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INTERGOVERNMENTAL PANEL ON climate change

Climate Change 2022

Impacts, Adaptation and Vulnerability

Frequently Asked Questions

WGII

Working Group II contribution to the
Sixth Assessment Report of the
Intergovernmental Panel on Climate Change

WMO UNEP

Climate Change 2022: Impacts, Adaptation and Vulnerability

Frequently Asked Questions

From the report accepted by Working Group II of the IPCC but not approved in detail

Part of the Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change

Edited by

Hans-Otto Pörtner
Working Group II Co-Chair

Debra C. Roberts
Working Group II Co-Chair

Melinda M. B. Tignor
Head of TSU

Elvira Poloczanska
Science Advisor to the WGII Co-Chairs and TSU

Katja Mintenbeck
Director of Science

Andrés Alegría
Graphics Officer

Marlies Craig
Science Officer

Stefanie Langsdorf
Graphics Officer

Sina Löschke
Communications Manager

Vincent Möller
Science Officer

Andrew Okem
Science Officer

Bardhyl Rama
Director of Operations

With editorial assistance from Daniel Belling, Wolfgang Dieck, Sandra Götze, Tijama Kersher, Philisiwe Mangele, Bastian Maus, Anka Mühle, Komila Nabiyeva, Maike Nicolai, Almut Niebuhr, Jan Petzold, Esté Prentzler, Jussi Savolainen, Hanna Scheuffele, Stefan Weisfeld and Nora Weyer

Working Group II Technical Support Unit

ISBN 978-92-9169-162-3

Front cover artwork: *A Borrowed Planet - Inherited from our ancestors. On loan from our children*. by Alisa Singer www.environmentalgraphiti.org

Foreword

Foreword

Climate change affects all parts of our world, but we know that impacts, risks, adaptation actions, and vulnerability differ from region to region. This complexity is further increased by various other non-climatic trends such as expanding unsustainable land use, biodiversity loss, or rapid urbanization that we have to take into account if we want to reduce climate risks and limit global warming. In brief: Text on climate science is often not easily understood - and we are very much aware that some or all of our report chapters tend to be written in expert language, which is often hard to read and understand for non-experts.

To make our report more accessible, our authors have made an effort to formulate and answer a set of key questions in a way everyone interested might understand. These expert answers summarize and explain some of our report's key findings. Whenever scientific terms are needed to describe trends and phenomena, these terms are explained in clear, non-expert language.

Our Frequently Asked Questions (FAQs) are written with the clear intention to share our report's key findings with as many people as possible because building climate literacy is key to securing a liveable future.

However, the FAQs focus on relevant aspects only and may serve as introductory elements to key topics. They do not cover all aspects that decision-makers might need to consider. Therefore, we highly recommend reading the related chapters' text as well.

In this FAQ brochure, the FAQ's first number indicates, in which Chapter or Cross-Chapter Paper the related scientific assessment can be found. For example: FAQ2.1 to 2.5 summarize some findings of our report Chapter 2: *Terrestrial and Freshwater Ecosystems and Their Services*. FAQs with a CCP-x in their title, represent key findings of the related Cross-Chapter Paper. For orientation, all Chapter and Cross-Chapter Paper titles and numbers can be found in the brochure's table of content.

DEBRA ROBERTS

Hans-Otto Pörtner
IPCC Working Group II Co-Chair

Debra C. Roberts
IPCC Working Group II Co-Chair

Frequently Asked Questions

FAQ

Frequently Asked Questions

These Frequently Asked Questions have been extracted from the chapters and papers of the underlying report and are compiled here. When referencing specific FAQs, please reference the corresponding chapter or paper in the report from where the FAQ originated (e.g., FAQ 3.1 is part of Chapter 3).

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Frequently Asked Questions

FAQ 1.1 | What are the goals of climate change adaptation?

The goals of climate change adaptation, as a broad concept, are to reduce risk and vulnerability to climate change, strengthen resilience, enhance well-being and the capacity to anticipate, and respond successfully to change. Existing international frameworks provide a high-level direction for coordinating, financing and assessing progress toward these goals. However, specifying the goals for specific adaptation actions is not straightforward because the impacts of climate change affect people and nature in many different ways requiring different adaptation actions. Thereby, goals that accompany these actions are diverse. Goals can relate to health, water or food security, jobs and employment, poverty eradication and social equity, biodiversity and ecosystem services at international, national and local levels.

Climate change adaptation entails the process of adjustment to actual or expected climate change and its effects in order to moderate harm or exploit beneficial opportunities. At a high level, international frameworks, including the Paris Agreement and the SDGs, have come to provide a direction for coordinating, financing and assessing global progress in these terms. The Paris Agreement calls for climate change adaptation actions, referring to these actions as those that reduce risk and vulnerability, strengthen resilience, enhance the capacity to anticipate and respond successfully, and ensure the availability of necessary financial resources, as these processes and outcomes relate to climate change. In addition, the Sustainable Development Goals include 17 targets (with a specific goal SDG 13 on climate action) to fulfil its mission to end extreme poverty by 2030, protect the planet and build more peaceful, just and inclusive societies. These goals are difficult to reach without successful adaptation to climate change. Other notable frameworks that identify climate change adaptation as important global priorities include the SFDRR, the finance-oriented Addis Ababa Action Agenda and the New Urban Agenda.

While vital for international finance, coordination and assessment, the global goals set forth by these frameworks and conventions do not necessarily provide sufficient guidance to plan, implement or evaluate specific adaptation efforts at the community level. Specifying goals of adaptation is harder than setting goals for reducing emissions of climate-warming GHG emissions. For instance, emission reduction effort is ultimately measured by the total amount of GHGs in the Earth's atmosphere. Instead, adaptation aims to reduce risk and vulnerability from climate change and helps to enhance well-being in each individual community worldwide.

Because the impacts of climate change affect people and nature in so many different ways, the specific goals of adaptation depend on the impact being managed and the action being taken. For human systems, adaptation includes actions aimed at reducing a specific risk, such as by fortifying a building against flooding, or actions aimed at multiple risks, such as requiring climate risk assessments in financial reporting in anticipation of different kinds of risk. At the local level, communities can take actions that include updating building codes and land use plans, improving soil management, enhancing water use efficiency, supporting migrants and taking measures to reduce poverty. For natural systems, adaptation includes organisms changing behaviours, migrating to new locations and genetic modifications in response to changing climate conditions. The goals for these adaptation actions can relate to health, water or food security, jobs and employment, poverty eradication and social equity, biodiversity and ecosystem services, among others. Articulating the goals of adaptation thus requires engaging with the concepts of equity, justice and effectiveness at the international, national and local levels.

Frequently Asked Questions

FAQ 1.2 | Is climate change adaptation urgent?

Climate impacts, such as stronger heat waves, longer droughts, more frequent floods, accelerating sea level rise and storm surges, are already being observed in some regions, and people around the world are increasingly perceiving changing climates, regarding these changes as significant and considering climate action as a matter of high urgency. Reducing climate risk to levels that avoid threatening private or social norms and ensuring sustainable development will require immediate and long-term adaptation efforts by governments, business, civil society and individuals at a scale and speed significantly faster than the current trends.

Current observed climate impacts and expected future risks include stronger and longer heat waves, unprecedented droughts and floods, accelerating sea level rise and storm surges affecting many geographies and communities. People around the world are increasingly perceiving changing climates, regarding these changes as significant and considering climate action as a matter of high urgency. In particular, marginalised and poor people, as well as island and coastal communities, experience relatively higher risks and vulnerability. The available evidence suggests that current adaptation efforts may be insufficient to help ensure sustainable development and other societal goals in many communities worldwide even under the most optimistic GHG emissions scenarios.

Climate change adaptation is, therefore, urgent to the extent that meeting important societal goals requires immediate and long-term action by governments, business, civil society and individuals at a scale and speed significantly faster than that represented by current trends.

FAQ

Frequently Asked Questions

FAQ 1.3 | What constitutes successful adaptation to climate change?

The success of climate change adaptation is dependent on the extent to which relevant actions reduce risk and vulnerability, as well as achieve their respective goals. At a global scale, these goals are set and tracked according to international frameworks and conventions. At smaller scales, such as local and national, goals are dependent on the specific impacts being managed, the actions being taken and the relevant scale. While success can take shape as uniquely as goals can, the degree to which an adaptation is feasible, effective and conforms to principles of justice represents important attributes for measuring success across actions. Adaptation responses that lead to increased risk and impacts are considered maladaptation.

Altogether, adaptation success is dependent on the extent to which adaptation actions achieve their respective goals of reducing climate risk, increasing resilience and pursuing other climate-related societal goals. Viewed globally, successful adaptation consists of actions anticipated to make significant contributions to meeting SDGs, such as ending extreme poverty, hunger and discrimination, and reduce risks to ecosystems, water, food systems, human settlements, and health and well-being. Viewed locally, successful adaptation consists of actions that help communities meet their diverse goals, including reducing anticipated current and future risks, enhancing capacity to adapt and transform, avoiding maladaptation, yielding benefits greater than costs and serving vulnerable populations, and arising from an inclusive, evidence-based and equitable decision process.

While success can be unique to an adaptation action, there are important attributes that constitute it as a successful solution. These include the extent to which an action is considered feasible, effective and conforms to principles of justice.

The degree to which an action is *feasible* is the extent to which it is appraised as possible and desirable, taking into consideration barriers, enablers, synergies and trade-offs. These considerations are based on financial or economic, political, physical, historical and social factors, depending on what is required for an action to be implemented. The degree to which an action is *effective* depends on the extent it reduces climate risk, as well as the extent an action achieves its intended goals or outcomes. An adaptation action can sometimes—usually inadvertently—increase risk or vulnerability for some or all affected individuals or communities. In some cases, such risk increases will be sufficient to call the actions maladaptation. The degree to which an action is *just* is when its outcomes, the process of implementing the action and the process of choosing the action respects principles of distributive, procedural and recognitional justice. Distributive justice refers to the different distributions of benefits and burdens of an action across members of society; procedural justice refers to ensuring the opportunity for fairness, transparency, inclusion and impartiality in the decision making of an action; and recognitional justice insists on recognising and including those who are or may be most affected by an action.

These attributes of adaptation success can be assessed throughout the adaptation process of planning, implementation, Monitoring & Evaluation adjustment and learning. However, at the same time, the success of many adaptation actions depends strongly on context and time. For instance, the effectiveness of adaptation will depend on the success of GHG mitigation efforts, as adaptation has strong synergies and trade-offs with mitigation efforts

Frequently Asked Questions

FAQ 1.4 | What is transformational adaptation?

Continuing and expanding current adaptation efforts can reduce some climate risks. But even with emission reductions sufficient to meet the Paris Agreement goals, transformational adaptation will be necessary.

Over six assessment reports, the IPCC has documented transformative changes in the Earth's climate and ecosystems caused by human actions. These changes are now unequivocal and projected to become even more significant in the years and decades ahead. This AR6 report also highlights climate adaptation actions people are taking and can take in response to these significant changes in the climate system.

Some adaptation is incremental, which only modifies existing systems. Other actions are transformational, leading to changes in the fundamental characteristics of a system. For instance, building a seawall to protect a coastal community from flooding might exemplify incremental adaptation. Changing land use regulations in that community and establishing a programme of managed retreat might exemplify transformational adaptation. There is no definitive line between incremental and transformational adaptation. Some incremental actions stay incremental. Others may expand the future space of solutions. For instance, including climate risk in mortgages and insurance might at first seem incremental but might lead to more transformational change over time.

Transformation can be deliberate, envisioned and intended by at least some societal actors, or forced, arising without explicit intent.

Deliberate transformational adaptation is not without risks because change can disturb existing power relationships and can unfold in difficult to predict and unintended ways. But transformational adaptation is important to consider because it may be needed to avoid intolerable risks from climate change and to help meet development goals as articulated in the SDGs. In addition, some types of societal transformation may be inevitable and deliberate rather than forced transformation and may bring society closer to its goals.

Some types of transformation may be inevitable because the amount of transformational adaptation needed to avoid intolerable risks depends in part on the level of GHG mitigation. Low concentration pathways consistent with Paris Agreement goals require deliberate transformations that lead to significant and rapid change in energy, land, urban and infrastructure, and industrial systems. Even with low concentration pathways, some transformational adaptation will be necessary to limit intolerable risks. But with higher concentration pathways, more extensive transformational adaptation would be required to limit (though not entirely avoid) intolerable risks. In such circumstances, insufficient deliberate transformation could lead to undesirable forced transformations.

Frequently Asked Questions

FAQ 1.5 | What is new in this 6th IPCC report on impacts, adaptation and vulnerability?

Since IPCC Fifth Assessment Report, many new sources of knowledge have been employed to provide better understanding of climate change risks, impacts, vulnerability and also societal responses through adaptation, mitigation and sustainable development. This new, more integrative assessment focuses more on risk and solutions, social justice, different forms of knowledge including IK and LK, the role of transformation and the urgency of fast climate actions.

The IPCC Sixth Assessment Report (AR6) has played a prominent role in science–policy–society interactions on the climate issue since 1988 and has advanced in interdisciplinary climate change assessment since AR5. Many new sources of knowledge have been employed to provide better understanding of climate change risks, impacts, vulnerability and also societal responses through adaptation, mitigation and sustainable development.

