RED CROSS/RED CRESCENT CLIMATE CENTRE

International Federation of Red Cross and Red Crescent Societies

The Netherlands Red Cross

IPCC Fifth Assessment Report (AR5) Working Group II Report: Impacts, Adaptation and Vulnerability

Key information for the Red Cross Red Crescent

This report[1] presents the best current scientific information on the risks of climate change and how to manage them.

To create this report, hundreds of scientists reviewed the current scientific information to summarize what is known about climate, and how certain we are about it. "Certainty" of any statement is described by:

- A qualitative *level of confidence* (from *low* to *very high*) that is higher if there is more evidence for that statement and the different pieces of evidence agree with each other (see Annex 1 Figure 1).
- A quantitative *likelihood* statement about the probability of something happening (from *exceptionally unlikely* to *virtually certain*)

For a full explanation of this terminology see Annex 1.

The report looks at climate change with a focus on risk (see Figure 1). It highlights that changes in the climate (hazards) interact with human exposure and vulnerability to create *risk*.

The report evaluates how patterns of risks and potential benefits are shifting due to climate change and how some of these risks can be reduced.

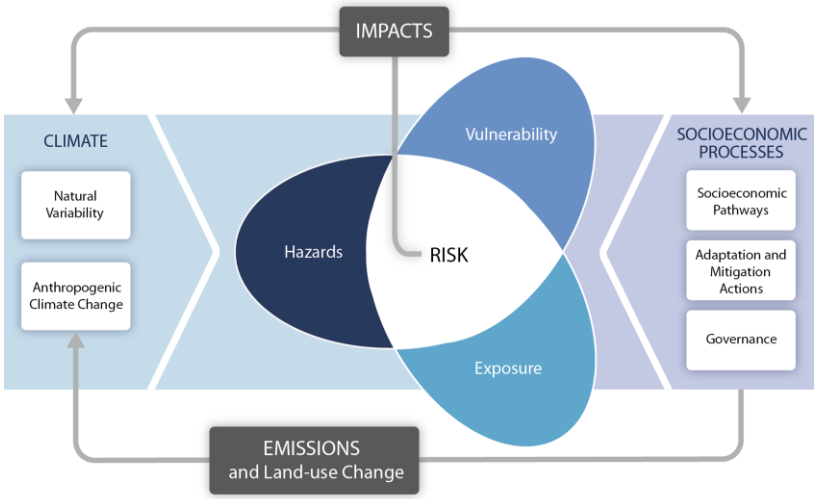


Figure 1: (SPM.1) Climate-related hazards, exposure, and vulnerability interact to produce risk. Changes in both the climate system (left) and development processes including adaptation and mitigation (right) are drivers of hazards, exposure, and vulnerability.

This summary reviews what the IPCC says about:

1) Climate change (hazards)
2) Vulnerability and exposure
3) Observed impacts
4) Future risks and the opportunities for adaptation (by sector)
5) Key risks by region
6) Global key risks and the main reasons for concern

[1] The report was developed by an international team of over 309 expert scientists and review editors, and went through a multi-stage review process generating almost 50,500 comments by expert reviewers and involving the governments of 70 countries. The Summary for Policymakers (SPM) was approved line-by-line by more than 110 governments and the entire report was accepted in March 2014. In this overview, we also include some information from the WG I report on the science of climate change (including observations and projections) which was approved in September 2013. For more information on the physical science on climate change, please see http://www.climatecentre.org/downloads/File/IPCC/IPCC-AR5-WGI_RCnotes_final.pdf)

1. Climate change (hazards)

The composition of the atmosphere has changed due to human activity and as a result temperatures are rising. Global average temperature has increased by 0.85°C since 1880. This trend is shown almost everywhere on earth.

Temperatures will continue to rise. However, not every year will be hotter than the last; there continues to be variability - ups and downs in temperature - from year to year, even while average temperatures are rising over time.

The temperature rise for the coming 20-30 years is almost independent of the actions we take to reduce greenhouse gas (GHG) emissions. Therefore, we have no choice but to adapt to the changes that are occurring.

However, **what happens in the second half of the 21st century strongly depends on emissions of greenhouse gases.** The IPCC uses various "emission scenarios". These are different estimates of how greenhouse gas emissions will increase or decrease over the coming century. Figure 2 shows how the global temperature could rise between now and 2100. The black line shows the observations of global temperature until now. The blue line is what happens if we reduce greenhouse gas emissions drastically (starting right away). The red line is what happens if we continue to emit greenhouse gases as we do today. In that case, we are headed for a global temperature rise of 2.6-4.8° C by the end of the century, which brings great risks (as discussed below).

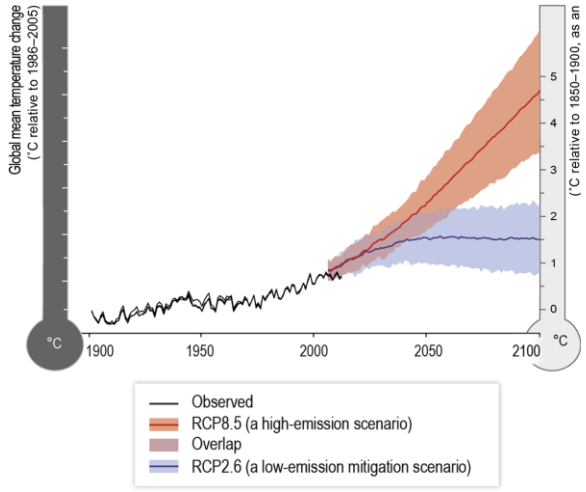


Figure 2: (Assessment Box SPM.1 Figure 1) Observed and projected future changes in global annual average temperature compared to 1986 – 2005. The blue line represents a scenario with low greenhouse gas emissions, and the red line, a scenario with high emissions.

Along with these rising temperatures, rainfall patterns will also continue to change, but *how* is less certain. Many areas that are currently dry could get drier, and areas that are already wet could get wetter. More specifically:

- Increases in average rainfall/snow are *likely* in mid-latitude wet regions, the high latitudes, and the Pacific Ocean near the equator.
- Decreases in average rainfall are *likely* in many mid-latitude dry regions.

It should be noted that rainfall usually has a lot of natural variability, which means we can continue to expect ups and downs from year to year.

