climaware

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CLIMAWARE REPORT 2020

Summary of the latest IPCC Reports for People

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For Erika, Albrecht (†), Ursula, Friedel, and all other grandparents, who bequeathed us this beautiful planet, our home, the only one.

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INTRODUCTION

About Climaware

Climaware was founded by Gabriel Baunach with the following mission:
Firstly, to help people understand the key findings of the reports by the Intergovernmental Panel on Climate Change (IPCC). Secondly, to share appealing climate change content through modern media. Thirdly, to communicate and to discuss approaches to address and solve the issue of climate change.

Climaware aims at explaining the scientific facts about climate change in the most comprehensible, accessible and appealing way. Therefore, the initiative hosts a podcast, summarizes IPCC reports and launches online information campaigns, e.g. via social media on Facebook, Instagram and LinkedIn, among others. Climaware is independent and the content is free of charge.

About this Report

This report was created for everybody who is interested in the facts about climate change, provided by credible climate scientists from around the world. It summarizes the headline statements and key findings of the latest four IPCC reports, namely the 2014 fifth Assessment Report (AR5), the 2018 Special Report on 1.5 Degrees of Global Warming (SR1.5), the 2019 Special Report on Climate Change and Land (SRCCL), and the 2019 Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC). The structure and work of the IPCC is explained in the following chapter.

Official IPCC reports are usually very long, complex and scientific. Furthermore, they only address other scientists and high-level policy makers. In contrast, the Climaware Report 2020 is for YOU. It provides a brief overview of the most important IPCC statements and graphs, whereby it only includes statements and facts, which are indicated with high or medium confidence by the IPCC.
The IPCC uses its own confidence and probability language with thorough rules in order to standardize its assessments, make them consistent, and to express scientific consensus verbally. You can find further information about the IPCC's treatment of uncertainties in the IPCC's Uncertainty Guidance Note, e.g. accessible through the IPCC homepage at ***https://www.ipcc.ch***.

Technical jargon, which you might not know or find difficult to remember, is explained in colored boxes within the text body. By this means, there is no need for a long and confusing glossary. You can find the references to the sources and further literature at the end of this report.

In the end, you will have a proper understanding of the latest IPCC climate science — without having to read hundreds of complicated pages of an original IPCC report. If you have any questions, concerns or comments, please do not hesitate to contact ***info@climaware.org***.

BACKGROUND KNOWLEDGE

before reading this report

Where does our knowledge concerning climate change come from?

What are facts, what just opinions? After all, the question of knowledge of a certain topic comes down to confidence and trust regarding the source of knowledge. So, why should we believe that human-caused climate change is an undeniable fact?

From the mid-20th century on, indications for a global warming trend increased, after scientists had already stated theories about the possibility of human influence regarding the so-called **GREENHOUSE EFFECT** in the 19th century. An increasing number of scientists assumed human influence on this global warming trend, mainly due to the emission of vast amounts of **GREENHOUSE GASES** since the industrialization. However, policymakers needed a reliable, coordinated and generally accepted knowledge source which provided them with regular scientific assessments on the current state of knowledge about climate change.

GREENHOUSE GASES (GHG)

Gases that absorb and emit radiant energy within the thermal infrared range (for example water vapor H2O, carbon dioxide CO2, methane CH4, nitrous oxide NxOx, among others). Quick fact about an often-used scientific unit: Gt CO2 eq. (Gt is a shortcut for giga tonnes) means carbon dioxide equivalent. This parameter makes the potential of greenhouse gases comparable by relating it with the global warming potential of CO2. **(SRCCL), (SROCC), (SR1.5)**

GREENHOUSE EFFECT

The greenhouse effect is a natural process that warms the Earth's surface. When the Sun's energy reaches the Earth's atmosphere, some of it is reflected back to space and the rest is absorbed and re-radiated by greenhouse gases. **(AG)**

To create this science-based, standardized source, the Intergovernmental Panel on Climate Change (IPCC) was founded as a body of the United Nations in 1988. Its main objective was — and still is — to assess the science related to climate change and provide the knowledge foundation for international climate negotiations, such as the annual world climate conferences.

WHAT IS THE IPCC?

And how does it work?

The IPCC involves...

- hundreds of scientists from around the globe who contribute to the work of the IPCC
- 195 countries that are members of the IPCC and accept its work
- about 150 observer organizations that watch the IPCC processes

How the IPCC works – in 10 bullets:

- governments and other UN organisations provide the financial budget for the IPCC
- hundreds of leading scientists volunteer their time and expertise to write assessments
- hundreds of other experts provide complementary expertise in specific areas
- in total, thousands of experts contribute to the comprehensive assessment reports
- authors and experts are unpaid (only travel expenses are covered)
- summary and assessment of tens of thousands of scientific papers published globally
- no conduct of own research
- an open, transparent and multistage review process by experts and all member states
- member states have to accept and approve the IPCC's work
- all of the paperwork, drafts and comments have to be published after the release of a report

By this means, the IPCC has published 5 general Assessment Reports on climate change and more than 10 Special Reports about specific topics related to climate change.

Due to its transparent and objective process and hundreds of highly qualified scientists involved, the IPCC reports can be considered as one of our most confident and trustworthy knowledge sources when it comes to climate change.

CLIMAWARE COMMENT

The IPCC is a unique, international platform involving almost all of the world's nations and hundreds of world-leading scientists. The goal is to reach scientific consensus by summarising and assessing the science related to climate change.

The latest IPCC Climate Science

Summary for People

"The ultimate objective (...) is to achieve (...) stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."
– (Article 2 of the United Nations Framework Convention on Climate Change, 1992)

ANTHROPOGENIC

Age in which humans have become one of the most important factors influencing the biological, geological and atmospheric processes on the earth. **(SROCC)**

ANTHROPOGENIC EMISSIONS

Emissions of greenhouse gases (GHGs) caused by human activities. These activities include for example the burning of fossil fuels, deforestation, waste management, and industrial processes. **(SROCC)**

What's the status quo of climate change, what are the observed changes and what has caused them?

What does the IPCC say — in general — about the status quo of climate change? The following 3 statements indicate the key findings of the IPCC in its Fifth Assessment Report in 2014:

*"**Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.** The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen."* **(AR5)**

*"**ANTHROPOGENIC GREENHOUSE GAS EMISSIONS** have increased since the **PRE-INDUSTRIAL** era, **driven largely by economic and population growth**, and are now higher than ever. This has led to **atmospheric concentrations of CARBON DIOXIDE**, **METHANE and NITROUS OXIDE that are unprecedented in at least the last 800,000 years.** Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century."* **(AR5)**

NITROUS OXIDE (N2O)

main anthropogenic source of the greenhouse gas N2O is agriculture (soil and animal manure management), but important contributions also come from sewage treatment, fossil fuel combustion, and chemical industrial processes. **(SRCCL)**

METHANE (CH4)

is the major component of natural gas and associated with all hydrocarbon fuels. It enlarges up to 28 times more the greenhouse effect than CO2 and is mainly produced by animal husbandry and paddy rice production. **(SRCCL)**

CARBON DIOXIDE (CO2)

A naturally occurring gas, CO2 is also a by-product of burning fossil fuels (such as oil, gas and coal), of burning biomass, of land-use changes (LUC) and of industrial processes (e.g. cement production). It is the principal anthropogenic greenhouse gas (GHG) that affects the Earth's radiative balance. **(SRCCL)**

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PRE-INDUSTRIAL

By pre-industrial era, the IPCC means the period before 1850, referring to the period from 1850-1900 to compare values with the current time. **(AR5)**

*"In recent decades, **changes in climate have caused impacts on natural and human systems on all continents** and across the oceans."* **(AR5)**

Besides these general statements, the following statement from the IPCC's Special Report on Global Warming of 1.5°C indicates the current level of global warming (in the year 2017):

*"**Human activities are estimated to have caused approximately 1.0°C of global warming** above pre-industrial levels, with a likely range of 0.8°C to 1.2°C."* **(SR1.5)**

In its Fifth Assessment Report, the IPCC states that *"human influence on the climate system is clear"* and provides a variety of evidences for anthropogenic climate change. The following two figures indicate the contributions of different drivers of global warming until 2010 and the difference of observed and simulated climate change for both **NATURAL AND ANTHROPOGENIC FORCING**.