This AR6 assessment focuses more on risk and solutions. The risk framing for the first time spans all three Working Groups. It includes risks from the responses to climate change, considers dynamic and cascading consequences, describes with more geographic detail risks to people and ecosystems, and assesses such risks over a range of scenarios. The solutions framing encompasses the interconnections among climate responses, sustainable development and transformation, and the implications for governance across scales within the public and private sectors. The assessment therefore includes climate-related decision making and risk management, climate resilient development pathways, implementation and evaluation of adaptation, and also limits to adaptation and loss and damage.

The AR6 emphasises the emergent issue on social justice and different forms of knowledge. As climate change impacts and responses are implemented, there is heightened awareness of the ways that climate responses interact with issues of justice and social progress. In this report, there is expanded attention on inequity in climate vulnerability and responses, the role of power and participation in processes of implementation, unequal and differential impacts, and climate justice. The historic focus on scientific literature is also accompanied by increased consideration and incorporation of Indigenous knowledge and local knowledge and associated scholars.

The AR6 has a more extensive focus on the role of transformation and the urgency of fast climate actions in meeting societal goals. This report assesses extensive literatures with an increasing diversity of topics and geographical areas with more sectoral and regional details. The literature also increasingly evaluates the lived experiences of climate change—the physical changes underway, the impacts for people and ecosystems, the perceptions of the risks, and adaptation and mitigation responses planned and implemented.

The assessment in AR6 is more integrative across multiple disciplines and combines experts across Working Groups, chapters, papers and disciplines, such as natural and social sciences, medical and health sciences, engineering, humanities, law and business administration. The emphasis on knowledge for action has also included the role of public communication, stories and narratives within assessment and associated outreach.

Frequently Asked Questions

FAQ 2.1 | Will species become extinct with climate change and is there anything we can do to prevent this?

Climate change is already posing major threats to biodiversity, and the most vulnerable plants and animals will probably go extinct. If climate change continues to worsen, it is expected to cause many more species to become extinct unless we take actions to improve the resilience of natural areas, through protection, connection and restoration. We can also help individual species that we care most about by reducing the stress that they are under from human activities, and even helping them move to new places as their climate space shifts and they need to shift to keep up.

Climate change has already caused some species to become extinct and is expected to drive more species to extinction. Extinction of species has always occurred in the history of our planet, but human activities are accelerating this process, such that the estimated 10% of species that humans have driven to extinction in the past 10,000 years is roughly 1,000 times the natural background rate. Recent research predicts that climate change would add to that, with estimates that about one-third of all plant and animal species are at high risk of extinction by 2070 if climate change continues at its current rate. Species can adapt to some extent to these rapidly changing climate patterns. We are seeing changes in behaviour, dispersal to new areas as the climate becomes more suitable, and genetic evolution. However, these changes are small, and adaptations are limited. Species that cannot adapt beyond their basic climate tolerances (their ability to survive extremes of temperature or rainfall) or successfully reproduce in a different climate environment from that in which they have evolved, will simply disappear. In the Arctic, for example, the sea ice is melting and, unless there are deep cuts in greenhouse-gas emissions, will probably disappear in summer within the century. This means that the animals that have evolved to live on sea ice—polar bears and some seals—will become extinct soon after the ice disappears.

Fortunately, there are some things we can do to help. We can take action to assist, protect and conserve natural ecosystems and prevent the loss of our planet's endangered wildlife, such as:

'Assisting' the migration of species. This has many names, 'assisted colonisation', 'assisted translocation', 'assisted migration' and 'assisted movement'. In effect, it is about helping endangered species to move to a new area with a good habitat for them to survive. 'Passive' assisted colonisation focusses on helping species move themselves, while the most 'active' form implies picking up individuals and transporting them to a new location. This is different from reintroductions that are already a normal part of conservation programs. Climate-driven translocations constitute moving plants or animals to an area where they have never lived historically, a new location that is now suitable for them due to climate change.

This active form of 'assisted colonisation' has been controversial, because exotic species can become invasive when they are moved between continents or oceans. For example, no one would advocate moving polar bears to Antarctica, as they would likely feast on native penguins, thus causing another conservation problem. However, moving species only a few hundred kilometers avoids most adverse outcomes, and this is often all that is needed to help a wild plant or animal cope with lower levels of climate change. In extreme cases, another type of assisted adaptation is to preserve species until we can stabilize then reverse climate change, and then reintroduce them to the wild. This might include moving them into zoos or into seed or frozen embryo banks.

Extending protected zones and their connectivity. The ability of species to move to new locations and track climate change are very limited, particularly when a habitat has been turned into a crop field or a city. To help species move between their natural habitats, we can increase the connectedness of protected areas, or simply create small patches or corridors of semi-wild nature within a largely agricultural or inhabited region that encourages wildlife to move through an area, and in which they are protected from hunting and poisons. These semi-wild protected areas can be very small, like the hedgerows between fields in England that provide both a habitat for many flowers, birds and insects and corridors to move between larger protected areas. Alternatively, it can just be an abandoned field that is now growing 'weeds' and with a ban on use of pesticides or herbicides, hunting or farming. For instance, in the USA, private landowners get a tax break by making their land a 'wildlife conservation' area by using no pesticide, not cutting weeds too often, putting up brush piles and bird boxes for nesting by mammals and birds, and providing a stable water source.

Assisting, protecting and conserving natural ecosystems would help enhance biodiversity overall as well as aiding already endangered species. Diverse plant and animal communities are more resilient to disturbances, including climate change. A healthy ecosystem also recovers more quickly from increases in extreme events, such as floods, droughts and heat waves, that are a part of human-driven climate change. Healthy ecosystems are critical to prevent

Box FAQ 2.1 (continued)

species' extinctions from climate change, but are also important for human health and well-being, providing clean, plentiful water, cleaning the air, providing recreation and holiday adventures, and making people feel happier, calmer and more content.

Possible actions to assist, protect, and conserve natural ecosystems and prevent the loss of our planet's endangered wildlife

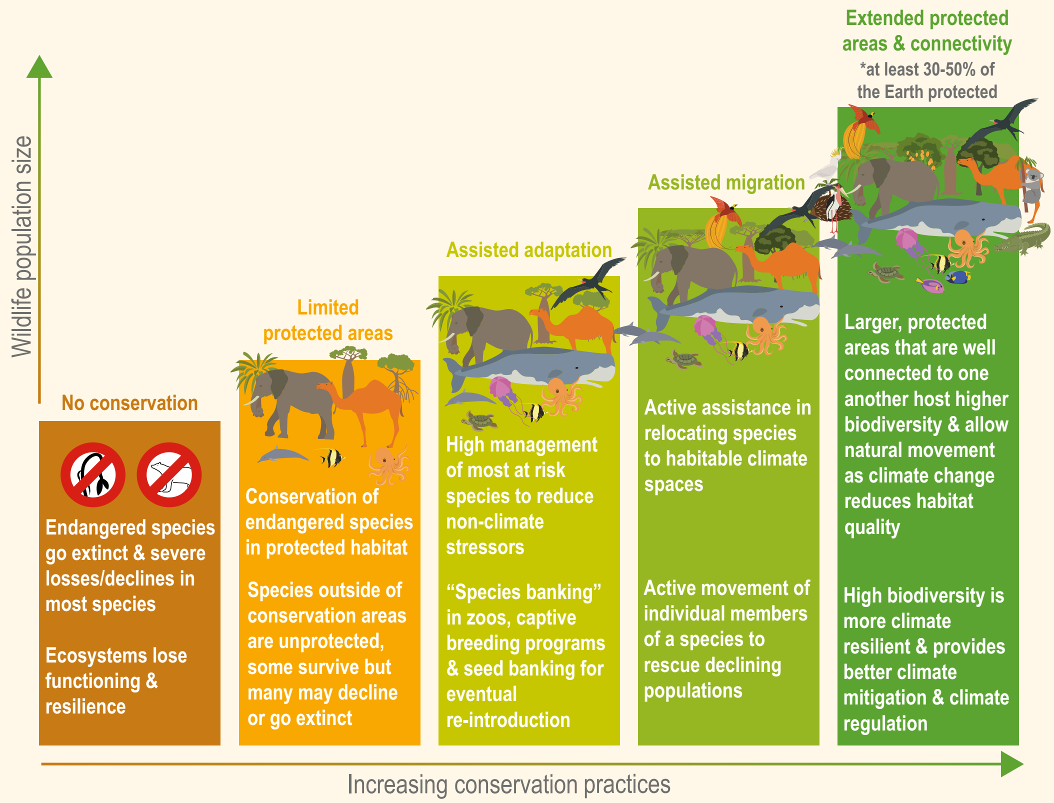


Figure FAQ2.1.1 | Possible actions to assist, protect and conserve natural ecosystems and prevent the loss of our planet's endangered wildlife in the face of continued climate change. (Inspired by the Natural Alliance website© Chris Heward/GWCT).

Frequently Asked Questions

FAQ 2.2 | How does climate change increase the risk of diseases?

Climate change is contributing to the spread of diseases in both wildlife and humans. Increased contact between wildlife and human populations increases disease risk, and climate change is altering where pathogens that cause diseases and the animals that carry them live. Disease risk can often be reduced by improving health care and sanitation systems, training the medical community to recognise and treat potential new diseases in their region, limiting human encroachment into natural areas, limiting wildlife trade and promoting sustainable and equitable socioeconomic development.

Diseases transmitted between humans and animals are called zoonoses. Zoonoses comprise nearly two-thirds of known human infectious diseases and the majority of newly emerging ones. COVID-19 is the most recent zoonosis and has killed millions of people globally while devastating economies. The risk posed by Emerging Infectious Diseases (EIDs) has increased because of: (1) the movement of wild animals and their parasites into new areas as a result of climate change, global trade and travel; (2) human intrusion in natural areas and the conversion of natural areas for agriculture, livestock, the extraction of industrial/raw materials and housing; (3) increased wildlife trade and consumption; (4) increased human mobility resulting from global trade, war/conflicts and migration, made faster and extending farther due to fossil fuel-powered travel; and (5) widespread antimicrobial use, which can promote antibiotic-resistant infections (Figure FAQ2.2.1).

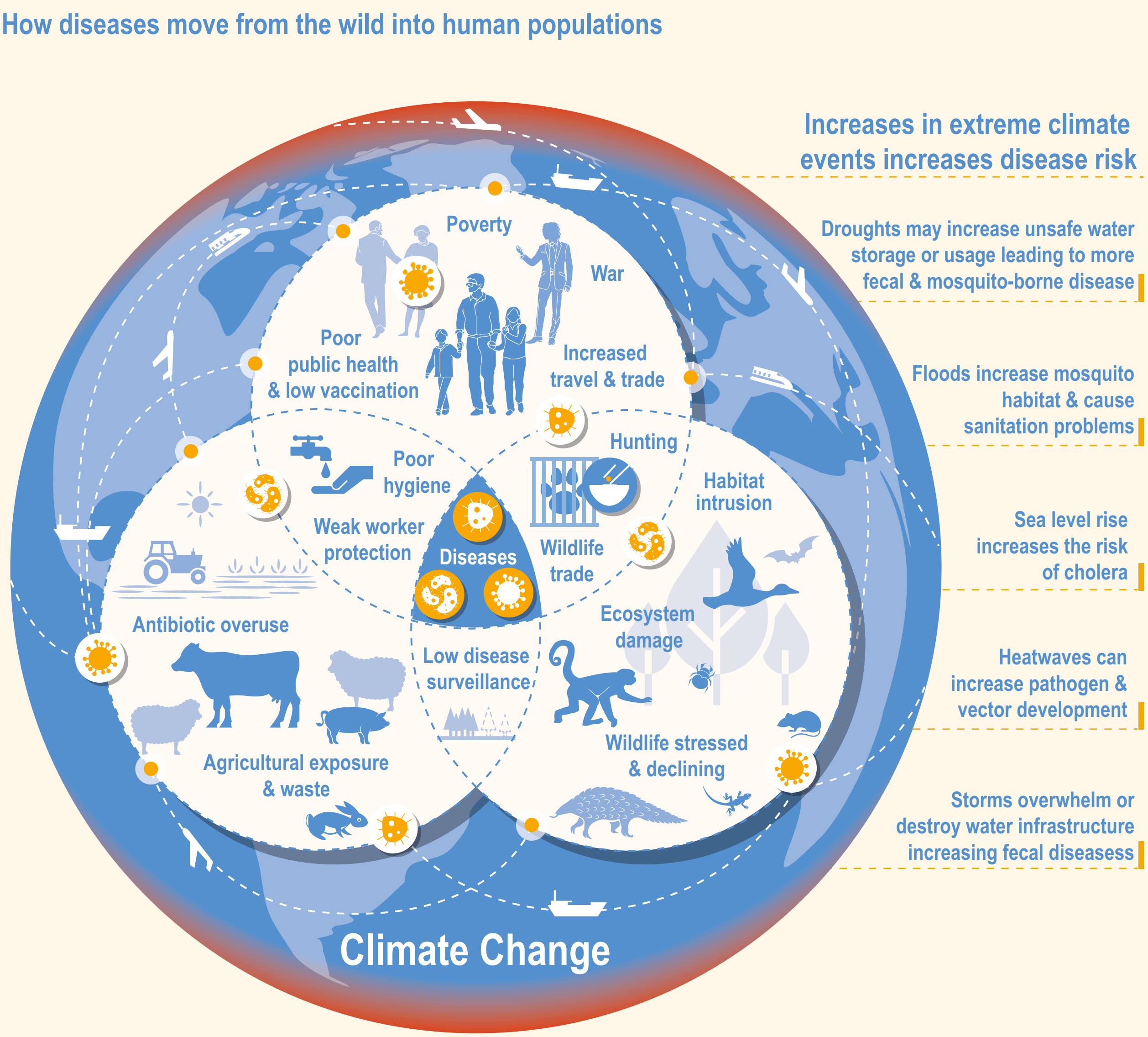


Figure FAQ2.2.1 | How diseases move from the wild into human populations. Climate change may increase diseases in nature, but whether or not this leads to an increase in the risk of disease in humans depends upon a range of societal, infrastructural and medical buffers that form a shield protecting humans.

