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Goethe University Science Magazine

Climate Crisis

2.2020

THE AIR OF THE ENTIRE WORLD

Exposing greenhouse gases thought dead

INVASION OF THE PARASITES

Are tropical diseases on the rise?

THE BETTER STORY

Combatting conspiracy theories with science communication

LEARNING ENVIRONMENTAL AWARENESS?

What education can contribute to sustainable action

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WILL WE SORT IT OUT OR NOT?

Standpoint:
Climate change controversy



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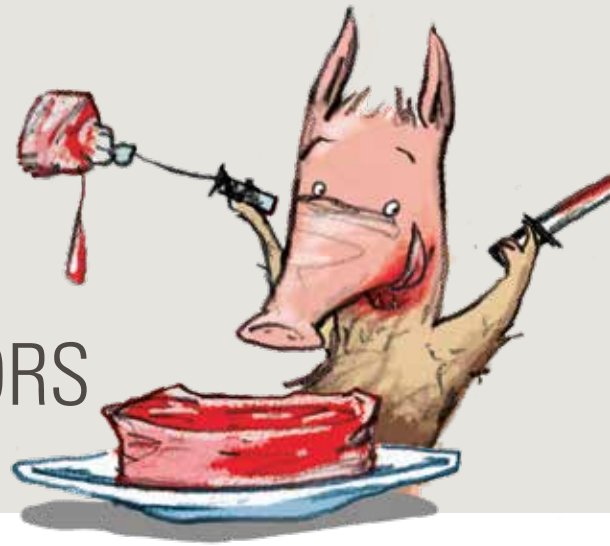
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MESSAGE FROM THE EDITORS



Dear reader,

By the end of the year, Germany will have emitted only 35 per cent less CO₂ compared to the baseline of 1990 instead of 40 per cent as targeted – and this despite greatly reduced mobility and the shutdown of the economy as a result of the coronavirus pandemic. In addition, the climate protection strategies of many large companies, such as of those which have joined Amazon's »Climate Pledge« (zero carbon by 2040) or which, like Bosch and Siemens, have set themselves even more ambitious targets, ultimately amount to mathematical climate neutrality: Companies compensate elsewhere for what they are unable to save, for instance by supporting carbon offset projects in the Global South. Such initiatives do not really help us to progress much further in the direction of climate neutrality; they can rather be ascribed to marketing and image building. Nevertheless, they are a first step.

When preparing this magazine on the climate crisis, we thought about how we »ordinary citizens« could also already take a first step. If the catastrophic impacts of climate change are to be mitigated, humanity must make concessions at all levels: Global, national and local. However, every company, every business, every institution must also strive to become carbon neutral – as well as every individual citizen. Accordingly, we collected together our heating and electricity bills, added up the kilometres we had travelled by car or train and calculated our families' carbon footprints with the help of online calculators from the German Environment Agency: Per family, it was 9 to 12 metric tons more CO₂ than the maximum of one metric ton per person we would have to achieve in order to


reach the climate change goals of the Paris Agreement. We have therefore compensated for this and paid climate protection agencies to support, among others, the purchase of energy-saving stoves in Africa and the rewetting of peatlands in Germany. This is, however, just a first step. We must also change our behaviour so that we do not produce so much CO₂ in the first place: By cycling more, flying less, consuming less. That is already more difficult.

In science, human-induced climate change is undisputed. The facts are on the table: The climate crisis will – and already does – have far-reaching consequences for people, societies and ecosystems, as researchers from Goethe University explain in their articles. Other articles in this issue illustrate how we can slow down climate change and adapt to the changing circumstances in our lives. Yet why do we find it so difficult to change our way of thinking? Psychologist Dr Jeannette Schmid and sociologist Professor Birgit Blättel-Mink comment on this in our magazine. Will we achieve the 1.5 °C goal set in Paris or not? There are differing opinions on this, even in the scientific community – as is revealed by the »Standpoints« of our two experts, Professor Volker Mosbrugger and Professor Joachim Curtius, at the end of this magazine. In any case, research at Goethe University will make its contribution because, as Professor Birgitta Wolff, the university's President, also says in an interview, this is ultimately its brand essence.

We therefore wish you an unsettling read with a glimmer of hope!

Anke Sauter and Markus Bernards
Forschung Frankfurt Editorial Team

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An aerial photograph of a terraced rice paddy field in a mountainous region. The terraces are arranged in a grid-like pattern, following the contours of the hills. A river winds through the landscape, and the surrounding area is covered in dense green vegetation. The image is overlaid with a dark blue circular graphic at the bottom.

WHAT INFLUENCES THE ATMOSPHERE

Global warming: once a promise, now a threat

On the research of the greenhouse effect up to the Paris Climate Agreement

By Markus Bernards

Almost 200 years passed between the discovery of the greenhouse effect and today's climate models. A foray through the history of climate change research until it finally found its voice in world politics.

Without greenhouse gases, it would be bitterly cold on our planet. Life would be almost impossible at average temperatures of minus 18°C. The fact that we owe our mild climate, in which most of the water is liquid, to the greenhouse effect, first occurred to the French mathematician Jean Baptiste Joseph Fourier. In 1824, he wondered how our earth could be so pleasantly temperate, with an average temperature of 14°C, when the sun sends its warming rays down to earth from such a tremendous distance. About 70 years later, the chemist and later Nobel Prize winner Svante Arrhenius from Sweden presented a theory according to which the greenhouse effect is caused by the gas carbon dioxide (CO₂). CO₂ allows short-wave sunlight to pass through the atmosphere, but absorbs the long-wave infrared light reflected back from the heated earth. CO₂ thus leads to the heating of the atmosphere. According to Arrhenius, water vapour also intensifies the effect of carbon dioxide. Today, the theory, which at that time was only discussed in narrow expert circles, has been confirmed, and what Svante Arrhenius predicted for the unchecked consumption of coal, oil and gas has also been confirmed: namely that the increasing amount of CO₂ in the atmosphere would lead to a significant increase in temperature. However, he was wrong in his conclusion, because he saw the temperature increase very

positively: »The increase of CO₂ in the atmosphere will allow future people to live under warmer skies.«

Today, the pleasant »warmer skies« have given way to threatening scenarios of global warming. In 2018, the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) lists the predictions for further global warming in its summary of global research findings: With rising sea levels, coastal cities and islands will sink, droughts in many regions will reduce harvests and make water scarce, elsewhere or at other times heavy rains will flood the land, in addition there will be wildfires and increasingly violent tropical storms. Joachim Curtius, atmospheric scientist at Goethe University, explains why: »The greenhouse gas concentrations in the atmosphere are changing so fast that the climate is also changing fast and neither ecosystems nor humans can adapt that quickly.«

1979: First World Climate Conference in Geneva

Although CO₂ only makes up 0.04 per cent of our air – 78 per cent nitrogen, 21 per cent oxygen and just under one per cent of the noble gas argon – it is the main driver of climate change. It was not until several decades following Arrhenius' calculations that this realisation was accepted. In 1938, shortly before the outbreak of the Second World War, the British chemist Guy Callendar calculated that there had been a

The most deforested part of the Amazon is the Brazilian state of Rondônia on the border to Bolivia. Rainforest clearing is the second largest source of CO₂ after the burning of fossil fuels and is also a threat to biodiversity.

global temperature rise in the previous 50 years and that this correlated with the rise in CO₂. His scientific paper was read in Germany by the climatologist Hermann Flohn and he was so deeply impressed by it that he addressed the possibility of man-made (anthropogenic) climate change in his habilitation three years later. Flohn went on to later become a scientific pioneer of the subject in Germany. He attended an international conference on an island off Stockholm in 1971, where some 60 experts from 20 countries con-

funding for the topic – the Transrapid was more important to the research minister, Flohn remarked biting in the special »Weather« issue of Geo magazine in 1982. In the following decades, however, the topic slowly gained priority in German research budgets.

When the Intergovernmental Panel on Climate Change (IPCC) was founded in 1988, climate models were already so sophisticated that the IPCC began its first assessment report in 1990 with the words: »We are certain of the fol-



ducted a very controversial discussion of anthropogenic climate change. Hermann Flohn later said about this conference: »We were all convinced that we absolutely had to do something about this problem, but also that it was still much too early to say anything about it.«

But the results of the three-week closed-door meeting found a broad echo in expert circles, and eight years later the World Meteorological Organisation of the United Nations organised the first World Climate Conference in Geneva, setting the international world climate research programme into motion. Intensive work began in the USA, France and Russia, but in Germany, even three years later, there was hardly any research

lowing: there is a natural greenhouse effect which already keeps the Earth warmer than it would otherwise be; emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases: carbon dioxide, methane, chlorofluorocarbons (CFCs) and nitrous oxide. These increases will enhance the greenhouse effect, resulting on average in an additional warming of the Earth's surface.« These scientists predicted then what we can measure today: A rise in the average global temperature of around 0.2°C per decade. They only went too far out on a limb when it came to estimating how quickly concrete consequences would occur. In 2014, the magazine »Cicero« touched this sore spot, running the headline: »Predictions that missed the mark«, because the 50 million climate refugees predicted in 1990 had not materialised, nor could the extinction of many species be attributed to climate change, and the IPCC had to revise their calculations of economic losses due to climate change downwards. The events of the following years, however, paint a different picture: the dry and hot

IN A NUTSHELL

- Natural greenhouse gases made life on Earth possible.
- Especially due to the release of CO₂ from fossil resources, the temperature is rising faster than the earth's ecosystems can cope with.
- To limit climate change to 1.5 °C global emissions must be drastically reduced within a few years.

summers of 2018 and 2019 and the forest fires of the past years have caused not only ecological but also major economic damage worldwide. Reinsurers rank climate change among the three biggest business risks, not only as a result of increased forest fires, but also due to crop failures, heavy rainfall and storms. And in 2019, the World Biodiversity Council IPBES estimated that one million species are at risk of extinction. Although increased land use is the main cause, it is exacerbated by climate change.

coral death. This death is visible as coral bleaching, where the coral polyps expel the unicellular algae they live with because the algae produce toxins when water temperatures are too high. For a short time, the corals can survive without their algae partners. If the water does not cool down, they die. In 2020, a quarter of the Great Barrier Reef off Australia was severely damaged in this way; following 2016 and 2017 it was the third coral bleaching of this largest coral reef on earth within a few years. It is questionable



Corals: When ecosystems topple

Nevertheless, models that make predictions about the effects of climate change are very difficult, as Joachim Curtius is well aware: »Certain interactions have not yet been described as well as we would like. For example, we don't know how much CO₂ and methane would be released from thawing permafrost. We would also like to know a lot more about whether and how, for example, the tracks of low-pressure systems are changing, or whether blocking high-pressure areas over Europe are becoming more frequent.« At the same time, however, he is certain: »We have understood the basic physics very, very well. So the fact that there is a greenhouse effect at all and that we will have a completely different planet with two, three or four degrees of warming – there is no reason to doubt that.«

If permafrost thaws, it could be one of the tipping points of climate change, with a small change in temperature of half a degree on average having big consequences – in this case a sudden release of large amounts of greenhouse gases. Another tipping point may be imminent:

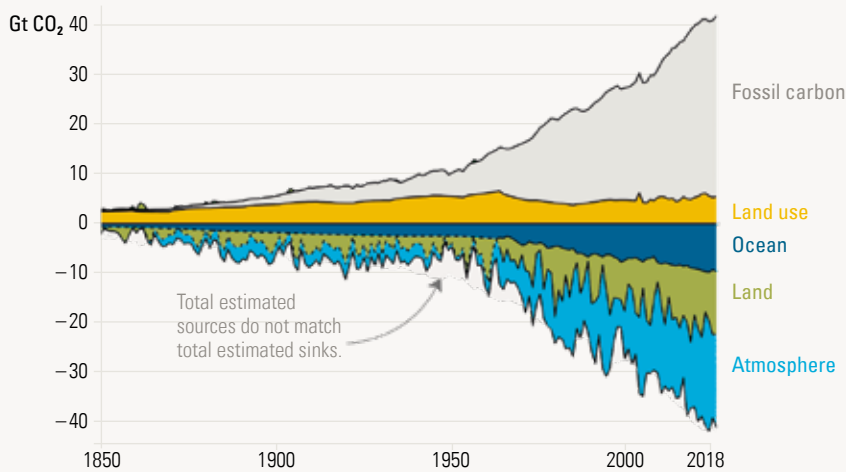
whether the scientists of the Hawai'i Institute of Marine Biology at the University of Hawai'i will be faster in their attempts to breed more heat-resistant corals than the continuing rise in temperatures. »We have already lost fifty per cent of the Earth's coral reefs«, says the Institute's director Ruth Gates. The coral reefs, also called »rainforests of the sea« because of their biodiversity, are not only threatened by long periods of higher water temperatures with one to two degrees being enough. More frequent storms and the acidification of the oceans are also affecting them, as CO₂ dissolves into carbonic acid in water.

Government reaction

Climate change has been on the agenda of world politics for 30 years. The first step was taken at the UN Conference in Rio de Janeiro in 1992, during which the international community accomplished a paradigm shift: environmental protection was placed on an equal footing with poverty reduction and social justice. Countries wanted to voluntarily reduce greenhouse gas

Global warming is impressively demonstrated by the retreat of glaciers: The Pedersen Glacier in Alaska retreated two kilometres from Aialik Bay between 1940 (left picture) and 2005. The former lagoon is filled with sediments and overgrown with grass and bushes.

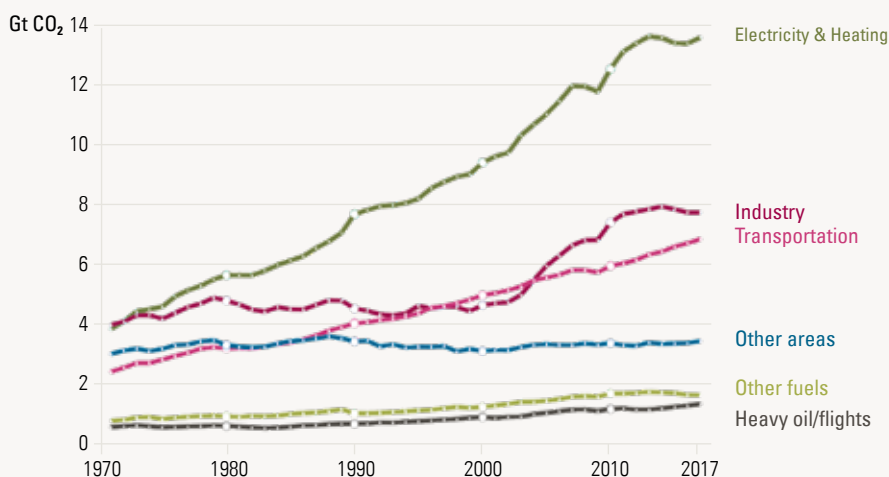
The CO₂ balance



Source: CDIAC; NOAA-ESRL; Houghton and Nassikas 2017; Hansis et al 2015; Joos et al 2013; Khatiwala et al. 2013; DeVries 2014; Friedlingstein et al 2019; Global Carbon Budget 2019

Fossil fuels and land use change – mainly rainforest clearing – have pushed annual CO₂ emissions up to nearly 40 gigatonnes between 1850 and 2018 (above the zero line). Not all emissions remain in the atmosphere: oceans absorb CO₂. Most is dissolved as carbonic acid and contributes to acidification. On land, CO₂ is stored by forests, bogs, humus, grasslands and lime formed during rock weathering.

CO₂ emissions from fossil fuels according to area



Source: IEA 2019; Peters et al 2019; Global Carbon Budget 2019.

According to the Global Carbon Project 2017, 45 per cent of CO₂ emissions from fossil fuels worldwide are generated for electricity and heating, 23 per cent by industry, 19 per cent by national transport and 3.5 per cent by international aviation and heavy oil consumption by ships. The remaining sectors account for just under 10 per cent.

According to the German Environment Agency, 85 per cent of the 720 million tonnes of greenhouse gases with which Germany heated up the atmosphere in 2018 were produced in the generation of energy. Electricity and heat production accounted for half of this, followed by transport (20 per cent), industry (15 per cent) and trade, commerce and service providers (5 per cent).



emissions. In the 1997 Kyoto Protocol, all industrialised countries except the USA committed to reducing annual greenhouse gas emissions to at least five per cent below 1990 levels. For many years and several conferences, no significant progress was made until the international community agreed in the 2015 Paris Agreement to keep global warming well below 2°C and, if possible, to limit it to 1.5°C.

In order to achieve this goal, climate researchers have calculated that humanity must not emit more than another 700 gigatonnes of CO₂. In view of the annual emissions of more than 35 gigatonnes of CO₂ via the burning of fossil fuels and cement production, this is not too much, especially since the concrete reduction targets of the Paris Agreement will not be sufficient. Joachim Curtius: »If all countries fully comply with their Paris commitments, we will still end up with about 3°C of warming in 2100, which is much more than the Earth can cope with. We have an extreme time problem: 1.5 degrees of warming will already be reached by 2040 with current emission trends.«

It is therefore high time for drastic reductions in global CO₂ emissions. In November 2020, the United Nations therefore called for a »Race to Zero [Emissions]«. Joachim Curtius from Goethe University is also participating as a »Scientist for Future« in science's warning cry to the global community: »When it comes to the

climate crisis, I see the danger that we will not experience the consequences first-hand until it is too late, because of the long time lag with which the climate reacts to greenhouse gas emissions. One of many challenges is to convince countries and the fossil fuel industries to stop producing coal, oil and gas. The remaining carbon budget of 700 gigatonnes is much, much less than the amount of CO₂ that will be released to the atmosphere if all the known fossil fuel reserves were exploited and burnt. That's why we have to convince states and companies to leave fossil energy reserves in the ground.« ●

About Joachim Curtius

Prof. Dr. Joachim Curtius is a professor for experimental atmospheric research at the Institute for Atmospheric and Environmental Sciences at Goethe University. On page 107 he explains why he believes that we can still achieve the 1.5°C goal of the Paris Climate Agreement.

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When the Arctic had a subtropical climate

What we can learn from Earth's past warm periods

By Anne Hardy

During earlier times in Earth's history, there were warm periods caused by strong greenhouse effects, with (sub)tropical temperatures across large parts of the planet and high sea levels. This is corroborated by palaeoclimatological data. By applying today's climate models to such geologically warm periods, we can test and improve them. In this way, palaeoclimatology is helping us to gain a more accurate insight into our future climate.

During deep-sea drilling operations near Antarctica in the late 1980s, geologists discovered indications of a previously unknown extinction event. It occurred ten million years after the dinosaurs had disappeared. Further drilling at other sites confirmed the findings, yet the work caused very little public furore when it was published in 1991. This might have been because most of the extinct species were just pinhead-sized, unicellular organisms, or foraminifera, which had lived partly on the seafloor and partly suspended in the water. They did not disappear as spectacularly as the dinosaurs through the impact of an asteroid, but during the warmest period ever to occur in the past sixty-five million years of Earth's history. This is what makes them so interesting for climate research today.

The extreme warm period referred to above occurred 56 million years ago, at the transition from the Palaeocene to the Eocene epoch, which is why geologists speak of the »Palaeocene-Eocene Thermal Maximum«, in short, the PETM. This event lasted about 200,000 years, which is hardly more than the blink of an eye in comparison to the Earth's history of 4.5 billion years, and only a single sharp spike on the world's temperature curve. At the start of the PETM, within just 4,000 years, the concentration of carbon dioxide (CO₂) in the atmosphere had risen rapidly. This rapid CO₂ increase makes the PETM

highly relevant in view of the current release of CO₂ from present-day human activities.

The average temperature in the warm PETM period was about five degrees higher than before and after, and this in a world already generally far warmer than today. Earth looked different then with no permanent ice sheets, Antarctica was green at that time, and sea levels were considerably higher.

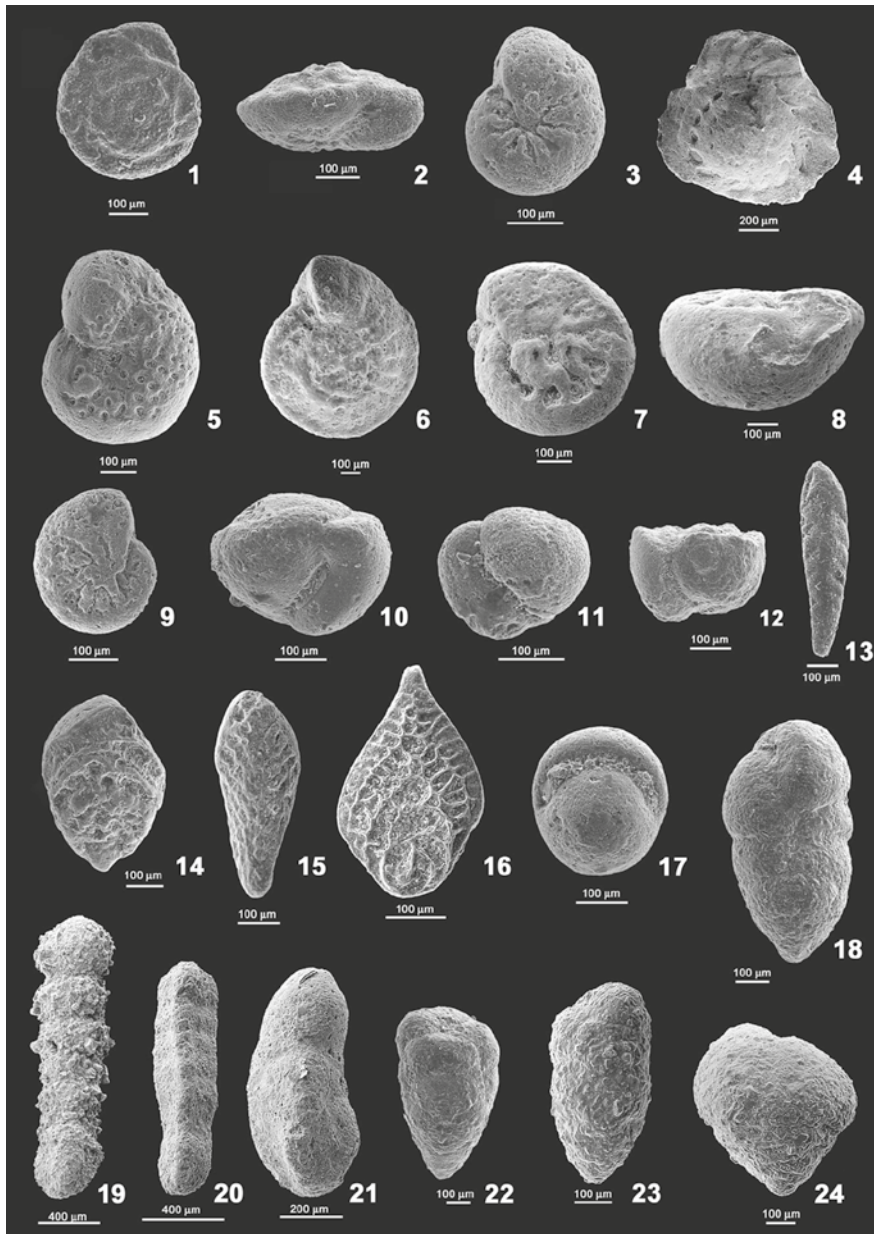
Mass extinction in the oceans

Due to the high concentration of CO₂ in the atmosphere of the PETM, greater quantities of it dissolved in the water. The result was an acidification of the oceans, in chemical terms a decrease in the pH value. As a consequence, many organisms with calcareous shells died because they were poorly adapted to more acidic water. In samples collected from sediment cores that are drilled by ships into the ocean floor, PETM sediments can be recognised by the fact that the light hue of the calcareous shells of the foraminifera disappears, and the colour is instead reddish like clay.

In addition, the seawater warmed up even at deeper levels, which led to the extinction of many marine inhabitants. Deep-sea organisms were particularly affected, which are less adaptable than land dwellers or marine life found near the surface.



In Nunavut, an Inuit territory in Canada, Johnny Issaluk holds in his hands the photograph of a swamp in South Carolina. During the Palaeocene-Eocene Temperature Maximum (PETM) 56 million years ago, when the CO₂ concentration in the atmosphere was far higher than today, parts of the Arctic looked like this swamp.



These foraminifera fossils give an impression of the enormous biodiversity of the just pinhead-sized unicellular organisms. All the species shown here lived on the seafloor and died out during the PETM because the oceans were so acidic due to the high CO₂ concentration in the atmosphere that the calcareous shells of the unicellular organisms dissolved.

(from: Guisberti, Galazzo, Thomas, *Clim. Past*, 12, 213-240, 2016)

IN A NUTSHELL

- At the transition from the Palaeocene to the Eocene about 56 million years ago, the CO₂ concentration in the atmosphere was far higher than today.
- The temperature difference between the arid and desert zones along the Equator and the subtropical polar regions was smaller than it is today. Climate modelling is so far unable to reproduce these states adequately.
- The rate at which humans are currently releasing greenhouse gases into the atmosphere exceeds the natural rate in earlier »high CO₂« periods many times over.

On land, areas in the equatorial region previously wooded turned into arid zones and deserts with local temperature peaks of well over 40 degrees, as plant fossils found in Wyoming or Tanzania indicate. The animals there adapted to the scarcity of plant nutrition by becoming smaller. This resulted in the onset of »dwarfism«, also among predators.

At the same time, the habitat of reptiles expanded close to the poles. Parts of the Arctic were a subtropical swamp and home – like the Everglades in present-day Florida – to ancestors of alligators, crocodiles and snakes. The warm climate and the previous disappearance of the dinosaurs rang in the era of mammals, whose habitat and diversity widened enormously. New species of animals emerged, among them whales and dolphins, camels, sheep, cows, and ultimately primates.

Volcanoes and methane hydrate

Up until today, what caused the Earth to heat up during the PETM is still a matter of debate. There were presumably several factors. First of all, there was the increased activity of volcanoes in the Mid-Atlantic Ridge, which not only released large quantities of CO₂ into the atmosphere but also covered Greenland, Iceland, Norway, Ireland and Scotland with lava.

In addition, large amounts of methane gas (CH₄) could have been released. This gas has a greenhouse effect 30-times greater than that of carbon dioxide. Methane forms during organic decomposition processes both on land and in ocean sediments, where dying organisms sink to the bottom and accumulate, layer upon layer, over millions of years. Under certain conditions, the gas is trapped within frozen water. During the PETM, the seawater warmed up even down to deeper levels, and as a result parts of the methane ice may have melted and released the potent greenhouse gas.

A combination of these processes triggered the gigantic increase of CO₂ and other greenhouse gases in the atmosphere. Between 2,400 and 4,500 gigatons of CO₂ probably accumulated within just 4,000 years. However, at a rate of about one gigaton per year, this natural release of CO₂ 56 million years ago was considerably slower than today's emissions: Humans produce ten gigatons per year. Although the PETM event shows how our current climate could evolve in a »high-CO₂« world, scientists are, however, reaching their limits as far as the search for comparable natural geological situations is concerned.

Deep-sea drillings as climate archive

It is thanks to isotope geochemistry experts such as Professor Wolfgang Müller that we have an

impression of the gigantic natural fluctuations that characterize Earth's climate in past geological eras. »Oceanic sediments are the best long-term climate archive we have on Earth because the stratigraphic sequence of dead organisms we find there is undisturbed.« explains Müller. He and his team have studied the shells of foraminifera extracted from such sediments. In this way, the scientists can reconstruct the temperature and CO₂ content of the ocean in different periods.

Many of the unicellular foraminifera, of which there are many species in the sea, build their shells from calcite, in chemical terms, calcium carbonate. To do so, they use dissolved carbonate extracted from the seawater. However, the more acidic the oceans become, the less carbonate is present, so that foraminifera find it more difficult to form their shell and thus may change size. In this way, samples from deep-sea drillings are still a source of information about CO₂ content in the oceans millions of years later.

In addition, geologists can reconstruct the temperatures which prevailed at that time by examining the magnesium content, which occurs as an impurity in the shell of the foraminifera. The unicellular organisms incorporate it into their calcium carbonate shells in place of calcium. And the warmer the ocean becomes, the more they do it. Dr David Evans, Müller's colleague, has further developed this »magnesium thermometer« and most notably applied it successfully to the Eocene environment.

Foraminifera also incorporate trace quantities of borate (BO₄) into their skeletons besides calcium carbonate. Boron has various isotopes. This means that the element's mass varies depending on the number of neutrons in the atomic nucleus. The most common is the isotope with six neutrons, but there are also stable isotopes with just five neutrons. Palaeoclimatology makes use of the fact that the frequency distribution of boron isotopes in seawater depends on the pH value. This makes it possible to draw conclusions about the CO₂ concentration in the water and, indirectly, also in the atmosphere. Müller and his team are also conducting similar studies on other marine organisms such as corals, molluscs and snails.

Improved climate models

Müller initiated and now coordinates the LOEWE consortium project VeWA, »Past Warm Periods as a Natural Analogue for our »High-CO₂« Climate Future«, a collaborative project, funded by the LOEWE programme of the state Hessen government, between Goethe University Frankfurt and the Senckenberg – Leibniz Institution for Biodiversity and Earth System Research (SGN). Within this consortium, which started work in

the summer of 2020, researchers in eleven sub-projects are studying different climate parameters, starting from the late Cretaceous period – the era of the dinosaurs – up until the end of the Eocene, when Antarctica froze over again.

»If we have data about past warm periods and their »high-CO₂« world that are as precise and reliable as possible, this is also a good test for present-day climate models,« explains Wolfgang Müller. »Because if, in retrospect, these models reproduce palaeoclimatic data (i.e. climate hindcasting), they can also be trusted to produce reliable predictions.

A method developed in 2020 at the Department of Geosciences promises even more accurate temperature data from the geological past. This technique developed by the research group led by Professor Jens Fiebig, which is also parti-



About Wolfgang Müller

Prof. Dr. Wolfgang Müller, born in 1967, has been professor for geology and palaeoenvironmental research, with a special focus on isotope geochemistry, at Goethe University Frankfurt since 2017. He studied geology at the University of Vienna (Austria). In 1998 he earned his doctoral degree at ETH Zurich. As a postdoctoral researcher, he spent his time in Switzerland and above all in Australia. From 2004 to 2017 he held a faculty position at Royal Holloway, University of London, where he was most recently professor for isotope geochemistry. He is initiator and spokesperson of the LOEWE project »VeWA« (Past Warm Periods), which began in the summer of 2020.

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cipating in the VeWA consortium, is based on the fact that the isotopic composition of the carbonates, more precisely the degree of »clumping« of their heavy isotopes, in the skeletons of sea and land dwellers is temperature-dependent. In addition, however, the respective circumstances under which mineralisation takes place also play a role, that is, the mechanism and speed of carbonate formation. This influence can now be subtracted. In the framework of the VeWA project, this isotope-based method will be applied to different carbonate archives of the Cretaceous period and the Eocene.

This should also help to improve climate simulations, which are currently unable to adequately reproduce a key indicator of past warm periods, namely the temperature gradient between the Equator and the poles. The smaller »meridional temperature gradient,« as it is known in technical language, shows that the tropical

Oceans heat up comparatively less in warm periods, but instead a lot of heat is transported from the tropics to the poles. Researchers plan to investigate this process in the framework of several VeWA subprojects.



During the PETM, foraminifera quickly died out and could no longer form any sediments. In drill cores – here a photograph by palaeoclimatologist James Zachos – this is visible as an abrupt, dark-brown colouration of the otherwise chalky-white sediment layers.

A lesson for the future

»If we wait for greenhouse gases to return naturally to pre-industrial levels, it will take far too long on the human time scale,« says Müller. After the PETM event, for example, the cooling phase lasted over 100,000 years. Weathering of silicate rocks, such as basalt, granite or gneiss, plays

an important role in this context. In this process, CO₂ is extracted from the air in the form of carbonic acid and many weathering products are transported via rivers into the ocean. There, marine organisms incorporate the carbonate into their shells, where it is stored as carbonate sediments for a long time, with the result that the CO₂ content in the atmosphere decreases. In one of the VeWA subprojects, researchers led by Professor Silke Voigt are especially studying the temperature-dependent weathering of silicates with the help of the isotopic composition of the element lithium, the lightest metal of all.

Can we tell from past warm periods what will happen if we fail to reduce CO₂ emissions? One of the research priorities in the VeWA project is the Eocene »hothouse«, when the CO₂ concentration in the atmosphere was, at times, greater than 1,000 parts per million (ppm). By comparison, today's figure is almost 415 ppm, which is already more than 130 ppm above pre-industrial levels, and CO₂ concentration is currently increasing by two to three ppm per year. Müller illustrates the substantial climate effects that can result from even relatively small fluctuations in CO₂ of »only« 100 ppm: »We know from Antarctic ice cores, which record the eight main cycles of warm and cold periods over the last 800,000 years: During the last cold phase 20,000 years ago, sea levels were 130 metres lower than today, and the atmospheric CO₂ concentration was 180 ppm. That's only 100 ppm below pre-industrial levels, but it was four degrees colder worldwide nonetheless.« At that time, the North Sea was dry, North America was connected with Russia, Australia with Papua New Guinea, and Indonesia with the Asian mainland.

For palaeoclimatologists like Müller it is high time to reverse the trend. »Without rapid counter-

measures, we may well risk approaching a tipping point,« he says, »even if we don't exactly know where these are«. At such a point, even a small external influence is sufficient to trigger abrupt changes in the climate system with self-amplifying effects that would no longer be reversible. If, for example, the polar ice caps were to melt due to an even stronger greenhouse effect, less sunlight will be reflected, which will heat up the Earth further still. Additional greenhouse gases will be released out of the thawing permafrost, especially potent methane, which will further intensify the greenhouse effect. And sea levels will rise rapidly as a result of destabilised ice sheets, like those present on Greenland.

»Unfortunately, people are very slow to change their habits,« says Müller regretfully. He points out that the last three summers in Europe have already been warmer than average, and he would like to see rapid and greater political pressure through a price for CO₂. He is nonetheless optimistic that we can – through more moderate consumption of resources and especially the use of renewable energies – still avoid steering towards the extreme climate of the geological warm periods. That is why it is also important to him and his colleagues in the VeWA consortium »Past Warm Periods« that knowledge of climate change is more quickly disseminated more widely among the wider public. For this reason, the twelfth VeWA subproject is dedicated to science communication: the results and background of the VeWA consortium will be presented at the Senckenberg Museum and elsewhere around Frankfurt through a number of activities, including a travelling exhibition, funded by the LOEWE initiative. ●



The author

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Greenhouse gases thought dead

Searching for traces in the atmosphere

By Jan Schwenkenbecher



In the Taunus Mountains, atmospheric researcher Kieran Stanley is able to study the air of the whole world. His work exposes entire regions when they emit greenhouse gases in fact long outlawed.

Once a week, Kieran Stanley, 32, gets into his car and winds his way up the snaking Hochtaunus Road, first past beech trees and then past spruce trees, until he finally reaches his destination 825 metres above sea level on Kleiner Feldberg: The Taunus Observatory of Goethe University. He has a good view from here. For one, Stanley can see half the Rhine-Main region at the foot of the Taunus. And for another, he can see how planet Earth is getting along.

For the latter, however, a couple of intermediate steps are necessary. That is why Stanley removes the samples from the instruments, checks the equipment and brings the collected material back to his workplace, the Institute for Atmospheric and Environmental Sciences of Goethe University on Riedberg Campus, 695 metres further down. He has been studying the planet's air here since May 2019, the same work he previously did at the University of Bristol,

where he is today still a visiting fellow. At the beginning of his research career, Stanley, who was born in the United Kingdom, was interested in peatlands, and his doctoral thesis centred on the carbon and nitrate cycle of wetlands. He has always had a very pronounced interest in the environment, he says, and, having completed his doctorate, he knew that he wanted to do something that involved analysing gas samples. That is how he arrived in Bristol, and greenhouse gases became his special field. Luckily for atmospheric research and possibly also for planet Earth, since at the beginning of 2020 he achieved rather a coup in this area: In a study with Stanley as first author and in collaboration with an international research team, he showed that somewhere in the world greater quantities of the greenhouse gas HFC-23, fluoroform, were being emitted than should actually be the case. The scientists' two main suspects: China and India.

Greater impact than CO₂

HFC-23 is a greenhouse gas and a very potent one at that. »If you look at a time period of 100 years, one ton of HFC-23 emissions corresponds to about 12,000 tons of CO₂« explains Kieran Stanley. »This is because it's very long-lived. The

Kieran Stanley on the roof of
Goethe University's Taunus
Observatory on Kleiner Feldberg.



overall lifetime of this gas in the atmosphere is about 228 years.« What do we humans need it for? In fact, nothing at all. It is used here and there as a refrigerant, says Stanley, but there are in fact more efficient gases. HFC-23 is still found nevertheless. It is usually an unwanted by-product from the manufacture of another gas: HCFC-22, chlorodifluoromethane, also a refrigerant – one of the more efficient ones.

Although HFC-23 is a much more potent greenhouse gas than CO₂, in absolute terms, its impact is probably less, simply because humans emit so much CO₂. »These and other halogenated hydrocarbons play an important role nonetheless,« says Stanley. »And if it's the case that we can make a difference by not emitting these gases, then it somehow makes sense to me that we should endeavour to do just that.«

Big profits with greenhouse gases

That is why Stanley and his former colleagues from Bristol had already been keeping an eye on HFC-23 for some time. »Many environmentalists and climate scientists see it as a kind of easy prey because you can prevent emissions really easily,« says Stanley. »In the production of HCFC-22, you can separate the two gases and remove or capture the HFC-23 through thermal oxidation so that it's no longer released into the atmosphere.« Indeed, global emissions have dropped over the past years and especially after 2005, when manufacturing companies were offered financial incentives for clean HCFC-22 production under the Clean Development Mechanism (CDM) established by the Kyoto Protocol.

