CHAPTER 17
Climate Change, Public Health, Social Peace

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Summary Human well-being results from multiple interactions between highly diverse issues and actors. Crucial factors range from basic hygiene to social cohesion and environmental integrity. In this century, the development of a critical triangle of challenges—consisting of climate change, public health, and social peace—will determine whether a good life for all people on Earth is possible, at least in principle. Those three challenges may seem rather unrelated at first glance, but they are closely tied together and cannot be properly understood in isolation. In this chapter, we highlight essential aspects and relationships according to the current state of the respective arts.

Climate Change

With respect to the global mean surface temperature, the year 2017 was the second-warmest on record, according to the European Centre for Medium-Range Weather Forecasts (ECMWF) (Anon., n.d.-b). That is a remarkable event, since it happened in the absence of El Niño, a recurring phenomenon in the tropical Pacific that transfers large amounts of upwelling heat from the ocean to the atmosphere every 3–5 years, thus boosting global tropospheric temperatures. Moreover, 2017 turned out to be an "*annus horribilis*," with a terrifying routine of breaking disaster records: unprecedented storms (Irma, etc.), downpours (in Houston, etc.), floods (in Nepal, etc.), heat waves (Lucifer, etc.), and wildfires (in California, etc.) shook societies around the planet, giving us a foretaste of what the *new environmental normal* might look like in times of climate change.

In particular, the hurricanes of 2017 received worldwide attention. One after another wreaked havoc with exceptionally high wind speeds (Hurricane Irma), slow movement and record rainfalls (Hurricane Harvey), and dramatic economic impacts

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(Hurricane Maria). The basic mechanism of how the surface temperature rise affects tropical cyclones is clear and undisputed: warmer ocean waters provide more energy to the storms, making them increasingly powerful. But the amount of rainfall they bring along will also increase: fundamental thermodynamics as expressed in the notorious Clausius–Clapeyron relation implies that the atmosphere can hold about 7% more water vapor with every degree of warming. Thus, the physics sets the stage for extreme rainfall events in the future, events that will be even more devastating than the one that shook East Houston in the wake of Hurricane Harvey. The downpours were already so exceptional that the US National Weather Service had to introduce a new color into its graphs in order to properly represent what happened. Finally, coastal storm surges become far more dangerous with rising seas due to global warming. One example that remains pertinent because it caused extensive subway flooding was the impact of Superstorm Sandy in the year 2012: without the roughly 30 cm of sea level rise that the New York area had already experienced by 2012, the flooding would have done significantly less harm.

And sea levels might rise even faster than anticipated by the most recent report from the Intergovernmental Panel on Climate Change (IPCC, 2013). Newer research findings, based on conceptual models that include the entire range of known contributions to the ocean rise, suggest that in a business-as-usual scenario we might have to expect an average rise of about 1.3 m worldwide by the end of this century, which would be twice that previously estimated (Nauels et al., 2017). Note, however, that there is no academic consensus yet on the specific processes of ice cliff disintegration that an earlier study (DeConto & Pollard, 2016) suggested could drive an accelerating Antarctic contribution to the ocean surge. Nevertheless, exploring the consequences of the assumption that those processes are real is quite illuminating: Nauels and colleagues connect the proposed ice physics with a new generation of emission scenarios, the *shared socioeconomic pathways*, and conclude that the sea level rise could still be limited to around 0.5 m in 2100—if an almost complete coal phaseout was achieved by midcentury. In other words, the truly big inundation can still be avoided, but the escape path becomes steeper every year without ambitious climate action.

One question, which is routinely raised in the media following extreme weather events, is whether a specific event has been caused by climate change. Given the complexity of the climate system and the nonlinearity of its dominant dynamics, this question is impossible to answer (and almost meaningless) in the strict sense. However, no-nonsense statistical statements can be made more and more often. The field that courageously tackles this task is called attribution studies and usually employs huge numbers of computationally expensive ensemble simulations (see, for example, van Oldenborgh et al. (2017) for an analysis with respect to Hurricane Harvey, and Mann et al. (2017) regarding planetary waves and extreme weather events). Although great steps forward are being taken, one might remain skeptical as to the ability of the models to capture the specific mechanisms involved in a single extreme event's formation. On the other hand, the scientific community may waste its time anyway by trying to answer the unanswerable, so it should, rather, focus on the impacts of events that are individually unaccountable but statistically unavoidable on the basis of the first principles of physics. One tricky aspect in this context has recently been highlighted in the *Bulletin of the American Meteorological Society*: in a warmer climate, not only is the damage arising from hurricanes likely to become more severe but also the forecasting might become more difficult too, as the storms intensify more rapidly just before landfall (Emanuel, 2017). The bulletin also issues a popular and quite useful series titled *Explaining Extreme Events from a Climate Perspective* (Anon., n.d.-c).