NATURAL/ANTHROPOGENIC RADIATIVE FORCING

Radiative forcing is a measure of the rule of the earth's energy balance due to the effect of radiation from space and is seen in W/m^2. The term radiation drive or climate drive is used in order to include the influence of external conditions on the radiation balance and the earth's climate system as part of the climate studies. **(SR1.5), (AR5)**

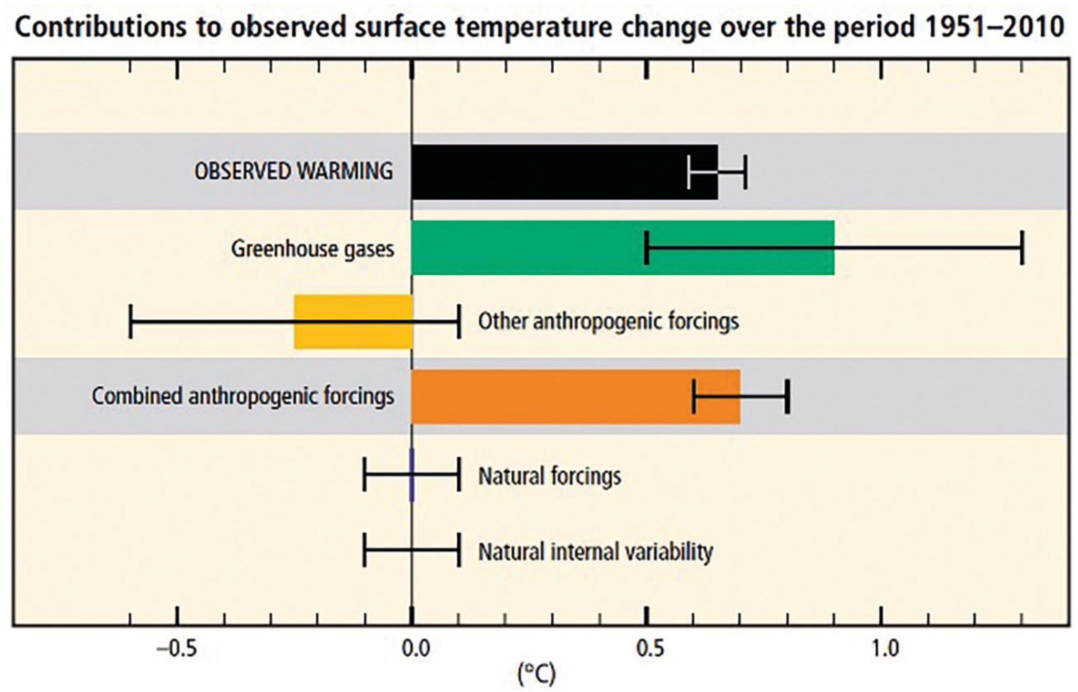

Figure 1: *Drivers of global warming and their contributions (whiskers indicate likely ranges) (IPCC, AR5, 2014).*

INTERNAL VARIABILITY

Climate variability refers to variations in statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. **(SR1.5)**

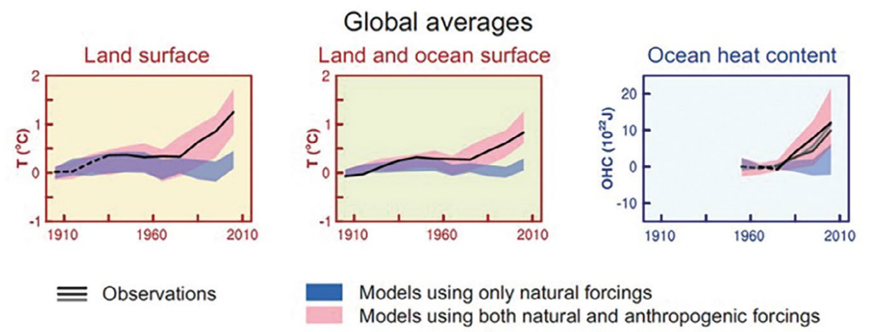

Figure 2: *Comparison of observed and simulated climate change from IPCC's CMIP5 multi-model ensemble ranges, based on three large-scale climate indicators (IPCC, AR5, 2014).*

KEY TAKE-AWAYS

FROM THE ABOVE GIVEN GRAPHS

- A significant increase of the global mean surface temperature can be observed empirically
- Greenhouse gases and anthropogenic forces are the main reasons for global warming

Now that we have learned about the IPCC's overall findings concerning the status quo and the causes of climate change, let us dive a bit deeper into the specific changes that have been observed. Firstly, let us explore the effects and causes of climate change on land specifically:

> *"Since the pre-industrial period, the **land surface air temperature has risen nearly twice as much as the global average temperature**. Climate change, including increases in frequency and intensity of extremes, has adversely impacted food security and terrestrial ecosystems as well as contributed to desertification and land degradation in many regions."* **(SRCCL)**

> *"Agriculture, Forestry and Other Land Use activities accounted for around (...) **23% of total net anthropogenic emissions of GHGs** [globally during 2007–2016]. (...) If emissions associated **with pre- and post-production activities in the global food system** are included, the emissions are estimated to be **21–37%** of total net anthropogenic GHG emissions."* **(SRCCL)**

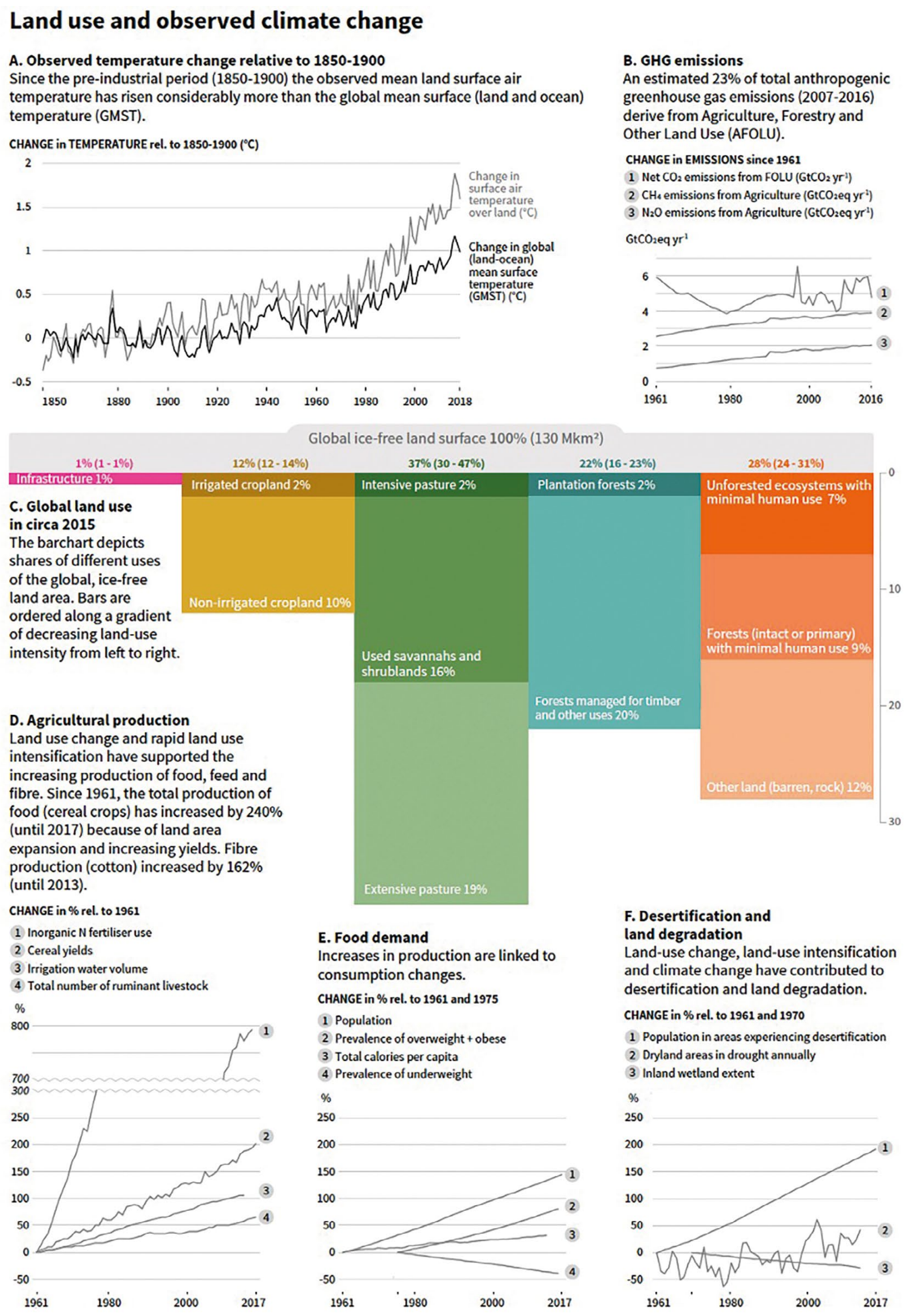

Figure 3: *A representation of the land use and observed climate change (IPCC, SRCCL, 2019)*

