MANAGING THE RISKS OF EXTREME EVENTS AND DISASTERS TO ADVANCE CLIMATE CHANGE ADAPTATION

SUMMARY FOR POLICYMAKERS

SPECIAL REPORT OF THE
INTERGOVERNMENTAL PANEL
ON CLIMATE CHANGE

SPM

Summary for Policymakers

Drafting Authors:
Simon K. Allen (Switzerland), Vicente Barros (Argentina), Ian Burton (Canada), Diarmid Campbell-Lendrum (UK), Omar-Dario Cardona (Colombia), Susan L. Cutter (USA), O. Pauline Dube (Botswana), Kristie L. Ebi (USA), Christopher B. Field (USA), John W. Handmer (Australia), Padma N. Lal (Australia), Allan Lavell (Costa Rica), Katharine J. Mach (USA), Michael D. Mastrandrea (USA), Gordon A. McBean (Canada), Reinhard Mechler (Germany), Tom Mitchell (UK), Neville Nicholls (Australia), Karen L. O'Brien (Norway), Taikan Oki (Japan), Michael Oppenheimer (USA), Mark Pelling (UK), Gian-Kasper Plattner (Switzerland), Roger S. Pulwarty (USA), Sonia I. Seneviratne (Switzerland), Thomas F. Stocker (Switzerland), Maarten K. van Aalst (Netherlands), Carolina S. Vera (Argentina), Thomas J. Wilbanks (USA)

This Summary for Policymakers should be cited as:

IPCC, 2012: Summary for Policymakers. In: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 1-19.

A. Context

This Summary for Policymakers presents key findings from the Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX). The SREX approaches the topic by assessing the scientific literature on issues that range from the relationship between climate change and extreme weather and climate events ('climate extremes') to the implications of these events for society and sustainable development. The assessment concerns the interaction of climatic, environmental, and human factors that can lead to impacts and disasters, options for managing the risks posed by impacts and disasters, and the important role that non-climatic factors play in determining impacts. Box SPM.1 defines concepts central to the SREX.

The character and severity of impacts from climate extremes depend not only on the extremes themselves but also on exposure and vulnerability. In this report, adverse impacts are considered disasters when they produce widespread damage and cause severe alterations in the normal functioning of communities or societies. Climate extremes, exposure, and vulnerability are influenced by a wide range of factors, including anthropogenic climate change, natural climate variability, and socioeconomic development (Figure SPM.1). Disaster risk management and adaptation to climate change focus on reducing exposure and vulnerability and increasing resilience to the potential adverse impacts of climate extremes, even though risks cannot fully be eliminated (Figure SPM.2). Although mitigation of climate change is not the focus of this report, adaptation and mitigation can complement each other and together can significantly reduce the risks of climate change. [SYR AR4, 5.3]

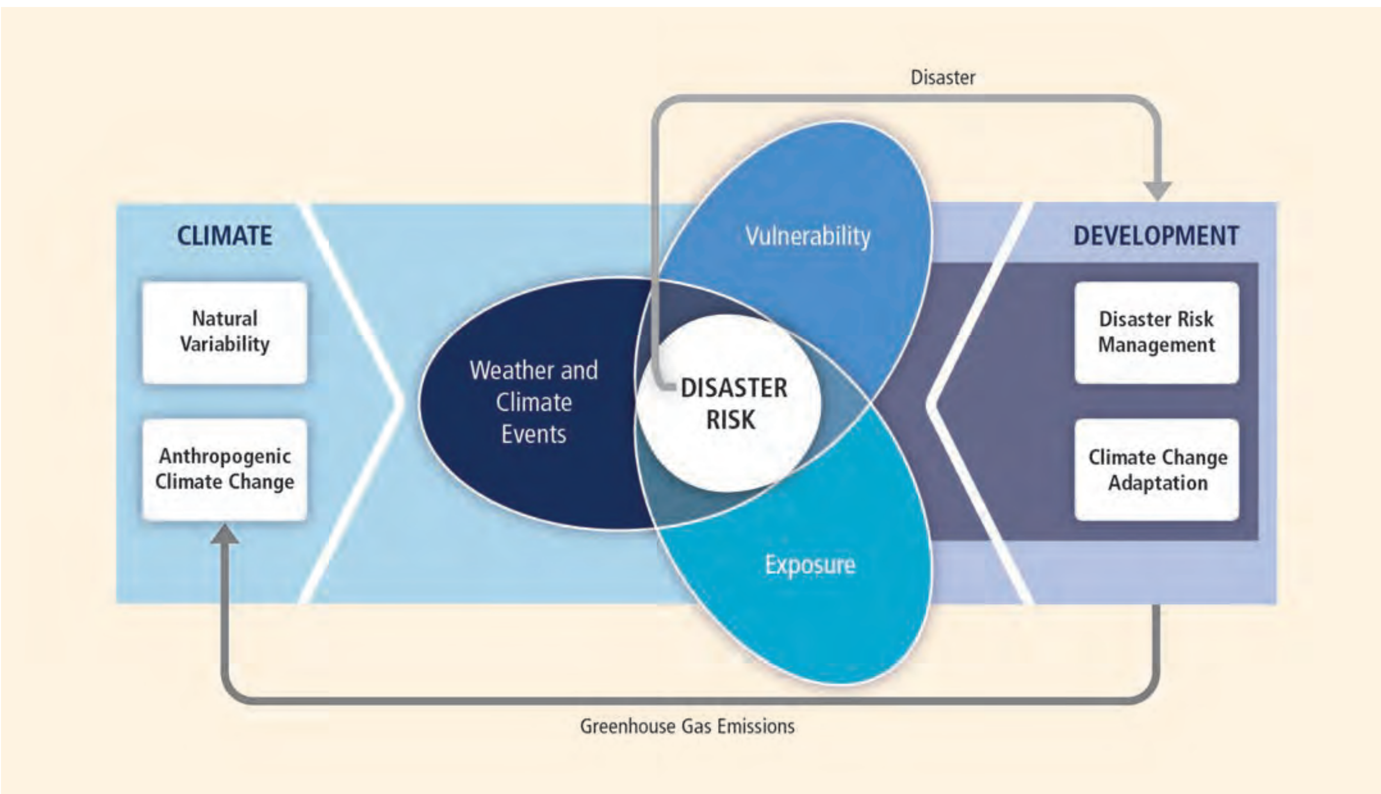


Figure SPM.1 | Illustration of the core concepts of SREX. The report assesses how exposure and vulnerability to weather and climate events determine impacts and the likelihood of disasters (disaster risk). It evaluates the influence of natural climate variability and anthropogenic climate change on climate extremes and other weather and climate events that can contribute to disasters, as well as the exposure and vulnerability of human society and natural ecosystems. It also considers the role of development in trends in exposure and vulnerability, implications for disaster risk, and interactions between disasters and development. The report examines how disaster risk management and adaptation to climate change can reduce exposure and vulnerability to weather and climate events and thus reduce disaster risk, as well as increase resilience to the risks that cannot be eliminated. Other important processes are largely outside the scope of this report, including the influence of development on greenhouse gas emissions and anthropogenic climate change, and the potential for mitigation of anthropogenic climate change. [1.1.2, Figure 1-1]

Box SPM.1 | Definitions Central to SREX

Core concepts defined in the SREX glossary[1] and used throughout the report include:

Climate Change: A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.[2]

Climate Extreme (extreme weather or climate event): The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes.' The full definition is provided in Section 3.1.2.

Exposure: The presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected.

Vulnerability: The propensity or predisposition to be adversely affected.

Disaster: Severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

Disaster Risk: The likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

Disaster Risk Management: Processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, resilience, and sustainable development.

Adaptation: In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate.

Resilience: The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.

Transformation: The altering of fundamental attributes of a system (including value systems; regulatory, legislative, or bureaucratic regimes; financial institutions; and technological or biological systems).

---

1 Reflecting the diversity of the communities involved in this assessment and progress in science, several of the definitions used in this Special Report differ in breadth or focus from those used in the Fourth Assessment Report and other IPCC reports.

2 This definition differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change is defined as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.

