Chapter 1
Why Sustainability?

Keywords Anthropocene · Planetary Boundaries · Doughnut Economics · Economic costs

This Chapter's Learning Goals

- You know the biggest social and environmental challenges facing the world today and understand the basic processes, causes, and effects of climate change.
- You know the concepts of the Planetary Boundaries and the Doughnut Economics.

1.1 The Anthropocene

Over the past 30 years, sustainable development has become the central term worldwide in discussions about the future development of humanity and planet Earth. The struggle to define what sustainable development really means and how to achieve it, has become a central theme of national and international politics, science, and increasingly also of business and civil society. But why has the concept of sustainable development become central to many disparate debates across the world?

Compared to our grandparents and great-grandparents, we live in a much better world. Never before in history have Earth's inhabitants been so diversely networked and closely connected in vital areas of knowledge, technology, and the exchange of goods. The proportion of people living in extreme poverty has halved in the last 20 years, life expectancy worldwide has risen by 10 years since 1973, and deaths from natural disasters have seen a large decline over the past century—from, in some years, millions of deaths per year to an average of 60,000 over the past decade. At the same time, the global average literacy rate has risen from 42% in 1960 to 86% in 2015, the number of people with access to electricity has risen steadily in recent decades, and in almost all countries in the world women now have the same voting

M. Fischer et al., *Sustainable Business*, SpringerBriefs in Business,
https://doi.org/10.1007/978-3-031-25397-3_1

rights as men (Our World in Data, n.d.). This list could go on. Encouraging trends in areas such as child mortality, access to education, child labor, and hunger have also significantly improved global living standards since the middle of the last century. To a large extent, this is due to global economic growth.

This unique development in such a short period of time has been made possible primarily by oil, especially by its cheap availability since the 1950s. But this miraculous development has also brought with it serious costs. In fueling our economy oil and gas have also ignited our hunger for resources in general, thus leading to serious global environmental problems such as the greenhouse effect, species extinction, and the pollution of soil, water, and air, etc. Moreover, the benefits and costs of this growth are highly unequally distributed. While we in the rich countries mainly enjoy the benefits of cheap goods and travel, etc., those in poorer countries tend to bear the bulk of the costs.

Figures 1.1 and 1.2, first published by Will Steffen et al. in 2004 and updated in 2015, show that the dramatic increase in human, mainly economic, activity (Fig. 1.1) since the middle of the last century seems to be coupled with a profound impact on life-supporting ecosystems (Fig. 1.2). Human activity, predominantly our global economic system heavily controlled by the so-called advanced economies, is now the main driver of change in Earth's system and has significantly destabilized the state of the Earth. This is why more and more scientists do not only agree that humans are driving these changes but that the changes are so immense that since the middle of the last century we have entered a new era in Earth's history: The Anthropocene, the "Age of Man." This replaces the Holocene, the most stable climate phase for at least 400,000 years and the essential basis for the development of human civilization.

1.2 The Ecological Challenges: Planetary Boundaries

Stable systems, be they ecological, social, economic, or cultural—can usually regenerate following disturbances or shocks. For example, heavily overgrazed grasslands can recover relatively quickly. Or in the case of waters that have been severely damaged by chemical or oil spills, flora and fauna will slowly reclaim this habitat and eventually people are able to use them again without danger.

But if pressure becomes too great and too widespread, such ecosystems can also tip over and change into another system state making them extremely inhospitable. If the ecological balance of the savannah is too heavily burdened by human activities (e.g., overgrazing, firewood production, removal of the humus layer or similar), the savannah landscape is transformed into a desert (desertification); an environment that is uninhabitable for most forms of life. Moreover, a shift back to the original savannah state is impossible (just as it is impossible to turn a loaf of bread back into flour) or only possible with great effort. One of the best known and largest ecosystems that has been tilted by human activities is the Aral Sea in Central Asia. Formerly the fourth largest inland lake in the world, within a few decades, it has