KEY TAKE-AWAYS

FROM THE ABOVE-GIVEN GRAPHS (A—F) ON CLIMATE CHANGE AND LAND

- Air temperature over land tends to rise twice as fast as global mean surface temperature
- Globally, CH4 and N2O emissions from agriculture are rising at a steady rate
- Food demand, food production and desertification have all increased continuously

After we have seen the influence of food production and agriculture, let us look at the effects and causes of climate change in the cryosphere and ocean specifically. In the following, 7 statements by the IPCC about the transforming state of the **CRYOSPHERE** are presented:

> *"Over the last decades, global warming has led to widespread shrinking of the cryosphere, with mass loss from ice sheets and glaciers, reductions in snow cover and Arctic sea ice extent and thickness, and increased* **PERMAFROST***, temperature."* **(SROCC)**

CRYOSPHERE

The amount of all frozen components of the Earth (for example snow, glaciers, sea ice, permafrost). **(SROCC)**

PERMAFROST

is permanently frozen soil, which is mainly found in the Arctic and Antarctic tundra. It contains at least twice as much carbon as currently contained in the atmosphere in form of CO2. **(NG)**

*"It is virtually certain that **the global ocean has warmed unabated since 1970**. Since 1993, the rate of ocean warming has more than doubled. **MARINE HEATWAVES** have very likely doubled in frequency since 1982 and are increasing in intensity. By absorbing more CO2, **the ocean has undergone increasing surface ACIDIFICATION**."* **(SROCC)**

HEATWAVES

A period of abnormally and uncomfortably hot weather. **(AR5)**

MARINE HEATWAVE

A marine heat wave (MHW) is a relatively long period of unusually high sea temperatures in a region. When Seawater temperatures exceed a seasonally-varying threshold for at least 5 consecutive days, it is called officially a marine heat wave. **(MHW)**

OCEAN ACIDIFICATION

Acidification of the ocean means a decrease in the pH value of the sea water. It is caused by the absorption of carbon dioxide (CO2) from the earth's atmosphere, which, along with global warming, is one of the main consequences of human emissions of carbon dioxide. **(SR1.5)**

*"**Global mean sea level** (GMSL) **is rising, with acceleration in recent decades due to increasing rates of ice loss from the Greenland and Antarctic ice sheets, as well as continued glacier mass loss and ocean thermal expansion.** Increases in tropical cyclone winds and rainfall, and increases in extreme waves, combined with relative sea level rise, exacerbate extreme sea level events and coastal hazards."* **(SROCC)**

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*"**Since about 1950 many marine species across various groups have undergone shifts** in (...) species composition, abundance and biomass production of ecosystems (...). Altered interactions between species have caused **cascading impacts** on ecosystem structure and functioning."* **(SROCC)**

*"**Since the mid-20th century, the shrinking cryosphere in the Arctic and high mountain areas has led to predominantly negative impacts** on food security, water resources, water quality, livelihoods, health and well-being, infrastructure, transportation, tourism and recreation, as well as culture of human societies, particularly for Indigenous peoples."* **(SROCC)**

*"**Coastal ecosystems are affected** by ocean warming, including intensified marine heatwaves, acidification, loss of oxygen, **SALINITY INTRUSION** and sea level rise, in combination with adverse effects from human activities on ocean and land."* **(SROCC)**

SALINITY INTRUSION

Salt intrusion refers to the penetration of salty water (salt water) into coastal sweetwater-systems. (USGS)

*"**Coastal communities are exposed to multiple climate-related hazards**, including tropical cyclones, extreme sea levels and flooding, marine heatwaves, sea ice loss, and permafrost thaw."* **(SROCC)**

CLIMAWARE COMMENT

Human actions, such as emitting vast amounts of greenhouse gases, are currently leading to a rapid global warming and massive changes in the earth's climate, which already pose severe threats to our livelihood today.

What will future climate change look like, what are the risks and impacts?

In the previous section, we shed light on the near past and present impacts of climate change and its causes. In this section, we will look at the future risks and possible impacts of climate change in the 21st century. The following 4 statements summarize the key findings of the IPCC in its Fifth Assessment Report in 2014:

> *"Cumulative emissions of carbon dioxide largely determine global mean surface warming by the late 21st century and beyond.* ***Projections of greenhouse gas emissions*** *vary over a wide range,* ***depending on both socio-economic development and climate policy.****"* **(AR5)**

> *"Surface temperature is projected to rise over the 21st century under all assessed emission scenarios. It is very likely that* ***heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent*** *in many regions. The ocean will continue to warm and acidify, and global mean sea level to rise."* **(AR5)**

> ***"Climate change will amplify existing risks and create new risks for natural and human systems.*** *Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development."* **(AR5)**

> *"Many aspects of climate change and associated* ***impacts will continue for centuries****, even if anthropogenic emissions of greenhouse gases are stopped.* ***The risks of abrupt or irreversible changes increase as the magnitude of the warming increases.****"* **(AR5)**

It becomes clear from the above overall statements that we need to stop global warming at some point. But what is a safe limit? The Paris Agreement, adopted in 2015 under the UNFCCC, declared the following goal:

> *"Holding the increase in the global average temperature to* ***well below 2°C*** *above pre-industrial levels and* ***pursuing efforts to limit the temperature increase to 1.5°C*** *above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change."* **(UNFCCC, Paris Agreement, 2015)**

...whereas...

> *"****Global warming is likely to reach 1.5°C between 2030 and 2052*** *if it continues to increase at the current rate."* **(SR1.5)**

So, the safe threshold for global warming has been declared to be somewhere between 1.5°C and 2°C. But half a degree more or less, this does not seem to make a big difference, does it? Hence, let us explore the difference of impacts of 1.5°C versus 2°C of global warming:

> *"****Warming from anthropogenic emissions from the pre-industrial period to the present will persist for centuries to millennia and will continue to cause further long-term changes in the climate system****, such as sea level rise, with associated impacts, but these emissions alone are unlikely to cause global warming of 1.5°C."* **(SR1.5)**

> *"****Climate-related risks*** *for natural and human systems are higher* ***for global warming of 1.5°C*** *than at present, but lower than at 2°C. (...) These differences include increases in: mean temperature in most land and ocean regions,* ***hot extremes*** *in most inhabited regions,* ***heavy precipitation*** *in several regions, and the* ***probability of drought*** *and precipitation deficits in some regions."* **(SR1.5)**

> *"On land, impacts on biodiversity and ecosystems, including* ***species loss and extinction****, are projected to be lower at 1.5°C of global warming compared to 2°C."* **(SR1.5)**

> *"Climate-related* ***risks to health, livelihoods, food security, water supply, human security, and economic growth*** *are projected to increase with global warming of 1.5°C and increase further with 2°C."* **(SR1.5)**

> *"By 2100,* ***global mean sea level rise*** *is projected to be around 0.1 metre lower with global warming of 1.5°C compared to 2°C."* **(SR1.5)**