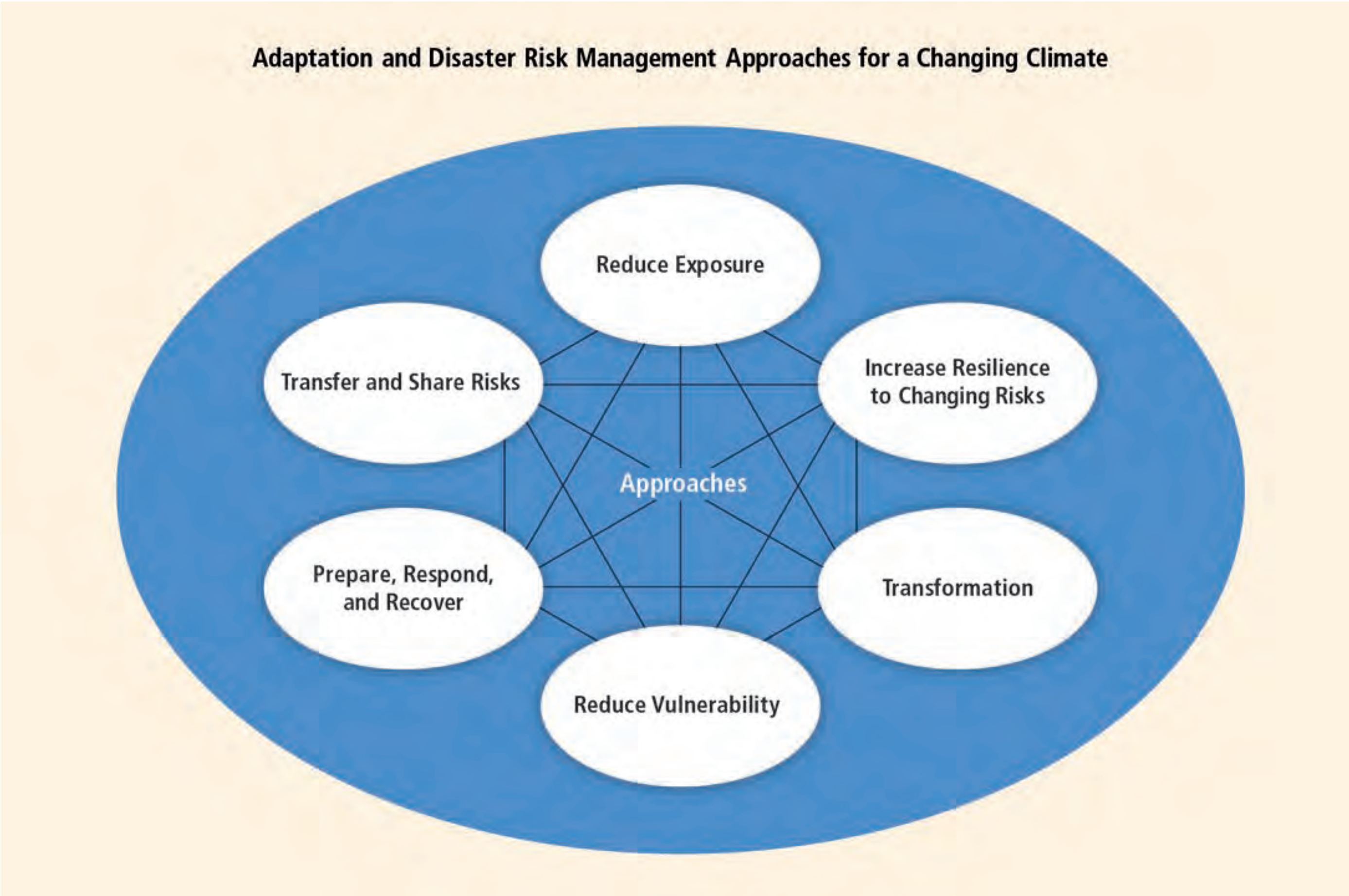


Figure SPM.2 | Adaptation and disaster risk management approaches for reducing and managing disaster risk in a changing climate. This report assesses a wide range of complementary adaptation and disaster risk management approaches that can reduce the risks of climate extremes and disasters and increase resilience to remaining risks as they change over time. These approaches can be overlapping and can be pursued simultaneously. [6.5, Figure 6-3, 8.6]

This report integrates perspectives from several historically distinct research communities studying climate science, climate impacts, adaptation to climate change, and disaster risk management. Each community brings different viewpoints, vocabularies, approaches, and goals, and all provide important insights into the status of the knowledge base and its gaps. Many of the key assessment findings come from the interfaces among these communities. These interfaces are also illustrated in Table SPM.1. To accurately convey the degree of certainty in key findings, the report relies on the consistent use of calibrated uncertainty language, introduced in Box SPM.2. The basis for substantive paragraphs in this Summary for Policymakers can be found in the chapter sections specified in square brackets.

Exposure and vulnerability are key determinants of disaster risk and of impacts when risk is realized. [1.1.2, 1.2.3, 1.3, 2.2.1, 2.3, 2.5] For example, a tropical cyclone can have very different impacts depending on where and when it makes landfall. [2.5.1, 3.1, 4.4.6] Similarly, a heat wave can have very different impacts on different populations depending on their vulnerability. [Box 4-4, 9.2.1] Extreme impacts on human, ecological, or physical systems can result from individual extreme weather or climate events. Extreme impacts can also result from non-extreme events where exposure and vulnerability are high [2.2.1, 2.3, 2.5] or from a compounding of events or their impacts. [1.1.2, 1.2.3, 3.1.3] For example, drought, coupled with extreme heat and low humidity, can increase the risk of wildfire. [Box 4-1, 9.2.2]

Extreme and non-extreme weather or climate events affect vulnerability to future extreme events by modifying resilience, coping capacity, and adaptive capacity. [2.4.3] In particular, the cumulative effects of disasters at local or sub-national levels can substantially affect livelihood options and resources and the capacity of societies and communities to prepare for and respond to future disasters. [2.2, 2.7]

A changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events. Changes in extremes can be linked to changes in the mean, variance, or shape of probability distributions, or all of these (Figure SPM.3). Some climate extremes (e.g., droughts) may be the result of an accumulation of weather or climate events that are not extreme when considered independently. Many extreme weather and climate events continue to be the result of natural climate variability. Natural variability will be an important factor in shaping future extremes in addition to the effect of anthropogenic changes in climate. [3.1]

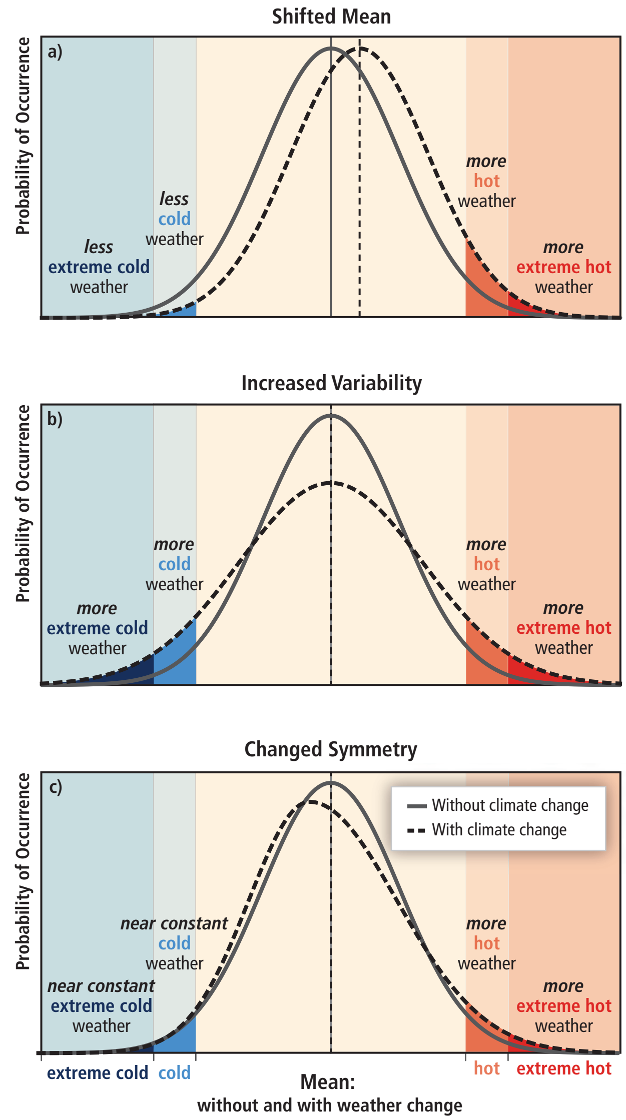


Figure SPM.3 | The effect of changes in temperature distribution on extremes. Different changes in temperature distributions between present and future climate and their effects on extreme values of the distributions: (a) effects of a simple shift of the entire distribution toward a warmer climate; (b) effects of an increase in temperature variability with no shift in the mean; (c) effects of an altered shape of the distribution, in this example a change in asymmetry toward the hotter part of the distribution. [Figure 1-2, 1.2.2]

B. Observations of Exposure, Vulnerability, Climate Extremes, Impacts, and Disaster Losses

The impacts of climate extremes and the potential for disasters result from the climate extremes themselves and from the exposure and vulnerability of human and natural systems. Observed changes in climate extremes reflect the influence of anthropogenic climate change in addition to natural climate variability, with changes in exposure and vulnerability influenced by both climatic and non-climatic factors.