Box FAQ 2.2 (continued)

Climate change further increases risk by altering pathogen and host animal (1) geographic ranges and habitats; (2) survival, growth and development; (3) reproduction and replication; (4) transmission and exposure (5) behaviour; and (6) access to immunologically naïve animals and people who lack resistance to infection. This can lead to novel disease emergence in new places, more frequent and larger outbreaks, and longer or shifted seasons of transmission. Climate change is making it possible for many EIDs to colonise historically colder areas that are becoming warmer and wetter in temperate and polar regions and in the mountains. Vector-borne diseases (VBDs) are diseases spread by vectors such as mosquitoes, sand flies, kissing bugs and ticks. For example, ticks that carry the virus that causes tick-borne encephalitis have moved into the northern subarctic regions of Asia and Europe. Viruses like dengue, chikungunya and Japanese encephalitis are emerging in Nepal in hilly and mountainous areas. Novel outbreaks of *Vibrio* bacteria seafood poisoning are being traced to the the Baltic States and Alaska where they were never documented before. Many scientific studies show that the transmission of infectious disease and the number of individuals infected depends on rainfall and temperature; climate change often makes these conditions more favourable for disease transmission.

Climate change can also have complicated, compounding and contradictory effects on pathogens and vectors. Increased rainfall creates more habitat for mosquitoes that transmit diseases like malaria, but too much rain washes away the habitat. Decreased rainfall also increases disease risk when people without reliable access to water use containers to store water where mosquitoes, such as the vectors of dengue fever *Aedes aegypti* and *A. albopictus*, lay their eggs. Hotter temperatures also increase mosquito-bite rate, parasite development and viral replication! Certain species of snails are intermediate hosts for many helminth parasites that make humans, livestock and wild animals sick. When it gets hot, the snails can produce 2–3 times as many infective larvae; however, if it becomes too hot, many pathogens and their vectors cannot survive or reproduce.

Humans also contract zoonoses directly through their skin, mucus membranes and lungs, when eating or butchering animals or when they come into contact with pathogens that are shed into the air or passed in urine and faeces and contaminate water, food, clothing and other surfaces. Any activity that increases contact with wildlife, especially in high-biodiversity regions like the Tropics and subtropics, increases disease risk. Climate change-related disease emergence events are often rare but may become more frequent. Fortunately, there are ways to reduce risks and protect our health, as described below.

Habitat and biodiversity protection. Human encroachment into natural areas, due to expansion of agriculture and livestock, timber harvests, extraction of resources and urban development, has increased human contact with wild animals and creates more opportunities for disease spill-over (transmission from an animal to a new species, including humans). By conserving, protecting and restoring wild habitats, we can build healthier ecosystems that provide other services, such as clean air, clean and abundant water, recreation, spiritual value and well-being, as well as reduced disease spill-over. If humans must go into wild areas or hunt, they should take appropriate precautions such as wearing protective clothing, using insect repellant, performing body checks for vectors like ticks and washing their hands and clothing well.

Food resilience. Investing in sustainable agro-ecological farming will alleviate the pressure to hunt wild animals and reduce the conversion of more land to agriculture/livestock use. Stopping illegal animal trading and poaching and decreasing reliance on wild meats and products made from animal parts will reduce direct contact with potentially infected animals. This has the added benefit of increasing food security and nutrition, improving soil, reducing erosion, preserving biodiversity and mitigating climate change.

Disease prevention and response. The level of protection against infection is linked directly to the level of development and wealth of a country. Improved education, high-quality medical and veterinary systems, high food security, proper sanitation of water and waste, high-quality housing, disease surveillance and alarm systems dramatically reduce disease risk and improve health. Utilising a One Biosecurity or One Health framework further improves resilience. Sharing knowledge within communities, municipalities, regionally and between national health authorities globally is important to assessing, preventing and responding to outbreaks and pandemics more efficiently and economically.

Box FAQ 2.2 (continued)

Humans are facing many direct and indirect challenges because of climate change. The increase in EIDs is one of our greatest challenges, due to our ever-growing interactions with wildlife and climatic changes creating new disease transmission patterns. COVID-19 is a current crisis, and follows other recent EIDs: SARS, HIV/AIDS, H1N1 influenza, Ebola, Zika and West Nile fever. EIDs have accelerated in recent decades, making it clear that new societal and environmental approaches to wildlife interactions, climate change and health are urgently needed to protect our current and future well-being as a species.

Frequently Asked Questions

FAQ 2.3 | Is climate change increasing wildfire?

In the Amazon, Australia, North America, Siberia and other regions, wildfires are burning wider areas than in the past. Analyses show that human-caused climate change has driven the increases in burned area in the forests of western North America. Elsewhere, deforestation, fire suppression, agricultural burning and short-term cycles like El Niño can exert a stronger influence than climate change. Many forests and grasslands naturally require fire for ecosystem health but excessive wildfire can kill people, destroy homes and damage ecosystems.

Climate change and wildfires

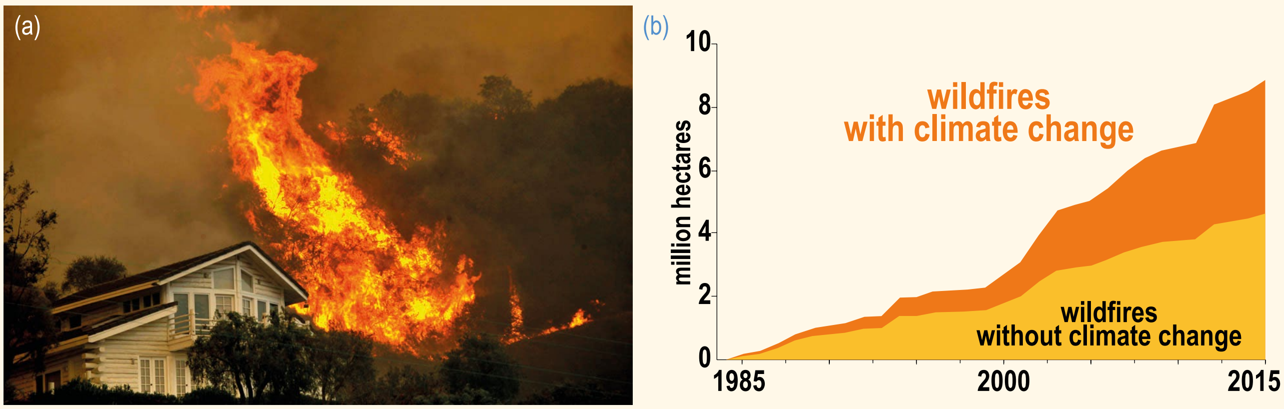


Figure FAQ2.3.1 | (a) Springs Fire, May 2, 2013, Thousand Oaks, California, USA (photo by Michael Robinson Chávez, Los Angeles Times). **(b)** Cumulative area burned by wildfire in the western USA, with (orange) and without (yellow) the increased heat and aridity of climate change.

Wildfire is a natural and essential part of many forest, woodland and grassland ecosystems, killing pests, releasing plant seeds to sprout, thinning out small trees and serving other functions essential for ecosystem health. Excessive wildfire, however, can kill people with the smoke causing breathing illnesses, destroy homes (Figure FAQ2.3.1a) and damage ecosystems.

Human-caused climate change increases wildfire by intensifying its principal driving factor, heat. The heat of climate change dries out vegetation and accelerates burning. Non-climate factors also cause wildfires. Agricultural companies, small-scale farmers and livestock herders in many tropical areas cut down forests and intentionally set fires to clear fields and pastures. Cities, towns and roads increase the number of fires that people ignite. Governments in many countries suppress fires, even natural ones, producing unnatural accumulations of fuel in the form of coarse woody debris and dense stands of small trees. The fuel accumulations cause particularly severe fires that burn upwards into tree crowns.

Evidence shows that human-caused climate change has driven increases in the area burned by wildfire in the forests of western North America. Across this region, the higher temperatures of human-caused climate change doubled burned area from 1984 to 2015, compared with what would have burned without climate change (Figure FAQ2.3.1b). The additional area burned, 4.9 million hectares, is greater than the land area of Switzerland. Human-caused climate change drove a drought from 2000 to 2020 that has been the most severe since the 1500s, severely increasing the aridity of vegetation. In British Columbia, Canada, the higher maximum temperatures of human-caused climate change increased burned area in 2017 to its widest extent in the 1950–2017 record, seven to eleven times the area that would have burned without climate change. Moreover, in national parks and other protected areas of Canada and the USA, most of the area burned from 1984 to 2014 can be attributed to climate factors (temperature, rainfall and aridity) and these outweigh local human factors (population density, roads and urban area).

In other regions, wildfires are also burning wider areas and occurring more often. This is consistent with climate change, but analyses have not yet shown if climate change is more important than other factors. In the Amazon, deforestation by companies, farmers and herders who cut down and intentionally burn rainforests to expand agricultural fields and pastures causes wildfires even in relatively moister years. Drought exacerbates these fires. In Australia, much of the southeastern part of the continent has experienced extreme wildfire years, but analyses

Box FAQ 2.3 (continued)

suggest that El Niño, a heat phenomenon that cycles up and down periodically, is more important than long-term climate change. In Indonesia, intentional burning of rainforests for oil palm plantations and El Niño seem to be more important than long-term climate change. In Mediterranean Europe, fire suppression seems to have prevented any increasing trend in burned area but the suppression and abandonment of agricultural lands have allowed fuel to build up in some areas and contribute to major fires in years of extreme heat. In Canada and Siberia, wildfires are now burning more often in permafrost areas where fire was rare, but analyses are lacking regarding the relative influence of climate change. For the world as a whole, satellite data indicate that the vast amount of land converted from forest to farmland in the period 1998–2015 actually decreased the total burned area. Nevertheless, the evidence from the forests of western North America shows that human-caused climate change has, at least on one continent, clearly driven increases in wildfire.

Frequently Asked Questions

FAQ 2.4 | How does nature benefit human health and well-being and how does climate change affect this?

Human health and well-being are highly dependent on the 'health' of nature. Nature provides material and economic services that are essential for human health and productive livelihoods. Studies also show that being in 'direct contact with natural environments' has direct positive effects on well-being, health and socio-cognitive abilities. Therefore, the loss of species and biodiversity due to climate change will reduce natural spaces and, in turn, decrease human well-being and health worldwide.

Human health and well-being are highly dependent on the 'health' of nature. Biodiversity—the variety of genes, species, communities and ecosystems—provides services that are essential for human health and productive livelihoods, such as breathable air, drinkable water, productive oceans and fertile soils for growing food and fuels. Natural ecosystems also help store carbon and regulate climate, floods, disease, pollution and water quality. The loss of species, leading to reduced biodiversity, has direct and measurable negative effects on all of these essential services, and therefore on humankind. A recent demonstration of this is the decline of pollinator species, with potential negative effects on crop pollination, a fundamental ecosystem function crucial for agriculture. The loss of wild relatives of the domesticated varieties that humans rely on for agriculture reduces the genetic variability that may be needed to support the adaptation of crops to future environmental and social challenges.