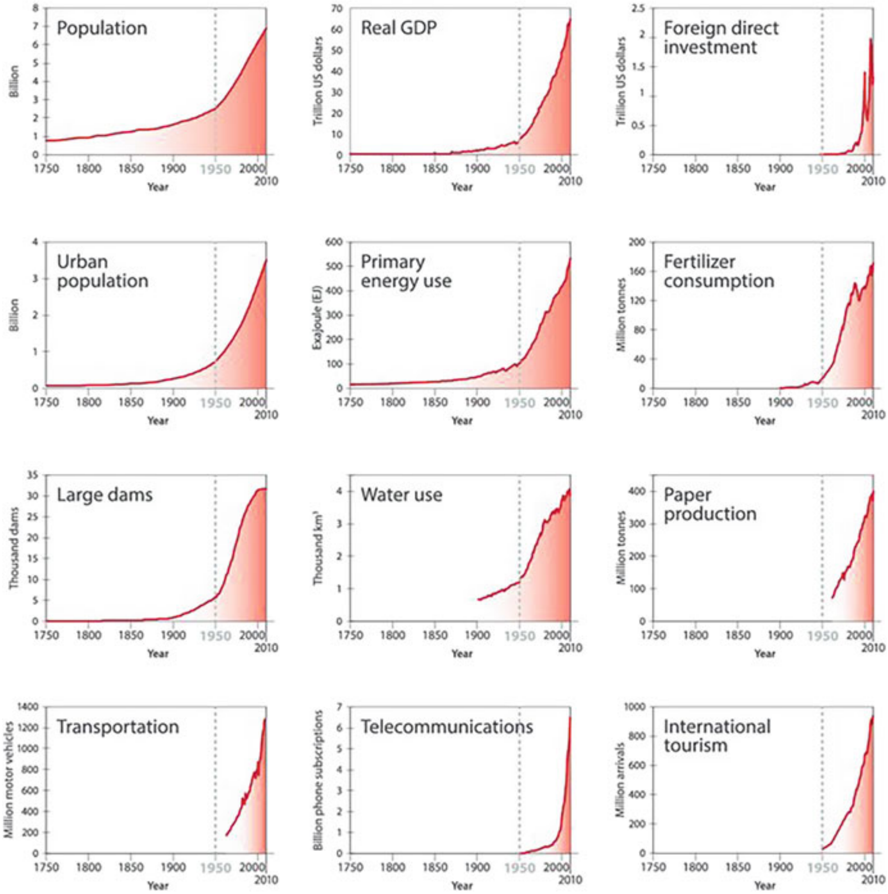

Fig. 1.1 Trends from 1750 to 2010 in globally aggregated indicators for socio-economic development (source: Steffen, Broadgate et al., 2015)

been salinated, silted up, and poisoned. The former lake bottom is now a huge salt desert where storms spread the salt over hundreds of kilometers, robbing millions of people of their livelihood. The draining and poisoning of the Aral Sea is unanimously described as one of the greatest environmental disasters ever caused by humankind.

The ability to survive crises and disturbances without permanent damage is called **resilience**. How resilient (eco-) systems are depends on various factors, which differ between systems and can change over time. You can find more information about resilience theory and resilience of (socio-)ecological systems at the end of this chapter under *Further Reading*.

The evolution of humans, the development of our societies, and our present high standard of living have been largely allowed by a stable climate, rich biodiversity, and an intact nutrient cycle. However, since industrialization, and especially in the