Sea levels have risen worldwide and are projected to increase further. In the most pessimistic scenario this will *likely* lead to a range of possible increase of 0.52 to 0.98 m by the end of the 21st century. **It is also *very likely* that there will be more often and higher sea level extremes in the second half of the 21st century. These could result in submergences, coastal flooding and coastal erosion**

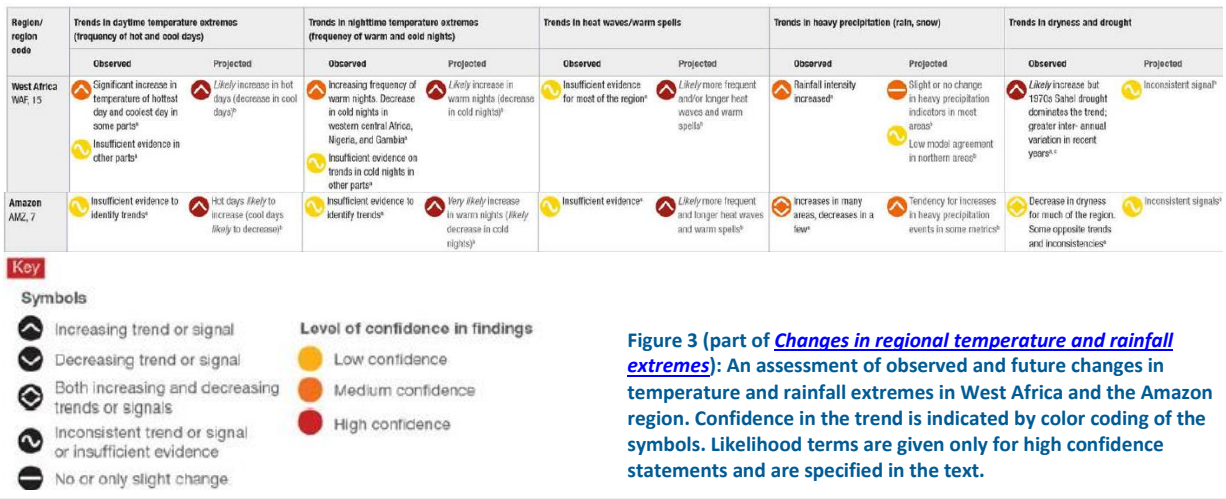
It should be noted that **sea level rise varies from place to place.** In some regions, sea level will rise faster than the global mean, of up to 30% above global mean in the Southern Ocean and North America and 10 to 20% above global mean in equatorial regions.

For an overview of the trends in rainfall, temperature and sea level (as observed in the past, and projected for the future), see overview figure: Overview of the trends in rainfall, temperature and sea level (as observed in the past, and projected for the future.

Extremes will also change. For more information on **global changes in all types of extremes** see *Global changes in climate extremes*, RCCC summarising key changes in extremes, rainfall patterns, temperature and sea level.

The IPCC now also provides regionally specific information. This information often shows quite clear trends for heat waves, but may be less certain for extreme rainfall and drought. **In many regions, we particularly face increasing uncertainty in what the future might hold.**

An example for West Africa and the Amazon is shown below in Figure 3. The full table with observed and projected future changes in regional temperature and precipitation extremes, as well as droughts is available in *Changes in regional temperature and rainfall extremes*.



Region/ region code	Trends in daytime temperature extremes (frequency of hot and cool days)		Trends in nighttime temperature extremes (frequency of warm and cold nights)		Trends in heat waves/warm spells		Trends in heavy precipitation (rain, snow)		Trends in dryness and drought	
	Observed	Projected	Observed	Projected	Observed	Projected	Observed	Projected	Observed	Projected
West Africa WAF, 15	Significant increase in temperature of hottest day and coolest day in some parts[a] Insufficient evidence in other parts[a]	*Likely* increase in hot days (decrease in cool days)[b]	Increasing frequency of warm nights. Decrease in cold nights in western central Africa, Nigeria, and Gambia[a] Insufficient evidence on trends in cold nights in other parts[a]	*Likely* increase in warm nights (decrease in cold nights)[b]	Insufficient evidence for most of the region[a]	*Likely* more frequent and/or longer heat waves and warm spells[b]	Rainfall intensity increased[a]	Slight or no change in heavy precipitation indicators in most areas[b] Low model agreement in northern areas[b]	*Likely* increase but 1970s Sahel drought dominates the trend; greater inter- annual variation in recent years[a,c]	Inconsistent signal[b]
Amazon AMZ, 7	Insufficient evidence to identify trends[a]	Hot days *likely* to increase (cool days *likely* to decrease)[b]	Insufficient evidence to identify trends[a]	*Very likely* increase in warm nights (*likely* decrease in cold nights)[b]	Insufficient evidence[a]	*Likely* more frequent and longer heat waves and warm spells[b]	Increases in many areas, decreases in a few[a]	Tendency for increases in heavy precipitation events in some metrics[b]	Decrease in dryness for much of the region. Some opposite trends and inconsistencies[a]	Inconsistent signals[b]

Key

Symbols

- Increasing trend or signal
- Decreasing trend or signal
- Both increasing and decreasing trends or signals
- Inconsistent trend or signal or insufficient evidence
- No or only slight change

Level of confidence in findings

- Low confidence
- Medium confidence
- High confidence

Figure 3 (part of *Changes in regional temperature and rainfall extremes*): An assessment of observed and future changes in temperature and rainfall extremes in West Africa and the Amazon region. Confidence in the trend is indicated by color coding of the symbols. Likelihood terms are given only for high confidence statements and are specified in the text.

2. Vulnerability and exposure

The patterns of future risk reflect not only the trends in climate, but also exposure and vulnerability of people, communities, societies, sectors and ecosystems.

Climate-related hazards constitute an **additional burden to people living in poverty**, acting as a threat multiplier often with negative outcomes for livelihoods (*high confidence*).

People who are socially, economically, culturally, politically, institutionally, or otherwise marginalized are especially vulnerable to climate change and also differentially affected by some adaptation and mitigation responses. Differences in vulnerability and exposure are rarely due to a single cause but result from the product of intersecting social processes that result in inequalities in socioeconomic status and income. Such social processes include, for example, discrimination on the basis of gender, class, ethnicity, age, and (dis)ability. These differences shape differential risks from climate change.

Uncertainties about future vulnerability, exposure, and responses of interlinked human and natural systems are large *(high confidence)*. Assessing future risk involves understanding these uncertainties which include a number of interacting social, economic, and cultural factors such as wealth and its distribution across society, demographics, migration, access to technology and information, employment patterns, the quality of adaptive responses, societal values, governance structures, and institutions to resolve conflicts. In addition, international dimensions such as trade and relations among states are also important for understanding the risks of climate change at regional scales.

3. Observed impacts

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

For instance, in many regions, changing rainfall or melting snow and ice are affecting water resources in terms of quantity and quality *(medium confidence)*. Glaciers continue to shrink almost worldwide due to climate change (*high confidence*), with implications for water supply for humans and ecosystems *(medium confidence)*.