As a consequence, the global community was able to significantly reduce HFC-23 emissions in a short space of time. »But then some manufacturing companies realised that money could be made from the mechanism,« says Stanley. In 2010, CDM Watch, a non-governmental organisation,

calculated that beneficiaries of the programme were receiving 65 to 75 times what it in fact cost to eliminate the gas. As a result, companies produced more and more HCFC-22 – more than was actually needed – in order in turn to save HFC-23, which otherwise would never have needed to be saved. »Emissions went up again, and in 2013/2014 the CDM for HFC-23 was stopped.«



About Kieran Stanley

Dr. Kieran Stanley, born in 1987, studied physical geography and French at Keele University, and water science, policy and management at the University of Oxford, both in the United Kingdom. He wrote his doctoral thesis on peatland biogeochemistry at Queen Mary University of London. After some time as a postdoctoral researcher at the University of Bristol in the field of atmospheric chemistry, since 2019 he has been a researcher at the Institute for Atmospheric and Environmental Sciences of Goethe University.

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Apparent stop of HFC-23 production

In 2016, numerous countries agreed in the framework of the »Kigali Amendment« to gradually reduce and finally end the use of all HFC compounds with high greenhouse gas potential over the next few years. However, the two main emitters, China and India, have so far failed to ratify the agreement. Both countries had, however, already announced their own programmes shortly after the end of the CDM, which aimed to stop emissions by their factories within a very short space of time. In 2017, they declared that almost all HFC-23 emissions had ceased – China had reported to the World Bank that it had already correctly disposed of 45 per cent in 2015, then 93 per cent in 2016 and finally 98 per cent in 2017. The world was happy. And researchers anticipated that global emissions should have fallen by about 90 per cent between 2015 and 2017. But then Kieran Stanley double-checked.

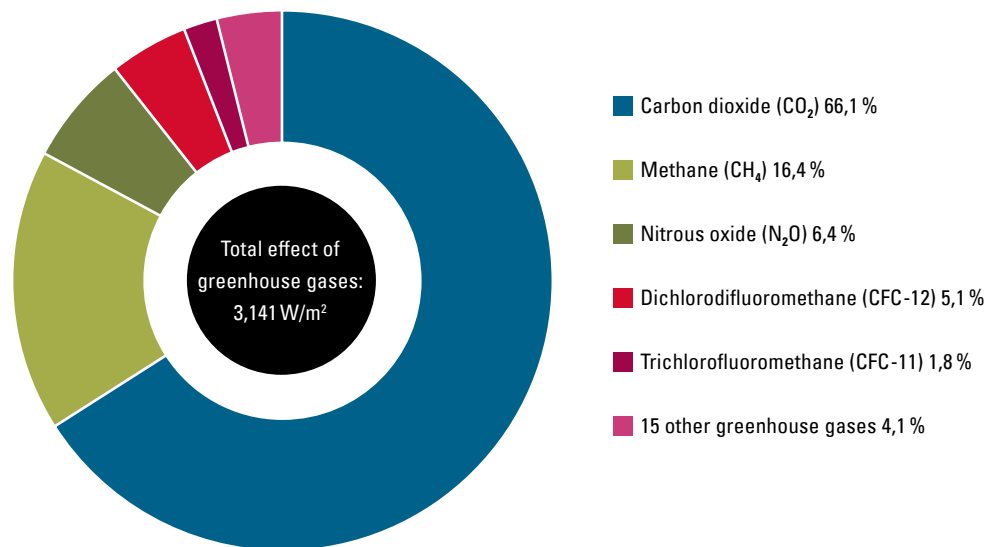
The thing is, how can you actually measure how many grams of a certain gas are floating about in the Earth's atmosphere? To do this, Stanley needed not just one measuring station but a whole network of stations – one like the Advanced Global Atmospheric Gases Experiment (AGAGE). The AGAGE network is an alliance of 15 measuring stations, scattered around the whole world from Ireland to Rwanda and South Korea to American Samoa. There is also a large number of associated centres, which

AGAGE: The Advanced Global Atmospheric Gases Experiment has been measuring the composition of the Earth's atmosphere since 1978. <https://agage.mit.edu>

IN A NUTSHELL

- Reductions in the potent greenhouse gas HFC-23 have been reported worldwide. Yet it is still being emitted.
- With the help of measurement data from a global network, to which the Taunus Observatory of Goethe University also belongs, scientists were able to prove this.
- Studies that focus on specific regions should in future show where HFC-23 is being produced so that emissions can be stopped.

Contribution to the greenhouse effect by carbon dioxide and long-lived greenhouse gases 2020



Source: German Environment Agency/NOAA Earth System Research Laboratory, the NOAA Annual Greenhouse Gas Index (AGGI) <https://www.esrl.noaa.gov/gmd/aggi/aggi.html>.

meanwhile also includes the Taunus Observatory of Goethe University. This is how Stanley and his colleagues were able to access the corresponding atmospheric data.

Suspects: China and India

In order now to calculate differences in the distribution of the gas, they divided the atmosphere into twelve compartments: They partitioned the Earth's surface into four sectors and then distinguished between three levels of altitude. »In this way, we were able to spot any differences and examine, with some climatic, physical and chemical variables, when which emissions must have occurred and from which direction they stem from a global perspective – from the northern hemisphere or the southern hemisphere,« says Stanley. »In fact, there's always a north-south gradient. This is due to how the world's population is distributed, and we can identify global emissions on that basis.«

When Stanley and his colleagues then analysed the data, they saw that global HFC-23 emissions had not – as originally assumed – dropped by up to 90 per cent. They had not even dropped a little bit. Instead, in 2018 concentration had risen to a new all-time high. The researchers suspect that the emissions must be coming from China or India – even though they were unable to prove this directly with their method. »But when you think that in 2017 China and India were together responsible for about three quarters of global HCFC-22 produc-

tion, then they're very probably the source of these emissions,« says Stanley.

At the beginning of 2020, Stanley and his colleagues published the results of their study in the research journal Nature Communications. The media reported on it, but politics did not react – at least not publicly. That such research work in the field of climate mitigation and the non-adherence to climate protection measures can nonetheless lead to significant consequences is shown by a very similar case with another halogenated hydrocarbon that happened two years before.

Search for climate culprits

In May 2018, a research team from the US-American National Oceanic and Atmospheric Administration (NOAA) discovered that emissions of a certain chemical compound were decreasing far more slowly than had actually been expected. The compound was CFC-11, trichlorofluoromethane, a greenhouse gas harmful to the ozone layer that belongs to the group of chlorofluorocarbons, better known by the abbreviation CFCs.

Once celebrated as miracle compounds, CFCs were used for numerous purposes in the 20th century: As coolants, for example in refrigerators, but also as propellants in spray cans, blowing agents in foams, and as detergents, solvents or extinguishing agents. Then, in the 1970s, there were first indications of the environmentally harmful effect of CFC compounds.



The author

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In May 1985, British researchers reported in the journal *Nature* that there was a pretty big hole in the ozone layer that surrounds the Earth and protects it from a large part of the UV rays emitted by the Sun. Two years later, in 1987, the world agreed in the framework of the Montreal Protocol first of all to use less CFC compounds and ultimately none. According to the agreement, there were to be no more manmade emissions of CFC-11 at all from 2010 onwards.

Crime scene: Eastern China

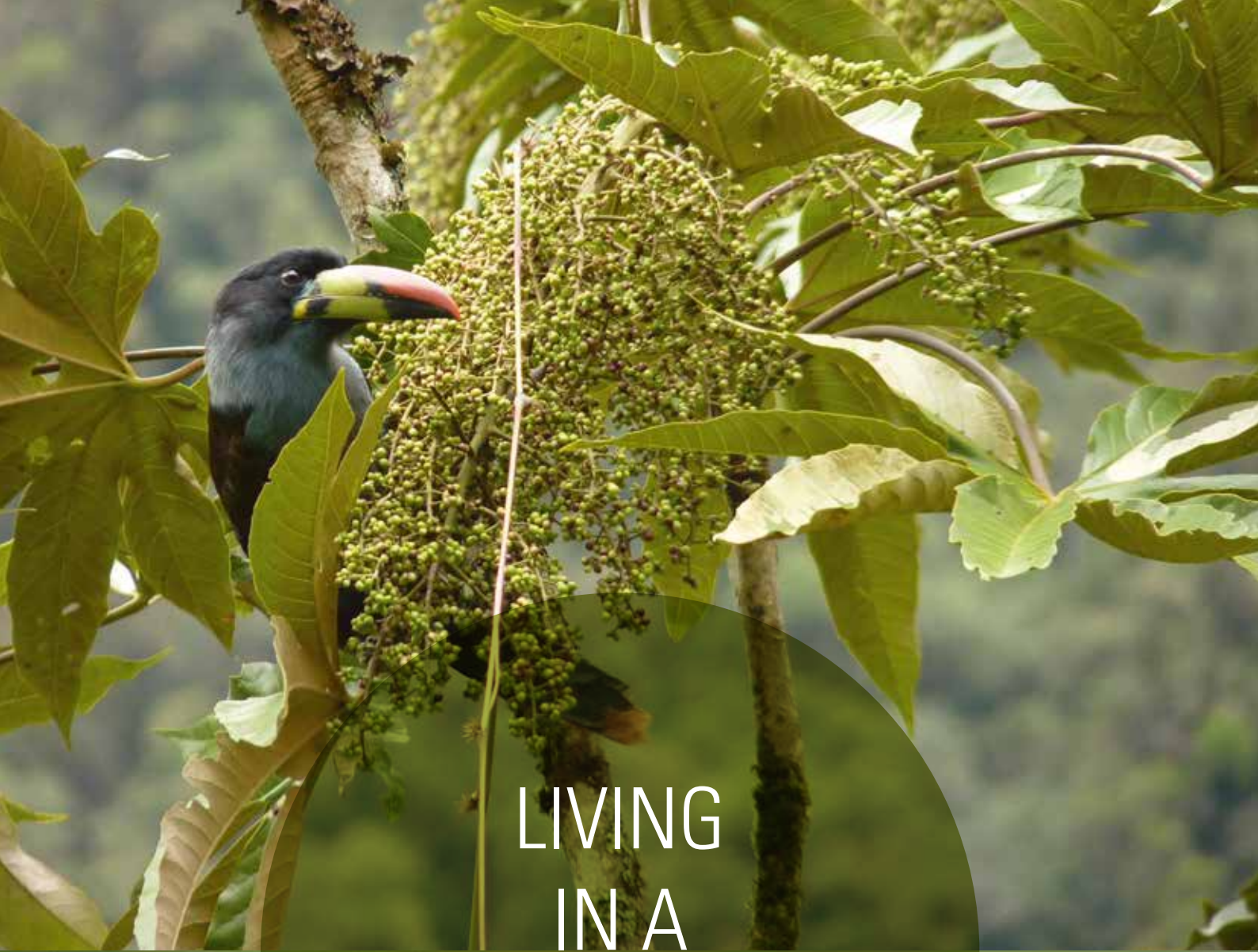
However, as the NOAA scientists revealed, somebody had apparently breached the agreement. The researchers had expected the results of their measurements to show that the CFC-11 content in the atmosphere had decreased continuously since the mid-1990s because emissions were supposed to drop more and more, and the remains of this long-lived gas would then dissipate over a couple of decades. They were indeed able to chart this as a declining line. However, at about the level of 2012, there was a kink in the line. From that point on, degradation of CFC-11 seemed to slow down. Apparently, somewhere in the world, the gas was being emitted again. Indeed, the NOAA researchers assumed that the gas was presumably entering the atmosphere from China. But they were unable to say for sure.

Then, in the summer of 2018, first of all the *New York Times* reported on several smaller

Chinese companies that its journalists had tracked down with independent investigators in the coastal province of Shandong. These companies were emitting CFC-11 because they were using it to foam plastics. The real evidence, however, surfaced in the spring of 2019, and the University of Bristol was involved here too. Led by Kieran Stanley's former research group, a large team of international scientists published an analysis which proved irrefutably that the global increase in CFC-11 emissions was coming from the eastern edge of China. According to reports in Chinese media, in the spring of 2020 the first factory manager was sentenced to ten months in prison.

Is this story currently repeating itself? His study has not led to any consequences so far, says Stanley. But he also says: »There are scientists from the AGAGE network who are working on a study that focuses on specific regions in order to assess whether the emissions really are coming from China and, if so, exactly where in China they are coming from.« ●

Back in the lab: Kieran Stanley connects the electropolished stainless steel flasks containing the air samples from the Taunus Observatory to the analysis system, with which he can identify around 50 halogenated hydrocarbons.



LIVING
IN A
CHANGING
CLIMATE



Adaptation or extinction: Species diversity in a warming world

Can mutually dependent plants and animals stay in sync?

By Markus Bernards

Species loss is occurring ten to a hundred times faster today than it would in a world free from humanity's enormous influence on the Earth system. The ecologist and biodiversity specialist Matthias Schleuning studies ways that plants and animals depend on each other. Understanding these interrelationships in complex ecosystems helps to clarify which species will be among the winners and losers of climate change and more intense land use by humans.

When Matthias Schleuning talks about his biodiversity research, he likes to take his listeners along with him on his travels and show them spectacular photographs of exotic animals and plants. The tropical Andes is a very special region for him and he has spent extended periods of time in the Manú National Park in Peru. Together with his listeners, Schleuning walks through the sparse and almost treeless landscape of his »Mountains of Diversity«, the high puna steppe some 4,000 metres above sea level. Then his journey takes him down the mountains, through mystical elfin forests with their mossy miniature trees and on through the misty mountain rainforest until he has descended some 3,000 metres and finally reaches the Amazon lowlands, where wide rivers measure out the rhythms of life. More than 1,000 species of birds are found here, four times more than in Germany, and almost ten times as many tree species can be found in a single hectare of forest.

Matthias Schleuning was already fascinated by biodiversity when he was a teenager. He was drawn to study biology and ecology and finally to conduct research in South America. Here in the tropical Andes, he seeks to understand how plants and animals live together and depend on each other: how a hermit hummingbird drinks nectar with its long, curved beak from *Heliconia*

flowers that have just the same shape, and picks up pollen it carries to the next flower in the process. Or how the grey-breasted mountain toucan eats the fruits of *Schefflera* trees and then disperses their seeds with its droppings.

Changing ecosystems

Matthias Schleuning and his team have traced thousands of such mutually dependent relationships over the years and mapped species interaction networks in Andean forests where about 90 per cent of trees and shrubs depend on animals for pollination or seed dispersal. The elevational gradients of the Andean slopes are ideal for such research, since many highly diverse ecosystems are found here in close proximity. Alexander von Humboldt, who travelled through Ecuador in 1802, compared the habitats of a snow-capped Andean mountain to habitats stretching from the Arctic to the equator.

But Matthias Schleuning does not merely strive to describe the current status quo in these rich habitats. »We use our insights to make better predictions for the future, too«, he explains. The habitats he studies are changing. Forests are now being cleared for grazing, crops and settlements in many locations throughout the tropical Andes. Species of birds and plants are being driven into higher regions where the forest remains. Climate change is also driving flora

Animal-plant-relationships:
The grey-breasted mountain toucan eats the fruits of a *Schefflera* plant and disperses its seeds (top). Female harebell carpenter bees gather pollen from harebells and are important pollinators of these plants.



The Manú National Park in Peru covers areas with an elevational difference of over 3,000 metres and it is one of the most species-rich areas on Earth.

and fauna to migrate towards higher ground in search of lower temperatures.

It can be discerned from the historical record that this trend is not new, but ongoing: Alexander von Humboldt sketched vegetation zones on the Andean mountain Chimborazo and entered the names of many plant species and vegetation types on this sketch. Scientists have compared the plants depicted on this historical sketch with the plants found on Chimborazo today and established that the different vegetation zones have moved upwards by at least 200 metres in the past 200 years, a finding that is consistent with the 1°C of atmospheric warming that has occurred since Humboldt's time.

Species thrive at their climatic optimum

Matthias Schleuning: »Every species has its own dynamic geographical range. But there is currently an observable trend for species to move to where they can find their preferred climatic conditions. Land use by humans, mainly for agriculture, is currently still having a stronger impact on biodiversity than climate change, but their negative impacts will ultimately amplify each other.«

When temperatures start to increase faster as climate change accelerates, species will have to move faster, too, to stay within their optimal temperature range. Temperatures are currently rising at a rate of approximately 0.2°C per decade, twice the speed seen in the previous hundred years. Schleuning and his team are investigating the significance of this development for the interdependent relationships between fruit-eating birds and plants that depend on these interactions for seed dispersal. »Global

observations show that species are currently moving about 10 metres upslope every decade. That is fast enough when environmental conditions do not change too quickly. The different climate zones on a mountain slope are not far apart, and that is favourable. But getting the timing right is still a major problem for these species«, Schleuning explains.

Seed dispersal by fruit eating birds is a complex and often protracted process. Most birds only disperse seeds over short distances. This leaves the important work of dispersing seeds over longer distances to a handful of bird species that are mostly quite large – to just the birds, in other words, that have already become rare in many regions, due to human impacts. This creates a substantial risk that not enough seeds will reach higher regions quickly enough for the plants to become established. Some plants species could be left behind and species from the tropical lowlands, especially, could go extinct in the medium term. »In simulation models for the Manú elevational gradient, we found that most plants would move too slowly in comparison with the speed at which temperatures on the mountain are rising«, Schleuning comments.

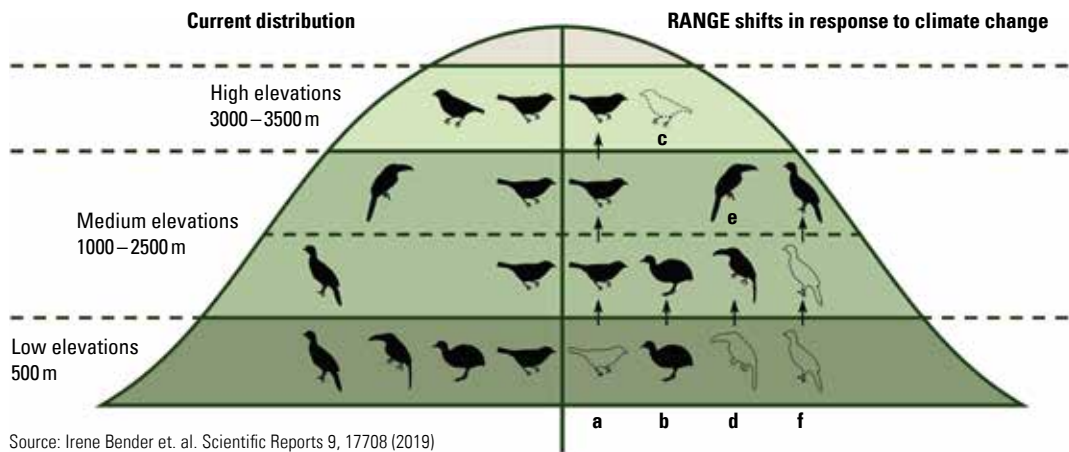
»Specialists« are severely threatened

Species belonging to the potential »losers« of climate change and now facing extinction are found all over the world and include species in Western and Central Europe. Schleuning and his colleagues have investigated interdependent relationships between more than 700 European species of plants and animals that assist with pollination and seed dispersal. One of the possible losers is the harebell carpenter bee, a wild bee species that collects pollen to feed its larvae exclusively from harebells. When harebells disappear, the harebell carpenter bee, as a specialist dependent on them, also disappears. The bee is doubly threatened by extinction because of its dependence on both harebells and specific climate conditions. In the other direction, harebells – like many kinds of plants – are less dependent on individual species of animals because they are visited and pollinated by a variety of insects.

Schleuning points out that climate change will see winners as well as losers. In Germany, for example, several bird species from around the Mediterranean will increasingly find conditions that suit them well. They include, for instance, the melodious warbler and the European bee-eater. Species that can move readily and are not highly specialised are generally better placed to cope with climate change than others.

Would it really be so bad if harebell carpenter bees were to disappear? »One species going extinct usually wouldn't have much of an effect on the entire ecosystem«, Schleuning com-

When it gets warmer: bird communities on the mountainside



Source: Irene Bender et. al. Scientific Reports 9, 17708 (2019)

- a:** Species die out at lower altitudes and their geographical range shrinks.
- b:** Species expand their geographical range upwards.
- c:** Species that already live at high levels die out because they cannot move further upwards.
- d, f:** Species shift their geographical range upwards.
- e:** Species adapt to changed climate conditions.

ments. »But if more and more species are lost, domino effects can trigger vast ramifications for ecosystems. Ecosystems are adaptable, but after major changes, the way back to an earlier system state can be completely cut off. That could mean that we could all lose important benefits provided by ecosystems that we need to thrive and survive.«

»What meaning should we attach to the disappearance of beauty?«

Animal pollinators, to give just one example of such benefits, play a major role in food production. The World Biodiversity Council (IPBES) estimates that 5–8 per cent of global crop production is directly attributable to animal pollination. On that basis, an annual market value amounting to 200–500 billion euros can be placed on this service. Practically all melon, cocoa and Kiwi flowers are pollinated by animals, for example, and about half of apple, pear and cherry production depends on animal pollination.

Schleuning remarks: »Species are going extinct at a rate that is at least ten times and possibly a hundred times faster than would be the case without human influence. This means that we are causing change to happen without being able to anticipate its consequences.« Such consequences could include tipping points prompting irreversible changes such as the collapse of pollination services in an ecosystem or the loss of a forest which is turned into a savannah. Our species-poor food crops could also be severely threatened by the emergence of

new pests or diseases. Species extinction and biodiversity loss actually also increase the risk of pandemics.

In addition to economic perspectives on species extinction, there are also ethical aspects, says the researcher: »What does it mean for each of us individually when species are irrevocably lost? When beauty disappears?«

Schleuning pleads for the importance of diversity to be recognised: »The more diverse our ecosystems are, the more resilient they will be. Species-poor ecosystems are a gamble against the future. Making predictions about the future of our planet is difficult because of the many interdependent relationships between species and the feedback effects in the Earth system. Today, unfortunately, we are losing species so rapidly that predicting the consequences this will have for us humans is virtually impossible.« ●



The author

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About Matthias Schleuning

Matthias Schleuning, born in 1978, studied biology at the University of Marburg and gained his doctorate there in 2008 with a thesis on the spatiotemporal dynamics of plant populations in Amazonian lowland forest in Peru. He subsequently conducted research at the universities of Mainz and Halle on African and Neotropical rainforests. He came to Frankfurt in 2010, initially as a research associate at the Senckenberg Biodiversity and Climate Research Centre (SBIK-F). He has headed a research group at the centre in »Functional Ecology and Global Change« as a senior scientist since 2015. In 2014, he gained his habilitation (*venia legendi*) at Goethe University with a thesis on plant-animal interaction networks. He teaches at the university as an adjunct professor. His research is mainly focused on mutualistic plant-animal networks and on modelling the consequences of global change for biodiversity.

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The forests of the future ...

- ● ● need different trees.
Researchers are working out which ones.

By Jan Schwenkenbecher

The air is hot and dry, the sandy soil cannot retain water: few forests in Germany are in worse shape now than Frankfurt City Forest. This makes it the perfect place for Wolfgang Brüggemann and Vera Holland to study climate-resilient tree species: the trees that do well here despite climate change are the ones that will survive anywhere.

Wolfgang Brüggemann and Vera Holland walk along the gravel path into Frankfurt's City Forest for just a few minutes before heading off into the undergrowth. Twigs and leaves snap and crunch under their hiking shoes. Far above their heads, clouds drift by, keeping their rain to themselves again today as so often. The sight of the clouds drifting across the sky perturbs Brüggemann, a professor of the ecophysiology of plants at Goethe University's Institute of Ecology, Evolution, and Diversity. »When you stand under an intact tree«, Brüggemann says, »you can't see the sky at all because the foliage is so dense.« He explains that healthy trees fill every gap and use every available ray of light for photosynthesis. »The damage we see here is massive«, the ecophysiologicalist says, pointing to the gnarled, leafless treetops. »We call that ›crown transparency‹. They are all doomed to die.«

On this Tuesday morning in late summer, Wolfgang Brüggemann and Vera Holland, who is also a plant ecophysiologicalist in Brüggemann's research group, make their way through the City Forest and to follow them is to take a small journey through time. When they come to one of two half-hectares of fenced-in land, Brüggemann pushes the gate open and steps into the future or, to be more precise, the »future forest«. That is what he and Holland call this little grove of trees in the middle of the forest where they have planted their own trees – trees that differ from those found elsewhere in the forest. They want to find out which trees could thrive here even as climate change causes conditions to become even more extreme. They have to hurry, though, for this future seems to be coming ever closer.

Nearly all the trees in the City Forest are sick

This is obvious in Frankfurt City Forest, which is already in extremely poor condition. Specialists use crown transparency as a measure of tree health. Many of the treetops in the City Forest are already quite transparent, and 97 per cent of the trees are visibly damaged – some more, some less.

Why is the City Forest in such trouble? »I cannot remember a time when it was this dry«, says Wolfgang Brüggemann. »2003 was bad«, he continues, »but that was just a single year. The last three years in a row – 2018, 2019, and 2020 – were all very dry.« This is especially obvious when one looks at a few 500-year-old oaks on the periphery of the City Forest near Schwanheim, Holland remarks: »Those trees have survived for many epochs, but the last few years have really taken a toll.«

Frankfurt City Forest is by no means the only forest that is currently suffering, as is evident in the Hessian report on forest conditions [*Waldschutzbericht*] for 2019. The average crown transparency of trees in Hesse's forests recorded in the report was 27 per cent, the highest rate recorded since Hesse began tracking this metric in 1984. 2.3 per cent of trees in Hesse died in 2019. While this might not seem like much, it is sevenfold the mortality rate for the previous year. In fact, since 1984, the rate had never exceeded one per cent before. Half of all the trees that died are Norway spruce trees. Well, they were Norway spruce trees. Spruce are particularly susceptible to bark beetles, although pines and beech trees are also afflicted by other pests.

Extremely hot, dry years

In addition to the changes made to woodland habitats by commercial forestry, the main factor

Frankfurt City Forest is suffering: dead and diseased trees testify to heat stress and drought.



About Wolfgang Brüggemann

Prof. Dr. Wolfgang Brüggemann, born in 1956, earned degrees in biology and chemistry and conducted postdoctoral research in Marburg and in Groningen in the Netherlands. He worked as a research assistant at the Institute for Environmental Plant Physiology in Düsseldorf and gained his habilitation (*venia legendi*) in botany in 1995 for his research on the development of chilling tolerance in the photosynthetic apparatus of the genus *Lycopersicon* (tomatoes). In 1997, he was called to a professorship in the Faculty of Biological Sciences at Goethe University. The project presented here is a cooperation project within the Senckenberg Biodiversity and Climate Research Centre.

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driving these problems is climate change. For one thing, winters have become milder. The population of harmful insects spikes after mild winters because more of them survive. In addition, climate change makes summers hotter and drier. The trees suffer directly from the resultant water stress, but they also became less resistant to insects.

2019 was the second-hottest year in Germany since the German Meteorological Service began tracking temperatures in 1881. It tied with 2014, while 2018 was the hottest year on record. There can always be a hot year every now and then, but in this case two extremely hot years came back-to-back. In addition to the exceptional heat – and the storms, which have also wrought extensive damage in the forests in recent years, as well – both years, and now also 2020, were drier than average.

Crown transparency is up for all species across all of Germany in comparison to last year. Over the next few decades, the composition of many forests throughout Germany will change.

The trouble with restructuring forests

Forests are an emotional topic for Germans. Much of Germany is forested – a third of the total area – and everyone has their own relationship to the greenery. People's individual interests vary greatly, too: some people want to hike or bike, while others want to harvest wood. Some want to protect animals, while others want to hunt. Each interest group has its own ideal forest, and the proposals span a gamut running from entirely *laissez-faire* approaches (»Just leave the forest alone; it will regulate itself«) to demands for cultivated plantations of neat rows of trees standing to attention. The tensions inherent between these varied viewpoints are now being further exacerbated by climate change and the urgent need to find and deliver solutions that it creates.

Brüggemann and Holland are on a mission to find a lasting compromise everyone – including the animals – can live with. They do not believe that there is time to wait for the forest to adapt to developments of its own accord. Nor do they believe that monocultures can work – they favour biodiversity instead.

Could the future forest be like a Spanish forest?

Brüggemann's approach to forecasting what might be able to grow in the future requires forecasting future conditions. Another trip into the future, if only an imaginary one. »In the immediate future«, he says, »we have to expect a climate like that of Freiburg, a little warmer and a little drier.« At some point, it will be even warmer and drier again and more like the current climate of Montpellier in southern France. »And finally, by 2100, we might have a climate like they have now in Barcelona, if the climate keeps changing as it has been changing up to now.« Travel, says Brüggemann, makes it possible to look forward in time, »as if we were driving into the future.«

And what trees do you see as you drive further into the future? What could supplant the European oak trees in Frankfurt City Forest? »The further we go towards the southwest,« says Brüggemann, »the more the forest changes.« In the Breisgau region around Freiburg, one already finds many sessile oaks instead of the local pedunculate oak. As you go further up the scale of drought-resistant oaks, you find downy oaks and evergreen holly oaks growing in southern France. In Spain, in areas at lower elevations, practically all the oaks found are holly oaks.

»Those that survive here can survive anywhere«

Does this mean that the holly oak will save the German forest? Or at least Frankfurt City Forest? For the time being, this is still just a thought game. As scientists, Brüggemann and Holland know that they must show that their ideas are feasible. Frankfurt offers a perfect opportunity to demonstrate this, because the City Forest is already experiencing extreme conditions today: it is dry, it is hot, and every thinning crown makes it hotter. The soil is almost entirely made of sand deposited here when the river Main was still close by. This sandy soil does not retain water. Normally, the trees can tap into the groundwater, but the water table has fallen so much that their roots are no longer deep enough. Other forests, which currently still have a sufficient water supply, will be affected by climate change in the future. Frankfurt City Forest, on the other hand, is already a prime example of how such changes can devastate a forest. This also means, as Brüggemann says, that »Those that survive here can survive anywhere.«

This is why the two plant ecophysiologicalists have their own fenced-in corner of the forest here. They are experimenting to see whether Hungarian, downy, or holly oaks can survive and thrive in this region. Their project, named SHOP – for »South Hesse Oak Project« – began in 2011. Brüggemann's research team began by planting small groups of several varieties of oak among the native flora. And not just in Frankfurt City Forest: as part of SHOP – and the subsequent expansion of the project with partners in Italy and Greece in 2017 in a cooperative project known as »Future Oaks IKYDA« – researchers have planted over 10,000 oaks, not only in southern Hesse but also as control groups in the species' native regions in Greece and Italy.

The forest has to like the trees

In front of one of these groups of trees in the City Forest, a white sign bears the text *Q. ilex* – i. e. holly oak. Vera Holland is standing behind it. She explains: »In order to study which varieties of oak thrive here, we take a number of physiological measurements in addition to recording the height and diameter of the tree.« They also record which trees survive. »The pedunculate oak, which is native here, grows very well, but then a lot of them die off«, Holland says. »The Mediterranean oak varieties that we have planted here have better survival rates, and the downy oak grows at least as quickly as pedunculate oak.«

A second important question is whether the forest habitat can thrive along with the trees. After all, no one wants a repeat of what happened with the black cherry, which is native to



About Vera Holland

Dr. Vera Holland, born in 1984, studied biology at Goethe University. She completed a dissertation on photosynthesis in oak hybrids in 2009 for which she was awarded the P&G Sustainability Award. Under Wolfgang Brüggemann's supervision, she completed a doctoral dissertation in 2015 about the effects of climate change on the ageing of European oak varieties.

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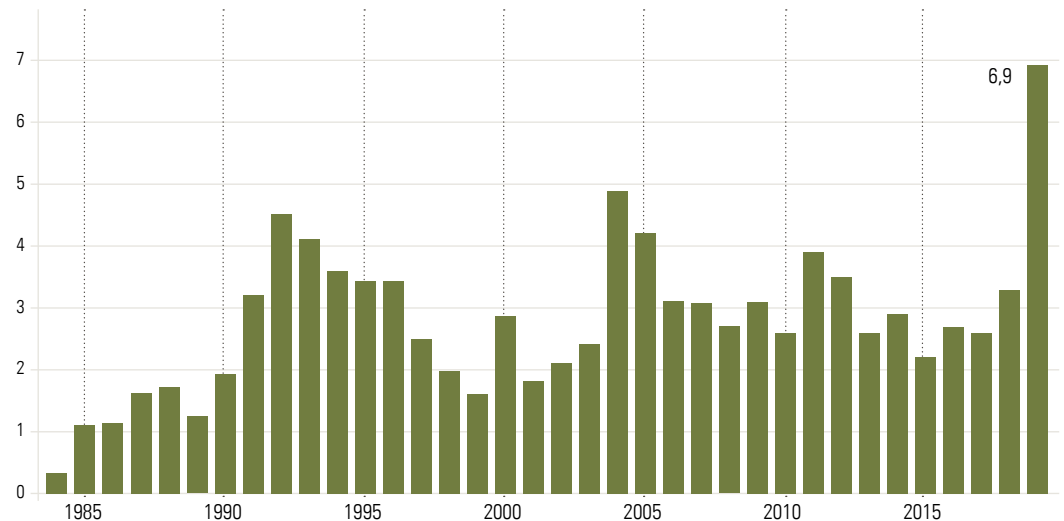
North America. It grows into large, attractive trees there, but when it was introduced into Europe, it turned out that the same species here grew more as a shrub and spread so quickly that the bushes often choked young native trees and robbed them of any light.

Why oaks, anyway? This preference goes back to the days when Brüggemann's institute was still in the Siesmayerstraße street in Frankfurt's Westend district. When research interns needed to measure photosynthesis in the winter, as occurred rather frequently, Brüggemann used to send them to a tree in the Botanical Gardens next door, an evergreen holly oak that was approximately six metres tall. The tree was so eminently suitable for this purpose that Brüggemann eventually planted a few holly oaks in the Institute's own garden in 2007.

Today those trees are living testimony against all who have rejected Brüggemann's suggestions and claimed that Mediterranean oaks cannot survive German winters. When the Institute moved to the new Riedberg Campus in

Percentage of extreme damage (including dead trees), tree species of all age classes

Stressed trees in Hesse
The fact that more trees (as a percentage) in all age classes in Hesse were in extremely poor condition or died in 2019 than in every other year since 1984 is primarily due to the spruce trees. This species was extremely negatively affected by the droughts in 2018 and 2019, and the heat benefited bark beetles and other insect pests.



Source: Waldzustandsbericht [Forest status report] 2019, Hessian Ministry for the Environment, Climate Protection, Agriculture and Consumer Protection

2012, the researchers even dug up the holly oaks and relocated them to the new experimental garden there. They survived the move, too, and today Brüggemann’s holly oaks are six metres tall and in the rudest of health.

downy oaks, along with some holly oaks, and leave the rest up to the natural succession of native species», Wolfgang Brüggemann answers. ●

Oaks harbour 400 types of insects

On a more serious note, oaks provide a valuable habitat for numerous species of fungi, lichens, and beetles – over 400 types of insects live on and in these trees! Brüggemann even counted those found just in the SHOP oaks: over 70 species of butterflies were spotted, and he estimates that they harbour at least 200 species of beetles. The majority of insects native to Germany that depend on oak habitats can also live in or around the Mediterranean oaks. Some of them could move to other trees if there were no more oaks, but many of them would be stuck. The great capricorn beetle, for example, one of Central Europe’s largest species of beetle at five centimetres long, is already endangered but still found in Frankfurt City Forest.

So what does Brüggemann and Holland’s research mean for Frankfurt City Forest? Can it be saved? And, if so, how should it be reforested so that it is likely to survive and maybe even thrive in the coming years, which are also likely to be warmer and drier? Its survival is important, for the forest captures the CO₂ the city produces and creates a cooling effect when the trees move water from the ground to the air. Brüggemann is somewhat reticent about giving policy advice, for he sees that as the role of politicians and forest managers. But what would he plant if he owned a bit of forest in this region himself? »As areas became free, I would plant primarily



The author

Jan Schwenkenbecher, born in 1989, is a science journalist resident in the Rhine-Main area. He studied psychology in Giessen and Mainz before training as a journalist at Süddeutsche Zeitung.

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IN A NUTSHELL

- Drought, heat stress, and the sandy soil have all contributed to the troubled state of trees in Frankfurt City Forest.
- This makes the City Forest an ideal location to experiment with climate-resilient trees that can cope with these conditions.
- In 2011, the South Hesse Oak Project (SHOP) planted oak varieties that thrive in southern Europe.
- The result: The southern European oak varieties have had higher survival rates than the native European oaks.

Tropical diseases: THE PARASITES INVASION

By Heinz Hänel

The fine hairs of the sandfly act as sound-absorbers so that it can approach its host almost noiselessly.

As the climate here in Germany becomes warmer, parasites that transmit formerly exotic diseases are finding ever more favourable conditions. Leishmaniasis is on the verge of becoming established, and Italy saw a local outbreak of dengue fever for the first time in the summer of 2020.

Sandflies approach noiselessly at twilight and hop around a few times after landing. Then they use their strong mouth parts to pierce their victim's skin. Blood starts to flow. The sandfly injects saliva to prevent it from clotting and to widen the surrounding blood vessels. After sucking up its meal of blood and lymph, it moves on to feed from its next host or lay its eggs. Sandflies are not picky about their hosts: all land vertebrates from frogs to human beings are possible hosts for these parasites, which are a mere 2 to 4 mm long and often sandy-coloured.