Not only American coasts are affected by hurricanes: Atlantic Storm Ophelia, for example, struck Ireland after forming unusually far to the east in October 2017. Actually, this might become more common in the future (Haarsma et al., 2013). The impacts of that specific hurricane were spectacular in two ways. Firstly, desert particles from Africa were swirled up in the air and carried far north, such that for an entire day the sunlight over England was transformed into a reddish glow, typical for dawn or dusk only. Secondly, and far more dramatically, the winds fanned the flames of devastating Iberian wildfires very late in the season. Wildfires are globally on the rise and are becoming more destructive, also because new settlements keep on intruding into formerly untouched landscapes. The wildfires in California in 2018, for example, brought about a huge loss of life, and this was probably only the beginning on a warming planet. High temperatures and absence of rain, often in combination with high winds, are basic ingredients for severe fire conditions, and more and more land is affected by monthly heat extremes now (Coumou & Robinson, 2013; Coumou, Robinson, & Rahmstorf, 2013). In fact, the number of record-breaking temperature extremes is already about five times larger than it would be in an unperturbed climate.

This development enhances the risks of fire and drought, but the bitter irony of anthropogenic climate change is that the contemporary rise in extremes also includes rainfall (as mentioned above). Recently, *Nature Climate Change* published a study applying interesting new diagnostics to computer simulations, involving both the humidity in the air and its vertical motion. It demonstrated that the basic thermodynamic relationships between temperature and precipitation intensity, which often capture the local reality well, need to be complemented by atmospheric fluid dynamics to get the big picture right. It turns out that in the midlatitudes (i.e., regions with low to intermediate temperatures) hourly precipitation extremes might increase by up to 15% per degree of warming (Fig. 17.1), roughly doubling the classical Clausius–Clapeyron relation (see Pfahl, O'Gorman, & Fischer (2017); see also Lenderink & Fowler (2017) for a "News & Views" contribution). This is in line with the more general analysis that a weakening of midlatitude circulation leads to more hot, cold, dry, and wet extremes (Lehmann & Coumou, 2015).

Returning briefly to the question about the anthropogenic causation of an individual meteorological extreme event, we wish to highlight a recent heat wave with an especially suitable name, Lucifer, which haunted the Mediterranean regions in the summer of 2017: this specific disaster was found to have been made four times more likely by anthropogenic climate change (World Weather Attribution Group, WWA; Anon., n.d.-e). During that heat wave, temperatures stayed above 30 °C around the clock for three consecutive days. Yet another record may have been reached in the Iranian city of Ahvaz on an afternoon in June 2017, when the temperature climbed to almost 54 °C. If that measurement was correct, it would practically

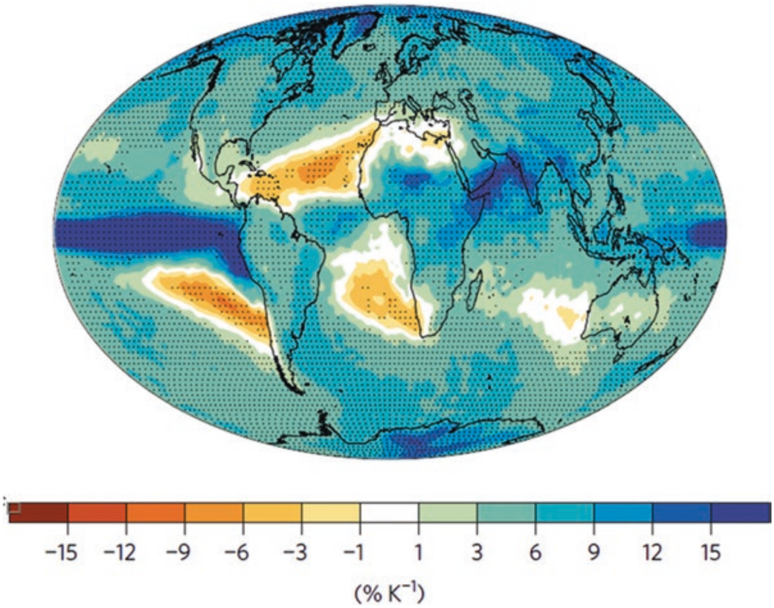

Fig. 17.1 The most extreme rainfall intensity will increase by up to 15% per degree of warming (Pfahl et al., 2017)

tie with the hottest temperature recorded on Earth since the beginning of modern measurements. The Ahvaz episode was made much worse by high concomitant air humidity, as we will explain below.