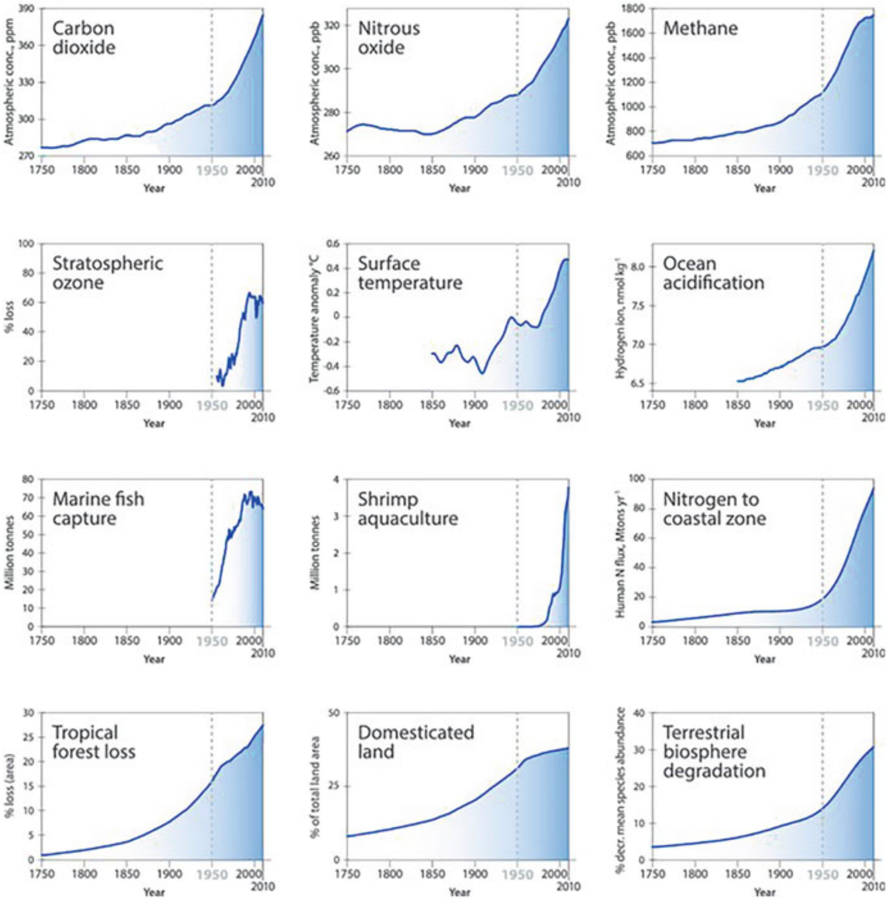

Fig. 1.2 Trends from 1750 to 2010 in indicators for the structure and functioning of the Earth System (source: Steffen, Broadgate et al., 2015)

second half of the last century, our way of life and economic activity have exposed these ecosystems, which have been functioning resiliently for thousands of years, to enormous pressures. There is a high risk that our way of life will cause Earth's ecosystems to tip into a new state and thus endanger our livelihood. However, our standard of living is not possible without natural resource extraction, land use, and emissions of harmful substances. Thus, a burden on ecosystems is unavoidable. The decisive questions therefore are: What can our ecosystems bear? At what point will humankind's activities tip ecosystems into another state that has serious consequences for life on earth?

A team of almost 30 leading scientists led by Johan Rockström addressed this question and developed the concept of planetary boundaries. Their work was first published in 2009 (Rockström et al., 2009) and updated in 2015 with new data and findings (Steffen, Richardson, et al., 2015). The concept has meanwhile become a fixed reference point for international and national environment and development policy—especially climate policy—and is constantly being developed further through new research findings.

The concept of **planetary boundaries** identifies nine factors that are central to the stability and resilience of our planet and defines a "safe operating space" in which environmental conditions are favorable for humanity. If we move within these boundaries, the risk of dangerous, irreversible environmental changes is relatively small. If we exceed these limits, we endanger the stability of ecosystems and thus the basis of human life (including the economy). Table 1.1 lists and briefly explains the nine planetary boundaries.

Scientists have been able to quantify eight of these ecological dimensions, five have already exceeded the exposure limit (climate change, loss of biosphere integrity (i.e., genetic diversity (E/MSY); functional diversity (BII) is not yet quantified), biochemical flows (i.e., nitrogen (N) and phosphorus (P) flows to biosphere and oceans), land-system change and novel entities) and one has not yet been quantified (aerosol loading). Figure 1.3 shows the extent to which these boundaries have already been exceeded.

Earth is one single, complex, and integrated system. This means that the nine planetary boundaries are highly dependent on each other. This has profound consequences for our efforts to achieve global ecological sustainability because it emphasizes the need to address multiple interacting environmental processes simultaneously. For instance, we can only stabilize the climate if we also manage our forests sustainably and ensure stable marine ecosystems (Steffen, Richardson, et al., 2015). Thus, the individual boundaries are not separated but form a system in which there are direct interactions. Taking the example of climate change, what this means is that as biodiversity is lost due to climate change this loss will also push climate change further over its boundary. We can imagine this happening as certain pollinators are lost, plants do not thrive as well thus reducing carbon sequestration in flora. It serves to underline the complexity and interactions of the systems.

Even if the limit of resilience from a global perspective has not yet been reached in all of the ecological dimensions, the limits of the corresponding dimension may long since be exceeded at a regional level, with serious consequences for the people living there. Figure 1.4 shows the regional differences based on the dimensions Biochemical Flows (phosphorus and nitrogen cycle), Land-System Change, and Freshwater Use. These illustrations also show that reliable data are not yet available for many regions of the world, which could mean that we are burdening the corresponding ecological dimension even more than currently assumed.

Similarly, the consequences of climate change do not threaten the people of our planet to the same extent everywhere. Rising sea levels—caused by the melting of polar ice, on the one hand, and the expansion of water due to warming on the other—is primarily an existential threat to people living in coastal areas. In Switzerland, however, the consequences will mostly be economic.

