenuity can be added. The system identifies the limits to respect to stay in the desired Holocene state, as well as identifies the impact of human activity on each of the boundaries and thus where we should act faster.

2.3 Human action/inaction is fundamental

While there are lots of factors contributing to climate change, scientists agree that the temperature increase over the last 50-100 years is without doubt a result of the overall increase in anthropogenic GHGs[47] in the atmosphere caused mainly by two interlinked elements:

1. An increase in the emission of GHGs into the atmosphere combined with
2. A progressive destruction of Earth's natural sinks and with that their ability to absorb CO2[48].

Human activity has therefore not only unleashed a large amount of stored carbon that would not have otherwise naturally been released (e.g., the burning of fossil fuels for energy), it has also reduced nature's ability to absorb CO2 (e.g., deforestation and other changes in land-use). We urgently need to reverse both trends.

Reducing GHG emissions

There are two main sources of GHG emissions, natural emissions from natural systems and anthropogenic emissions from human activities. GHG emissions from natural systems include forest fires, oceans, wetlands, permafrost, mud volcanoes, volcanoes, and earthquakes. GHG emissions

[45] Steven J. Lade et al, Human impacts on planetary boundaries amplified by Earth system interactions, Nature Sustainability, 2020
[46] Johan Rockström, SDG Academy, Planetary Boundaries and Human Opportunities, online course
[47] IPCC, 5th Assessment Report (AR5), Synthesis Report, 2014
[48] Climate Council, LAND CARBON: No Substitution for action on fossil fuels, 2016

from human activity include fossil-fuel combustion for energy production, land-use change and cattle and sheep rearing.

While the science of measuring GHG still has certain levels of uncertainty and must be improved, there is broad scientific agreement that the global annual GHG emissions range approximately between 54 and 75 Gt CO2-equivalent, with the percentage of anthropogenic GHGs emissions being only slightly higher than the natural emissions[49]. The ability of Earth systems (ocean and terrestrial ecosystems) to absorb GHG emission is estimated to be around 26.5 Gt CO2-eq, roughly the same as the level of natural system GHG emissions. This finding suggests that the GHG emissions generated by human activity exert extra pressure on what is otherwise a self-balancing Earth system[50].

Despite the level of uncertainty in measuring and distinguishing between natural and anthropogenic sources of emissions, there is no doubt that the anthropogenic GHG emissions (CO2 included) have substantially increased since 1900, and even more so since 1950, as can be observed in Fig 13. The primary reason for the increase in GHGs is the increase in burning of fossil fuels for the production of electricity and heat in homes, in industry and for transportation of persons and goods in an increasingly globalised world (Fig 13).

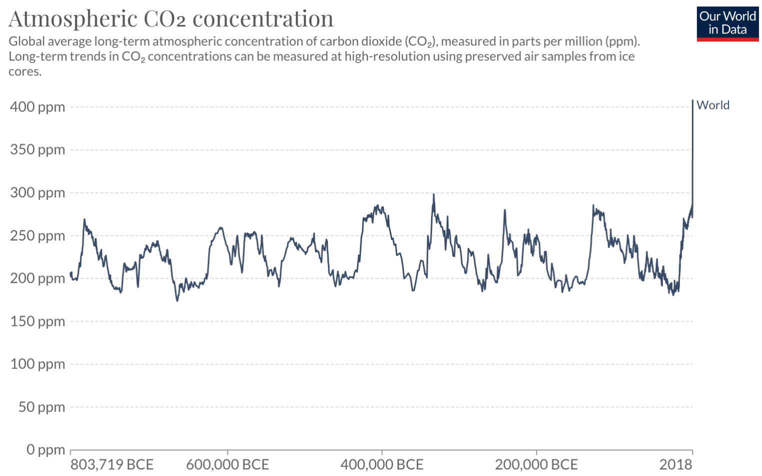

Fig 13: Atmospheric CO2 concentrations, Our World in Data
https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions

Atmospheric GHG and CO2 concentrations are measured in "parts per million" (ppm) and scientists are in broad agreement that 450 ppm, is the point beyond which we risk very damaging and even dangerous temperature rise[51]. Atmospheric CO2 measured at Mauna Loa Observatory by the National Oceanic and Atmospheric Association (NOAA) indicates that 400 ppm were reached in 2014 and this increased to 414,7 in 2019[52]. We are getting dangerously close to the 450-ppm mark that would put Earth in a danger zone (see Fig 13). The Planetary Boundary framework, applying the precautionary principle, sets the **boundary at 350 ppm** as the limit of our safe operating space[53].