The **health** of human populations is sensitive to shifts in weather patterns and other aspects of climate change (*very high confidence*). The IPCC only identifies **two specific health issues that have already been observed to have changed:**

- An **increased heat-related mortality and decreased cold-related mortality** in some regions as a result of warming (*medium confidence*).
- **Changes in the distribution of some water-borne illnesses and disease vectors** due to local changes in temperature and rainfall *(medium confidence)*.

There is a *high confidence* that negative impacts of climate change on crop yields have been more common than positive impacts. For example, some high latitude areas have a lengthened growing season, but most agricultural impacts are negative. Climate change has negatively affected wheat and maize yields for many regions and in the global aggregate (*medium confidence*). Effects on rice and soybean yield have been smaller in major production regions and globally. Recent periods of rapid food and cereal price increases have indicated that current markets in key producing regions are sensitive to climate extremes *(medium confidence)*.

In response to ongoing climate change there is *high confidence* that land and water species have shifted their ranges, seasonal activities, and migration patterns. In the past, the natural climate changed at rates much slower than current anthropogenic change, and these slower changes caused significant ecosystem shifts and species extinction during the past millions of years *(high confidence)*. Both shifts and extinctions are expected to occur with the current human-caused climate change, but at a more accelerated rate.

4. Future risks and the opportunities for adaptation

Adaptation to climate change is highly place and context specific, with no single approach for reducing risks appropriate across all settings. It often builds on existing approaches to manage current risks, by reducing vulnerability and exposure. One common example is early-warning systems, which help to anticipate and address the risk of extreme events in a more uncertain climate. Another example is ecosystem management, such as mangrove replantation to protect against storm surges, or reforestation to reduce the risk of landslide and flash floods. For a much wider range of options to adapt to climate change, see Annex 2: Examples of adapting to climate change.

Box 1: Adaptation and mitigation

There is *very high confidence* that there can be significant synergies but also trade-offs between mitigation and adaptation and between alternative adaptation responses. Examples of mitigation actions with adaptation co-benefits include: improved energy efficiency and cleaner energy sources, leading to reduced local emissions of health-damaging climate-altering air pollutants; reduced energy and water consumption in urban areas through greening cities and recycling water; sustainable agriculture and forestry; and protection of ecosystems for carbon storage and other ecosystem services.

The following paragraphs review risks for several key sectors and themes, including the risks and potential for adaptation.

Freshwater resources

Freshwater-related risks of climate change increase significantly with increasing greenhouse gas

concentrations (*robust evidence, high agreement)*. The fraction of global population experiencing water scarcity and the fraction affected by major river floods increase with the level of warming in the 21st century. By the end of the 21st century, three times more people are projected to be exposed to major river floods for the highest emission scenario as compared to the lowest (Figure 4). In presently dry regions, drought frequency will *likely* increase by the end of this century under the highest emission scenario (*medium confidence*).

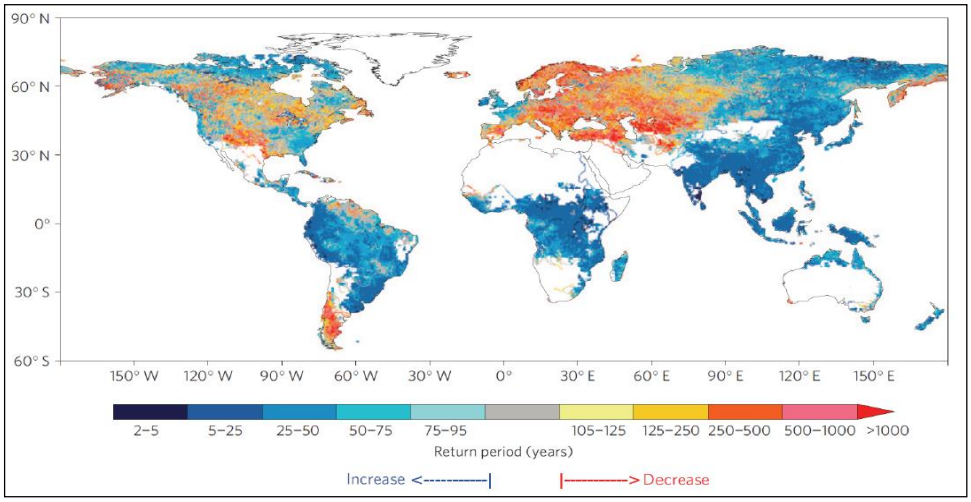


Figure 4 (TS.6): Projected change in river flood return period and exposure in the 2080s under the highest emission scenario, based on one hydrological model driven by climate models and on global population in 2005. A return period indicates the amount of years (on average) between each extreme event. The 20th-century 100-year flood, a flood occurring on average only every 100 years in the 20th century, is used as a base. The maps show the change in the median return period (in years) for this every 100-year flood event.

Climate change will reduce renewable surface water and groundwater resources significantly in most dry subtropical regions *(robust evidence, high agreement)*, intensifying competition for water among sectors *(limited evidence, medium agreement)*; in contrast, water resources will increase at high latitudes *(robust evidence, high agreement)*. Increased temperatures, heavy rainfall, floods and droughts can all affect water quality.

Adaptive water management techniques, including scenario planning, learning-based approaches, and flexible and low-regret solutions, can help create resilience to uncertain hydrological changes and impacts due to climate change (*limited evidence, high agreement*).

Coastal systems and low-lying areas

Due to sea-level rise projected throughout the 21th century and beyond, coastal systems and low-lying areas will increasingly experience adverse impacts such as submergence, coastal flooding, and coastal erosion (*very high confidence*). The population and assets exposed to coastal risks as well as human pressure on coastal ecosystems will increase significantly in the coming decades due to population growth, economic development, and urbanization (*high confidence*).

By 2100, due to climate change and development patterns and without adaptation, hundreds of millions of people would be affected by coastal flooding and displaced due to land loss (*high confidence*). The majority affected will be in East, Southeast, and South Asia. Some low-lying developing countries and small island states are expected to face very high impacts and associated annual damage and adaptation costs of several percentage points of GDP.

Food security and food production systems

For the major crops (wheat, rice, and maize) in tropical and temperate regions, climate change without adaptation is projected to negatively impact production for local temperature increases of 2°C or more above late-20th-century levels, although individual locations may benefit (*medium confidence*). With or without adaptation, climate change will reduce median yields by 0 to 2% per decade for the rest of the century, as compared to a baseline without climate change. These projected impacts will occur in the context of rising

crop demand, projected to increase by about 14% per decade until 2050. Risks are greatest for tropical countries, given projected impacts that exceed adaptive capacity and higher poverty rates compared with temperate regions. Climate change will progressively increase inter-annual variability of crop yields in many regions.