The powerful itch that follows the bites is by no means the biggest problem that they cause: some types of sandfly are parasites that can also transmit other parasites, the single-celled *Leishmania* that attack the white blood cells of mammals and can – depending on the strain involved – cause skin and mucosal ulcers or extremely dangerous changes to the liver, spleen, and bone marrow. Not all infections result in symptoms, but symptoms may occur years after an initial infection.

Sandflies have already arrived in Hesse

Sandflies are an intermediate host for *Leishmania*. Around 100 of more than 1,000 known sandfly species around the world can transmit *Leishmania*, and the interaction between the single-celled parasites and the sandflies is elaborately choreographed to facilitate the infection of further hosts: the *Leishmania* reproduce in the sandfly gut and obstruct it. After making several vain attempts to suck up blood, the sandfly regurgitates blood and up to 100 *Leishmania* parasites into the open wound. The sandfly saliva helps the *Leishmania* not only by preventing clotting, but also by attracting white blood cells to the bite wound that can then be attacked by the tiny parasites.

Leishmaniasis is a tropical disease chiefly found in South and Central America. In Europe, it is known only from southern areas around the Mediterranean and the Black Sea. Fortunately, sandflies are exceptionally poor flyers: they can manage no more than 200 metres, and even that only in very calm conditions, which is good news. Unfortunately, the bad news is that sandflies have nevertheless arrived in Germany already: parasitologists at Goethe University and the Senckenberg Nature Research Society identified them in North Hesse as far back as 2014.

If sandflies migrate to Germany and are seen here more often, that would be a very problematic development even if the new arrivals were free of *Leishmania*, as they appear to have been thus far. We currently see around 20 leishmaniasis cases every year in Germany, and those infections have all been picked up outside the country by travellers. But *Leishmania* are already here

– circulating in the blood of »man's best friend«. It has been estimated that there are between 20,000 and 100,000 dogs in Germany that are infected with the parasites. Some of them – unprotected by a vaccine – picked up an infection during a holiday. Others have been smuggled in illegally by dealers or are former strays brought here from Southern Europe by animal protection agencies. The city of Vienna estimates that 200,000 puppies are imported illegally into German-speaking countries every year, bypassing veterinary inspections and the tax authorities, and that unscrupulous puppy dealers are reaping vast profits from the trade.

2020: A local dengue fever outbreak in Italy

Ever milder winters, the migration of sandflies to Central Europe, and dogs imported without health checks mean that it is only a matter of time until Germany and Central Europe start to see autochthonous cases of leishmaniasis.

And this new tropical disease will not be the only new arrival. Over the last 40 years, the Asian tiger mosquito (*Aedes albopictus*) has spread to Europe. It was probably accidentally introduced into Germany in freight transport from Italy. It is now found in parts of Bavaria, Baden-Württemberg, Thuringia and Hesse. It can potentially transmit more than 20 pathogens including yellow fever virus, West Nile virus and dengue virus.

A case from the summer of 2020 involving an Italian traveller shows how quickly local outbreaks of a tropical fever can develop. The woman had been infected by dengue viruses in Indonesia, but only displayed symptoms after her return to a small north

Italian town near Vicenza. Three weeks later, five of the seven members of her household also contracted dengue fever – the viruses were presumably transported by the tiger mosquitoes that are already widespread in northern Italy.

The local health authorities reacted immediately: intense pest control activities to combat mosquitoes were carried out over three days in a 200 m radius of the house and people who had run a fever anywhere in the province in the previous 30 days were tested for traces of dengue viruses. The police distributed information flyers door-to-door and donations of blood and organs in the entire province were screened for the virus. Only then could the all-clear be given: this time, the outbreak had not flared up into a major outbreak. The restrictions that were in force because of the ongoing COVID-19 pandemic possibly contributed to this outcome, along with the watchfulness of health authorities that have already been preparing for the invasion of tropical diseases with a surveillance regime designed to pick up on exotic fevers.



The author

Prof. Dr. Heinz Hänel, born in 1955, is responsible for antidiabetic drugs research and development at Sanofi-Aventis. He studied biology at Goethe University, wrote his Diplom thesis in Canberra, Australia, and gained his doctorate at the Bee Research Institute in Oberursel and in Kuala Lumpur, Malaysia. His habilitation thesis dealt with the penetration of mammalian cells by yeasts. He has been teaching at Goethe University since 1994 and he has held an honorary professorship in zoology at the Faculty of Biological Sciences since 2001. Professor Hänel also serves on the Board of Directors of the Friends and Sponsors of the University of Frankfurt and has chaired Goethe University's Alumni Council since 2008.

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» West Nile fever, hantavirus infections and leishmaniasis will soon become highly relevant diseases in Central Europe«



An interview with the scientist Sven Klimpel, a parasitology and infection biology expert

Markus Bernards: Professor Klimpel, your research is on infectious diseases spread by animals (vectors), typically ticks, mosquitoes, and small mammals like rodents or bats. And you predict that such infectious diseases will increase globally. Why?

Sven Klimpel: According to the current figures from the World Health Organization, about 20 per cent of the infectious diseases known today are vector-borne diseases (VBD). More than 50 per cent of the world's population live in areas where the risk of contracting vector-borne infectious diseases is extremely high. In Europe alone, more than 80,000 people contract such an infectious disease on average each year. The pathogens causing these diseases are not usually transmitted through direct or indirect contact with infected people, as is the case with other disease pathogens such as influenza viruses or SARS-CoV-2. Instead, the pathogens are transmitted and disseminated by other organisms, which we call vectors. Once vectors have picked up a pathogen, they often remain

infectious throughout their entire lifespan, but the pathogen does not make them sick and they can thus act as a reservoir for it. Bloodsucking insects like sandflies, blackflies and mosquitoes are the most important vectors globally and in our latitudes, closely followed by rodents, bats and fruit bats. Especially in times of global change, countless new pathogens and vectors are finding their way into new habitats. We are also increasingly discovering novel pathogens, although their arrival in industrialized countries is often delayed. Changes in climate and ecosystems, lifestyles, the environment and host-vector interactions can influence the distribution and behaviour of vectors and open up new habitats for many species. In the coming decades, we can expect many vector-borne diseases to become much more widespread – in our own latitudes and in other parts of the world.

Which vector-borne diseases do you expect to see here in Central Europe in the future?

Since 2010, we have been contributing work in European programmes for the surveillance of vectors and reservoir hosts. We anticipate that the West Nile virus, hantaviruses and *Leishmania* parasites will become more widespread and will have a greater impact in Central Europe in the future. We recorded the first occurrence of sandflies in Hesse, which is the northernmost location they have ever been found. Sandflies are a suitable vector for the transmission of the *Leishmania* parasites that cause leishmaniasis. The West Nile virus has been present in Europe since the 1960s, but we expect to see more autochthonous West Nile virus infections in Europe soon. The virus is already circulating in France, Austria and the Czech Republic. Our mathematical distribution models and ecological niche models show that the pathogen distribution follows the vector distribution after an initial lag phase. We can expect an increase in numbers of autochthonous leishmaniasis cases and West Nile virus infections in the next 10 to 15 years.

Autochthonous outbreaks are outbreaks with local transmission.

Yes, exactly – outbreaks that start from an infection contracted in the region where you live, rather than during a trip abroad. For example, we could pinpoint the areas in Europe where autochthonous Zika virus infections are most likely. Our modelling is remarkably accurate. We were able to predict areas in France where local transmission of the Zika virus subsequently occurred and was recorded.

So the West Nile virus and the Zika virus have both already arrived in Europe?

Yes, but they have not yet spread all that extensively. We are now analysing why this is the case. Reservoir hosts that carry the virus, such as racoons or starlings, are needed. But vectors are also needed: mosquitoes that suck blood from these infected hosts. And then the virus must be able to replicate in the mosquito and be passed on to a person during the next blood meal of the mosquito. We do not yet know exactly how all these factors interact. The transmission mechanisms in Europe are not yet fully understood.

And what about our native mosquito and tick species?

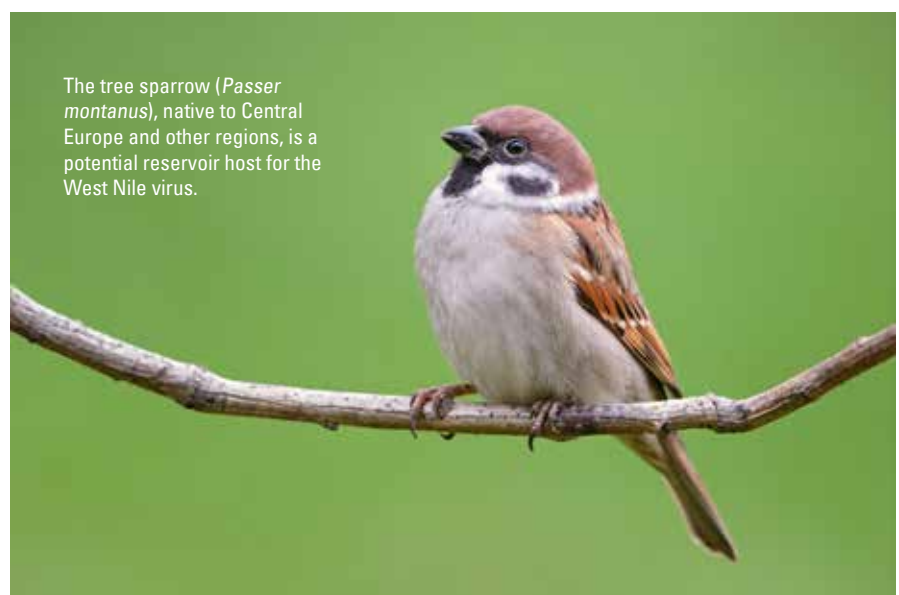
They are also an important part of the equation. In addition to invasive species like the Asian tiger mosquito or the Asian bush mosquito, our native mosquitoes can also act as vectors. Central European mosquito species of the genus *Culex*, for example, are very well suited as vectors for the West Nile virus. This has been demonstrated in extensive laboratory studies. Their adaptation to our climate is already excellent, but they will benefit from climate change because higher temperatures and more rainfall will suit them well. Favourable conditions will allow them to produce multiple generations per year and this will potentially increase the risk of transmission of infectious diseases to humans and domestic animals.

We are still in the middle of the SARS-CoV-2 pandemic. What lessons should we learn from it?

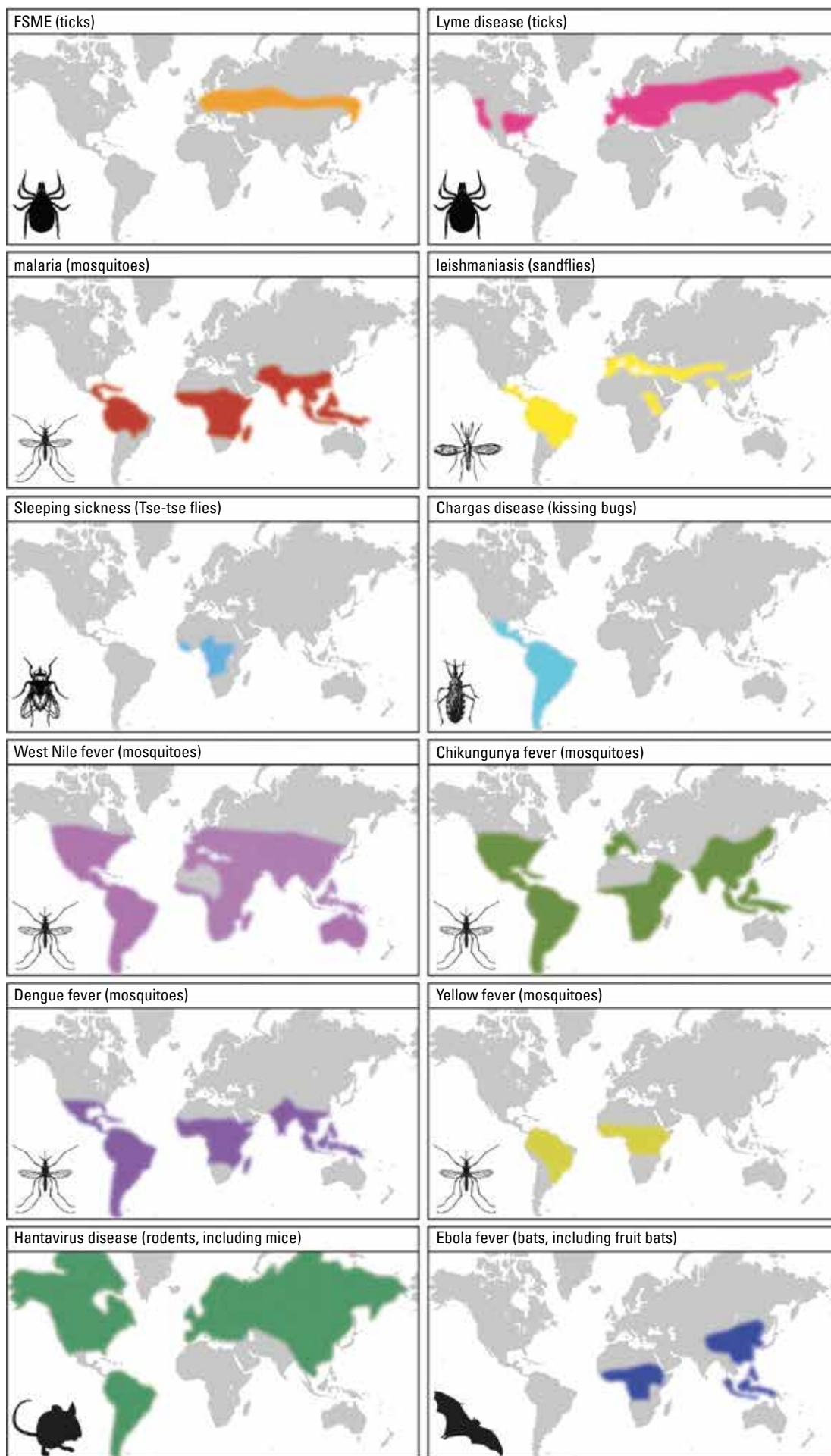
That is not easy to answer, because we are still in the middle of an evolving situation. The complex dynamics of the disease are not yet sufficiently understood. Many serious infectious diseases such as HIV/AIDS, tuberculosis and malaria have been pushed into the background because SARS-CoV-2 poses such an immediate threat to the health of so many people and because so much money is at stake in the race for vaccines. But we should not close our eyes to the fact that 38 million people world-

wide are currently infected with HIV and suffering from AIDS. Two-thirds of them have no access to medication. Antibiotic resistance and multi-resistant pathogens also pose a major future threat. Large pharmaceutical companies have almost completely abandoned research on genuinely novel antibiotics. This regrettable state of affairs could lead to extreme challenges for health-care systems and to a significant reduction of the global population in the near future. We should act carefully now and avoid putting all our resources into COVID-19 research. We need to maintain a broader focus and set up and support relevant structures in various disciplines. Infection biology can contribute by clarifying whether viruses and other pathogens are transmitted by vectors and survive persistently in reservoir hosts. Essential questions that can be addressed include, for example: What ecological niches do these animals occupy? How can we control them? How quickly do they reproduce? In what ways do pathogens survive in these animal populations? Insights into these kinds of questions make it possible to tackle infectious diseases on multiple fronts. In addition to combating pathogens using medical science, we can also work to understand and control their vectors, hosts and reservoir hosts – all the animals that play a role in the chain of transmission.

So we should take a more interdisciplinary approach to pandemics and epidemiological challenges?



The tree sparrow (*Passer montanus*), native to Central Europe and other regions, is a potential reservoir host for the West Nile virus.



The global distribution of infectious diseases and their vectors

Source: Koch, Dörge, Klimpel: Vektorassoziierte Infektionskrankheiten, Pharmakon 3/2020.

Of course. That is essential. I would advocate for One Health approaches (adapted for specific pathogens) that can bring together experts from medicine and the life sciences with, for example, experts from business, economics and law to develop strategies for the economy and the legislative process. I believe that the German Federal Communicable Diseases Act (*Infektionsschutzgesetz*) needs to be revised and adapted, and we need psychologists to understand the impacts at the level of the individual. A holistic approach would be effective in the long term. This should be one take-away from the current crisis. Only pumping huge amounts of funding into research when an epidemic or a pandemic is emerging or already underway is very short-sighted and will always be one step behind events. It is important that we do not just take a reactionary approach to developments, but take proactive and targeted steps at an earlier stage.

How can we prevent further tropical diseases which may be on their way to us from emerging here?

We cannot prevent their arrival. We can only work on relevant topics as early as possible. And we should focus on regions where the pathogens that cause these infectious diseases are already present. In my view, it is essential to build up and expand the health-care systems in these countries and improve the training there. This would be a targeted form of development aid and support with lasting effects. Fighting infectious diseases in the countries where they originate would reduce the threat of their spreading around the world. Our efforts to date are not enough.

Stories in the media about diverse tropical pathogens are becoming more common: Zika, Chikungunya, Dengue, Chagas, Usutu and so on. Are stories like these making people more nervous?

People are indeed noticing stories about novel pathogens or first-time discoveries of exotic diseases and disease vectors in new places more frequently and more quickly than they used to, because SARS-CoV-2 is currently in the media everywhere. However, I also believe that people now want to know more about

infectious diseases. There has been an increasing interest in tropical and sub-tropical infectious diseases, and people want to know how they are transmitted and how likely they are to become a threat in our latitudes. I think this increased level of interest is a positive sign. People are becoming better informed because information is flowing, and that in turn means that they can understand the new information better and make more sense of the details.

Thank you for this interview,
Professor Klimpel.



About Sven Klimpel

Prof. Dr. Sven Klimpel has been a Professor of Integrative Parasitology and Zoophysiology (IPZ) at Goethe University since 2010 and he heads the Medical Biodiversity and Parasitology research unit at the Senckenberg Biodiversity and Climate Research Centre (SBIK-F). Born in 1973, Klimpel studied biology at the University of Kiel and the Helmholtz Centre for Ocean Research Kiel (GEOMAR) and went on to complete a doctorate at the Institute for Zoomorphology, Cell Biology and Parasitology at the University of Düsseldorf, where he subsequently directed the research group »Aquatic and Terrestrial Parasitology«. In 2008, he gained his habilitation (*venia legendi*) in Parasitology and Infection Biology. This was followed by countless stays abroad for research purposes (including Chile, USA, Indonesia). In 2010, Klimpel took up a professorship at Goethe University. Between 2011 and 2013, he also managed the Senckenberg German Entomological Institute, a Leibniz Institute, as its Director. Between 2014 and 2017, he headed the Institute for Ecology, Evolution and Diversity within Faculty 15 – Biological Sciences, a faculty he has led as Dean since 2017. His research focus areas include the identification of new pathogens and vectors (and of pathogens and vectors that are becoming increasingly significant), the determination of their present distribution, and research on aspects including the genetic evolution of their dispersal capabilities, climatic tolerance, and vector competence (infection paths).

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A large red irrigation machine is positioned in a lush green vegetable field. A powerful stream of water is being sprayed from the machine, creating a wide arc that reaches across the field. In the background, a line of trees is visible under a clear blue sky. A faint rainbow is visible in the sky, partially obscured by the water spray. The overall scene is bright and clear, suggesting a sunny day.

The source of life

How climate change affects global groundwater levels

By Tim Schröder

During drought periods vegetable fields like this in the Netherlands need to be irrigated. Often, the water is taken from ground water wells.

Groundwater could become scarce in many regions around the world as climate change progresses. This is clear from a large international study initiated by the geographer Petra Döll and the doctoral researcher Robert Reinecke. Water shortages may arise or become more severe in many locations. Other regions are likely to struggle with rising groundwater levels. Cultivable land could become waterlogged.

Groundwater is a vital resource. In many countries, it is the principal source of drinking water. Pumping groundwater upwards from deep wells also enables fields to be irrigated and cereals, fruit and vegetables to be grown in arid regions. Despite its great importance, groundwater was largely ignored by many people in Central Europe for a long time because supplies were generally adequate. The extremely arid summers seen in the past three years have, however, kindled fears that water could become scarce as the climate becomes warmer.

Professor Petra Döll, the geographer who heads the Hydrology Research Group at Goethe University, was already interested in groundwater well before this more recent discussion took off. Döll is something of an exotic rarity among her hydrologist colleagues, as she comments: »Hydrologists are typically interested in studying streams and rivers, in looking at surface water«. Groundwater and the hazards climate change presents for it only became a major issue in recent years. Sustainable groundwater resources could decline in many areas, threatening the supply of water to agriculture, industry and households, as climate change progresses.

Too much here, not enough there

Droughts and sinking groundwater levels are by no means the only problems. Rising groundwater levels are also a likely hazard. Experts expect precipitation to increase in some regions due to climate change. This could raise groundwater levels. »In some parts of Germany«, Petra Döll explains, »the groundwater is only two or maybe five metres below the surface. If the water table rises, areas under cultivation could become waterlogged and agriculturally used areas could be lost. Cellars would need costly

protection against groundwater leaking in. Any deviations from what is normal now – both rising and sinking groundwater levels – could cause issues.«

Together with the doctoral researcher Robert Reinecke and cooperation partners from research institutes in Belgium, Japan, the Netherlands and many other countries, Petra Döll has recently looked into the future. In a complex study, the researchers drew on global hydrological models that calculate groundwater recharge on the Earth's entire terrestrial surface to determine the regions that could be affected by sinking or rising groundwater levels in the future. This involved a huge amount of work, since the international team drew on and combined the results of multiple hydrological models that were in turn driven by various climate scenarios derived by multiple climate models.

In West Africa, where this picture was taken, it is anticipated that the water table will become considerably lower in some regions. This well could be one of those to fall dry as a result.



This study would not have been possible without the major international ISIMIP project coordinated by the Potsdam Institute for Climate Impact Research (PIK). More than a hundred groups of researchers involved in ISIMIP are modelling the impact of anthropogenic climate change could have by the end of the current century, not only on water resources, but also, for example, on vegetation and crop yields. As nobody today can say how greenhouse gas emissions will change over the coming decades because of climate protection measures, researchers of the ISIMIP project are modelling four different scenarios that correspond to the emis-



About Petra Döll

Prof. Dr. Petra Döll, born in 1962, studied geology at the Universities of Erlangen and Colorado and earned a Master of Science focused on geohydrology from the University of Colorado. She subsequently worked in the Geological Survey at the Ministry of Urban Development and the Environment in Hamburg and went on to complete a doctoral degree in soil science at TU Berlin. She gained her habilitation (*venia legendi*) in Environmental Systems Analysis from the University of Kassel and has been a Professor for Hydrology at the Institute of Physical Geography at Goethe University since 2003.

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sions scenarios of the Intergovernmental Panel on Climate Change. These range from a strong reduction in greenhouse gas emissions to the grim scenario that emissions continue to rise at the current rate. For each of the four emissions scenarios, four different climate scenarios calculated by four global climate models are available.

Unique combination of climate data and groundwater expertise

The groundwater experts have now linked the climate scenarios provided by the ISIMIP project

– the expected future CO₂, precipitation and temperature values – with eight different global hydrological models.

One challenge that presented itself was that the global hydrological models reach their results in quite different ways. Some consider vegetation changes attributable to climate change while others do not, for example. The results of the eight different global hydrological models differ starkly as a result – vegetation, after all, has considerable influence on evapotranspiration and thus also on groundwater recharging. »Plants transpire water into the atmosphere. And plants, especially forests, also capture and store water in the ground«, Petra Döll says. The models yielded highly divergent results for several world regions including South-East Asia. While it seems relatively clear to climate researchers that monsoon rainfall in India will increase because of climate change, the groundwater models cannot give clear and solid predictions on how this will affect groundwater.

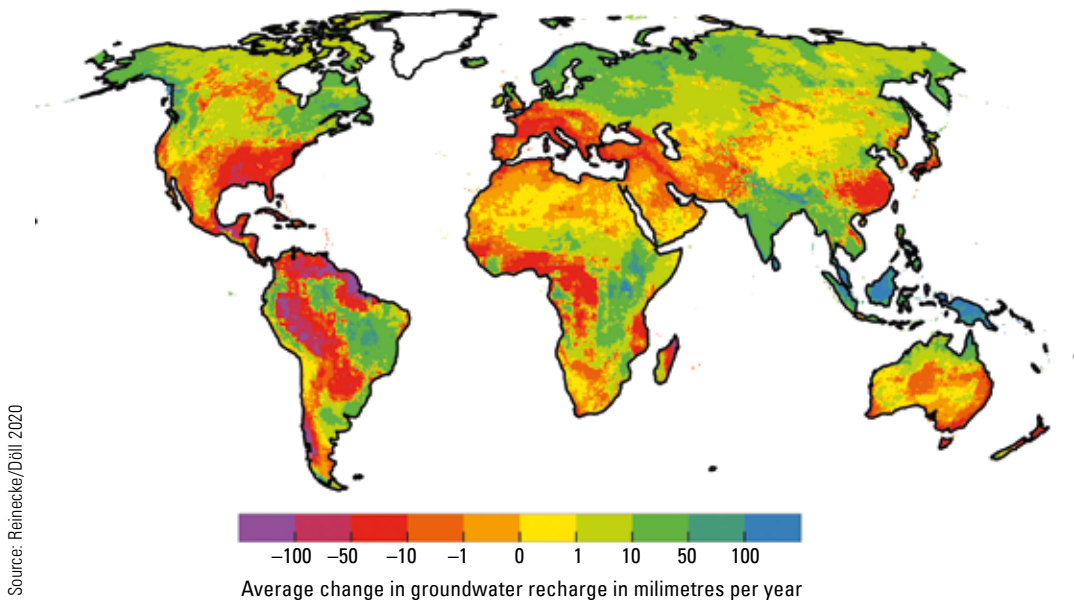
Water shortages in the Mediterranean Basin and Northeast Brazil

In other parts of the world, as Petra Döll reports, the study yielded unambiguous results – vegetation or no vegetation. The data show that groundwater recharge is likely to decline in two regions that are already affected by water shortages today, the Mediterranean Basin and Brazil's dry northeastern region. »Many people associate Brazil with the perpetually moist Amazon rainforest. But there are areas close to the equator that are already hot and dry today. Both in Northeast Brazil and the entire Mediterranean region, climate change is likely to exacerbate existing water shortages with negative consequences in particular for agriculture.«

Sinking groundwater levels can lead to several problems. Pumping wells constructed at great expense could run completely dry. Even deeper wells could be bored to reach deeper groundwater layers, but the availability of groundwater at these deeper levels could also gradually decline over time if less and less groundwater is replenished. »The overuse of groundwater is a known problem«, Petra Döll explains. »To conserve natural aquifers, it is important to remove less water than can be replaced by groundwater recharge. Removing the same quantity of water as the amount that can be replaced by recharging is already a no-go because that does not leave any water for habitats, rivers or the vegetation.«

Sinking groundwater levels could also become a problem for the Amazon rainforest. It does not rain all year round there, as many people think; rainy periods and dry periods alternate. If groundwater levels sink so much that

Changes in renewable groundwater resources in the climate scenario of »3°C warming«



At an average global temperature 3 °C above preindustrial temperatures in and around the year 1850, groundwater recharge levels in substantial parts of the world would differ significantly from current levels.

IN A NUTSHELL

- New computer simulations predict where groundwater levels will rise or sink due to climate change.
- Eight different global hydrological models were linked with a range of climate scenarios to enable these simulations.
- Modelling predicts that water shortages will worsen in the area around the Mediterranean because of climate change and that increased winter precipitation in parts of Germany may lead to fields becoming waterlogged.
- The predictions for many regions are characterised by relatively high levels of uncertainty because the vegetation shifts that will occur in response to climate change cannot yet be predicted clearly.

lating groundwater recharge processes have never been combined in this way before. Our work thus provides a solid basis for policy interventions – for projects and initiatives that enable people in the areas affected to prepare for the impact of climate change in time.« More efficient irrigation methods could be used, for instance, or the areas under irrigation reduced. The study results are also relevant for regions where different models produce quite divergent results on future changes in groundwater levels. »Let us say that we have an overall prediction that a region's groundwater recharge is expected to decline by between 10 and 40 per cent. A highly risk-averse approach would be to implement water management measures that make it possible to live with a decline of 40 per cent. Policy-makers who are willing to tolerate more risk could initiate measures designed to adapt to a 10 per cent decline.« ●



The author

Tim Schröder, Tim Schröder, born in 1970, studied biology with ocean physics as a minor, worked as a trainee journalist at the newspaper *Nordwest-Zeitung* and then as a science editor at the *Berliner Zeitung*. He has been working as a freelance journalist specialising in the natural sciences, energy and the environment since 2001.

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the trees can no longer reach water with their deep roots during dry periods, parts of the forest could die back. That would be a further burden for a rainforest already under pressure from logging and forest fires.

Important insights for adaptation measures

As Petra Döll, the initiator and coordinator of the international study, emphasises, »Global climate data and a wide variety of models simu-



HUMANS AND CLIMATE CRISIS

The end of a singularly beautiful, calm spring day

For the political philosopher Darrel Moellendorf,
climate policy is a question of global justice

By Rolf Wiggershaus

How can we recognise and assess the opportunities and dangers inherent in human agency? How should we deal with the repercussions of human actions? These questions underlie the research of Darrel Moellendorf, who teaches political philosophy at Goethe University. A conversation about climate change, ethics, justice, and the Anthropocene.

Many things dread and wonderful, none though more dread than mankind.« These words, which Sophocles penned for the chorus in *Antigone* in the fifth century BCE, have long since become aphoristic. In the last strophe of the chorus, the audience then hears, more as foreshadowing than as a genuine warning: »Cunning beyond fancy's dream is the fertile skill which brings him, now to evil, now to good.« That sounds rather like a glimpse into our own age, for which the atmospheric chemist Paul Crutzen proposed the name of the »Anthropocene«. Crutzen, who won the Nobel Prize for Chemistry in 1995 for his research on the thinning of the ozone layer, discovered something that was long so incomprehensible to him – and to other scientists, too – that he initially doubted the accuracy of his measurements, namely, »that just a few chlorofluorocarbons in the huge atmosphere could have such an effect.«

How should we approach these wondrous powers we have? How can we recognise and assess the opportunities and dangers entailed in human agency? Who becomes accountable for what as a result? Kant's old questions reappear here in a new and fresh guise: What can I know? What should I do? What may I hope? In short: What is it to be human? These questions have explosive potential when applied to the topic of »climate change«. We want to explore them in

conversation with Professor Darrel Moellendorf, who teaches international political theory and philosophy at Goethe University. His current research involves climate change and justice, the normative significance of the Anthropocene, and hope.

Inequality in the age of climate change

In the late 1990s, global inequality and global justice became central themes for Darrel Moellendorf. Asked about authors who were important in bringing these issues to his attention, Moellendorf immediately names two: Dale Jamieson, professor of environmental studies and philosophy at New York University, and Henry Shue, professor emeritus of politics and international relations at the University of Oxford. »They are«, in Moellendorf's words, »the two philosophical grandfathers of climate research who published the first significant philosophy texts on the climate in the early 1990s.«

For Moellendorf, climate change and the increasing insight into its causes and effects brings a factor into play that increasingly highlighted problems of poverty, social inequality, and unequal development. As he describes »inequality in the age of climate change«, it means that »poor countries are particularly exposed and at risk – and, at the same time, they

The most adversely affected victims of the climate crisis live far away from the wealthy West, for example in Bangladesh, where the Padma river rose above its banks in July 2020 and thousands of people lost their homes.

have fewer resources to protect themselves and adapt than the wealthier nations do, the very nations that are mainly responsible for climate change.«

In this situation, the relevance of responsible and ethical political approaches and actions could grow. But has it grown? Moellendorf observes that international cooperation has long been made more difficult by strong competition between states. From the beginning of the international negotiations on reining in climate change, a certain scepticism has been evident among developing nations, who fear that such agreements might impede their economic progress. These countries assert their moral right to economic expansion. Since the publication of Moellendorf's book »The Moral Challenge of

Dangerous Climate Change« in 2014, the situation has broadly become even more grave, and that is why he has given his next book – to be published this year with Oxford University Press – the title »Mobilizing Hope«.

A right to sustainable development?

Moeller sees a starting point for hope in the »right to sustainable development« formulated in the »United Nations Framework Convention on Climate Change« from 1992. »If you take that seriously«, he says, »it means that precisely because energy is so central to societies' developing, global energy policies should not increase the cost of development. If it is more expensive to produce renewable energy than to rely on fossil fuels, there must be some sort of subsidy for this from the highly industrialised countries.« Moellendorf argues that such an action would be appropriate in relations between civilised nations: »That would not be aid, but justice.« Such policies would allow developing nations to skip the stage of burning coal, which is particularly damaging to the environment, and move directly to using renewable energy sources.

These are moral considerations which assume that humanity is a species capable of using the global commons in a rational, sustainable manner. But the reality in highly industrialised countries, as Moellendorf points out, is that »certain political powers are interested in reaping returns for decades on their investments in fossil fuels. Australia, and China as well, provide countries that should be spared from both with coal-fired power stations and coal.« As the atmosphere is the shared property of all humankind, Moellendorf comments that continuing to allow business and political interests to unscrupulously dump emissions into the atmosphere – although we know better and have other options – amounts to abuse and wilful damage. Taking the right to sustainable development seriously demands the exact opposite and would counteract the short-sighted strategies driven by self-interest that undermine climate protection efforts.

Protecting the climate and adapting to change – Moral challenges at different levels

There is a necessary distinction to be made between climate change mitigation and climate change adaptation, Moellendorf explains. The Paris Agreement signed in 2015 outlined a shared responsibility of all countries to avoid dangerous climate change. The long-term goal outlined was to limit the global increase in temperature to below 2°C more than pre-industrial values. In addition, every country presented its own climate policies. »There was no compul-

IN A NUTSHELL

- The atmospheric chemist Paul Crutzen adopted and popularised the term »Anthropocene« for our age to express humankind's unprecedented power and responsibility.
- For the political philosopher Darrel Moellendorf, climate change is a factor that amplifies the gradient between wealthy nations and poorer ones. This underscores the urgency of a »right to sustainable development«.
- Strategies to mitigate and adapt to climate change present moral challenges at different levels. Mitigation efforts seek to limit the global increase in temperatures to below 2°C. Efforts geared towards adaptation can undermine international solidarity because the financial resources to overcome the impact of global warming are not distributed equally.
- In Moellendorf's opinion, encouraging and accelerating the transition to renewable energy can play a more decisive role in reducing greenhouse gas emissions than criticising economic growth per se. This approach can open opportunities for the developing world.
- Scepticism about the potential of climate protection strategies alone demands, from Moellendorf's point of view, that the deployment of geoengineering approaches (at least of the variants that aim to remove CO₂ from the atmosphere) should at least be contemplated.



sion«, according to Moellendorf, and »every country contributed its own agenda. That was the only way that the Paris Agreement was possible.« In the end, however, the commitments made were insufficient for achieving the jointly determined 2°C objective. There was no general allotment of the overall permissible carbon dioxide budget available to individual nations. Even now this has not happened, and the chances that it might happen practically shrank to zero when the United States abandoned the agreement, if not before.

As a result, adaptations to climate change like building levees and expanding air-conditioning in houses and transportation have become all the more important. Unfortunately, such projects require less cooperation between wealthy nations than protecting the climate itself, and the more short-term and geographically limited such projects are, the less cooperation they require. »Every rich nation that can protect itself and adapt to climate change in this way reduces the pressure for rich and poor nations to cooperate and the chances of achieving cooperation. There is a risk that poorer nations will be left to find the funds for adaptations on their own. The less we work together to mitigate climate change, the higher the bill for adaptation will be that many poorer nations may have to pay out of their own resources.« Two hopes remain in Moellendorf's eyes. One is based on the specifically human capacity to think and act in moral terms: The populations of

highly developed countries could see themselves as ethically obliged to support the populations of developing nations as a matter of justice. So far, however, this has not worked. The other hope is based on humans' capacity to ascertain and serve their own interests, as could happen when »the highly industrialised countries realise that no wall is high enough and no ocean deep enough to protect them from the problems in the developing world and the people fleeing them.«

Other hopes remain necessarily vague. Perhaps an international movement of young people who began thinking for the long-term at a young age will not be fobbed off with compensations and distractions in the face of mounting crises and increasingly tangible evidence for global warming.

Without geoengineering, it is not achievable

Moellendorf is not primarily concerned with criticising growth. While he agrees with the argument – made most prominently by the economist Amartya Sen – that we need an alternative, holistic form of growth that considers human development rather than just economic factors, the way the global economy is connected means that slowing economic growth in the highly industrialised countries now would also create difficulties for the developing world. Moellendorf thus considers it more important to develop policies that give the developing world cause to hope for a better future in which every-

Paltry harvests: In Zanzibar (Tanzania), women collect seaweed used in cosmetics and medicine. Rising water temperatures attributable to climate change damage the seaweed, however, causing it to die prematurely.

one can live a life of prosperity. This paradigm of »growth without fossil fuels« should, he believes, be introduced as soon as possible. It is currently still aspirational, no more than a »mere hope«.

And this brings us on to the topic of geo-engineering. A good six years ago, in 2015, Moellendorf gave listeners at a panel discussion on the topic of »Climate Change and Justice« in Bad Homburg something to reflect on. He commented at this time that there could be no alternative to an ambitious strategy and a truly global effort to end our reliance on fossil fuels, but that other strategies to deal with climate change would also be needed if emissions cuts alone did not suffice to achieve the objective of limiting global warming to 2°C or less. In that scenario, the hour of the climate engineers would strike, and it would be their turn to suppress the effects of rising global temperatures.



About Darrel Moellendorf

Darrel Moellendorf is a professor of international political theory and philosophy at Goethe University with a focus on political theory and environmental, moral, and political philosophy. His philosophical research is driven primarily by the current problems of the world in which we live.