Positive relationship between human health and well-being and nature conservation

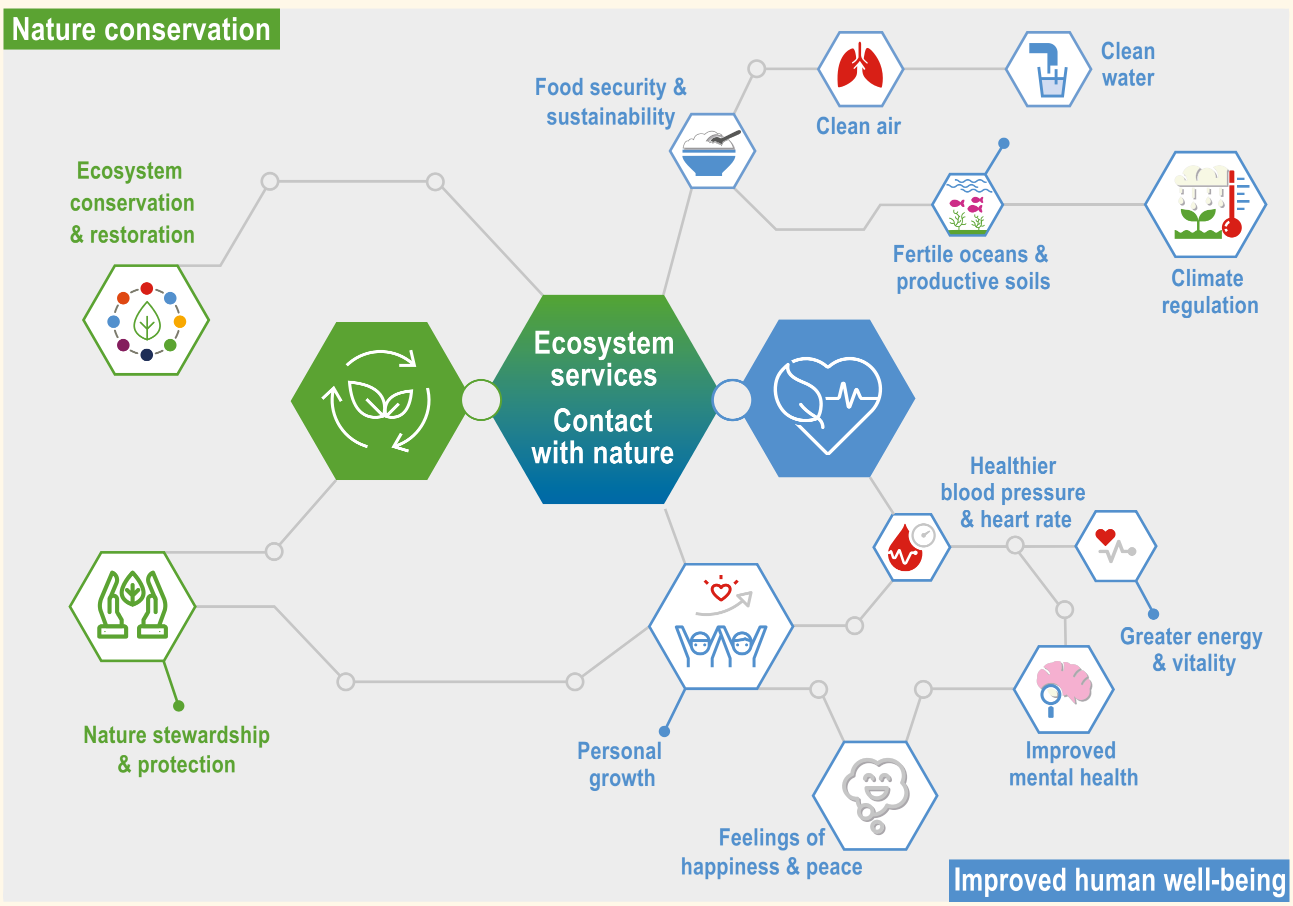


Figure FAQ2.4.1 | The positive relationship between human health and well-being and nature conservation. Nature provides essential services to humans including material and economic services (i.e., ecosystem services) as well as cultural, experiential and recreational services, which, in turn, enhance human psychological and physical health and well-being. People who are more connected to nature are not only happier and healthier but are also more likely to engage in pro-nature behaviours, making the enhancement of human–nature connectedness worldwide a valuable win–win solution for humans and nature to face environmental challenges.

Box FAQ 2.4 (continued)

The number of species that can be lost before negative impacts occur is not known and is likely to differ in different systems. However, in general, more diverse systems are more resilient to disturbances and able to recover from extreme events more quickly. Biodiversity loss means there are fewer connections within an ecosystem. A simpler food web with fewer interactions means less redundancy in the system, reducing the stability and ability of plants and animal communities to recover from disturbances and extreme weather events such as floods and drought.

In addition to 'material' and economic services such as eco-tourism, nature also provides cultural services such as recreation, spirituality and well-being. Specifically, being in 'direct contact with natural environments' (vs. an urban environment) has a high positive impact on human well-being (e.g., mood, happiness), psychological and physical health (energy, vitality, heart rate, depression) and socio-cognitive abilities (attention, memory, hyperactivity, altruism, cooperation). Therefore, the loss of species from climate change and urbanisation will reduce natural spaces, decrease biodiversity, and, in turn, decrease human well-being and health worldwide.

Finally, the extent to which humans consider themselves part of the natural world—known as human-nature connectedness—has been demonstrated to be closely associated with human health and well-being. Individuals who are more connected to nature are not only happier and healthier but also tend to engage more in pro-nature behaviours, making the enhancement of human–nature connectedness worldwide a valuable win–win solution for humans and nature to face environmental challenges.

Frequently Asked Questions

FAQ 2.5 | How can we reduce the risks of climate change to people by protecting and managing nature better?

Damage to our natural environment can increase the risks that climate change poses to people. Protecting and restoring nature can be a way to adapt to climate change, with benefits for both humans and biodiversity. Examples include reducing flood risk by restoring catchments and coastal habitats, the cooling effects of natural vegetation and shade from trees and reducing the risk of extreme wildfires by better management of natural fires.

Protecting and restoring natural environments, such as forests and wetlands, can reduce the risks that climate change poses to people as well as supporting biodiversity, storing carbon and providing many other benefits for human health and well-being. Climate change is bringing an increasing number of threats to people, including flooding, droughts, wildfire, heat waves and rising sea levels. These threats can, however, be reduced or aggravated, depending on how land, sea and freshwater are managed or protected. There is now clear evidence that 'Nature-based Solutions' (NbS) can reduce the risks that climate change presents to people. 'Ecosystem-based Adaptation' (EbA) is a part of NbS and includes:

- *Natural flood management:* As warm air holds more water and, in some places, because of changing seasonal rainfall patterns, we are seeing more heavy downpours in many parts of the world. This can create serious flooding problems, with loss of life, homes and livelihoods. The risk of flooding is higher where natural vegetation has been removed, wetlands drained or channels straightened. In these circumstances, water flows quicker and the risk of flood defences being breached is increased. Restoring the natural hydrology of upstream catchments by restoring vegetation, creating wetlands and re-naturalising watercourse channels and reinstating connections with the floodplain can reduce this risk. In a natural catchment with trees or other vegetation, water flows slowly overland and much of it soaks into the soil. When the water reaches a watercourse, it moves slowly down the channel, both because of the longer distance it travels when the channel bends and because vegetation and fallen trees slow the flow. Wetlands, ponds and lakes can also hold water back and slowly release it into river systems.
- *Restoring natural coastal defences:* Rising sea levels as a result of climate change mean that coasts are eroding at a fast rate and storm surges are more likely to cause damaging coastal flooding. Natural coastal vegetation, such as saltmarshes and mangrove swamps can, in the right places, stabilise the shoreline and act as a buffer, absorbing the force of waves. On a natural coast, the shoreline will move inland and as the sea level rises, the coastal vegetation will gradually move inland with it. This contrasts with hard coastal defences such as sea walls and banks, which can be overwhelmed and fail. In many places, however, coastal habitats have been cleared and where there are hard sea defences behind the coastal zone, the vegetation disappears as the coast erodes rather than moving inland. This is often referred to as 'coastal squeeze' as the vegetation is squeezed between the sea and the sea wall. Restoring coastal habitats and removing hard sea defences, can help reduce the risks of catastrophic flooding.
- *Providing local cooling:* Climate change is bringing higher temperatures globally, which can result in heat waves that affect people's health, comfort and agriculture. In cities, this can be a particular problem for health as temperatures are typically higher than in the countryside. Trees give shade, which people, in both rural and urban areas, have long used to provide cool places for themselves, for growing crops such as coffee and for livestock. Planting trees in the right place can be a valuable, low-cost natural-based solution to reduce the effects of increasing heat, including reducing water temperatures in streams and rivers which can help to maintain fisheries. Trees and other vegetation also have a cooling effect as a result of water being lost from their leaves through evaporation and transpiration (i.e., the loss of water through pores in the leaves, known as stomata). Natural areas, parks, gardens in urban areas can help reduce air temperatures by up to a few degrees.
- *Restoring natural fire regimes:* Some natural ecosystems are adapted to burning, such as savannas and some temperate and boreal forests. Where fire has been suppressed or non-native species of trees are planted in more open habitats, there is a risk that potential fuel accumulates, which can result in larger and hotter fires. Solutions can include restoring natural fire regimes and removing non-native species to decrease the vulnerability of people and ecosystems to the exacerbated fire risk that climate change is bringing due to higher temperatures and, in some places, changing rainfall patterns.

NbS, including protecting and restoring mangroves, forests and peatlands, also play an important part in reducing greenhouse gas emissions and taking carbon dioxide out of the atmosphere. They can also help people in a wide range of other ways, including through providing food, materials and opportunities for recreation. There is increasing evidence that spending time in natural surroundings is good for physical and mental health.

Box FAQ 2.5 (continued)

Ecosystem health influences prospects for climate resilient development

(a) Human activities that degrade ecosystems also drive global warming and negatively impact nature and people

(b) Human activities that protect, conserve and restore ecosystems contribute to climate resilient development

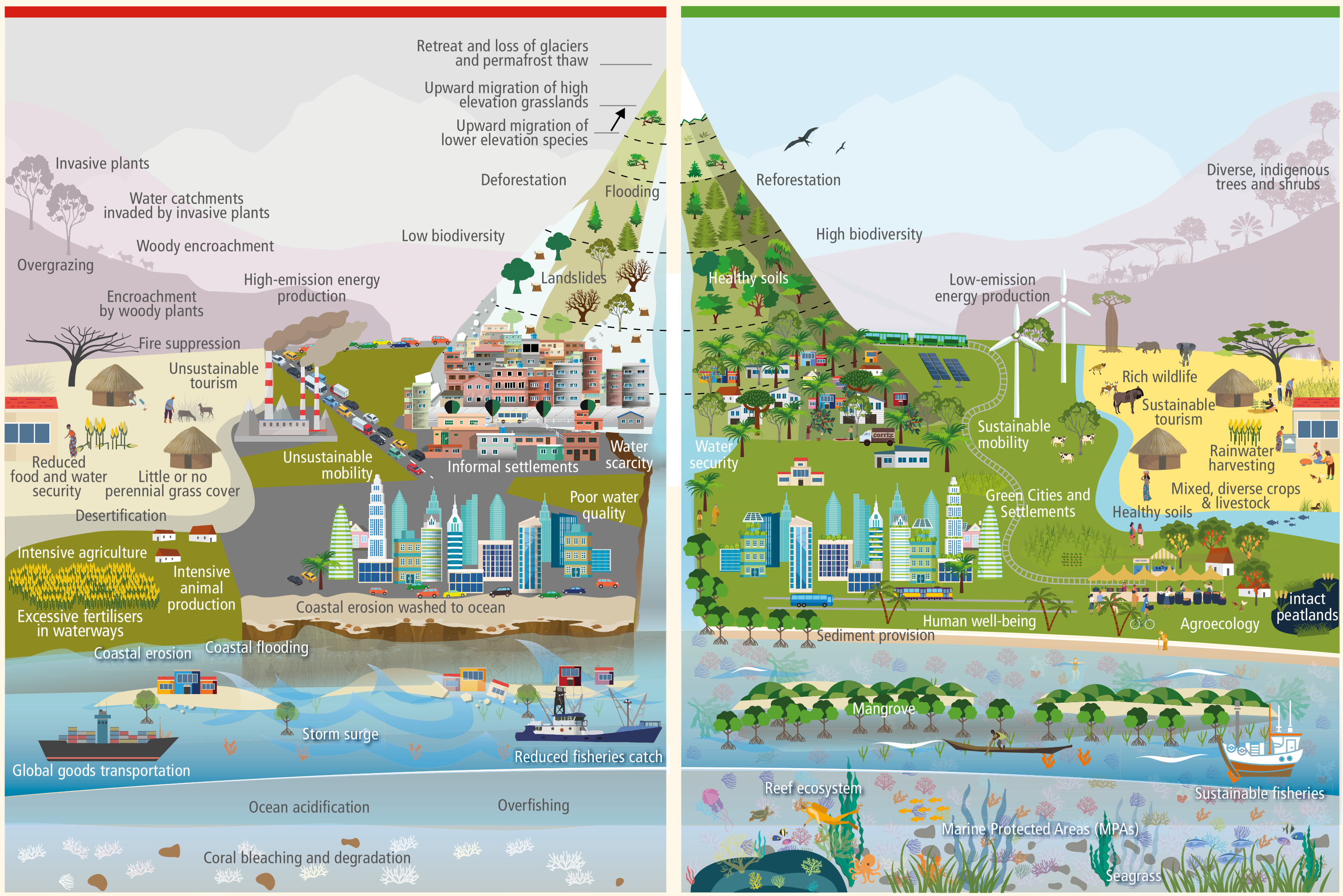


Figure FAQ2.5.1 | Different NbS strategies that contribute to climate resilient development

Box FAQ 2.5 (continued)

If NbS are to be effective, it is important that the right adaptation actions are carried out in the right place and that local communities play an active part in making decisions about their local environment. When they are not part of the process, conflicts can emerge and benefits can be lost.

While NbS help us to adapt to climate change and reduce the amount of greenhouse gases in the atmosphere, it is important to note that there are limits to what they can do. To provide a safe environment for both people and nature, it will be essential to radically reduce greenhouse gas emissions, especially those from fossil-fuel burning in the near future.

Frequently Asked Questions

FAQ 2.6 | Can tree planting tackle climate change?

Restoring and preventing further loss of native forests is essential for combatting climate change. Planting trees in historically unforested areas (grasslands, shrublands, savannas and some peatlands) can reduce biodiversity and increase the risks of damage from climate change. It is therefore essential to target tree planting to the appropriate locations and use appropriate species. Restoring and protecting forests reduces human vulnerability to climate change, reduces air pollution, stores carbon and builds the resilience of natural systems.

Like all living plants, trees remove carbon dioxide from the atmosphere through the process of photosynthesis. In trees, this carbon uptake is relatively long-term, since much of it is stored in the trees' woody stems and roots. Therefore, tree planting can be a valuable contribution to reducing climate change. Besides capturing carbon, planting trees can reduce some negative impacts of climate change by providing shade and cooling. It can also help prevent erosion and reduce flood risk by slowing water flow and improving ground water storage. Restoring forest in degraded areas supports biodiversity and can provide benefits to people, ranging from timber to food and recreation.