Exposure and Vulnerability

Exposure and vulnerability are dynamic, varying across temporal and spatial scales, and depend on economic, social, geographic, demographic, cultural, institutional, governance, and environmental factors (*high confidence*). [2.2, 2.3, 2.5] Individuals and communities are differentially exposed and vulnerable based on inequalities expressed through levels of wealth and education, disability, and health status, as well as gender, age, class, and other social and cultural characteristics. [2.5]

Settlement patterns, urbanization, and changes in socioeconomic conditions have all influenced observed trends in exposure and vulnerability to climate extremes (*high confidence*). [4.2, 4.3.5] For example, coastal settlements, including in small islands and megadeltas, and mountain settlements are exposed and vulnerable to climate extremes in both developed and developing countries, but with differences among regions and countries. [4.3.5, 4.4.3, 4.4.6, 4.4.9, 4.4.10] Rapid urbanization and the growth of megacities, especially in developing countries, have led to the emergence of highly vulnerable urban communities, particularly through informal settlements and inadequate land management (*high agreement, robust evidence*). [5.5.1] See also Case Studies 9.2.8 and 9.2.9. Vulnerable populations also include refugees, internally displaced people, and those living in marginal areas. [4.2, 4.3.5]

Climate Extremes and Impacts

There is evidence from observations gathered since 1950 of change in some extremes. Confidence in observed changes in extremes depends on the quality and quantity of data and the availability of studies analyzing these data, which vary across regions and for different extremes. Assigning 'low confidence' in observed changes in a specific extreme on regional or global scales neither implies nor excludes the possibility of changes in this extreme. Extreme events are rare, which means there are few data available to make assessments regarding changes in their frequency or intensity. The more rare the event the more difficult it is to identify long-term changes. Global-scale trends in a specific extreme may be either more reliable (e.g., for temperature extremes) or less reliable (e.g., for droughts) than some regional-scale trends, depending on the geographical uniformity of the trends in the specific extreme. The following paragraphs provide further details for specific climate extremes from observations since 1950. [3.1.5, 3.1.6, 3.2.1]

It is *very likely* that there has been an overall decrease in the number of cold days and nights,[3] and an overall increase in the number of warm days and nights,[3] at the global scale, that is, for most land areas with sufficient data. It is *likely* that these changes have also occurred at the continental scale in North America, Europe, and Australia. There is *medium confidence* in a warming trend in daily temperature extremes in much of Asia. Confidence in observed trends in daily temperature extremes in Africa and South America generally varies from *low* to *medium* depending on the region. In many (but not all) regions over the globe with sufficient data, there is *medium confidence* that the length or number of warm spells or heat waves[3] has increased. [3.3.1, Table 3-2]

There have been statistically significant trends in the number of heavy precipitation events in some regions. It is *likely* that more of these regions have experienced increases than decreases, although there are strong regional and subregional variations in these trends. [3.3.2]

There is *low confidence* in any observed long-term (i.e., 40 years or more) increases in tropical cyclone activity (i.e., intensity, frequency, duration), after accounting for past changes in observing capabilities. It is *likely* that there has been a poleward shift in the main Northern and Southern Hemisphere extratropical storm tracks. There is *low confidence* in observed trends in small spatial-scale phenomena such as tornadoes and hail because of data inhomogeneities and inadequacies in monitoring systems. [3.3.2, 3.3.3, 3.4.4, 3.4.5]

There is *medium confidence* that some regions of the world have experienced more intense and longer droughts, in particular in southern Europe and West Africa, but in some regions droughts have become less frequent, less intense, or shorter, for example, in central North America and northwestern Australia. [3.5.1]

There is *limited* to *medium evidence* available to assess climate-driven observed changes in the magnitude and frequency of floods at regional scales because the available instrumental records of floods at gauge stations are limited in space and time, and because of confounding effects of changes in land use and engineering. Furthermore, there is *low agreement* in this evidence, and thus overall *low confidence* at the global scale regarding even the sign of these changes. [3.5.2]

[3] See SREX Glossary for definition of these terms: cold days / cold nights, warm days / warm nights, and warm spell – heat wave.

It is *likely* that there has been an increase in extreme coastal high water related to increases in mean sea level. [3.5.3]

There is evidence that some extremes have changed as a result of anthropogenic influences, including increases in atmospheric concentrations of greenhouse gases. It is *likely* that anthropogenic influences have led to warming of extreme daily minimum and maximum temperatures at the global scale. There is *medium confidence* that anthropogenic influences have contributed to intensification of extreme precipitation at the global scale. It is *likely* that there has been an anthropogenic influence on increasing extreme coastal high water due to an increase in mean sea level. The uncertainties in the historical tropical cyclone records, the incomplete understanding of the physical mechanisms linking tropical cyclone metrics to climate change, and the degree of tropical cyclone variability provide only *low confidence* for the attribution of any detectable changes in tropical cyclone activity to anthropogenic influences. Attribution of single extreme events to anthropogenic climate change is challenging. [3.2.2, 3.3.1, 3.3.2, 3.4.4, 3.5.3, Table 3-1]

Disaster Losses

Economic losses from weather- and climate-related disasters have increased, but with large spatial and interannual variability (*high confidence*, based on *high agreement*, *medium evidence*). Global weather- and climate-related disaster losses reported over the last few decades reflect mainly monetized direct damages to assets, and are unequally distributed. Estimates of annual losses have ranged since 1980 from a few US$ billion to above 200 billion (in 2010 dollars), with the highest value for 2005 (the year of Hurricane Katrina). Loss estimates are lower-bound estimates because many impacts, such as loss of human lives, cultural heritage, and ecosystem services, are difficult to value and monetize, and thus they are poorly reflected in estimates of losses. Impacts on the informal or undocumented economy as well as indirect economic effects can be very important in some areas and sectors, but are generally not counted in reported estimates of losses. [4.5.1, 4.5.3, 4.5.4]

Economic, including insured, disaster losses associated with weather, climate, and geophysical events[4] are higher in developed countries. Fatality rates and economic losses expressed as a proportion of gross domestic product (GDP) are higher in developing countries (*high confidence*). During the period from 1970 to 2008, over 95% of deaths from natural disasters occurred in developing countries. Middle-income countries with rapidly expanding asset bases have borne the largest burden. During the period from 2001 to 2006, losses amounted to about 1% of GDP for middle-income countries, while this ratio has been about 0.3% of GDP for low-income countries and less than 0.1% of GDP for high-income countries, based on *limited evidence*. In small exposed countries, particularly small island developing states, losses expressed as a percentage of GDP have been particularly high, exceeding 1% in many cases and 8% in the most extreme cases, averaged over both disaster and non-disaster years for the period from 1970 to 2010. [4.5.2, 4.5.4]

Increasing exposure of people and economic assets has been the major cause of long-term increases in economic losses from weather- and climate-related disasters (*high confidence*). Long-term trends in economic disaster losses adjusted for wealth and population increases have not been attributed to climate change, but a role for climate change has not been excluded (*high agreement, medium evidence*). These conclusions are subject to a number of limitations in studies to date. Vulnerability is a key factor in disaster losses, yet it is not well accounted for. Other limitations are: (i) data availability, as most data are available for standard economic sectors in developed countries; and (ii) type of hazards studied, as most studies focus on cyclones, where confidence in observed trends and attribution of changes to human influence is *low*. The second conclusion is subject to additional limitations: (iii) the processes used to adjust loss data over time, and (iv) record length. [4.5.3]

4 Economic losses and fatalities described in this paragraph pertain to all disasters associated with weather, climate, and geophysical events.

C. Disaster Risk Management and Adaptation to Climate Change: Past Experience with Climate Extremes

Past experience with climate extremes contributes to understanding of effective disaster risk management and adaptation approaches to manage risks.

The severity of the impacts of climate extremes depends strongly on the level of the exposure and vulnerability to these extremes (*high confidence*). [2.1.1, 2.3, 2.5]

Trends in exposure and vulnerability are major drivers of changes in disaster risk (*high confidence*). [2.5] Understanding the multi-faceted nature of both exposure and vulnerability is a prerequisite for determining how weather and climate events contribute to the occurrence of disasters, and for designing and implementing effective adaptation and disaster risk management strategies. [2.2, 2.6] Vulnerability reduction is a core common element of adaptation and disaster risk management. [2.2, 2.3]

Development practice, policy, and outcomes are critical to shaping disaster risk, which may be increased by shortcomings in development (*high confidence*). [1.1.2, 1.1.3] High exposure and vulnerability are generally the outcome of skewed development processes such as those associated with environmental degradation, rapid and unplanned urbanization in hazardous areas, failures of governance, and the scarcity of livelihood options for the poor. [2.2.2, 2.5] Increasing global interconnectivity and the mutual interdependence of economic and ecological systems can have sometimes contrasting effects, reducing or amplifying vulnerability and disaster risk. [7.2.1] Countries more effectively manage disaster risk if they include considerations of disaster risk in national development and sector plans and if they adopt climate change adaptation strategies, translating these plans and strategies into actions targeting vulnerable areas and groups. [6.2, 6.5.2]

Data on disasters and disaster risk reduction are lacking at the local level, which can constrain improvements in local vulnerability reduction (*high agreement, medium evidence*). [5.7] There are few examples of national disaster risk management systems and associated risk management measures explicitly integrating knowledge of and uncertainties in projected changes in exposure, vulnerability, and climate extremes. [6.6.2, 6.6.4]

Inequalities influence local coping and adaptive capacity, and pose disaster risk management and adaptation challenges from the local to national levels (*high agreement, robust evidence*). These inequalities reflect socioeconomic, demographic, and health-related differences and differences in governance, access to livelihoods, entitlements, and other factors. [5.5.1, 6.2] Inequalities also exist across countries: developed countries are often better equipped financially and institutionally to adopt explicit measures to effectively respond and adapt to projected changes in exposure, vulnerability, and climate extremes than are developing countries. Nonetheless, all countries face challenges in assessing, understanding, and responding to such projected changes. [6.3.2, 6.6]

Humanitarian relief is often required when disaster risk reduction measures are absent or inadequate (*high agreement, robust evidence*). [5.2.1] Smaller or economically less-diversified countries face particular challenges in providing the public goods associated with disaster risk management, in absorbing the losses caused by climate extremes and disasters, and in providing relief and reconstruction assistance. [6.4.3]

Post-disaster recovery and reconstruction provide an opportunity for reducing weather- and climate-related disaster risk and for improving adaptive capacity (*high agreement, robust evidence*). An emphasis on rapidly rebuilding houses, reconstructing infrastructure, and rehabilitating livelihoods often leads to recovering in ways that recreate or even increase existing vulnerabilities, and that preclude longer-term planning and policy changes for enhancing resilience and sustainable development. [5.2.3] See also assessment in Sections 8.4.1 and 8.5.2.