The projects he mentioned then ranged from reflecting sunlight back into space through the injection of aerosols into the stratosphere to pushing greenhouse gases deep underground. In Norway, for instance, a plant that captures carbon dioxide released from the ground in the process of drilling for natural gas and immediately pumps it back into the ground was developed at the end of the last millennium and has since evolved into a major project in the carbon capture and storage (CCS) business.

Today, Moellendorf's view of the situation has become even more clear-cut: »There is already too much CO₂ in the atmosphere. We must not only reduce our emissions to zero but also remove CO₂ from the atmosphere and bury it somewhere deep under the ground or the ocean.« Approaches like planting trees will not suffice to solve the problems, he believes, as there is not room enough on the Earth to plant enough trees and the existing space is also needed to grow food for all. Coping with the

destructive impact of the growing prosperity of industrialised societies cannot be achieved, he considers, without developing and testing new technological solutions. Diverse projections are being made and technologies being trialled, and Moellendorf urges those responsible to always consider the question of the extent to which they exacerbate or alleviate distributive injustices.

Humankind is destroying its own »stage«

During the summer of 2020, yet another hot and dry summer, the *Süddeutsche Zeitung* reported that the earth had provided humankind with a stable backdrop for an unusually long favourable climatic phase lasting almost 10,000 years – the climate history equivalent, as it were, of an unusually pleasant and calm spring day. After almost two million years in which humans had existed as hunter-gatherers, the introduction of tillage and animal husbandry had ushered in the »neolithic revolution« and human civilisation in a story given the title »Man Makes Himself« in a book on the subject published by Australian prehistorian Vere Gordon Childe in 1936. The book has since been republished and updated several times, but does that title have a different ring to it now? At this juncture when humanity's once so solid stage has become rickety and started to collapse like a house of cards?

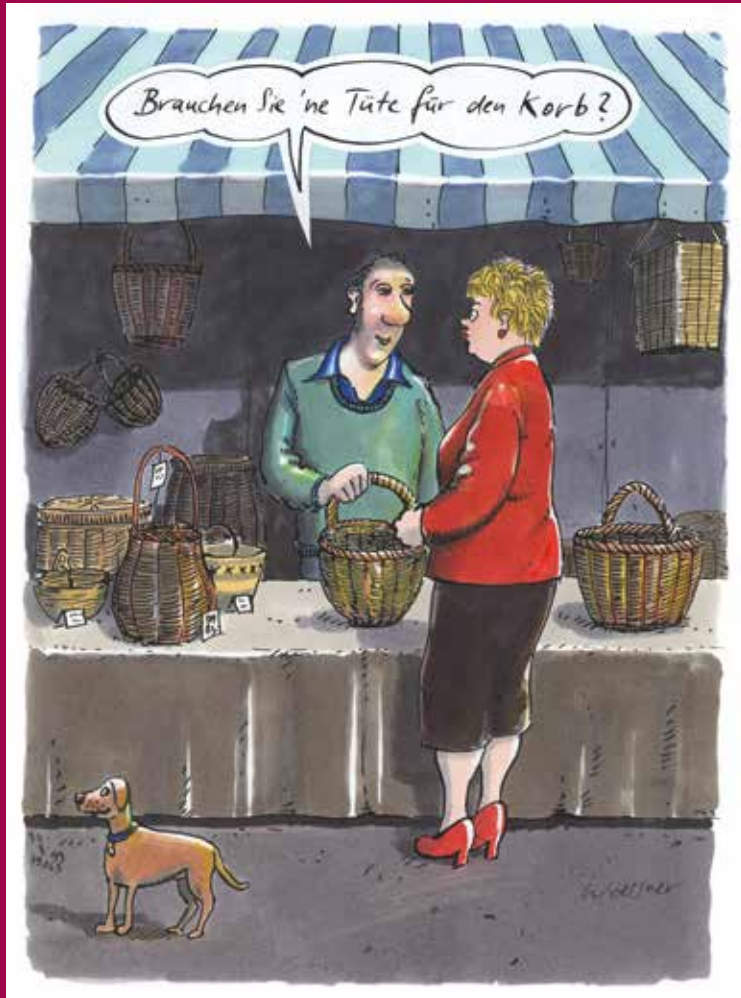
The philosopher Moellendorf sums up the problem in two pointed questions: If new technological capabilities make it possible to gradually replace or improve parts of a human – »Is that still a human being, or something else?« And if humans consider themselves capable of manipulating every aspect of their environment and proceed to do just that – »Does nature then still have a tangible existence independently of its configuration by humans?« Moellendorf considers the term »Anthropocene« appropriate for our age, but also fraught with deep meaning: »At the end of our conversation, we have reached the topic of the »Anthropocene«. The Anthropocene is an era that is utterly different from anything humans have experienced before: there are no longer any places on which they have not left their mark.« ●

The author

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THE POWER OF THE PEN



»Would you like a bag for your basket?«



»Do you seriously believe that even one person would still have gotten into their car if we had known this back then?«

Humour is when you laugh nonetheless. However, as far as climate change and related topics are concerned, it can well be the case that the one or other chuckle gets painfully stuck in the throat. Berlin illustrator and caricaturist **Freimut Wössner**, originally from Swabia, succeeds like hardly any other in skewering the small and large shortcomings of human beings with his pen. The topic of climate crisis and environmental protection offers plenty of material here: A culture of boundless consumption and unthinking laziness while preaching at the same time about environmental protection – nobody is really immune to this, and Wössner holds up a mirror to them. Perhaps the eight semesters he spent studying psychology in Munich, Marburg and Saarbrücken are of assistance here. F.W. Bernstein once called Wössner a »chronicler of our post-modern Biedermeier.« [asa](#)



»Grandpa, what kind of bird is that on the roof?«
 »A stork. But there's no point in you learning that anymore.«



»I am not going to let my child go to a Fridays-for-future demonstration by herself!«

I consume, therefore I am

Why sustainable consumer behaviour
is so difficult to realise

By Birgit Blättel-Mink



Our modern industrialised society is based on consumerism: people's degree of consumption defines their position in society. From a sociological stance, changing this behaviour towards sustainability will require a major effort on the part of society.

Consumption is a multi-phase process. It begins with the genesis of needs and information retrieval, continues with the decision in favour of a specific product, its use and/or consumption, and terminates with its disposal. According to the United Nations and its Sustainable Development Goal No. 12, the consumption (and production) of goods is sustainable if it satisfies basic needs and improves the quality of life of people while at the same time minimising the use of natural resources and toxic materials, as well as waste, and also preventing contaminants from being released into the ground, air or water across the life cycle of a product. Such consumption would lead to safeguarding satisfying the needs of future generations in a global context as this would decelerate the advance of man-made climate change with its fatal consequences for mankind and fauna.

What does this mean for our daily consumption? We should all eat less meat, renounce disposable plates and cutlery, throw away less food, save electricity, walk and cycle more, take fewer flights, and we should ensure that the products we buy are produced fairly – our consumption should be accompanied by greater awareness, therefore. These proposals for the »Sustainable Shopping Cart« (RENN.süd, 2020) all sound very reasonable. Those who stick to such resolutions probably lead healthier lives and have a cleaner conscience. This is also documented by the most recent environmental awareness study in Germany, in which only 19 per cent of the respondents were of the opinion that the German population is doing enough or about enough for environmental and climate protection; 78 per cent did advocate, however, that for the benefit of the environment »everybody should be prepared to cut back on our current standard of living« (BMU, 2019).

Consumption creates identity

Why can consumption as a whole not be more sustainable, however? The amount of packaging waste is constantly increasing, more and more microplastics are contaminating the oceans, over-fertilised fields are impairing the quality of drinking water. From a sociological stance consumption is more than just buying a loaf of bread and eating it, for instance. Rather consumption is understood to be a set of practices which allow people to express their self-identity, indicate their affiliation to social groups, accumulate resources, demonstrate social distinction and ensure participation in social activities (Heiler et al., 2009: 37). While consumption serves to satisfy the needs of the individual, it also serves to acquire and secure identity, and ensure distinction from others. Accordingly, consumption is a form of social agency with comprehensive individual, yet also societal functions. Consumption secures jobs and ensures growth. Consumption is one of the pillars that support modern society. Transforming consumption, and consequently also reducing it, so as to assume responsibility for current and future generations is thus a most unlikely undertaking – unless sustainable consumption opens up the opportunity for in-demand social and cultural resources, for example social recognition.

If one looks to the past, the close links between consumption and recognition can be substantiated: in preindustrial societies »demonstrative consumption«, showing what one had and what one could afford, therefore, was the preserve of the nobility. In civic society the upper social classes adopted such mechanisms of demonstration and distinction, the demarcation from other social strata or classes through consumption. In order for the owner of a company, for example, to be able to maintain

»Cathedral of consumption«: Social status and consumer conduct often go hand in hand in modern society. Shopping malls such as Frankfurt's »My Zeil« take this into account with a diversity of shopping offerings.

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distinctive consumption, people are required who demand the growing offering of produced goods. This is how the mass consumption of wage-earners developed. Industrialised society is also a consumer society, and consumerism is its cultural substrate, a socially standardised life-style therefore, which is geared to always satisfying the need for consumer goods. As long ago as 1949 the sociologist Theodor Geiger argued that in such a society it is no longer the social position which determines the »appropriate consumption«, but rather the »affordable consumption« determines the social standing of the individual.

Questioning the barriers in one's own mind

The consumption-intensive western lifestyle still plays a very large part in climate researchers assuming there will be global warming of 2.5 to 5.5 °C and warning that a policy of »business as usual« will be fatal. The introduction to an anthology published by scientists in Frankfurt states that in order to bring about the societal and economic transformations that are indispensable to limiting climate change and maintaining the basis for our own existence, we have to dare to imagine a different world and question the barriers in our minds. (Blätzel-Mink and Hickler, 2021)

Such a different world and a different form of consumption is offered by so-called zero waste shops; these allow consumers to fill their own containers with foods and everyday commodities, and thus forego secondary packaging of consumer goods to a large extent. In the framework of her master's thesis in my specialist area Sina Jäger carried out a focus group discussion with persons who avail of such offerings. Even though all the respondents are highly motivated and want to practice this form of sustainable and sufficient consumption, the focus group revealed that there are still various barriers. (In this respect sufficient consumption constitutes a form of sustainable behaviour which, in contrast to the orientation to efficiency for instance, does not accept »business as usual«, but demands a fundamental change in consumption (and also in production). »Less is more!«)

The following barriers were identified with regard to achieving sufficiency: firstly there is the overcoming of regular, entrenched routines, which is perceived as a difficult process: One participant in the focus group talked about the constant habit of always having bags and containers with her. She repeatedly tried to get used to this, kept putting these things in her rucksack to make sure she had them, then she would go shopping, the bags and containers were filled and she would put them in the kitchen some-

where and so she no longer had any in her rucksack... and then she saw that she had to plan a lot more and consider in advance when she are going to go shopping and what she are going to buy, what she needs with her, and this means one needs to give a lot more consideration to one's shopping. (Jäger, 2019: 65).

Sustainable consumption as a daily challenge

Alongside routines, other barriers to sufficient consumption were identified. There is no social recognition on the part of the majority in society, which insist on their »natural right to abundance« (Baudrillard, 1998) and accordingly afford very little appreciation for »lack of consumption«; this is why people often have to justify such a form of sustainable consumption – for example if compliance with hygiene standards is called into doubt in zero waste shops. In addition, the respondents stated that in view of the diverse offering it is by no means easy to practise abstinence, e. g. to forego vegetables from other countries which are only available in the respondents' region in a particular season. In the focus group discussion it also



The author

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became clear that consistently practicing sustainability is a major daily challenge. Thus the respondents stated that they had to start planning their day on a morning, i.e. what they would take with them to eat or where they could make purchases without plastic packaging. The logistics of sufficiency are anything but simple.

That these results are also applicable in other areas is shown by Bianka Zurek (2020) in her bachelor's thesis on day-to-day mobility. She surveyed, likewise in the framework of a focus group, highly mobile persons on the topic of car-sharing. One not particularly surprising result is that the idea of foregoing having a car at the front door represents a major challenge for the respondents. A multitude of reasons are stated as to why people would not like to shift over to car-sharing: availability, inadequate maintenance, the assumption that other users would be less responsible, and the comparatively high costs. In this respect it is noticeable that the listed barriers do not always match up with the facts. Thus, for example, the network of car-sharing offerings, at least in the urban context, is now very dense.

Having your own car is the standard in Germany

Motorised private transport still plays a very major role in Germany. Thus, in the environmental awareness study 70 per cent of the respondents stated that they use their own car on a daily basis or several times a week, whereas a mere 22 per cent use local public transport daily or several times a week (BMU 2019). We are a long way away from a transformation of transportation towards it becoming sustainable – and this despite the high level of environmental awareness on the part of the population. Of course, there are groups of people who forego owning their own car, but these are still an

exception: older women in rural areas who cannot afford a car, young people in cities who do not need a car thanks to greater bicycle friendliness and attractive local public transport offerings. Yet these two groups do not primarily have an eye on the environment, but adopt these measures due to their low income or – in the case of young people – thanks to their media use, which allows them to gather information quickly.

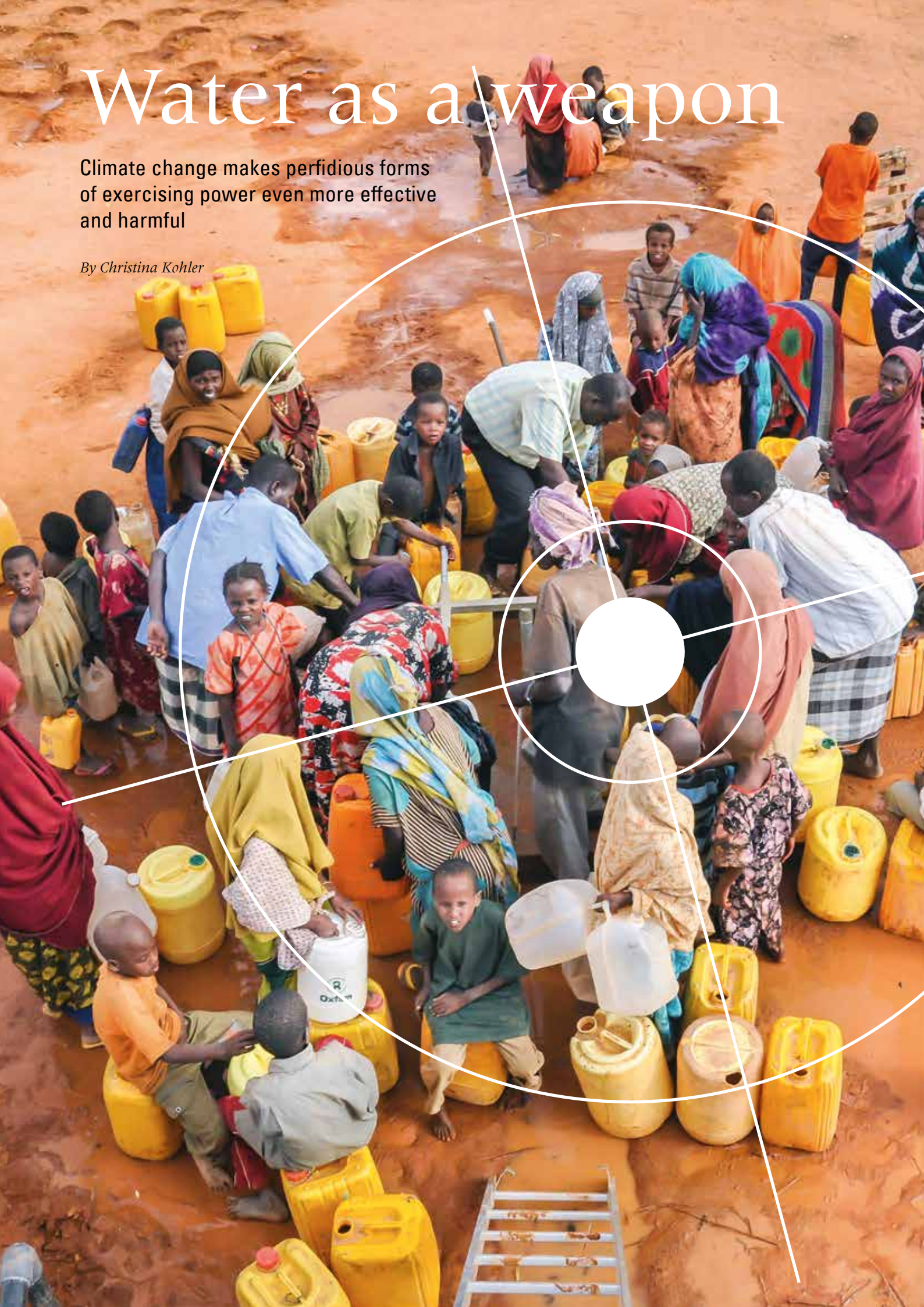
On the whole it is not just the consumers who have to change their behaviour; there has to be the will on the part of the society in total to stop climate change. Industry and business have to offer more climate-friendly goods; consistently more sustainable, more sufficient consumption has to be appreciated by society, and the world of politics should be a reliable partner on this path. At present very little trust is placed in the worlds of business and politics being able to counter the challenges of climate change: in 2018 a mere 14 per cent of the respondents believed that the German government was doing enough or about enough for nature conservation and climate protection. The figure for the business world is even lower, at 7 per cent (BMU 2019). There is still quite a bit to be done, and in a post-coronavirus age it will require concerted action on the part of all the protagonists to ensure that there is the nature conservation and climate protection that will undoubtedly be necessary when faced with the dictum of economic growth. ●

No waste thanks to reusable containers: Frankfurt's first zero waste shop goes by the name »gramm.genau« and is located in the Bockenheim district. Its advertising woos consumers with the claim it makes shopping without packaging as practical and as stress-free as possible.

Water as a weapon

Climate change makes perfidious forms of exercising power even more effective and harmful

By Christina Kohler



Throughout history, actors have used their power over water supply to stabilise their authority, weaken their enemies, and expand their realms. Today, global climate change and associated water scarcity make this practice even more effective and harmful. To raise awareness of this long-neglected phenomenon and to support affected populations, an interdisciplinary research approach is essential.

Throughout history, actors have used their power over water supply to stabilise their authority, weaken their enemies, and expand their realms. Today, global climate change and associated water scarcity make this practice even more effective and harmful. To raise awareness of this long-neglected phenomenon and to support affected populations, an interdisciplinary research approach is essential.

Water and water infrastructure have long been weaponised in military conflicts: Wells, dams, reservoirs, sewage treatment facilities and pipelines are targeted and destroyed; drinking water is poisoned or contaminated. By using water as a weapon, actors can show their power, oppress and kill enemies or gain ground in conflict in the name of a political, economic, religious, or social objective.

During World War II, for example, warring parties in both Europe and Asia repeatedly targeted dams in their strategic bombing raids. Nazi Germany deployed this tactic particularly often. They used strategic flooding along the river Ay in Normandy against their opponents and occupied areas like the Pontine Marshes in Italy to punish residents for alleged »disloyalty«. However, the use of water as a weapon was long considered an exceptional and rather sporadic event during armed conflicts (von Lassow, 2020). Climate change and associated water scarcity have increased the strategic importance of water and water infrastructure. This in turn has increased the use of water as a weapon, making this tactic more attractive to actors.

Syria: Government cuts 5.5 million people off from water supply

Since the mass uprisings in the Middle East in 2011, the weaponization of water has been reported more frequently about the use of water as a weapon in the region. Incidents were reported predominantly in Iraq, Syria, and Yemen that had long suffered from water scarcity. According to media coverage, the Syrian government in Damascus intentionally attacked water resources in 2017 to cut 5.5 million peo-

ple off from their water supply. The so-called Islamic State (IS) adopted this tactic as an integral part of its strategy for monopolising power and establishing a caliphate. In Iraq and Syria, IS used dams, canals, and reservoirs to deny water and energy to regions outside their territories and to flood the route of approaching enemy armies. Though, such use of water and water infrastructure as a weapon extends well beyond the Middle East. For instance, in 2017, Al-Shabab poisoned a well in Somalia, allegedly to deny Somali government forces access to water, ultimately killing 32 civilians who drank from the poisoned well. Various incidents have also recently been reported from the disputed Crimea region.

A large number of examples collected by the Pacific Institute (<https://www.worldwater.org/water-conflict>) demonstrate that the use of water as a weapon occurs during different types of conflict – including armed conflict, civil war, intercommunal violence, or social conflict – and is carried out by a multiplicity of state forces as well as by non-state actors. Initial findings indicate that this practice is already having devastating effects on vulnerable populations in drought-stressed regions (Kohler et al., 2019; Gleick, 2014). In Syria, it has led to increased displacement from rural to urban areas. It has even accelerated migrant flows to Europe and beyond. Despite the growing urgency of the problem, the links between water scarcity and the weaponization of water remain largely unexplored, the security implications unknown and the quantitative assessment of the global scale of this phenomenon severely under-reported.

Existing research on the links between climate-related water and violent conflicts has thus far focused predominantly on the role of

Drought and famine pose serious threats to human survival in many places in the southern hemisphere and heighten the vulnerability of local populations to resource-related threats. The image shows emaciated cattle in the Maasai territory of Kenya.



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water as a trigger for conflict or cooperation – for example in the case of the ongoing disputes between Ethiopia, Sudan, and Egypt over infrastructure projects like dams along the Nile. By contrast, however, in the practice discussed here, water becomes a weapon and water or related infrastructure is used with the specific aim of harming individuals or depriving populations of this natural resource. In fact, the use of water and water infrastructure as a weapon can destabilize whole societies, as all human life is based on water resources and related systems. Moreover, the links between this practice and looming climate change with related water scarcity bring new dynamics into play.

Interactions between climate change and conflict

Water scarcity is an intensifying threat in many regions of the world. It disrupts the livelihoods of millions of people and makes populations vulnerable to the weaponisation of water and related infrastructure. The Intergovernmental Panel on Climate Change (IPCC) projects that an increase in average global temperatures of 1.5 °C by 2050 would result in new and more severe water shortages affecting 243.3 million people – 4 per cent of the world’s population. Therefore, climate change is one important factor – in addition to a growing population, weak institutions, and ineffective governance and distribution of water resources – causing water scarcity. It increases the number of people vulnerable to political actors’ use of water and water infrastructure as a weapon and magnifies the strategy’s impact, making it more harmful and effective.

A general consensus exists among researchers that climate change impacts human societies. However, the extent of its effects on human security remains controversial (*Friedensgutachten*, 2020). Two potential pathways are discussed in the literature: accelerating climate change affects the likelihood of conflict directly via physiological and/or psychological factors and resource scarcity or indirectly by reducing economic output and agricultural incomes, raising food prices, and increasing migration flows (Koubi, 2019). Climate’s direct or indirect effect on different types of conflict, however, also depends on context-specific socioeconomic and political factors that intensify or weaken its effects.

Empirical research has long shown that changes in the availability of natural resources are of great importance as they link climate change to conflict: poor nations that are highly dependent on natural resources including, for example, water for irrigating crops, are *indirectly* very vulnerable to climate events and conflicts are more likely to occur there (Ide et al., 2014). In addition, weather events such as storms, floods, and landslides can *directly* cause or increase scarcity that in turn can lead to conflict by, for example, damaging public and private water infrastructure, destroying crops, and killing livestock.

The use of water and related infrastructure as a weapon may point to a distinct mechanism linking climate change and conflict. Violent actors take advantage of climate-related water scarcity by incorporating the increased vulnerability of the population into strategies to harm or control populations. As a result, climate influences conflict via the tactical considerations of actors. As this practice results from climate change-induced water scarcity and can consequently be considered a growing risk, empirical data on this mechanism is urgently needed.

An urgent security risk that scholars should address

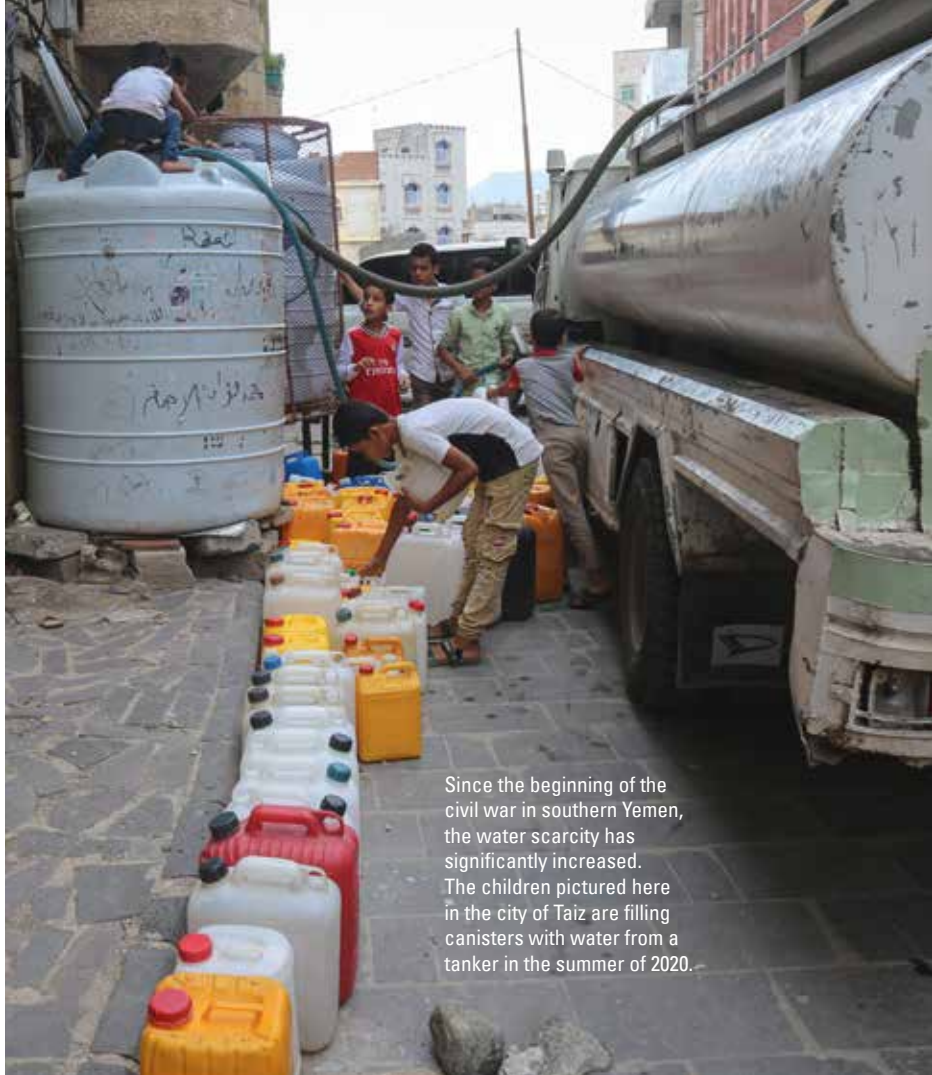
The weaponisation of water and water infrastructure has already contributed to human security threats in many regions of the world. It led to the deterioration of economic and social well-being of affected populations. Climate change increases water scarcity and is therefore likely to increase the use of water and water infrastructure as a weapon in regions such as the Middle East, where this use is already practiced by state and non-state actors. As climate change accelerates, this phenomenon could spread to other regions, especially those affected by drought, and become a powerful weapon in various types of conflicts in the future. Given such dire prospects, it is urgent that awareness

IN A NUTSHELL

- Manipulating water resources has long been used by actors to harm their enemies. Recent examples exist in Syria, Somalia, Iraq and the Crimean Peninsula.
- Existing research has long treated this tactic as a rare occurrence. Until today, it has not been addressed in depth.
- Climate change and associated water scarcity make the use of water as a weapon more effective and harmful.
- This tendency must be mitigated with comprehensive and interdisciplinary research as well as increased awareness and appropriate political measures.

be increased, and action triggered among decision makers in order to foster scientific research on this phenomenon.

To understand the implications of this strategy for human security and the possible global repercussions, violent actors and their victims must be identified and mapped. Furthermore, it must be examined what role climate-related water scarcity plays in the tactical considerations of violent actors to generate a fuller understanding of the mechanisms at work in the weaponisation of water. Interdisciplinary studies are of central importance here: On the one hand, climatic events such as droughts must be analysed in terms of their manifestations and regional characteristics from the perspective of natural science Earth system research. On the other hand, the analysis of social scientists, economists, and political scientists is necessary to understand the vulnerabilities and resilience of local systems to climatic events. Such a comprehensive approach based on a wide spectrum of interdisciplinary research methods and perspectives may advance understanding on the links between the climate and conflicts. ●



Since the beginning of the civil war in southern Yemen, the water scarcity has significantly increased. The children pictured here in the city of Taiz are filling canisters with water from a tanker in the summer of 2020.



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»As if the Earth were for all time Earth«

How German literature relates the story of the era
of the Great Acceleration

By Bernhard Malkmus

Climate change is not the only pressing question about the future which mankind has to answer. A closer look at the literature of the twentieth century reveals that quite a number of renowned literary figures have grappled with the systemic transformation of ecological systems by mankind in their works.

In the summer of 1921 the German doctor and novelist Alfred Döblin is holidaying on the Baltic Sea. While walking along the beach his attention is captivated by a number of pebbles. Constantly in motion between the sea and the mainland, they bear witness to a time frame that the human imagination cannot conceive. Döblin picks up a pebble. The energy and powers possessed by the Earth are revealed to him in the beauty of the stone. »Something was

moved in me, around me«, he writes later of this moment (49).

Upon returning to Berlin Döblin begins to conduct research into natural history, before rewriting the manuscript of the novel he has been working on for some time. To speak of mankind as has been customary for centuries in the European novelist tradition without giving consideration to the bigger picture that is nature now seems outmoded to him. He frenetically rewrites his novel *Mountains Seas and Giants*, turning it into a work that is both a technocratic dysto-

pia and a reflection on natural philosophy. Here Döblin projects the mechanised warfare of the First World War onto a history of mankind, envisioning this history through to the 27th century. Industrialised killing with poison gas, fragmentation grenades and submarines, which he witnessed as a military doctor, develops into global internecine warfare, ultimately culminating in an attempt to melt the ice sheet in Greenland and colonise new regions. In doing so primeval giants are released, hybrid monsters made up of animal, plant and mineral parts. They represent the natural powers that have been unleashed and with which mankind has never learned to live in the course of civilisation.

Harbingers of the »Great Acceleration«

Here war is not the »continuation of diplomacy with other means«, but a happening which is driven above all by industrial production; war is conducted because the means to do so are available. By highlighting this momentum Döblin anticipates a fundamental aspect of something which historians now describe as the Great Acceleration. In this manner the dramatic explosion of production and consumption in the industrialised countries after 1945 is outlined, something which has networked the Earth in economic terms and homogenised it in ecological terms through renewed bursts of globalisation. (We experienced one consequence of this at the beginning of the year when an epidemic developed into a pandemic in a matter of weeks.)

The Great Acceleration was fuelled by a period of ideological competition between the East and the West, and encompasses the post-war period up to the oil crisis at the beginning of the 1970s. The statistical curves for production and consumption display the characteristic hockey stick shape: a sudden and exponential upward

Quo vadis, mankind?
Alfred Döblin anticipates
the major issues in the
Anthropocene debate as
early as 1924 in his novel
»Mountains Seas and Giants«.





movement is to be seen in the middle of the twentieth century (Steffen et al.). This trend is continuing, with the effect that since the 1990s one can speak of a second Great Acceleration with the commencement of bursts of digital globalisation. Thanks to Earth System science we increasingly have more accurate knowledge of the extent to which the entire planet is being transformed by human activity. For not only are the climate and the atmosphere being changed by mankind, but also other key Earth systems whose interplay allow for and regulate life on earth: the biosphere, hydrosphere, lithosphere – and the chemical macrocycles carbon dioxide, nitrogen, phosphorus:

»The cumulative impacts of human activity rank alongside other planetary-scale geological events in Earth's history. [...] The Anthropocene is a turning point in the history of humanity, the history of life and the history of the Earth itself.« (Lewis and Maslin, 5)

The discussion surrounding the Anthropocene shows us that limiting the questions that will decide our future to climate change is not just wrong, but also dangerous. Like a rabbit in front of a snake, we are staring at global warming and ignoring the other ecological limits placed on

the burdens our home planet can withstand, such as the integrity of biogeochemical cycles and the natural acidity of the oceans or the intactness of the biosphere and freshwater resources. Jonathan Franzen's analysis is apposite when he writes »our preoccupation with future catastrophes prevents us from tackling the solvable environmental problems we face right now« (30).

Work as »second nature«

From a philosophical stance the Great Acceleration may be described, as Hannah Arendt writes in 1958, as »a rebellion by man against his own existence« – against that »which was presented to him at birth as a gift and which he now wishes to exchange for conditions which he creates himself as it were« (10). The modern trend towards »Earth alienation« culminates on the one hand in »flight from Earth to the universe«, on the other hand in »flight from the world to the self-consciousness« (15). Arendt primarily sees the danger that man only perceives himself as human through work on a »second nature«. In doing so he forgets, on the one hand, the dependence of human life on metabolism with nature and, on the other hand, he loses the ability

Where is the »natural beauty«? In front of »Teddy« Adorno in the mists of the Engadin valley or behind him in the beige anorak?

to conceive of himself as a primarily political (and not as a working) being – for Arendt a prerequisite for a functioning democracy.

In literature there are early traces of an examination of these far-reaching changes. As early as 1957 Samuel Beckett's one-act play *Endgame* transported audiences in many European theatres to a post-apocalyptic world. This experience of extreme material acceleration in the 1950s is driven by the recollection of two world wars: man is actually capable of creating a world of scorched earth – without »forests«, »rain« and »nature«, as Beckett says. Naturally Beckett is also alluding to the nuclear arms race, the so-called »balance of terror«, the mutually assured destruction (MAD). As the Cold War was coming to the boil at the beginning of the 1960s Friedrich Dürrenmatt wrote his play *The Physicists*. In it he does not just raise the ethical question of how scientists should deal with their findings (which predominated in the play's reception); in the figure of the »psychiatrist« Fräulein Doktor Mathilde von Zahnd Dürren-

How can we live
in a damaged biosphere?
Ingeborg Bachmann seeks
a lyrical answer.



matt alludes to the fact that the ethical soul-searching of science has long since been rendered obsolete by that which the American President Dwight Eisenhower had warned of in his farewell address in 1961: the »military-industrial complex«.

Jünger's drones as machine-humans

Using the narrative means of a dystopia, Ernst Jünger had already considered established military-industrial structures in *The Glass Bees* from 1957. Although the story is set in the future, the

principal figure, cavalry captain Richard, represents the generation destroyed by the mechanised warfare of the First World War and whose belief in the assurances made by technology has been dashed. In his desperate search for work Richard has an interview with the Zapparoni company, a manufacturer of miniature robots, including the eponymous bees: espionage androids which imitate bees perfectly and which are actually referred to as »drones«. They devour the nectar produced by flowers, but do not contribute to their pollination. Thus they epitomise the exploitive attitude of the »machine-humans«, whom they serve, towards nature. The Zapparoni empire in Jünger's work is an allegory for the penetration of further areas of life by technology – and a presentiment of what we now describe as surveillance capitalism.

In the same year Ingeborg Bachmann conceptualises the loss of a relationship to the world in the atomic age and under the conditions of the Great Acceleration in an absurd metaphor: in her poem »Safe Conduct (Aria II)« the Earth requests »safe conduct to space« so as to escape man, the world's master builder – and thus to guarantee »that from ancient beauty renewed graces on a thousand and one mornings will arise«. The biosphere is no longer at home on an anthropogenic planet and can only impart its regenerative power in the form of hope placed in the future. The lyricist takes the role of Scheherazade: survival is to be secured – as in *One Thousand and One Nights* – by relating the story of the Earth and evoking its poetic beauty. The Earth can also »spit out any creature« which the »mushroom cloud« has enforced upon it. This concept of being spat out, the total loss of civilising accomplishments, is the central theme of Marlen Haushofer's post-apocalyptic novel *The Wall* from 1963.