After 2050 the risk of more severe yield impacts increases, and depends on the level of warming. Global temperature increases of ~4°C or more above late-20th-century levels, combined with increasing food demand, would pose large risks to food security globally and regionally (*high confidence*). Risks to food security are generally greater in low-latitude areas. Recent periods of rapid food and cereal price increases have indicated that current markets in key producing regions are sensitive to climate extremes.

On average, adaptation improves yields by the equivalent of ~15-18% of current yields, but the effectiveness of adaptation is highly variable *(medium confidence)*. In Africa, adaptive agricultural processes such as collaborative, participatory research that includes scientists and farmers, strengthened communication systems for anticipating and responding to climate risks, and increased flexibility in livelihood options provide potential pathways for strengthening adaptive capacities.

Rural & urban areas

In the near-term and beyond, rural areas will face major impacts on water availability and supply, food security, and agricultural incomes, including shifts in production areas of food and non-food crops across the world (*high confidence*). These impacts are expected to disproportionately affect the welfare of the poor in rural areas, such as female-headed households and those with limited access to land, modern agricultural inputs, infrastructure, and education. Further adaptations for agriculture, water, forestry, and biodiversity can occur through policies taking account of rural decision-making contexts.

Heat stress, extreme precipitation, inland and coastal flooding, landslides, air pollution, drought, and water scarcity pose risks in urban areas for people, assets, economies, and ecosystems (*very high confidence*). Risks are amplified for those lacking essential infrastructure and services or living in poor-quality housing and exposed areas. Reducing basic service deficits, improving housing, and building resilient infrastructure systems could significantly reduce vulnerability and exposure in urban areas. Urban adaptation benefits from effective multi-level urban risk governance, alignment of policies and incentives, strengthened local government and community adaptation capacity, synergies with the private sector, appropriate financing and institutional development, and increased capacity, voice and influence of low-income groups and vulnerable communities and their partnerships with local governments (*medium confidence*).

Livelihoods and poverty

Throughout the 21st century, climate-change impacts will slow down economic growth, make poverty reduction more difficult, further erode food security, and prolong existing and create new poverty traps, the latter particularly in urban areas and emerging hotspots of hunger (*medium confidence*). Climate change will exacerbate poverty in most developing countries and create new poverty pockets in countries with increasing inequality, in both developed and developing countries. In urban and rural areas, wage-labor-dependent poor households that are net buyers of food will be particularly affected due to food price increases, including in regions with high food insecurity and high inequality (particularly Africa).

Solutions include insurance programs, social protection measures, and disaster risk management to enhance long-term livelihood resilience among poor and marginalized people, if policies address poverty and multidimensional inequalities.

Human health

Until mid-century, climate change will impact human health mainly by exacerbating health problems that already exist (*very high confidence*). Climate change throughout the 21st century will lead to increases in ill-health in many regions and especially in developing countries with low income, as compared to a baseline without climate change (*high confidence*).

Climate change affects health in three ways;

1) Directly, such as greater likelihood of injury, disease, and death due to more intense heat waves and fires *(very high confidence)* and the mortality and morbidity (including "heat exhaustion") due to floods, and other extreme weather events in which climate change may play a role;
2) Indirect impacts from environmental and ecosystem changes, such as shifts in patterns of disease-carrying mosquitoes and ticks, or increased risks from food- and water-borne diseases *(very high confidence)* and vector-borne diseases *(medium confidence)*; and
3) Indirect impacts through societal systems, such as under nutrition and mental illness from diminished food production in poor regions (*high confidence*), stress and violent conflict caused by population displacement, economic losses due to widespread "heat exhaustion" impacts from lost work capacity and reduced labor productivity in vulnerable populations, or other environmental stressors, and damage to health care systems by extreme weather events.

Positive effects are expected to include modest reductions in cold related mortality and morbidity in some areas due to fewer cold extremes (*low confidence*), geographical shifts in food production (*medium confidence*), and reduced capacity of vectors to transmit some diseases. But globally over the 21st century, the magnitude and severity of negative impacts are projected to increasingly outweigh positive impacts (*high confidence*).

Effective adaptation measures include basic public health measures such as provision of clean water and sanitation, securing essential health care including vaccination and child health services, increasing capacity for disaster preparedness and response, and alleviating poverty (*very high confidence*). For the highest emission scenario by 2100, the combination of high temperature and humidity in some areas for parts of the year will compromise normal human activities, including growing food or working outdoors (*high confidence*).

Human security

Violent conflict increases vulnerability to climate change (*medium evidence, high agreement*). Large-scale **violent conflict harms assets that facilitate adaptation, including infrastructure, institutions, natural resources, social capital, and livelihood opportunities.**

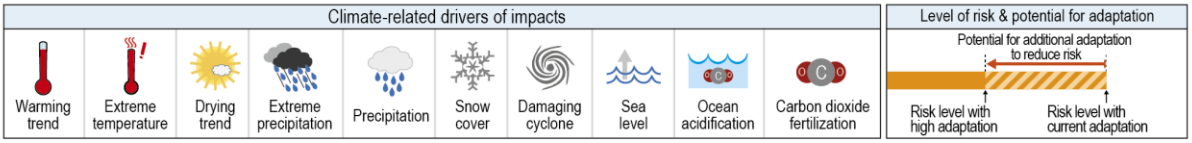
Climate change over the 21st century is projected to increase migration of people and can increase risks of violent conflicts by amplifying drivers of these conflicts such as poverty and economic shocks. Risk of displacement depends on specific opportunities and events, and can be affected by extreme weather events as well as long-term climate fluctuations and trends. Because of this complexity, we cannot project how many people will move in any given location. However, it is clear that many climate change impacts, such as sea level rise or changes to transboundary river basins, will influence national and international policies.

The impacts of climate change on the critical infrastructure and territorial integrity of many states are expected to influence national security policies.

5. Key risks by region

Risks will vary through time across regions and populations, dependent on many factors including the extent of adaptation and mitigation. A selection of key regional risks identified with *medium* to *high confidence* is presented in the table below (Table 1)

Table 1 (Assessment Box SPM.2 Table 1): Key regional risks from climate change and the potential for reducing risks through adaptation and mitigation. Each key risk is characterized as very low to very high for three timeframes: the present, near-term (here, assessed over 2030-2040), and longer-term (here, assessed over 2080-2100). In the near-term, projected levels of global mean temperature increase do not diverge substantially for different emission scenarios. For the longer-term, risk levels are presented for two scenarios of global mean temperature increase (2°C and 4°C above preindustrial levels). These scenarios illustrate the potential for mitigation and adaptation to reduce the risks related to climate change. Climate-related drivers of impacts are indicated by icons.