Public Health and Social Peace

When one thinks about public health in the context of climate change, one of the first questions that come to mind is if and how the human body will be able to adapt to the altered conditions. Steven Sherwood and Matthew Huber have suggested that unabated climate change might occasionally enforce the transgression of a rather critical threshold for human physiology (Sherwood & Huber, 2010). A combined measure of humidity and heat, called the *wet-bulb temperature*, sets limits to our body's acclimatization capacity. In a business-as-usual scenario, this limit might be approached in some world regions by the end of this century and could even be exceeded in a few locations, where unfavorable geographic conditions reign (Im, Pal, & Eltahir, 2017; Pal & Eltahir, 2015). Two of these literal hot spots happen to be in superdensely populated areas—namely, in the agricultural regions of the Indus and the Ganges river basin. The wet-bulb temperature sets an upper limit to adaptability; however, heat extremes with temperatures far below this threshold can cost lives, especially those of the sick, old, and very young. A recent metastudy on

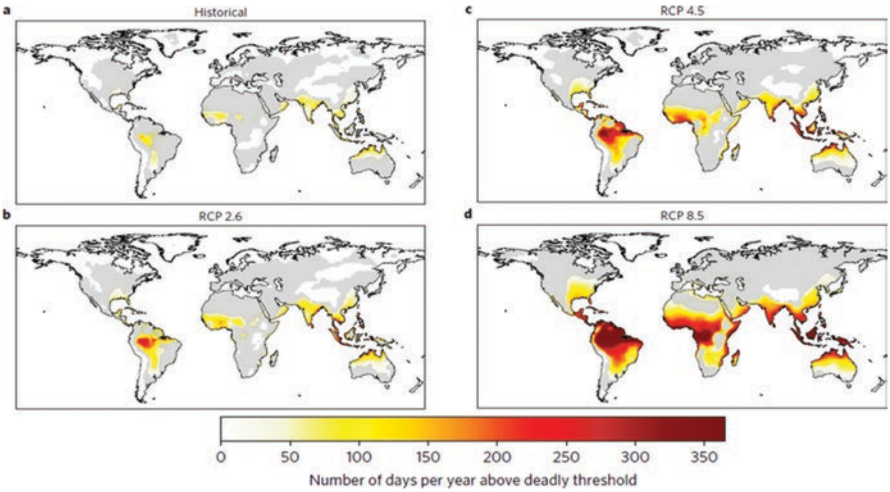

Fig. 17.2 Geographical distribution of deadly climatic conditions in different emission scenarios (Mora et al., 2017). *RCP* representative concentration pathway

observed excess heat mortality (Mora et al., 2017) found that around 30% of the world's population is already suffering from potentially fatal climatic conditions on more than 20 days of the year. In a business-as-usual scenario, this percentage is estimated to rise to almost three quarters of the human population by 2100 (Fig. 17.2).

Beyond extreme heat, climate change affects and threatens public health in various other ways (see, e.g., McMichael, Woodruff, & Hales (2006))—that is, through storms, floods, and wildfires such as the 2017 events in North America, Europe, and Asia, highlighted above. The impacts of climate change on public health also have a crucial socioeconomic dimension: shifting environmental conditions will be felt most strongly in poor and already risk-exposed communities. This applies both to the socially disadvantaged within industrialized countries and to poor societies in developing countries—a matter of social justice across scales. Within affluent countries, physical weakness and lack of monetary freedom reduce resilience against extreme events such as heat waves, fires, or flooding. In developing countries, health challenges related to diarrhea, vector-borne diseases, and childhood stunting may become much more salient.