Risk sharing and transfer mechanisms at local, national, regional, and global scales can increase resilience to climate extremes (*medium confidence*). Mechanisms include informal and traditional risk sharing mechanisms, micro-insurance, insurance, reinsurance, and national, regional, and global risk pools. [5.6.3, 6.4.3, 6.5.3, 7.4] These mechanisms are linked to disaster risk reduction and climate change adaptation by providing means to finance relief, recovery of livelihoods, and reconstruction; reducing vulnerability; and providing knowledge and incentives for reducing risk. [5.5.2, 6.2.2] Under certain conditions, however, such mechanisms can provide disincentives for reducing disaster risk. [5.6.3, 6.5.3, 7.4.4] Uptake of formal risk sharing and transfer mechanisms is unequally distributed across regions and hazards. [6.5.3] See also Case Study 9.2.13.

Attention to the temporal and spatial dynamics of exposure and vulnerability is particularly important given that the design and implementation of adaptation and disaster risk management strategies and policies can reduce risk in the short term, but may increase exposure and vulnerability over the longer term (*high agreement, medium evidence*). For instance, dike systems can reduce flood exposure by offering immediate protection, but also encourage settlement patterns that may increase risk in the long term. [2.4.2, 2.5.4, 2.6.2] See also assessment in Sections 1.4.3, 5.3.2, and 8.3.1.

National systems are at the core of countries' capacity to meet the challenges of observed and projected trends in exposure, vulnerability, and weather and climate extremes (*high agreement, robust evidence*). Effective national systems comprise multiple actors from national and sub-national governments, the private sector, research bodies, and civil society including community-based organizations, playing differential but complementary roles to manage risk, according to their accepted functions and capacities. [6.2]

Closer integration of disaster risk management and climate change adaptation, along with the incorporation of both into local, sub-national, national, and international development policies and practices, could provide benefits at all scales (*high agreement, medium evidence*). [5.4, 5.5, 5.6, 6.3.1, 6.3.2, 6.4.2, 6.6, 7.4] Addressing social welfare, quality of life, infrastructure, and livelihoods, and incorporating a multi-hazards approach into planning and action for disasters in the short term, facilitates adaptation to climate extremes in the longer term, as is increasingly recognized internationally. [5.4, 5.5, 5.6, 7.3] Strategies and policies are more effective when they acknowledge multiple stressors, different prioritized values, and competing policy goals. [8.2, 8.3, 8.7]

D. Future Climate Extremes, Impacts, and Disaster Losses

Future changes in exposure, vulnerability, and climate extremes resulting from natural climate variability, anthropogenic climate change, and socioeconomic development can alter the impacts of climate extremes on natural and human systems and the potential for disasters.

Climate Extremes and Impacts

Confidence in projecting changes in the direction and magnitude of climate extremes depends on many factors, including the type of extreme, the region and season, the amount and quality of observational data, the level of understanding of the underlying processes, and the reliability of their simulation in models. Projected changes in climate extremes under different emissions scenarios[5] generally do not strongly diverge in the coming two to three decades, but these signals are relatively small compared to natural climate variability over this time frame. Even the sign of projected changes in some climate extremes over this time frame is uncertain. For projected changes by the end of the 21st century, either model uncertainty or uncertainties associated with emissions scenarios used becomes dominant, depending on the extreme. Low-probability, high-impact changes associated with

[5] Emissions scenarios for radiatively important substances result from pathways of socioeconomic and technological development. This report uses a subset (B1, A1B, A2) of the 40 scenarios extending to the year 2100 that are described in the IPCC Special Report on Emissions Scenarios (SRES) and that did not include additional climate initiatives. These scenarios have been widely used in climate change projections and encompass a substantial range of carbon dioxide equivalent concentrations, but not the entire range of the scenarios included in the SRES.

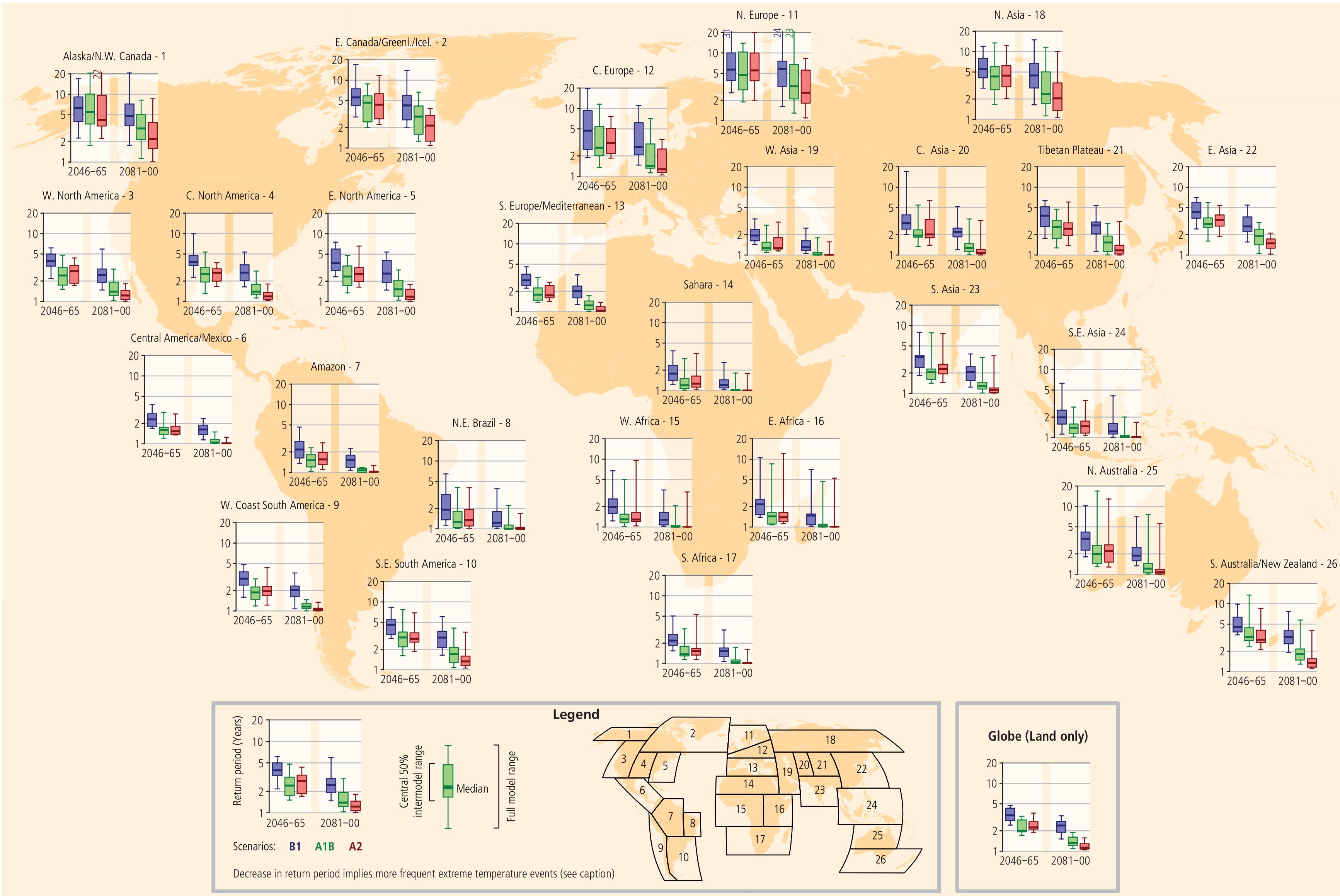


Figure SPM.4A | Projected return periods for the maximum daily temperature that was exceeded on average once during a 20-year period in the late 20th century (1981–2000). A decrease in return period implies more frequent extreme temperature events (i.e., less time between events on average). The box plots show results for regionally averaged projections for two time horizons, 2046 to 2065 and 2081 to 2100, as compared to the late 20th century, and for three different SRES emissions scenarios (B1, A1B, A2) (see legend). Results are based on 12 global climate models (GCMs) contributing to the third phase of the Coupled Model Intercomparison Project (CMIP3). The level of agreement among the models is indicated by the size of the colored boxes (in which 50% of the model projections are contained), and the length of the whiskers (indicating the maximum and minimum projections from all models). See legend for defined extent of regions. Values are computed for land points only. The 'Globe' inset box displays the values computed using all land grid points. [3.3.1, Figure 3-1, Figure 3-5] the crossing of poorly understood climate thresholds cannot be excluded, given the transient and complex nature of the climate system. Assigning 'low confidence' for projections of a specific extreme neither implies nor excludes the possibility of changes in this extreme. The following assessments of the likelihood and/or confidence of projections are generally for the end of the 21st century and relative to the climate at the end of the 20th century. [3.1.5, 3.1.7, 3.2.3, Box 3-2]

Models project substantial warming in temperature extremes by the end of the 21st century. It is *virtually certain* that increases in the frequency and magnitude of warm daily temperature extremes and decreases in cold extremes will occur in the 21st century at the global scale. It is *very likely* that the length, frequency, and/or intensity of warm spells or heat waves will increase over most land areas. Based on the A1B and A2 emissions scenarios, a 1-in-20 year hottest day is *likely* to become a 1-in-2 year event by the end of the 21st century in most regions, except in the high latitudes of the Northern Hemisphere, where it is *likely* to become a 1-in-5 year event (see Figure SPM.4A). Under the B1 scenario, a 1-in-20 year event would *likely* become a 1-in-5 year event (and a 1-in-10 year event in Northern Hemisphere high latitudes). The 1-in-20 year extreme daily maximum temperature (i.e., a value that was exceeded on average only once during the period 1981–2000) will *likely* increase by about 1°C to 3°C by the mid-21st century and by about 2°C to 5°C by the late 21st century, depending on the region and emissions scenario (based on the B1, A1B, and A2 scenarios). [3.3.1, 3.1.6, Table 3-3, Figure 3-5]