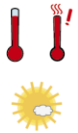
Africa

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Compounded stress on water resources facing significant strain from overexploitation and degradation at present and increased demand in the future, with drought stress exacerbated in drought-prone regions of Africa (high confidence) [22.3-4]	• Reducing non-climate stressors on water resources • Strengthening institutional capacities for demand management, groundwater assessment, integrated water-wastewater planning, and integrated land and water governance • Sustainable urban development		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very-low / Medium / Very high
Reduced crop productivity associated with heat and drought stress, with strong adverse effects on regional, national, and household livelihood and food security, also given increased pest and disease damage and flood impacts on food system infrastructure (high confidence) [22.3-4]	• Technological adaptation responses (e.g., stress-tolerant crop varieties, irrigation, enhanced observation systems) • Enhancing smallholder access to credit and other critical production resources; Diversifying livelihoods • Strengthening institutions at local, national, and regional levels to support agriculture (including early warning systems) and gender-oriented policy • Agronomic adaptation responses (e.g., agroforestry, conservation agriculture)		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Verylow / Medium / Very high
Changes in the incidence and geographic range of vector- and water-borne diseases due to changes in the mean and variability of temperature and precipitation, particularly along the edges of their distribution (medium confidence) [22.3]	• Achieving development goals, particularly improved access to safe water and improved sanitation, and enhancement of public health functions such as surveillance • Vulnerability mapping and early warning systems • Coordination across sectors • Sustainable urban development		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very-low / Medium / Very high

Europe

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Increased economic losses and people affected by flooding in river basins and coasts, driven by increasing urbanization, increasing sea levels, coastal erosion, and peak river discharges (high confidence) [23.2-3, 23.7]	Adaptation can prevent most of the projected damages (high confidence). • Significant experience in hard flood-protection technologies and increasing experience with restoring wetlands • High costs for increasing flood protection • Potential barriers to implementation: demand for land in Europe and environmental and landscape concerns		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very-low / Medium / Very high
Increased water restrictions. Significant reduction in water availability from river abstraction and from groundwater resources, combined with increased water demand (e.g., for irrigation, energy and industry, domestic use) and with reduced water drainage and runoff as a result of increased evaporative demand, particularly in southern Europe (high confidence) [23.4, 23.7]	• Proven adaptation potential from adoption of more water-efficient technologies and of water-saving strategies (e.g., for irrigation, crop species, land cover, industries, domestic use) • Implementation of best practices and governance instruments in river basin management plans and integrated water management		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very-low / Medium / Very high
Increased economic losses and people affected by extreme heat events: impacts on health and well-being, labor productivity, crop production, air quality, and increasing risk of wildfires, particularly in southern Europe and in Russian boreal region (medium confidence) [23.3-7, Table 23-1]	• Implementation of warning systems • Adaptation of dwellings and workplaces and of transport and energy infrastructure • Reductions in emissions to improve air quality • Improved wildfire management • Development of insurance products against weather-related yield variations		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very-low / Medium / Very high

Asia

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Increased riverine, coastal, and urban flooding leading to widespread damage to infrastructure, livelihoods, and settlements in Asia (medium confidence) [24.4]	• Exposure reduction via structural and non-structural measures, effective land-use planning, and selective relocation • Reduction in the vulnerability of lifeline infrastructure and services (e.g., water, energy, waste management, food, biomass, mobility, local ecosystems, telecommunications) • Construction of monitoring and early warning systems; measures to identify exposed areas, assist vulnerable areas and households, and diversify livelihoods • Economic diversification		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low – Medium – Very high
Increased risk of heat-related mortality (high confidence) [24.4]	• Heat health warning systems • Urban planning to reduce heat islands; improvement of the built environment; development of sustainable cities • New work practices to avoid heat stress among outdoor workers		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low – Medium – Very high
Increased risk of drought-related water and food shortage causing malnutrition (high confidence) [24.4]	• Disaster preparedness including early-warning systems and local coping strategies • Adaptive/integrated water resource management • Water infrastructure and reservoir development • Diversification of water sources including water re-use • More efficient use of water (e.g., improved agricultural practices, irrigation management, and resilient agriculture)		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low – Medium – Very high

Australasia

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Significant change in community composition and structure of coral reef systems in Australia (high confidence) [25.6, 30.5, Boxes CC-CR and CC-OA]	• Ability of corals to adapt naturally appears limited and insufficient to offset the detrimental effects of rising temperatures and acidification. • Other options are mostly limited to reducing other stresses (water quality, tourism, fishing) and early warning systems; direct interventions such as assisted colonization and shading have been proposed but remain untested at scale.		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low – Medium – Very high
Increased frequency and intensity of flood damage to infrastructure and settlements in Australia and New Zealand (high confidence) [Table 25-1, Boxes 25-8 and 25-9]	• Significant adaptation deficit in some regions to current flood risk. • Effective adaptation includes land-use controls and relocation as well as protection and accommodation of increased risk to ensure flexibility.		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low – Medium – Very high
Increasing risks to coastal infrastructure and low-lying ecosystems in Australia and New Zealand, with widespread damage towards the upper end of projected sea-level-rise ranges (high confidence) [25.6, 25.10, Box 25-1]	• Adaptation deficit in some locations to current coastal erosion and flood risk. Successive building and protection cycles constrain flexible responses. • Effective adaptation includes land-use controls and ultimately relocation as well as protection and accommodation.		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low – Medium – Very high

North America

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Wildfire-induced loss of ecosystem integrity, property loss, human morbidity, and mortality as a result of increased drying trend and temperature trend (high confidence) [26.4, 26.8, Box 26-2]	• Some ecosystems are more fire-adapted than others. Forest managers and municipal planners are increasingly incorporating fire protection measures (e.g., prescribed burning, introduction of resilient vegetation). Institutional capacity to support ecosystem adaptation is limited. • Adaptation of human settlements is constrained by rapid private property development in high-risk areas and by limited household-level adaptive capacity. • Agroforestry can be an effective strategy for reduction of slash and burn practices in Mexico.		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low – Medium – Very high

North America (continued)

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation (Very low / Medium / Very high)
Heat-related human mortality (high confidence) [26.6, 26.8]	• Residential air conditioning (A/C) can effectively reduce risk. However, availability and usage of A/C is highly variable and is subject to complete loss during power failures. Vulnerable populations include athletes and outdoor workers for whom A/C is not available. • Community- and household-scale adaptations have the potential to reduce exposure to heat extremes via family support, early heat warning systems, cooling centers, greening, and high-albedo surfaces.		Present Near-term (2030-2040) Long-term (2080-2100) 2°C Long-term (2080-2100) 4°C	
Urban floods in riverine and coastal areas, inducing property and infrastructure damage; supply chain, ecosystem, and social system disruption; public health impacts; and water quality impairment due to sea-level rise, extreme precipitation, and cyclones (high confidence) [26.2-4, 26.8]	• Implementing management of urban drainage is expensive and disruptive to urban areas. • Low-regret strategies with co-benefits include less impervious surfaces leading to more groundwater recharge, green infrastructure, and rooftop gardens. • Sea-level rise increases water elevations in coastal outfalls, which impedes drainage. In many cases, older rainfall design standards are being used that need to be updated to reflect current climate conditions. • Conservation of wetlands, including mangroves, and land-use planning strategies can reduce the intensity of flood events.		Present Near-term (2030-2040) Long-term (2080-2100) 2°C Long-term (2080-2100) 4°C	

