A 1.5°C warmer world:
A guide for policy-makers and practitioners

Roop Singh,
Red Cross Red Crescent Climate Centre

Lucinda Fairhurst,
Independent Consultant

Jenny Clover,
Independent Consultant

Natalie Belew,
Columbia University

BRACED

Seven key messages from the Special Report

1.
Global warming of 1.5°C is not safe for most countries.

2.
Countries must swiftly increase their ambition and action on both mitigation and adaptation.

3.
Half a degree matters, each year matters, each choice matters.

4.
The consequences of warming are not equal.

5.
Transformational adaptation is required in high-risk regions.

6.
There are limits to adaptation.

7.
The risks at 1.5°C will require humanitarian and development practitioners to adapt programming using a climate lens.

Cover photo: Denis Onyodi/URCS-DRK-Climate Centre

About the Special Report on warming of 1.5°C

In the Paris Agreement, the United Nations Framework Convention on Climate Change (UNFCCC) invited the Intergovernmental Panel on Climate Change (IPCC) to produce a special report on the 'impacts of global warming of 1.5°C 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'.[1] On 8 October 2018, the IPCC member countries approved the Special Report. It was prepared by 91 authors and review editors from 40 countries, cites over 6,000 scientific research articles and integrates over 42,000 expert and government review comments. It is the most current and comprehensive assessment of the science for limiting warming to 1.5°C; adaptation needs and opportunities; and potential impacts.

1 Hereafter referred to as 'the Special Report'. References to the Special Report in the footnotes use the abbreviation 'SR'. References to the Summary for Policymakers use 'SPM'.

About this guide

This guide aims to make the findings of the Special Report more accessible to humanitarian and development practitioners and policy-makers working at global and regional scale. It provides an interpretation of the findings with a focus on the adaptation implications of the Special Report. The guide synthesises information from the report, adds case studies to illustrate key messages and points readers to additional resources where they can obtain more information.

The guide begins with a basic overview of the feasibility of limiting warming to 1.5°C, and what it would take to do this. Based on this background, it then outlines the impacts associated with 1.5°C and greater warming. This section includes possible risk hotspots, trends, and tipping points. This is followed by a section on sectoral impacts in order to inform readers on how the risks associated with warming are projected to manifest. In the context of the mitigation findings, the guide goes on to explain the adaptation implications of the report, including guidance on implementing adaptation as well as areas that need to be strengthened.

How to cite this guide: Singh, R., Fairhurst, L., Clover, J. and Belew, N. (2018) *A 1.5°C warmer world: a guide for policy-makers and practitioners*. New York, NY: BRACED Knowledge Manager

Table of Contents

Key messages from the Special Report (expanded)

1. Global warming of 1.5°C is not safe for most countries. It presents serious risks to human and natural systems, with a high probability of irreversible changes, such as the complete loss of some ecosystems (e.g. coral reefs). In a 1.5°C world, we can expect more extreme heat (high confidence), more heavy precipitation in several regions (high confidence) and more intense or frequent droughts in some regions (medium confidence). Increases in extreme weather will lead to increased risks to health, livelihoods, food security, water supply human security and economic growth.[1]

2. Countries must swiftly increase ambition and action on both mitigation and adaptation. Swift and aggressive mitigation action will reduce the burden to adapt, and related costs and potential damages. Through effective and rapid mitigation, it is possible to reduce the need to adapt and thus the costs and complications that come with it. Limiting global warming would give people and ecosystems more room to adapt and remain below relevant risk thresholds, making it easier to achieve the United Nations Sustainable Development Goals. In tandem, there is an urgent need, particularly in high-risk regions, to start planning for and investing in adaptation. The changes that are needed signify a transformation of the way in which existing systems are configured.

3. Half a degree matters, each year matters, each choice matters. We need to act now to avoid serious consequences. The lower estimate for when we will start to see the impacts of 1.5°C is in the next 12 years – by 2030. Every single year matters in terms of emissions reductions; the faster we act and make changes, the better off we will be in terms of reaching emissions targets and avoiding the worst impacts. Some powerful messages to come out of the Special Report are that half a degree matters, each year matters and each choice matters as we aim to reduce the threat of climate change through ambitious mitigation and accelerated adaptation. Some of the necessary actions to tackle climate change are already underway but it is necessary to accelerate and upscale these. The decisions we make today are critical to ensure a safe and sustainable world for everyone, both now and in the future.

4. The consequences of warming are not equal. The Special Report integrates climate mitigation and adaptation action in the context of sustainable development and poverty alleviation efforts. It notes that the impacts of warming regionally (and more locally) will depend on geographical location (small islands, low-lying coastal areas and drylands being worst affected), the socio-economic status of communities and associated vulnerabilities, as well as the choice of mitigation and adaptation approaches (Malik, 2018).

5. Transformational adaptation is required in high-risk regions. In some regions, incremental adaptation will not be enough to adapt to effects of 1.5°C of warming.[2] Instead, transformational adaptation will be required to implement measures such as alternative lifestyles and employment for people, and new types of city planning to safeguard people and infrastructure. This will require development that considers multidimensional poverty, entrenched inequalities, local culture, and local knowledge in decision-making.[3]

6. There are limits to adaptation. For certain risks there are unavoidable impacts that will occur in a 1.5°C warmer world for which there is no or limited adaptation potential. These include 'hard limits' such as the loss of 70-90% of coral reefs by mid-century in a 1.5 °C and 'soft limits' such as exposing millions more people to climate risks and poverty which may be overcome with carefully applied transformational adaptation.[4]

7. The risks at 1.5°C will require humanitarian and development practitioners to adapt programming using a climate lens. A climate lens should be used across work and programming should be adapted accordingly. Changing climate risks need to be integrated into planning and humanitarian action across key areas of humanitarian work, including food security, health and water, in both rural and urban contexts. Climate can be a risk magnifier for displacement and conflict but also pose additional risks to people already affected by conflict and displacement.

Background

On 12 December 2015, the world watched Paris as 195 countries adopted a universal climate change deal after 21 years of fraught negotiations (Schellnhuber et al., 2016). This momentous event set forward a plan to reduce greenhouse gas emissions, adapt to climate impacts and finance the necessary low-carbon economy transformation in the upcoming decades in the form of the Paris Agreement. However, the primary achievement lay in getting delegates from around the world to agree to limit long-term temperature warming to below 2°C before 2100, while 'pursuing efforts' towards the much more ambitious limit of 1.5°C (UNFCCC, 2015).

Box 1: What do the numbers 1.5°C and 2°C mean?

Long-term temperature limits, like 2°C or 1.5°C, have long been used as 'goalposts' for climate change mitigation (Rogeli, 2017). These temperature targets serve as a metric referring to the human-induced (anthropogenic) increase in temperature averaged over the entire globe since the 'pre-industrial' period. Pre-industrial is a baseline set in the mid-1800s when the Industrial Revolutions in Europe, North America and other regions led to a concentrated increase of recorded carbon dioxide in the atmosphere. These goalposts are necessary to ensure all countries are measuring and tracking the same things. While a 2°C or 1.5°C increase may sound like a small change, it is significant because the global average temperature has never changed this quickly in at least the past 10,000 years, (see https://www.esrl.noaa.gov/gmd/outreach/faq_cat-1.html) and these changes are occurring on a global scale. The targets of 2°C or 1.5°C are not exact tipping points, but rather a translation of 'dangerous anthropogenic interference' into a policy target that is based on risk assessments conducted by the Intergovernmental Panel on Climate Change (IPCC) over several decades (Schleussner et al., 2016). The 1.5°C temperature limit is particularly important for the people and countries that are the most vulnerable to climate change, especially small island and low-income nations, given the higher risks they face.