There are some areas where replacing lost trees is useful. These include forest that has been recently cut down and where reforestation is usually practical. However, it is very important to correctly identify areas of forest that are degraded or have definitely been deforested. Reforesting places, especially where existing native forest patches occur, brings benefits both in sucking up carbon from the atmosphere and helping us to adapt to climate change. Plantations of a non-native species, although offering some economic benefits, do not usually provide the same range of positive impacts, generally have lower biodiversity, reduced carbon uptake and storage, and are less resilient to climate change.

Reforestation options include the natural regeneration of the forest, assisted restoration, enrichment planting, native-tree plantations, commercial plantations and directed tree planting in agro-forestry systems and urban areas. Reforestation with native species usually contributes to a wide range of sustainability goals, including biodiversity recovery, improved water filtration and groundwater recharge. It can reduce the risks of soil erosion and floods. In cities, planting trees can support climate change adaptation by reducing the heat of the area, and promote a wide range of social benefits such as providing shade and benefitting outdoor recreation. Urban trees can also lower energy costs by reducing the demand for conventional sources of cooling like air-conditioning, especially during peak-demand periods. It is therefore important to recognise that there are a wide range of different planting and forest management strategies. The choice will depend on the objectives and the location.

Not everywhere is suitable for tree planting. It is particularly problematic in native non-forested ecosystems. These natural ecosystems are not deforested and degraded but are instead naturally occurring non-forested ecosystems. These areas vary from open grasslands to densely wooded savannas and shrublands. Here, restoring the natural ecosystems instead of afforesting them will better contribute to increasing carbon storage and increasing the area's resilience to climate change and other environmental changes. It is important to remember that, just because a tree can grow somewhere, it does not mean that it should. These systems are very important in their own right, storing carbon in soils, supporting rich biodiversity and providing people with important ecosystem services such as grasslands for animal grazing. Planting trees in these areas destroys the ecosystem and threatens the biodiversity which is adapted to these environments. They can also impact on ecosystem services such as forage for livestock, on which many people rely.

Many of these open areas also occur in low-rainfall areas. Planting trees there uses a lot of water and can cause reductions in stream flow and groundwater. Many of these locations also burn regularly, and planting trees threatens the establishing trees but can also increase the intensity of the fires from that of a grass-fuelled fire to that of a wood-fuelled fire. Swapping grassy ecosystems for forests may contribute to warming, as forests absorb more incoming radiation (warmth) than grasslands. Aside from the negative impacts to adaptation, it is also questionable just how much carbon can be sequestered in these landscapes as planting trees in grassy ecosystems can reduce carbon gains. Furthermore, a high below-ground carbon store prevents carbon loss to fire in these fire-prone environments.

Another example is peatlands. Peat stores an incredible amount of carbon; maintaining and restoring peatlands is therefore important to reduce atmospheric carbon. However, the restoration actions depend on what type of peatland it is and where it is located. Many temperate and boreal peatlands are naturally treeless. Here, planting trees is often only possible following drainage, but draining and planting (especially of non-native species) destroys native biodiversity and releases GHGs. Many peatlands, especially in the Tropics, are naturally forested, and restoring them requires re-wetting and restoring the natural tree cover (see Figure FAQ2.2.1) which will increase carbon storage.

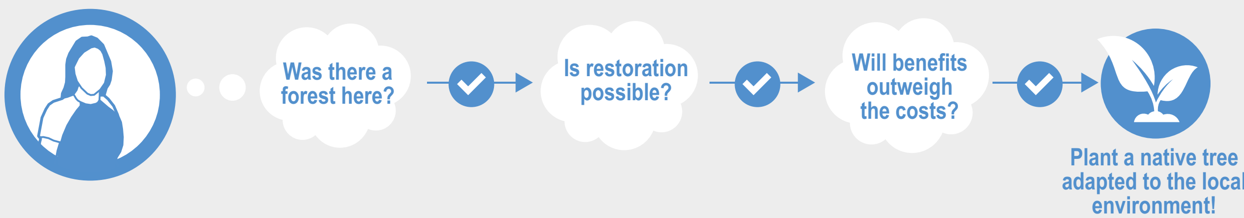
Box FAQ 2.6 (continued)

There are actions we can perform instead of planting trees in non-forested ecosystems, and these include:

- Address the causes of deforestation, forest degradation and widespread ecosystem loss
- Reduce carbon emissions from fossil fuels
- Focus on ecosystem restoration over tree planting. For example, in restoring tropical grassy ecosystems, we can look at actions that cut down trees, enhance grass regrowth and restore natural fire regimes. We then have a much better chance of both enhancing carbon capture and reducing some of the harmful effects of climate change.

In between the two extremes of where planting trees is highly suitable and areas where it is not, it is important to remember that the context matters and that decisions to (re)forest should look beyond simply the act of planting trees. We can consider **what the ecological, social and economic goals are of tree planting**. It is then important to verify the local context and decide **what restoration action will be most effective**. It is also more efficient and effective to conserve existing forests before worrying about reforesting.

Basic biome specific guidelines when planting in natural and semi-natural vegetation



Is the land naturally unforested? Many people mistakenly assume open areas like grasslands, savannas and some peatlands are degraded forests.

Check with local experts to determine what the historical ecosystem was.

Planting trees in areas where they don't belong can stress local water supplies, harm native biodiversity, damage peoples' livelihoods and reduce resilience to climate change.

Can the forest regenerate naturally? Has the local community been consulted and are they supportive/involved in the decision making process?

Is it better to use the land for livestock grazing or agriculture because it would be too difficult/costly to restore?

Will the trees benefit ecosystem services? Will they help with flood protection, reduce erosion, carbon storage, heat mitigation, provide food or timber products?

Or will trees displace people, reduce water supply, reduce biodiversity, or harm food production?

What are the costs associated with restoration and who will pay for them? Will trees survive climate change impacts like increased and more severe fires or droughts?

Figure FAQ2.6.1 | Some places are more appropriate for tree planting than others and caution needs to be applied when planting in different biomes, with some biomes being more suitable than others. This figure highlights some basic biome-specific guidelines when planting in natural and semi-natural vegetation.

Frequently Asked Questions

FAQ 3.1 | How do we know which changes to marine ecosystems are specifically caused by climate change?

To attribute changes in marine ecosystems to human-induced climate change, scientists use paleorecords (reconstructing the links between climate, evolutionary and ecological changes in the geological past), contemporary observations (assessing current climate and ecological responses in the field and through experiments) and models. We refer to these as multiple lines of evidence, meaning that the evidence comes from diverse approaches, as described below.

Emissions of greenhouse gases like carbon dioxide from human activity cause ocean warming, acidification, oxygen loss, and other physical and chemical changes that are affecting marine ecosystems around the world. At the same time, natural climate variability and direct human impacts, such as overfishing and pollution, also affect marine ecosystems locally, regionally and globally. These climate and non-climate impact drivers counteract each other, add up or multiply to produce smaller or larger changes than expected from individual drivers. Attribution of changes in marine ecosystems requires evaluating the often-interacting roles of natural climate variability, non-climate drivers, and human-induced climate change. To do this work, scientists use

- paleorecords: reconstructing the links between climate and evolutionary and ecological changes of the past;
- contemporary observations: assessing current climate and ecological responses;
- manipulation experiments: measuring responses of organisms and ecosystems to different climate conditions; and
- models: testing whether we understand how organisms and ecosystems are impacted by different stressors, and quantifying the relative importance of different stressors.

Paleorecords can be used to trace the correlation between past changes in climate and marine life. Paleoclimate is reconstructed from the chemical composition of shells and teeth or from sediments and ice cores. Changes to sea life signalled by changing biodiversity, extinction or distributional shifts are reconstructed from fossils. Using large datasets, we can infer the effects of climate change on sea life over relatively long time scales–usually hundreds to millions of years. The advantage of paleorecords is that they provide insights into how climate change affects life from organisms to ecosystems, without the complicating influence of direct human impacts. A key drawback is that the paleo and modern worlds do not have fully comparable paleoclimate regimes, dominant marine species and rates of climate change. Nevertheless, the paleorecord can be used to derive fundamental rules by which organisms, ecosystems, environments and regions are typically most affected by climate change. For example, the paleorecord shows that coral reefs repeatedly underwent declines during past warming events, supporting the inference that corals may not be able to adapt to current climate warming.

Contemporary observations over recent decades allow scientists to relate the status of marine species and ecosystems to changes in climate or other factors. For example, scientists compile large datasets to determine whether species usually associated with warm water are appearing in traditionally cool-water areas that are rapidly warming. A similar pattern observed in multiple regions and over several decades (i.e., longer than time scales of natural variability) provides confidence that climate change is altering community structure. This evidence is weighed against findings from other approaches, such as manipulation experiments, to provide a robust picture of climate-change impacts in the modern ocean.

In manipulation experiments, scientists expose organisms or communities of organisms to multiple stressors, for example, elevated CO_2, high temperature, or both, based on values drawn from future climate projections. Such experiments will involve multiple treatments (i.e., different aquarium tanks) in which organisms are exposed to different combinations of the stressors. This approach enables scientists to understand the effects of individual stressors as well as their interactions to explore physiological thresholds of marine organisms and communities. The scale of manipulation experiments can range from small tabletop tanks to large installations or natural ocean experiments involving tens of thousands of litres of water.

Ecological effects of climate change are also explored within models developed from fundamental scientific principles and observations. Using these numerical representations of marine ecosystems, scientists can explore how different levels of climate change and non-climate stressors influence species and ecosystems at scales not possible with experiments. Models are commonly used to simulate the ecological response to climate change over recent decades and centuries. Convergence between the model results and the observations suggests that our understanding of the key processes is sufficient to attribute the observed ecological changes to climate change, and to use the models to project future ecological changes. Differences between model results and observations indicate gaps in knowledge to be filled in order to better detect and attribute the impacts of climate change on marine life.

Box FAQ 3.1 (continued)

Using peer-reviewed research spanning the full range of scientific approaches (paleorecords, observations, experiments and models), we can assess the level of confidence in the impact of climate change on observed modifications in marine ecosystems. We refer to this as multiple lines of evidence, meaning that the evidence comes from the diverse approaches described above. This allows policymakers and managers to address the specific actions needed to reduce climate change and other impacts.

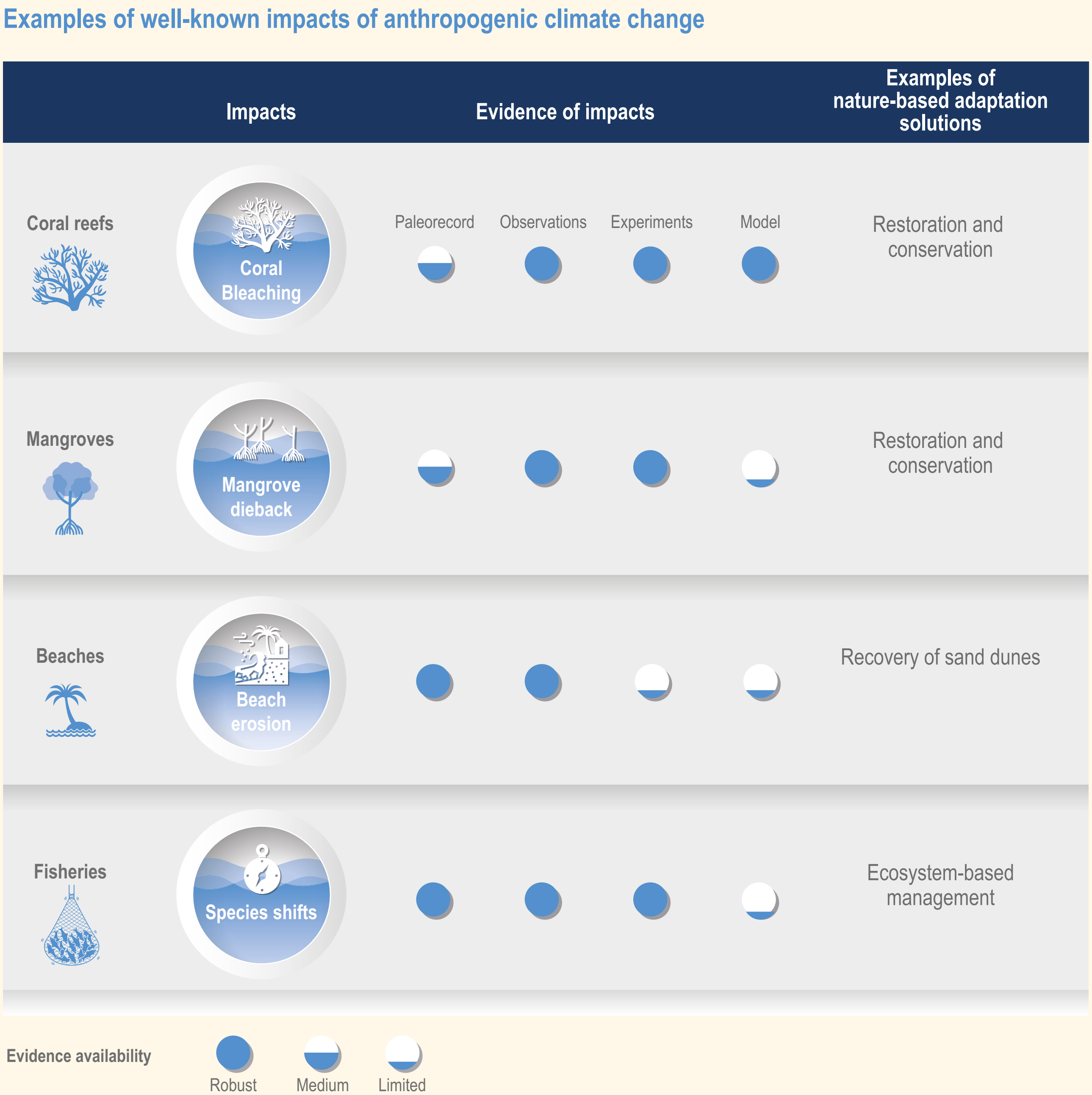


Figure FAQ3.1.1 | Examples of well-known impacts of anthropogenic climate change and associated nature-based adaptation. To attribute changes in marine ecosystems to anthropogenic climate change, scientists use multiple lines of evidence including paleorecords, contemporary observations, manipulation experiments and models.