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49 Xi-Liu YUE, Qing-Xian GAO, Contributions of natural systems and human activity to greenhouse gas emissions, Advances in Climate Change Research, Volume 9, Issue 4, 2018
50 Xi-Liu YUE, Qing-Xian GAO, Contributions of natural systems and human activity to greenhouse gas emissions, Advances in Climate Change Research, Volume 9, Issue 4, 2018

51 IPCC, 5th Assessment Report (AR5), Synthesis Report, 2014
52 National Oceanic and Atmospheric Association (NOAA), 2020
53 Johan Rockström et al, A safe operating space for humanity, 2009

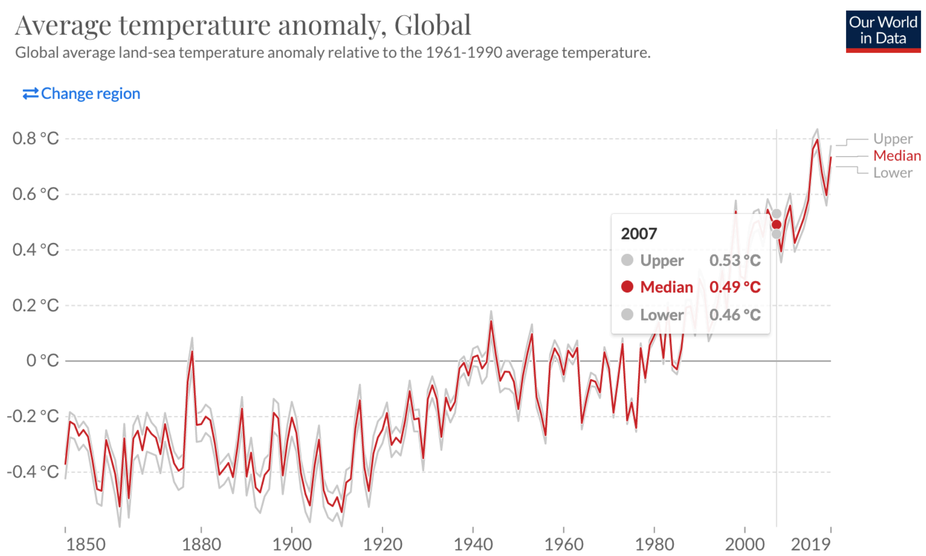

Fig 14: Average temperature anomaly, Global, Our World in Data

According to IPCC's leading scientists, there is unequivocal agreement that the increase of anthropogenic GHG emissions in the atmosphere are warming Earth (Fig 14), and that this warming will continue as we keep emitting GHGs into the atmosphere. They warn that it is fundamental to keep the global temperature rise below 1,5C° as it is the only way to avoid the worst impacts of climate change. Every fraction of a degree makes a difference in our quest to reduce extremes weather events such as heatwaves, heavy rainfall, and droughts, as well as long-term impacts and the risk of crossing tipping points of the Earth System.

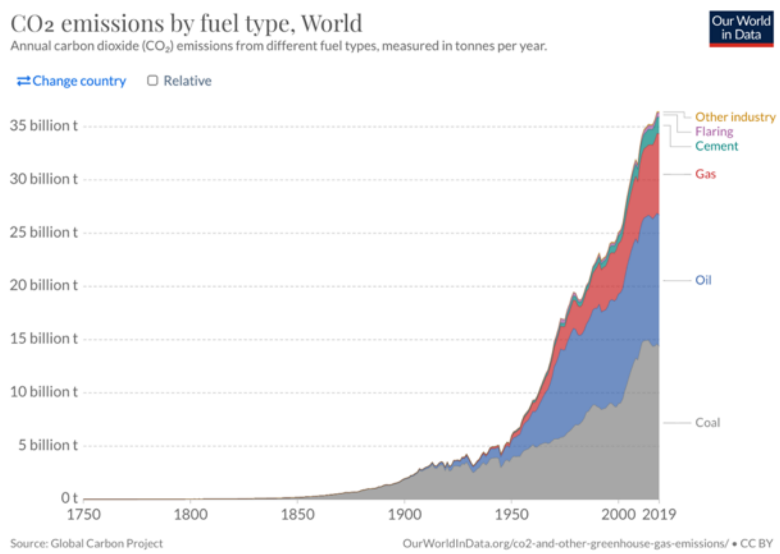

Fig 14: Our World in Data, CO2 emission by fuel type, World, Our World in Data

The increase in atmospheric CO2 and temperature increase goes hand in hand with humanity's increase of consumption of fossil fuels (Fig 14). Unless we reverse the trend of emitting GHG and CO2 from the combustion of fossil fuels we will certainly pass the 450-ppm that will put Earth in a danger zone very soon.