Table 1.1 Short description of the nine planetary boundaries

Climate change	There are several well-defined thresholds above which rapid physical feedback mechanisms can drive the Earth system into a much warmer state with sea levels meters higher than present. Climate-carbon cycle feedbacks accelerate Earth's warming and intensify the climate impacts. A major question is how long we can remain over this boundary before large, irreversible changes become unavoidable
Changes in biosphere integrity (biodiversity loss and extinctions)	The changes to ecosystems due to human activity have been more rapid in the past 50 years than at any time in human history. This has increased the risk of abrupt and irreversible changes. The main drivers of change are the demand for food, water, and natural resources, causing severe biodiversity loss and leading to changes in ecosystem services
Stratospheric ozone depletion	The stratospheric ozone layer in the atmosphere filters out ultraviolet (UV) radiation from the sun. As this layer degrades increasing amounts of UV radiation reach ground level. This causes a higher incidence of skin cancer in humans as well as damage to terrestrial and marine biological systems
Ocean acidification	Around a quarter of the CO_2 that humanity emits into the atmosphere is ultimately dissolved in the oceans. Here it forms carbonic acid, altering ocean chemistry and decreasing the pH of the surface water. This increased acidity reduces the amount of available carbonate ions, an essential "building block" used by many marine species for shell and skeleton formation. Beyond a threshold concentration, this rising acidity makes it hard for organisms such as corals and some shellfish and plankton species to grow and survive. Losses of these species would change the structure and dynamics of ocean ecosystems and could potentially lead to drastic reductions in fish stocks. Compared to pre-industrial times, surface ocean acidity has already increased by 30%. Unlike most other human impacts on the marine environment, which are often local, the ocean acidification boundary has ramifications for the whole planet
Biogeochemical flows	The biogeochemical cycles of nitrogen and phosphorus have been radically changed by humans through many industrial and agricultural processes. Human activities now convert more atmospheric nitrogen into reactive forms than all the Earth's terrestrial processes combined. Much of this new reactive nitrogen is emitted to the atmosphere. When it is washed out, it pollutes waterways and coastal zones or accumulates in the terrestrial biosphere. A significant fraction of the used nitrogen and phosphorus makes its way to the sea and may push marine and aquatic systems to exceed their own ecological thresholds

(continued)

Table 1.1 (continued)

Land-system change	Land is converted to human use all over the planet. Forests, grasslands, wetlands, and other vegetation types have primarily been converted to agricultural land. This land-use change is one driving force behind biodiversity loss. Moreover, conversion has impacts on water flows and biogeochemical cycles of carbon, nitrogen, phosphorus, and other important elements. While each incident of land cover change occurs locally, the aggregate impacts have consequences for Earth system processes on a global scale. A boundary for human changes to land systems needs to reflect not just the absolute quantity of land, but also its function, quality, and spatial distribution
Freshwater use	The freshwater cycle is strongly affected by climate change and its boundary is closely linked to the climate boundary. Human pressure is now the dominant driving force determining the functioning and distribution of global freshwater systems. The consequences of human modification of water bodies include both global-scale river flow changes and shifts in vapor flows arising from land-use change. These shifts in the hydrological system can be abrupt and irreversible. Water is becoming increasingly scarce—by 2050, about half a billion people are likely to be subject to water-stress, increasing the pressure to seek and exploit even more water systems.
Atmospheric aerosol loading	An atmospheric aerosol planetary boundary was proposed primarily because of the influence of aerosols on Earth's climate system. Through their interaction with water vapor, aerosols play a critically important role in the hydrological cycle affecting cloud formation and global and regional patterns of atmospheric circulation, such as the monsoon systems in tropical regions. They also have a direct effect on climate, by changing how much solar radiation is reflected or absorbed in the atmosphere. Humans change the aerosol loading by emitting atmospheric pollution, and through land-use change that increases the release of dust and smoke into the air. Shifts in climate patterns and monsoon systems have already been seen in highly polluted environments. A further reason for an aerosol boundary is that aerosols have adverse effects on many living organisms. Inhaling highly polluted air causes roughly 800,000 people to die prematurely each year
Introduction of novel entities	Emissions of toxic and long-lived substances such as synthetic organic pollutants, heavy metal compounds, and radioactive materials represent some of the key human-driven changes to the planetary environment. These compounds can have potentially irreversible effects on living organisms and on the physical environment (by affecting atmospheric processes and climate)

Source: According to Stockholm Resilience Center (n.d.)