Frequently Asked Questions

FAQ 3.2 | How are marine heatwaves affecting marine life and human communities?

Heatwaves happen in the ocean as well as in the atmosphere. Marine heatwaves (MHWs) are extended periods of unusually warm ocean temperatures relative to the typical temperatures for that location and time of year. Due to climate change, the number of days with MHWs have increased by 54% over the past century. These MHWs cause mortalities in a wide variety of marine species, from corals to kelp to seagrasses to fish to seabirds, and have consequent effects on ecosystems and industries like aquaculture and fisheries.

Extreme events in the ocean can have damaging effects on marine ecosystems and the human communities that depend on them. The most common form of ocean extremes are MHWs, which are becoming more frequent and intense due to global warming. Because seawater absorbs and releases heat more slowly than air, temperature extremes in the ocean are not as pronounced as over land, but they can persist for much longer, often for weeks to months over areas covering hundreds of thousands of square kilometres. These MHWs can be more detrimental for marine species, in comparison with land species, because marine species are usually adapted to relatively stable temperatures.

A commonly used definition of MHWs is a period of at least 5 days whose temperatures are warmer than 90% of the historical records for that location and time of year. Marine heatwaves are described by their abruptness, magnitude, duration, intensity and other metrics. In addition, targeted methods are used to characterize MHWs that threaten particular ecosystems; for example, the accumulated heat stress above typical summer temperatures, described by 'degree heating weeks', is used to estimate the likelihood of coral bleaching.

Over the past century, MHWs have doubled in frequency, become more intense, lasted for longer and extended over larger areas. Marine heatwaves have occurred in every ocean region over the past few decades, most markedly in association with regional climate phenomena such as the El Niño/Southern Oscillation. During the 2015–2016 El Niño event, 70% of the world's ocean surface encountered MHWs.

Such MHWs cause mortality of a wide variety of marine species, from corals to kelp to seagrasses to fish to seabirds, and they have consequent effects on ecosystems and industries such as mariculture and fisheries. Warm-water coral reefs, estuarine seagrass meadows and cold-temperate kelp forests are among the ecosystems most threatened by MHWs since they are attached to the seafloor (see FAQ 3.2). Unusually warm temperatures cause bleaching and associated death of warm-water corals, which can lead to shifts to low-diversity or algae-dominated reefs, changes in fish communities and deterioration of the physical reef structure, which causes habitat loss and increases the vulnerability of nearby shorelines to large-wave events and SLR. Since the early 1980s, the frequency and severity of mass coral bleaching events have increased sharply worldwide. For example, from 2016 through 2020, the Great Barrier Reef experienced mass coral bleaching three times in 5 years.

Mass loss of kelp from MHWs effects on the canopy-forming species has occurred across ocean basins, including the coasts of Japan, Canada, Mexico, Australia and New Zealand. In southern Norway and the northeast USA, mortality from MHWs contributed to the decline of sugar kelp over the past two decades and the spread of turf algal ecosystems that prevent recolonisation by the original canopy-forming species.

One of the largest and longest-duration MHWs, nicknamed the 'Blob', occurred in the Northeast Pacific Ocean, extending from California north towards the Bering Sea, from 2013 through 2015. Warming from the MHW persisted into 2016 off the West Coast of the USA and into 2018 in the deeper waters of a Canadian fjord. The consequent effects of this expansive MHW included widespread shifts in abundance, distribution and nutritional value of invertebrates and fish, a bloom of toxic algae off the West Coast of the USA that impacted fisheries, the decline of California kelp forests that contributed to the collapse of the abalone fishery, and mass mortality of seabirds.

The projected increase in the frequency, severity, duration and areal extent of MHWs threaten many marine species and ecosystems. These MHWs may exceed the thermal limits of species, and they may occur too frequently for the species to acclimate or for populations to recover. The majority of the world's coral reefs are projected to decline and begin eroding due to more frequent bleaching-level MHWs if the world warms by more than 1.5°C. Recent research suggests possible shifts to more heat-tolerant coral communities but at the expense of species and habitat diversity. Other systems, including kelp forests, are most threatened near the edges of their ranges, although more research is needed into the effect of re-occurring MHWs on kelp forests and other vulnerable systems.

Box FAQ 3.2 (continued)

The projected ecological impacts of MHWs threaten local communities and Indigenous Peoples, incomes, fisheries, tourism and, in the case of coral reefs, shoreline protection from waves. High-resolution forecasts and early-warning systems, currently most advanced for coral reefs, can help people and industries prepare for MHWs and also collect data on their effects. Identifying and protecting locations and habitats with reduced exposure to MHWs is a key scientific endeavour. For example, corals may be protected from MHWs in tidally stirred waters or in reefs where cooler water upwells from subsurface. Marine protected areas and no-take zones, in addition to terrestrial protection surrounding vulnerable coastal ecosystems, cannot prevent MHWs from occurring. But, depending on the location and adherence by people to restrictions on certain activities, the cumulative effect of other stressors on vulnerable ecosystems can be reduced, potentially helping to enhance the rate of recovery of marine life.

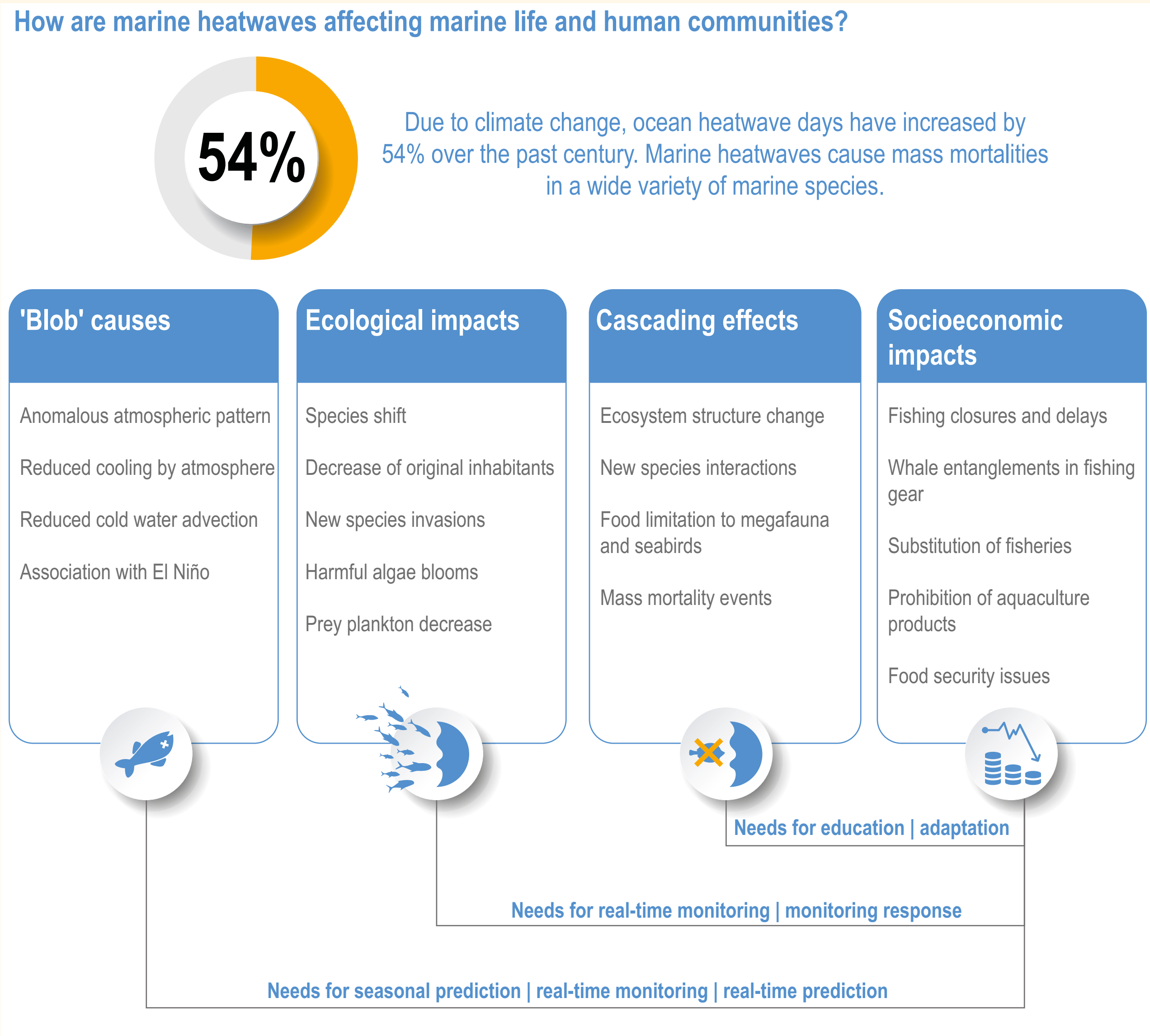


Figure FAQ3.2.1 | Impact pathway of a massive extreme marine heatwave, the northwest Pacific 'Blob', from causal mechanisms to initial effects, resulting nonlinear effects and the consequent impacts for humans. Lessons learnt from the Blob include the need to advance seasonal forecasts, real-time predictions, monitoring responses, education, possible fisheries impacts and adaptation.

Frequently Asked Questions

FAQ 3.3 | Are we approaching so-called tipping points in the ocean and what can we do about it?

A tipping point is a threshold beyond which an abrupt or rapid change in a system occurs. Tipping points that have already been reached in ocean systems include the melting of sea ice in the Arctic, thermal bleaching of tropical coral reefs and the loss of kelp forests. Human-induced climate change will continue to force ecosystems into abrupt and often irreversible change, without strong mitigation and adaptation action.

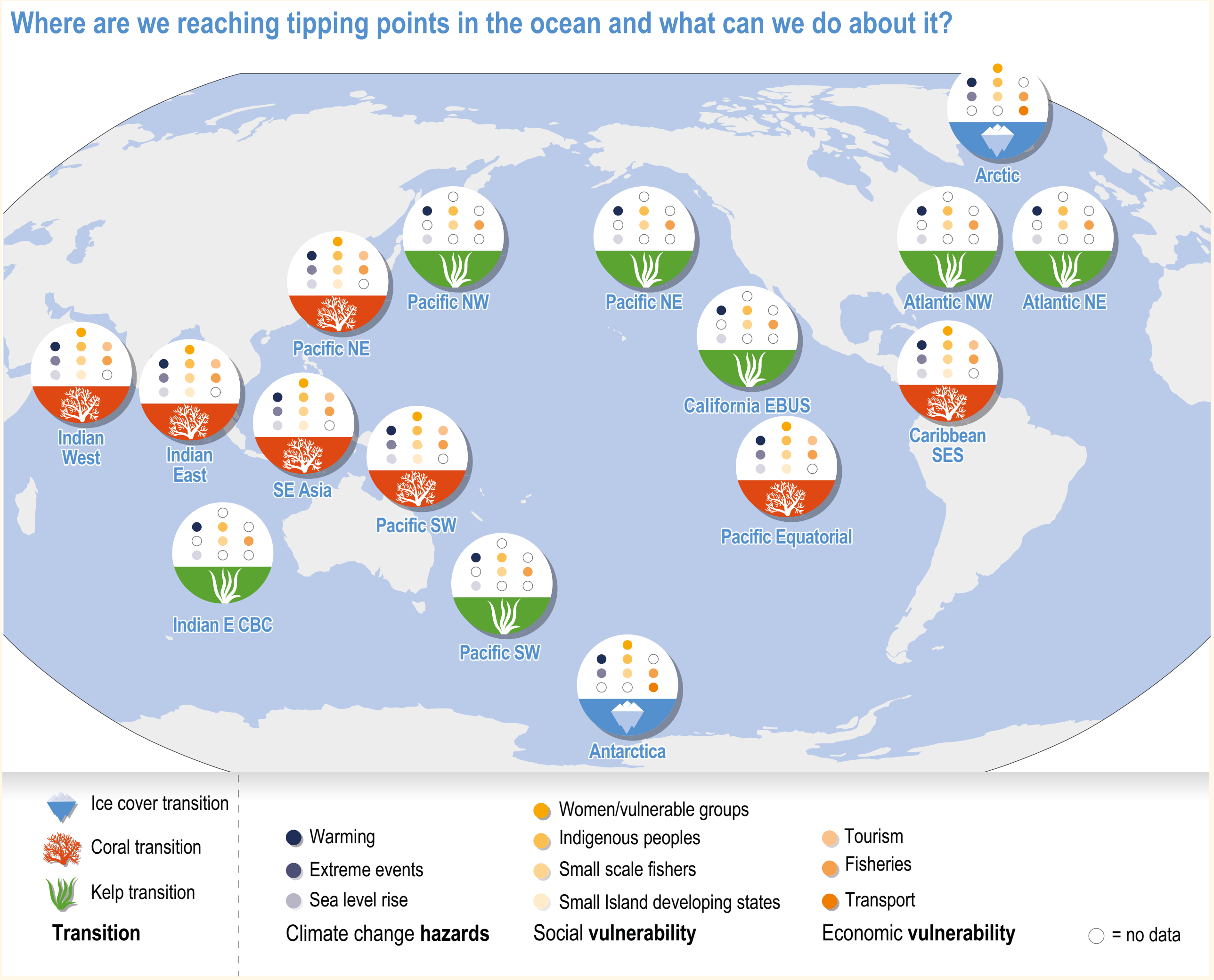


Figure FAQ3.3.1 | Global map with examples of tipping points that have been passed in ocean systems around the world. Tipping points in ecological systems are linked to increasing impacts and vulnerability of dependent human communities. SES: semi-enclosed sea; EBUS: eastern boundary upwelling system; CBC; coastal boundary current.