If, however, we continue business as usual, then global emissions will continue to rise leading us far off the 450-pmm and the 1,5C° goal. To avoid this, we must develop and implement effective strategies and technologies that not only reduced GHG emissions but also implement methods and technologies that remove CO_2 from the atmosphere.

Differentiated approach and responsibility for GHG emissions

Predictions by the International Energy Agency suggest that to meet the Sustainable Development Goals and the Paris Agreements on climate, global primary energy demand must decline by around 7% between now and 2030, with demand in advanced economies falling by more than 15%, while in emerging and developing economies it must stabilise. This overall decline must occur despite strong economic growth as the result of energy efficiency measures and increased electrification of end-use sectors.

In advanced economies this entails facing out coal by 2030, a gradual reduction of oil and natural gas with an increase in renewables and bioenergy as energy sources, and electricity taking the place of combustion in many sections of the final energy consumption such as in cars.

In emerging and developing economies the increase in demand for energy will be partially offset by energy efficiency and electrification, and thus overall primary energy demand will remain relatively unchanged. All fossil fuels will be gradually phased out, even if not totally by 2030, being replaced by electricity which will increasingly be generated from renewables[54].

Strengthen biodiversity and ecosystems

Biodiversity, also called biological diversity, is defined as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems"[55]. Biodiversity is the result of 3.5 billion years of evolution[56], and comprises microorganisms, plants, animals, and ecosystems, such as coral reefs, forests, rainforests, deserts, etc. and it refers to the number or abundance of different species living within a particular region.

Biodiversity is fundamental for healthy ecosystems, and both are important to human life on earth as they provide us with many essentials such as food and water, medicine, clothing and shelter, and services that helps regulate climate, control of local rainfall, filters air and water, and mitigates the impact of natural disasters such as landslides and coastal storms[57].

While natural carbon sinks like the ocean, wetlands and forests contribute to the reduction of global CO_2 emissions, nature-based solutions, such as protecting and restoring forests, wetland, and coastal ecosystems, can also go a long way to help humanity mitigate, adapt and build resilience in the face of climate change. A transition to more suitable land use is vital and urgent as is reducing the negative impact on Earth's most important natural sinks[58].

A recent innovative and encouraging example of how to use natural carbon sinks is the city of Milan's ambitious decade-long urban forestry project called "Forestami", an initiative launched in 2020 with the commitment to plant a new tree for every inhabitant of the city, thus aiming for three million newly planted trees by 2030[59].

[54] IEA, WEO, 2020
[55] Art 2 UN Convention on Biological Diversity
[56] King Island-Natural Resource Management
[57] UN Environment's sixth Global Environment Outlook, 2019
[58] Lear more about biodiversity loss in Annex 1
[59] https://forestami.org/en/

Furthermore, indigenous people and local communities often have traditional knowledge needed to play a key role in protecting and restoring biodiversity and can offer excellent bottom-up, self-driven, cost-effective, and innovative solutions that often can be scaled up and inform national and international practice[60].

Carbon sinks and carbon sources

A carbon sink is anything that absorbs more carbon from the atmosphere than it releases. The ocean, soil and forests are the world's largest carbon sinks. A carbon source, on the other hand, is anything that releases more carbon into the atmosphere than it absorbs. Examples of carbon sources include the burning of fossil fuels or volcanic eruptions.

Protecting carbon sinks is essential for tackling climate change and keeping our climate stable. But they are all increasingly under threat.

Forests

The world's forests can act as both a carbon sink and a carbon source (Fig 15). It is important to ensure that we optimise on the absorption ability of forests. This includes preserving and protecting all forests that act as a sink, and equally important to convert the forests that have become a carbon source back to its original sustainable state where possible.