This guide focuses on the adaptation implications of the Special Report. However, the adaptation implications should be understood in the context of the findings around what it would take to reduce greenhouse gas emissions to keep temperatures below the limit of 1.5°C.

Current progress: where do we stand on mitigation?

The world has already warmed about 1°C above pre-industrial levels.[5] This warming is manifested today in more frequent and intense extreme events.[6] Extreme events such as heatwaves in Asia, drought in places like Cape Town and hurricanes for example Hurricane Harvey, which devastated Houston, Texas, in 2017 are among the events that scientists have attributed to climate change (Otto et al., 2018, van Oldenborgh et al, 2018, Imada et al.,2018)

If countries fail to act, the impacts of a 1.5°C world as outlined in the Special Report are likely to become our reality in between 12 and 34 years.[7] Current emissions trajectories indicate global average surface temperatures will pass the 1.5°C limit between 2030 and 2052.[8] Countries submitted Intended Nationally Determined Contributions (INDCs) in Paris, outlining their post-2020 climate action plans. Many of these have been

converted to National Determined Contributions (NDCs) as countries have submitted their instruments of ratification to join the Paris Agreement. These collectively represent reduced aggregate greenhouse gas emissions compared with current policies, but still imply a median warming of 2.6–3.1°C by 2100 (Rogelj and Schleussner, 2017). Current pledges under the Paris Agreement are not in line with limiting global warming to 1.5°C but the Agreement includes a mechanism to ratchet up ambition every five years. There is an important opportunity to increase mitigation ambition and adaptation action during the first Global Stocktake of the Paris Agreement in 2023. The work to increase ambition needs to start immediately.

Limiting warming to 1.5°C: what will it take?

It is technically possible to limit warming to 1.5°C. Doing so will require global efforts to rapidly transform energy, land, urban areas, buildings, transport and industrial systems. This means unprecedented transitions in all aspects of society. While there are some documented examples of rapid transitions at the pace needed to make the changes, none has occurred at the scale needed to limit warming to 1.5°C.[9]

In order to limit warming to 1.5°C, carbon emissions need to rapidly decline to net zero by 2050, alongside rapid reductions in other greenhouse gases like methane, as well as black carbon.[10] Any remaining emissions would need to be balanced by removing carbon dioxide from the air through the use of Carbon Dioxide Removal (CDR), and/or Bioenergy with Carbon Capture and Storage (BECCS),[11] in which atmospheric carbon dioxide is absorbed by plants and trees as they grow and then the plant material (biomass) is burned to produce bioenergy. This is particularly needed in a scenario in which the global temperature temporarily exceeds 1.5°C, called 'overshoot'. The Special Report makes clear that the overshoot scenario is not ideal because it would still result in the impacts that we expect to see in a 1.5°C world, which include irreversible changes such as loss of biodiversity and coral reefs, for example. In addition, it would require use of CDR technologies, which have different potentials for success, are not currently viable at large scale and may carry significant risks.[12, 13]

Even if these are done, there is still only a 50% chance of staying under the 1.5°C threshold, owing to uncertainties in how the atmosphere will respond to additional greenhouse gases..[14] In other words, it is a necessity to strive for 1.5°C but the feasibility of achieving it presents scientific and political challenges (Schellnhuber et al., 2017).

Learn More: The Special Report outlines 1.5°C mitigation pathways, including their key characteristics, and challenges, opportunities and co-impacts associated with these pathways.

Geoengineering

Geoengineering is a deliberate, large-scale manipulation of the earth's climate, and is typically referred to in the context of efforts to counteract the effects of global warming. The Special Report refrains from using the term 'geoengineering', choosing instead to use the more specific Solar Radiation Management (SRM), and assesses the characteristics of four of the most-studied methods. Most methods involve reducing the amount of solar radiation that reaches the earth's surface or increasing the amount of longwave radiation that is released out to space. Methods can range from injecting particles into the atmosphere to reflect incoming solar rays, to more benign interventions like changing the reflectivity of the earth's surface by whitening roofs, for example. The Special Report considers SRM a 'remedial measure' that has the aim to temporarily reduce or offset warming,[15] particularly in overshoot scenarios, rather than as a mitigation or adaptation measure. It does not include SRM in the pathways it has assessed to limit warming to 1.5°C. While SRM technology has the potential to lower global temperatures, it also comes with considerable risks. It would not address and could even worsen the negative effects from continued ocean acidification, and also presents serious risks associated with suddenly stopping SRM, which may cause a rapid temperature rise and associated impacts.[16]

Learn More: The Special Report outlines four of the most-studied Solar Radiation Management methods and their main characteristics.

Although the IPCC considers geoengineering only as a supplemental measure to mitigation, this is not necessarily how other actors choose to think about it. Currently, no international governance mechanism exists to regulate whether or not geoengineering is deployed. The technology is cheap enough that it could be deployed at a large scale,[17] with impacts on global temperature, and an unknown number of other earth systems, including global weather patterns. Humanitarian and development actors have largely been absent in the conversation around geoengineering governance, despite the considerable impacts it could have on vulnerable people around the world (Suarez and van Aalst, 2017). Risks associated with rogue state or non-state actors unilaterally implementing geoengineering require that any governance agreement be equitable and multilateral in order to avoid negative precipitation or extreme weather affects across borders.[18]

Impacts of 1.5 ˚C

There is no single 1.5°C warmer world, the Special Report authors conclude.[19] A 1.5°C world is highly dependent on the choices made around managing human and natural systems, and mitigating greenhouse gases. Scientific measurements indicate that the global surface mean temperature is already at 1°C above pre-industrial levels of human contributions of carbon dioxide into the atmosphere (Schleussner et al., 2016). Many regions of the world are also already experiencing warming that is greater than the global average; others are experiencing warming that is slightly lower than the global average.[20]

The mitigation choices made will affect some of the impacts observed in the future. For example, changes to land use (e.g. reforestation, agricultural expansion, land management) can have feedbacks on regional climate, particularly on extreme temperatures.[21] For instance, adding more trees to an area near an urban centre may help also reduce temperatures. There may also be competing demands, such as among using land for mitigation purposes (e.g. growing crops for BECCS), meeting the needs of growing populations by increasing food production and adaptation needs (e.g. afforestation on lands held by indigenous people who do not have land rights).[22] Large-scale deployment of CDR would have serious implications for land and water availability and in turn affect food production, biodiversity and other ecosystem services.[23] Policies related to improving air quality, if strengthened and strictly enforced in the coming decades, are likely to have implications for regional temperature and rainfall.[24] Aerosols generally have a cooling effect on the atmosphere, so, if air pollution policies reduce these aerosol emissions in the coming decades, temperature may warm faster in those regions where there is a strong aerosol affect (e.g. the Indian sub-continent).[25] Reducing air pollution has serious co-benefits for human health and reducing deforestation.[26]

Uncertainty and non-linearity of risks

In the Special Report, each key message is assigned a qualifier to demonstrate the level of confidence in the findings.[2] The probability of certain outcomes is also assessed, using a calibrated language scale.[3] There are uncertainties in the future climate and impact projections, related to inherent limitations in both the climate models and the impact models. How climate change evolves – whether or not it will include overshoot – will affect the uncertainty related to impacts. In some cases, risks and impacts may not be linear. This is particularly true if temperatures rise by between 2°C and 4°C and associated with risks such as water availability, heat extremes and bleaching of coral reefs. Coral reefs may be one example of a non-linear change where certain species may be better able to resist bleaching or recover, so reefs may change rather than disappear entirely at 1.5 °C[27].