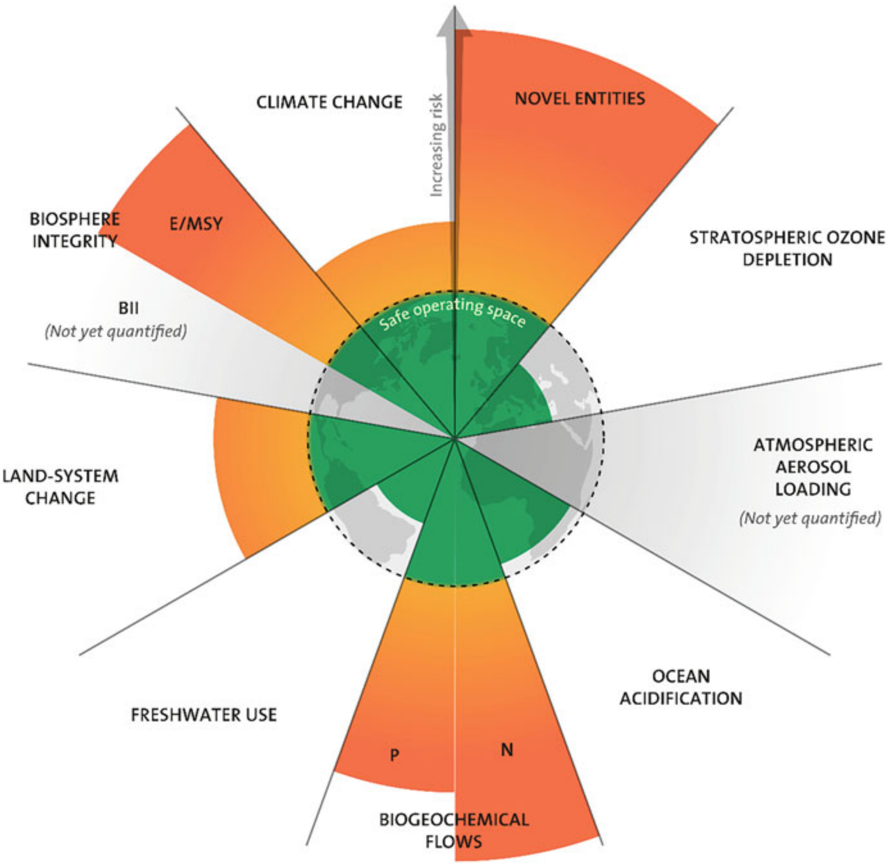

Fig. 1.3 Planetary boundaries (credit: Designed by Azote for Stockholm Resilience Centre, based on analysis in Persson et al. 2022 and Steffen, Richardson, et al., 2015)

1.3 Adding the Social Dimension

Natural resources such as water, soil, clean air, or mineral resources form the basis for our quality of life. As we have seen in the previous chapter, the overexploitation of these resources pushes the planet's environmental systems to the limits of stability. The nine boundaries and all their complex interactions are particularly important for the global ecosystem and exceeding their fixed limits has existential consequences for humanity.

There is complex feedback between our society and the ecosystem. Poverty, wars, inequality, global health issues, and oppression pose a serious threat to human society and directly or indirectly also to the ecological state of the planet. People fleeing for their lives or otherwise struggling to survive do not have the resources to focus on sustainability but rather focus on day-by-day goals. On the

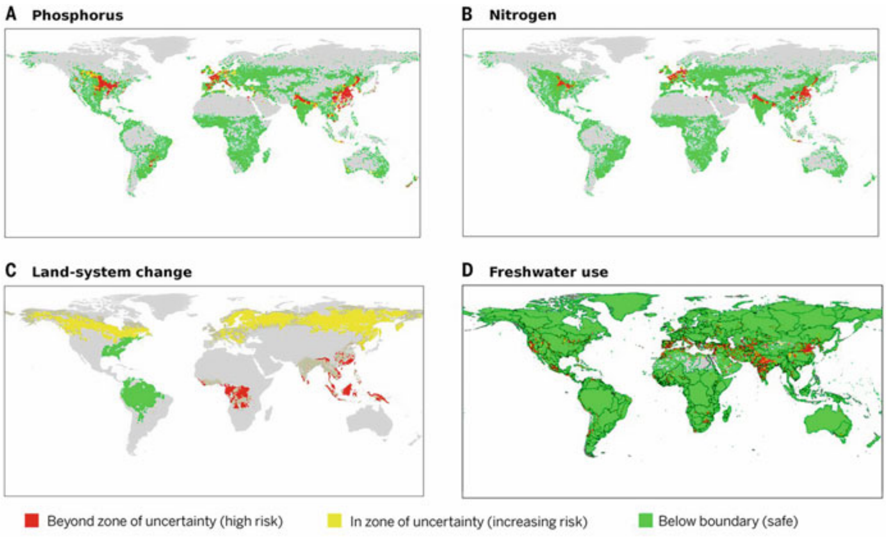

Fig. 1.4 The global distributions and current status of the control variables for (**a**) biogeochemical flows—P, (**b**) biogeochemical flows—N, (**c**) land-system change, and (**d**) freshwater use (source: Steffen, Richardson, et al., 2015)

other hand, increasing social prosperity usually leads to more consumption (meat instead of vegetables, car instead of public transport, bigger apartment, ...), which in turn can have a negative impact on the environment.