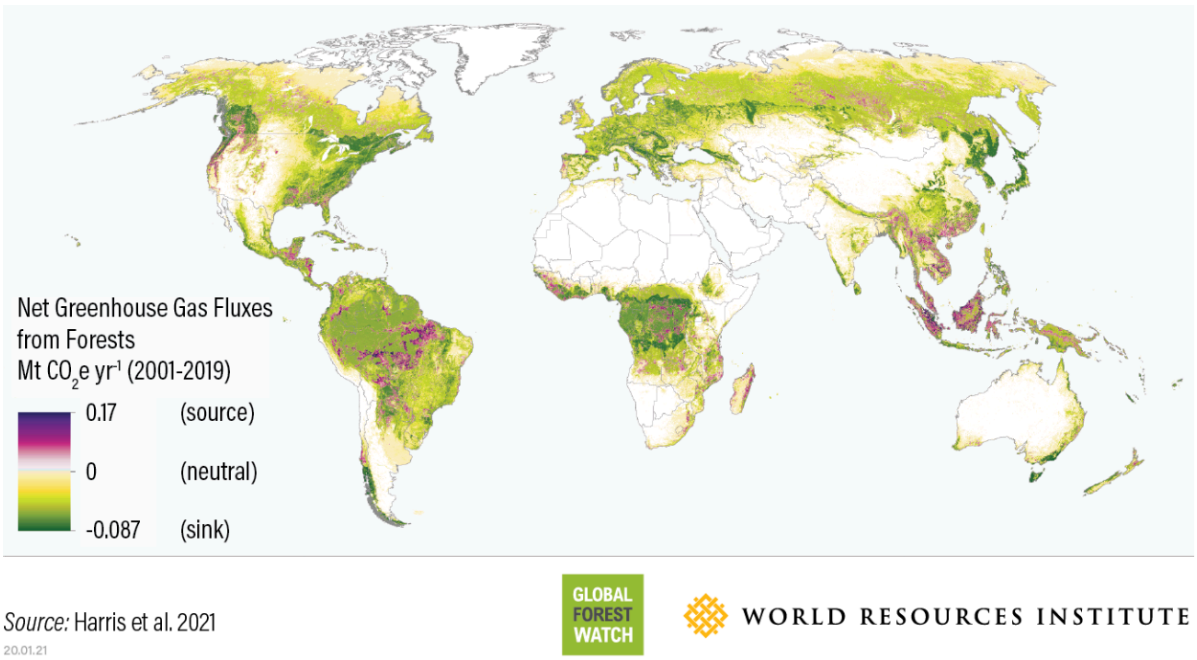

Fig 15: Forests: Carbon sinks or carbon sources? Harris et Al. 2021 (https://www.wri.org/insights/forests-absorb-twice-much-carbon-they-emit-each-year)

Recent scientific data document that the world's forests absorb twice as much CO2 per year as they emit. However, current trends are going in the wrong direction, and this must be urgently addressed.

By far the most important ecosystems for mitigating climate change are the tropical rainforests. Collectively they sequester more carbon from the atmosphere than temperate or boreal forests. However, they are gradually being destroyed for agricultural development. The Amazon, the Congo River basin and Southeast Asia are home to the three largest tropical rainforests.

[60] UN Environment's sixth Global Environment Outlook, 2019

Due to clearing for plantations, uncontrolled fires and drainage of peat soils, the forests across Southeast Asia have collectively become a net source of CO2 emissions over the past 20 years.

The Amazon River basin, which spans nine South American nations, is still a net carbon sink but is on the verge of switching to a net source if current rates of forest loss continue. Deforestation in the Amazon basin has increased recently as a result of fire damage and clearance for cattle pasture.

Only the Congo River basin has enough remaining standing forest to continue to be a significant net carbon sink. Tropical rainforest of the Democratic Republic of the Congo absorbs 600 million metric tonnes more CO2 each year than it emits.

In order to combat climate change, it is essential to preserve the last remaining trees in all three forests.

The world's largest managed forests are located in the United States, Canada, China, Europe, and Russia. These serve to provide lumber, and have designated patches of trees that are periodically cut down or thinned, causing CO2 emissions, while other patches are left alone to regenerate and absorb CO2.

Whether these forests are CO2 sources or sinks ultimately depends on how they are managed, including the length of time between harvest cycles, the amount of forest harvested, the age of the trees, and, most significantly, the total area used to compute fluxes.

Recent research shows that keeping existing forests standing remains our best hope for maintaining the vast amount of carbon forests store and continuing the carbon sequestration that, if halted, will worsen the effects of climate change. Although important to plant new trees and give these young forests the chance to grow into old ones, protecting primary and mature secondary forests today is most important for curbing climate change.

Oceans

The ocean makes up more than 70% of the planet's surface. It is where life initiated, and continues to allow life to flourish, both in the waters and on land. Marine phytoplankton have produced about half of the world's oxygen, meaning every second breath you take came from the ocean.