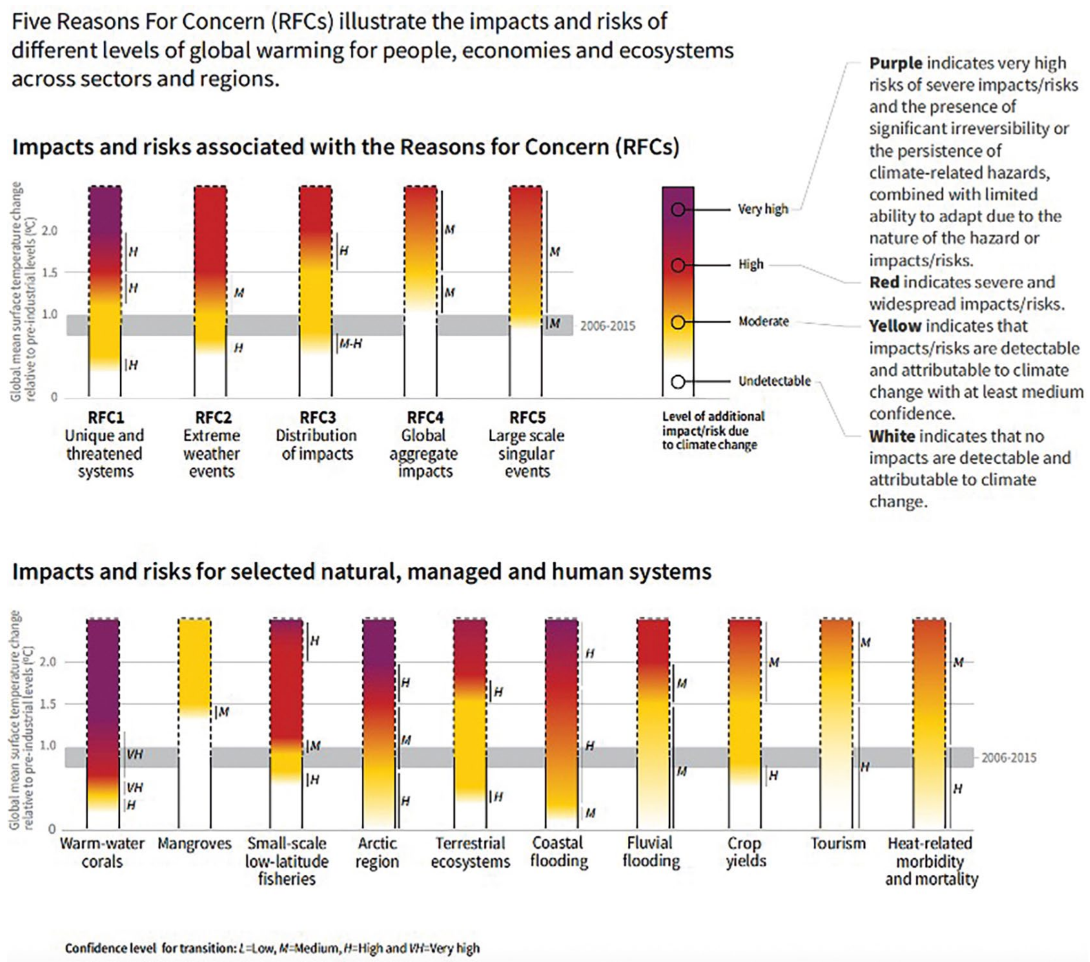

Figure 4: *Key climate change impacts and risks across sectors and regions, for people, economies and ecosystems, illustrated as colored bars (IPCC, SR1.5, 2018).*

2 KEY TAKE-AWAYS

FROM THE ABOVE-GIVEN GRAPH

- Unique and threatened systems, such as the Arctic and coastal regions, are exposed to high risks at 1.5°C of global warming already
- Warm-water corals will have limited ability to adapt to 1.5°C of global warming, i.e. it's very likely that we will lose the majority of warm-water corals, even in the best-case scenario

The above-presented risk bars indicate that half a degree of global warming does matter indeed, but what are the risks of exceeding the upper limit of 2°C? In the following, we provide the IPCC risk assessment for likely impacts on land specifically:

> *"Climate change creates additional stresses on land, exacerbating existing risks to livelihoods, biodiversity, human and ecosystem health, infrastructure, and food systems.* ***Increasing impacts on land are projected under all future GHG emission scenarios.****"* **(SRCCL)**

...whereas...

> *"The level of risk posed by climate change depends both on the level of warming and on* ***how population, consumption, production, technological development, and land management patterns evolve.****"* **(SRCCL)**

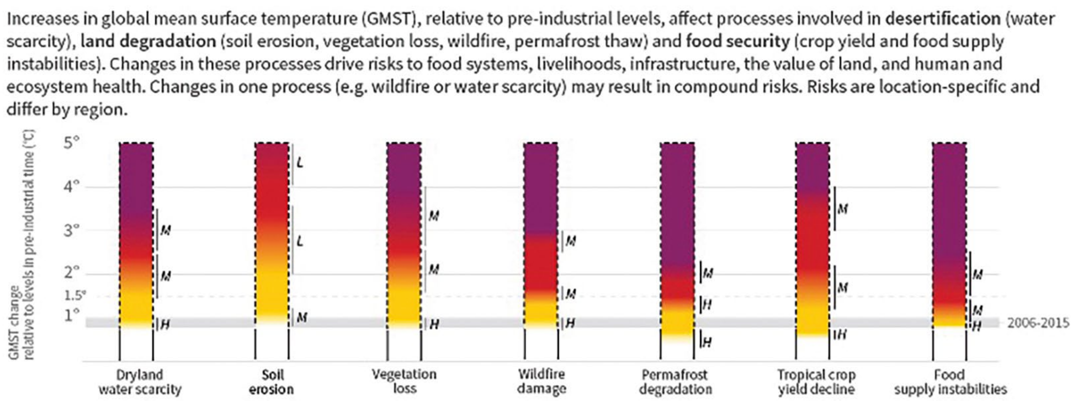

Figure 5: *Risks to humans ecosystems from changes in land-based processes as a result of climate change(IPCC, SRCCL, 2019).*

THE KEY TAKE-AWAY

FROM THE ABOVE-GIVEN GRAPH

- Reaching the 1.5°C target guarantees relatively safe conditions on land in the future

According to the IPCC, exceeding the limits of 1.5°C or 2°C will result in increasing water scarcity, vegetation loss, wildfire damage, and tropical crop yield decline. On land, most critical impacts include severe food supply instabilities and permafrost degradation, including irreversibilities.

To illustrate the urgency of reaching the 1.5°C target, in the following, we provide 10 IPCC statements and a risk assessment concerning the cryosphere and ocean in particular:

> *"****Global-scale glacier mass loss, permafrost thaw, and decline in snow cover and Arctic sea ice extent are projected to continue in the near-term (2031–2050)*** *(...). The Greenland and Antarctic Ice Sheets are projected to lose mass at an increasing rate throughout the 21st century and beyond. (...)* ***Strong reductions in greenhouse gas emissions in the coming decades are projected to reduce further changes after 2050.****"* **(SROCC)**

> *"****Over the 21st century, the ocean is projected to transition to unprecedented conditions*** *with increased temperatures, greater upper ocean* **STRATIFICATION***, further acidification, oxygen decline, and altered net primary production. Marine heatwaves and extreme* **EL NIÑO AND LA NIÑA** *events are projected to become more frequent. The* **ATLANTIC MERIDIONAL OVERTURNING CIRCULATION** *is projected to weaken."* **(SROCC)**

STRATIFICATION

Forming of layers of (ocean) water with different properties, such as salinity, density and temperature, that act as barrier for water mixing. The strengthening of near-surface stratification generally results in warmer surface waters, decreased oxygen levels in deeper water, and intensification of ocean acidification in the upper ocean. (SROCC)

EL NIÑO AND LA NIÑA

This oceanic event is associated with a fluctuation of a global-scale tropical and subtropical surface pressure pattern called the Southern Oscillation. The phenomenon has a great impact on the wind, sea surface temperature and precipitation patterns in the tropical Pacific. The cold phase of El Niño is called La Niña. **(SR1.5)**

ATLANTIC MERIDIONAL OVERTURNING CIRCULATION (AMOC)

The Atlantic Meridional Overturning Circulation (AMOC) consists of warm, northward currents near the surface, sinking water masses at high latitudes and deep bottom currents at the western edge. AMOC is part of a global oceanic redistribution system for heat and freshwater. **(MPG)**

"Sea level continues to rise at an increasing rate. ***Extreme sea level events that are historically rare (once per century in the recent past) are projected to occur frequently (at least once per year) at many locations by 2050*** *(...)."* **(SROCC)**

*"****Sea level will continue to rise well beyond 2100****, and the magnitude and rate of this rise depend on future emission pathways.* ***A slower rate of sea level rise enables greater opportunities for adaptation*** *in the human and ecological systems of small islands, low-lying coastal areas and deltas."* **(SROCC)**