Central and South America

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation (Very low / Medium / Very high)
Water availability in semi-arid and glacier-melt-dependent regions and Central America; flooding and landslides in urban and rural areas due to extreme precipitation (high confidence) [27.3]	• Integrated water resource management • Urban and rural flood management (including infrastructure), early warning systems, better weather and runoff forecasts, and infectious disease control		Present Near-term (2030-2040) Long-term (2080-2100) 2°C Long-term (2080-2100) 4°C	
Decreased food production and food quality (medium confidence) [27.3]	• Development of new crop varieties more adapted to climate change (temperature and drought) • Offsetting of human and animal health impacts of reduced food quality • Offsetting of economic impacts of land-use change • Strengthening traditional indigenous knowledge systems and practices		Present Near-term (2030-2040) Long-term (2080-2100) 2°C Long-term (2080-2100) 4°C	
Spread of vector-borne diseases in altitude and latitude (high confidence) [27.3]	• Development of early warning systems for disease control and mitigation based on climatic and other relevant inputs. Many factors augment vulnerability. • Establishing programs to extend basic public health services		Present Near-term (2030-2040) Long-term (2080-2100) 2°C: not available Long-term (2080-2100) 4°C: not available	

Polar Regions

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation (Very low / Medium / Very high)
Risks for freshwater and terrestrial ecosystems (high confidence) and marine ecosystems (medium confidence), due to changes in ice, snow cover, permafrost, and freshwater/ocean conditions, affecting species' habitat quality, ranges, phenology, and productivity, as well as dependent economies [28.2-4]	• Improved understanding through scientific and indigenous knowledge, producing more effective solutions and/or technological innovations • Enhanced monitoring, regulation, and warning systems that achieve safe and sustainable use of ecosystem resources • Hunting or fishing for different species, if possible, and diversifying income sources		Present Near-term (2030-2040) Long-term (2080-2100) 2°C Long-term (2080-2100) 4°C	
Risks for the health and well-being of Arctic residents, resulting from injuries and illness from the changing physical environment, food insecurity, lack of reliable and safe drinking water, and damage to infrastructure, including infrastructure in permafrost regions (high confidence) [28.2-4]	• Co-production of more robust solutions that combine science and technology with indigenous knowledge • Enhanced observation, monitoring, and warning systems • Improved communications, education, and training • Shifting resource bases, land use, and/or settlement areas		Present Near-term (2030-2040) Long-term (2080-2100) 2°C Long-term (2080-2100) 4°C	

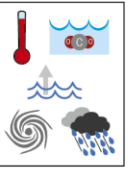
Polar Regions (continued)

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Unprecedented challenges for northern communities due to complex inter-linkages between climate-related hazards and societal factors, particularly if rate of change is faster than social systems can adapt (high confidence) [28.2-4]	• Co-production of more robust solutions that combine science and technology with indigenous knowledge • Enhanced observation, monitoring, and warning systems • Improved communications, education, and training • Adaptive co-management responses developed through the settlement of land claims		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low – Medium – Very high

Small Islands

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Loss of livelihoods, coastal settlements, infrastructure, ecosystem services, and economic stability (high confidence) [29.6, 29.8, Figure 29-4]	• Significant potential exists for adaptation in islands, but additional external resources and technologies will enhance response. • Maintenance and enhancement of ecosystem functions and services and of water and food security • Efficacy of traditional community coping strategies is expected to be substantially reduced in the future.		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low – Medium – Very high
The interaction of rising global mean sea level in the 21st century with high-water-level events will threaten low-lying coastal areas (high confidence) [29.4, Table 29-1; WGI AR5 13.5, Table 13.5]	• High ratio of coastal area to land mass will make adaptation a significant financial and resource challenge for islands. • Adaptation options include maintenance and restoration of coastal landforms and ecosystems, improved management of soils and freshwater resources, and appropriate building codes and settlement patterns.		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low – Medium – Very high

The Ocean

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Distributional shift in fish and invertebrate species, and decrease in fisheries catch potential at low latitudes, e.g., in equatorial upwelling and coastal boundary systems and sub-tropical gyres (high confidence) [6.3, 30.5-6, Tables 6-6 and 30-3, Box CC-MB]	• Evolutionary adaptation potential of fish and invertebrate species to warming is limited as indicated by their changes in distribution to maintain temperatures. • Human adaptation options: Large-scale translocation of industrial fishing activities following the regional decreases (low latitude) vs. possibly transient increases (high latitude) in catch potential; Flexible management that can react to variability and change; Improvement of fish resilience to thermal stress by reducing other stressors such as pollution and eutrophication; Expansion of sustainable aquaculture and the development of alternative livelihoods in some regions.		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low – Medium – Very high
Reduced biodiversity, fisheries abundance, and coastal protection by coral reefs due to heat-induced mass coral bleaching and mortality increases, exacerbated by ocean acidification, e.g., in coastal boundary systems and sub-tropical gyres (high confidence) [5.4, 6.4, 30.3, 30.5-6, Tables 6-6 and 30-3, Box CC-CR]	• Evidence of rapid evolution by corals is very limited. Some corals may migrate to higher latitudes, but entire reef systems are not expected to be able to track the high rates of temperature shifts. • Human adaptation options are limited to reducing other stresses, mainly by enhancing water quality, and limiting pressures from tourism and fishing. These options will delay human impacts of climate change by a few decades, but their efficacy will be severely reduced as thermal stress increases.		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low – Medium – Very high
Coastal inundation and habitat loss due to sea-level rise, extreme events, changes in precipitation, and reduced ecological resilience, e.g., in coastal boundary systems and sub-tropical gyres (medium to high confidence) [5.5, 30.5-6, Tables 6-6 and 30-3, Box CC-CR]	• Human adaptation options are limited to reducing other stresses, mainly by reducing pollution and limiting pressures from tourism, fishing, physical destruction, and unsustainable aquaculture. • Reducing deforestation and increasing reforestation of river catchments and coastal areas to retain sediments and nutrients • Increased mangrove, coral reef, and seagrass protection, and restoration to protect numerous ecosystem goods and services such as coastal protection, tourist value, and fish habitat		Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low – Medium – Very high

6. Global key risks and the main reasons for concern

The report has identified a few key risks, potentially severe impacts spanning several sectors and regions, relevant to "**dangerous anthropogenic interference with the climate system**" (as described in Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC)). Preventing dangerous anthropogenic interference means stabilizing GHG concentrations in the atmosphere at a level and during a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

Many of these risks may be particularly challenging for the least developed countries and vulnerable communities, given their higher vulnerability and limited ability to cope.