It is *likely* that the frequency of heavy precipitation or the proportion of total rainfall from heavy falls will increase in the 21st century over many areas of the globe. This is particularly the case in the high latitudes and tropical regions, and in winter in the northern mid-latitudes. Heavy rainfalls associated with tropical cyclones are *likely* to increase with continued warming. There is *medium confidence* that, in some regions, increases in heavy precipitation will occur despite projected decreases in total precipitation in those regions. Based on a range of emissions scenarios (B1, A1B, A2), a 1-in-20 year annual maximum daily precipitation amount is *likely* to become a 1-in-5 to 1-in-15 year event by the end of the 21st century in many regions, and in most regions the higher emissions scenarios (A1B and A2) lead to a stronger projected decrease in return period. See Figure SPM.4B. [3.3.2, 3.4.4, Table 3-3, Figure 3-7]

Average tropical cyclone maximum wind speed is *likely* to increase, although increases may not occur in all ocean basins. It is *likely* that the global frequency of tropical cyclones will either decrease or remain essentially unchanged. [3.4.4]

There is *medium confidence* that there will be a reduction in the number of extratropical cyclones averaged over each hemisphere. While there is *low confidence* in the detailed geographical projections of extratropical cyclone activity, there is *medium confidence* in a projected poleward shift of extratropical storm tracks. There is *low confidence* in projections of small spatial-scale phenomena such as tornadoes and hail because competing physical processes may affect future trends and because current climate models do not simulate such phenomena. [3.3.2, 3.3.3, 3.4.5]

There is *medium confidence* that droughts will intensify in the 21st century in some seasons and areas, due to reduced precipitation and/or increased evapotranspiration. This applies to regions including southern Europe and the Mediterranean region, central Europe, central North America, Central America and Mexico, northeast Brazil, and southern Africa. Elsewhere there is overall *low confidence* because of inconsistent projections of drought changes (dependent both on model and dryness index). Definitional issues, lack of observational data, and the inability of models to include all the factors that influence droughts preclude stronger confidence than *medium* in drought projections. See Figure SPM.5. [3.5.1, Table 3-3, Box 3-3]

Projected precipitation and temperature changes imply possible changes in floods, although overall there is *low confidence* in projections of changes in fluvial floods. Confidence is *low* due to *limited evidence* and because the causes of regional changes are complex, although there are exceptions to this statement. There is *medium confidence* (based on physical reasoning) that projected increases in heavy rainfall would contribute to increases in local flooding in some catchments or regions. [3.5.2]

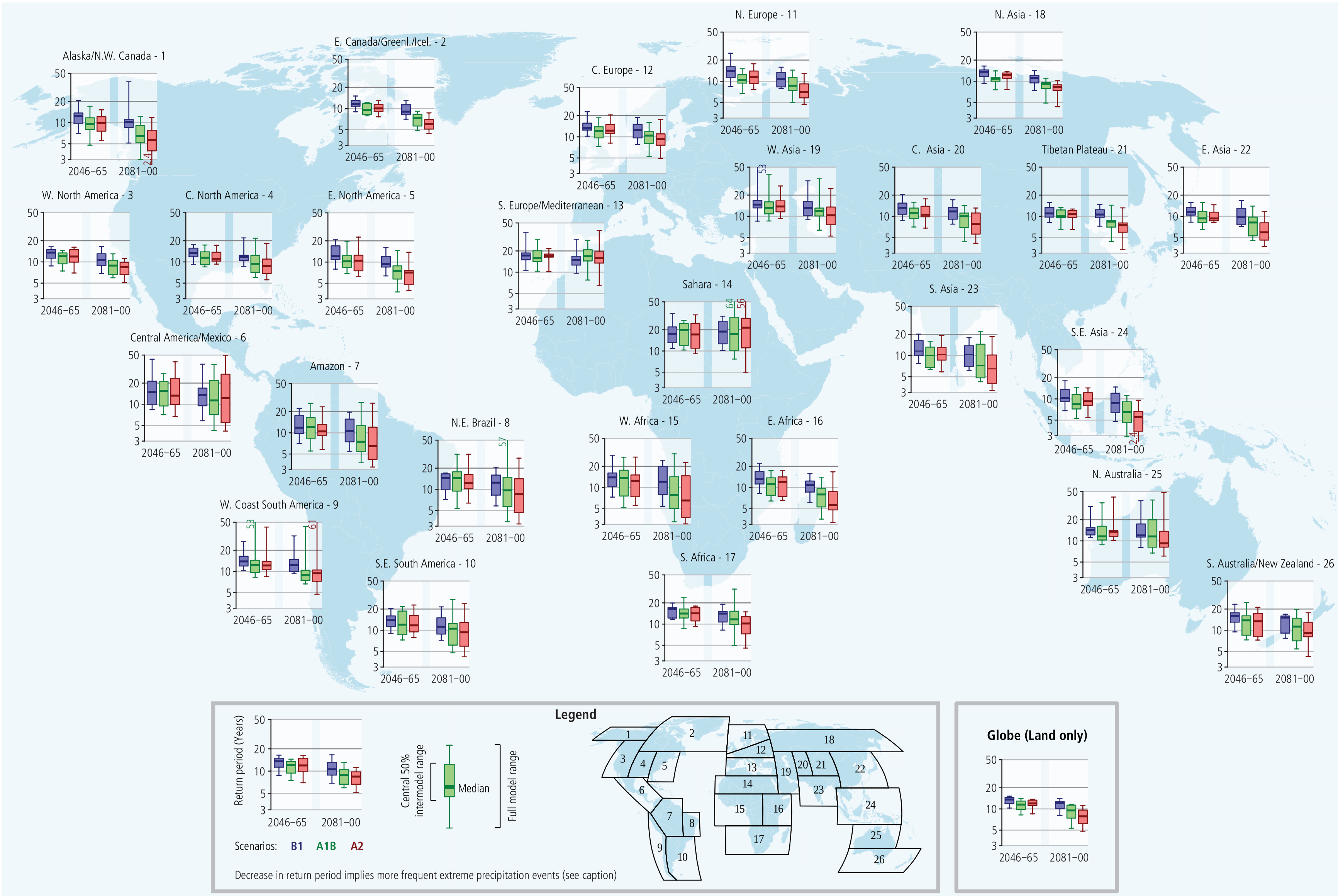


Figure SPM.4B | Projected return periods for a daily precipitation event that was exceeded in the late 20th century on average once during a 20-year period (1981–2000). A decrease in return period implies more frequent extreme precipitation events (i.e., less time between events on average). The box plots show results for regionally averaged projections for two time horizons, 2046 to 2065 and 2081 to 2100, as compared to the late 20th century, and for three different SRES emissions scenarios (B1, A1B, A2) (see legend). Results are based on 14 GCMs contributing to the CMIP3. The level of agreement among the models is indicated by the size of the colored boxes (in which 50% of the model projections are contained), and the length of the whiskers (indicating the maximum and minimum projections from all models). See legend for defined extent of regions. Values are computed for land points only. The 'Globe' inset box displays the values computed using all land grid points. [3.3.2, Figure 3-1, Figure 3-7]

It is *very likely* that mean sea level rise will contribute to upward trends in extreme coastal high water levels in the future. There is *high confidence* that locations currently experiencing adverse impacts such as coastal erosion and inundation will continue to do so in the future due to increasing sea levels, all other contributing factors being equal. The *very likely* contribution of mean sea level rise to increased extreme coastal high water levels, coupled with the *likely* increase in tropical cyclone maximum wind speed, is a specific issue for tropical small island states. [3.5.3, 3.5.5, Box 3-4]

There is *high confidence* that changes in heat waves, glacial retreat, and/or permafrost degradation will affect high mountain phenomena such as slope instabilities, movements of mass, and glacial lake outburst floods. There is also *high confidence* that changes in heavy precipitation will affect landslides in some regions. [3.5.6]

There is *low confidence* in projections of changes in large-scale patterns of natural climate variability. Confidence is *low* in projections of changes in monsoons (rainfall, circulation) because there is little consensus in climate models regarding the sign of future change in the monsoons. Model projections of changes in El Niño–Southern