A gradual change in water temperature or oxygen concentration can lead to a fundamental shift in the structure and/or composition of an ecosystem when a tipping point is exceeded. For example, all species have upper temperature limits below which they can thrive. In the tropics, prolonged warm temperatures can cause fatal 'bleaching' of tropical corals, leading reef ecosystems to degrade and become dominated by algae. In temperate regions, MHWs can kill or reduce the growth of kelp, threatening the other species that depend on the tall canopy-forming marine plants for habitat. In the Arctic, rising temperatures are melting sea ice and reducing the available habitat for communities of ice-dependent species.

Box FAQ 3.3 (continued)

Once a tipping point is passed, the effects can be long-lasting and/or irreversible over time scales of decades or longer. An ecosystem or a population can remain in the new state, even if the driver of the change returns to previous levels. For example, once a coral reef has been affected by bleaching, it can take decades for corals to grow back, even if temperatures remain below the bleaching threshold. Crossing a tipping point can cause entire populations to collapse, causing local extinctions.

Tipping points are widespread across oceanic provinces and their ecosystems for climate variables like water temperature, oxygen concentration and acidification. Evidence suggests that ocean tipping points are being surpassed more frequently as the climate changes; scientists have estimated that abrupt shifts in communities of marine species occurred over 14% of the ocean in 2015, up from 0.25% of the ocean in the 1980s. Other human stressors to the ocean, including habitat destruction, overfishing, pollution and the spread of diseases, combine with climate change to push marine systems beyond tipping points. As an example, nutrient pollution from land together with climate change can lead to low-oxygen coastal areas referred to as 'dead zones'.

Human communities can also experience tipping points that alter people's relationships with marine ecosystem services. Indigenous Peoples and local communities may be forced to move from a particular location due to SLR, erosion or loss of marine resources. Current activities that help sustain Indigenous Peoples and their cultures may no longer be possible in the coming decades, and traditional diets or territories may have to be abandoned. These tipping points have implications for physical and mental health of marine-dependent human communities.

Adaptation solutions to the effects of ecological tipping points are rarely able to reverse their environmental impacts, and instead often require human communities to transform their livelihoods in different ways. Examples include diversifying income by shifting from fishing to tourism and relocating communities threatened by flooding to other areas to continue their livelihoods. Tipping points are being passed already in coral reefs and polar systems, and more will probably be reached in the near future given climate-change projections. Nevertheless, the chances of moving beyond additional tipping points in the future will be minimised if we reduce greenhouse gas emissions and we also act to limit other human impacts on the ocean, such as overfishing and nutrient pollution.

Frequently Asked Questions

FAQ 3.4 | Which industries and jobs are most vulnerable to the impacts of climate change in the oceans?

The global ocean underpins human well-being through the provision of resources that directly and indirectly feed and employ many millions of people. In many regions, climate change is degrading ocean health and altering stocks of marine resources. Together with over-harvesting, climate change is threatening the future of the sustenance provided to Indigenous Peoples, the livelihoods of artisanal fisheries, and marine-based industries including tourism, shipping and transportation.

The ocean is the lifeblood of the planet. In addition to regulating planetary cycles of carbon, water and heat, the ocean and its vast resources support human livelihoods, cultural practices, jobs and industries. The impacts of climate change on the ocean can influence human activities and employment by altering resource availability, spreading pathogens, flooding shorelines and degrading ocean ecosystems. Fishing and mariculture are highly exposed to change. The global ocean and inland waters together provide more than 3.3 billion people at least 20% of the protein they eat and provide livelihoods for 60 million people. Changes in the nutritional quality or abundance of food from the oceans could influence billions of people.

Substantial economic losses for fisheries resulting from recent climate-driven harmful algal blooms and marine pathogen outbreaks have been recorded in Asia, North America and South America. A 2016 event in Chile caused an estimated loss of 800 million USD in the farmed-salmon industry and led to regional government protests. The recent closure of the Dungeness crab and razor clam fishery in the USA, due to a climate-driven algal bloom, harmed 84% of surveyed residents from 16 California coastal communities. Fishers and service industries that support commercial and recreational fishing experienced the most substantial economic losses, and fishers were the least able to recover their losses. This same event also disrupted subsistence and recreational fishing for razor clams, important activities for Indigenous Peoples and local communities in the Pacific Northwest of the USA.

Other goods from the ocean, including non-food products like dietary supplements, food preservatives, pharmaceuticals, biofuels, sponges and cosmetic products, as well as luxury products like jewellery coral, cultured pearls and aquarium species, will change in abundance or quality due to climate change. For instance, ocean warming is endangering the 'candlefish' ooligan (*Thaleichthys pacificus*), whose oil is a traditional food source and medicine of Indigenous Peoples of the Pacific Northwest of North America. Declines in tourism and real estate values, associated with climate-driven harmful algal blooms, have also been recorded in the USA, France and England.

Small-scale fisheries livelihoods and jobs are the most vulnerable to climate-driven changes in marine resources and ecosystem services. The abundance and composition of their harvest depend on suitable environmental conditions and on IKLK developed over generations. Large-scale fisheries, though still vulnerable, are more able to adapt to climate change due to greater mobility and greater resources for changing technologies. These fisheries are already adapting by broadening catch diversity, increasing their mobility to follow shifting species, and changing gear, technology and strategies. Adaptation in large-scale fisheries, however, is at times constrained by regulations and governance challenges.

Jobs, industries and livelihoods which depend on particular species or are tied to the coast can also be at risk to climate change. Species-dependent livelihoods (e.g., a lobster fishery or oyster farm) are vulnerable due to a lack of substitutes if the fished species are declining, biodiversity is reduced, or mariculture is threatened by climate change or ocean acidification. Coastal activities and industries ranging from fishing (e.g., gleaning on a tidal flat) to tourism to shipping and transportation are also vulnerable to sea level rise and other climate-change impacts on the coastal environment. The ability of coastal systems to protect the shoreline will decline due to sea level rise and simultaneous degradation of nearshore systems including coral reefs, kelp forests and coastal wetlands.

The vulnerability of communities to losses in marine ecosystem services varies within and among communities. Tourists seeking to replace lost cultural services can adapt by engaging in the activity elsewhere. But communities who depend on tourism for income or who have strong cultural identity linked to the ocean have a more difficult time. Furthermore, climate-change impacts exacerbate existing inequalities already experienced by some communities, including Indigenous Peoples, Pacific Island countries and territories and marginalised peoples, such as migrants and women in fisheries and mariculture. These inequities increase the risk to their fundamental human rights by disrupting livelihoods and food security, while leading to loss of social, economic and cultural rights. These maladaptive outcomes can be avoided by securing tenure and access rights to resources and territories for all people depending on the ocean, and by supporting decision-making processes that are just, participatory and equitable.

Box FAQ 3.4 (continued)

A key adaptation solution is improving access to credit and insurance in order to buffer against variability in resource access and abundance. Further actions that decrease social and institutional vulnerability are also important, such as inclusive decision-making processes, access to resources and land for Indigenous Peoples, and participatory approaches in management. For the fishing industry, international fisheries agreements and investing in sustainable mariculture and fisheries reforms is often recommended. Immediate adaptations to other challenges, such as harmful algal blooms, frequently include fishing-area closures; these can be informed by early-warning forecasts, public communications; and education. These types of adaptations are more effective when built on trusted relationships and effective coordination among involved parties, and are inclusive of the diversity of actors in a coastal community.

Box FAQ 3.4 (continued)

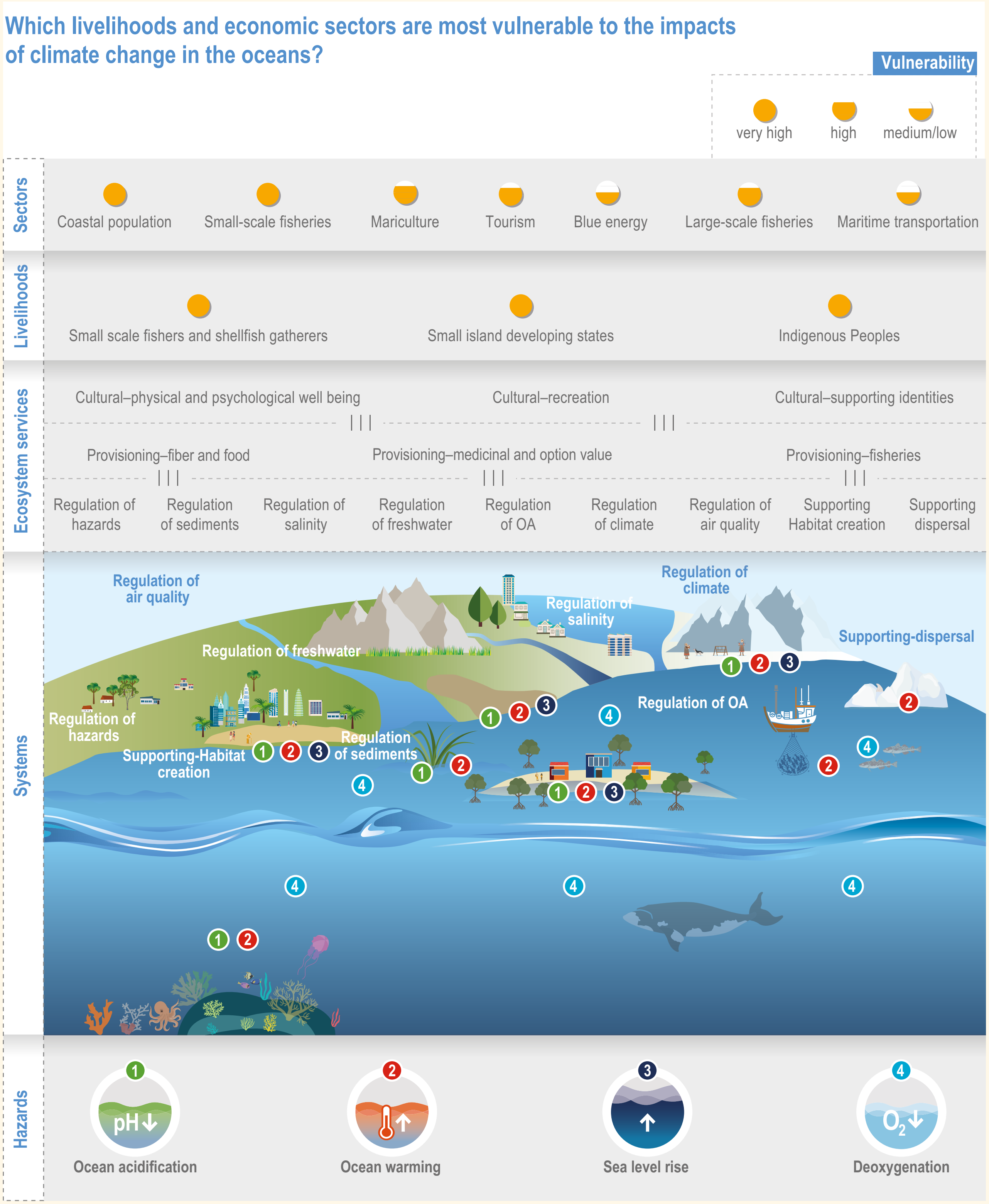


Figure FAQ3.4.1 | Illustration of vulnerable ocean and coastal groups, the climate-induced hazards they experience, and anticipated outcomes for human systems.

Frequently Asked Questions

FAQ 3.5 | How can nature-based solutions, including Marine protected areas, help us to adapt to climate-driven changes in the oceans?

Coastal habitats, such as mangroves or vegetated dunes, protect coastal communities from sea level rise and storm surges while supporting fisheries, sequestering carbon and providing other ecosystem services as well. Efforts to restore, conserve and/or recover these natural habitats help people confront the impacts of climate change. These marine nature-based solutions (NbS), such as Marine protected areas (MPAs), habitat restoration and sustainable fisheries, are cost-effective and provide myriad benefits to society.

In the oceans, NbS comprise attempts to recover, restore or conserve coastal and marine habitats to reduce the impacts of climate change on nature and society. Marine habitats, such as seagrasses and coral reefs, provide services like food and flood regulation in the same way as forests do so on land. Coastal habitats, such as mangroves or vegetated dunes, protect coastal communities from sea level rise and storm surges while supporting fisheries as well as recreational and aesthetic services. Seagrasses, coral reefs and kelp forests also provide important benefits that help humans adapt to climate change, including sustainable fishing, recreation and shoreline protection services. By recognising these services and benefits of the ocean, NbS can improve the quality and integrity of the marine ecosystems.