RCP2.6, RCP4.5, RCP6.0 AND RCP8.5 (REPRESENTATIVE CONCENTRATION PATHWAYS)

RCP2.6 is a pathway where radiative forcing peaks at approximately 3 W/m2 before 2100 with a following decline. In contrast, RCP4.5 and RCP6.0 are two stabilization pathways in which radiative forcing is stabilized at approximately 4.5 W/m² and 6.0 W/m2 after 2100, whereas RCP8.5 is a high pathway for which radiative forcing exceeds 8.5 W/m² by 2100 and continues to rise thereafter. (AR5)

"In coming centuries under **RCP8.5***, sea level rise is projected to exceed rates of several centimetres per year resulting in* ***multi-metre rise*** *(...). Extreme sea levels and coastal hazards will be exacerbated by projected* ***increases in tropical cyclone intensity and precipitation."*** **(SROCC)**

"Future land cryosphere changes will continue to alter terrestrial and freshwater ecosystems in high mountain and polar regions with major shifts in species distributions resulting in changes in ecosystem structure and functioning, and eventual ***loss of globally unique biodiversity. Wildfire is projected to increase significantly for the rest of this century across most tundra and boreal regions****, and also in some mountain regions."* **(SROCC)**

*"****A decrease in global biomass of marine animal communities, their production, and fisheries catch potential****, and a shift in species composition are projected over the 21st century in ocean ecosystems from the surface to the deep seafloor under all emission scenarios."* **(SROCC)**

> *“**Risks of severe impacts on biodiversity, structure and function of coastal ecosystems** are projected to be higher for elevated temperatures under high compared to low emissions scenarios in the 21st century and beyond. Projected ecosystem responses include losses of species habitat and diversity, and degradation of ecosystem functions. **The capacity of organisms and ecosystems to adjust and adapt is higher at lower emissions scenarios.**”* **(SROCC)**

> *“**Future shifts in fish distribution and decreases in their abundance and fisheries catch potential** due to climate change are projected to affect income, livelihoods, and food security of marine resource-dependent communities. Long-term loss and degradation of marine ecosystems compromises the ocean’s role in cultural, recreational, and intrinsic values important for human identity and well-being.”* **(SROCC)**

> *“**Increased mean and extreme sea level, alongside ocean warming and acidification**, are projected to exacerbate risks for human communities in low-lying coastal areas. In Arctic human communities without rapid land uplift, and in urban atoll islands, risks are projected to be moderate to high even under a low emissions scenario (RCP2.6), including **reaching adaptation limits**. Under a high emissions scenario (RCP8.5), delta regions and resource rich coastal cities are projected to experience moderate to high risk levels after 2050 under current adaptation.”* **(SROCC)**

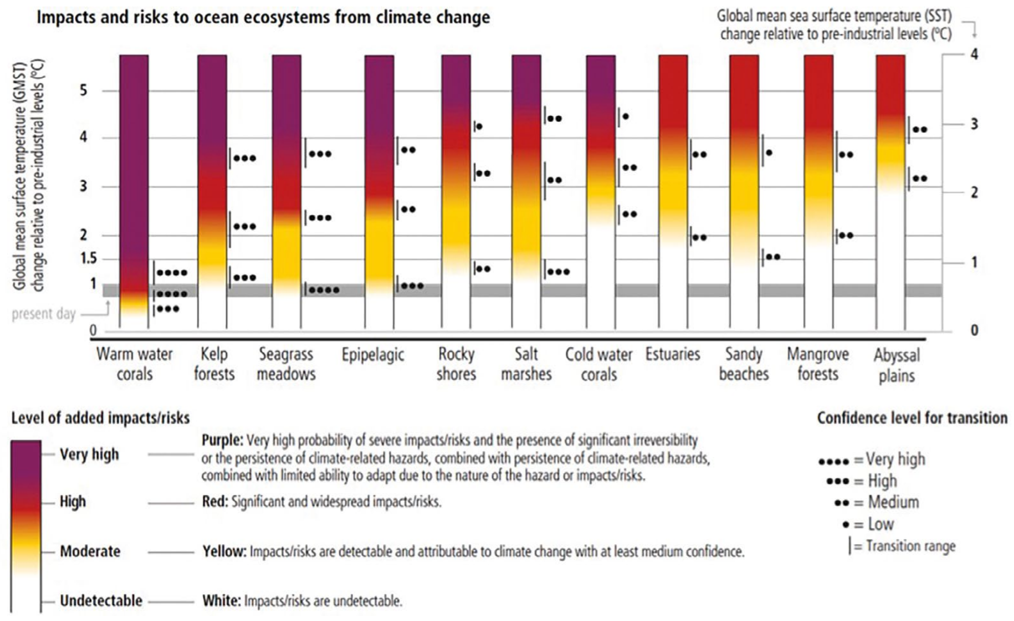

Figure 6: *Impacts and risks to ocean ecosystems from climate change (IPCC, SROCC, 2019).*

2 KEY TAKE-AWAYS

FROM THE ABOVE-GIVEN GRAPH

- Even with global warming coming to a halt at 1.5°C, warm water corals are unlikely to be able to adapt to climate change
- Exceeding the 2°C target will severely jeopardize kelp forests, seagrass meadows, upper-ocean and coastal ecosystems

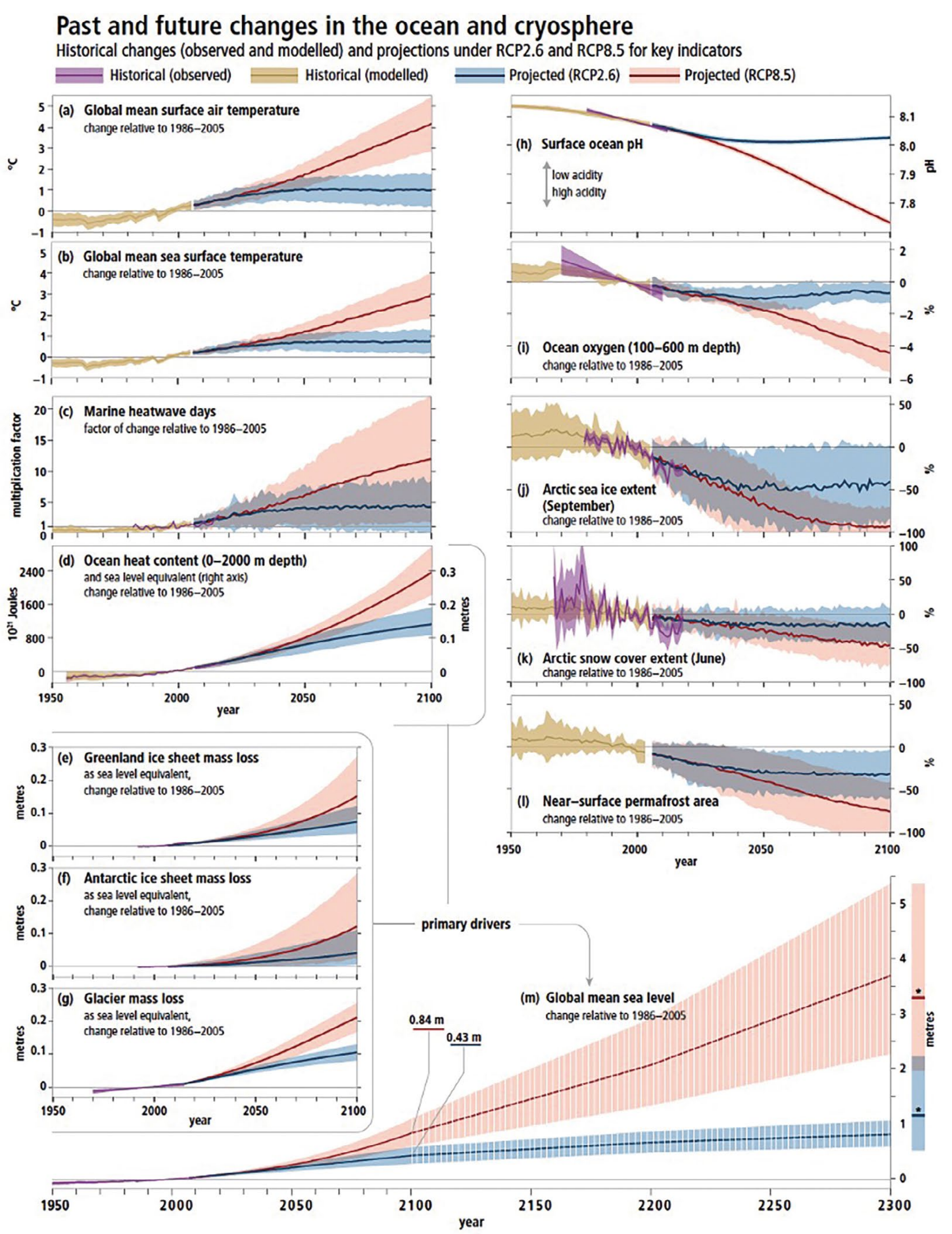

Figure 7: *Observed and modelled historical changes in the ocean and cryosphere since 1950, and projected future changes under low (RCP2.6) and high (RCP8.5) greenhouse gas emissions scenarios (IPCC, SROCC, 2019).*