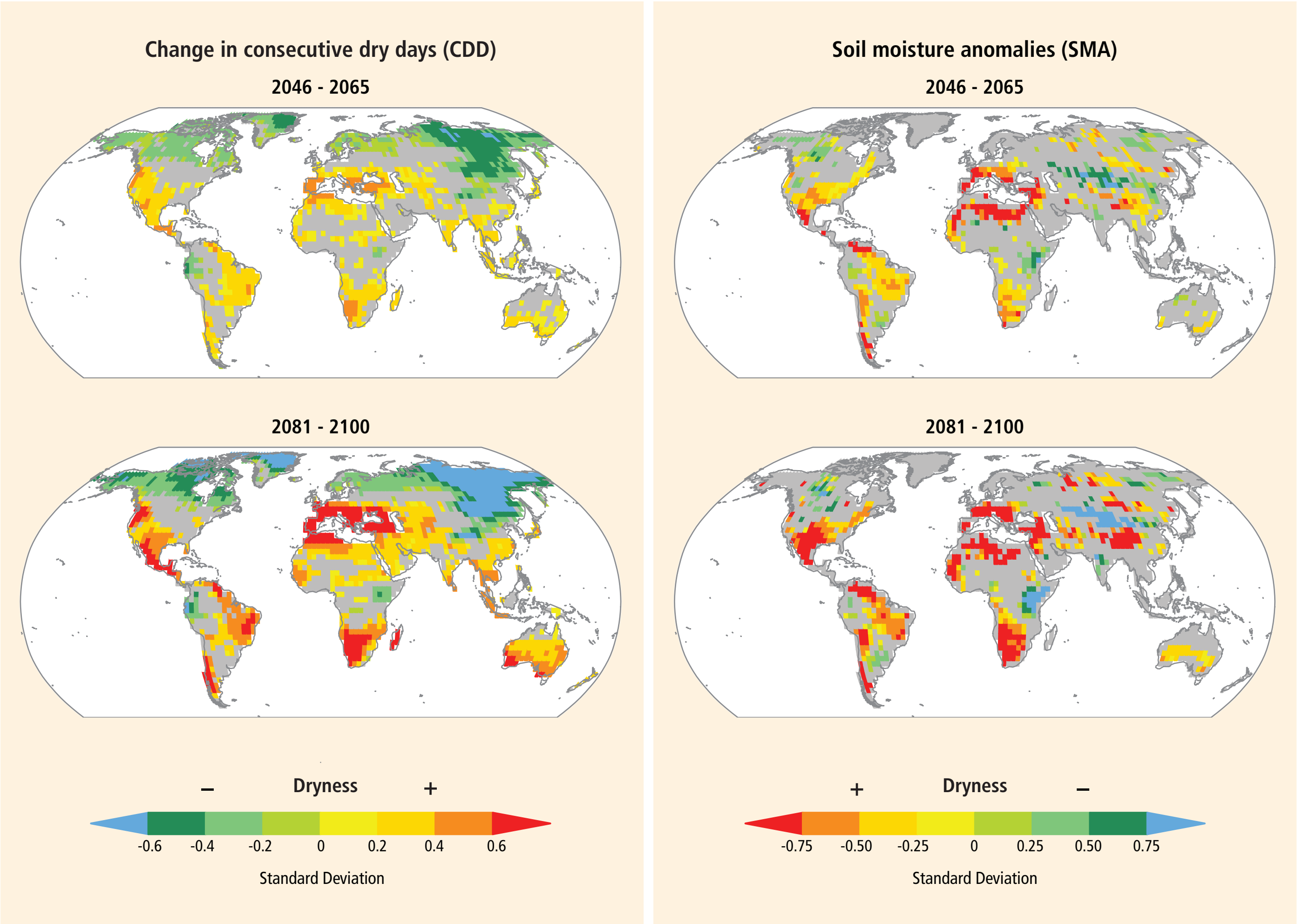


Figure SPM.5 | Projected annual changes in dryness assessed from two indices. Left column: Change in annual maximum number of consecutive dry days (CDD: days with precipitation <1 mm). Right column: Changes in soil moisture (soil moisture anomalies, SMA). Increased dryness is indicated with yellow to red colors; decreased dryness with green to blue. Projected changes are expressed in units of standard deviation of the interannual variability in the three 20-year periods 1980–1999, 2046–2065, and 2081–2100. The figures show changes for two time horizons, 2046–2065 and 2081–2100, as compared to late 20th-century values (1980–1999), based on GCM simulations under emissions scenario SRES A2 relative to corresponding simulations for the late 20th century. Results are based on 17 (CDD) and 15 (SMA) GCMs contributing to the CMIP3. Colored shading is applied for areas where at least 66% (12 out of 17 for CDD, 10 out of 15 for SMA) of the models agree on the sign of the change; stippling is added for regions where at least 90% (16 out of 17 for CDD, 14 out of 15 for SMA) of all models agree on the sign of the change. Grey shading indicates where there is insufficient model agreement (<66%). [3.5.1, Figure 3-9]

Oscillation variability and the frequency of El Niño episodes are not consistent, and so there is *low confidence* in projections of changes in this phenomenon. [3.4.1, 3.4.2, 3.4.3]

Human Impacts and Disaster Losses

Extreme events will have greater impacts on sectors with closer links to climate, such as water, agriculture and food security, forestry, health, and tourism. For example, while it is not currently possible to reliably project specific changes at the catchment scale, there is *high confidence* that changes in climate have the potential to seriously affect water management systems. However, climate change is in many instances only one of the drivers of future changes, and is not necessarily the most important driver at the local scale. Climate-related extremes are also expected to produce large impacts on infrastructure, although detailed analysis of potential and projected damages are limited to a few countries, infrastructure types, and sectors. [4.3.2, 4.3.5]

In many regions, the main drivers of future increases in economic losses due to some climate extremes will be socioeconomic in nature (*medium confidence*, based on *medium agreement*, *limited evidence*). Climate extremes are only one of the factors that affect risks, but few studies have specifically quantified the effects of changes in population, exposure of people and assets, and vulnerability as determinants of loss. However, the few studies available generally underline the important role of projected changes (increases) in population and capital at risk. [4.5.4]

Increases in exposure will result in higher direct economic losses from tropical cyclones. Losses will also depend on future changes in tropical cyclone frequency and intensity (*high confidence*). Overall losses due to extratropical cyclones will also increase, with possible decreases or no change in some areas (*medium confidence*). Although future flood losses in many locations will increase in the absence of additional protection measures (*high agreement, medium evidence*), the size of the estimated change is highly variable, depending on location, climate scenarios used, and methods used to assess impacts on river flow and flood occurrence. [4.5.4]

Disasters associated with climate extremes influence population mobility and relocation, affecting host and origin communities (*medium agreement, medium evidence*). If disasters occur more frequently and/or with greater magnitude, some local areas will become increasingly marginal as places to live or in which to maintain livelihoods. In such cases, migration and displacement could become permanent and could introduce new pressures in areas of relocation. For locations such as atolls, in some cases it is possible that many residents will have to relocate. [5.2.2]

E. Managing Changing Risks of Climate Extremes and Disasters

Adaptation to climate change and disaster risk management provide a range of complementary approaches for managing the risks of climate extremes and disasters (Figure SPM.2). Effectively applying and combining approaches may benefit from considering the broader challenge of sustainable development.

Measures that provide benefits under current climate and a range of future climate change scenarios, called low-regrets measures, are available starting points for addressing projected trends in exposure, vulnerability, and climate extremes. They have the potential to offer benefits now and lay the foundation for addressing projected changes (*high agreement, medium evidence*). Many of these low-regrets strategies produce co-benefits, help address other development goals, such as improvements in livelihoods, human well-being, and biodiversity conservation, and help minimize the scope for maladaptation. [6.3.1, Table 6-1]

Potential low-regrets measures include early warning systems; risk communication between decisionmakers and local citizens; sustainable land management, including land use planning; and ecosystem management and restoration.

Other low-regrets measures include improvements to health surveillance, water supply, sanitation, and irrigation and drainage systems; climate-proofing of infrastructure; development and enforcement of building codes; and better education and awareness. [5.3.1, 5.3.3, 6.3.1, 6.5.1, 6.5.2] See also Case Studies 9.2.11 and 9.2.14, and assessment in Section 7.4.3.

Effective risk management generally involves a portfolio of actions to reduce and transfer risk and to respond to events and disasters, as opposed to a singular focus on any one action or type of action (*high confidence*). [1.1.2, 1.1.4, 1.3.3] Such integrated approaches are more effective when they are informed by and customized to specific local circumstances (*high agreement, robust evidence*). [5.1] Successful strategies include a combination of hard infrastructure-based responses and soft solutions such as individual and institutional capacity building and ecosystem-based responses. [6.5.2]

Multi-hazard risk management approaches provide opportunities to reduce complex and compound hazards (*high agreement, robust evidence*). Considering multiple types of hazards reduces the likelihood that risk reduction efforts targeting one type of hazard will increase exposure and vulnerability to other hazards, in the present and future. [8.2.5, 8.5.2, 8.7]

Opportunities exist to create synergies in international finance for disaster risk management and adaptation to climate change, but these have not yet been fully realized (*high confidence*). International funding for disaster risk reduction remains relatively low as compared to the scale of spending on international humanitarian response. [7.4.2] Technology transfer and cooperation to advance disaster risk reduction and climate change adaptation are important. Coordination on technology transfer and cooperation between these two fields has been lacking, which has led to fragmented implementation. [7.4.3]

Stronger efforts at the international level do not necessarily lead to substantive and rapid results at the local level (*high confidence*). There is room for improved integration across scales from international to local. [7.6]

Integration of local knowledge with additional scientific and technical knowledge can improve disaster risk reduction and climate change adaptation (*high agreement, robust evidence*). Local populations document their experiences with the changing climate, particularly extreme weather events, in many different ways, and this self-generated knowledge can uncover existing capacity within the community and important current shortcomings. [5.4.4] Local participation supports community-based adaptation to benefit management of disaster risk and climate extremes. However, improvements in the availability of human and financial capital and of disaster risk and climate information customized for local stakeholders can enhance community-based adaptation (*medium agreement, medium evidence)*. [5.6]

Appropriate and timely risk communication is critical for effective adaptation and disaster risk management (*high confidence*). Explicit characterization of uncertainty and complexity strengthens risk communication. [2.6.3] Effective risk communication builds on exchanging, sharing, and integrating knowledge about climate-related risks among all stakeholder groups. Among individual stakeholders and groups, perceptions of risk are driven by psychological and cultural factors, values, and beliefs. [1.1.4, 1.3.1, 1.4.2] See also assessment in Section 7.4.5.