Climate change is causing the planet to warm up, and the increased heat and carbon emissions are pushing the ocean to its limits as it has absorbed approximately a quarter of the additional CO2 released and 90 percent of the heat.

Phytoplankton are the main reason the ocean is one of the biggest carbon sinks. These microscopic marine algae and bacteria play a huge role in the world's carbon cycle, absorbing about as much carbon as all the plants and trees on land combined. Meanwhile, slow-moving currents drive dissolved carbon into the ocean's cold depths or is buried in the sediments of the seafloor, where it is buried for centuries.

The ocean has protected us from the worst consequences of climate change, but at a cost to itself as it is increasingly acidifying and heating up. Increased levels of CO2 in the water are causing the oceans to become more acidic making it harder for some species to form their shells; and rising ocean temperatures are causing a variety of problems, including loss of sea ice, more frequent, intense storms, and marine heat waves that can kill off millions of animals.

Recent research document that it is essential to identify solutions that can remove CO2 and heat from the ocean. Likewise, industrial and fisheries management policies that are adaptive and forward thinking must be implemented and waste management policies must be properly designed, implemented and monitored so that pollution becomes a thing of the past.

2.4 Building the future we want

In order to keep the temperature below 1,5C°, as recommended by the IPCC scientists, we must curb our GHG emissions and reach net-zero emissions by 2050 at the latest[61]. Currently we emit approximately 50 billion tons a year, the task at hand is not a small one.

To be able to face so many interlinked challenges we must start thinking differently about global social integration. We are increasingly interlinked and interdependent, experiencing new types of migration, new social movements, new types of economics, new types of viruses, and we should be trying to envision new ways in which we could live on the planet more positively collectively.

The 2030 Agenda strives to achieve a world in which all people are given the opportunities to live fulfilling lives within the limits of the biosphere. While Rachel Carson and the Brundtland Report generated widespread environmental interest, they also initiated a shift in global environmental consciousness which stimulated a new and ever-evolving form of thinking about sustainable development. The latter have inspired many global agreements striving to guide us towards a better and fairer life in harmony with the needs of the biosphere.

"The future depends on what you do today."
Mahatma Gandhi

The role of science and the precautionary principle

We have landed in the 'environmental paradox' where human well-being has reached levels that is threatening our planetary life support system. When determining the way forward in such a situation it is advisable to follow the precautionary principle[62]. The precautionary principle acknowledges that while science and technology has often brought great benefits to humanity, it has also contributed to the creation of new threats and risks. It implies that there is a social responsibility, especially from public bodies to protect humanity from exposure to such harm, when scientific investigation has found a plausible risk. These protections should be relaxed only if further scientific findings emerge that provide sound evidence that no harm will result and hence would justify setting in motion all necessary means to stay within the safe operating space of the planetary boundaries.

The Intergovernmental Panel on Climate Change (IPCC) was created in 1988 by the members of the United Nations with the objective to provide governments at all levels with scientific information needed to develop climate policy as well as constructive input into international climate change negotiations. The IPCC currently has 195 members.

Thousands of scientists from all over the world contribute to the work of the IPCC through the publication of various assessment reports. Thousands of climate related scientific papers are published each year, and these are assessed by the IPCC authors to provide a comprehensive

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[61] IPCC 2018 Special Report on Global Warming of 1.5°C highlights that limiting global warming to 1.5°C compared to 2°C will have clear benefits to people and natural ecosystems and will require rapid, far-reaching and unprecedented changes in all aspects of society including Global net human-caused emissions of carbon dioxide (CO2) to fall by about 45 percent from 2010 levels by 2030, reaching 'net zero' around 2050. This means that any remaining emissions would need to be balanced by removing CO2 from the air.
[62] Will Steffen et al., Planetary boundaries: Guiding human development on a changing planet, 2015

summary of the latest drivers of climate change. The latter include impacts and future risks, how adaptation and mitigation can reduce those risks, and how to most accurately calculate GHG emissions and removals. The open and transparent review by experts and governments around the world is an essential part of the IPCC process and ensures an objective and complete assessment which reflects a diverse range of views and expertise. The IPCC also indicates where scientific evidence is weak and further research is needed.

As such, the publications of the IPCC provide a key contribution and support to the decision-making regarding climate change of national as well as international organisations, including the UNFCCC agreement which took place in Paris in 2014, also called the Paris Agreement. The Paris Agreement is a legally binding international treaty on climate change, which was adopted by 196 parties on 4. November 2015. The overarching goal of the Paris Agreement is to keep "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels."