2 Very low, through low, medium and high to very high.

3 Exceptionally unlikely (66%), very likely (>90%), extremely likely (>95%), virtually certain (>99%).

Tipping Points

The Special Report defines tipping points as critical thresholds in a system that, when exceeded, can lead to a significant change in the state of the system, often with an understanding that the change is irreversible.

Learn More: Some tipping points that are of particular relevance to the humanitarian and development community are highlighted below, while the full list can be found in Chapter 3, Section 3.5.5

Heatwaves, unprecedented heat and human health impacts

Heatwaves – periods of time when temperatures are unusually high and hazardous to human health and well-being – are a serious and deadly human health risk. People living in urban areas are particularly vulnerable because the 'urban heat island effect' leads to higher temperatures within cities than in the surrounding countryside. The elderly, infants and people who are chronically ill, work outside, live in informal settlements or lack essential infrastructure and services are vulnerable to heat-related illnesses and even death. The Special Report says that it is 'plausible that coping strategies will not be in place for many regions, with potentially significant impacts on communities with low adaptive capacity, effectively representing the occurrence of a local/regional tipping point'.[28]

The rise in extreme heat is one of the clearest and most certain impacts of climate change under 1.5°C and greater warming. There could be a substantial increase in deadly heatwaves in cities at both 1.5°C and 2°C of warming, with 'twice as many megacities as present (such as Lagos, Nigeria, and Shanghai, China)' becoming heat stressed and 'exposing more than 350 million more people to deadly heat stress by 2050'.[29] The Special Report authors provide an illustrative example. In 2015, a heatwave in India killed at least 2,200 people; with 2°C of warming, this kind of heatwave is projected to happen every single year somewhere in South Asia (medium confidence). Whether or not the same impacts, in terms of human lives, are observed depends on the adaptation work that is done to prepare cities for these increasing temperatures. Interventions that reduce the urban heat island effect, like creating more reflecting roofs and urban surfaces, as well as heat-health early warning systems, can play a significant role in reducing impacts (Toloo et al., 2013).

Box 2: Climate change and human health

Climate change adversely affects human health by increasing exposure and vulnerability to climate-related stresses, and decreasing the capacity of health systems to manage changes in the magnitude and pattern of climate-sensitive health outcomes. Human health risks vary regionally. Warmer temperatures will affect the transmission of some climate-sensitive infectious diseases, with increases and decreases projected depending on disease, region and degree of temperature change. Recent projections of the potential impacts of climate change on malaria confirm that weather and climate are among the drivers of the geographic range, intensity of transmission and seasonality of malaria.

There is *very high confidence* that each additional unit of warming will increase heat-related morbidity and mortality. The projected risks of heat-related morbidity, mortality and mosquito ranges are generally higher under warming of 2°C than 1.5°C (SR 1.5, Chapter 5, cross-chapter box 12).

Adaptation may reduce the magnitude of health-related climate impacts, and some human health sector adaptation options include:

- heat-health early warning systems to help lower injuries, illnesses and deaths
- reducing adverse health outcomes and risks through (1) institutions being better equipped to share information, (2) indicators for distinguishing climate-sensitive illnesses, (3) enhanced delivery of basic health care services and (4) collaboration with other sectors (SR 1.5, Chapter 5, Section 5.3).

Case study: Heat-health early warning systems have been implemented across Europe since the devastating 2003 heatwave, which resulted in, by some estimates, an excess of 70,000 deaths (Robine et al., 2008). Studies have shown that they are effective at reducing impacts. In Ahmedabad, India, following a deadly heatwave in May 2010, city leaders, meteorologists, researchers and health and environmental groups partnered to develop an early warning system that would alert the city to an impending heatwave, and a heat preparedness plan that would outline actions to save lives during the heatwave. This resulted in improved access to forecasts, better coordination between health and the city government, increased awareness of heat risks and likely saved lives in subsequent extreme heat events. For the full case study see here (Shah et al., n.d.).

Agricultural systems: key staple crops and livestock in the tropics and subtropics

Many of the most vulnerable rural people in the world are dependent on livelihoods that involve subsistence agriculture or livestock. The Special Report includes sobering findings about the potential impacts of climate change on these livelihoods. Maize crops are a key staple around the world, and many studies indicate that yields will be lower with increasing temperatures, in particular in regions where there will be reductions in rainfall. While there are not many studies that have looked at how increased heat stress above a critical threshold will affect livestock, there is some evidence from case studies that 'the difference in heat stress for livestock between 1.5°C and 2°C is likely to exceed the limits for normal thermoregulation and result in persistent heat stress for livestock animals'.[30] This means that fewer areas may be viable for livestock production, although the evidence is currently lacking in order to quantify this change.[31]

Box 3: Agriculture and food security

Projected impacts of climate change pose risks to food security through crop nutrient content and yields, livestock, fisheries and aquaculture and land use (cover type and management). The impacts of climate change on yield, area, pests, price and food supplies are projected to have major implications for sustainable development and poverty eradication and will affect the achievement of almost all the Sustainable Development Goals (SDGs), specifically 1 and 2 (extreme poverty and hunger, respectively).

Case study: In Nepal farmers have switched from cultivating traditional crops such as maize, rice and lentils to cultivating lemongrass, citronella and other essential oil. This has allowed farmers to cultivate the land all year round and increase their income. Read the full case study here (Pariyar et al., 2018).

Adaptation measures to meet food security include greater investment in crop diversification and integrated agriculture-aquaculture practices, improving water use technologies (e.g. irrigation, pond capacity improvement, rainwater harvesting), soil management and strengthening allied sectors such as livestock-rearing and aquaculture. The consequences could be reduced substantially at 1.5°C with appropriate investment, awareness-raising to help inform farmers of new technologies for maintaining yield and strong adaptation strategies that develop sustainable agricultural choices, such as 'climate-smart' food production and distribution systems. Adaptation could also include strengthening social safety nets and livelihood assets, while ensuring adaptation plans are mainstreamed into broader development goals. However, there is also a growing recognition that transformational adaptation is needed within the agricultural sector, which includes enacting deep, systemic change such as introducing new crop varieties or type(s) of farming.[32] The process of getting there may require a mix of incremental and transformational adaptation, for example slowly improving crop management while new crop varieties are being tested.

Selected sectoral impacts and adaptation options

Learn More: The impacts, timing and practical implications for selected sectors are summarised below, while the Special Report provides further details on the sustainable development implications of avoided impacts between 1.5°C and 2°C for different sectors.

Disasters

Climate change has increased the frequency, intensity and duration of some extreme events (i.e. atmospheric-related natural disasters such as heatwaves, hurricanes, tornados and droughts), and the changes vary from region to region. The links between natural disasters and climate change, although complex, are important to understand and communicate, as they play a significant role in encouraging policy-makers and citizens to take action. The level of impact associated with disasters is a result of the vulnerability and exposure of human and built systems to those extreme events. Extreme events have impacts on health, livelihoods, food security, water availability, human security and economic growth.

El Niño–Southern Oscillation (ENSO): The frequency of extreme El Niño events (RFC 5)[4] increases linearly with the global mean temperature, and the number of such events may double (one event every ten years) under 1.5°C of global warming. This pattern is projected to persist for a century after stabilisation at 1.5°C, challenging the limits to adaptation.[33] Even at 1.5°C, this indicates possible negative implications for economic growth in the Southern Hemisphere subtropical regions.