1. Risk of death, injury, ill-health or disrupted livelihoods in low-lying coastal zones and small island developing states and other small islands, due to storm surges, coastal flooding, and sea-level rise.
2. Risk of severe ill-health and disrupted livelihoods for large urban populations due to inland flooding in some regions.
3. Systemic risks due to extreme weather events leading to breakdown of infrastructure networks and critical services such as electricity, water supply, and health and emergency services.
4. Risk of excess mortality, and morbidity during periods of extreme heat, particularly for vulnerable urban populations and those working outside.
5. Risk of food insecurity and the breakdown of food systems linked to warming, drought, flooding, and precipitation variability and extremes, particularly for poorer populations.
6. Risk of loss of rural livelihoods and income due to insufficient access to drinking and irrigation water and reduced agricultural productivity, particularly for farmers and pastoralists with minimal capital in semi-arid regions.
7. Risk of loss of marine and coastal ecosystems, biodiversity, the ecosystem goods and services they provide for coastal livelihoods, especially for fishing communities in the tropics and the Arctic.
8. Risk of loss of terrestrial and inland water ecosystems, biodiversity, the ecosystem goods and services they provide for livelihoods.

Figure 5 summarizes information from across the key risks into **five integrative reasons for concern, and shows how the risks across these five risk categories increase as temperatures increase.**

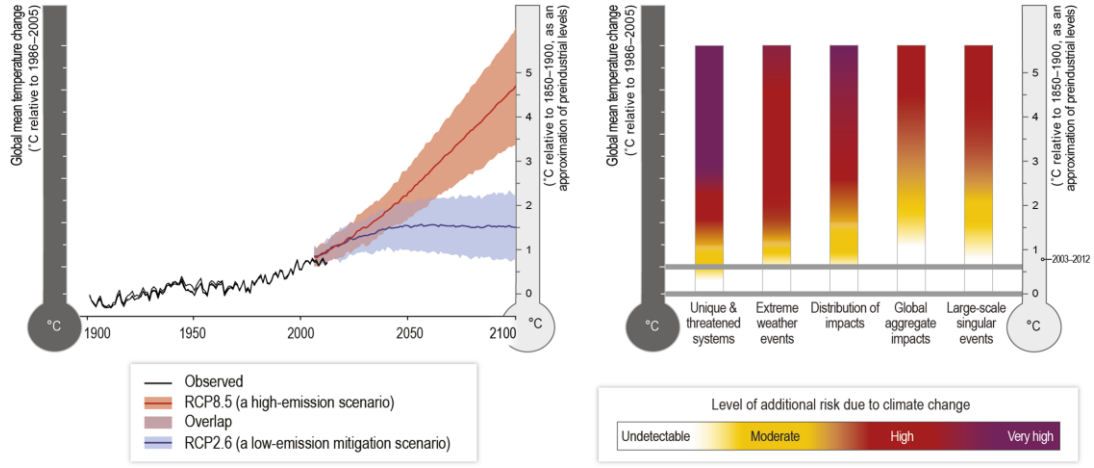


Figure 5 (Assessment Box SPM.1 Figure 1): (right panel) The dependence of risks associated with reasons for concern on the level of climate change, updated based on assessment of the literature and expert judgments. Purple shading indicates very high risk of severe impacts and the presence of significant irreversibility combined with limited adaptive capacity.
(left panel) Observed and projected future changes in global annual average temperature relative to 1986 – 2005, as in Figure 2. The blue line represents a scenario with low greenhouse gas emissions, and the red line, a scenario with high emissions.

The key risks are:

- **Unique and threatened human and ecological systems:** Ecosystems and cultures are already at moderate risk of severe consequences from climate change at recent temperatures (see Figure 4). The number of human and natural systems at risk increases at additional warming of around 1°C. For example, coastal

settlements are threatened by rising sea levels while delicate marine ecosystems are at risk from increases in sea temperatures. Particularly vulnerable are Arctic sea ice systems and coral reefs as they have limited adaptive capacity.

- **Extreme weather events:** While there is *high confidence* that extreme events such as heat waves, extreme precipitation, and coastal flooding are already a moderate risk at recent temperatures, these risks become high with 1°C additional warming (*medium confidence*). Risks associated with some types of extreme events (for example heat waves) increase further at higher temperatures (*high confidence*). **The risk that climate change increases the divide between the have's and the have-not's, the strong and the vulnerable:** Risks are unevenly distributed and are generally greater for disadvantaged and exposed people and communities in countries at all levels of development. Risks from climate change have already been observed because of regionally differentiated impacts on crop production in particular (*medium* to *high confidence*). Risks of unevenly distributed impacts are high for additional warming above 2°C due to projected decreases in regional crop yields and water availability (*medium confidence*). For example, variability in rainfall and higher temperatures are expected to have adverse effects on crops such as rice.
- **Global aggregate impacts:** The global economy and Earth's biodiversity are at moderate risk for additional warming between 1-2°C (*medium confidence*) and at high risk around 3°C (*low confidence*). Many industries are dependent on ecosystem services and natural resources, however the effects of climate change on these systems and thus the economy are not well understood. However there is *high confidence* in the risks of extensive biodiversity loss with associated loss of ecosystem goods and services.
- **Drastic changes to the physical world:** Early warning signs indicate that both warm water coral reefs and Arctic ecosystems are already experiencing irreversible damage. Risks become high for sustained warming of 1-4°C with the potential for large and irreversible sea-level rise from ice sheet loss which in the case of Greenland would occur over a millennium or more.

Figure 7 clearly shows that that **risks have already increased, and will continue to rise** for several decades to come (even if we drastically cut greenhouse gas emissions today). This implies **we have to do more to anticipate and reduce risks** rather than just respond after impacts have occurred.

For the second half of the century, we face a bigger choice – one that needs to be made now. **If we do not cut greenhouse gas emissions drastically and quite soon, we will face greater and greater risks** (with potentially severe humanitarian consequences).