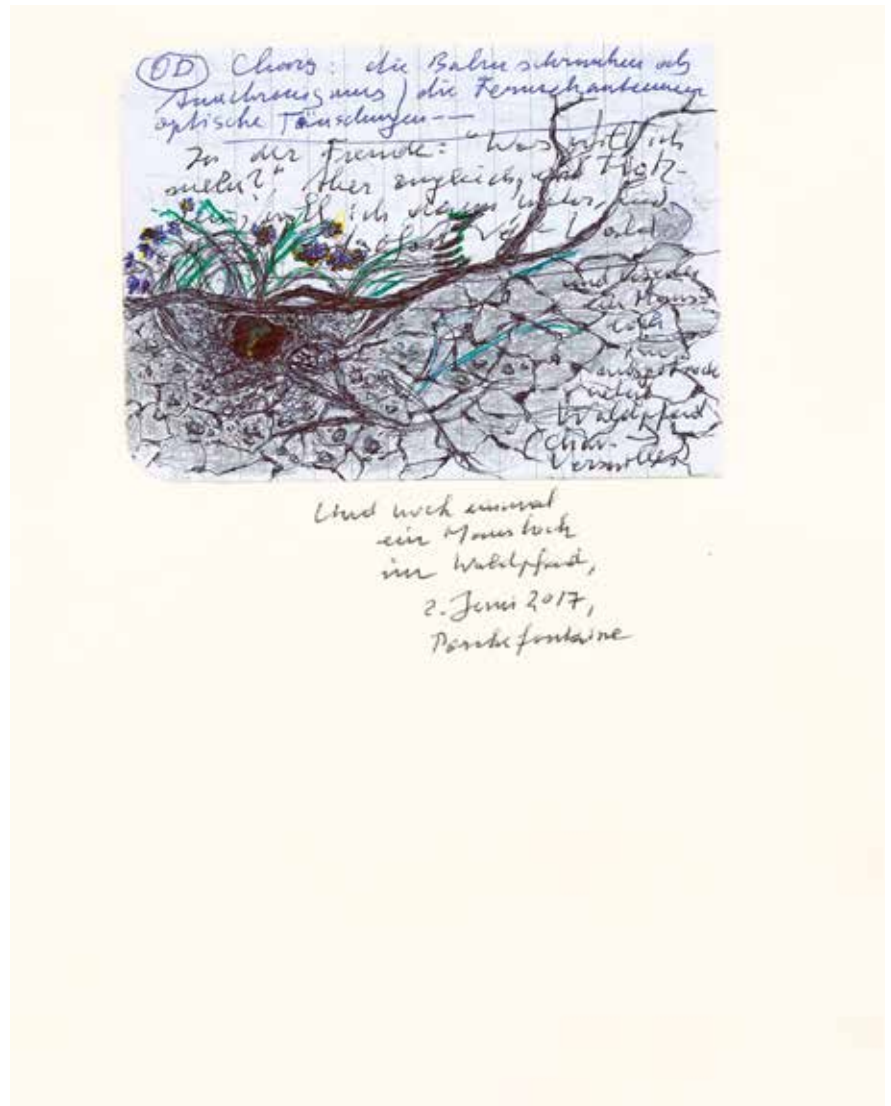
During the 1970s – as awareness of the global ecological crisis was growing following the oil crisis and the first Earth Day – traces of a retrospective discussion of the Great Acceleration are to be found in literature. By conjuring up a vision of the ideal primordial landscape Peter Rosei's *Entwurf für eine Welt ohne Menschen* (1975) (*Draft for a world without humans*), for example, lays bare the fact that the very same landscape has been irretrievably lost. In Max Frisch's experimental novella *Man in the Holocene* (1979), a retired *homo faber* in an alpine valley in the Ticino canton is cut off from the outside world by a landslide. As a result not only is he confronted by his advancing dementia, but also by Earth's systemic forces which have forged the geology of the Alps, and also by the intrusions of mankind, the consequences of which are on the verge of assuming geological dimensions: »When the Arctic ice melts, New

York will be under water.« The novel form itself, the embodiment of bourgeois self-reflection is eroded at the same time: »Novels are no use at all on days like these, they deal with people and their relationships, with themselves and others, fathers and mothers and daughters or sons, lovers, etc., with individual souls, usually unhappy ones, with society, etc., as if the place for these things were assured, the earth for all time earth, the sea level fixed for all time.« (16)

Handke in search of the Earth's own time

At the same time Peter Handke is endeavouring to write his way out of a creative crisis – in a style which seems to be a reaction to Frisch's existential uncertainty. In his stories *Slow Homecoming* (1979) and *The Lesson of Mont Sainte-Victoire* (1980) he sends the geologist Valentin Sorger from Alaska via California, the East Coast, and the south of France to Salzburg. This journey is not just a departure and an arrival; it is also an *éducation écologique*, slowly accustoming himself to the ability to track down the Earth's own time by sieving through human civilisation: »He was obliged to take the environing world seriously in the least of its forms – a groove in the rock, a change of colour in the mud, a windblown pile of sand at the foot of a plant – as seriously as only a child can do« (15). This »exercise in trusting the world« (17) is also a search for the manner in which to tell the story of the world. The ability to perceive the topography as a sentient being with its own temporality allows for the growth of a new form of narration, which thus knows that the »place« for a tale is not »assured«, but has to be conquered anew every time.

The 1980s are dominated by the debate regarding the apocalyptic dangers of certain technological developments, for instance in Günter Grass' *The Rat* (1986) and Christa Wolf's *Accident. A Day's News* (1987). In haunting texts such as *Old Rendering Plant* (1991) and *The Tidings of the*

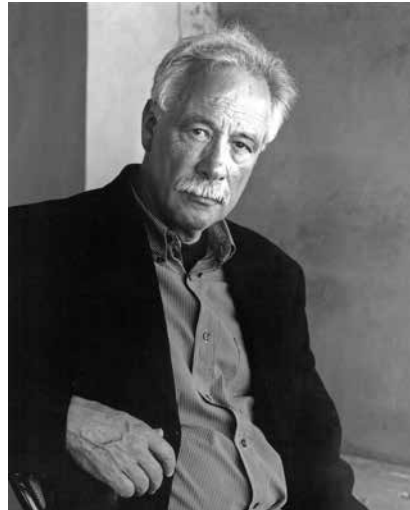


Trees (1992) Wolfgang Hilbig follows people seeking to flee the Great Acceleration in eastern Germany on the rubbish tips and waste heaps. In *The Rings of Saturn* (1995) W.G. Sebald describes a summer walking tour of Norfolk and Suffolk in eastern England, in the course of which his narrator reveals, layer by layer, the history of violence on the part of the modern age buried deep within our cultural landscape. Like an archaeologist he exposes the tracks of various bursts of industrialisation in this remote swathe of land, and in doing so contrasts the industrial decline in post-war England with the narrative of progress told by the Great Acceleration. The notion of a virtually inexhaustible biosphere, such as that seen in the murderous frenzy of industrial herring fishing, gives way to a growing awareness of the limits placed on ecosystems – limits which man draws ever closer to himself:

»By the seventeenth century, only a few insignificant remnants of the erstwhile forests survived in the islands, most of them untended

Where are we at home? Max Frisch doubts that our world can be narrated (left). Peter Handke meanwhile seeks new forms of narration with an aesthetic of mindfulness (above).

Where have we come from?
W.G. Sebald thematises
the prehistory to the Great
Acceleration. His narrator
wanders through the
ruined landscape
of British imperialism.



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and decaying. The great fires were now lit on the other side of the ocean. It is not for nothing that Brazil owes its name to the French word for charcoal. Our spread over the earth was fuelled by reducing the higher species of vegetation to charcoal, by incessantly burning whatever would burn.» (202)

Here Sebald was probably harking back to a concept which Theodor W. Adorno had already discussed with Walter Benjamin in a philosophical debate in 1932 and which gained currency in his *Negative Dialectics* (1966): »natural history«. By this he did not mean the evolutionary dimension of nature, but rather that the human illusion, the anthropogenic »second nature«, is independent of the history of life. The world of transformed matter conveys to mankind the impression that it is independent of nature and can impose its own laws upon itself. As soon as we can no longer hold together the structures of »second nature« with meaningful narratives, they return – believe Benjamin and Adorno – to their state of natural history and become ruins of their former meanings. Sebald tracks down the ruined landscape of British industrial imperialism and sensitises us for the future ruins, whose foundations we are already laying with our desire to shape the world.

Adorno continues to follow this train of thought in his unfinished *Aesthetic Theory*: »No sublimation succeeds that does not guard in itself what it sublimates.« (145) During extensive summer vacations in the mountains of Switzerland he develops his theory of »natural beauty«, through which he would like to transform man's flight from the world as described by Arendt into a utopia of »a communal recollection of nature in the subject«. (224) The »natural beauty« does not convey »the simple experience of nature«, but »that of a ›cultivated landscape«, the epitome of successful mediation

between the world of humans and nature.« (224) This presupposes that humans are prepared to marvel at nature – as when Döblin stood by the Baltic Sea and was plagued by the worrying question: »What will become of humanity if it keeps on living like this?« ●



The author

Bernhard Malkmus is Professor of German Studies at Newcastle University in England. He is currently a Humboldt Fellow at Goethe University as a guest of Professor Roland Borgards. He seeks to understand modernisation processes from the perspective of History and Philosophy of Science. In this respect he is particularly interested in the change to key concepts such as »life«, »environment«, »nature«, »landscape«, with which humanity seeks to conceptualise its relationship to the surrounding contemporary environment, and the epistemological and aesthetic reflection of these changes. Malkmus is the co-head of the Anthropocene Research Group at Newcastle University.

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BACK TO THE FUTURE

How a new stage play evolved at Schauspiel Frankfurt

By Anke Sauter

It is the year 2114. The young democratic Republic of Greenland is on the brink of a bright and hopeful future. The climate wars are over, fossil fuels have been replaced by alternative energy sources, and humanity has put aside its ethnic and social conflicts. But then dreadful news reaches Greenlandic society from Europe, the former centre of power: »Planetary consciousness«, which enables a life in harmony with nature and fellow creatures, is evidently in the process of being displaced by individualism once again. A Greenlandic research team is getting to the bottom of these anachronistic stirrings.

In his play »Eternal Peace« at Schauspiel Frankfurt, the city's largest theatre, Alexander Eisenach devotes himself to the topic of climate change in an unusual way. From the not-too-distant future, he directs our attention to a past that is not dissimilar to our present and leaves us at a loss. What is also exciting about the production is that the play only evolved in the course of rehearsals. »Alexander Eisenach came to

the first rehearsal holding a draft of just a few pages. The play developed little by little out of this within the five weeks of rehearsals – as a result of working together with the actors and actresses,« says playwright Katrin Spira, describing the development process. The play, commissioned especially for Schauspiel Frankfurt, plays with the »science fiction« genre and exhibits an ambiguous sense of humour: Some of the things we take for granted today seem quite bizarre when viewed from the distance of the future world. Concepts such as growth and productivity, apparently so elementary for our coexistence today, no longer – supposedly – have a place in this world of eternal peace. Yet at the same time the question arises of how such a world was ultimately able to dominate. In any event, the journey into a foundering Europe illuminates the crisis we are steering towards and holds up a mirror to us contemporaries.

Science fiction is a genre particularly suitable for making the leap into the utopian possible and tangible, says playwright Spira.

Through its hypothetical nature, elements that today seem impossible to us can be overridden, allowing us to think things further in an extreme way. In the course of the rehearsal process, the actors and actresses discussed and introduced their own different experiences and viewpoints, which the author and director then transposed into the future setting when writing and producing the play.

The premiere, which was scheduled for 20 November, had to be postponed due to the coronavirus pandemic. It is not yet certain when the play will be presented on stage for the first time in front of an audience.

www.schauspielfrankfurt.de

»Conspiracy theorists have the better stories«

Stephanie Dreyfürst champions improved communication of scientific topics through GWUP, the German Society for the Scientific Investigation of Parasciences.

How can mankind be to blame for climate change when it is only responsible for three per cent of CO₂ emissions? Can you provide an answer to this question off the cuff?

Off-the-cuff answers are rarely a good idea. Even if the speed we associate with the internet and the real-time stories on social media also seemingly result in people expecting statements and comments to be made off the cuff.

How do you react to such a question then?

I try to take away some of the pressure by saying: Let us sit down and calmly research what acknowledged experts and institutions that have been examining the science of climate change have to say on the subject. And in particular it pays to be sceptical if concrete figures are stated.

Those who are convinced that climate change is a man-made phenomenon but are not climate researchers are going to feel a little bit unsettled in such a situation. What should they do here?

If the climate change denier is someone they know well or don't feel indifferently about, then it is worth considering: is this person prepared to take a critical look at their own position? Ask them: what would it take to change your opinion? Are there sources or positions that could prompt you to do so? Some think about it and then say, maybe, but no, not really. In such cases you know that every word is a waste of breath. Then you could ask why they want to believe something. Many of them then start to give some thought to the matter and say: well, then I have less of a guilty conscience, because I have just bought an SUV. If someone believes that humans are not to blame for climate change anyway, this exonerates the individual.



Have you ever experienced someone pausing for a moment and then admitting why they refuse to believe the results provided by science?

Sometimes, yes. This is often related to the demeanour you adopt when addressing this person and how you speak to them. Nobody likes to be lectured, and nobody likes to be attacked for their convictions. This stirs up resistance, as people tend to want to save face. This means the friendlier and more understanding the approach you take to them, the greater the probability that the other person will not immediately go on the defensive. This has a lot to do with psychology and not primarily with facts at all. But this discussion and exploration on the human level is difficult to train. One tip is to maintain an authentic interest in the person with whom you are holding a discussion if you have got the impression it is worthwhile. But if someone is totally impervious to facts, then every word is a waste of time, the whole experience is just strenuous.

You are a member of the national executive board of GWUP, the Society for the Scientific Investigation of Parasciences. Each year this organisation hosts SkepKon, the sceptics conference, with a principal topic, yet is also open to answering questions. How frequently do you receive queries relating to climate change?

The queries go to our office in Roßdorf near Darmstadt, where we have our only full-time employee, Dr. Martin Mahner. I would estimate that everything relating to the topic of climate change, including alternative energies and also the question »is there such a thing as a perpetual motion machine«, to be perhaps ten per cent at most.

That is a considerable amount.

Yes, although in the strictest sense it is not a parascientific topic, but still so important for our future that we often place it on the agenda at our annual conference and try to find speakers able to address all possible aspects in the field of climate change and the production of green energy.

What are the concrete questions you receive?

Many people doubt the scenarios painted by climate research, for example the rise in sea levels and the melting of the ice caps and glaciers. Others would like support in placing findings and studies in an overall context.

How can one counter those who doubt that climate change is a man-made phenomenon?

You can say that even if climate change is not man-made, we still have to stop it because the consequences for mankind, for the planet, for the ecosystem are so catastrophic that it makes no difference what has caused climate change. And even if it should turn out that there is no such thing as man-made climate change, we would still be doing something good for the planet (and us) by switching over to using bicycles more, for example, and it would not have been in vain.

Is there a hit-list of the topics which play a role at GWUP?

At the moment the topics are often dominated by conspiracy theories. These have been given a further massive boost by the coronavirus crisis. Our record for new members has also been broken this year because we have become more well-known through the subject of conspiracy theories. We conduct research and check whether there is any truth in something. This ranges from claims made by conspiracy theorists Attila Hildmann (a chef) and Xavier Naidoo (a musician), through those by members of the anti-government *Reichsbürger* movement, to those by people denying the existence of the coronavirus.

Some of these things are so outrageous, for example the assertion that children are kidnapped to drink their blood. Do you also receive such questions?

As the director of Wiesbaden's Community College I just initiated a series of events focusing on facts, fake news, and conspiracy myths; it has led to some highly interesting experiences. Some of the lectures met with considerable resistance. For example on the subject of alleged satanic paedophilia, I received about 50 emails protesting about the event – but it could be verified that the protest had been organised. The lecture still took place.

Why is it so difficult for these people when they are confronted with reality?

If people firmly believe in something, then they tend to cling to this belief equally firmly. And if somebody comes along and tells them that none of it is true, then it hurts a lot. I like to compare this with the fairy tale »The emperor's new clothes«. Suddenly there is a small child saying that the emperor is not wearing anything at all. This destroys the illusion of a whole crowd of people whose beliefs are then shattered. Serving as someone who debunks beliefs and myths is a very thankless task, you have to have a very thick skin. For individuals at our organisation this is also no laughing matter as they have become the object of hostility and even faced threats of rape and murder.

But the event did not just attract protests?

No. There was considerable interest and we had fascinating discussions. A lot of the attendees gathered really practical information; they wanted to find out how they could tell that someone was talking nonsense. Or how to conduct research alone and find out whether images actually originate from a specific event or whether the images might be older and have been taken out of their original context. This is helping people to help themselves.

Both sides are increasing their digital weaponry.

At GWUP we have learnt a number of tricks over the years, and we are pleased to pass these tips on in lectures and articles. Those not yet familiar with Google Reverse Image Search or the fact-checking site Mimikama can discover a whole new world. You can see for yourself where an image or a story has already been published.

Has the youth movement »Fridays for Future« made a difference to the issue of climate change?

It has led to more interest, but also to more resistance. Resistance that is focused on Greta Thunberg in a very personal and derogatory manner. You have to ask yourself why people think it is okay to treat a young woman, who is still almost a child, in this manner when she actually just wants to cause positive change. We try to break up this black-and-white image a little and point out that the world is not easy to understand. The seductive aspect is that there are people presenting supposedly simple solutions to this complex world. If I do not understand something there is somebody there to take the burden off me personally by saying: No, no, climate change is not caused by us.



About Stephanie Dreyfürst

Stephanie Dreyfürst, 45, has a Ph.D. in German Literary Studies and was the founding Director of the Writing Centre at Goethe University for ten years. Since May 2020 she has been the Director of Wiesbaden's Community College, where she initiated a series of events in the autumn semester focusing on conspiracy theories and critical thinking.

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Why is it so difficult to communicate scientific findings on a broad basis? What needs to change?

Those wanting to achieve expertise in a small area have to make a lot of sacrifices, spend years reaching a level where they can say they are an expert in this area. Acquiring specialist expertise in the German university system and at the same time producing reader-oriented texts or informing the general public about one's own field is virtually impossible. Naturally there are notable exceptions such as Christian Drosten, who is an absolute expert yet is modest and always highlights the limits of his knowledge and his expertise.

But not everybody is Christian Drosten.

Yes. This is why more jobs should be created which focus on excellent external communication. If the world of science does not want to lose contact to the population – which is supposed to understand what science does and why – then we should earmark funding to give science a face and try to tell »good stories«. For this is what instinctively sets conspiracy theorists apart: they offer better stories. They are told in a more exciting manner and are packed full of emotion. We have to try and find a language which does not downplay science, but does not pose too much of a challenge for people, while making scientific findings intelligible, accessible and tangible.

The interview was conducted by Dr. Anke Sauter.

CLIMATE ACTION

FROM
KNOWLEDGE
TO ACTION



Wrangling at length

A brief overview of the (less than successful) »pas de deux« between science and politics in the struggle to mitigate climate change

By Birgit Blättel-Mink

The greenhouse effect was discovered as far back as the early 19th century. But it took many further decades for humanity to realise how it affects the world's climate. A retrospective view of the uphill struggle to use insights gleaned by research to set politics on the right track.

The greenhouse effect was discovered in 1824. But only towards the end of the 1950s did improved measuring methods and a broader data basis make it possible to quantify the warming effect of the ever-increasing concentrations of carbon dioxide (CO₂) in the Earth's atmosphere. In 1972, the publication of »Limits of Growth« by the Club of Rome caught the attention of a global audience. A consensus started to build that the increasing atmospheric concentration of CO₂ would lead to the Earth warming. In the 1990s, with more advanced computer models and a deeper understanding of cold periods, the following consensus emerged: greenhouse gases play a major role in climate change and emissions caused by humans are chiefly responsible for ongoing global warming.

(See: https://de.wikipedia.org/wiki/Forschungsgeschichte_des_Klimawandels)

IPCC consolidates findings from around the globe

As political efforts have led to climate research and Earth system research being funded and supported, we have politics as well as science to thank for revealing and tracing the nexus between climate change and global warming with its attendant disastrous consequences for life on Earth. Delegates at the first United Nations World Climate Conference called the World Climate Research Programme into being

in 1979. In 1988, the United Nations Environment Programme (UNEP) and the World Meteorological Organisation (WMO) went on to set up the Intergovernmental Panel on Climate Change (IPCC). The IPCC evaluates international research findings without conducting research of its own. Its principal task is to collate and disseminate information about climate change, its risks and consequences, and opportunities for avoiding or mitigating hazardous developments and adapting to change.

The year 1987 saw both the determination of the »one-degree-goal« and the publication of »Our Common Future« (by the World Commission on Environment and Development (WCED) and its Chair, Gro Harlem Brundtland). The »Brundtland Report« contained a definition of »sustainable development« that influenced much future thinking: »Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.« (WCED 1987).

In 1990, the IPCC published its First Assessment Report (FAR). It established that a natural greenhouse effect existed, that human activity was increasing the atmospheric concentration of several greenhouse gases, and that this would lead to a rise in the global temperature. The IPCC's Second Assessment Report (SAR) in 1996 was already able to state that human activity was

»How dare you!«:
The Swedish teenager Greta Thunberg gives a highly emotional speech at the World Climate Summit in Madrid in 2019. She speaks in the name of a generation of young people who form a global protest movement.

IN A NUTSHELL

- In the 1970s, consensus grew that increasing concentrations of CO₂ lead to global warming.
- At the first United Nations Conference on the World Climate in 1979, the World Climate Research Programme was established. In 1988, the Intergovernmental Panel on Climate Change (IPCC) was called into being to make information about climate change available and formulate recommendations.
- The UN Conference on Environment and Development in Rio de Janeiro in 1992 is widely seen as a major milestone, especially because of the UN Framework Convention on Climate Change which was agreed here.
- Since 1995, the United Nations Climate Change Conferences (also referred to as World Climate Conferences or Climate Summits) have been taking place as Conferences of the Parties to the UN Framework Convention on Climate Change (COP). These conferences sought to implement climate protection policy instruments that would be binding under international law and could replace the Kyoto Protocol from 1997. In 2015, a decision to limit the average global temperature increase to below 2 °C was adopted in Paris. Sanctions for non-compliance were not designed into the agreement.
- The most vociferous and, up to now, most pointed criticism of climate inaction has come from young people around the world since 2019. The protest movement »Fridays for Future« has vehemently demanded that the looming climate crisis finally be taken seriously and tackled decisively.

having a »discernible influence« on the global climate in the 20th century. The 2 °C objective was then formulated as the boundary between a barely tolerable rise in temperature and an unacceptable level of global warming. The 2 °C objective was defined on the basis of hypotheses that exceeding more than 2 °C of global warming would cause tipping points to be reached that could trigger irreversible changes with almost unimaginable negative consequences.

From a »discernible influence« to the »Anthropocene«

In 2001, the IPCC's Third Assessment Report was published, which found »stronger evidence« that humans are changing the Earth's climate. In 2008, the Geological Society of London stated that the »Anthropocene« had begun: There were now sufficient arguments for recognising a new chronostratigraphic epoch triggered by human influence on the Earth. Anthropogenic activity is now seen as the primary factor driving developments on the planet. In the IPCC's Fourth Assessment Report (AR4 from 2007), anthropogenic greenhouse gas emissions were described as responsible for »most of the observed increase in global average temperatures since the mid-20th century« – with a probability level described as »very likely« (i. e. > 90 per cent). In the IPCC's Fifth

Assessment Report (AR5 from 2013/2014, the last report released to date), the margin of uncertainty regarding the significance of anthropogenic influence on the climate was slashed yet further, with the probability that anthropogenic influences are responsible for the rise in global warming observed since 1950 now being described as »extremely likely.«

Emissions rights:

Emissions trading as an alternative to reductions

The United Nations Framework Convention on Climate Change was among several agreements reached at the Earth Summit (the United

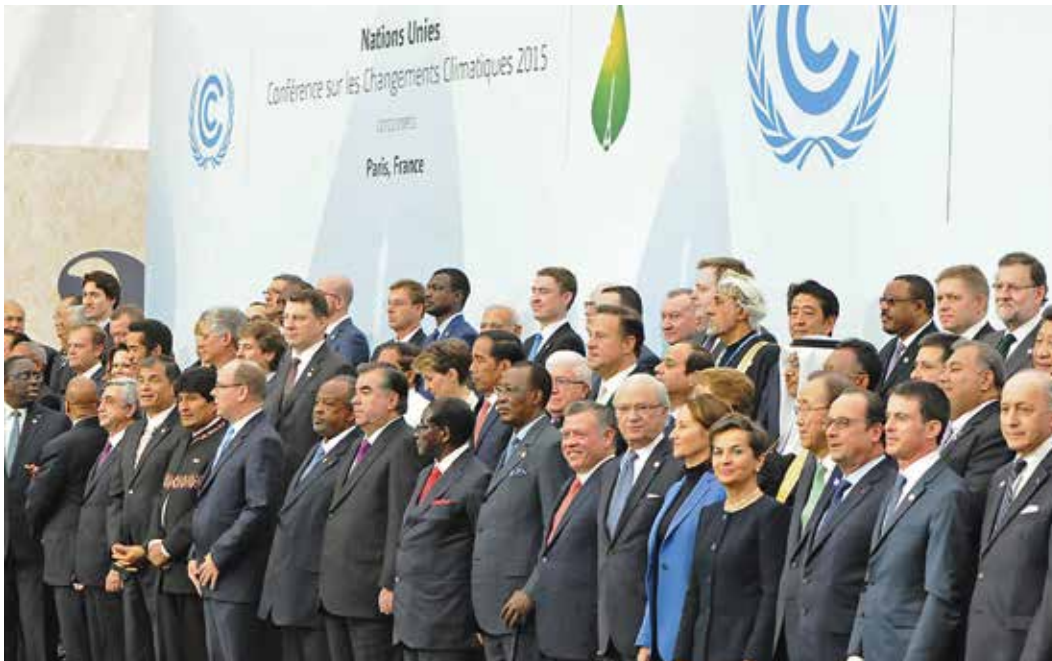
Nations Conference on Environment and Development) in Rio de Janeiro in 1992. It established the following goal: »[...] stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.« (UNFCCC, Article 2)

It was agreed that the path towards reaching this goal would be defined at successive annual UN climate change conferences. The Kyoto Protocol introduced market-based mechanisms for trading emissions allowances and certified emissions reductions in pursuit of this goal in 1997. Upper limits were defined for certain categories of emissions in defined regions and trading mechanisms were developed. Many industrialised countries in the global North purchased certificates from countries in the global South that had lower greenhouse gas emissions because of their economic situation.

Further UN conferences since then have aimed to develop strategies for tackling climate protection and environmental protection goals that have not been reached so far and to find solutions to new global challenges as they arise (the ozone hole, rapid biodiversity loss, the impact of climate change).

The agreements reached at the »Rio+20« UN conference in Rio de Janeiro in 2012 once more emphasised the importance of uniting to combat poverty, recognising and reaffirming the principles of the Rio declaration and existing environmental and sustainability strategies, and developing a green economy based on sustainable development and combating poverty. The idea of »green growth« has repeatedly attracted criticism, for example by the economist Alberto Acosta, who has described the model of a green economy as a green facade (with the green colour coming from US dollar notes). In light of the unbroken march of climate change and a billion people going hungry, he considered that a paradigm shift was urgently required and that Rio had not introduced one by any stretch. (See: https://www.nachhaltigkeit.info/artikel/weltgipfel_rio_20_rio_de_janeiro_2012_1419.html; Accessed: 14 June 2020)

At the 2015 UN conference in New York, the »Sustainable Development Goals« (SDGs) of the 2030 Agenda for Sustainable Development were adopted. These have since been regarded as the global goals agreed on by the international community to mitigate climate change and combat poverty and inequality. »While the SDGs are not legally binding,



Since 1995, the UN Climate Change Conference has taken place in locations that change every year. In 2015, a global post-Kyoto climate regime was agreed at COP 21 in Paris – a step forward that many people had no longer reckoned with after the collapse of the Copenhagen Summit in 2009.

governments are expected to take ownership and establish national frameworks for the achievement of the 17 goals. Countries have the primary responsibility for follow-up and review of the progress made in implementing the Goals, which will require quality, accessible and timely data collection. Regional follow-up and review will be based on national-level analyses and contribute to followup and review at the global level.« (See: <http://www.un.org/sustainabledevelopment/development-agenda>; Accessed: 14 June 2020). Goal no.13 includes immediate measures to mitigate climate change and its impact.

Climate targets not backed by sanctions

In the same year, the UN Climate Change Conference (COP 21) took place in Paris. The 197 participating states agreed on a new climate treaty that came into force in 2016. The Paris Agreement formulated the goal of substantially reducing global greenhouse gas emissions and limiting the global temperature increase to 2 °C (with preindustrial temperatures as the baseline) while also pursuing means to limit the increase even further, to 1.5 °C. Each state then set »intended nationally determined contributions (INDC)« of its own to define the extent of reductions in greenhouse gas emissions to be



Since 2019, the world's young people have made their voices loudly heard in vehement protests. The »Fridays for Future« movement has been forceful and persistent in its demands for policy and politics to finally take scientific findings seriously and set the necessary steps in train.

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achieved by 2025/2030 (in the industrial countries) or the extent to which rises in emissions should be limited (in the emerging economies / the global South). Failing to meet these targets, for example due to underinvestment in renewable energy infrastructure, is not sanctioned by the international community. Climate simulation models currently indicate that the world is on course for global average temperature increases between 2.5 °C and 5.5 °C in the 21st century.

The failure of the United Nations to galvanise its members into mitigating climate change has been criticised from many angles. Representatives of eco-feminism, for instance, have argued that gender-specific climate impacts have been largely ignored by policymakers and demanded that more women should participate in international negotiations (e.g. Hackfort, 2014). The loudest and clearest criticism so far came from the world's young people in 2019. Their new protest movement »Fridays for Future« rapidly became ubiquitously established. Konrad Götz from the Institute for Social-Ecological Research (ISOE) in Frankfurt analysed the new situation in a contribution for the German newspaper *Die Tageszeitung* (»taz«) published on 19 January

2020. In this article, he writes that the real success of this movement has been the surprisingly new discourse about the issue of climate protection that it has managed to get under way, and that a rethinking is in train now. He observes that this problem that has been known ever since the Club of Rome report came out in 1972, so for nearly 50 years now, has taken on an astonishing new urgency. The direct connection made between the issue and humanity, between the issue and the young generation themselves is what is new, and the source of their forceful dynamism. And he quotes Greta Thunberg in her »How dare you« speech: »People are suffering. People are dying. Entire ecosystems are collapsing. We are in the beginning of a mass extinction. And all you can talk about is money and fairytales of eternal economic growth. How dare you!« Fridays for Future points to climate science and demands that its findings should finally be taken seriously and translated into action by politics. The future will show what will to act this mobilises in political circles – where the approach taken by the young people has already impressed quite a few players. But the time they have left to act is running out. ●



In the dock: GERMAN CLIMATE POLICY

What if the victims of climate change were to hold policymakers responsible for it? If 31 states in the global South were to sue the Federal Republic of Germany? This scenario, projected into the year 2034, is the basis for a new TV drama from the German public broadcaster ARD. *Ökozid* (»Ecocide«) was shown for the first time in 2020 during a theme week on the lives we lead. The comprehensively researched courtroom drama shows the dilemma faced by industrialised states: politicians who depend on a flourishing economy for re-election, or at least believe that this is the case, are liable to take the wrong decisions or to continually postpone the task of getting back on track towards a

better future. By 2034, the not-so-distant future depicted in the drama, the consequences of this action or inaction have become even more palpable than they already are today, especially in the world's poorer countries. These countries unite to create a precedent by bringing German politics before the International Court of Justice (ICJ). As the case unfolds in court, people threatened in their very existence by climate change and decision-makers from politics and business who bear responsibility for it give evidence, among them even »former« German Chancellor Angela Merkel, and the court ultimately must decide whether it will uphold the claim of the 31 states and create a precedent that will surely

prompt an avalanche of trials and claims for damages. The TV production stars famous actors including Edgar Selge as the presiding judge (left-hand image, centre), Ulrich Tukur as a lawyer for the defence and Nina Kunzendorf (right-hand image, in the foreground on the right) representing the complainants. It was originally conceived of as a documentary reprising German climate change politics in recent decades. But events then started to move so quickly that the project could no longer keep pace with reality – until its makers finally got ahead by moving the plot into the future and looking back at today's debate from that vantage point. A daring approach – but one does sometimes see more clearly from a distance. Anke Sauter



Overcoming our weaker ecological self

Why it is so difficult
to abandon old habits

By Jeannette Schmid

To combat climate change, we must take decisions and alter our behaviour. But this will not be easy – not least because of our »weaker ecological self«.

Many of us have already made the acquaintance of our »weaker self«, for instance when we need to motivate ourselves to get more physical exercise or want to change our eating habits. This weaker self raises its ugly head especially when significant behavioural changes are required which do demand considerable effort on our part. In this article, which is based on a talk I gave at »Students for Future«, some classic theories of social psychology should help us to track down this stubborn animal: *The Theory of Reasoned Action* of Icek Ajzen and Martin Fishbein and two of Leon Festinger's theories, namely the *Theory of Cognitive Dissonance* and the *Theory of Social Comparison Processes*.

Why does the weaker self, let us call it the »ecological« one, have such an easy time with this topic? Because it takes a lot of effort to behave in a climate-friendly way, since this necessitates a whole number of changes to our behaviour. From mobility (foregoing air travel or big cars) to diet (doing without or at least signifi-

cantly reducing our consumption of meat and fish) to waste separation, switching to green electricity and sustainable products. To change all this, we must change our lives. We do the things we have always done, but not without reason. It is convenient, affordable, familiar...

The *Theory of Reasoned Action* describes how a behavioural intention develops, which can then lead to a change in behaviour. One of the prerequisites is *perceived behavioral control*: »Can I behave this way at all, does the situation allow it?« Perhaps we would like to use an environmentally friendly means of transport to get to work, but public transport is too expensive, operates at the wrong times, is unreliable, or the connection we need does not exist in the first place. The outcome: »I'd like to, but it's just not possible.« The solution lies in changing the situation that prevents this environmentally friendly behaviour by a) Research – perhaps we have overlooked certain possibilities, b) Action – perhaps we can push for better transport connections, c) Rethinking – perhaps we can work from home now and again and do not need to leave the house in the first place, or we could cycle to work.

A second factor in the development of a behavioural intention is the *subjective norm*. What would the people important to me think

Illustrations: Tobias Borries, Wiesbaden

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about my plans to change my behaviour? Perhaps I don't want to eat meat anymore, but the rest of my family does? That would perhaps mean cooking two different meals more often, and that's expensive. Will I annoy my loved ones with my new eating habits? Simply by striving to follow an environmentally friendly diet I hold up a mirror to others in which they reluctantly recognise themselves. The subjective norm only then becomes an accelerator rather than an obstacle when more and more of the people around me change their behaviour.

Rewards as incentives

The third factor is the *attitude towards the behaviour*. Would I benefit if I changed my behaviour, and what harm could I expect if I don't change it? If I avoid waste, the dustbin is emptier. The prospect of this »reward« has little impact. And if I don't do it, will the Atlantic come to visit me tomorrow and deposit its plastic waste on my kitchen floor? Of course not. To acquire a positive attitude towards a type of behaviour which is environmentally friendly, rewards must be created: Waste separation as the starting point for creative upcycling or repair skills, a meat-free diet is an invitation to produce sophisticated yet uncomplicated dishes.

Behavioural changes are tender plants

We will next turn our attention to the *Theory of Cognitive Dissonance*. Let us assume that we are on the right track: We have already changed some of our behaviour patterns (e.g. waste separation, green electricity, no more meat), but

plenty of others still remain that do not quite fit in with our aspired self-image of an environmentally aware individual. However, if our behaviour does not mirror our attitude, if they jar with each other in some way (if there is dissonance), this is experienced as unpleasant. One solution could be to align our remaining behaviour patterns with ecological criteria. That means hard work. We can try a justification: »Okay, I'll fly, but I'll pay an eco-fee for it, then it's not so bad, and I don't fly that often anyway.« The worst method of reducing dissonance for climate goals lies in a change in attitude: »After all, it's still questionable whether things are really going to get that bad with climate change...«. New behaviour patterns are tender plants, always in danger of being abandoned. One »false step« can result in the abandonment of the purpose. However, we should forgive ourselves such aberrations, provided we do not slacken our efforts.

There is also an aspect of cognitive dissonance that works in our favour. The longer we have persevered with a change in our behaviour and the more sacrifices we have made for it, the more difficult it becomes to abandon it again. We are bound by our investment.

We like to compare ourselves downwards

The theory of cognitive dissonance already brings us to the question: What does my behaviour say about me? How »good« am I, compared others? At first sight, there is nothing wrong with this question, but there is a downside. In order for the comparison to turn out



positive for us, we look for people who are similar to us but come off slightly worse. If need be, we even make sure that they come off worse. This is what is meant by the *Theory of Social Comparison Processes*. It is a comparison »downwards.« And since we are not the only ones who act in this way, it has tangible consequences.

Even if we have perhaps changed some of our ecological behaviour patterns, »weak points« still remain. This is where we are vulnerable. And that is exactly where others may try to declare their moral superiority because – in contrast to us – they have already given up air travel, cars and non-ecological products. On the other hand, they possibly still eat loads of meat and fish and do not bother to avoid waste or save energy. Experiencing put-downs and reproaches vastly increases cognitive dissonance and thus increases the risk that our first attempts at climate-friendly behaviour are abandoned again. Pointing fingers at others does not help – on the contrary: It is even counterproductive.

In closing, a little encouragement: We often hear that individuals are powerless when state or society fail to act. However, this does not take into account the immense impact of the example. Each person who successfully changes behaviour prompts others to follow suit. The individual example is powerful. And people can do a lot for each other, encourage each other, exchange ideas on how to implement things, start playing a politically active role. ●



The author

Dr. Jeannette Schmid, born in 1958, is a psychologist who holds a post-doctoral degree (Habilitation) and specialises in psychology of language, social psychology and legal psychology. She is currently responsible for OLAT, Goethe University's learning platform at the University Computer Centre, and is deputy senator. This article is based on a talk Jeannette Schmid gave at the Public Climate School (PCS) of Students for Future.

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An illustration of a woman in a black dress and high heels, carrying a yellow watering can, watering a small tree with a green trunk and branches. The background is a bright green field with a blue sky and white clouds. The woman is walking from left to right, and the watering can is tilted, pouring water onto the tree. The tree has several green leaves and a small green flag on its branch. The overall style is modern and minimalist.

(In)credibly green?

How investors seek
orientation in the booming
green bond market

By Pia Barth

Climate protection has finally arrived in the world of finance. At least, that is the impression awakened by the growing range of »green bonds« on offer. These securities raise capital for industries and projects that are explicitly climate-friendly. However, can investors be sure that they are investing their money in a climate-friendly carbon footprint and not aiding and abetting the »greenwashing« of a company which is rapidly depleting natural resources? Economist Julia Kapraun has looked at the credibility of green bonds.