The scientific evidence produced by leading scientists is guiding global leaders when implementing the precautionary principle regarding climate change.

Adaptation and mitigation to climate change

When following the precautionary principle in relation to the climate challenge, actions usually fall into one of two strategies: mitigation efforts to lower or remove GHG emissions in the atmosphere, and adaptation efforts to adjust systems and societies to withstand the impacts of climate change. It is fundamental to pursue both strategies in parallel to be as resilient as possible to future climate related events.

Mitigation is the reduction of something harmful or the reduction of its harmful effects. The goal of mitigation is to reduce human interference with the climate system as much as possible in order to "stabilise GHG levels in a timeframe sufficient to allow ecosystems to adapt naturally to climate change and ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner"[63]. To mitigate anthropogenic CO2 and GHGs we need to reduce overall emissions by changing behaviour and where consumption cannot be reduced identify technologies that can make each of these sources free of GHG emission. Once such sustainable, or green alternatives, have been identified they must be made economically competitive so that they become both the environmental and economic best option and as such adopted at scale.

Transport provides a useful example: first we must reduce our emission by taking less planes, using public transport and biking and walking where possible. Where personal transport is still the only solution, we should adopt more sustainable solutions such as electric vehicle (EV) or hybrid vehicles and fuel them from renewable sources. To get the consumer buy-in it is important that the cost of the EVs or hybrid is competitive with the traditional cars, and this should happen at the same time as the electricity system moves from fossil to renewable generation. Over the last few years, the cost of EVs and hybrid car has come down substantially, however where the cost is not yet fully competitive it is important to use policy appropriately to incentivise the buyers. While incentives can be useful to help an industry become competitive, certain industries are simply not sufficiently mature, such as the cement and steel industries for example, and much research and development must be invested in finding the "green alternatives" of these manufacturing industries to reduce their GHG emissions sufficiently[64].

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[63] IPCC, AR5, Climate Change 2014: Mitigation of Climate Change, 2014
[64] Bill Gates, How to avoid a climate disaster, 2021

Adaptation on the other hand, in reference to climate change, involves adjusting to actual or expected future climate and its effects. Adaptation seeks to moderate or avoid harm or exploit beneficial opportunities[65]. The goal is to reduce the vulnerability to the harmful effects of climate change such as increasing sea-levels, more intense extreme weather events or food insecurity. It also encompasses making the most of any potential beneficial opportunities associated with climate change, such as seasonal changes allowing for increased crop yields or changes in output. Differences in vulnerability to climate-related extremes such as heat waves, droughts, floods, cyclones, wildfires, and other dangerous weather types differ greatly and are related to non-climatic factors and from multidimensional inequalities often produced by uneven development processes[66]. The vulnerable and poorer segments of society and geographical regions are always more at risk as they are not able to make the adjustments needed. Policies must be put in place to help and support the vulnerable segment of society adapt on an equal footing with the rest of society.

Governments at various levels in all countries, are responsible for adaptation to climate change through strategic development plans including addressing extreme weather, protecting coastlines from rising sea-levels, better land, forest, and water management, developing more resilient crop varieties and protecting energy and public infrastructure. Furthermore, the rich countries have the power and means to adapt while the poorer countries suffer the greatest consequences[67]. Therefore, the more affluent countries have a duty to assist poorer countries in their efforts towards adaptation. The Paris Agreement aims to facilitate developments in this direction. As a matter of fact, Art 9, 10 and 11 on finance, technology, and capacity-building support as well as Art 8 on loss and damages provide for a solid framework and a valid support mechanism in this respect.

Case-studies that inspire – How science led the way to saving the ozone layer[68]

In the mid-1970s, scientists warned that man-made chemicals in everyday products like aerosols, foams, refrigerators, and air-conditioners were harming the ozone layer. At that time, they didn't know the scale of the problem. But in 1985, a hole was confirmed in the ozone layer over Antarctica. The world's natural sun shield, which protects humans, plants, animals, and ecosystems from excessive ultraviolet radiation, had been breached.

Suddenly, a future blighted by skin cancers, cataracts, dying plants and crops and damaged ecosystems loomed. There was no time to lose. Scientists had raised the alarm and the world listened.

In 1985, governments adopted the Vienna Convention for the Protection of the Ozone Layer, which provided the framework for the Montreal Protocol to phase out ozone-depleting substances, including chlorofluorocarbons (CFCs). The Protocol came into effect in 1989 and by 2008, it was the first and only UN environmental agreement to be ratified by every country in the world.