3 KEY TAKE-AWAYS

FROM THE ABOVE-GIVEN GRAPHS (A—M) ON THE OCEAN AND CRYOSPHERE IN A CHANGING CLIMATE:

- Global mean sea level will reach 0.43m to 0.84m by 2100 and between 1m (best case) and up to 4—5m (worst case) by 2300
- Under less optimistic scenarios, the ocean will lose oxygen and continue to acidify
- Under the worst-case scenarios, the Arctic will be ice-free in the summer by 2050 and the permafrost area might disappear completely by the end of the century

CLIMAWARE COMMENT

It appears, that reaching the 1.5°C target is the only way for humanity to stay within safe boundaries and to save most of the world's unique ecosystems. Moreover, missing the 2°C target will likely lead to unprecedented and devastating disasters for humanity.

This includes the risk of large-scale, rapid, irreversible and perhaps cascading climate change impacts, when the climate system's tipping points are crossed.

What are possible future pathways for MITIGATION, ADAPTATION and SUSTAINABLE DEVELOPMENT?

MITIGATION

A human intervention to reduce emissions or enhance the sinks of greenhouse gases. (SR1.5), (SRCCL)

ADAPTATION

The process of adjustment to actual or expected climate change and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. (AR5)

SUSTAINABLE DEVELOPMENT

Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). (AR5)

Having reflected on the observed changes, the risks and possible future impacts of climate change, we will now look at the IPCC's concepts and future pathways to limit global warming to 1.5°C or 2°C. First of all, 3 overall IPCC statements about mitigation and adaptation are provided below:

> *"**Without additional mitigation efforts beyond those in place today, and even with adaptation, warming by the end of the 21st century will lead to high to very high risk of severe, widespread, and irreversible impacts globally**. Mitigation involves some level of co-benefits and of risks due to adverse side-effects, but these risks do not involve the same possibility of severe, widespread, and irreversible impacts as risks from climate change, increasing the benefits from near-term mitigation efforts."* **(AR5)**

*“**Adaptation can reduce the risks of climate change impacts, but there are limits to its effectiveness**, especially with greater magnitudes and rates of climate change. Taking a longer-term perspective, in the context of sustainable development, increases the likelihood that more immediate adaptation actions will also enhance future options and preparedness.”* **(AR5)**

*“There are multiple mitigation pathways that are likely to limit warming to below 2°C relative to pre-industrial levels. These pathways would **require substantial emissions reductions over the next few decades** (...). Implementing such reductions poses substantial technological, economic, social, and institutional challenges, which increase with delays in additional mitigation and if key technologies are not available. Limiting warming to lower or higher levels involves similar challenges, but on different timescales.”* **(AR5)**

It is clear from the above statements that we have to reduce global GHG emissions, but on which timescales and to what extend? The Special Report on Global Warming of 1.5°C provides some precise options and scenarios. Let us explore them in the following passage:

*“In model pathways with no or limited overshoot of **1.5°C, global net anthropogenic CO2 emissions decline by about 45%** from 2010 levels **by 2030**, reaching net **zero around 2050**. For limiting global warming to **below 2°C CO2 emissions are projected to decline by about 25% by 2030** in most pathways and reach net **zero around 2070**. Non-CO2 emissions in pathways that limit global warming to 1.5°C show deep reductions that are similar to those in pathways limiting warming to 2°C.”* **(SR1.5)**

The following two figures show the possible pathways to limit global warming to 1.5°C. The third figure presents four illustrative socio-economical scenarios which influence these modelled pathways.

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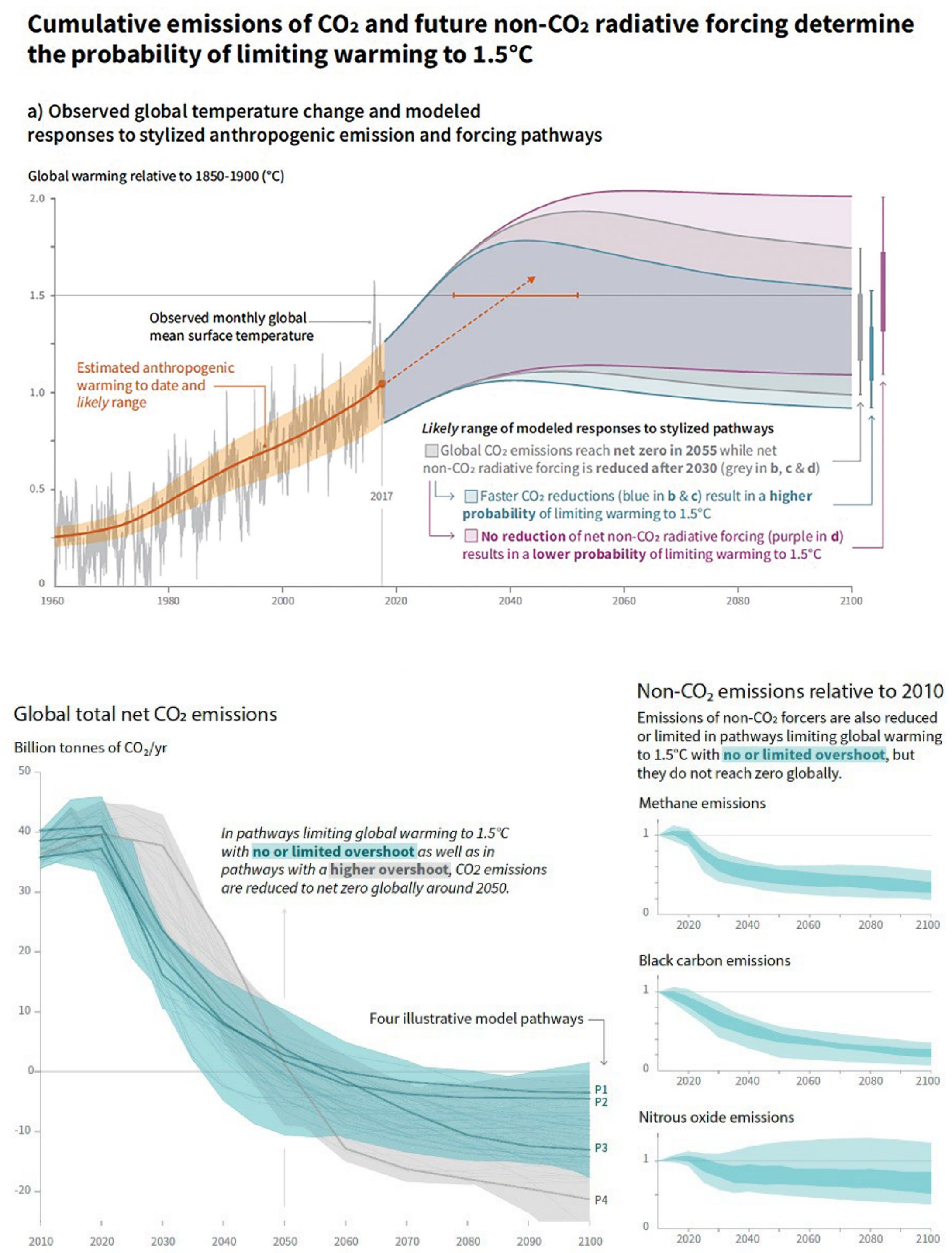