Adaptation options

Disaster risk management promotes resilience that emphasises self-reliance. It is, however, critical that this does not intensify the burden on the already vulnerable (i.e. the elderly, migrants and low-income citizens). Some of the types of actions that are required include strengthened anticipatory capacity (disaster preparedness) through investing in risk identification, early warning systems and climate information services. There is also a need to strengthen traditional disaster response and recovery, but lack of institutional, technical and financial capacity often presents challenges for frontline agencies.[34]

Resilience at the local level can be strengthened by promoting autonomous adaptation capacity and mainstreaming community-based adaptation (CbA) and ecosystem-based approaches (EbAs), which can help bridge the divide between the disaster risk reduction and climate change adaptation fields of practice. Social protection programmes, when combined with a comprehensive climate risk management approach, can build generic adaptive capacity.[35] These programmes can include protective instruments such as classic food- and cash-based safety nets, insurance, social support schemes and disaster risk management by building development co-benefits (e.g. shelters doubling as community spaces or flood protection infrastructure doubling as roads) and unlocking economic potential.

4 Large-scale singularities/singular events.

Box 4: Forecast-based Financing to build anticipatory and absorptive capacity

FbF is a mechanism for releasing humanitarian funding triggered by a pre-established forecast threshold, to ensure rapid mobilisation of pre-planned activities to reduce risks, enhance preparedness and improve response.

FbF has been tested in 10 countries, including in Mongolia, where *dzud* is a type of disaster that results from severe drought followed by extreme winter. *Dzud* puts millions of livestock at risk of dying in a place where livestock are the main source of food, transport and income for herders. Based on a 'Dzud Risk Map' that identified the 40 most-at-risk *soums*, the Mongolian Red Cross Society provided 2,000 herder households with unrestricted cash grants and animal care products. This action strengthened cooperation between local government, the National Emergency Management Agency and other actors and built their capacity to anticipate a potential *dzud* before it happened using the Dzud Risk Map. It also created a long-term contract with the financial service provider to transfer cash grants, which are intended to increase herder capacity to absorb the impacts of the drought followed by extreme winter. In addition, the initiative used a complaints hot-line in order to gather feedback and foster community engagement. For the full case study see here (IFRC, 2018).

Coastal and small island developing states

Globally, millions of people may be at risk from sea level rise during the 21st century. Average sea levels are rising, accelerating and producing significant impacts for both coasts and small island developing states (SIDS). At 1.5°C, limits to adaptation will be reached for several key impacts in SIDS, resulting in residual impacts and loss and damage. We are already locked into certain impacts such as sea level rise, owing to the greenhouse gases we have already emitted. However, the amount of sea level rise will be less and its rate of rise will be lower at 1.5°C, giving us more time to adapt.[36] In a 1.5°C world, about 40,000 fewer people living in SIDS would be inundated than in a 2°C world.[37]

Differences in global sea level between 1.5°C and 2°C depend on the time scale considered and will fully materialise only after 2100. At 2°C of warming, more than 70% of global coastlines will experience sea level rise greater than 0. 2m, with regional differences as to the exact rate. There are multiple inter-related risks that are higher at 2°C – coastal flooding, impacts on infrastructure and assets, freshwater stress and impacts on marine ecosystems. Coastal flooding could be more widespread in sensitive systems such as small islands. Rising sea levels and other oceanic climate change may lead to increased flooding and damage to infrastructure from extreme events, plus salinisation of groundwater. The compounding impacts of rainfall, temperature, tropical cyclones and sea levels will still be significant for SIDs, even at 1.5°C of global warming.[38]

Adaptation options

Adaptation is fundamentally a local issue. It must be done by a community and not to a community. Increasing resilience to the multiple drivers of coastal change, including sea level rise, are essential, and include building anticipatory capacity, for example by developing scenarios and projections relating to climate parameters, including sea level, storm intensity/surges, wind speeds and temperature variability. Accommodating, by raising roads and carrying out ecosystem-based adaptation, such as through restoration of ecosystems and planting mangrove forests is also a key adaptation

option. In addition, defending by using options such as sea walls and engineering solutions for ports, which may reduce or delay coastal impacts and exposure can be used. Retreating is also an option, through migration or retreating and/or abandoning development in high-risk areas. We can also combine 'hard and soft' approaches in which traditional strategies that focus on hard engineering[5] can be complemented with 'soft' approaches.[6]

All coastal adaptation practices listed above are likely to be most effective if they include participatory decision-making processes. Limits to coastal adaptation may arise with low levels of mean sea level rise – that is, low-lying islands and coasts with attendant implications for loss and damage. It is important to note that the limits may be specific to individual SIDS and that one option will not necessarily be appropriate for all, and instead appropriate options need to be assessed locally through an iterative and inclusive process.

Learn More: The IPCC has assessed the limits to adaptation for coastal areas in more detail.

Cities

The majority of the world's population is now urban, with nearly 1.5 billion currently living in informal settlements and slums in some of the most hazard-prone zones globally. Cities are growing rapidly: urban areas have 1.4 million people added to them every week, and more than half of the land projected to be urban by 2030 has not yet been developed. It is also noteworthy that 90% of expected urban growth will take place in resource-constrained developing countries in Sub-Saharan Africa and Asia. The significant exposure of infrastructure and high concentration of people in cities means the extent of impacts in cities will undoubtedly be high (Kumar, 2018). Urban forms and functions mediate their exposure and vulnerability to risk. Poor urban dwellers are those likely to be most vulnerable. The primary risks to urban areas are heat-related extreme events, variability in precipitation and sea level rise, including storm surge. Vulnerability will be dependent upon the location (coastal or non-coastal), infrastructure (energy, water, transport), levels of poverty and the mix of formal and informal settlements.

At 1.5°C, twice as many megacities could become heat-stressed compared to today, exposing a possible 350 million additional people to deadly heatwaves by 2050.[39] Extreme events could also affect vulnerable assets, including urban infrastructure – energy, water, transport and buildings – through direct impacts on operations (e.g. sea level rise and storm surge) and through impacts on supply and demand, with the risks varying significantly across geographic region, season and time. Air quality could deteriorate as a result of high fossil fuel use. Indirect risks may arise from interactions between urbanisation and natural systems.

5 Such as *improving dam and irrigation infrastructure* to secure freshwater supplies.

6 Such as r*egulating development and land use*, integrating *early warning systems*, improved *disaster risk and preparedness* capacity of communities and implementing nature-based solutions such as the restoration of large natural ecosystems (i.e. restoration of sand dunes and mangroves) or protected areas.

Learn More: Cities groups have created a 'Summary for Urban Policymakers' to translate the findings of the Special Report for urban policymakers including on the feasibility, practical action and funding for an urban transition to a 1.5°C world.

Adaptation options

The IPCC has assessed that green infrastructure and sustainable water management, followed by sustainable land use and urban planning, are the most feasible adaptation strategies for urban and infrastructure transitions required for a 1.5°C world.[40] Transformational adaptation may be needed, especially to address the root causes of poverty, failures of sustainable development and a lack of focus on social justice.[41]

Some types of adaptation measure may include nature-based solutions can be used across a range of sectors (water, energy, transport) and scenarios, from megacities to small remote coastal communities. They can involve rivers, streams and floodplains, mangroves, seagrasses, oyster and coral reefs, green roofs, streets and parking lots, among others (Dunn and Velez, 2018). Cities, specifically coastal and developing cities, have the ability to significantly contribute to climate-resilient development pathways (CRDPs).[42] They can be seen as being at the frontline of adaptation and mitigation, given their rapid growth rates and their currently undetermined spatial and development plans.

Building climate resilient cities and infrastructure by integrating sustainable and innovative solutions into land use planning is also important. Densification and affordable mass transit systems are practical strategies that are becoming more common. A resource efficiency agenda can also help cities become more resilient, through managing resources efficiently (such as through efficient solid waste management) and reducing exposure to the risk of shortfalls in essential inputs – energy, water and food. Renewable energy provides the co-benefits of improved indoor air quality, less fire risk and reduced deforestation. Waste can be treated to generate energy in the form of electricity, heat or transport fuels. It is also critical that adaptation strategies be supported by wider efforts to improve urban infrastructure and services, and by integrated development planning.