"The Uninhabitable Village," a recent interactive report by the *New York Times*, gives a vivid and shocking impression of quintessential humanitarian aspects of global warming (Anand & Singh, 2017). It tells the story of families left behind by their husbands and fathers—Indian farmers—who killed themselves because they felt personally responsible for crop failures that climate researchers believe to result mainly from rising temperatures and the associated extreme events (Fig. 17.3). Suicides by farmers are part of an escalating tragedy on that subcontinent, with hundreds of thousands of cases occurring over the past three decades. This sad phenomenon is partially rooted in local social and economic challenges that are tied to global

Fig. 17.3 Interactive reportage from the *New York Times* (Anand & Singh, 2017)

inequalities in intricate ways. However, the problem is not merely one of status, wealth, and allocation; it is also one of fierce environmental reality. Hot days and the number of suicides correlate, and researchers have estimated that nearly 60,000 cases during the last 30 years might have been caused by the warming trend (Carleton, 2017). The social ripple effects of the phenomenon propagate through space and time: with women and children left behind and deprived of basic income, trauma is passed on to the next generations and families are left with daunting choices. They have to decide between staying and trying to survive under worsening conditions in already nearly uninhabitable regions or, alternatively, migrating to the cities, where their points of arrival are generally slums with dire living conditions and prospects.

Another major example of a climate change–related health threat is the rising sea. Salinization and other associated impacts force communities to give up their homesteads, which no longer provide them with essential nutrients. Some small island developing states (SIDS), such as certain Pacific islands, are already becoming uninhabitable as a result of the degradation of formerly fertile ground. Since these secluded islands are difficult to reach, supply from the outside is not a reliable alternative. Remoteness and a dire lack of adaptive capacity force islanders to consider moving away decades before they actually lose their lands to the sea.

Environmental migration has actually become a global phenomenon now, which is both embedded in and transforming the traditional movement patterns. This type of migration is difficult to quantify, mainly because of a lack of data. Seasonal or permanent movements following single extreme events or long-term environmental degradation are poorly documented so far, not least because those movements happen predominantly in developing countries without pertinent scientific communities.

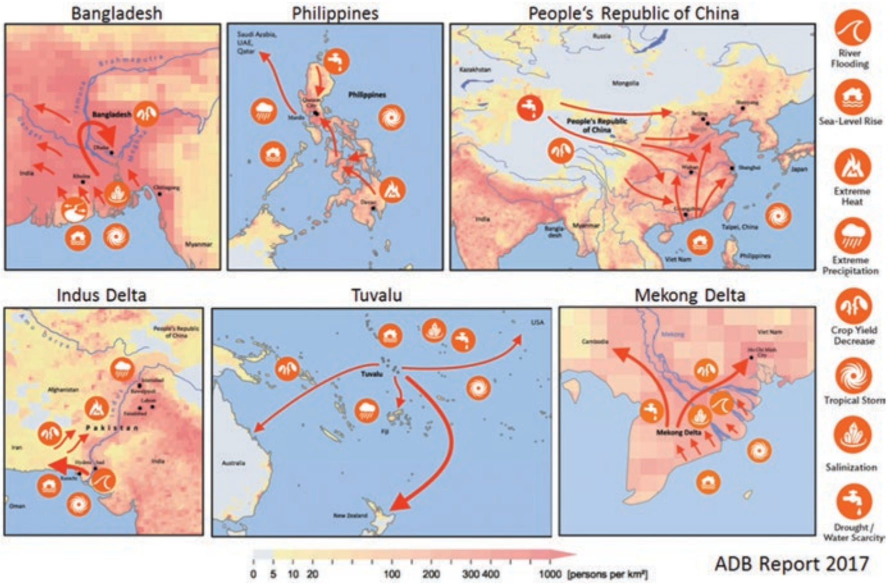

Fig. 17.4 Climate impacts and possible migration routes in the Asia-Pacific region (Vinke et al., 2017). *ADB* Asian Development Bank, *UAE* United Arab Emirates

Moreover, each migrfromion decision is based on a complex mix of very individual motivations. There is, however, new impetus in the scientific community to gain a better understanding of the overall phenomenon. Some of the most recent insights have been compiled in the *Atlas of Environmental Migration* (Ionesco, Mokhnacheva, & Gemenne, 2016): more than ten million people are forcibly displaced by weather-related sudden-onset hazards (such as floods, storms, wildfires, or heat waves) each year. Many others migrate in response to slow-onset hazards. Some households even use migration to prepare for future crises looming because of natural disaster risks, demonstrating that at least in certain cases, adaptation options can be realized by mobility decisions—which does not necessarily mean, however, that the decision to move is taken truly voluntarily (Melde, Laczko, & Gemenne, 2017). In 2015, 85% of all displacement due to sudden-onset events happened in South and East Asia. A recent report on the human dimensions of climate change in that region, issued by the Asian Development Bank with major contributions by the Potsdam Institute for Climate Impact Research (Vinke et al., 2017), sheds light on relevant aspects such as human health, urban development, security, migration, and trade networks. Among others, climate impacts and possible migration routes are explored (Fig. 17.4).