Figure 9: *Modelled global greenhouse gas emissions pathways (IPCC, SR1.5, 2018).*

THE KEY TAKE-AWAY

FROM THE ABOVE-GIVEN GRAPHS

- In almost all modeled pathways (achieving the 1.5°C target) GHG emission peak in 2020, decline rapidly afterward, reach net zero in 2050 and become negative afterwards

BLACK CARBON (BC)

A relatively pure form of carbon, also known as soot, arising from the incomplete combustion of fossil fuels, biofuel, and biomass. It stays in the atmosphere only for days or weeks. Black carbon is a climate forcing agent with strong warming effect, both in the atmosphere and when deposited on snow or ice. (SRCCL)

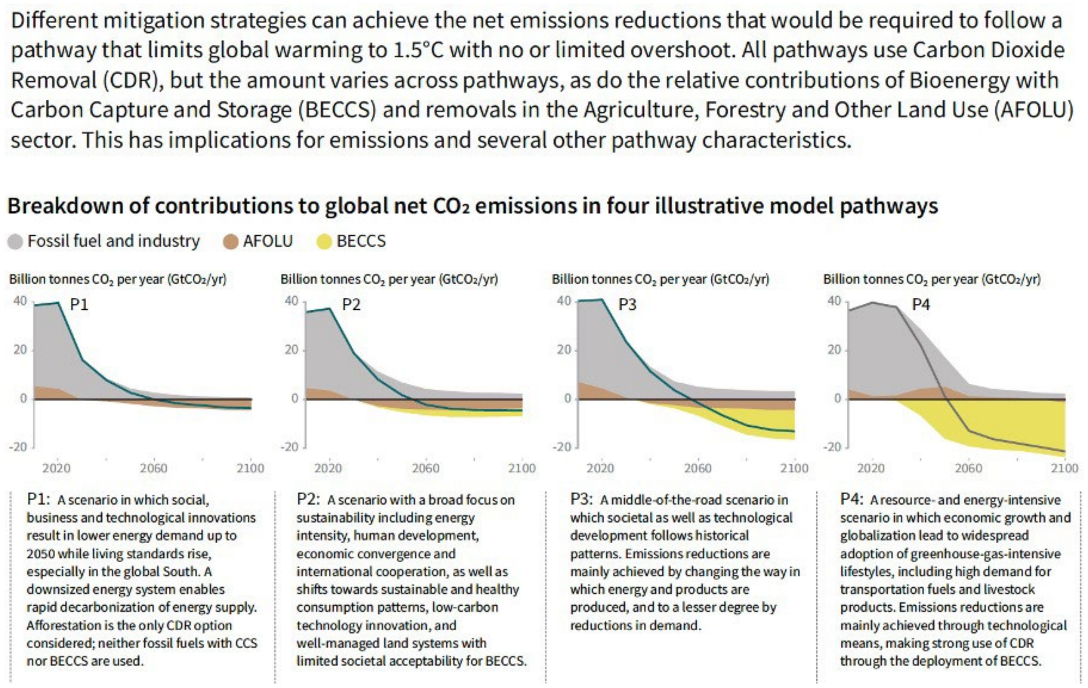

Figure 10: *Four different scenarios as mitigation strategies to limit global warming to 1.5°C (IPCC, SR1.5, 2018).*

3 KEY TAKE-AWAYS

FROM THE ABOVE-GIVEN GRAPHS

- It is highly unlikely to reach the 1.5°C target without negative emissions
- A delay in emissions reduction of only few years after 2020 increases the need for negative emissions after 2050, such as the use of **BIOENERGY WITH CARBON CAPTURE AND STORAGE (BECCS)**
- The rate of fossil fuel emission reductions, the scale of agriculture changes and reforestation and socio-economic influences will determine the possibility of reaching the 1.5°C target

BIOENERGY WITH CARBON CAPTURE AND STORAGE (BECCS)

Is the name of the application of Carbon Dioxide Capture and Storage (CCS)technology to bioenergy conversion processes. BECCS has the potential for net carbon dioxide (CO2) removal from the atmosphere. **(AR5)**

*"Pathways limiting global warming to 1.5°C with no or limited overshoot **would require rapid and far-reaching transitions** in energy, land, urban and infrastructure (including transport and buildings), and industrial systems. **These systems transitions are unprecedented in terms of scale**, but not necessarily in terms of speed, and imply **deep emissions reductions in all sectors**, a wide portfolio of mitigation options and a significant upscaling of investments in those options."* **(SR1.5)**

*"All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of **CARBON DIOXIDE REMOVAL (CDR)** on the order of 100–1000 GtCO2 over the 21st century. [However,] **CDR deployment of several hundreds of GtCO2 is subject to multiple feasibility and sustainability constraints.**"* **(SR1.5)**

CARBON DIOXIDE REMOVAL (CDR)

Carbon Dioxide Removal methods refer to a set of techniques that aim to remove CO2 directly from the atmosphere by either (1.) increasing natural sinks for carbon or (2.) using chemical engineering to remove CO2, with the intent of reducing the atmospheric CO2 concentration. **(AR5)**

*"All assessed modelled pathways that **limit warming to 1.5°C or well below 2°C require land-based mitigation and land-use change**, with most including different combinations of **reforestation, afforestation, reduced deforestation, and bioenergy**. [However,] at the deployment scale of several GtCO2/year, this **increased demand for land conversion could lead to adverse side effects** for adaptation, desertification, land degradation and food security."* **(SRCCL)**

***"Most adaptation needs will be lower for global warming of 1.5°C compared to 2°C** (...) [and] the avoided climate change impacts on sustainable development, eradication of poverty and reducing inequalities would be greater."* **(SR1.5)**

The previous section clarified the urgency of rapid system transformation in the context of climate change mitigation and adaptation, if we want to limit global warming to 1.5°C, and also in the case of the 2°C limit. But how can we achieve this? What are the implications and synergies of mitigation and adaptation? What is the current state of global climate action?

The following passage sheds light on these questions. It begins with 5 overall statements by the IPCC:

*"Adaptation and mitigation responses are underpinned by common enabling factors. These include **effective institutions and governance, innovation and investments in environmentally sound technologies and infrastructure, sustainable livelihoods, and behavioral and lifestyle choices.**"* **(AR5)**

*"Adaptation options exist in all sectors, but their context for implementation and potential to reduce climate-related risks differs across sectors and regions. (...)**Increasing climate change will increase challenges for many adaptation options**."* **(AR5)**

*"Mitigation options are available in every major sector. **Mitigation can be more cost-effective if using an integrated approach** that combines measures to reduce energy use and the greenhouse gas intensity of end-use sectors, decarbonize energy supply, reduce net emissions and enhance carbon sinks in land-based sectors." (AR5)*

*"Effective adaptation and mitigation responses will **depend on policies and measures across multiple scales: international, regional, national and sub-national.** Policies across all scales supporting technology development, diffusion and transfer, as well as finance for responses to climate change, can complement and enhance the effectiveness of policies that directly promote adaptation and mitigation."* **(AR5)**

*"**Climate change is a threat to sustainable development.** Nonetheless, there are many opportunities to link mitigation, adaptation and the pursuit of other societal objectives through integrated responses. Successful implementation relies on relevant tools, suitable governance structures and enhanced capacity to respond."* **(AR5)**

The mission is clear, but what is the current status of global climate action by all governments?

*"Estimates of the global emissions outcome of **current nationally stated mitigation ambitions** as submitted under the Paris Agreement **would lead to global greenhouse gas emissions in 2030of 52–58 GtCO2eq/year.**"* **(SR1.5)**

These nationally stated mitigation ambitions are consistent with the IPCC's RCP6.0 scenario, leading to global warming of 3°C to 4°C by 2100. Hence, current governments' commitments are insufficient to limit global warming to well below 2°C (or even 1.5°C). Therefore, apart from ramping up national ambitions, the question is what ought to be done — and how? The IPCC states:

"Limiting the risks from global warming of 1.5°C in the context of sustainable development and poverty eradication implies ***system transitions*** *that can be enabled by an increase of* ***adaptation and mitigation investments, policy instruments, the acceleration of technological innovation and behaviour changes****."* **(SR1.5)**

*"****Strengthening the capacities for climate action of national and sub-national authorities, civil society, the private sector, indigenous peoples and local communities*** *can support the implementation of ambitious actions implied by limiting global warming to 1.5°C.* ***International cooperation can provide an enabling environment*** *for this to be achieved in all countries and for all people, in the context of sustainable development."* **(SR1.5)**

"The ***effectiveness of decision-making and governance is enhanced by the involvement of local stakeholders*** *(particularly those most vulnerable to climate change including indigenous peoples and local communities, women, and the poor and marginalised) (…)."* **(SRCCL)**

According to these general statements, collective action is more effective. This is clear. Now, we need to ask, what are the key enabling factors and concrete near-term actions?