An iterative process of monitoring, research, evaluation, learning, and innovation can reduce disaster risk and promote adaptive management in the context of climate extremes (*high agreement*, *robust evidence*). [8.6.3, 8.7] Adaptation efforts benefit from iterative risk management strategies because of the complexity, uncertainties, and long time frame associated with climate change (*high confidence*). [1.3.2] Addressing knowledge gaps through enhanced observation and research can reduce uncertainty and help in designing effective adaptation and risk management strategies. [3.2, 6.2.5, Table 6-3, 7.5, 8.6.3] See also assessment in Section 6.6.

Table SPM.1 presents examples of how observed and projected trends in exposure, vulnerability, and climate extremes can inform risk management and adaptation strategies, policies, and measures. The

Table SPM.1 | Illustrative examples of options for risk management and adaptation in the context of changes in exposure, vulnerability, and climate extremes. In each example, information is characterized at the scale directly relevant to decisionmaking. Observed and projected changes in climate extremes at global and regional scales illustrate that the direction of, magnitude of, and/or degree of certainty for changes may differ across scales.

The examples were selected based on availability of evidence in the underlying chapters, including on exposure, vulnerability, climate information, and risk management and adaptation options. They are intended to reflect relevant risk management themes and scales, rather than to provide comprehensive information by region. The examples are not intended to reflect any regional differences in exposure and vulnerability, or in experience in risk management.

The confidence in projected changes in climate extremes at local scales is often more limited than the confidence in projected regional and global changes. This limited confidence in changes places a focus on low-regrets risk management options that aim to reduce exposure and vulnerability and to increase resilience and preparedness for risks that cannot be entirely eliminated. Higher-confidence projected changes in climate extremes, at a scale relevant to adaptation and risk management decisions, can inform more targeted adjustments in strategies, policies, and measures. [3.1.6, Box 3-2, 6.3.1, 6.5.2]

Example	Exposure and vulnerability at scale of risk management in the example	Information on Climate Extreme Across Spatial Scales			Options for risk management and adaptation in the example
		GLOBAL Observed (since 1950) and projected (to 2100) global changes	**REGIONAL** Observed (since 1950) and projected (to 2100) changes in the example	**SCALE OF RISK MANAGEMENT** Available information for the example	
Inundation related to **extreme sea levels** in tropical small island developing states	Small island states in the Pacific, Indian, and Atlantic Oceans, often with low elevation, are particularly vulnerable to rising sea levels and impacts such as erosion, inundation, shoreline change, and saltwater intrusion into coastal aquifers. These impacts can result in ecosystem disruption, decreased agricultural productivity, changes in disease patterns, economic losses such as in tourism industries, and population displacement – all of which reinforce vulnerability to extreme weather events. [3.5.5, Box 3-4, 4.3.5, 4.4.10, 9.2.9]	Observed: *Likely* increase in extreme coastal high water worldwide related to increases in mean sea level. Projected: *Very likely* that mean sea level rise will contribute to upward trends in extreme coastal high water levels. *High confidence* that locations currently experiencing coastal erosion and inundation will continue to do so due to increasing sea level, in the absence of changes in other contributing factors. *Likely* that the global frequency of tropical cyclones will either decrease or remain essentially unchanged. *Likely* increase in average tropical cyclone maximum wind speed, although increases may not occur in all ocean basins. [Table 3-1, 3.4.4, 3.5.3, 3.5.5]	Observed: Tides and El Niño–Southern Oscillation have contributed to the more frequent occurrence of extreme coastal high water levels and associated flooding experienced on some Pacific Islands in recent years. Projected: The *very likely* contribution of mean sea level rise to increased extreme coastal high water levels, coupled with the *likely* increase in tropical cyclone maximum wind speed, is a specific issue for tropical small island states. See global changes column for information on global projections for tropical cyclones. [Box 3-4, 3.4.4, 3.5.3]	Sparse regional and temporal coverage of terrestrial-based observation networks and limited in situ ocean observing network, but with improved satellite-based observations in recent decades. While changes in storminess may contribute to changes in extreme coastal high water levels, the limited geographical coverage of studies to date and the uncertainties associated with storminess changes overall mean that a general assessment of the effects of storminess changes on storm surge is not possible at this time. [Box 3-4, 3.5.3]	Low-regrets options that reduce exposure and vulnerability across a range of hazard trends: • Maintenance of drainage systems • Well technologies to limit saltwater contamination of groundwater • Improved early warning systems • Regional risk pooling • Mangrove conservation, restoration, and replanting Specific adaptation options include, for instance, rendering national economies more climate-independent and adaptive management involving iterative learning. In some cases there may be a need to consider relocation, for example, for atolls where storm surges may completely inundate them. [4.3.5, 4.4.10, 5.2.2, 6.3.2, 6.5.2, 6.6.2, 7.4.4, 9.2.9, 9.2.11, 9.2.13]
Flash floods in informal settlements in Nairobi, Kenya	Rapid expansion of poor people living in informal settlements around Nairobi has led to houses of weak building materials being constructed immediately adjacent to rivers and to blockage of natural drainage areas, increasing exposure and vulnerability. [6.4.2, Box 6-2]	Observed: *Low confidence* at global scale regarding (climate-driven) observed changes in the magnitude and frequency of floods. Projected: *Low confidence* in projections of changes in floods because of limited evidence and because the causes of regional changes are complex. However, *medium confidence* (based on physical reasoning) that projected increases in heavy precipitation will contribute to rain-generated local flooding in some catchments or regions. [Table 3-1, 3.5.2]	Observed: *Low confidence* regarding trends in heavy precipitation in East Africa, because of insufficient evidence. Projected: *Likely* increase in heavy precipitation indicators in East Africa. [Table 3-2, Table 3-3, 3.3.2]	Limited ability to provide local flash flood projections. [3.5.2]	Low-regrets options that reduce exposure and vulnerability across a range of hazard trends: • Strengthening building design and regulation • Poverty reduction schemes • City-wide drainage and sewerage improvements The Nairobi Rivers Rehabilitation and Restoration Programme includes installation of riparian buffers, canals, and drainage channels and clearance of existing channels; attention to climate variability and change in the location and design of wastewater infrastructure; and environmental monitoring for flood early warning. [6.3, 6.4.2, Box 6-2, Box 6-6]

Continued next page →

Table SPM.1 (continued)

Example	Exposure and vulnerability at scale of risk management in the example	Information on Climate Extreme Across Spatial Scales: GLOBAL Observed (since 1950) and projected (to 2100) global changes	REGIONAL Observed (since 1950) and projected (to 2100) changes in the example	SCALE OF RISK MANAGEMENT Available information for the example	Options for risk management and adaptation in the example
Impacts of **heat waves** in urban areas in Europe	Factors affecting exposure and vulnerability include age, pre-existing health status, level of outdoor activity, socioeconomic factors including poverty and social isolation, access to and use of cooling, physiological and behavioral adaptation of the population, and urban infrastructure. [2.5.2, 4.3.5, 4.3.6, 4.4.5, 9.2.1]	Observed: *Medium confidence* that the length or number of warm spells or heat waves has increased since the middle of the 20th century, in many (but not all) regions over the globe. *Very likely* increase in number of warm days and nights at the global scale. Projected: *Very likely* increase in length, frequency, and/or intensity of warm spells or heat waves over most land areas. *Virtually certain* increase in frequency and magnitude of warm days and nights at the global scale. [Table 3-1, 3.3.1]	Observed: *Medium confidence* in increase in heat waves or warm spells in Europe. *Likely* overall increase in warm days and nights over most of the continent. Projected: *Likely* more frequent, longer, and/or more intense heat waves or warm spells in Europe. *Very likely* increase in warm days and nights. [Table 3-2, Table 3-3, 3.3.1]	Observations and projections can provide information for specific urban areas in the region, with increased heat waves expected due to regional trends and urban heat island effects. [3.3.1, 4.4.5]	Low-regrets options that reduce exposure and vulnerability across a range of hazard trends: • Early warning systems that reach particularly vulnerable groups (e.g., the elderly) • Vulnerability mapping and corresponding measures • Public information on what to do during heat waves, including behavioral advice • Use of social care networks to reach vulnerable groups Specific adjustments in strategies, policies, and measures informed by trends in heat waves include awareness raising of heat waves as a public health concern; changes in urban infrastructure and land use planning, for example, increasing urban green space; changes in approaches to cooling for public facilities; and adjustments in energy generation and transmission infrastructure. [Table 6-1, 9.2.1]
Increasing losses from **hurricanes** in the USA and the Caribbean	Exposure and vulnerability are increasing due to growth in population and increase in property values, particularly along the Gulf and Atlantic coasts of the United States. Some of this increase has been offset by improved building codes. [4.4.6]	Observed: *Low confidence* in any observed long-term (i.e., 40 years or more) increases in tropical cyclone activity, after accounting for past changes in observing capabilities. Projected: *Likely* that the global frequency of tropical cyclones will either decrease or remain essentially unchanged. *Likely* increase in average tropical cyclone maximum wind speed, although increases may not occur in all ocean basins. Heavy rainfalls associated with tropical cyclones are *likely* to increase. Projected sea level rise is expected to further compound tropical cyclone surge impacts. [Table 3-1, 3.4.4]	See global changes column for global projections.	Limited model capability to project changes relevant to specific settlements or other locations, due to the inability of global models to accurately simulate factors relevant to tropical cyclone genesis, track, and intensity evolution. [3.4.4]	Low-regrets options that reduce exposure and vulnerability across a range of hazard trends: • Adoption and enforcement of improved building codes • Improved forecasting capacity and implementation of improved early warning systems (including evacuation plans and infrastructures) • Regional risk pooling In the context of high underlying variability and uncertainty regarding trends, options can include emphasizing adaptive management involving learning and flexibility (e.g., Cayman Islands National Hurricane Committee). [5.5.3, 6.5.2, 6.6.2, Box 6-7, Table 6-1, 7.4.4, 9.2.5, 9.2.11, 9.2.13]
Droughts in the context of food security in West Africa	Less advanced agricultural practices render region vulnerable to increasing variability in seasonal rainfall, drought, and weather extremes. Vulnerability is exacerbated by population growth, degradation of ecosystems, and overuse of natural resources, as well as poor standards for health, education, and governance. [2.2.2, 2.3, 2.5, 4.4.2, 9.2.3]	Observed: *Medium confidence* that some regions of the world have experienced more intense and longer droughts, but in some regions droughts have become less frequent, less intense, or shorter. Projected: *Medium confidence* in projected intensification of drought in some seasons and areas. Elsewhere there is overall *low confidence* because of inconsistent projections. [Table 3-1, 3.5.1]	Observed: *Medium confidence* in an increase in dryness. Recent years characterized by greater interannual variability than previous 40 years, with the western Sahel remaining dry and the eastern Sahel returning to wetter conditions. Projected: *Low confidence* due to inconsistent signal in model projections. [Table 3-2, Table 3-3, 3.5.1]	Sub-seasonal, seasonal, and interannual forecasts with increasing uncertainty over longer time scales. Improved monitoring, instrumentation, and data associated with early warning systems, but with limited participation and dissemination to at-risk populations. [5.3.1, 5.5.3, 7.3.1, 9.2.3, 9.2.11]	Low-regrets options that reduce exposure and vulnerability across a range of hazard trends: • Traditional rain and groundwater harvesting and storage systems • Water demand management and improved irrigation efficiency measures • Conservation agriculture, crop rotation, and livelihood diversification • Increasing use of drought-resistant crop varieties • Early warning systems integrating seasonal forecasts with drought projections, with improved communication involving extension services • Risk pooling at the regional or national level [2.5.4, 5.3.1, 5.3.3, 6.5, Table 6-3, 9.2.3, 9.2.11]