A paper written 54 years ago by Kenneth Boulding, an economist nominated several times for the Nobel Prize who held 33 honorary doctorates and was an acknowledged maverick in his field, starts with the words: »We are currently in the middle of a long process of transition, in which people's perception of themselves and their environment is changing.«

Primitive men imagined themselves, he said, to be living on a virtually illimitable plane and believed they could always go somewhere else if things became difficult. No sooner did the natural environment deteriorate than man, with the seemingly endless horizon in sight, simply moved on. Meanwhile, we know that the Earth is a sphere, that is, a system which for us is relatively limited and closed. The benchmark of our type of economy is, however, more and more consumption, more throughput, more use of resources – instead of the nature, extent and quality of consumption as well as the state of people's bodies and minds. »Especially economists,« commented Boulding laconically in 1966, »at least the majority of them, have not managed to draw fundamental conclusions from this,« that is, from the fact that the Earth is a sphere.

From niche product to green bond hype

The first green bonds were issued in 2006. The European Investment Bank, and a short time later the World Bank, offered what were known as »Climate Awareness Bonds«, the purpose of which was to finance renewable energies and projects aimed at enhancing energy efficiency. Investors now had the possibility to invest in projects for a certain period of time and at a fixed interest rate that pursued

specific ethical, ecological or social objectives or even to withdraw their money from projects that depended on fossil fuels. At this point in time, green bonds were a niche product.

Ten years later, bonds to the value of \$81 billion satisfied increasing demand – the UN Climate Conference in Paris in 2015 and the growing attention paid by international organisations and investors towards climate change were making an impact. The aim was to redirect international financial flows away from oil, gas and coal in the direction of climate-friendly projects, for example. Green bonds were considered important catalysts and potentially the linchpin for shifting the global economy towards less carbon use. If you do not act ecologically, you will lose out economically – this notion began entering the heads of entrepreneurs, development banks and commercial banks, companies or governments that otherwise did not have much to offer in the way of »green«.

But just how credible are »green bonds«? Can investors rely on all bonds with a »green« label actually financing climate-friendly and environmentally compatible projects? She can remember, says Julia Kapraun, author of the study »(In)-Credibly Green: Which Bonds Trade at a Green Bond Premium?«, that »years ago, staff in a company would sometimes run around like headless chickens to see if green labels fitted a product.« Just as issuers frantically dash about to find climate-friendly companies, investors search for criteria that underpin the credibility of such new bonds. First scientific studies accompanying the green bond boom, which compare the prices and return on investment of green bonds with those of conventional bonds, draw a contradictory picture. Some conclude that investors

Ranking of countries by environmental performance

Country	Rank	EPI Score
Denmark	1	82,5
Luxembourg	2	82,3
Switzerland	3	81,5
United Kingdom	4	81,3
France	5	80,0
Austria	6	79,6
Finland	7	78,9
Sweden	8	78,7
Norway	9	77,7
Germany	10	77,2

Source: <https://epi.yale.edu/epi-results/2020/component/epi>, status: October 2020.

Which country has the most environmentally friendly financial market policy? Yale University publishes an annual ranking of 180 countries on the basis of a comprehensive catalogue of criteria.

invest in green bonds regardless of their profitability. Others stress that green bonds only score if they are on a par with their conventional counterparts in terms of revenue. Some analyses focus on the primary market, that is, the playing field of the major stakeholders who, due to the booming demand, are scouring the markets for sustainable bonds. Others examine the interest in green bonds on the secondary market, where above all smaller companies and pri-

vate investors are underway. However, the samples studied are often too small, the bonds too heterogeneous and the methods used too different, says Julia Kapraun, to be able to make any reliable statements. This was what she and her co-author Christopher Scheins wanted to change with their study.

Who defines what is »green«?

Each company, each bank, each country can set down its own criteria for its green bonds. This can include dispensing with fossil energy sources as well as actively promoting wind power or the development of an electric vehicle or funding photovoltaics. As of late, institutions such as the International Capital Market Association or more recently the European Union are attempting to assure the quality of green bonds through a standard catalogue. Applying these guidelines is, however, voluntary. Under these circumstances, it is difficult to dispel the suspicion that green bonds are more a case of green marketing or »greenwashing«.

Still, the Environmental Performance Index (EPI) of Yale University gives prospective buyers a decision-making tool with which to evaluate those countries which issue bonds, explains Kapraun in her study. 180 countries are screened and evaluated in terms of the weight they attach to environmental policy and the implementation of environmental measures. China, for example, ranks only 120th in the country index – but is one of the top three issuers on the green bond market. With Denmark, Luxembourg and Switzerland at the top, European countries rank in the top 20 places – but this does not rule out, says Kapraun, that they might also have dubious, i. e. less sustainable, bonds in their portfolio.

Big players are ready to run the risk of higher prices

The criteria for a bond's credibility are therefore wide and varied, and the situation is complex. Do investors prefer green bonds with no »ifs or buts,« that is, are they willing to accept a lower return on investment than from conventional bonds or to pay a higher premium? Does the primary market with the major financial service providers, whose abundant portfolio of green bonds boosts their reputation and satisfies booming demand, differ from the secondary market, whose investors possibly only have return on investment in mind or else shy away from green bonds out of uncertainty? These are questions that economist Julia Kapraun explores in her study within the context of investors' readiness to pay a premium for green bonds.

In so doing, she looks at the total number of green bonds offered up until the end of 2018 where data are available. She then compares

IN A NUTSHELL

- Green bonds are considered a linchpin for shifting the global economy towards less carbon use.
- However, there is no binding definition of what is »green«: Each company, each bank, each country can set down its own criteria for the green bonds it issues.
- Investors are willing to pay a higher price for green bonds. However, in the jungle of bonds on offer, they search for criteria that underpin credibility.
- State institutions, countries and supranational organisations enjoy greater credibility as bond issuers than do companies.
- Investors trust green bonds issued by companies above all when these are certified, that is, have been checked by a third party.

Leading companies in the green bond market

(Status: End of 2018)

Bond issuer	Vol. in \$bn	Number of green bonds	Sector	ESG-rating
European Investment Bank	40.19	49	Banking Services	88.09
WindMW GmbH	29.37	80	Electric Utilities & IPPS	Unavailable
Électricité de France S.A.	26.19	18	Multiline Utilities	86.25
IBRD	17.00	158	Banking Services	67.31
Industrial Bank Co Ltd	16.93	7	Banking Services	53.77
KfW	14.74	18	Banking Services	93.26
Mexico City Airport	12.00	8	Collective Investments	Unavailable
International Finance Corp	8.46	77	Investment Banking & Investment Services	78*
NRW Bank	7.86	10	Banking Services	77*
Shanghai Pudong Development Bank Co Ltd	7.59	3	Banking Services	50.66

ESG Rating: August 2020, source Sustainalytics; *Last available data as per 1 July 2019.

How sustainable companies really are: Environmental institutes, sustainability agencies and auditors compile annual ratings, such as the ESG Rating (Environment, Social, Governance), to help evaluate corporate bonds. Service providers, such as Sustainalytics, MSCI or S&P, rate companies according to specific criteria on an ascending scale from 0 to 100, depending on how serious their declaration of intent is with regard to sustainability. The 2020 list shows that companies with the best »green« image compete in the marketplace with less convincing rivals.

these with corresponding conventional bonds. In the secondary market, these are also issued by the same body.

One result of her study: Above all in the primary market, investors are indeed prepared to pay a higher price for a green bond, that is, to earn up to 0.4 per cent less return on investment, than for a comparable conventional bond. The big players apparently want to make a contribution to a lower carbon footprint and seem to expect an image boost for themselves from holding a varied assortment of green bonds.

The level of acceptance towards green bonds is high – yet subject to certain conditions. One of the criteria is the credibility of the issuer: While major banks, financial institutions and energy companies as well as state institutions are among the top bond providers, players in the primary and secondary markets place far more trust in state institutions, countries and supra-national institutions than in corporations. In fact, they are even prepared to pay 0.2 to 0.4 per cent more for their securities.

Certified bonds are more successful

Moreover, in the case of corporations, investors are only prepared to forego a return on investment if the bond exceeds a certain size. Many want to get involved »in a big way«, meaning that they would like to exert as much positive influence as possible on the environment. This trust is, however, coupled with the condition that the corporate bond has been certified as »green« by a third party, e.g. an auditing company, environmental institute or sustainability rating agency (such as Sustainalytics, Cicero, Vigeo Eiris, etc.). A company that issues its

bonds without third-party certification loses out: Here, the return on investment has to be above average, e.g. ten basis points (0.1 per cent) above comparable types of investment. »Investors are by no means so naive that they trust a green label unreservedly,« summarises Julia Kapraun.

However, green bonds traded on what are known as »green exchanges« are apparently given the benefit of the doubt. These are exchanges that include a segment for sustainable investment products in their portfolio. They contribute to the transparency and liquidity of the green bond market by ensuring that bonds listed there are reliable, that is, controlled. Many

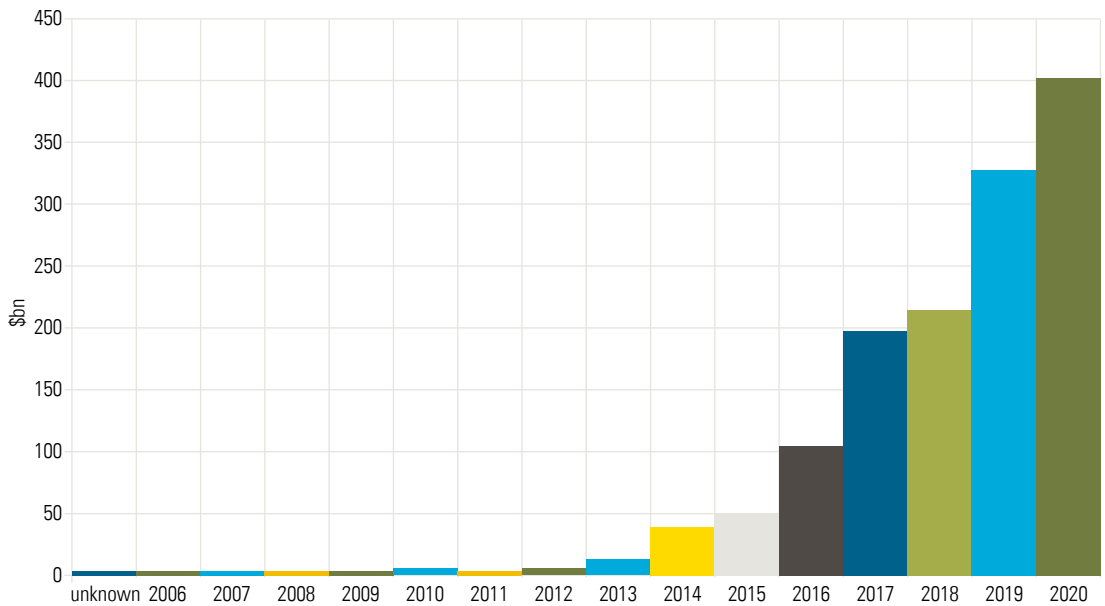


About Julia Kapraun

Julia Kapraun, 37, studied mathematics in Berlin and earned her doctoral degree at the Chair of Finance, WHU – Otto Beisheim School of Management. In 2017, she joined the Department of Finance at the Faculty of Economics and Business Administration of Goethe University as a postdoctoral researcher. Her main research interests are sustainable finance, behavioural finance and portfolio management. Her current research projects are concerned with sustainable investment products, their evaluation as well as the perception and acceptance of sustainability labels by investors on various markets and investment platforms.

Market volume of green bonds per year

The range of environmentally friendly investment opportunities on offer in the global financial market has rocketed since the early days back in 2006. The chart shows the volume of green bonds in billions of dollars for the respective calendar year.



Source: bonddata.org, retrieved on 20.10.2020.



The author

Pia Barth works as a public relations editor at Goethe University. Influenced by her studies of philosophy and literature, her interest in economics has only gradually awakened – above all since she became aware that nothing will change in the way humans treat their planet without impetus from the financial sector. However, without a new financial economy, nothing will change either.

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green exchanges convert recommendations into liabilities.

Financial expert Kapraun has discovered that the currency in which the green bond is issued also creates trust. The US dollar and the euro are more or less on a par in investors' affections, whereby twice as much is invested in EU bonds than in those issued in US dollars, with this figure set to increase in future. In third place, however, is the Chinese yen, which is also muscling in as a key player in the green bond market, although the requirements placed on Chinese bonds are far lower than the recommended standards for European bonds: Recommended standards in China stipulate that only half the volume of the green bond must be invested in sustainable projects, compared with 95 per cent in the case of European bonds. In China, however, explains Julia Kapraun, the recommended 50 per cent really is invested in green projects. By contrast, she adds, how many of the more demanding recommendations for European bonds are actually transformed into climate-friendly reality remains open.

Rethinking is rewarded

If an investor's experience with a first bond has been positive, this does not, however, have any influence on their acceptance of subsequent products: Investors particularly reward the first green bond issued by a company, even if it has not previously made a name for itself on the

basis of its environmental awareness. They are even prepared to accept up to 0.18 per cent less return on investment. Trusting in a company's change of heart, it would seem that investors want to make a statement.

Surprisingly, however, the primary and the secondary market differ: Investors who engage in the stock market as private individuals tend more to opt for green bonds if these can be bought at a lower or the same price as conventional bonds. Return on investment evidently takes priority, followed by the environment. Economists can only speculate about the reasons: Is the environmental awareness of smaller investors really less pronounced? Or do they find conflicting recommendations, standards and ratings bewildering?

In a study with the University of Zurich still underway, Julia Kapraun has endeavoured to gain an initial insight into the investment behaviour of private individuals. Even after they had been informed in detail about the sustainability ratings of companies and had even been given »guidelines«, their decisions for or against a company hardly changed. »The result was pretty unreliable. There is still a huge gap between thinking and doing.« says Kapraun. A lot suggests that investors do not sufficiently understand sustainable investment products, their labels and ratings. Why this is the case and what could help to change it – this is what Julia Kapraun wants to explore in future.

Experts estimate that currently only about 2 per cent of all global securities fill ecological and social purposes. Their total volume amounts to \$1,137.35 billion.

The European Union is currently working on a binding label for »green« investment products.

In 2020 too, investment opportunities that offer a safe return on investment and make the world greener and more equitable remain rare. The more money to be pumped into a »green project,« the more difficult it becomes: Still too few companies are questioning the »nature, extent and quality« of their consumption to date and seeking new, environmentally friendly ways.

The main topic of Science Year 2020 launched by Germany's Federal Ministry of Education and Research is the bioeconomy – that is, the transformation of an economy based on fossil resources into sustainable, biobased business practices. The theme was recently prolonged for a further year. So maybe responsibility for green bonds will soon shift from a company's marketing department to its management after all. ●

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PLASTIK IM HAUSHALT



Flasche
(durch Glas
ersetzbar)

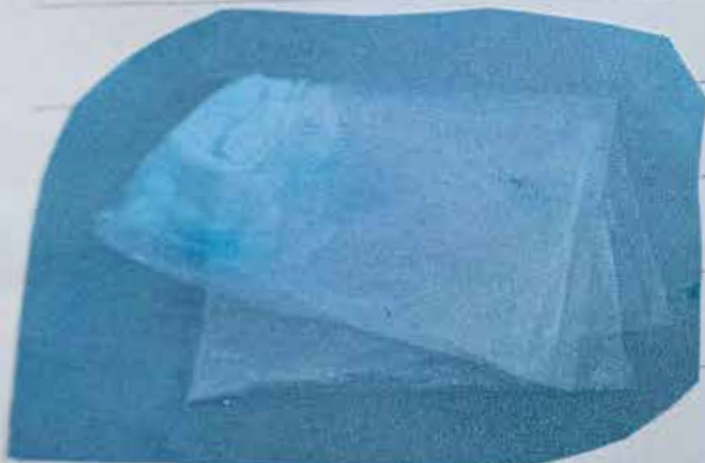


Lineal
(durch
Holz ersetzbar)



Lang-Figur

Armband
(durch Glasperlen
ersetzbar)



Tüte (durch Papier
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Can education prevent forest fires?

Between drill and personal responsibility:
How education in the spirit of sustainable development might look

By Helge Kminek

How can upbringing and education contribute to making society sustainable? Should they subtly inject the concept of sustainability into children and adolescents so that they act in a climate-friendly way? Or should upbringing and education aim to produce autonomous individuals?

As I am writing this article, the forests in California are burning. Forest fires in the west of the USA are not unusual at this time of year – new, however, are the scale and intensity. We often read that this is already a consequence of human-induced climate change.

Climate change is undoubtedly humanity's most pressing problem. However, there are further phenomena that are impacting on humankind's relationship to its natural resources, such as loss of biodiversity. Many educational concepts, which see themselves as »education for sustainable development«, claim to contribute to solving this and other problems. Yet how can education contribute to making people live their lives in a more sustainable manner? How should it proceed in order to prepare young people for a bright future? This is by all means a contentious issue. The following article aims to outline and discuss concepts that regard themselves as expedient approaches to an education in the direction of sustainable development. They aim to provide answers to the question: How can education contribute to solving manmade problems?

Young people's emotions as a lever for change?

From the perspective of educational psychology, colleagues from Australia and New Zealand recently called for efficient approaches with which to achieve the desired objectives. One of the main findings of their research is that people care significantly less about the environment when they cannot picture climate change and its consequences or react emotionally to imagined consequences (cf. Stanley et al., 2018). It seems to be a logical conclusion that the authors, against the background of this result, call for school students to develop stronger feelings about the future impacts of human-induced climate change. Accordingly, educational inter-

ventions need, in their opinion, to be developed, implemented and improved, perhaps with the support of further research, which successfully stimulate such emotions. To give a specific example, this could be a lesson where school students deal with the idea of a fire in the Indonesian rainforest, which they perceive as so real that they react emotionally to it. If they additionally see the reason for the fire in their own consumption of convenience food – the Indonesian rainforest is chopped down for palm oil plantations because this oil is needed for convenience food, for example, (cf. Hartmann, 2015) –, then this would be a good enough reason for a change in behaviour.

Making school students the authors of their own lives

Munich philosopher Julian Nida-Rümelin strongly opposes such approaches. He points out that the principle of personal responsibility is fundamental to our political order. In his view, educational concepts that negate the objective of personal responsibility, for instance by subtly targeting and attempting to alter school students' emotions, undermine this order and thus implicitly question our notions of democracy or rule of law and the ways we practise them – and thus the basis of our social coexistence. That is why Nida-Rümelin rejects approaches like the one described above. He calls instead for an education in the direction of authorship, which encourages individual school students in a way that allows them to be the authors of their own lives. This type of education should specifically foster their ability to reflect and is based on a confrontation with rational reasons. In this way, each individual is free to make decisions but also able to assume responsibility. This would be the case, for example, in the following scenario: In class

Learning about the environment with scissors and glue: Already at primary school, children learn how to behave in an environmentally friendly way, for example by separating waste properly.

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[last retrieved: 24.09.2020].

and together with their teacher, students should think about whether future generations should be able to have an intact rainforest. If »Yes«, the next question is whether something should be done or not done so that there is a reasonable prospect of future generations having an intact rainforest – and, if so, what this »something« might be.

Practising behavioural changes

Jürgen Menthe, then again, chemistry education expert at the University of Hildesheim, assumes that an upbringing or education that targets authorship or personal responsibility can no longer be the aim nowadays because this notion is based on the assumption of a strong and autonomous subject and can no more be upheld. Many studies, he says, have long shown convincingly that we not only do not »rule the roost« but also that we humans do not do those things which we know we ought to do (cf. Entzian, 2015). That is why he

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- How can education contribute to solving manmade problems? Research has revealed some partly diametrically opposed concepts.
- Since people care less about the environment when they cannot picture climate change and, as a result, are unable respond emotionally to its imagined consequences, scientists from Australia and New Zealand are calling for education to stimulate emotions in school students.
- By contrast, philosopher Julian Nida-Rümelin appeals for educational concepts that foster school students' sense of personal responsibility – and justifies this with the basic principles of democracy.
- UNESCO's concept paper »Education for Sustainable Development Goals: Learning Objectives« endeavours to resolve the controversy but also raises new questions. Children and adolescents should be educated to the point where they are free to make their own decisions and yet develop the competencies needed for sustainable development. However, it remains unclear whether these competencies are actually used to deliver this contribution.

advocates practising alternative behavioural patterns, for example in the form of cooking classes for a meat-free diet. In this way, in his opinion, schools and lessons could contribute to changing students' behaviour and thus to climate protection. This educational programme, similar to the targeting of emotions proposed by Stanley et al., is designed in such a way that the underlying intention is not explicitly communicated to the students. There are thus two roughly opposing approaches: The one stresses the importance of reflection and argumentation (Nida-Rümelin), the other the expectable impacts of educational interventions (Menthe, Stanley et al.).

Developing competencies

UNESCO's concept paper »Education for Sustainable Development Goals: Learning Objectives« (UNESCO, 2017) can be understood as an attempt to resolve the controversy between the approaches discussed so far. The authors suggest fostering competencies among school students that empower them to help solve problems in future without »drilling them« to act according to particular behavioural patterns through upbringing and education. This means that whether school students change their eating habits (in future) and, if so, how they do it, remains their own personal decision.

Yet this concept is not undisputed (cf. e.g. Kminek, 2020a, 2020b). Problems result, for instance, from the fact that competencies are defined without any reference to content or ethics.

For example, the critical thinking competency is defined as »the ability to question norms, practices and opinions; to reflect on own one's values, perceptions and actions; and to take a position in the sustainability discourse« (UNESCO, 2017, p. 10). Due to the arbitrariness in terms of content and ethics, a person who argues that the consumption of convenience food should be reduced in the interest of climate protection and a person who argues that consumption secures jobs both have the envisaged competency. The competencies called for by UNESCO do not therefore necessarily lead to changes in behaviour in the sense of climate protection, which would, however, be required in view of the acute threats. The example specifically criticises what is also criticised systematically. As far as the reasoning is concerned, it is not clear from UNESCO's competency model itself whether the competencies are to be used to help solve the problem. There is a step missing in the line of argument. Scholars at medieval universities would have called out: *Non sequitur* (it does not follow)!



Practical training in alternative behaviour: These children are learning that a delicious meal can be prepared even without meat.

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The author

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He earned his doctorate in 2017 with a thesis on »Philosophy and Philosophising in the Classroom. Empirical Investigation of a Contradictory Practice«. He is currently acting professor for social pedagogy and family research at the Faculty of Educational Sciences.

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Pinpointing the problems

It is not, however, surprising that UNESCO's concept paper does not state clearly what an expedient solution to the problem would be, that is, what sustainable development would be, since no one is able to say exactly what in fact constitutes sustainable development. Indeed, there are measures, such as the significant reduction of meat consumption, which many stakeholders view as an important element of sustainable development. But many things are still open and must first of all be explored in

greater depth. How can we overcome the difficulty of not knowing exactly what constitutes sustainable development?

Resolving this difficulty and raising awareness of the many problems in the framework of educational interventions – this is what Philip Wallmeier and the author (2020) propose. In the case of diet, for example, this would mean broaching the contentious topic of meat consumption mentioned above in order to raise awareness of the problem in all its different aspects. ●

TAKING
ACTION ON
CLIMATE
CHANGE



Main? Or Milan?

How climate change is making itself felt in Frankfurt am Main and what the city can do about it

By Stephan M. Hübner

In 2019, Frankfurt broke a record: On 25 July, the highest temperature on that day – 40.2 °C – was measured in Westend, one of its suburbs. This made Frankfurt the hottest place in Hessen since weather records began in 1881. A superlative that shows how climate change is posing major challenges for cities too. Ways to deal with its consequences need to be found.

Rosemarie Heilig is on Goetheplatz, a square in Frankfurt's city centre. Lots of traffic, rows of houses all around, here and there a dot of colour: Japanese pagoda trees. To the east is the Zeil, Frankfurt's famous shopping street, to the west the Freßgass, one of its culinary miles. For Heilig, biologist and city councillor for the environment and women (Bündnis 90/Die Grünen), one thing is sure: »The square was built in entirely the wrong way for the challenges of climate change.« She says that this is due, among others, to the underground car park below: »It makes it impossible to plant really big trees where people could sit in the shade.« In her view, this is one of the reasons why the square dramatically loses its appeal at the latest when the temperature rises beyond 30 °C. »We have to prepare ourselves for the same scenario here in Frankfurt as in Milan,« she says, »and that will make a different kind of open space attractive than has been the case in the past.«

She points to the ground. It was previously too dark and heated up too much as a result. That is why sample areas with different, lighter coloured substrates have been laid in the square that store less heat. »We presented them to the local advisory council and the people of Frankfurt because we want to have a material here that meets with a high level of acceptance.« In her opinion, participation is particularly impor-

tant when it comes to climate protection and adaptation so that – as far as possible – everyone pulls together in the end. In this context, climate protection means protecting the global climate, while climate adaptation, on the other hand, is a more regional or local challenge. For her, this makes Goetheplatz a kind of outside laboratory in which to try out how existing urban structures could be adjusted to the new challenges.

The aim of the »Green Rooms«, benches with green roofs and side walls, is to communicate how pleasant greenery in the city can be.



»The square was built in entirely the wrong way for the challenges of climate change.« Rosemarie Heilig, city councillor for the environment, wants to combat overheating in the city centre through more greenery.



Green roofs can help prevent the city from overheating in the summer.

Also a question of location

That Frankfurt is particularly affected by climate change is due to the city's location at the northern end of the Upper Rhine Lowlands. The climate here is naturally mild, annual rainfall tends to be low. In the height of summer, weather conditions with high mean and extreme temperatures and little natural air exchange dominate. And now there is climate change on top. In 2018, 108 warm days (over 25 °C) and 43 hot days (over 30 °C) were recorded in Frankfurt – in 2011, 75 warm days and 25 hot days had been forecast for 2050! Nowadays, annual rainfall is only a good two thirds of that which was normal in the past, and at the same time air pressure is increasing, which leads, among others, to less cloud formation [1]. One of the outcomes of this is more and more bad weather with storms, heavy rain and flash floods. Overheating poses health problems, above all for small children and elderly people, and calls into question the locations and amenities of hospitals, retirement homes and nursery schools. Last but not least, over 95 per cent of the trees in Frankfurt meanwhile display heat and drought damage (see also the article by Jan Schwenkenbecher, page 24).

Think green

It is the plants that are particularly close to Rosemarie Heilig's heart. She is campaigning for more planning to be done in Frankfurt in future »from a green perspective«. Why? Because plants provide shade and bind climate-relevant carbon dioxide (CO₂). And they evaporate water via their leaves, which cools the air, evens out temperature peaks and improves the microclimate. All this helps the city, she says, to remain a nice place to live despite climate change. She is convinced: »The population needs to become

aware of this.« That is why the »Green Rooms« have been set up on Goetheplatz, she says, benches with green roofs and walls with an integrated photovoltaic self-irrigation system. »The people of Frankfurt can experience for themselves the refreshing effect of plants on the climate and how nice it feels to sit there,« explains Heilig. The »rooms« are mostly decorated with herbs, grasses and shrubs – suggestions for what people could plant on their own balconies or in their own front gardens, and at the same time an advertisement for the city's campaign »Frankfurt Freshens Up«. »The aim is to encourage more green roofs, facades and backyards in Frankfurt,« says Rosemarie Heilig. In the framework of the programme, each property can apply for funds of up to € 50,000, she says. And advice on dealing with climate conditions as well as how and what to plant is also available. Over 100 applications for funding have been submitted so far and a good 40 have already been put into practice.

»Frankfurt Freshens Up« and the »Green Rooms« are just two examples of how the city wants to introduce its citizens to a more climate-friendly way of life. Overall, the bundle of measures naturally includes more. For example, additional trees are being planted in the streets and sealed surfaces converted to green spaces, parks are being preserved or expanded, for instance by acquiring privately owned land or breaking up sealed areas. That is why Rosemarie Heilig is also against the new underground rail link to Westend Campus which is to run under Grüneburg Park and the Palm Garden – in times of climate change, she says, you cannot endanger one of Frankfurt's largest parks by forcing a railway line under it. Heilig recommends a more ecological option, even if it costs more money – because »climate protection doesn't come for free.«

An easier time for heat-loving species

When it comes to making Frankfurt greener, a certain topic pops up again and again: Namely, that plant species from warmer and drier regions are likely to have an easier time in Frankfurt in the future than indigenous vegetation. »We also see this with plants that migrate naturally to Frankfurt,« says botanist Professor Georg Zizka of Goethe University's Institute of Ecology, Diversity and Evolution. Zizka, who is also deputy director of the Senckenberg Research Institute and Natural History Museum in Frankfurt, is able to trace the development of Frankfurt's vegetation back over decades. »In the climatic mosaic of the city, those plants will have it increasingly easy which are better adapted to drought and heat.« If they are not, they find themselves subjected to increasing stress, become

more prone to disease and contribute to making the urban ecosystem fragile – with consequences for people and all other living things in the city that can hardly be estimated. However, Zizka says that »there are currently too few data available« to be able to judge whether certain heat-loving wild plants have already made their way to Frankfurt on their own initiative due to climate change. He adds, however, that there is clear evidence that over 400 plant species have disappeared from Frankfurt since 1900 as a result, for example, of changes in land use or because green spaces were destroyed which are now to be restored for reasons of climate protection.

Alternatives to private cars

Of course, climate protection and adaptation in a city like Frankfurt cannot succeed solely through the management of green spaces. There are other key factors: Urban planning, construction, water, health as well as mobility and transport. The latter is a topic that concerns Dr Jutta Deffner from the ISOE – Institute for Social-Ecological Research in Frankfurt. The institution was founded in 1989 as an interdisciplinary, independent research institution, among others by Professor Egon Becker, who was a science and higher education researcher at Goethe University.

For Jutta Deffner, the topic of mobility and transport occupies a key role in the climate debate, as car emissions often serve as an example of the volume of climate-relevant greenhouse gas emissions that need to be reduced. As a mobility researcher and urbanologist, she is looking for practical alternatives to current forms of mobility and transport infrastructures. »Tak-

ing a look at what is known as the »modal split« can help here. This is an indicator that shows the percentage share of the individual modes of transport. And we can see from this that traffic within Frankfurt is by all means already climate-friendly. People do a lot on foot or by bike, or else they use public transport.« It is commuter traffic that causes more problems. Finding a solution which is feasible under climate considerations is a task, she says, that only the region as a whole can master. »There are already many projects in the planning stage, such as the North Main Suburban Line from Frankfurt to Hanau or the Western Regional Tangent. But the processes are taking so long that lots of people think nothing is happening.«

Admittedly, says Deffner, there is still sufficient scope within Frankfurt as well for more climate-friendly mobility and traffic planning. The network of cycleways, for example, is not yet ideal, calls for further expansion and needs to be more homogeneous, more clearly signposted and thus safer. Pedestrians also still come up against obstacles in too many places in the city, she adds. Pavements and other infrastructures, for example, do not always invite people to use them; they are too unattractive or too confusing. As an alternative to owning your own car, Jutta Deffner also mentions the »Mobility as a Service« (MaaS) initiative. This concept was developed above all by Sonja Heikkilä and Sampo Hietanen from Finland; Helsinki, the Finnish capital, is one of the places where it is already being successfully put into practice: »With MaaS, you calculate your own individual mobility budget, put together, for example, from

Literature

The data pool comes from the Frankfurt Climate Plan Atlas (1994, 2008 and 2016), ongoing climatic studies since the 1970s and a microclimatic simulation and a local climate projection from 2011, compiled by Hans-Georg Dannert of the Environmental Office of the City of Frankfurt.

www.nordmainische-s-bahn.de
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The problem of commuter traffic: People who live in Frankfurt cycle or use public transport rather than travelling by car. However, the commuter traffic that pours into the city from outside every day is still substantial.

public transport flat rate, cargo bike sharing or e-scooter minutes. In our case, RMV, the Rhine-Main Transport Association, could provide the platform for this. An example from Vienna is also interesting: There, citizens can purchase a public transport ticket for € 365, but at the same time all car users without exception must now pay for parking spaces in the districts. In this way, people are gently urged, as it were, to use their cars less.«

Dreams of a building exhibition

All things considered, there are two ways for the City of Frankfurt to cope with climate change and remain a good place to live: to transform existing urban space in a climate-friendly way and to continue urban development under consideration of climate adaptation aspects. In this context, motivating the population to become involved is one side of the coin.

According to Heilig as city councillor for the environment, the City of Frankfurt is by all means prepared to assume a pioneering role. Behind the scenes at Römer City Hall, staff are working on exactly this: In 2019, for example, the city council said ›Yes‹ to the »Frankfurt Climate Alliance« – a broad catalogue of measures intended to help minimise the consequences of the climate crisis for Frankfurt. These include, for example, more funding for photovoltaic systems, greater use of service water or the obligation to use land economically in the light of progressing densification.

Maintaining the city's appeal as an attractive place to live makes the search for new approaches even more pressing. At the present time, over 60,000 people move to Frankfurt each year, which makes climate-conscious planning and construction indispensable. This raises many questions: Where are there cold air corridors? How can they be preserved and optimised? How can storm and flood protection be improved? The city's »Guidebook on Climate Change and Environmental Protection in Planning and Construction« gives planners and builders advice on how to renovate, convert and construct new buildings in a climate-friendly way. Overall, climate protection criteria need to be given greater weight in building competitions.

As far as new buildings are concerned, putting passive house standards into practice, which could save up to 75 per cent of heating energy, is of particular importance to Rosemarie Heilig. »Passive houses are our showcase project in Frankfurt,« she says. »The new Old Town has also been built in this way.« Nonetheless, there is still a lot of catching up to do, she says, specifically in the area of planning and construction. »We need to move towards becoming a very green city with a car-free city centre. That's the

IN A NUTSHELL

- Climate change is impacting on living conditions in cities such as Frankfurt am Main.
- It is important to reflect as a society on climate adaptation and climate protection, that is, to rebuild existing urban space in a climate-friendly way and to continue urban development under consideration of climate adaptation aspects.
- Important aspects of Frankfurt's climate-friendly development are above all urban green spaces and transport.



The author

Stephan M. Hübner, born in 1974, studied biology at Goethe University and works above all as education and science editor at hr-INFO radio. Previous stages in his career were the Public Relations & Communications Department of Goethe University and the Polytechnic Foundation of Frankfurt am Main. He specialises in biodiversity, zoo biology and science communication.

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challenge for all departments. Commerce, environment, planning: Everyone must pull together,« says Heilig, appealing to her colleagues. Her wish: »An international building exhibition with precisely this motto: How do we want to shape not only Frankfurt but the entire Rhine-Main area in the future? How should the new suburbs look, where people will still be able to live a good life in 30 years and won't be groaning under the burden of climate change and having to put up with its consequences for their health?« When? Preferably already in 2021. As far as protecting the climate is concerned, every second counts. ●



MOTIVES

Making mobility climate-friendly without sacrifice

By Anja Störiko

A liveable, beautiful city with lots of green and short distances – this is something that is actually desirable to everyone. Mobility researcher Martin Lanzendorf and his working group are investigating how we can arrive there. Human beings are the focus of this research: how do they behave in public areas, what are their motives, goals, and desires – and how can their behaviour be influenced?

Our goal is to reduce the resource-devouring mobility in our cities – without having to sacrifice too much and preferably with benefits for the people living there,« explains Professor Martin Lanzendorf, mobility researcher at the Institute for Human Geography at the Faculty of Geosciences/Geography. Every demand to reduce automobility is met with protest and many different kinds of resistance, but these would often be quick to vanish – as soon as it could be made clear that the changes go hand in hand with a better quality of life.

One example is the project »QuartierMobil« in Bornheim, which Lanzendorf's working

group is involved in: The local advisory council initiated the project with the goal of reducing conflicts in traffic and parking. Using a questionnaire, the members of the working group determined the quarter's residents' habits and desires about their daily mobility, means of transportation and conflict situations. The findings served as the basis for the City of Frankfurt, together with planning offices, to develop proposals for redesigning Freiligrathstraße in Bornheim with more greenery and a changed parking situation. »It is important to enter into a dialogue,« says Lanzendorf, emphasising the importance of the survey, which revealed, for example, that some residents wanted trees along the street, while others were concerned about the amount of light coming into their homes. As a compromise, bushes may now be planted, an obvious solution. It is interesting to note that new regulations are more likely to be accepted if they affect everyone, such as generally removing parking spaces or the construction of neighbourhood garages. »In principle, the willingness to convert parking spaces into bicycle spaces, for example, is surprisingly high, even among car owners,« the studies found.

People who cycle are not only doing something for the environment. The number of cyclists is growing, and cities are well advised to respond with better infrastructure and more safety on cycle paths.

5-times

as much profit is generated by bicycle parking spaces compared to car parking spaces with the same area.

A private vehicle is parked
**for 23 of 24
hours.**

Residents of traffic-calmed streets have

3-times

as many acquaintances in the immediate vicinity compared to people who live on streets with a high volume of car traffic.

81 %

of trips in Frankfurt and Offenbach are shorter than 10 km.

»So many little things all too often complicate the path to such compromises: things like lowering the kerb, narrower streets, street greening, and markings have to be planned precisely – and many offices are involved in this,« says the mobility researcher. In his opinion, it is crucial that city and transport planners work more closely together in this process and do not plan past each other. The development of the discussion about the Mainkai in Frankfurt is exemplary of this: the majority wanted traffic calming, but during the year-long closure there was no convincing concept of how the gained road space could be ideally used. »People often forget to explain the advantages – but communication is so important in traffic planning,« says Lanzendorf.

Which colour is optimal?