Ecosystems

1.5°C warming is not considered 'safe' for most ecosystems, with the worst impacts expected to be felt among agricultural and coastal-dependent livelihoods.[43] Globally, around 7% and 13% of land area experiences biome shifts, at 1.5°C and 2°C, respectively.[44] At 3°C of warming, biome shifts and species range losses escalate to very high levels and the systems have very little capacity to adapt.

Limiting global warming would limit the increases in ocean temperature and acidity and decreases in ocean oxygen levels and so would reduce risks to marine biodiversity, fisheries and ecosystems. For coral reefs, there is high confidence of growing impacts in the transition of warming from 0.4°C to 1.3°C. The distribution and abundance of coral reefs has decreased by approximately 50% over the past 30 years. Coral reefs would decline by between 70% and 90% with 1.5°C warming, but a 2°C rise would mean the loss of virtually all coral reefs (99%). In Bangladesh, by 2050, damages and losses are expected for poor households dependent on freshwater fish stocks resultant from

insufficient mobility and access to land.[45] Constraining warming to 1.5°C rather than 2°C would reduce risks to endangered and unique ecosystems and safeguard the services they provide, thereby making adaptation easier.[46]

Adaptation options

There are a wide variety of adaptation options available for ecosystems, depending on the type of ecosystem and other contextual features, such as governance and institutional capacity. The Special Report highlights conservation agriculture, efficient irrigation, agroforestry, ecosystem restoration and avoided deforestation, and coastal defence and hardening as feasible options.[47]

Some additional examples include cross-sectoral adaptation options such as Integrated Water Resource Management, Integrated Coastal Zone Management, CbA and EbA are viewed as more effective than standalone efforts to reduce climate-related risks. CbA, as well as the integration of CbA with EbA, holds promise especially in efforts to alleviate poverty. Payment for ecosystem services can provide incentives to land owners and natural resource managers to preserve environmental services. Land and watershed management (such as the removal of alien vegetation in critical catchments) contributes to reducing flood risks and improving water quality by improving naturally functioning ecosystems that deliver valuable services to people, such as water and climate regulation, soil formation and disaster risk reduction. It is also important to address issues related to the appropriate use of natural or human-caused fire in maintaining the ecological values and integrity of certain ecosystems.

Wetland management strategies and rehabilitation interventions (such as building of gabion structures to arrest erosion, trap sediment and re-saturate drained wetland areas) dampen the effect of climate extremes such as flooding and fires. Addressing both the causes and the effects of land degradation, including adjustments in infrastructural, behavioural and institutional practices – such as those that draw on the principles of adaptive co-management – has clear implications for adaptation. Lastly, the restoration of coastal systems includes mangrove restoration to reduce coastal vulnerability, protecting marine and terrestrial ecosystems, and increasing local food security.

Box 5: Preserving the mangrove greenbelt and creating opportunity

Indonesia has around 3,000,000 ha of mangrove forest, making up 20% of the world mangrove forest. Mangroves provide important ecosystem services, such as protecting the beach from coastal erosion and supporting fish and crab breeding, as well as acting as an important carbon sink. In the coastal area in Berahan Wetan village, Wedung sub-district, Demak district, the mangroves were devastated, along with community fishponds that once were a key income source for coast communities.

The Demak office of the Indonesian Red Cross and its partners worked to replant mangroves, involving communities to take care of the trees, which had a 96–98% success rate. The mangroves proved able to protect the beach from coastal erosion. In addition, the plants are able to create a living space for water creatures that have high economic value like crabs and clams and that are becoming an alternative livelihood for the surrounding community. For the full case study see here (Partners for Resilience, 2018).

Migration, Displacement and Conflict

Migration, displacement and conflict are complex issues linked to many social, economic and environmental factors. There is rarely a single cause for migration, instead work, education, quality of life, family ties, access to resources and development all play a role, with changing weather, climate or environmental conditions sometimes factored into the decision depending on the situation.[48] At 2°C there is a potential for significant displacement in tropical areas, which would lead to a concentration of people in tropical margins and the subtropics, increasing population density.[49]

Research indicates the need for caution in linking conflict to climate change, as sampling bias and lack of consideration of the multiple drivers of conflict leads to inconsistent associations.[50] In some least developed countries (e.g. in sub-Saharan Africa, Middle East), drought can increase the likelihood for sustained conflict due to the dependence on agricultural livelihoods.[51] However, under most circumstances the relationship between drought and conflict in weak. Despite the unclear causal relationship, extreme events that occur in conflict-affected places do increase the vulnerability of people already affected by conflict, highlighting the need to address these issues in conflict-affected places.

Box 6: Mediating between different livelihoods – joint training in a conflict scenario with pastoralists and settled communities

The BRACED Livestock Mobility project works at regional, national and local levels to secure routes used during transhumance, working in two cross-border areas, one between Mauritania, Mali and Senegal and the other across Mali, Niger and Burkina Faso. One important element of this work is 'training modules' on Livestock Trading in the Sahel. These are a series of workshops that mediate between pastoralists and the settled communities through which they journey, helping each side understand the other's livelihood and the benefits to all of transhumance. The module lasts for five to seven days and operates on the basis that working one's own way to a conclusion is a more powerful way to change mindsets than training that simply tries to tell people to behave differently. Participants are led through a discussion to understand the pastoralist lifestyle. At a local level, the project is succeeding in securing corridors for transhumance and others resources such as access to water points. For the full case study see here (Powell and Amadou Ly, 2017).

Climate resilience

Adapting and mitigating to present and future climate change is no longer an option – it is a necessity. Curbing the associated risks calls for transitions that enable and increase investments, enhance policy instruments, strengthen institutional arrangements for climate action and accelerate technological innovation and behaviour changes. The IPCC highlights the need for 'rapid and decisive adaptation actions to reduce the costs and magnitude of potential climate impacts' through 'i) enabling conditions, especially improved governance, economic measures and financing; ii) enhanced clarity on adaptation options to help identify strategic priorities, sequencing and timing of implementation; iii) robust monitoring and evaluation frameworks; and iv) political leadership'.[52]

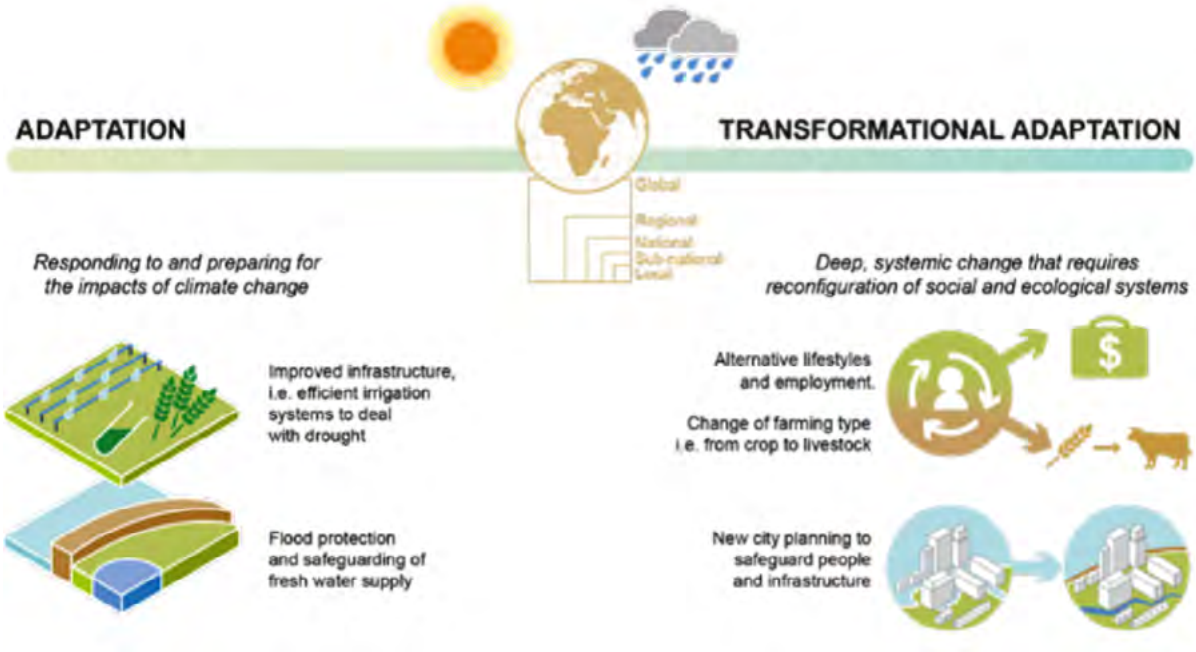
Understanding the implications for adaptation