The social dimension is therefore likewise important for the path to sustainable development, which can be described as the challenge of meeting the needs of the present without compromising the ability of future generations to meet their needs (more on the definition of sustainable development in Chap. 2).

The Oxford economist Kate Raworth—frustrated over the dogmatic teaching of mainstream theory at universities disconnected from growing real-world problems—combined the well-established concept of planetary boundaries with the complementary concept of social boundaries and created a visual framework for sustainable development and for a new economic model—The Doughnut or **Doughnut economics**.

> What if we started economics not with its long-established theories, but with humanity's long-term goals, and then sought out the economic thinking that would enable us to achieve them? I tried to draw a picture of those goals and, ridiculous though it sounds, it came out looking like a doughnut—yes, the American kind with a hole in the middle. (Raworth, 2017a, p. 10).

The Doughnut (Fig. 1.5) was first presented in a discussion paper in 2012. In 2017, Raworth published the book Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist.

The Doughnut of social and planetary boundaries is a new economic model; an alternative to the current economic system, which is based on growth, materialism,

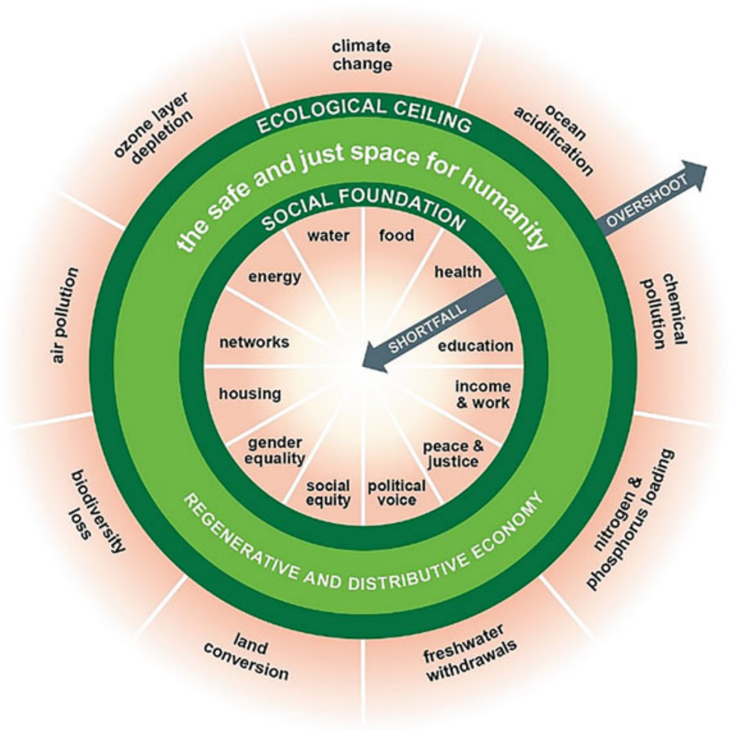

Fig. 1.5 The doughnut (source: Wikipedia. (n.d.). Retrieved September 09, 2020 from https://en.wikipedia.org/wiki/Doughnut_(economic_model))

and capitalism and does not take into account crises such as climate change, loss of biodiversity. Instead of growth targets and the standard indicators of gross domestic product, it proposes new targets and indicators that focus on human well-being and ecological boundaries.

The environmental ceiling consists of the nine planetary boundaries. The twelve elements of the social foundation are derived from internationally agreed minimum social standards, as identified by the world's governments in the Sustainable Development Goals (see Sect. 2.4). Between these social and planetary boundaries lies an environmentally safe and socially just space in which humanity can thrive (Raworth, 2012).