The results have been dramatic. Around 99 per cent of ozone-depleting substances have been phased out and the protective ozone layer above Earth is being replenished. The Antarctic ozone hole is expected to close by the 2060s, while other regions will return to pre-1980s values even earlier. Every year, an estimated two million people are saved from skin cancer and there are broader benefits too, as many of the ozone-depleting gases also drive-up global temperatures.

Although tremendous progress has been made, the ozone holes will take decades yet to heal, and only if there is full and continuous compliance with the Montreal Protocol. Close and continuous

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[65] IPCC, AR5, Climate Change 2014: Impacts, Adaptation, and Vulnerability, 2014
[66] IPCC, AR5, Climate Change 2014: Impacts, Adaptation, and Vulnerability, 2014
[67] SDG 13A and 13B, https://www.un.org/sustainabledevelopment/climate-change/.
[68] https://www.unep.org/news-and-stories/story/rebuilding-ozone-layer-how-world-came-together-ultimate-repair-job

monitoring of the atmosphere, even for supposedly banned substances and for the possible effects rising surface temperatures in polar regions may have on stratospheric ozone is needed.

Scientists discover new risks every day, and in 2016, the Montreal Protocol was updated to include the Kigali Amendment to phase down hydrofluorocarbons (HFCs), potent GHGs often used as replacements for the banned ozone-depleting substances in refrigerators and air-conditioners. The Kigali Amendment came into force in 2019 and has today been ratified by 123 countries. It also encourages the development and use of more energy-efficient cooling technologies. Adopting low-global-warming-potential alternative refrigerants could potentially double the climate benefits of the Amendment, according to this recent scientific assessment.

The global dimension of the challenges of climate change are not the first humanity has had to face. The Montreal Protocol, and subsequent additions such as the Kigali amendment, have proven that international agreements based on sound scientific evidence can lead to action that changes the course for humanity on Earth. As such we have a precedent for what needs to be done for climate change and we can be hopeful in our mission to identify and implement solutions to global issues.

New economic thinking for the 21st century

To facilitate the change in mindset and for sustainability to take off we need to acknowledge that the capitalist model upon which globalisation is based is causing and fuelling inequality, food and health insecurity and climate change on local as well as global scale.

In 2011 Kate Raworth took a 'new look' at what the starting point for economic principles could be other than perpetual GDP growth. She found that humanity's long-term goal of "meeting the human rights of every person within the means of our life-giving planet" should be the starting point which economic principles should help us achieve. She came up with the concept of 'doughnut economics', and when the UN delegates were negotiating the 17 SDG's "the image of the Doughnut was on the table as a reminder of the big-picture goals they were aiming at"[69]. Kate Raworth's model strives to break with the past century of economics blindly pursuing ever-increasing GDP, or national output, as its primary measure of progress, and to change the economic mindset to one that is never set but is instead always evolving[70].

The SDGs are very close to what Kate defines as the Doughnut's inner ring – its social foundations – which sets out the basics of life on which no one should be left falling short, and she combines this with Johan Rockström's framework of the planetary boundaries, and as such has mapped the safe and just space for humanity to continue to thrive.

The goal of economics is to eliminate both shortfalls and overshoot at the same time and requires a dynamic balance rather than endless GDP growth. Such dynamic balance is found in designing an economic model for sustainable development. The various limits (shortfalls and overshoots) are of course deeply interconnected and do in many instances reinforce each other both negatively and positively, and cannot be addressed in isolation but as part of a complex socio-ecological system.

[69] Kate Raworth, Doughnut Economics, 2018
[70] Learn more about Kate's seven ways to think like a 21st century economist: https://www.kateraworth.com/