The temperature of our planet is warming faster than ever. Limiting warming to 1.5°C will require an unprecedented response, and the longer countries delay the more difficult and costly it will be. We are currently on track for a 3–5°C increase in temperature, which could result in catastrophic impacts. It is not possible to separate development and adaptation, particularly when we consider the most vulnerable people in the world. The development mantra/humanitarian call associated with the SDGs is 'leave no one behind', which has led to the development of Climate Resilient Development Pathways (CRDPs).[7] CDRPs are decision trajectories that fulfil the goals of limiting warming to 1.5°C, while also achieving the SDGs. They will include a mix of mitigation and adaptation actions that will build resilience, enhance human capacities to adapt, while also addressing issues of poverty, inequality and vulnerability.[53] In addition to incremental adaptation, CDRPs often require transformational adaptation. There are no standardised methods for developing or monitoring CDRPs, instead they require deliberations with various stakeholders, iterative decision making, continuous learning, and experimentation.[54] These speak to a broader concern of development paths that are sustainable at all scales – international and national, and at the local level. Adaptation needs to be facilitated by a range of different enabling conditions.

7 The characteristics of which are not standard across communities and nations.

Box 7: What is transformational adaptation?

In contrast to incremental adaptation, transformational adaptation entails deep, systematic change that requires a reconfiguration of social and ecological systems. For example, if the climate changes so significantly that the current agricultural practices are no longer viable, it may require an entirely new agricultural system including new types of agriculture (e.g. livestock instead of crops), new methods (e.g. drip irrigation instead of flood irrigation), and completely new crop varieties.



Source: *modified from SR1.5, Chapter 4, FAQ 4.3, Figure 1*

While recognising that many adaptation measures bring benefit, such as enhanced disaster preparedness, they will often come with difficult decisions and trade-offs. The biggest message with respect to adaptation in the Special Report is that *ambitious mitigation is the surest and best form of adaptation*. Through *effective and rapid mitigation, it is possible to reduce the need to adapt* and thus to reduce the costs and complications that come with that. As we are already noting, for many around the world (i.e. those in low-lying areas and some of the SIDs), it is not possible to adapt to the changes that we are already 'locked in to'.

Learn More: The Special Report includes a number of case studies that highlight different adaptation examples in specific contexts.

The Special Report warns that 'if mitigation pathways are not rapidly activated, much more expensive and complex adaptation measures would have to be taken to avoid the impacts of higher global warming on the Earth system'.[55] In addition to being a strong warning for the world to rapidly adopt stronger mitigation policies, this also serves as warning of the likely scale of the adaptation challenge if global leaders fail to act swiftly to reduce emissions.

Learn More: To illustrate the possible futures, the Special Report Authors created a set of three storylines under different mitigation options and internal climate responses.

Half a degree matters. The Summary for Policymakers (SPM) provides four big system transitions that are essential in terms of energy, land, urban infrastructure and industry. While these are crucial for bending the curve of climate change we need to recognise (1) that these systems are also vulnerable to the impacts of climate change and (2) the synergies between adaptation and mitigation as mechanisms to increase climate resilience. *Adaptation has to be contextually appropriate* while we respond to the local calls of people and local needs.

Learn More: The Special Report presents some examples from different social-ecological systems as examples of risks of 1.5°C warming and higher, adaptation options to respond to these risk and their implications for poverty, livelihoods and sustainability.

Adaptation policy

The current rapid rate of climate change will impose new and potentially overwhelming pressures on existing adaptation capacity. Adaptation policy provides a basis from which integrated actions to adapt to climate change can be developed. It guides the selection of appropriate responses and interventions, sets priorities for these interventions and outlines how they may be implemented. Policy is a key procedure at national scale to facilitate targeted adaptation strategies and coordinated risk governance while maximising the synergies between mitigation and developmental actions.

Adaptation policy framework – preparing the ground:

1. *Adaptation policy and measures are assessed in a developmental context*. As sustainable development is the framing context for the SDGs, which is the architecture for sustainable development up to 2040, it is important to ensure that climate responses/ actions are key in allowing us to achieve a more sustainable and equitable world. Fundamentally, climate change will interact with and compound baseline stresses that, in many cases, are the primary drivers of vulnerability and poverty (UNDP, 2018, p. 20). New development paths will, therefore, have to be developed and implemented to provide the enabling environments that will enhance climate resilience and adaptive capacity. While baseline development is required to reach targets for poverty reduction and climate action, realising development goals through climate change action is more likely through approaches that combine climate change adaptation, mitigation and development based on social equity, to achieve the 'triple dividends of resilience': saving lives and avoiding losses; unlocking economic potential; and generating development co-benefits.

2. *Adaptation to short-term climate variability and extreme events is explicitly included as a step towards reducing vulnerability to long-term change.* However, understanding the implications of short-term actions on longer timescales is critical to pre-empt potentially maladaptive trajectories, as some adaptation interventions in the present have trade-offs in the future. Furthermore, adaptation measures on their own may not be enough to prevent climate change impacts entirely. The more global temperature rises, the more frequent, severe and erratic the impacts will be, and adaptation may not protect against all risks.

3. To realise the *multiple benefits of disaster risk reduction* in the face of extreme events, policy actions are necessary to comprehensively consider the linkages between reducing disaster risk and responding to climate change, guiding national and regional action to integrate policies and practices and strengthening capacities to support the integration of disaster reduction and climate change by all actors (UNISDR, n.d.).

4. *Adaptation occurs at different scales in society, including the local.* Mainstreaming adaptation to climate change into national development policies, regional and local planning, and economic development presents an opportunity for addressing multiple, interacting stresses. Develop specific policies at the national and local level on the linkages between reducing disaster risk and responding to climate change, guiding national and local action to integrate policies and practices, and strengthen capacities to support the integration of disaster reduction and climate change by all actors.

5. *Transformational adaptation:* Equitable transformational change is required in some high-risk regions at a 1.5°C warmer world. This means going beyond just adjusting existing practices to making deep, systematic changes. The Special Report authors highlight a case study in Nepal where villagers have transformed their employment from agricultural and pastoralist livelihoods to stores, hotel and tea shops in response to changing rainfall patterns and environmental degradation.[56]

6. *The adaptation strategy, and the inclusive process by which it is implemented, are equally important.* Policy has to guide the selection of appropriate responses and interventions, to set priorities for these interventions and to outline how these interventions may be implemented. It is important to harness the policy instruments that are available, thereby reaping the benefits of technological innovation and encouraging behaviour change, while striking a balance between 'hard' and 'soft interventions'. Where vulnerabilities and risks are so large (as is the case in certain regions, populations or resource systems, and where severe climate change overwhelms even robust human use systems), an incremental adaptation strategy may not be adequate; then transformational adaptation has a place. A transformative adaptation strategy is defined as 'actions aiming

at adapting to climate change resulting in significant changes in structure or function that go beyond adjusting existing practices, including approaches that enable new ways of decision-making on adaptation'.[57] Many strategies for sustainable development enable transformational adaptation for a 1.5°C warmer world, provided attention is paid to reducing poverty in all its forms and to promoting equity and participation in decision-making. When implementation is conducted in a participatory and integrated manner, it can enable rapid, systemic transitions.