The potential indirect consequences of a single extreme event can sometimes be enormous. The devastations wrought by Hurricane Maria, for instance, which hit Puerto Rico exceptionally hard on September 20, 2017, and destroyed large parts of the electrical infrastructure there, eventually may have significant political implications at a distance. The *New York Times* reported on the huge number of islanders (estimated to have amounted to more than 200,000 in the first 2 months after the event) flowing into the Orlando area as a response to the havoc left behind by the storm (Tackett, 2017). Since Puerto Ricans are US citizens who predominantly favor the Democratic Party, their inflow might tip political majorities in the swing state Florida. Solomon Hsiang and Trevor Houser, directors of the Climate Impact Lab (Anon., n.d.-a), calculated that it could take 26 years for the island's economy to return to its state before the storm (Hsiang & Houser, 2017). This implies that the Puerto Ricans moving to Florida might not have a strong motivation to return home in the foreseeable future. So, apart from the social injustice resulting from climate change–related threats to the least resilient (the old, very young, and poor) *within* industrialized countries, this provides a rather surprising example of how climate change might impact those who are mainly responsible for it—industrialized countries.

It is quite evident that migratory movements can be a threat to social peace under unfavorable circumstances. Even catastrophic developments such as the ongoing Syrian civil war have been related to anthropogenic climate change. Colin Kelley and colleagues analyzed the historic drought that prevailed in the years before 2011, when the uprising started (Kelley et al., 2015). Their study emphasized that a drought of that caliber has become more than twice as likely as a result of global warming. This extreme event most likely contributed to certain migratory movements toward the cities, yet it must be placed within a tangle of drivers that include unsustainable water management, rising food prices, corruption, and political instability, as well as the specific motives of the different social and cultural groups involved. Recently, a number of studies have shed light on pertinent aspects. One study revealed that groups depending on agriculture and politically marginalized people are particularly vulnerable to droughts and may resort to violence because of their lack of coping capacity (von Uexkull et al., 2016). Another study found that the risk of armed conflict in the aftermath of climate-related disasters is significantly higher in ethnically fractionalized countries (Schleussner et al., 2016). Of course, almost nowhere is climate change the single cause of conflicts, which generally result from complex socioeconomic dynamics and depend heavily on local contexts. This is reflected in a lively debate on the subject, especially with respect to the Syrian case (Selby et al., 2017). However, in the sense of *threat multipliers*, climate impacts have the potential to exacerbate certain existing conflicts or to push other ones out of latency.

A Radically Logical Proposal

How can we deal with all of these challenges brought about by global warming, even if the temperature rise is confined to "only" 2 °C? We do think that multilaterally arranged climate migration—not compulsory eviction—will be a key element of an appropriate adaptation strategy. Defending all areas on Earth against sea level rise, desertification, and increasingly intense "natural" disasters will not be possible, so a relocation process of unprecedented dimensions needs to be considered (WBGU, 2016). This cannot be organized rigorously top-down, however, and the whole enterprise must be guided by humanitarian values. There are already ambi-

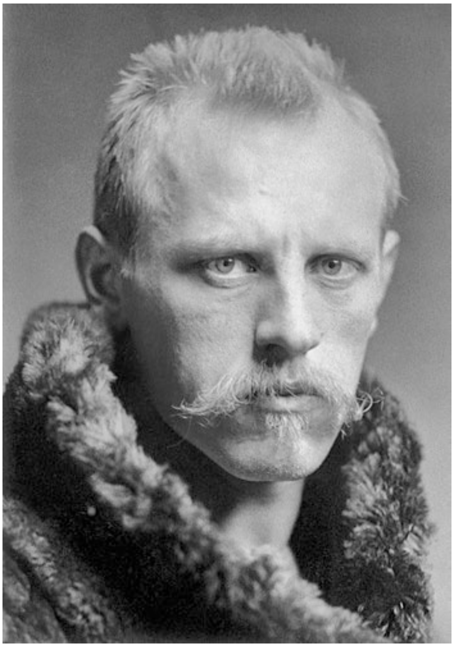

Fig. 17.5 Fridtjof Nansen (1897)

tious projects such as the *Nansen Initiative* (Anon., n.d.-d), which was launched in 2012 by Switzerland and Norway, and is aimed at establishing an international consultative process in order to raise awareness and build consensus among states on a protection agenda for persons displaced by climate change.