In Offenbach, the working group is supporting the development of six bicycle lanes as part of the LOEWE focus »Infrastructure – Design – Society«. With the support of the Federal Ministry for the Environment, the city wants to redesignate an entire network of streets on which bicycles have priority and cars are not allowed to drive, or only as a secondary priority and at low speeds. The survey of residents on the first of these project streets revealed a surprisingly positive attitude towards cycling – much more positive than in another residential area in Offenbach with otherwise similar characteristics. Together with the Offenbach University of Art and Design, the working group asked the opinion of Offenbach residents: What is the optimal pavement colour? How should the road run? What kind of vegetation do the residents want? And how should intersections be designed? For example, hatchings are being tested to make the space in which a car door is likely to open visible along parked cars. The mobility design project funded by the Hessian state programme LOEWE aims to clarify whether and how bicycle lanes actually contribute to a change in mobility behaviour, and how they are perceived and evaluated.

Citizens' initiatives in many cities have been pushing for a traffic turnaround since 2016, mostly on the basis of referendums. These »bicycle referendums« have brought movement into the traffic discussion that was previously unthinkable, says Lanzendorf. »People want to live and experience things differently in the inner cities – the car as a status symbol is losing importance. Something is changing in a noticeable way,« says Lanzendorf, summarising the development of the last decade. Many people have realised that cars



Intersection design as well as markings along parked cars in the *Taunusstraße* bicycle lane in Offenbach. After being tested with chalk markings, these design approaches were implemented permanently.



About Martin Lanzendorf

Prof. Dr. Martin Lanzendorf (54) holds the professorship for Mobility Research at the Faculty of Geosciences/Geography. This professorship was established in 2008 as a foundation of the *Rhein-Main-Verkehrsverbund* (RMV) and *ivm GmbH* (Integrated Transport and Mobility Management for the Frankfurt/Rhine-Main region). After studying mathematics and geography in Bonn, Lanzendorf wanted to »do something in the real world«, to make a difference, and moved to the *Wuppertal Institute for Climate, Environment, Energy* for his doctorate. After working in Utrecht, Munich and Leipzig, he came to Frankfurt. At the *Institute of Human Geography*, his department offers a Master's degree in »Geographies of Globalisation« with a minor in »Mobility Research«.

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take up a lot of space in cities – space that could be used differently and better.

Thinking public transport and cycling together

Within the framework of the National Cycling Plan, the working group therefore participated in another project. It aims to link bicycle use and public transport more closely. The free bicycle transport that is a matter of course in the *Rhein-Main-Verkehrsverbund* (Rhine-Main Transport Association) is by no means common everywhere. »Often public transport still sees the bicycle as a competitor,« says Lanzendorf. This perception needs to be changed. Lanzendorf advocates that in future tenders for public transport contracts should also include concepts for networking with cycling. As examples of such a successful concept, he mentions the Mainz rental bike concept or the very safe and practical bike parking facilities at Dutch railway stations. Public transport must also become »smaller, more flexible and more digital«. Berlin, for example, is currently experimenting with the »BerlKönig«, a minibus call system via app, in which the minibus drives around the clock from door to door. »On the one hand, we complain that e-scooters are standing around in the way, but we don't see the fat cars parked in front of the bakery,« says Lanzendorf and suggests a change of perspective: »There is a raging battle for scarce space in cities. On the one hand it is attractive when there is a lot going on. On the other hand everyone wants peace and quiet for themselves personally.« It is the task of politics and society to lead this discussion and to »take people along« on the path to more climate-friendly mobility. Lanzendorf pleads for limiting automobility in a planned way, but at the same time creating incentives that increase acceptance for this path.

It is also important to include all social classes. »People affected and threatened by poverty are less and differently mobile than the average population,« says Stefanie Schwerdtfeger, a member of the working group. In the »Social2Mobility« project in Hanover, the researchers want to increase the social participation of people affected or threatened by financial poverty through mobility offers. »With the *Hartz IV* rate of 36 euros for mobility, for example, you won't get very far in Frankfurt,« says Lanzendorf, talking about the connection between low income and lack of mobility. In an earlier study, his working group had already identified this fact as an important reason for using public transport without a ticket. »Numerous people travel without a ticket because they simply cannot afford it,« says Schwerdtfeger, explaining a finding from a cooperation project with the *Rhein-Main-Verkehrsverbund*. The fact

IN A NUTSHELL

- Mobility research, as conducted at Goethe University, takes place in the midst of society and with the people affected.
- All city residents are caught in a dichotomy between their own comfort and the desire for quiet but lively neighbourhoods.
- Mobility research seeks new paths for liveable cities with flexible mobility for all.

that there are low-price or free tickets in Hesse for pupils, students, senior citizens, job and state employees is very commendable. However, there is still no *Sozialticket* for people with low incomes. »Even the *Frankfurt Pass* does not sufficiently reduce the price of tickets. So people with few financial resources are excluded from public mobility – or alternatively choose illegal strategies of mobility,« she says.

The Lincoln-Siedlung as model

In addition, according to the research team, future settlement planning must take greater account of quality of life. An exciting example is the Lincoln-Siedlung in Darmstadt, which only provides 0.5 parking spaces per flat, limiting options for buying or renting underground parking spaces. Instead, cargo bikes, bicycle and e-car sharing as well as an attractive tram connection are offered. In a current project within the framework of QuartierMobil, the working group is eagerly observing how the concept is accepted, and what needs to be changed and adapted.

Lanzendorf is particularly concerned with urban areas, because: »The change in transport must start in the cities.« It must be possible to satisfy the people there with their diverse needs. Integration with the countryside is another big step. In the Frankfurt area, a first project was the introduction of express bus lines; a next step is the expansion of the S-Bahn ring. But suitable and flexible options must also be made available for groups such as commuters and craftsmen.

You can get ideas from abroad, says Lanzendorf, and cites examples: The congestion charge in Stockholm, for example, which is paid via cameras and the revenue from which flows into improving public transport. Barcelona, on the other hand, is creating »superblocks« out of rows of houses in which cyclists and pedestrians have priority; only walking speed is allowed on



the planted streets – which are becoming »green living rooms«.

This is close to Lanzendorf's vision for the coming decades: »Half as much car traffic in the cities, twice as much green for rest and recreation areas«. In Frankfurt, every second journey by car is less than five kilometres, which means it can easily be covered by bike, on foot or by public transport. »A beautiful city for walking around, shopping, with attractive streets, lots of pedestrian and bicycle traffic – that's a city worth living in,« he says. The decisive factor is the »human scale«. This term was coined by the Danish urban planner Jan Gehl, who inspired Copenhagen to become one of the most liveable cities in the world, with an exemplary amount of pedestrian and bicycle traffic. It has become a »metropolis for the people« as strived for by Lanzendorf and his team. ●

Trendsetting? In Offenbach, bicycle lanes are being installed as part of a federally funded project. Martin Lanzendorf's team scientifically accompanied the redesign, here Senefelderstraße, as part of the LOEWE project.



The author

Dr. Anja Störiko, 55, has a doctorate in microbiology. She works as a freelance journalist for consumer magazines, is editor of the trade journal »BIOspektrum« and has written books on health topics. As a passionate everyday cyclist, she enjoys research projects that make mobility more environmentally friendly.

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Underwater battery in a quarry lake

Innovative intermediate storage for solar and wind energy

By Anne Hardy

Without short-term storage for renewable energy there will be no energy transition – of this, physicist Horst Schmidt-Böcking is convinced. He wants to realise his idea of building underwater pumped-storage power plants at the open-pit coal mine Hambacher Loch.

Horst Schmidt-Böcking points to a graph that shows how many current spikes from solar and wind energy we are unable to use: »In Germany in 2018, we had to deliver 50 billion kilowatt hours of excess ecological electricity to other countries, or discard it, and shut down wind turbines as well,« he regrets. That is far more energy than what the power plants in the Rhenish lignite mining region produce in a year, i. e. 31 billion kilowatt hours (kWh). This unused energy is in turn missing on days that are windless or cloudy. This makes electricity expensive and increases CO₂ emissions.

The retired physics professor estimates that we need ten times as much renewable energy storage capacity for short-term storage as is currently available in Germany through water pumped storage plants. »One bright spot for storage is the huge advances in lithium-ion batteries that have been made recently,« he explains. However, he says, due to the chemicals used, among other things, battery production is not environmentally friendly. In addition, the lifespan is limited to about 3000 charging cycles. »In the short and medium term, you will not be able to cover the demand for short-term storage with such batteries,« Schmidt-Böcking estimates.

Pumped-storage power plants as a model

The Frankfurt atomic physicist from and his retired colleague Gerhard Luther from the University of Saarbrücken have been thinking about an environmentally friendly alternative

to batteries since 2009. They based their work on the principle of pumped-storage power plants. Traditionally, a lake or river is dammed and connected to a lower or higher reservoir. To generate electricity, the water from the upper reservoir is allowed to drive turbines down on a lower altitude. Conversely, excess energy can be stored by pumping the water back up against gravity.

Unfortunately, the geographical conditions for this type of pumped-storage power plant in Germany are not favourable. The recently realised Goldisthal power plant in Thuringia was heavily criticised by environmentalists because of the severe disruption to the landscape and ecosystems and was temporarily stopped by a lawsuit filed by the environmental organisation BUND Thüringen. The top of the mountain Großer Farmdenkopf had to be removed for the reservoir. With its storage capacity of 8.5 gigawatt hours, the power plant, which went into operation in 2003, is one of the largest in Europe.

That is about one third less than the city of Frankfurt consumes in electricity per day. Accordingly, the estimated short-term storage requirement of 400 gigawatt hours is many times that amount. More pumped-storage power plants would have to be built. But

In November 2016, the prototype of the »underwater battery« was lowered to the bottoms of Lake Constance and tested for four weeks. The hollow sphere can temporarily store electricity at the bottom of bodies of water.

IN A NUTSHELL

- The »sea egg« for storing surplus green electricity is based on the principle of the pumped storage power plant.
- A feasibility study at Lake Constance showed that 90 per cent of the stored electricity can be recovered.
- A gigantic »water battery« in the Hambacher Loch could play a key role in the energy transition and secure the future of the Rhenish mining area as an energy region.

that is unrealistic, as the most recent project planned in Atdorf in the Black Forest has shown. The energy provider finally abandoned the project in 2017 because the legally required reviews of the ecological mapping and the land compensation concept seemed too time-consuming and cost-intensive.

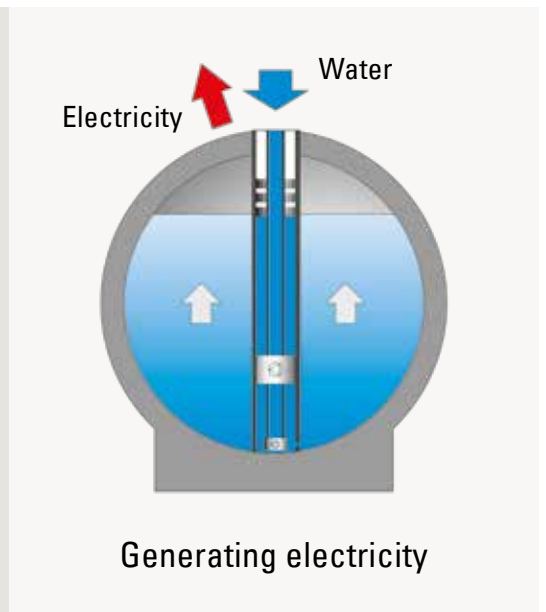
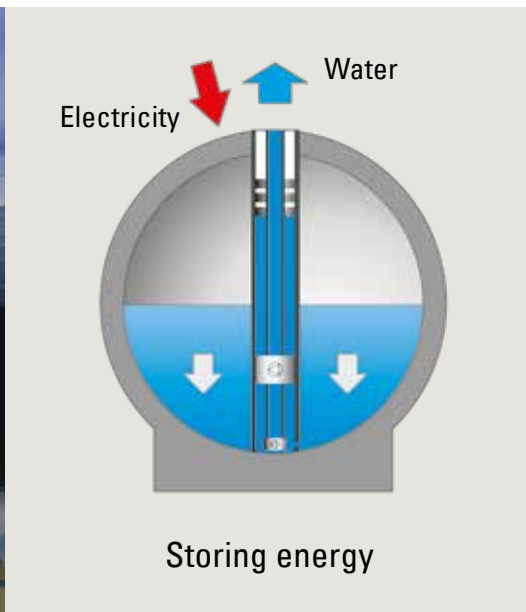
The »sea-egg« in Lake Constance

After the successful feasibility study, Schmidt-Böcking and Luther have further developed their idea on a larger scale: »We propose a huge water battery in the former Hambacher Loch opencast lignite mine explains the physicist. When no more lignite is mined here in 2038, there are plans to flood the area. At present, the groundwater level is being lowered so much that the dryness of the upper soil layers is making itself felt as far away as Luxembourg, 100 kilometres away. Large quantities of groundwater are being pumped into the nearby Erft river. This is less than ideal from an ecological standpoint, as the chemical composition of the water is different from that in the river.

ence in Berlin, which was about the technical realisation of the energy transition. In the bottom of the pit, which is on average about 450 metres deep, a cavity about 100 metres high could be built from concrete over an area of four square kilometres. To make it stable and inexpensive, the interior would be divided into many segments. These would have a much larger volume than the »sea egg« and could be equipped with commercially available turbines.

An invisible underwater pumped-storage power plant such as this could store more than 300 gigawatt hours (GWh) in one cycle. By comparison, that is more than seven times as much as all the existing water pumped-storage plants in Germany combined. At 100 filling cycles per year, the plant would store about 30 billion kilowatt hours (30 terawatt hours, TWh), which corresponds to the amount of energy currently produced in the Rhenish lignite mining area. If one thinks in even larger dimensions and doubles the height of the cavity to 200 metres, the storage capacity of the »water battery« increases to about 400 GWh. At 200 cycles

At the bottom of the lake, an electric pump turbine pumps the sphere empty against the high external pressure of the water. This is how energy is stored. If water is allowed to flow in, the pump turbine generates electricity again (graphic on the right). Entire rows of such spheres could thus temporarily store large amounts of solar or wind power (graphic on the left).



If the Hambacher Loch is flooded, Germany's second largest lake landscape after Lake Constance could be created in North Rhine-Westphalia. This would not only increase the recreational value of the former Rhenish mining area: »You could also build a pumped-storage power plant at the deepest point of the pit, which would store more electrical power than the lignite-fired power plants there have produced so far,« says Schmidt-Böcking. He also calculated this at the beginning of the year at the Handelsblatt confer-

per year, it could cover Germany's entire short-term storage needs for renewable energies.

If all of Germany's surplus wind and solar energy were stored in the Hambach pumped hydro power plant, carbon dioxide emissions could be reduced by more than 30 to 50 million tonnes per year. That corresponds to about five percent of Germany's total CO₂ emissions. You would have to subtract the CO₂ footprint of the concrete structure from that. »You could also save concrete by weighting the cavity against



After the end of open-cast mining, the »Hambacher Loch« will fill with groundwater. Before that, the idea is that an underwater pumped storage power plant could be installed at the deepest point.

buoyancy with overburden, which is produced anyway during earthworks,« Schmidt-Böcking says. He estimates that the carbon dioxide balance would then be compensated after about two years.

Energy transition in the Rhenish mining area

Schmidt-Böcking has sought talks with politicians for the realisation of the project. The timing is favourable, because a total of 14.8 billion euros is to flow into the structural transformation of the Rhenish mining area after the phase-out of lignite by 2038. With the support of the state, the region has already selected 100 projects with which it wants to become a pioneer of the energy transition.

In spring 2020, the city of Kerpen, whose jurisdiction includes the adjacent Hambach open-cast mine, submitted a funding application for the »Speicher Stadt Kerpen« (Storage City Kerpen) to the state of North Rhine-Westphalia together with partners from business and science. Among the 83 future projects, an »energy arena« consisting of wind turbines and photovoltaic systems is planned at the Hambach Loch. It would make sense to combine these with a water battery. Schmidt-Böcking and Luther were able to inspire the technical councillor of the city of Kerpen with the idea.

The physicist proposes to start building the first segments of the pumped hydro power plant



About Horst Schmidt-Böcking

Prof. Dr. Horst Schmidt-Böcking, born in 1939, was a professor at the Institute for Nuclear Physics at Goethe University from 1982 to 2004. With his research group, he developed the COLTRIMS reaction microscope, which is now used by laboratories worldwide to measure reactions in atomic and molecular beams with the highest temporal resolution. He received numerous awards for his work, including the prestigious Stern-Gerlach Medal of the German Physical Society and the Davisson-Germer Prize of the American Physical Society, the first German to do so. Since his retirement, he has been committed to making the historical achievements of Frankfurt physicists known to a broad public. Together with Karin Reich, he wrote a biography of Nobel Prize winner Otto Stern.



The future lake in the Hambacher Loch would have ebb and flow like the North Sea with a large underwater pumped storage power plant. A dam (black line) with sluices (red) could limit the tides in the shore zone to make it usable for recreational activities.

parallel to the phasing out of lignite mining. In this way, there could be a continuous transition from fossil to renewable energy. In addition, many existing jobs would be preserved, because earthworks would still be necessary. Initially, a small auxiliary lake could be created in the shallow area of the Hambacher Loch, connected to the first hollow segments via a pipe system. When lignite mining ends in 2038 and all the hollow-body segments are completed, the pipe connections to the auxiliary lake would be removed and the entire Hambacher Loch flooded. This proposal was included in the final report on the energy reuse of residual opencast mining holes in North Rhine-Westphalia published at the end of 2019, which was commissioned by the North Rhine-Westphalian Ministry of Economics.

kilometres, Schmidt-Böcking proposes separating the shore zone by a ring-shaped dam in which the ebb-tide movement is limited to less than one metre. This stabilises the living conditions for animal and plant life.

In the meantime, Schmidt-Böcking and Luther have contacted the engineering firm schlaich bergemann und partner. The Stuttgart-based company specialises in the planning and construction of visionary facilities in the field of renewable energy. The company will analyse the feasibility and make reliable calculations that can serve as a basis for political decisions. The two physicists hope that politicians will then demonstrate the necessary pioneering spirit. Because that will also be important if the energy transition is to succeed. »I'm 81 now,« says Schmidt-Böcking, »and I'd like to live to see it.« ●



The author

Dr. Anne Hardy, born in 1965, studied physics and holds a doctoral degree in history of science. As a freelance journalist, she specialises in natural science and medical topics.
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A lake with tides

To use the lake landscape as a local recreation area, the tides at the lake need to be factored in. The tidal range depends on the volume of the water battery. »If you want to limit the tidal range to a maximum of one metre, then the maximum storage capacity would be limited to 40 gigawatt hours per cycle,« Schmidt-Böcking calculates. If, on the other hand, the »big solution« with a storage capacity of 250 gigawatt hours is the goal, the tidal range would be about seven metres. Since the flooded lake will ultimately have a water surface of about 42 square

Foto: Philipp Trocha Photography

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Vermögensaufbau trotz Nullzins

Seit Jahren kennen die Zinsen nur eine Richtung: nach unten. Eine Zinswende ist nicht in Sicht. Umso mehr kommt es auf die richtigen Lösungen für attraktive Geldanlagen und eine passgenaue Altersvorsorge an. In einem großen Vergleichstest der Fachzeitschrift „Euro am Sonntag“ zur Beratungsqualität von Banken beim Vermögensaufbau erreichte die BBBank jüngst den ersten Platz.

Die gute Nachricht: Trotz Nullzinsen lohnt es auch heute noch zu sparen. Das sollte allerdings in anderen Bahnen als früher erfolgen. Die BBBank bietet eine ganzheitliche und nachhaltige Anlage- und Vorsorgeberatung auf höchstem Niveau.

Das unterstreichen auch externe Experten immer wieder. Jüngstes Beispiel: Die Finanzzeitschrift „Euro am Sonntag“ hat in einer großen Vergleichsstudie zum Vermögensaufbau (Ausgabe 37/2020) die hervorragende Arbeit der BBBank bestätigt. In der Gesamtbewertung erreichte die BBBank den ersten Platz und die Note „sehr gut“.

„Euro am Sonntag“ urteilte: „In allen Gesprächen wurden die Risikobereitschaft der Testkunden, ihre Erfahrungen mit Vermögensanlagen, ihre bevorzugten Produkte zum Vermögensaufbau und ihre persönlichen Ziele besprochen. Die Berater machten sich ein umfassendes Bild von den konkreten Lebensumständen der Kunden und fielen damit auf, dass sie allesamt eine konkrete Produktempfehlung aussprachen. Das ist deswegen eine Erwähnung wert, weil das im Test nicht immer der Fall war. Die Erläuterungen zu den empfohlenen Produkten, darunter auch Mischfonds, die nicht komplett in Aktien anlegen, und eine fondsbasierte Rentenversicherung, empfanden die Tester als ausführlich und sehr verständlich.“

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An aerial photograph of a large-scale construction site, likely for a fusion reactor, captured during the golden hour of sunrise. The scene is dominated by several tall tower cranes with long horizontal jibs, their silhouettes standing against the soft, orange and pink light of the sky. The ground is a complex of concrete foundations, steel structures, and various construction materials. In the background, a thick layer of mist or fog blankets the valley, with rolling hills visible in the distance under a sky filled with wispy clouds. The overall atmosphere is one of quiet industry and hope for a clean energy future.

Fusion energy: Solar fire on Earth

The vision of clean and inexhaustible electricity

By Dirk Eidemüller

ITER, the experimental fusion reactor, is approaching the operational phase – important input is also coming from Frankfurt. Although the new technology will not contribute to reducing greenhouse gases in the short term, it could form an important pillar of future electricity supply.

It is an old dream of nuclear physics: Fusing light hydrogen atomic nuclei to tap the very energy source that lets stars like the Sun shine for billions of years. Through stable nuclear fusion, power plants would be conceivable that deliver a practically inexhaustible supply of electricity: As much energy could be extracted from 30 kilograms of hydrogen as from a super-tanker with 260,000 metric tons of oil. At the same time, there would be significantly fewer problems with radiating nuclear waste than with nuclear power plants. Although fusion power plants indeed also produce radioactive materials, they are far less and not as long-lived either – this is, in fact, the real problem with highly radioactive waste from power plants.

Way back in the 1950s, fusion power was already proclaimed as the panacea for the era after nuclear energy. At that time, it was said that fusion power would be ready to go in 50 years at the latest. This prediction has, however, hardly changed at all over the last 70 years because, even in optimistic estimates, it will still take several decades until the first fusion power plants go into operation. This is the reason why some of those people who scoff at fusion power have compared it to a certain Berlin airport, whose opening was also repeatedly postponed. However, building an airport is distinctly less complex than building a fusion power plant.

ITER is big enough for solar fire

»After some initial difficulties, work on ITER, the world's largest fusion reactor, is meanwhile

progressing well,« says Holger Podlech, professor for accelerator physics at Goethe University. In a fusion reactor, an extremely hot and very thin plasma is enclosed in a doughnut-shaped ring with the help of special magnetic fields. It must not touch the wall, otherwise it would cool down immediately, making any form of fusion impossible. By means of microwaves, the plasma is heated to a very high temperature – several million degrees – until finally the atomic nuclei can overcome their reciprocal electrostatic repulsion, and the fusion reaction starts. This then releases enormous amounts of energy.

»This means that quite a lot of energy has to be put into the plasma first, before it produces energy itself,« explains Podlech. Thus, to obtain a positive energy balance overall, fusion power plants must be relatively big. In smaller plants, too much plasma is lost, making them uneconomical. ITER is large enough to enable ignition of the solar fire. It is not, however, suitable as a power plant that operates economically. It should serve as an experimental fusion reactor that allows researchers over the coming years to study the behaviour of the hot plasma. ITER should go into operation around the middle of the decade, initially, however, without properly igniting the plasma.

After about ten years of extensive material tests and experiments with the plasma, around 2035 the solar fire in the plasma chamber should then shine for the first time, that is, a stable fusion reaction will be ignited. This is exactly what earlier experiments had also promised, but they failed time and again due to unforeseen difficulties, such as peculiar turbulences in the hot plasma. Through sophisticated computer simulations and thanks to ITER's larger size, it should be possible to get these problems under control. »I'm absolutely certain that ITER will be a success,« says Podlech. The fundamental principles are meanwhile well enough understood,

The ITER experimental reactor has been under construction in France since 2007. It will be used to test whether electricity can be produced from energy generated by nuclear fusion.



The ITER construction site in February 2020. According to the current planning status, the first plasma will be ignited in 2025. Power generation tests will start ten years later.

IN A NUTSHELL

- Fusion energy generated when hydrogen nuclei fuse could become a just about inexhaustible source of energy.
- Better simulations of the solar fire in the fusion reactor and the development of new materials will help to solve scientific and technical problems.
- Fusion power plants will go into operation too late to help achieve the climate goal of 1.5 °C. However, they could one day cover the base load in conurbations.

and the problems of the preceding projects have been analysed in detail. In the past, fusion research was approached a little too optimistically. In the meantime, many of the properties of fusion plasmas that could only be roughly gauged at the time (and were gauged too positively) can be simulated in detail

Only a small amount of hot and hazardous material

The material properties of the chamber enclosing the solar fire play a particularly important role in the operation of future fusion power plants. It has to stand up to quite a bit, although the hot plasma is very thin, and the chamber houses just a few grams of it. This is a major safety advantage compared to nuclear power plants, which hold many tons of uranium and fission products. If something goes wrong in a fusion power plant, not a lot can happen. The amount of hot and hazardous material is simply too small. However, ignited plasma produces tremendous heat, and then there is the problem of extensive neutron radiation. This penetrates deep into the wall structure, blasts against the atomic nuclei of the materials and violently shakes their inner structure. It also allows gases to form which can also damage the wall structures from the inside.

»Indeed, the forces to which the materials in the torus are subjected are enormous and one of the biggest engineering challenges in the construction of fusion power plants,« explains Podlech. Researchers are currently working on composites made from special types of high-strength steel, which are expected to guarantee a certain durability. If the expensive structures had to be replaced too often, this would make operating a fusion power plant unprofitable.

At the present time, however, there is no possibility to conduct trials with such materials on a test stand under conditions as harsh as

those the solar fire will create in the plasma chamber – not even in the most powerful research reactors. Simulations are not suitable either because they can never reproduce all the dimensions of such an extreme load. That is why the working group led by accelerator expert Podlech was involved in developing what is known as the International Fusion Materials Irradiation Facility (IFMIF). In this large-scale facility, powerful particle accelerators will produce a high-energy neutron beam that displays similar properties to the ignited plasma in a fusion power plant. This will make it possible to test materials that are to be used at ITER around the year 2035, when it can hopefully be said: The solar fire is burning steadily.

No panacea against climate change

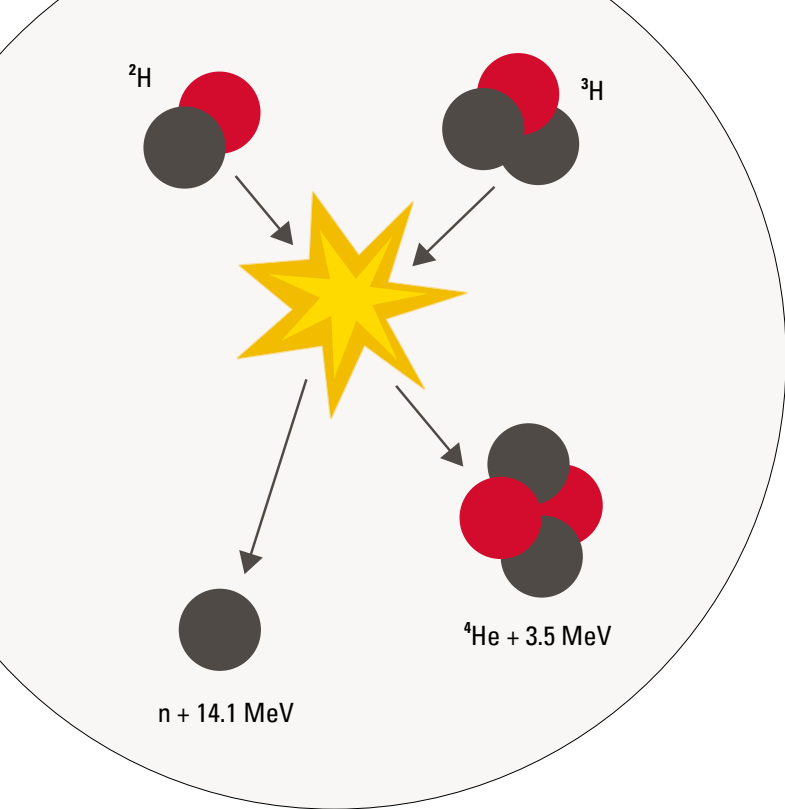
But how does the future of fusion power look? Major developments in renewable energies have been seen worldwide over the last years in view of climate change – unfortunately with considerable delay – but nonetheless they are finally taking root. However, at least so far, renewable energies are scarcely suitable for covering the base load because electricity grids are insufficiently interconnected and storage possibilities are to date far too small (however, please see too the article »Electricity Storage«, page 89). Some countries are placing their bets on nuclear



About Holger Podlech

Prof. Dr. Holger Podlech, born in 1968, is head of the LINAC WG at the Institute of Applied Physics, which is working on the development of particle accelerators and their subcomponents. One of his projects deals with transmutation, which should help to shorten the half-lives of radioactive waste from nuclear power plants. Physicist Podlech has been professor at Goethe University since 2012, prior to which he worked as a lecturer and researcher there as well as at Michigan State University and the Max Planck Institute for Nuclear Physics in Heidelberg.

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When the atomic nuclei of the two heavy hydrogen isotopes deuterium (2H) and tritium (3H) fuse, helium (4He) and a neutron (n) are produced. Researchers are exploring whether the energy released in this reaction can be used to generate electricity.

energy, at least as a bridge technology, while other countries, such as Germany, are focusing on coal, which is particularly harmful to the environment. According to calculations by climate researchers, humanity would have to consistently lower global greenhouse gas emissions down to zero already by the middle of this century in order to avoid dangerous global warming with highly negative consequences.

»Fusion power will not be a panacea for the 2050s, that's already obvious,« says Podlech. Even if everything at ITER goes as hoped, and the experiments deliver all the desired results by about 2040, the construction of countless large-scale fusion power plants could not be expected immediately afterwards. »After an experimental reactor like ITER, a larger prototype power plant would first be built, which although already suitable for electricity production also serves to gather experience in the operation of such plants,« says Podlech.



The author

Dirk Eidemüller, born in 1975, studied physics (major) and philosophy (minor) in Darmstadt, Heidelberg, Rome and Berlin, earning a Diplom in astroparticle physics and his doctoral degree in philosophy of science. He lives in Berlin and works as a freelance author and science journalist.

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Future electricity supplier for conurbations

The planning and construction of such a prototype fusion power plant would certainly take well over a decade. Once it has supplied energy for a few years as planned, a more standardised construction line of commercial fusion power plants could then be developed on the basis of this experience. Building such large plants is also likely to take 10 to 20 years. This means that fusion power – even if everything were to run like clockwork – could not contribute to solving climate problems by 2050. It could, however, nonetheless serve as an interesting

energy source later this century. Compared to renewable energies, it has the advantage of being able to generate a tremendous amount of energy in a small space. A fusion power plant could deliver about twice as much electricity as a large nuclear power plant. This makes the technology interesting for conurbations as well as for regions where not enough electricity for industry and the local population can be generated from either solar or wind power.

Of course, it is difficult to predict how prices in the energy market will develop up until the second half of this century. It might be that by then fusion power is hopelessly outpaced for reasons of economics, and regenerative energy sources, such as hydrogen or biofuels, or innovative storage technologies will be able to cover the entire energy demand at unbeatably low prices – but perhaps not. »I think we should explore fusion energy in depth,« says Podlech. »It's always good to have an ace up our sleeve in case we run into difficulties with other types of energy.« This could also be the case if conflicts over land use erupt or there are interventions in the landscape. Even if fusion research costs a few billion: Compared to international expenditure for energy supply, this is an almost infinitesimal sum. ●



How EU agricultural policy could contribute to climate protection

By Heike Nitsch
and Jörg Schramek

More than 7 percent of the greenhouse gases released in Germany come from agriculture: from ruminant cattle, for example, and from nitrogenous fertilisers. In addition, there are emissions from drained organic soils or from rotting humus from ploughed-up grassland. Around 58 billion euros flow from the EU budget into European agriculture every year. This gives the federal and state governments many opportunities to do something for climate protection.

The dangers of climate change are known, and climate protection targets have been adopted. We know where greenhouse gases come from and how they develop. Scientific investigations into where to start in order to reduce emissions have been going on for a long time. However, the implementation of the goals must take place through concrete instruments and measures.

To achieve the climate protection goals to which Germany has committed itself, agriculture must also contribute. The EU's Common Agricultural Policy (CAP) is of great importance

for shaping agriculture in the EU due to its considerable budget and the large area it reaches, and thus also for climate protection in connection with this sector.

One focus of the work of the Institute for Rural Development Research at Goethe University (IFRS) is the analysis of the influence of agriculture on the environment. The IFRS uses scientific findings for the evaluation and further development of political steering instruments. The upcoming reform of the Common Agricultural Policy therefore prompted the IFRS to conduct a study that was financially supported by *Landwirtschaftliche Rentenbank* (Nitsch & Schramek, 2020). The study examined which options for climate protection are made possible by the support measures of the Common Agricultural Policy and the extent to which the federal states use them.

Greenhouse gas emissions from agriculture

In 2017, the agricultural sector accounted for 7.3 per cent of the total greenhouse gas emissions reported for Germany (UBA, 2019). These have not decreased significantly in recent years (see figure on page 102). The generation of emissions from agriculture is due, on the one hand, to the keeping of ruminants – cattle,

Trees in fields and pastures: Agroforestry systems increase the humus content of arable land and thus bind CO₂. They also improve groundwater recharge, create a humid microclimate in dry summers and protect against sun and wind. www.agroforst-info.de

27 million pigs and 12 million cattle in Germany produce large quantities of liquid manure, which is spread on fields as agricultural fertiliser. The greenhouse gas nitrous oxide (N_2O) escapes from the manure while still in the stable.



sheep and goats – which produce the greenhouse gas methane through natural microorganism activity in their rumen. In addition, nitrogen oxides (N_2O) escape into the atmosphere during the storage of farm manure such as slurry and due to nitrogen fertilisation. In addition to these 7.3 per cent, there are emissions of carbon dioxide (CO_2) from soils due to the decomposition of organic matter, especially the cultivation of peat soils and the ploughing up of grassland. With regard to the reported greenhouse gas emissions, it must be taken into account that energy use in agriculture as well as energy use in the production of fertilisers and associated emissions are not directly assigned to the agriculture sector. Emissions in other countries from which animal feed is imported are not reported either.

With regard to emissions from livestock farming, the most effective approach to climate protection would be to reduce the number of animals. However, if animal food consumption remains unchanged, this problem will merely be shifted to other regions of the world. However, demand for products and nutrition are not directly influenced by the EU's Common Agricultural Policy. This article focuses on climate protection measures on agricultural land. These are particularly related to the use of nitrogenous fertilisers and the storage of organic carbon in the soil.

Measures in the Common Agricultural Policy

The focus of the Common Agricultural Policy has changed in recent decades. While for many decades it served market and price policy, the largest share now goes to what are known as direct payments, which are granted to farms per hectare. Since 2005, these payments have been linked to compliance with standards in the areas of food safety, plant and animal health, environmental protection and animal welfare (cross compliance). In 2015, a greening component was also introduced, which, among other things, restricts the conversion of grassland. Agricultural enterprises receiving direct payments must comply with these minimum standards.

In addition, within the framework of the Common Agricultural Policy, there are support measures in which farms and other target groups can participate on a voluntary basis. The EU co-finances this support, and the Member States – or in Germany's case the Federal Government and the *Länder* – use state funds for the other part of the financing. The *Länder* present these support measures within in their rural development programmes (RDPs).

One of the declared objectives of the EU's Common Agricultural Policy in the current funding period (2014–2020) as well as the

Common Agricultural Policy after 2020 is to contribute to climate protection. And the Climate Protection Programme 2030 (BMU, 2016) for Germany emphasises that the national design of the Common Agricultural Policy of the EU offers Member States comprehensive opportunities to increase the level of environmental and climate protection.

Climate-relevant measures by the Länder

Agri-environmental and climate measures (AECM) of the Common Agricultural Policy, which remunerate certain management requirements, and the promotion of organic farming are central measures in the current funding period that are intended to contribute to the reduction of greenhouse gas emissions from agricultural land use. Throughout Germany, however, only individual agri-environmental and climate measures are primarily assigned to climate protection. This applies above all to the low-emission application of manure and the conversion of arable land to grassland. In some *Länder* there are further agri-environmental and climate measures for grassland that are aimed at organic soils and thus mostly at conserving soil carbon. Usually, these are measures that support adapted management even at elevated water levels and can thus accompany rewetting or counteract possible intensification or drainage. Beyond these measures, climate protection is a side effect of activities that primarily serve other goals. This is the case, for example, with organic farming, the promotion



Foto: Löwenzahn/pixelio

of diverse crops in arable farming with a minimum proportion of nitrogen-fixing legumes such as beans, clover or lucerne, the cultivation of catch crops and undersown crops, and various measures for the extensification of grassland. Individual *Länder* promote techniques of targeted and demand-oriented nitrogen use in order to reduce losses in fertilisation.

Financial support for investments, for example in equipment for low-emission slurry spreading or in gas-tight covers for slurry stores, also contributes to reducing greenhouse gas emissions and is widely offered. Investments for peatland protection may also be part of the support.

Forestry support measures go beyond agricultural land use and are expected to contribute in particular to carbon storage and the provision of renewable energy. However, they play a minor role in the budget of rural development programmes compared to measures on agricultural land. Increased energy efficiency, which was also not a focus of this study, can be part of support for investments in farms, for example in connection with the conversion of stables, greenhouses or in the context of processing and marketing.