importance of these trends for decisionmaking depends on their magnitude and degree of certainty at the temporal and spatial scale of the risk being managed and on the available capacity to implement risk management options (see Table SPM.1).

Implications for Sustainable Development

Actions that range from incremental steps to transformational changes are essential for reducing risk from climate extremes (*high agreement, robust evidence*). Incremental steps aim to improve efficiency within existing technological, governance, and value systems, whereas transformation may involve alterations of fundamental attributes of those systems. Transformations, where they are required, are also facilitated through increased emphasis on adaptive management and learning. Where vulnerability is high and adaptive capacity low, changes in climate extremes can make it difficult for systems to adapt sustainably without transformational changes. Vulnerability is often concentrated in lower-income countries or groups, although higher-income countries or groups can also be vulnerable to climate extremes. [8.6, 8.6.3, 8.7]

Social, economic, and environmental sustainability can be enhanced by disaster risk management and adaptation approaches. A prerequisite for sustainability in the context of climate change is addressing the underlying causes of vulnerability, including the structural inequalities that create and sustain poverty and constrain access to resources (*medium agreement, robust evidence*). This involves integrating disaster risk management and adaptation into all social, economic, and environmental policy domains. [8.6.2, 8.7]

The most effective adaptation and disaster risk reduction actions are those that offer development benefits in the relatively near term, as well as reductions in vulnerability over the longer term (*high agreement, medium evidence*). There are tradeoffs between current decisions and long-term goals linked to diverse values, interests, and priorities for the future. Short- and long-term perspectives on disaster risk management and adaptation to climate change thus can be difficult to reconcile. Such reconciliation involves overcoming the disconnect between local risk management practices and national institutional and legal frameworks, policy, and planning. [8.2.1, 8.3.1, 8.3.2, 8.6.1]

Progress toward resilient and sustainable development in the context of changing climate extremes can benefit from questioning assumptions and paradigms and stimulating innovation to encourage new patterns of response (*medium agreement, robust evidence*). Successfully addressing disaster risk, climate change, and other stressors often involves embracing broad participation in strategy development, the capacity to combine multiple perspectives, and contrasting ways of organizing social relations. [8.2.5, 8.6.3, 8.7]

The interactions among climate change mitigation, adaptation, and disaster risk management may have a major influence on resilient and sustainable pathways (*high agreement, limited evidence*). Interactions between the goals of mitigation and adaptation in particular will play out locally, but have global consequences. [8.2.5, 8.5.2]

There are many approaches and pathways to a sustainable and resilient future. [8.2.3, 8.4.1, 8.6.1, 8.7] However, limits to resilience are faced when thresholds or tipping points associated with social and/or natural systems are exceeded, posing severe challenges for adaptation. [8.5.1] Choices and outcomes for adaptive actions to climate events must reflect divergent capacities and resources and multiple interacting processes. Actions are framed by tradeoffs between competing prioritized values and objectives, and different visions of development that can change over time. Iterative approaches allow development pathways to integrate risk management so that diverse policy solutions can be considered, as risk and its measurement, perception, and understanding evolve over time. [8.2.3, 8.4.1, 8.6.1, 8.7]

Box SPM.2 | Treatment of Uncertainty

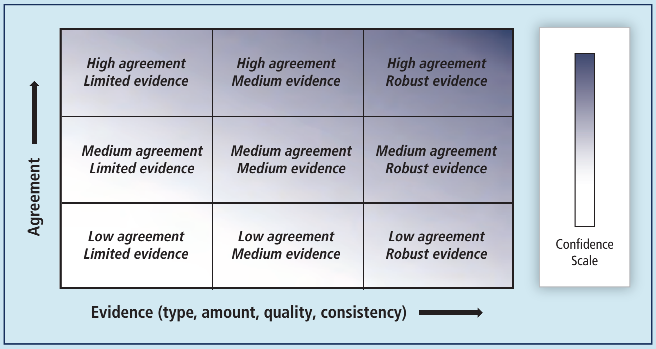
Based on the Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties,[6] this Summary for Policymakers relies on two metrics for communicating the degree of certainty in key findings, which is based on author teams' evaluations of underlying scientific understanding:

- Confidence in the validity of a finding, based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgment) and the degree of agreement. Confidence is expressed qualitatively.
- Quantified measures of uncertainty in a finding expressed probabilistically (based on statistical analysis of observations or model results, or expert judgment).

This Guidance Note refines the guidance provided to support the IPCC Third and Fourth Assessment Reports. Direct comparisons between assessment of uncertainties in findings in this report and those in the IPCC Fourth Assessment Report are difficult if not impossible, because of the application of the revised guidance note on uncertainties, as well as the availability of new information, improved scientific understanding, continued analyses of data and models, and specific differences in methodologies applied in the assessed studies. For some extremes, different aspects have been assessed and therefore a direct comparison would be inappropriate.

Each key finding is based on an author team's evaluation of associated evidence and agreement. The confidence metric provides a qualitative synthesis of an author team's judgment about the validity of a finding, as determined through evaluation of evidence and agreement. If uncertainties can be quantified probabilistically, an author team can characterize a finding using the calibrated likelihood language or a more precise presentation of probability. Unless otherwise indicated, *high* or *very high confidence* is associated with findings for which an author team has assigned a likelihood term.

The following summary terms are used to describe the available evidence: *limited*, *medium*, or *robust*; and for the degree of agreement: *low*, *medium*, or *high*. A level of confidence is expressed using five qualifiers: *very low*, *low*, *medium*, *high*, and *very high*. The accompanying figure depicts summary statements for evidence and agreement and their relationship to confidence. There is flexibility in this relationship; for a given evidence and agreement statement, different confidence levels can be assigned, but increasing levels of evidence and degrees of agreement are correlated with increasing confidence.



A depiction of evidence and agreement statements and their relationship to confidence. Confidence increases toward the top-right corner as suggested by the increasing strength of shading. Generally, evidence is most robust when there are multiple, consistent independent lines of high-quality evidence.

The following terms indicate the assessed likelihood:

Term*	Likelihood of the Outcome
Virtually certain	99–100% probability
Very likely	90–100% probability
Likely	66–100% probability
About as likely as not	33–66% probability
Unlikely	0–33% probability
Very unlikely	0–10% probability
Exceptionally unlikely	0–1% probability

* Additional terms that were used in limited circumstances in the Fourth Assessment Report (*extremely likely:* 95–100% probability, *more likely than not:* >50–100% probability, and *extremely unlikely:* 0–5% probability) may also be used when appropriate.

[6] Mastrandrea, M.D., C.B. Field, T.F. Stocker, O. Edenhofer, K.L. Ebi, D.J. Frame, H. Held, E. Kriegler, K.J. Mach, P.R. Matschoss, G.-K. Plattner, G.W. Yohe, and F.W. Zwiers, 2010: *Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties*. Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland, www.ipcc.ch.