Despite our unprecedented progress described in the beginning of this chapter, we are far outside the doughnut's boundaries on both sides (see Fig. 1.6). Millions of people still live below each of the social foundation's minimum standards. Most people in the world live still in poverty (about two-thirds live on less than 10 international dollars per day), 11% (about 820 million people) of the global population is undernourished. Unsafe water is responsible for 1.2 million deaths each year and almost one person in three (29%) do not have access to safe drinking water (source: Our World in Data). Furthermore, one child in six aged 12–15 is not in school (the

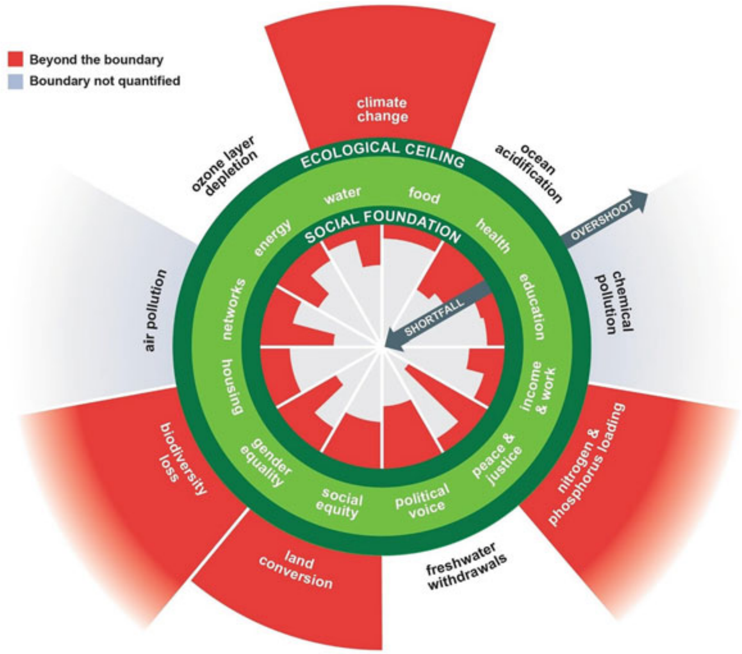

Fig. 1.6 Transgressing both sides of the Doughnut's boundaries (source: Kate Raworth. (2017). Retrieved September 09, 2020 from http://www.kateraworth.com/doughnut/#)

vast majority of them girls), one in eight young people cannot find work, and more of the world's population live in countries where people severely lack political voice or stable social institutions (Raworth, 2017a, p. 51).

Since the first publication in 2012, the doughnut model hast been widely applied within academia, policymaking, business, urban planning, and civil society as a tool for reconceptualizing sustainable development (Raworth, 2017b). It seems clear that in the long term, we cannot afford to base our performance solely on economic indicators. For a sustainable world, social and ecological aspects must increasingly be considered. It also becomes clear that the environmental dimension and the social dimension are interrelated. Due to global warming and its consequences like rising sea levels people are losing their land and the ability to produce food. This is leading to regional conflicts over water, soil, or other resources. People are having to flee or emigrate to other countries which is again causing other social challenges such as integration, employability, and social justice. This in turn not only causes ecological and social costs, but it an array of negative, also has significant negative economic consequences.

1.4 The Role of Economic Growth

Environmental sustainability is closely linked to economic growth and hence **economic costs**. Episodes of severe weather such as torrential rainfall and flooding cause substantial costs and given current climate trends, these costs are likely to increase. Hsiang et al. (2017) collected national data documenting how short-term weather fluctuations affect six economic sectors in the USA. These data were combined with a set of global climate models and used to estimate the future costs of climate change for the rest of this century. They conclude: “The combined value of market and nonmarket damage across analyzed sectors—agriculture, crime, coastal storms, energy, human mortality, and labor (. . .) costing roughly 1.2% of gross domestic product per +1 °C on average. Importantly, risk is distributed unequally across locations, generating a large transfer of value northward and westward that increases economic inequality. By the late twenty-first century, the poorest third of counties are projected to experience damages between 2 and 20% of county income (90% chance) under business-as-usual emissions.” (Hsiang et al., 2017) (see Fig. 1.7).