"Enabling climate resilience and sustainable development ***depends critically on urgent and ambitious emissions reductions coupled with coordinated sustained and increasingly ambitious adaptation actions.****"* **(SROCC)**
Essential enablers *are:*
• Education and climate literacy,
• monitoring and forecasting,
• use of all available knowledge sources,
• sharing of data, information and knowledge,
• finance,
• addressing social vulnerability and equity,
• institutional support

*"****Actions*** *can be taken in the near-term, based on existing knowledge,* ***to address desertification, land degradation and food security*** *while supporting longer-term responses that enable adaptation and mitigation to climate change."* **(SRCCL)**
Actions *are:*
• build individual and institutional capacity
• accelerate knowledge transfer
• enhance technology transfer and deployment
• enable financial mechanisms
• implement early warning systems
• undertake risk management
• address gaps in implementation and upscaling

In its reports, the IPCC states numerous positive synergies between sustainable development and climate change mitigation and adaptation, such as the following:

"Most of the response options assessed contribute positively to sustainable development and other societal goals." **(IPCC, SRCCL, 2019)**

CLIMAWARE COMMENT

Mitigating climate change by limiting global warming to 1.5°C poses a great challenge for humanity, maybe the greatest it has ever faced. In any scenario, the world will need to implement adaptation measures. However, there is no possibility to adapt to unchecked climate change.

Reaching net-zero GHG emissions by 2050 or briefly afterwards is a must. Only collective action, i.e. international cooperation, can enable the needed rapid and far-reaching systems transition — away from fossil fuel-based toward a net-zero emissions, sustainable world economy.

CONCLUSION

to this third chapter.

As a conclusion to this third chapter of the Climaware Report, we provide the four overall headline statements from the Assessment Report 5 by the IPCC:

> *"**Human influence on the climate system is clear**, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems."* **(AR5)**

> *"Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, **increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems**. Limiting climate change would **require substantial and sustained reductions in greenhouse gas emissions** which, together with adaptation, can limit climate change risks."* **(AR5)**

> *"**Adaptation and mitigation** are complementary strategies for reducing and managing the risks of climate change. **Substantial emissions reductions over the next few decades can reduce climate risks** in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term, and contribute to climate-resilient pathways for sustainable development."* **(AR5)**

> *"Many adaptation and mitigation options can help address climate change, but **no single option is sufficient by itself**. Effective implementation depends on **policies and cooperation at all scales**, and can be enhanced through integrated responses that **link adaptation and mitigation** with other societal objectives."* **(AR5)**

A BRIEF HISTORY OF GOVERNING CLIMATE CHANGE

How international politics responded.

1979

First "World Climate Conference" (WCC 1)

This first scientific international climate conference took place in Geneva and was organized by the WMO. United Nations experts advised on the mitigation of harmful impacts due to anthropogenic climate change. The main forecast was an increasing concentration of CO2 in the atmosphere, resulting from fossil fuel combustion and deforestation. A major outcome was the foundation of the World Climate Program (WCP), aiming at increased internationally standardized climate research.

1988

Intergovernmental Panel on Climate Change (IPCC)

This intergovernmental organization was founded by UNEP and WMO. It summarizes and assesses the science related to climate change. Its Assessment Reports (AR) provide the knowledge basis for decisions by policy makers. The list of the IPCC's Assessment Reports (AR): AR1 in 1990; AR2 in 1995; AR3 in 2001; AR4 in 2007; AR5 in 2014; AR6 in 2021/22. More information in chapter 2.

1992

United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC is an international, multilateral agreement aimed at preventing dangerous impacts resulting from climate change, slowing global warming and mitigating its consequences. It was founded in Rio de Janeiro during the United Nations Conference on Environment and Development and entered into force in 1994. Its conferences are called "Conferences of the Parties" (COPs) and involve 197 states of the world.

1997

Kyoto-Protocol, at COP 3

This supplementary agreement, with 191 contracting states within the UNFCCC, is binding under international law. It aims at reducing global greenhouse gas (GHG) emissions in the time periods of 2008-2012 and 2013-2020, by committing industrialized countries to legally binding mitigation targets, while allowing GHG emission budgets for developing countries. The official enactment was in 2005 and the expiration of the second term will be after 2020.

2005

COP 11/CMP 1 “Montreal“

The eleventh meeting of the signatory states to the UNFCCC (COP 11) was accompanied by the first meeting of the signatory states of the Kyoto Protocol (CMP 1), adopted by COP 3 in Kyoto, Japan. The goal was to advise on the implementation of the Kyoto Protocol and to enforce the reduction of GHG emissions by 5.2% compared to 1990 emission levels. CMP stands for „Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol“. The Montreal protocol succeeded in reducing the ozone hole by restricting FCKW gases (hydrochlorofluorocarbons).

2009

COP 15 (/CMP 5) “Copenhagen”

At COP 15 (CMP 5), the goal to decide on a succession regulation for the expiring Kyoto Protocol could not be achieved. Instead, it was agreed to take note of the non-binding „Copenhagen Agreement“. This conference is considered a major failure in international climate politics. A global follow-up agreement for the Kyoto-Protocol seemed unlikely after this COP 15.

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2012

COP 18 (/CMP 8) “Doha”

Major results of this important conference were a renewed extension of the Kyoto Protocol until 2020, a review of the CO2 reduction targets, and the confirmed goal to establish a legally binding global climate agreement for all countries (including developing countries). Additionally, to finance climate change, developed countries and countries affected by climate change have pledged USD 100 billion/year in commitments.

2015

COP 21 (/CMP 11) “Paris Agreement”

Two weeks of tireless negotiations at the UN Climate Change Conference in Paris led to a moment of triumph: for the first time, 195 countries adopted a universal agreement to curb emissions and take common climate action. It was decided that global warming should be limited to well below 2°C, preferably to 1.5°C, above pre-industrial levels. According to the Paris Agreement, global greenhouse gas emissions are to be reduced to net-zero in the second half of this century.

2018

IPCC “Special Report on 1.5 Degree Global Warming“ (SR1.5)

The report was adopted by 195 member states. It provides knowledge about the difference between the 2°C and the 1°C target, set out in the 2015 Paris Agreement, including scenarios on how the 1.5°C target could be achieved. The whole title gives a good impression about the report’s content: „Global warming of 1.5°C – The IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.“

2018

COP 24 (/CMP 14) “Katowice“

The conference made great progress in two areas: Firstly, the international community adopted a rule book that enables the Paris climate agreement to be implemented. Secondly, for the first time, there are binding transparency standards for all countries in place.

2019

COP 25 “Madrid”

Only weeks before the start of COP 25 in Santiago, Chile, COP 25 was suspended and had to change location to Madrid, Spain. The conference failed to establish a global market-based mitigation mechanism under Article 6 of the Paris Agreement. The decision was postponed to COP 26.

2020/21

COP 26 “Glasgow”

COP 26 was postponed to 2021 due to the Corona Pandemic. Initially, member states of the Paris Agreement should have updated their Nationally Determined Contribution (NDC) pledges, i.e. their voluntary national GHG mitigation targets, by the end of 2020. However, delays seem possible.

2022

IPCC AR6

The IPCC will publish its sixth Assessment Report (AR6) about the scientific consensus concerning climate change, including local impacts of climate change because of better climate models.

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2023

Global Stocktake

Member states to the Paris Agreement will review what progress has been made in achieving the goals of the Paris Agreement.

2025

New round of NDCs

2028

Second Global Stocktake

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Gabriel Baunach studied Mechanical Engineering and Energy Technology in Boston, Aachen, Stanford and London. He has a deep passion for climate change, gained professional experience at the UN Climate Change Secretariat (UNFCCC) and founded Climaware in 2020.

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