7. *Encourage behaviour changes.* These are enabled by effective governance arrangements and by accelerated technological innovation, and by enhancing the capacities of public, private and financial institutions to accelerate climate change policy planning and implementation. Examples of such actions are strengthened global-to-local financial architecture that enables greater access to finance and technology; improved climate education and greater public awareness; and strengthened climate monitoring and evaluation systems. A transformative policy could, for example, be the adoption of massive social protection programmes to lift people out of poverty that is geared towards climate resilience and green jobs.[8]

8. A*ddress the residual (increased and unavoidable) risks of climate change.* There are limits to adaptation: soft adaptation limits (adaptive actions currently not available) and hard adaptation limits (adaptive actions appear infeasible leading to unavoidable impacts). These will have implications for sustainable development, poverty and inequalities, which demand consideration of compensatory, distributive and procedural equity concerns. SIDS, for example, are expected to experience challenging conditions at 1.5°C warming owing to the increased risk of internal migration and displacement and limits to adaptation. Accepting and dealing with residual risks includes responses such as income loss insurance for farmers; government reserves and enhanced insurance for coastal regions; and fisheries insurance. There are synergies with disaster risk reduction policies, calling for an integration of responses such as enhanced preparedness measures for more frequent and intense extremes, but also careful consideration for slow-onset and potentially irreversible impacts and risk.

9. *Building adaptive capacity to cope with current climate is one way of preparing society to better cope with future climate.* Implementation of policy requires an enabling environment, such as sufficient institutional capacity, strong governance and political will at local, national and international levels. 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.

8 Shared Socioeconomic Pathways constitute an important first step in providing a framework for the integrated assessment of adaptation and mitigation and their climate-development linkages.

Key principles of adaptation practice

One of the key ways to enhance resilience and adaptive capacity is to *increase investment in basic infrastructure, both physical and social.*

1. It is necessary to *shift adaptation measures to system-wide transformations, yet at different scales*. Efforts that address multiple sector entry points and the SDGs, that make better use of partnerships and that mainstream, scale up and accelerate climate adaptation are important.

2. Pursue *place-specific adaptation pathways at all levels* of development,[58] at country and community level, applying solution-oriented trajectories and decision-making processes that are about context- and place-specific opportunities, challenges and trade-offs. This necessitates a diversity of adaptation options based on people's values and trade-offs they consider acceptable, maximising synergies with sustainable development through inclusive, participatory and deliberative processes, and facilitating equitable transformation.

3. Identify 'win-win' *synergies and trade-offs between adaptation strategies that can result in trade-offs with and among the SDGs (Chapter 5) and adaptation and mitigation options (Chapter 4).* There are moral, political and practical challenges – and trade-offs – to negotiating what is fair and to whom, that must be deliberated and negotiated. A 1.5°C warmer world requires complementary adaptation and development action, typically at local and national scale. Chapter 5 highlights the potential that combined mitigation, development and poverty reduction offer for accelerated decarbonisation.

4. *Devise a set of principles* for the design and implementation of adaptation interventions. The political economy shapes choices between possible pathways, at different scales and for different groups of people. Overlooking this can lead to maladaptive pathways that preclude alternative, locally relevant and sustainable development initiatives, exacerbate inequalities and increase vulnerabilities. Synergistic outcomes between development and adaptation interventions are enhanced by participatory processes in adaptation decision-making, horizontally and vertically, within government and between government and non-state actors; sustainability-led programming that addresses the barriers to replication and scaling-up of promising adaptation innovations; and *capacity development* for policy design, programming, implementation and monitoring and evaluation among all stakeholders, within and outside government.

5. Ensure on-going *climate information collection*, storage, analysis and sharing of data, and use of climate information for decision-making and *monitoring and evaluation*. Climate services can play a critical role in aiding adaptation decision-making.

Financing of adaptation

Adaptation finance is difficult to put a value on. Adaptation actions will require reliable and large sources of financing and call for the unlocking of new forms of public, private and public–private financing. The economics of adaptation will be a key consideration in making improved investments in climate change adaptation – critical questions need to be asked to form the most efficient policy response – and will inform where and when investments should be made. For example, disaster risk reduction, climate information and early warnings provide important examples on the relative return on investment of climate change adaptation. Policies (including fiscal policies) and institutional arrangements, and associated economic instruments and finance, are critical to make solutions work.

What's next?

The lack of global consensus on a political level to match the scientific imperative to act lends the Special Report an important role in the facilitative dialogue process in 2018, which will focus on how to close the gap between current policies, NDCs and emission pathways consistent with the Paris Agreement in 2025 and 2030. While many countries are developing NDCs and adaptation plans, this effort needs to move rapidly towards implementation of plans and commitments to avoid the worst impacts.

The Paris Agreement requires the signatory members to come together every five years to reassess and strengthen their original targets, a policy term known as 'the ratcheting mechanism', in order to increase mitigation ambition and adaptation action to meet the temperature target of 1.5°C. The UNFCCC expects substantial ratcheting of greenhouse gas emission reduction targets and rapid and massive decarbonisation of the global energy system (Schleussner et al., 2016). However, these proposed aggressive near-term reductions fail to account for fluctuations in global and national economies or potential geopolitical strife. They will require international cooperation, and strengthened institutional capacity from national to local level, from civil society, the private sector, cities, local communities and indigenous peoples.[59]

For the development and humanitarian community, the Special Report serves as both a wake-up call on the urgency of the climate problem and a scientific consensus to support what practitioners have been observing for years – that the climate is already changing and that changes are felt most acutely by the most vulnerable people. While many adaptation solutions are already underway, there needs to be increased efforts to scale up adaptation and to apply a long-term lens in planning across all development and humanitarian work.

References

Full citation for the Special Report

IPCC (2018) 'Global warming of 1.5°C. An 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' [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds)]. In press.

Summary for Policymakers

IPCC (2018) 'Summary for policymakers'. In 'Global warming of 1.5°C. An 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' [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor and T. Waterfield (eds)]. In press.

Other references

Dunn, B. and Velez, C.R. (2018) 'Managing the perfect storm: how healthy ecosystems increase resilience: Protecting and enhancing natural ecosystems and biodiversity can increase resilience in Asia and the Pacific' (https://www.preventionweb.net/news/view/61572)

IFRC – International Federation of Red Cross and Red Crescent Societies (2018) 'Forecast-based Financing for vulnerable herders in Mongolia'. DRR in Action Case Study (http://media.ifrc.org/wp-content/uploads/sites/5/2018/06/CaseStudy16_Mongolia-FbF-Final.pdf)

Imada, Y., Siogama, H., Takahashi, C., Watanabe, M., Mori, M., Kamae, Y. and Maeda, S. (2018) 'Climate change increased the likelihood of the 2016 heat extremes in Asia' [in "Explaining Extreme Events of 2016 from a Climate Perspective"]. *Bull. Amer. Meteor.* Soc., 99 (1): S97–S101, doi:10.1175/BAMS-D-17-0109.1.