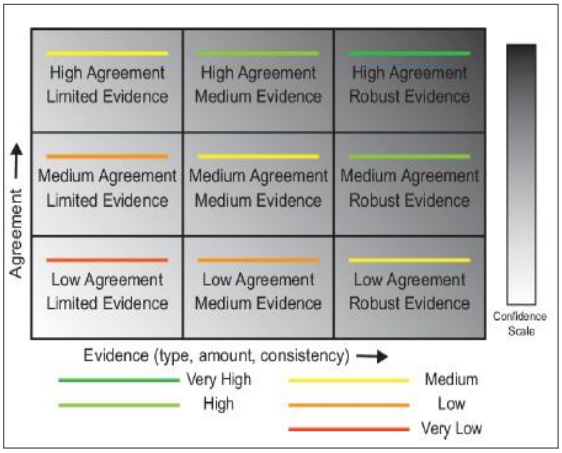
Annex 1: IPCC Uncertainty Language

The IPCC interprets an enormous amount of scientific information to create these reports. The authors therefore try to indicate not only their findings based on that information, but also their best estimate of how certain we are about those findings.

In presenting that level of certainty, the IPCC uses very precise terminology, which may differ slightly from how these terms are used in daily life. For instance, even when they are very certain about a particular finding, scientists will almost never say they are sure, but rather that something is "very likely".

The IPCC uses two different metrics to communicate the degree of certainty in key findings:

- A qualitative *level of confidence* that is higher if there is more evidence for that statement and the different pieces of evidence agree with each other (see Figure 1 Annex 1).
- A quantitative *likelihood* statement about the probability of something happening (based on statistics and expert judgment)



Annex 1 Figure 1 (WG I Figure 1.12): The basis for the confidence level is given as a combination of evidence (limited, medium, robust) and agreement (low, medium, and high). The confidence level is given for five levels (very high, high, medium, low, and very low) and given in colours.

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

Annex 1 Table 1 (WG I SPM Table 1.1): Likelihood terms associated with outcomes used in the AR5.
Notes: Additional terms that were used in limited circumstances in the AR4 (extremely likely: 95–100% probability, more likely than not: 50–100% probability) may also be used in the AR5 when appropriate.

Annex 2: Examples of adapting to climate change

Annex 2 Table 1 (Table SPM.1): Adapting example to illustrate different entry points and categories for climate risk management.

Overlapping Approaches	Category	Examples
Vulnerability & Exposure Reduction through development, planning, & practices including many low-regrets measures; Adaptation including incremental & transformational adjustments; Transformation	Human development	Improved access to education, nutrition, health facilities, energy, safe housing & settlement structures, & social support structures; Reduced gender inequality & marginalization in other forms.
	Poverty alleviation	Improved access to & control of local resources; Land tenure; Disaster risk reduction; Social safety nets & social protection; Insurance schemes.
	Livelihood security	Income, asset, & livelihood diversification; Improved infrastructure; Access to technology & decision-making fora; Increased decision-making power; Changed cropping, livestock, & aquaculture practices; Reliance on social networks.
	Disaster risk management	Early warning systems; Hazard & vulnerability mapping; Diversifying water resources; Improved drainage; Flood & cyclone shelters; Building codes & practices; Storm & wastewater management; Transport & road infrastructure improvements.
	Ecosystem management	Maintaining wetlands & urban green spaces; Coastal afforestation; Watershed & reservoir management; Reduction of other stressors on ecosystems & of habitat fragmentation; Maintenance of genetic diversity; Manipulation of disturbance regimes; Community-based natural resource management.
	Spatial or land-use planning	Provisioning of adequate housing, infrastructure, & services; Managing development in flood prone & other high risk areas; Urban planning & upgrading programs; Land zoning laws; Easements; Protected areas.
	Structural/physical	***Engineered & built-environment options***: Sea walls & coastal protection structures; Flood levees; Water storage; Improved drainage; Flood & cyclone shelters; Building codes & practices; Storm & wastewater management; Transport & road infrastructure improvements; Floating houses; Power plant & electricity grid adjustments.
		Technological options: New crop & animal varieties; Indigenous, traditional, & local knowledge, technologies, & methods; Efficient irrigation; Water-saving technologies; Desalinization; Conservation agriculture; Food storage & preservation facilities; Hazard & vulnerability mapping & monitoring; Early warning systems; Building insulation; Mechanical & passive cooling; Technology development, transfer, & diffusion.
		Ecosystem-based options: Ecological restoration; Soil conservation; Afforestation & reforestation; Mangrove conservation & replanting; Green infrastructure (e.g., shade trees, green roofs); Controlling overfishing; Fisheries co-management; Assisted species migration & dispersal; Ecological corridors; Seed banks, gene banks, & other *ex situ* conservation; Community-based natural resource management.
		Services: Social safety nets & social protection; Food banks & distribution of food surplus; Municipal services including water & sanitation; Vaccination programs; Essential public health services; Enhanced emergency medical services.
	Institutional	***Economic options***: Financial incentives; Insurance; Catastrophe bonds; Payments for ecosystem services; Pricing water to encourage universal provision and careful use; Microfinance; Disaster contingency funds; Cash transfers; Public-private partnerships.
		Laws & regulations: Land zoning laws; Building standards & practices; Easements; Water regulations & agreements; Laws to support disaster risk reduction; Laws to encourage insurance purchasing; Defined property rights & land tenure security; Protected areas; Fishing quotas; Patent pools & technology transfer.
		National & government policies & programs: National & regional adaptation plans including mainstreaming; Sub-national & local adaptation plans; Economic diversification; Urban upgrading programs; Municipal water management programs; Disaster planning & preparedness; Integrated water resource management; Integrated coastal zone management; Ecosystem-based management; Community-based adaptation.
	Social	***Educational options***: Awareness raising & integrating into education; Gender equity in education; Extension services; Sharing indigenous, traditional, & local knowledge; Participatory action research & social learning; Knowledge-sharing & learning platforms.
		Informational options: Hazard & vulnerability mapping; Early warning & response systems; Systematic monitoring & remote sensing; Climate services; Use of indigenous climate observations; Participatory scenario development; Integrated assessments.
		Behavioral options: Household preparation & evacuation planning; Migration; Soil & water conservation; Storm drain clearance; Livelihood diversification; Changed cropping, livestock, & aquaculture practices; Reliance on social networks.
	Spheres of change	***Practical***: Social & technical innovations, behavioral shifts, or institutional & managerial changes that produce substantial shifts in outcomes.
		Political: Political, social, cultural, & ecological decisions & actions consistent with reducing vulnerability & risk & supporting adaptation, mitigation, & sustainable development.
		Personal: Individual & collective assumptions, beliefs, values, & worldviews influencing climate-change responses.

Annex 3: List of background documents to be found on the RCCC website

1: *Changes in regional temperature and rainfall extremes*
2: *Global changes in climate extremes*
3: Overview figure: Overview of the trends in rainfall, temperature and sea level (as observed in the past, and projected for the future)