But the challenges are enormous: identifying climate refugees among other migrants is highly difficult, especially since voluntary and forced migration are not easily discernible. There is also a legal gap in dealing with this group of people, particularly when it comes to cross-border movements. So far, the very term *climate refugees* (which suggests that it describes refugees in the sense of the 1951 Refugee Convention and the obligation to grant asylum) has not been established in international law, and the necessary debate is only beginning now.

However, climate migration is already a reality (in the South Pacific, for instance) and the human calamities resulting from it may become unspeakable in the future unless a novel institutional set of measures comes to the rescue. Here we mention just one, which could become a true game-changer. Our suggestion departs from a famous historical analogue and a name already mentioned above: Fridtjof Nansen (1861–1930; see Fig. 17.5)—a top diplomat for the League of Nations, a Nobel Peace Prize laureate, and arguably the most important pioneer of polar research worldwide—created a certificate, called the *Nansen Passport*, for stateless persons who were deprived of their citizenship in the cruel vagaries of the First World War and its aftermath. The document was launched on July 5, 1922, and eventually accepted by 53 countries, which opened their borders to the holders (such as Igor Stravinsky, Rudolf Nureyev, and Aristotle Onassis) of that supranational passport.

Today, a similar certificate—a *planet passport* or *climate passport*—could become a key instrument for dealing, in a liberal and humane way, with migration triggered by climate change. The passport should give people who lose their home—and possibly even their national territory—to the impacts of anthropogenic global warming access to all countries bearing a significant responsibility for that loss. The fundamental idea underlying this proposal can be epitomized by the following: *If someone destroys the house of another person, he should be obliged to open his own house to that person.*

There are many evident and also more subtle aspects of our proposal that need to be carefully discussed, not least by experts in international law and moral philosophy. Here we confine ourselves to highlighting just two critical dimensions of such a certificate—namely (a) *eligibility* and (b) *accessibility*. The first one is fairly straightforward in the case of inhabitants of island states threatened in their entirety by sea level rise or citizens of countries (such as Bangladesh) that will lose large portions of their territory to the sea. However, things become more complicated when one considers displacement due to heat, drought, or erosion, for instance, as the previous discussion about the difficulties in attribution studies has shown. One could think of setting up an *international climate court* that would decide on eligibility on the basis of the best scientific evidence available. Secondly, a *principle of the perpetrator* would have to lay the basis for identifying the states bound to accept climate passport holders. For example, a 2% rule (in the vein of the 2 °C guardrail for climate mitigation) could objectively name the few (and mostly economically prosperous) countries (or blocs) that have been individually responsible for a significant share of the global cumulative emissions since the industrial revolution (see Fig. 17.6).

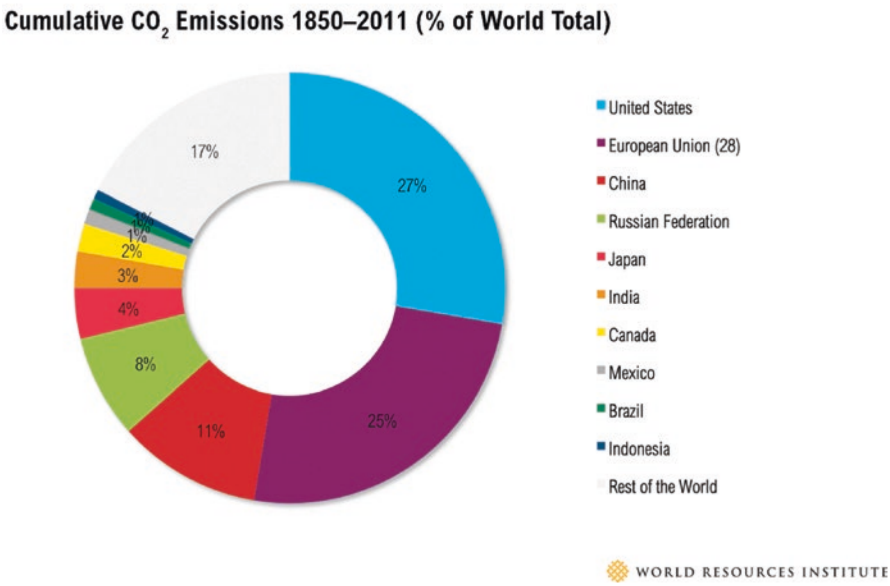

Fig. 17.6 Share of total cumulative emissions by country or political union. *Source*: World Resources Institute