Kumar, E. (2018) 'What can cities do in response to these findings?' (https://www.preventionweb.net/news/view/61319)

Malik, M.M. (2018) 'IPCC report: accelerating the response to climate change'. OPM, November (https://www.opml.co.uk/blog/ipcc-report-accelerating-response-climate-change)

Otto, F. E. L., Wolski, P., Lehner, F., Tebaldi, C., van Oldenborgh, G.J., Hogesteeger, S., Singh, R., Holden, P., Fuckar, N. S., Odoulami, R. C., and New, M. (2018) 'Anthropogenic influence on the drivers of the Western Cape drought 2015-2017' *Environ. Res. Lett.* 13(12), doi: 10.1088

Partners for Resilience (2018) 'A journey for a thousand smiles. Stories of resilient people'. (https://www.carenederland.org/wp-content/uploads/2018/08/RS315_Journey-for-a-Thousands-Smile_PfR.pdf)

Powell, A. and Amadou Ly, M. (2017) 'Mediating between different livelihoods: joint training in a conflict scenario with pastoralists and settled communities'. BRACED Resilience Exchange Story of Change (https://braced-rx.org/wp-content/uploads/2017/08/BRCJ5481_Stories_12_170726_WEB.pdf)

Robine, J.M., Cheung, S.L.K., Le Roy, S. et al. (2008) 'Death toll exceeded 70,000 in Europe during the summer of 2003' *Comptes Rendus Biologies* 331(2): 171–178

Rogelj, Joeri, and Carl-Friedrich Schleussner. (2017) 'Guest Post: Interpreting the Paris Agreement's 1.5C Temperature Limit." Carbon Brief (www.carbonbrief.org/guest-post-interpreting-paris-agreements-1-point-5-c-temperature-limit)

Schellnhuber, H.J., Rahmstorf, S. and Winkelmann, R. (2016) 'Why the right climate target was agreed in Paris' *Nature Climate Change* 6(7): 649–653

Schleussner, C.-F., Schaeffer, M., Lissner, T. and Hare, W. (2016) 'Science and policy characteristics of the Paris Agreement temperature goal' *Nature Climate Change* 6(9): 827–835

Shah, T., Mavalankar, P., Ganguly, P. et al. (n.d.) 'Innovative heat wave early warning system and action plan in Ahmedabad, India'. (http://ghhin.org/assets/case_study_pdf/WHO-WMO_Case_Stage_6_CH6a.pdf)

Suarez, P. and van Aalst, M.K. (2017) 'Geoengineering: a humanitarian concern' *Earth's Future* 5: 183–195

Toloo, G.S., Fitzgerald, G., Aitken, P. et al. (2013) 'Are heat warning systems effective?' *Environmental Health: A Global Access Science Source* 12(27): doi:10.1186/1476-069X-12-27

UNDP – United Nations Development Programme (2018) *Climate change adaptation in Africa: UNDP synthesis of experiences and recommendations.* New York: UNDP.

UNFCCC – United Nations Framework Convention on Climate Change (2015) 'Adoption of the Paris Agreement'. FCCC/CP/2015/L.9/Rev.1

UNISDR – United Nations Office for Disaster Risk Reduction (n.d.) 'Climate change adaptation'. (https://www.unisdr.org/we/advocate/climate-change)

van Oldenborgh, G.J., van der Wiel, K., Sebastain, A., Singh, R., Arrighi, J., Otto, F., Haustein, K., Li, S., Vecchi, G., and Cullen, H. (2018) 'Attribution of extreme rainfall from Hurricane Harvey, August 2017' *Environ. Res. Lett.* 12(12) doi: 10.1088

Acknowledgements

The authors would like to thank Shaban Mwanda, Chandni Singh, Debbie Ley, James Ford and Julie Arrighi for their expert review of the guide. We also thank Natalie Belew and Saraoja Schwager for their help reviewing the Special Report and preparing this guide. In addition, we thank Carina Bachofen for her guidance in developing the guide and her review of earlier drafts. We would also like to acknowledge Eszter Sarody for designing this guide and Roo Griffiths for copy-editing.

1 SPM, B5
2 SR 1.5, Chapter 5, Section 4.2.2.2
3 Ibid.
4 SR 1.5, Chapter 5, Cross-chapter box 12
5 SR 1.5, Chapter 1, Section 1.2.1
6 SPM, A.1.3, medium confidence
7 SPM, A.1, high confidence
8 Ibid.
9 SPM, C2, medium confidence
10 SPM, C1, high confidence
11 SPM, C2, high confidence
12 SR 1.5, Chapter 2, Section 2.6.3
13 SR 1.5, Chapter 2, Executive Summary
14 SPM, C1.2, medium confidence
15 SR 1.5, Chapter 1, Section 1.4.1
16 SR 1.5, Chapter 4, cross-chapter Box 10
17 SR 1.5, Chapter 4, Section 4.3.8
18 Ibid.
19 SR 1.5, Chapter 3, cross-chapter Box 8
20 SPM, A1.3, high confidence
21 SR 1.5, Chapter 3, Section 3.6.2
22 Ibid.
23 SR 1.5, Chapter 3, cross-chapter Box 7
24 SR 1.5, Chapter 3, Section 3.6.2.3
25 SR 1.5, Chapter 3, Section 3.6.2.2
26 SR 1.5, Chapter 4, Section 4.3.6
27 SR 1.5, Chapter 1, Section 1.3.3
28 SR 1.5, Chapter 3, Section 3.5.5.8
29 Ibid.
30 SR 1.5, Chapter 3, Section 3.5.5
31 Ibid.
32 SR 1.5, Chapter 3, Section 4.5.3
33 SR 1.5, Chapter 3, Section 3.5.2
34 SR1.5, Chapter 4, Section 4.3.5.1
35 SR 1.5, Chapter 4, Section 4.3.5.2
36 SR 1.5, Chapter 3, Section 3.6.3.2
37 SR 1.5, Chapter 3, Section 3.5.4
38 Ibid.
39 SR 1.5, Chapter 3, Section 3.5.5.8
40 SR 1.5, Chapter 4, Section 4.5.3
41 Ibid.
42 SPM, C5, medium evidence, medium agreement
43 SPM, C5, medium evidence, high agreement
44 SR1.5, Chapter 5, Section 5.2.3
45 Ibid.
46 Ibid.
47 SR 1.5, Chapter 4, Section 4.5.3
48 SR1.5, Chapter 3, Section 3.4.10.2
49 Ibid.
50 Ibid.
51 Ibid.
52 SR 1.5 Chapter 4, Section 4.5.3
53 SR1.5, Chapter 5, Section 5.5.3
54 Ibid.
55 SR1.5, Chapter 3, cross-chapter Box 8
56 SR 1.5, Chapter 4, Section 4.2.2.2
57 SR 1.5, Chapter 4, Section 4.2.2.2
58 SR1.5, Chapter 5, Section 5.3.3
59 SPM, D6, high confidence

Published December 2018
Designed and typeset by Eszter Sarody

Website: www.braced.org
Twitter: @Braced
Facebook: www.facebook.com/bracedforclimatechange

BRACED aims to build the resilience of vulnerable people against climate extremes and disasters. It does so through NGO-consortia working across the Sahel, East Africa and South Asia.

The BRACED Knowledge Manager generates evidence and learning on resilience and adaptation in partnership with the BRACED projects and the wider resilience community. It gathers robust evidence of what works to strengthen resilience to climate extremes and disasters, and initiates and supports processes to ensure that evidence is put into use in policy and programmes. The Knowledge Manager also fosters partnerships to amplify the impact of new evidence and learning, in order to significantly improve levels of resilience in poor and vulnerable countries and communities around the world.