Knowledge transfer and advisory services as well as studies and planning are supported as flanking, preparatory or indirect measures. Pilot projects can also promote the development of innovative, resource- and environmentally-friendly products and processes in the area of climate protection. In addition, the promotion of joint concepts or cooperation can be relevant and is used accordingly in individual *Länder*, e.g. to support the regional cooperation necessary in the rewetting of peatland.

It must be taken into account, however, that the rural development programmes only represent a portion of the funding measures offered in Germany. Other measures are promoted outside these programmes using only *Land* resources or other funds. This applies, for example, in part

Around 80 per cent of organic soils in Germany are used for agriculture and forestry, such as this meadow near the Verden Moor in Lower Saxony. For this purpose, peatland areas are drained, which leads to the decomposing peat releasing large amounts of CO₂.

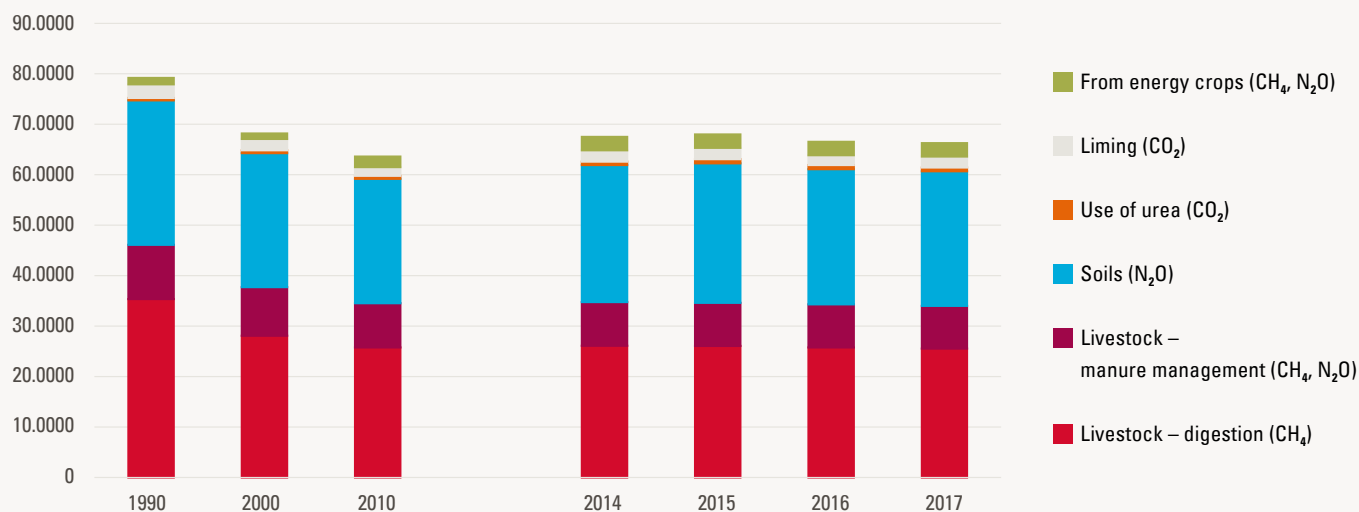
IN A NUTSHELL

- The EU's Common Agricultural Policy (CAP) must contribute to climate protection. There are several approaches it pursues.
- In the voluntary support measures offered so far, such as the agri-environmental and climate measures, climate protection is usually more of a side effect.
- In future, the conditions for receiving funding should take greater account of climate protection effects.
- Based on an exchange of experience, the *Länder* should optimise voluntary climate protection measures and offer them more widely, also taking into account newer approaches, such as the adapted use of rewetted organic soils.

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Greenhouse gas emissions from German agriculture and changes in relation to 1990 in percent



Starting points for climate protection measures in agricultural land use

(for a more detailed presentation and literature sources see Nitsch & Schramek, 2020)

- Increase the efficiency of nitrogen fertilisation:**
 Improved nitrogen utilisation through better nutrient balancing and fertiliser planning and the use of appropriate crop rotations and emission-reducing techniques in the storage, treatment and application of fertilisers can reduce nitrogen losses and consequently N₂O emissions as well.
- Protection of agriculturally used organic soils:**
 The key measure for climate protection is raising the water level on drained sites. Rewetted areas are taken out of production, can be grazed or maintained as wet meadows, or can continue to be used in the future for the production of animal feed or substrates for material or energy use with the help of wetland-loving plants such as cattails, reeds or alders as »paludiculture«.
- Protection of permanent grassland:**
 Avoiding the conversion of permanent grassland prevents greenhouse gas emissions due to the resulting humus depletion. This is particularly important on humus-rich soils (especially peatlands).
- Conversion of arable land into permanent grassland:**
 Provided that the resulting grassland is maintained in the long term, there is an accumulation of organic carbon in the soil. However, the increase is much slower than the loss in the case of grassland conversion.
- Preservation and promotion of humus content in arable soils:**
 Organic fertilisation, the incorporation of crop residues and the increased cultivation of crops with intensive root penetration or of woody biomass can increase the humus content and thus contribute to CO₂ storage. However, the contribution to climate protection via these measures is fraught with great uncertainties, is limited in time and without lasting guarantee. While the use of pyrolysed biochar can be expected to fix carbon in the long term, there is still a need for research on further effects.
- Organic farming:**
 In terms of area, organic farming results in lower greenhouse gas emissions due to higher stocks of soil organic matter and lower nitrogen surpluses. However, this advantage is relativised when it is related to yield.

Many of these measures result in synergies with other environmental objectives such as water and biodiversity protection, soil fertility and adapting to climate change.

to peatland protection. In addition, there are more and more predominantly private-sector initiatives that reward carbon enrichment on contractually bound land, finance this through the sale of certificates for voluntary greenhouse gas compensation, and use this to fund the rewetting of peatlands or humus enrichment on arable land. The promotion of renewable energies is mainly done with energy policy instruments.

Moreover, voluntary support measures can only complement other climate protection instruments. For example, regulatory requirements under fertiliser law limit the use of fertilisers. Mandatory requirements can no longer be supported by voluntary funding measures. Another instrument and a consistent step would be to price external costs arising from activities. This could be done with reference to climate protection, e. g. via a nitrogen levy or via a pricing of greenhouse gas emissions (cf. Isermeyer et al., 2019).

Outlook for climate protection in the Common Agricultural Policy after 2020

The EU Commission has submitted a proposal for the Common Agricultural Policy after 2020, which are currently being discussed with the EU Parliament and the Member States and must then be jointly decided. It offers sufficient opportunities for intervention and scope to use it in favour of climate protection.

This starts with regulations on the conditions under which land may receive direct payments. To increase farmers' willingness to participate, for example, direct payments should be maintained on rewetted organic soils, even if they are no longer used for agriculture. This also applies to land on which agricultural use continues under photovoltaic systems. The minimum standards for receiving payments should, for example, exclude the deepening drainage of peat soils.

The *Länder* should exchange experiences to identify particularly effective existing climate-protection measures and implementation options for the voluntary promotion measures, and optimise these measures and offer them on a widespread basis. To this end, newer approaches for possible promotion should also be taken into account. One example would be the promotion of agroforestry systems. These are land use systems in which agricultural land use is combined with the planting of trees or hedges. Furthermore, paludiculture could be promoted, i. e. farming on rewetted peat soils, as well as innovative techniques in the field of fertilisation, such as the acidification of slurry, which can reduce ammonia emissions even before it is applied. With regard to the increasingly discussed storage of carbon in arable soils, the use of biochar for long-term carbon sequestration may become relevant in the future.

A broad mix of instruments and measures is necessary for climate-friendly agriculture. The post-2020 Common Agricultural Policy must contribute to this goal. ●

The authors



Heike Nitsch, born in 1968, studied geocology at the University of Bayreuth and graduated with a thesis on the nutrient effect of biowaste compost. She worked as a research assistant at the Institute of Rural Studies of the Thünen Institute for nine years and at the Helmholtz Centre for Environmental Research (UFZ) in Leipzig for one and a half years. Since 2013, she has been working at the Institute for Rural Development Research (IfLS) as a research associate focusing on the analysis and evaluation of land use management measures and sustainable land use for the protection of abiotic and biotic resources with a current focus on climate protection.

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Jörg Schramek, born in 1966, studied agriculture at the Technical University of Munich and graduated with a thesis on the effects of rain on the surface structure («roughness») of arable soils in relation to soil type. He has worked at the IfLS since 1994, first as a research assistant and then as head of the Department of Rural Development, Agriculture and Environment. In 2008, he also took over the management of the IfLS. His work focuses on the evaluation of rural development programmes, policy impact assessment, advice on the further development of agricultural policy instruments, the socio-economics of nature conservation-oriented regional development, organic farming and agriculture in urban areas.

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»Research is our lever«

Professor Birgitta Wolff, president of Goethe University, on the growing significance of sustainability research during her term of office

Anke Sauter: Professor Wolff, there are universities that have supposedly already been climate neutral for years. How climate friendly is Goethe University?

Birgitta Wolff: We need to differentiate here: How do we behave as an organisation and what can we, as a research and education institution, offer society? As an organisation, it's naturally important precisely in view of our size that our actions are as environmentally friendly as possible. But as a university with outstanding researchers, we've so much more to offer: We produce sound research results that can advance humanity as a whole.

When you look back at your six-year term of office: What has changed in this field of research?

During my term of office, we launched a profile-building process that embraced the whole of Goethe University and involved a large number of researchers. The result of this multi-stage process is a profile that aims to mirror the dynamics of the research landscape. We now have six profile areas, of which »Climate, Earth, Environment« is a separate one, meaning that we have repositioned sustainability research. Sustainability is now firmly established at the »top« level of our research goals and will in future make a significant contribution to Goethe University's profile. This topic did not appear in our previous research profile with the »tiles«.

Presumably because in the past there was no Collaborative Research Centre in this field?

Perhaps. In fact, there is still no Collaborative Research Centre, but there are

other formats instead. And we've created a solid foundation for further developing this profile area. However, there will, of course, still be enough to do here for my successor Enrico Schleiff.

What are the consequences for sustainability research now that it has its own profile area?

The research profile allows us to enhance the visibility of this area and support it in a more targeted manner. Overall, it's already very lively: There are not only projects with the German Research Foundation but also with and for the Federal State of Hessen as well as with the City of Frankfurt. That's the great thing about this very broad field of work – the fact that it has very many facets. You can explore very abstract aspects of ecological, economic and social sustainability, but also prompt very concrete changes. Georg Zizka, for example, has a project where he is compiling a biotope mapping of the City of Frankfurt, Wolfgang Brüggemann is running a project with the Federal State of Hessen on the woodlands of the future. The researchers working in the area of »Climate, Earth, Environment« feel responsible for current problems. As far as the topic of environment is concerned, this is more or less automatic.

Scientific findings are one thing, but above all it's also a matter of communicating existing knowledge to a broader public.

This is where the profile-building process has also triggered a lot of new activities and brought various research disciplines together. Professor Böhning-Gaese and the researchers at Senckenberg, for example, want to take the »Planetary Thinking« format to the next level and the

Forschungskolleg Humanwissenschaften in Bad Homburg is involved as a platform. There are some great cross-disciplinary initiatives; we will have to see in which direction they develop and how we can give them a boost.

Another central topic is science communication: How can scientific results be communicated to people in a more understandable way?

I believe it's less a case of a fundamental lack of knowledge or information when it comes to sustainability issues. The difficulty lies rather in putting knowledge into practice. This phenomenon can also be observed in change management in organisations; I dealt with this many years ago in my postdoctoral dissertation. Knowing what needs to be done is not the be-all and end-all. Getting people to put this knowledge into practice is an art. But I'm optimistic that this will work eventually. After all, we've seen with digitalisation, for example, that it works: If we had asked around a year ago who uses videoconferencing or – at the university, for example, – who likes working with the OLAT platform, we would have reaped totally different answers than now. The way we communicate specialist topics is, of course, also important: We need to convey the urgency in a credible manner, make behavioural changes attractive and not intimidate people with a menacing scenario of future apocalypses. And we have to create clear guidelines for appropriate behaviour.

The focus is also on the economy as a major energy consumer, the automotive industry so sluggish at adapting. To what extent, in your view, is the onus here on the Faculty of Economics and Business Administration?

Experts at the Faculty of Economics and Business Administration are working on the topic too. There is the Green Finance branch at SAFE, the new Leibniz Institute, too. Both environmental as well as business economists at the faculty are thinking about it; economic decisions need to be reviewed under consideration of cost aspects and reputation, and corporate management needs to adjust accordingly. There is still a lot of research work to be done on this in all areas of

»We've repositioned sustainability research«: For Birgitta Wolff, president of Goethe University, the climate crisis is very high up on the research agenda.



a high level of computing performance in a more environmentally friendly way.

The Fridays-for-Future movement has given environmental topics another powerful boost. Has this also had an impact at administrative level?

We belong to the »Carbon-neutral Hessen Network« and are working together with the regional government. As far as climate policy goals are concerned, the university and the state are on the same wavelength. I believe, however, that at the end of the day we as Goethe University can make a much, much greater contribution through environment-related research and environmental education. I would always consider environment-related research to be our greater contribution than our own efforts at prevention.

On the initiative of students and other groups, the Goethe Green Office has been set up. What's the current status?

The decision has been made; it has started to operate in a preliminary way. Here too, we need to proceed in a scientifically sound manner. Many of the Green Office people have already familiarised themselves in depth with the different topics and are putting forward a variety of ideas. We need to see, together with the experts from our Energy Management team, whether all these good ideas can actually be put into practice. It seems that some of them cannot be implemented one to one. An example is bicycle leasing: The lovely idea that we, as employers, subsidise the use of bicycles is difficult insofar as we have state budget regulations and receive our funds explicitly for research and teaching. I think there is a lot of work ahead for a future Green Office.

Thank you very much for the interview.

the social sciences, more so than in the natural sciences. We also need to understand how different variants of environmental pricing work. Do we place our bets on emissions trading or on completely different mechanisms? It's often very difficult to gauge what can work and what cannot, and the debate here often gets stifled by the hum of political controversies. We as a university can support this discourse more.

How do you, as an economist, see the role of the economy in the transformation process?

As an economist, I think that as a society we should reduce environmental impacts where it's easiest, simplest and least costly for society as a whole. How these costs are then borne by society and not offloaded onto individual companies, which, in the immediate sense, are the polluters, needs to be discussed. The »Joe Bloggs« solution of simply raising environmental standards for German companies is not a good one; everyone knows that. Because as long as environmental standards only apply in Germany, there will be no worldwide improvement whatsoever. Instead, the dirty industries can simply continue to shift to locations

where regulation is less rigorous. International cooperation will be crucial.

Can we talk a bit more about Goethe University as an organisation? If it wants to behave in an environmentally friendly manner, it's dependent on each individual.

Yes, the Federal State of Hessen compensates for official travel, for example. That is, of course, a completely different approach to avoiding official travel altogether. I believe we can make a contribution here. We're seeing right now in times of the pandemic just how superfluous a lot of official travel is. On the other hand, we're also learning how detrimental to the environment an excessive use of computers and videoconferencing is. And this brings us back to our brand essence – research: Consider the topic of high-performance computing, a field where Volker Lindenstruth is making tremendous progress. His research results are not only exciting for science but also for us as an organisation. We're using his technology and thus have lower energy consumption in high-performance computing than if we were to use conventional computers. At the same time, we can also offer this knowledge to others and help to supply

NO

STANDPOINT:

Will we manage to halt climate change and stop global warming at 1.5 °C?

We will not manage to do this, that is, at least not within the goals of the Paris Agreement. We need to differentiate here: We will undoubtedly manage to halt climate change, but only above the targeted 2°C. And that is precisely the reason why we should, on the one hand, do everything in our power to reduce global anthropogenic emissions of greenhouse gases as quickly as possible (mitigation), but also, on the other hand, focus just as intently on adaptation.

I would like to list four problems by way of example:

1. The trend problem: Atmospheric CO₂ concentration has risen continuously since 1960. Depending on the season, it is now between 410 and 420 ppm (about 280 ppm would be normal), and absolutely no change in this trend, as a result, for example, of the IPCC reports or the international climate conferences in Copenhagen or Paris, is anywhere in sight. There is no evidence which suggests

that this will change significantly in the next 40 years.

2. The freeloader problem: It is a profoundly human phenomenon: If a good (such as the atmosphere) is freely available, then why should I, as a person or a state, be the one to restrict myself in its use, when others – either the bigger polluters of the atmosphere or those most affected by climate change – should set a good example first? Here too, there is absolutely no evidence that this freeloader problem in the community of nations will be resolved in the near future.

3. The complexity problem: The climate problem is very closely linked with other sustainability issues: That is why we speak of an »Earth system«, where the main components – atmosphere, hydrosphere, biosphere and geosphere – are closely interconnected. For example, burning biomass, that is, woodlands, produces a significant percentage of all anthropogenic CO₂ emissions; the increase in atmospheric CO₂ leads to ocean acidifica-

tion and coral mortality. In this complex web of interactions, there are countless conflicting goals which are hard to resolve: Biodiesel is good for climate protection but harmful for biodiversity, climate engineering (e.g. the introduction of large amounts of sulphur dioxide into the stratosphere in order to reduce solar radiation on the Earth) as well as »final storage« of CO₂ underground (»carbon capture and storage«) are rejected by the (German) population for safety reasons; a type of agriculture which is better balanced from a climatic and ecological perspective is unenforceable at political level. This situation will not change either.

4. The distribution problem: On a global average, CO₂ emissions per capita/year are currently about 4.5 metric tons. However, around three billion people greatly exceed this average (USA: approximately 15 metric tons of CO₂ per capita/year, Germany: approximately 8 metric tons of CO₂ per capita/year). Four billion people currently produce less than 2 metric tons of CO₂ emissions per capita/year (IEA data from 2020 which, however, refer only to energy-related CO₂ emissions). That the IPCC's aspired goal of around two metric tons of CO₂ per capita and citizen can be achieved in due time – with this unequal distribution of CO₂ emissions per capita/year and the problems 1 – 3 described above – is indeed highly unlikely.

What is possible in theory and with models is simply endlessly more difficult in practice. Nevertheless, there is no question about it: There is a pressing need for action! After all, the latest models estimate that we will have to resettle between 150 and 630 million people by the end of this century due to rising sea levels induced by climate change, depending on how CO₂ emissions develop. We should therefore work hard not only on mitigation but also on adaptation.



The author

Volker Mosbrugger, born in 1953, studied biology, marine biology and chemistry at the University of Freiburg and in Montpellier, France, and earned his doctoral degree in Freiburg in 1983 with a thesis in the field of palaeontology. He completed his post-doctoral degree (Habilitation) at the University of Bonn in 1989, was professor at the Department of Geosciences of the

University of Tübingen from 1990 to 2005 and then became director general of the Senckenberg Research Institute and Natural History Museum and professor at the Department of Geosciences of Goethe University. His main research interests are the evolution and constructional morphology of land plants, the evolution of terrestrial ecosystems and terrestrial palaeoclimatology. Studying the impact of climate change and the subsequent loss of biodiversity on humans and the Earth system is his main concern. Professor Mosbrugger has received numerous distinctions, including the Gottfried Wilhelm Leibniz Prize of the German Research Foundation and an honorary doctorate from the University of Lyon.

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WILL WE SORT IT OUT OR NOT?

YES

I am a climate optimist. Climate change poses a huge challenge, it is a task for the whole of humanity – and it will take more than **one** Hercules or **one** Greta Thunberg to prevent a catastrophe from developing. It will take all of us. Will we together, will our global society be able to master this task?

I call for realistic optimism in answering this question. Only with optimism will we all be able to find the strength and inner drive – despite all obstacles, constraints, habits, comforts and our weaker selves – to change course quickly enough. And I am firmly convinced: We can do it!

Climate protection has become a central task: What makes me so optimistic? A few facts: Between 2010 and 2019, the United Kingdom managed to reduce its greenhouse gas emissions by 29 per cent. In the summer of 2020, China announced for the first time that it would be carbon-neutral by 2060. In many places, solar power is meanwhile less expensive than electricity generated from fossil fuels – and this without subsidies. Nowadays, even CEOs no longer regard sustainability as a troublesome side issue but as a central task that also offers huge opportunities for companies. The first to deliver environmentally friendly, sustainable and climate-neutral concepts, technologies and business ideas will reap the rewards. By contrast, those who persist with fossil technology will not survive the next 20 years.

Enormous increase in knowledge: At the present time, 80 per cent of global energy production is based on fossil fuels, and global CO₂ emissions have risen by 63 per cent in the last 30 years. These are two facts that make me pessimistic. In these 30 years, however, our knowledge about climate change and the protective measures required has multiplied. All strata of society and not just experts and environmental activists are now taking them seriously. With the 1.5°C target, the Paris Agreement has set a rea-

sonable limit, one that Fridays for Future everywhere is vehemently calling for.

We are already feeling the consequences: The consequences of climate change already predicted long ago are indeed occurring more and more frequently and causing increasingly serious damage. And this not only in far-off countries. Instead, we are seeing horrendous damage to our own forests right on our doorstep and experiencing heat waves at first hand. We are fully aware that forest fires, such as those that raged in Australia, Siberia and California this year, will strike even more dramatically with each further tenth of a degree that global warming increases. If we keep these images in mind, we will succeed in turning knowledge into action.

Instruments are in place: The necessary instruments have been developed over the past years: Carbon pricing systems and

emissions trading, which is now finally working and having an impact. Technical solutions to replace combustion engines, coal-fired power plants, oil and gas heating, sustainability concepts for transport and agriculture and above all the readiness among a broad majority of the population to tackle the problem resolutely and collectively self-impose the regulations needed to reduce emissions. We still have a long way to go, and gigantic efforts are necessary, but I am convinced that in 20 to 30 years' time the use of fossil energy will be globally outlawed just like the production of CFCs is today.

Anyone who has children understands his or her own responsibility. We must ensure that their future is not severely constrained by our overuse of the atmosphere and the biosphere. We also understand that their future prospects are not limited to material prosperity, but that we must do a lot more to protect biodiversity, climate and the environment.

The author

Joachim Curtius, born in 1969, studied physics at the University of Heidelberg and wrote his doctoral thesis at the Max Planck Institute for Nuclear Physics in Heidelberg, where he conducted research into sulphuric acid in the atmosphere and the condensation trails of jet aircraft. After some time as a post-doctoral researcher in Heidelberg and at the Aeronomy Laboratory of the National Oceanic and Atmospheric Administration NOAA in Boulder (Colorado, USA), he joined the Institute of Physics at Johannes Gutenberg University Mainz (JGU). In 2007, he was appointed as professor for experimental atmospheric research at the Institute for Atmospheric and Environmental Sciences of Goethe University. His main research interests are the study of aerosols, ions, ice nuclei and trace gases in the atmosphere, aerosol-cloud interactions, aircraft emissions and the influence of aerosol particles on the climate. Joachim Curtius is a recipient of the Otto Hahn Medal of the Max Planck Society. He is actively involved with Scientists for Future, among others.

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NEWS

from science and research

Folding of SARS-CoV2 genome reveals drug targets – and preparation for »SARS-CoV-3«

For the first time, an international research alliance has observed the RNA folding structures of the SARS-CoV2 genome with which the virus controls the infection process. Since these structures are very similar among various beta corona viruses, the scientists not only laid the foundation for the targeted development of novel drugs for treating COVID-19, but also for future occurrences of infection with new corona viruses that may develop in the future.

The genetic code of the SARS-CoV2 virus is exactly 29,902 characters long, strung through a long RNA molecule. It contains the information for the production of 27 proteins. This is not much compared to the possible 40,000 kinds of protein that a human cell can produce. Viruses, however, use the metabolic processes of their host cells to multiply. Crucial to this strategy is that viruses can precisely control the synthesis of their own proteins.

SARS-CoV2 uses the spatial folding of its RNA hereditary molecule as control element for the production of proteins: predominantly in areas that do not code for the viral proteins, RNA single strands adopt structures with RNA double strand sections and loops. However, until now the only models of these foldings have been based on computer analyses and indirect experimental evidence.

Now, an international team of scientists led by chemists and biochemists at Goethe University and TU Darmstadt have experimentally tested the models for the first time. Researchers from the Israeli Weizmann Institute of Science, the Swedish Karolinska

Institute and the Catholic University of Valencia were also involved.

The researchers were able to characterize the structure of a total of 15 of these regulatory elements. To do so, they used nuclear magnetic resonance (NMR) spectroscopy in which the atoms of the RNA are exposed to a strong magnetic field, and thereby reveal something about their spatial arrangement. They compared the findings from this method with the findings from a chemical process (dimethyl sulphate footprint) which allows RNA single strand regions to be distinguished from RNA double strand regions.

The coordinator of the consortium, Professor Harald Schwalbe from the Center for Biomolecular Magnetic Resonance at Goethe University Frankfurt, explains: »Our findings have laid a broad foundation for future understanding of how exactly SARS-CoV2 controls the infection process. Scientifically, this was a huge, very labour-intensive effort which we were only able to accomplish because of the extraordinary commitment of the teams here in Frankfurt and Darmstadt together with our partners in the COVID-19-NMR consortium. But the work goes on: together with our part-

ners, we are currently investigating which viral proteins and which proteins of the human host cells interact with the folded regulatory regions of the RNA, and whether this may result in therapeutic approaches.«

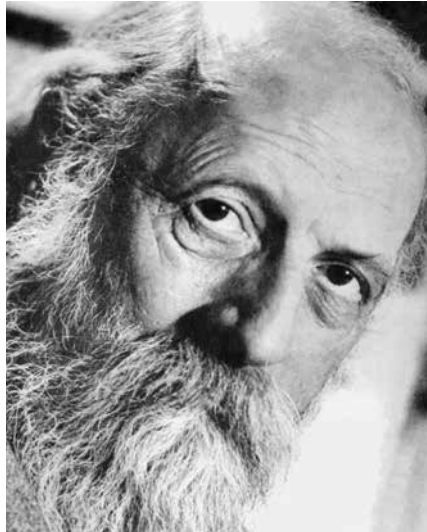
Worldwide, over 40 working groups with 200 scientists are conducting research within the COVID-19-NMR consortium, including 45 doctoral and postdoctoral students in Frankfurt working in two shifts per day, seven days of the week since the end of March 2020.

Schwalbe is convinced that the potential for discovery goes beyond new therapeutic options for infections with SARS-CoV2: »The control regions of viral RNA whose structure we examined are, for example, almost identical for SARS-CoV and also very similar for other beta-coronaviruses. For this reason, we hope that we can contribute to being better prepared for future »SARS-CoV3« viruses.«

<https://tinygu.de/GenomeFolding>

Funding for 24 years of Buber Research

Approximately 40,000 letters from Martin Buber's correspondence with his contemporaries exist, but to this day, they have hardly been accessible. A funding commitment from the federal and state governments should now change this: an academy project for the digitalisation and annotation of this valuable estate will be funded with almost € 400,000 per year. The project by Professor Christian Wiese, scholar in the field of Jewish Studies and holder of the Martin-Buber-Chair in Jewish Religious Philosophy at Goethe University and his cooperation partners Professor Martin Leiner (Friedrich Schiller University Jena), Professor Abigail Gilman (Boston University) and the National Library of Israel is designed for 24 years. As part of the project, the letters, which are primarily located in Europe, Israel and the USA, are now to be collected and grouped according to thematic modules that stretch over several years, and made digitally accessible in close collaboration with the Academy of Sciences and Literature in Mainz. Depending on the content, transcripts and – where necessary – translations from the Hebrew along with annotations will be added.



Important thinker of the German-Jewish intellectual world: Martin Buber

Martin Buber (1868 – 1965) worked at the University of Frankfurt am Main from 1924 to 1933 – first as lecturer and later as honorary professor for Jewish religious teachings and ethics. He resigned from the professorship in 1933 after Hitler took power in anticipation of having his professorship revoked. He sub-

sequently worked on setting up the Central Office for Jewish Adult Education with the Reichsvertretung of German Jews until it was forced to give up its work. Buber emigrated to Israel in 1938 before the November pogrom. Throughout his entire life, Martin Buber was in contact with personalities from all areas of intellectual life, including many writers such as Margarete Susman, Hermann Hesse, Arnold Zweig, Thomas Mann and Franz Kafka. Here, he did not shy away from controversial discussions.

<https://aktuelles.uni-frankfurt.de/englisch/24-years-for-buber-research-in-the-digital-age>

Bioplastics are not harmless

So-called »bioplastics« are marketed as an environmentally friendly alternative to conventional, petroleum-based plastics. They can be made from renewable feedstock, might be bio-degradable or even both. A study published in the journal *Environment International*, however, found the chemicals these alternatives contain are similarly toxic to those in conventional plastics. It is the most comprehensive study to date that analyses the chemical composition and toxicity of bioplastics and plant-based materials and compares them with conventional plastics. It was carried out by scientists from Goethe University led by the Institute for Social-Ecological Research (ISOE) in collaboration with the Norwegian University of Science and Technology.

<https://aktuelles.uni-frankfurt.de/englisch/chemicals-in-bioplastics-not-safer-than-those-in-conventional-plastics>

Public opinion after Berlin terrorist attack

The 2018 attack on the Christmas market at the Gedächtniskirche led to a reduction in the acceptance of refugees among the German population. This is indicated by the results of a study by sociologists Professor Alexander Schmidt-Catran and Dr Christian Czymara from Goethe University. However, the change in acceptance did not take place immediately, but unfolded gradually over several weeks. The trend could not be explained by the media coverage in the aftermath of the attack. In contrast with the change in public attitudes that took place over weeks, the online media analysed in the study reacted very quickly to the attack, and the prominence of the topic in these media ebbed away just as quickly. Attitudes towards immigration in general remained unchanged after the attack.

World record in short time measurement

In the global race to measure ever shorter time spans, physicists from Goethe University Frankfurt have now taken the lead: together with colleagues at the accelerator facility DESY in Hamburg and the Fritz-Haber-Institute in Berlin, they have measured a process that lies within the realm of zeptoseconds for the first time: the propagation of light within a molecule. A zeptosecond is a trillionth of a billionth of a second (10^{21} seconds).

Atomic physicists led by Professor Reinhard Dörner (Goethe University) have determined how long it takes for a light particle (photon) to cross a hydrogen molecule, namely about 247 zeptoseconds for the average bond length of the molecule. The electron shell in a molecule does not react to light everywhere at the same time. The time delay is due to the fact that the information in the molecule only spreads at the speed of light.

<https://aktuelles.uni-frankfurt.de/englisch/physics-zeptoseconds-new-world-record-in-short-time-measurement>

New Centre for German Africa Research

A new hub for German research in the humanities and social sciences in Africa is currently being established at the University of Ghana: the Maria Sibylla Merian Institute for Advanced Studies in Africa (MIASA). The Federal Ministry of Education and Research (BMBF) has



The University of Ghana.

now approved the funding for the main phase. The Centre for Interdisciplinary Research on Africa (ZIAF) at Goethe University and the Point Sud Research Institute in Bamako, Mali, are contributing with an important sub-project for which a further 1.8 million euros have been pledged.

MIASA's tasks include developing an intellectual programme and a research agenda that will strengthen African perspectives in science and politics and thus contribute to reducing global knowledge asymmetries. One thematic focus is on sustainable governance. Current topics such as migration, democratisation and ecological transformation are to be addressed in a more interdisciplinary manner. The project was launched in 2018 and the BMBF has now approved 11 million euros for the main phase.

How cosmic diamonds are formed

Geoscientists at Goethe University led by Professor Frank Brenker have found the largest extraterrestrial diamonds ever discovered in meteorites. Together with an international team of researchers, they were able to prove that these diamonds were formed in the early days of our solar system during the collision of small planets with each other or with large asteroids.

Meteorites come from the asteroid belt that orbits the sun. Ureilites are a special type of meteorite. They are fragments of a larger celestial body – most likely a minor planet – that has been completely shattered by violent collisions with other minor planets or large asteroids. Ureilites often contain larger amounts of carbon, among other things in the form of graphite or nano-diamonds. The diamonds on the scale of over 0.1 and more millimetres now discovered cannot have formed when the meteoroids hit the Earth. Impact events with such vast energies would make the meteoroids evaporate completely. That is why it was so far



Diamonds were once formed during collisions of small planets.

assumed that these larger diamonds – similar to those in the Earth's interior – must have been formed by continuous pressure in the interior of planetary precursors the size of Mars or Mercury.

<https://aktuelles.uni-frankfurt.de/englisch/geoscience-cosmic-diamonds-formed-during-gigantic-planetary-collisions>

Artificial cell organelles for biotechnology

Cells of higher organisms use cell organelles to separate metabolic processes from each other. This is how cell respiration takes place in the mitochondria, the cell's power plants. They can be compared to sealed laboratory rooms in the large factory of the cell. A research team at Goethe University led by Dr Joanna Tripp from the Institute for Molecular Biosciences has now succeeded in creating artificial cell organelles and using them for their own devised biochemical reactions.

This represents a milestone from a biotechnical perspective. Genetically altered yeast cells already produce industrially interesting molecules on a grand scale, such as anti-malaria medicine. However, undesirable by-products or toxic intermediates often occur as well. This is where the synthetic cell organelles can provide a remedy.

<https://aktuelles.uni-frankfurt.de/englisch/researchers-at-goethe-university-create-artificial-cell-organelles-for-biotechnology>

Leppin elected chair of Historisches Kolleg

Professor Hartmut Leppin, scholar of ancient history at Goethe University, has been elected as the new chair of the Historisches Kolleg by its Board of Trustees. The term of office is two years. Leppin succeeds Professor Martin Schulze Wessel, who resigned from the board after ten years in accordance with the statutes.

The Historisches Kolleg was founded in 1980 by the Stiftungsfonds der Deutschen Bank (Deutsche Bank Foundation Fund) and the Stifterverband für die Deutsche Wissenschaft (Donors' Association for the Promotion of Sciences and Humanities in Germany). The sponsor is the Foundation for the Promotion of the Historical Commission at the Bavarian Academy of Sciences and Humanities and the Historisches Kolleg. The fellowships of the Historisches Kolleg allow researchers to work undisturbed on large book projects. The Historisches Kolleg awards the Prize of the Historisches Kolleg to outstanding historians.

How direct democracy affects equality

Direct-democratic (legislative) proposals on social, political or legal equality are primarily aimed at eliminating inequality in society and expanding equality. Studies on Switzerland and the USA had recently led to contradictory results, focusing on dangers posed by direct democracy to equality.

The current study by political scientists at Goethe University on the subject of inequality and direct democracy cannot confirm this sceptical view. However, not every direct-democratic proposal is equally successful: direct-democratic proposals have the best chance of approval when they focus on improving the social and economic situation of population groups. In the case of proposals aimed at legal and political equality, whether the »unequal« groups are considered to belong or not plays a central role. In some societies, for example, equality for homosexuals is taken for granted – direct-democratic votes allow same-sex marriage. In other societies, they are denied this equality.

Differences are also evident between procedures that are brought to parliaments by citizens' initiatives via signature campaigns (bottom-up) or are given a referendum by parliaments (top-down). Bottom-up procedures are much more successful when they strive for social and economic equality in society. Motions are particularly effective when civil society groups join forces with political parties or other groups.



One goal of direct democracy is to promote equality.

Minorities with little influence can gain strength through coalitions, according to the study.

Tsetse flytraps using biotechnology

Because the tsetse fly can transmit sleeping sickness, it is controlled in Africa with insecticides or caught in traps. Bioscientists led by Julia Hitschler from the Institute for Molecular Biosciences at Goethe University have now developed a process with which the attractant for the traps can be produced in yeasts in a biotechnological process. In the future, the researchers hope, the attractants

could be produced cost-effectively on site in rural areas of Africa. For this purpose, the yeasts could grow almost free of charge in nutrient solutions based on plant waste, food or feed residues.

The tsetse fly occurs in large regions of sub-Saharan Africa. The flies feed on human and animal blood, transmitting trypanosoma in the process – small, single-cell organisms that use the flies as intermediate host and cause a dangerous inflammation of the lymph and nervous system in both animals and humans. There is no vaccination for this sleeping sickness; untreated, it usually ends in death. In agriculture, particularly cattle breeding, sleeping sickness – or trypanosomiasis – causes enormous damages in the form of sick and dead animals.

<https://aktuelles.uni-frankfurt.de/englisch/tsetse-fly-traps-biotechnology-for-africas-rural-population>



A tsetse flytrap in Africa.

Judicial deals in practice

In order to quickly obtain a confession and thus shorten proceedings, the judge holds out the prospect of lighter sentences. There has been a legal framework for this type of agreement since 2009: Agreements must be transparent, i. e. documented. The verification of confessions is »compulsory«. And the specific promise of a lighter sentence is not permitted, only an indication of the »corridor« in which the sentence will lie.

In an expert report for the Federal Ministry of Justice, the legal scholars Professor Matthias Jahn (Goethe University), Professor Jörg Kinzig (University of Tübingen) and Professor Karsten Altenhain (University of Düsseldorf) show that all existing regulations are violated in the courts: The plea bargain takes place unofficially, precise details of the expected sentence are given, and confessions are not checked.

LEGAL NOTICE

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THE NEXT ISSUE



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- 6. Vermeiden Sie das Berühren von Oberflächen.
- 7. Vermeiden Sie das Berühren von Augen, Nase und Mund.
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The coronavirus shift

Even if the »coronavirus year« 2020 has ended – SARS-CoV-2 continues to accompany us into the future. We certainly hope that medical treatment and vaccinations will soon make the risk manageable. But how has the pandemic already affected our society? Will our behaviour change permanently? Will we communicate, work, and travel differently than before the coronavirus? What long-term effects do COVID-19 patients continue to live with even after they have recovered? And how are we preparing ourselves for SARS-CoV-3? Goethe University scientists seek answers and scenarios for the future in numerous research projects.

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