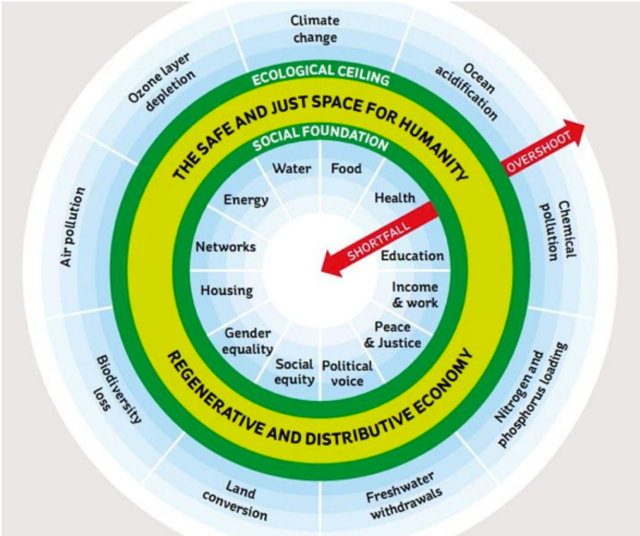

Fig 16 The doughnut: a 21st century compass

As we have observed, humanity has been and is increasingly putting pressures on Earth's life-giving systems and this has resulted in at least four of the nine boundaries having been transgressed. Similarly, despite unprecedented progress in human well-being over the past 70 years, we continue to fall short on many of the social foundations (Fig 17). We can measure and monitor the shortfalls of the social foundations as well as planetary overshoots, and we must assure the transition to a globally sustainable future that addresses both shortcomings and overshoots. This is the task of every government, every company, and every member of a community. Therefore we must re-evaluate the way we shop, eat, travel, earn a living etc. (more in chapter 3 and 4).

To achieve the SDGs while protecting our planet, we must ensure that the future gains of sustainable economic development primarily go towards increasing the capacity and opportunities of the least advantaged people in societies. The resources spent in educating girls, improving the status and opportunities for women, and enabling poor people to achieve full participation in society will strengthen both economic and human development, and reduce alienation and conflicts in society at large. In the words of Joseph Stiglitz "The only sustainable prosperity is shared prosperity"[71]. Reducing inequality both within societies and between nations must be a priority for the benefit for all[72].

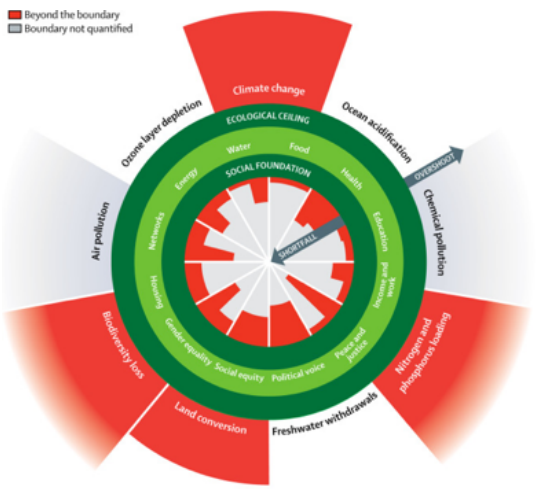

Fig 17 – Transgression of both social and ecological boundaries

[71] Joseph Stiglitz, Our Planet, Our Future, An Urgent Call for Action, 2021
[72] UN Environment's sixth Global Environment Outlook, 2019

Concluding remarks

We must acknowledge that the exponential rise of pressures on Earth has been caused primarily by the rich minority on planet Earth, the 1.5 billion affluent people, that have benefitted from the Industrial Revolution. This trend continues today and is documented in a recent study by Oxfam and the Swedish Environment Institute where they found that in the period from 1990 – 2015, the richest 10% of the population were responsible for 52% of cumulative global emissions in that period while the poorest 50% of the population in that same period were responsible for 7% of cumulative global emissions[73]. While the richest pollute the most, the impact of these emissions is disproportionally impacting the poorest regions in the world, with an estimated 140 million displaced people in sub-Saharan Africa, South Asia, and South America by 2050[74].

Furthermore, it is only in the recent past and in the future that the global middle-class will grow substantially and with that consumerism will go to scale as billions of people have and are rising out of poverty and will be demanding the same affluent lifestyle as the rest of the middle and upper classes. While it is certainly a positive thing that increased economic prosperity will allow many citizens on the Earth to have a right to development, without significant changes in how we all consume, the pressures the Earth is being put under will continue to grow in magnitude.

While the Agenda 2030 is striving to achieve a certain minimum standard of living for all, if 10.4 billion people on Earth are going to live unsustainable lives, we will reach many of Earth's tipping points and we may face a planetary collapse. We are the first generation that may eradicate absolute poverty and hunger. To facilitate healthy and affluent lifestyles of 10.4 billion peoples will require continued economic development, but this development must be sustainable and within the planetary boundaries.

This scientifically founded concern for the future is coupled with an immense share of hope based on humanity's ability to adapt, innovate, and design new solutions to even the biggest problems. While it is a huge challenge, humanity can succeed in a global transition to a world within a safe operating space of planetary boundaries. However, time is becoming increasingly limited[75].

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