At the same time, economic growth is also an important driver of environmental problems. As discussed in Sect. 1.1, the enormous economic growth in recent years has only been possible because of the consumption of many natural resources—especially oil. Hence, if we want to successfully address our environmental problems, we are left with two options. First, we **decouple** economic growth and resource consumption. Although some countries such as China have significantly improved their material productivity (i.e., domestic material consumption per unit of GDP) over time and other countries such as Switzerland already have a high material productivity, global material productivity remains almost constant over time at a level above 1 (see Fig. 1.8). Hence, we have not yet achieved such decoupling. To

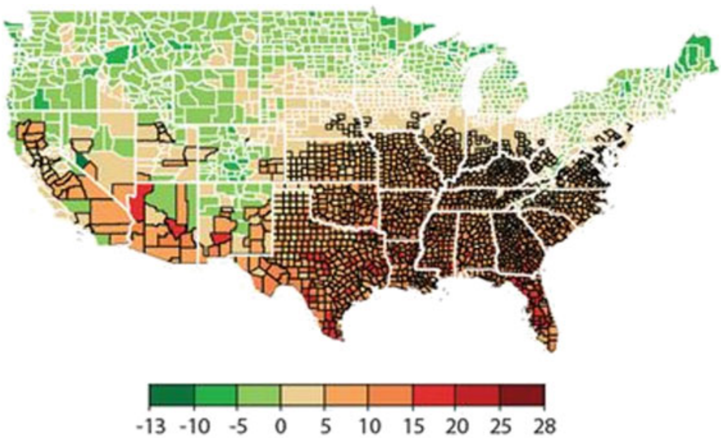

Fig. 1.7 The economic damage from climate change in the United States by 2100 (% of GDP) (source: Hsiang et al. 2017)

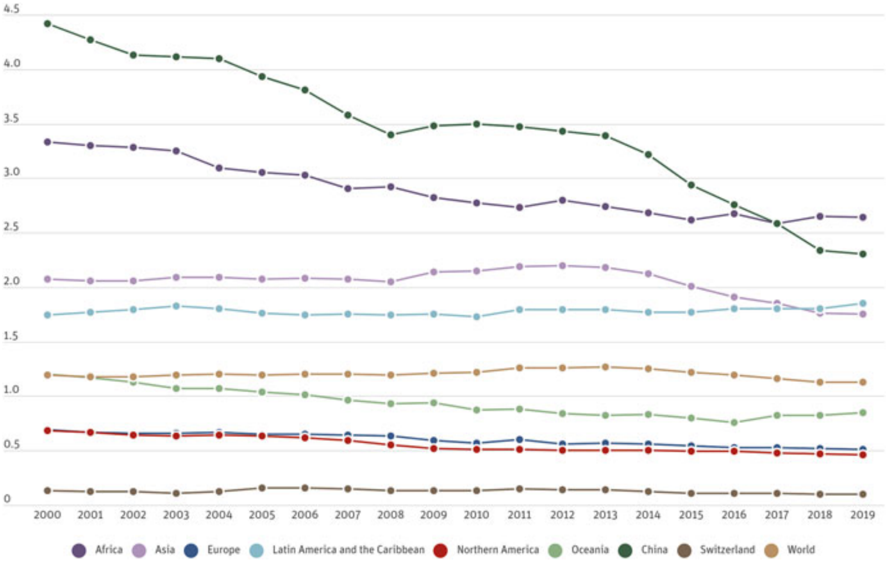

Fig. 1.8 Development of domestic material consumption per unit of economic growth (GDP) for the period 2000–2019 for different regions (source: own representation based on UNEP, 2021), The use of National Resources in the Economy: a Global Manual on Economy Wide Material Flow Accounting)

achieve this goal, we will have to use our materials more efficiently, which is the main goal of a circular economy (see Chap. 9). Second, we slow down our economic growth. This is the goal of the **post-growth economy**. Post-growth postulates that society will function better without the demand of constant economic growth: the central goal of the current—capitalist—economic system. Proponents of post-growth propose economic systems that focus on social well-being, economic justice, and ecological regeneration instead of economic growth. Post-growth economists also argue that growth in GDP cannot be decoupled from growth of environmental impacts, e.g., due to consumption saturation, the so-called **rebound effects**, and declining energy and resource **efficiency**.

Real-World Example: Economics of Climate Change Risks

In its report "Economics of Climate Change Risks" Swiss Re analyzes how climate change will affect a number of countries. The expected losses in global gross domestic product (GDP) by 2050 compared with a world without climate change (i.e., 0 °C change) are enormous:

- Minus 18% for a temperature rise of 3.2 °C, i.e. with society doing nothing to combat climate change.

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- Minus 11–14% for a temperature increase of 2–2.6 °C, i.e. if climate change stays on the currently anticipated trajectory, and the Paris Agreement and 2050 net-zero emissions targets are not met.
- Minus 4% for a temperature increase of less than 2 °C, i.e. if the targets are tightened in such a way that the goals of the Paris Agreement are achieved.

Source: https://www.swissre.com/institute/research/topics-and-risk-dialogues/climate-and-natural-catastrophe-risk/expertise-publication-economics-of-climate-change.html

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