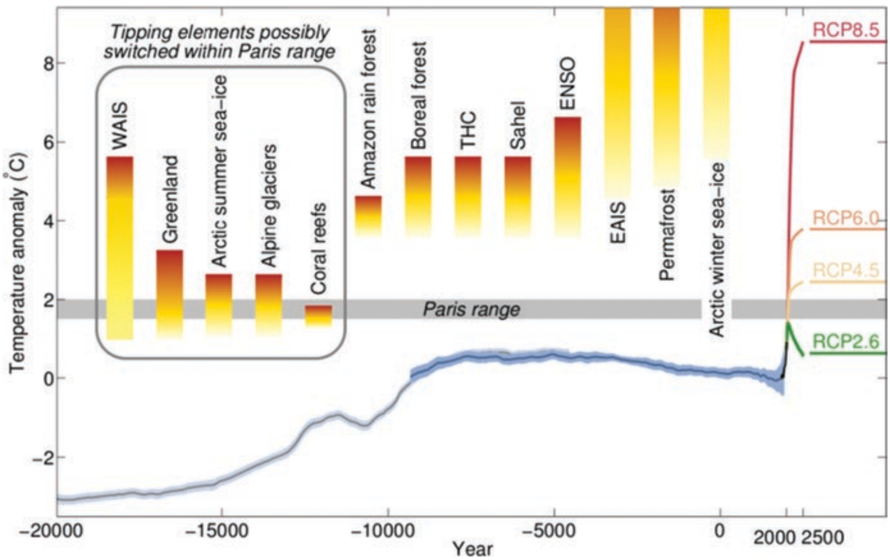

Fig. 17.7 Tipping elements of the Earth System and their potential disruption ranges in the context of the global mean temperature development over the last 20,000 years (Schellnhuber et al., 2016). *EAIS* East Antarctic Ice Sheet, *ENSO* El Nino southern oscillation, *RCP* representative concentration pathway, *THC* thermohaline circulation, *WAIS* West Antarctic Ice Sheet

A climate passport (or the already serious discussion of such a format) could help set a countertrend against the currently observable *race to the bottom* of moral standards in the treatment of refugees, manifesting itself not least in the rise of reactionary, xenophobic, and nationalistic political parties in the developed world. Also, if a given nation comes to the conclusion that the burden of giving shelter to climate-displaced persons is too heavy, then it might at least raise its mitigation ambitions and help reduce the very causes of the displacement abroad. Rapid decarbonization is clearly the choice to be made then.

Conclusion and Outlook

What are the implications of the most recent climate research findings for our civilization? If we step back a little and let our eyes roam over the possible future states of the Earth System, we have to consider the fact that the changes humans are causing will not happen, as a rule, in a gradual and reversible manner. In particular, there are tipping points in the global climate system (Lenton et al., 2008), where the operation and interaction of crucial components of the planetary machinery, called "tipping elements"—such as the large ice sheets, the Amazon and Congo rainforests, the major ocean currents, the monsoon patterns, and the jet streams—can change their character in a highly nonlinear and possibly irreversible way (for more information please consult our contribution to the Pontifical Academy of Sciences

(PAS) and Pontifical Academy of Social Sciences (PASS) publication *Sustainable Humanity, Sustainable Nature: Our Responsibility* (Schellnhuber & Martin, 2014)).

Putting the latest insights on tipping elements into a relationship with the bygone, stable environmental regime of the Holocene and with the new, rapidly changing one of the Anthropocene, it becomes clear that the world might look very different in only a couple of centuries (Fig. 17.7). A drastic change of course is essential to prevent massive climatic disruptions (Schellnhuber, Rahmstorf, & Winkelmann, 2016), which, through tipping cascades, might eventually result in the Earth System locking into a hothouse state (Steffen et al., 2018), with conditions similar to the climate 15–17 million years ago.

Therefore, staying within the temperature range agreed upon in Paris will be crucial for limiting the associated damage to public health and social peace.

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