Nature-based solutions offer a wide range of potential benefits, including protecting ecosystem services, supporting biodiversity and mitigating climate change. Coastal and marine examples include MPA, habitat restoration, habitat development and maintaining sustainable fisheries. While local communities with limited resources might find NbS challenging to implement, they are generally 'no-regret' options, which bring societal and ecological benefits regardless of the level of climate change.

Carefully designed and placed MPAs, especially when they exclude fishing, can increase resilience to climate change by removing additional stressors on ecosystems. While MPAs do not prevent extreme events, such as marine heatwaves (FAQ3.2), they can provide marine plants and animals with a better chance to adapt to a changing climate. Current MPAs, however, are often too small, too poorly connected and too static to account for climate-induced shifts in the range of marine species. Marine protected area networks that are large, connected, have adaptable boundaries and are designed following systematic analysis of future climate projections can better support climate resilience.

Habitat restoration and development in coastal systems can support biodiversity, protect communities from flooding and erosion, support the local economy and enhance the livelihoods and well-being of coastal peoples. Restorations of mangroves, salt marshes and seagrass meadows provide effective ways to remove carbon dioxide from the atmosphere and at the same time protect coasts from the impacts of storms and SLR. Active restoration techniques that target heat-resistant individuals or species are increasingly recommended for coral reefs and kelp forests, which are highly vulnerable to marine heatwaves and climate change.

Sustainable fishing is also seen as an NbS because managing marine commercial species within sustainable limits maximises the catch and food production, thus contributing to the UN's Sustainable Development Goal 2 (Zero Hunger). Currently, the oceans provide 17% of the animal protein eaten by the global population, but the contribution could be larger if fisheries were managed sustainably. Aquaculture, such as oyster farming, can be an efficient and sustainable means of food production and also provide additional benefits like shoreline protection. Through NbS that conserve and restore marine habitats and species, we can sustain marine biodiversity, respond to climate change and provide benefits to society.

Box FAQ 3.5 (continued)

Contributions of nature-based solutions in the oceans to the Sustainable Development Goals

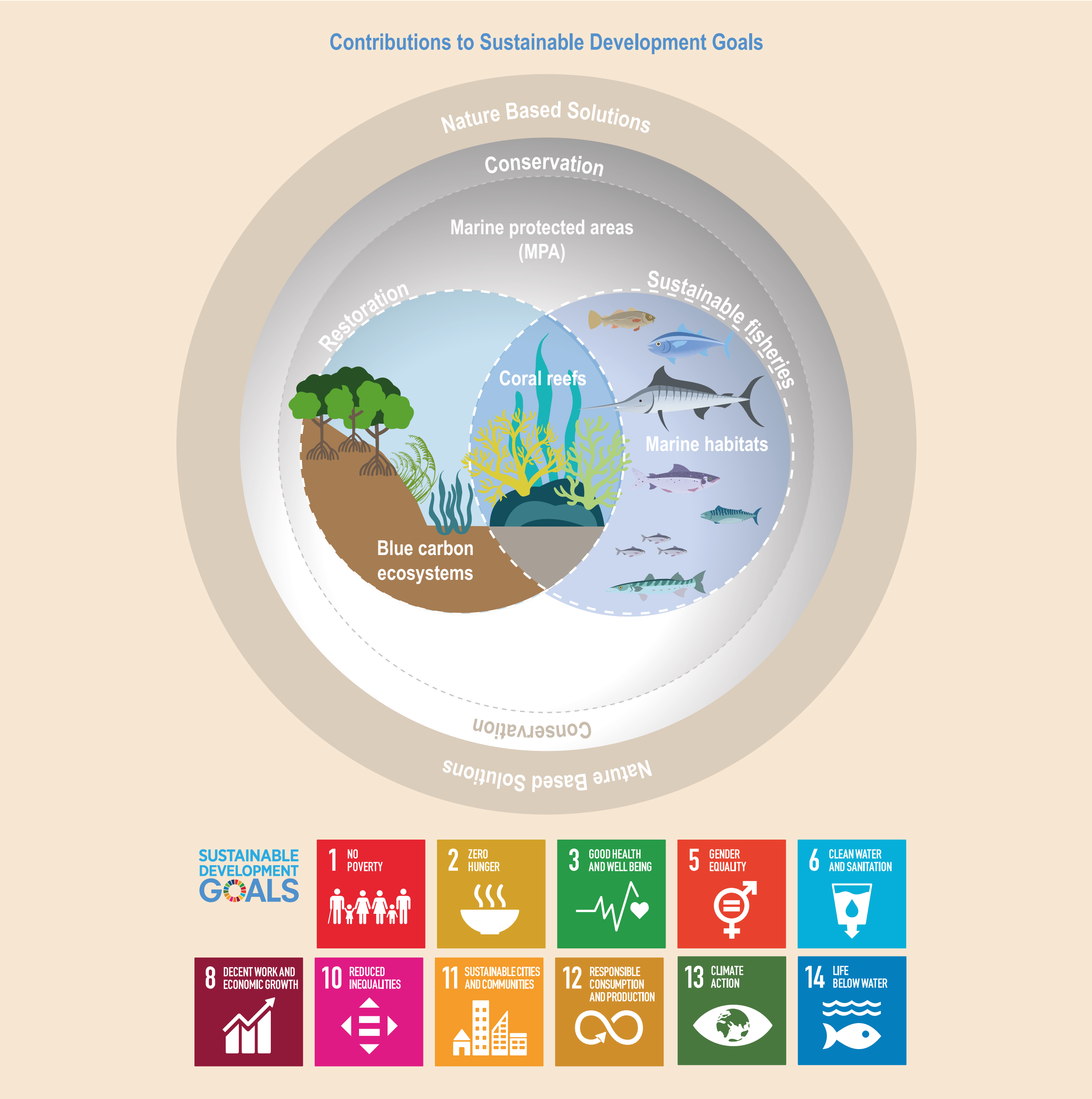


Figure FAQ3.5.1 | Contributions of nature-based solutions (NbS) in the oceans to the Sustainable Development Goals. The icons at the bottom show the Sustainable Development Goals to which NbS in the ocean possibly contribute.

Frequently Asked Questions

FAQ 4.1 | What is water security, and how will climate change affect it?

Water is essential for all societal and ecosystems needs. Water security is multi-dimensional and not just about water availability. Water needs to be available in sufficient quantity and quality and needs to be accessible in an acceptable form. Accordingly, a situation of water security indicates the availability and accessibility of sufficient clean water to allow a population to sustainably ensure its livelihoods, health, socioeconomic development and political stability. Many socioeconomic factors, such as population growth and food consumption patterns, play an important role in determining water security. Still, climate change is increasingly shown to be an important contributor to water insecurity worldwide, with some regions more at risk than others.

Climate change can affect these different dimensions of water security in different ways. Most directly, climate change is affecting the overall availability of water across regions and during important seasons. More extended periods of dry spells and droughts are already affecting water availability, especially in the arid areas of India, China, the USA and Africa. Other extremes, such as heavy precipitation and flooding, can affect water quality, making water unsafe for drinking, for example. In coastal regions and small islands, the combined effects of higher sea levels and more intense storms affect water security by increasing the salinisation of groundwater resources. Indirect effects of climate change on water security include impacts on infrastructure for the provision and recovery of water resources, which can affect the safe access to adequate water resources, both in terms of quality and quantity.

In terms of assessing the extent of water scarcity, studies estimate that currently, between 1.5 and 2.5 billion people live within areas exposed to water scarcity globally. These numbers are projected to increase continuously, with estimates of up to 3 billion at 2°C and up to 4 billion at 4°C by 2050. Many socioeconomic factors, such as population growth and food consumption patterns, determine water scarcity. Still, climate is increasingly shown to be an important component that drives scarcity across the world. Water scarcity is often a seasonal occurrence, and climate change is projected to increase seasonal extremes. Often, consecutive years with drier conditions lead to a long-term decrease in groundwater tables, affecting water availability directly and soil moisture in the longer term.

As an essential component of water security, climate change will affect water quality in different ways. Drier conditions lead to a reduction in water availability, causing a potential increase in the concentration of contaminants. Increasing runoff and floods can wash pollutants into water bodies. With climate change projected to increase the variability of rain over space and time, such impacts on water quality are becoming increasingly likely. Higher temperatures add to deteriorating water quality by reducing oxygen levels.

Another critical component to ensure secure access to water resources is adequate water infrastructure for access, disposal and sanitation. Unfortunately, increasing extremes due to climate change, especially floods and increasing storm activity, have great potential to damage such infrastructure, especially in developing world regions, where infrastructure is much more susceptible to damage and pollution.

There are substantial differences in the distribution of risks across regions, with some areas facing a much higher risk burden than others. Also, projections of the potential impacts of climate change on water security vary across regions. However, patterns of projected water-related extremes are emerging more clearly globally with increasing confidence.

Frequently Asked Questions

FAQ 4.2 | Which places are becoming wetter and which are becoming drier, and what risks do these bring to people?

Due to climate change, substantial numbers of people are now living in climates with average precipitation levels significantly different to the average over the 20th century. Nearly half a billion people are living in unfamiliar wet conditions, mostly in mid- and high latitudes, and over 160 million people are living in unfamiliar dry conditions, mostly in the tropics and subtropics. In addition to changes in average precipitation, precipitation patterns over time are also changing, as well as river flows. Societal impacts and increased risks from both wetter and drier conditions are starting to emerge.

Some parts of the world are becoming wetter, and some are becoming drier, in terms of either changes in precipitation and/or the water available in the soil, in rivers or underground. Soil moisture, river water and groundwater are affected by changes in precipitation and also by changes in evaporation, which is affected by temperature and by uptake by vegetation.

All these factors are affected by climate change. Rising temperatures drive higher evaporation, which dries the landscape, although this can be offset in some areas by reduced uptake of water from the soil by plants in response to rising CO_2 concentrations. A warming climate brings more precipitation overall, although changes in global wind patterns mean that some areas are seeing less precipitation.

As a result, substantial numbers of people are now living in climates with average precipitation levels significantly different to the average over the 20th century. Nearly half a billion people are living in unfamiliar wet conditions, mostly in mid- and high latitudes, and over 160 million in unfamiliar dry conditions, mostly in the tropics and subtropics (Figure FAQ4.2.1).

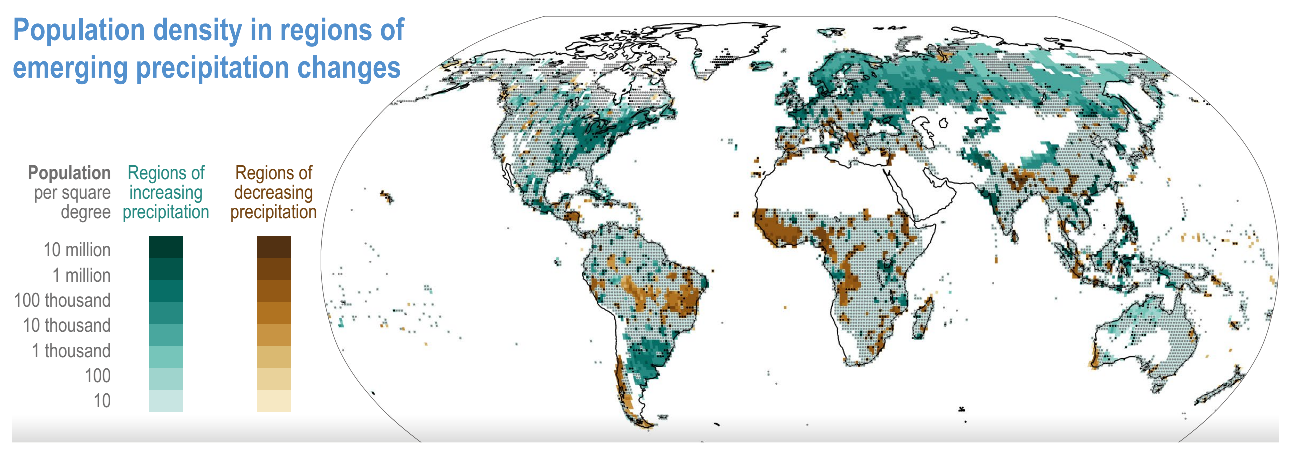


Figure FAQ4.2.1 | Numbers of people seeing increases and decreases in precipitation.

In addition to changes in average precipitation, the patterns over time are also changing, such as the length of dry spells and the amount of precipitation falling in heavy events. Again, these changes vary across the world due to shifting wind patterns. Approximately 600 million people live in places with longer dry spells than in the 1950s, mostly in West Africa, south Asia and parts of South America. Approximately 360 million people experience shorter dry spells, in North America, northern Asia and other parts of South America.

In contrast, far more people (about 600 million people) are seeing heavier precipitation than less heavy precipitation (80 million). A more widespread increase in heavy precipitation is expected in a warming world, where the warmer atmosphere takes up more moisture and hotter ground drives more intense storms.

River flows are also changing in many parts of the world, often due to changes in precipitation, although direct human impacts are also important. Generally, the most widespread increased river flows are seen in high latitudes, while decreasing flows are seen in mid- and low latitudes, although there are major exceptions to these trends and data is sparse in many regions (Figure FAQ4.2.2).

FAQ

FAQ 4.2 (continued)

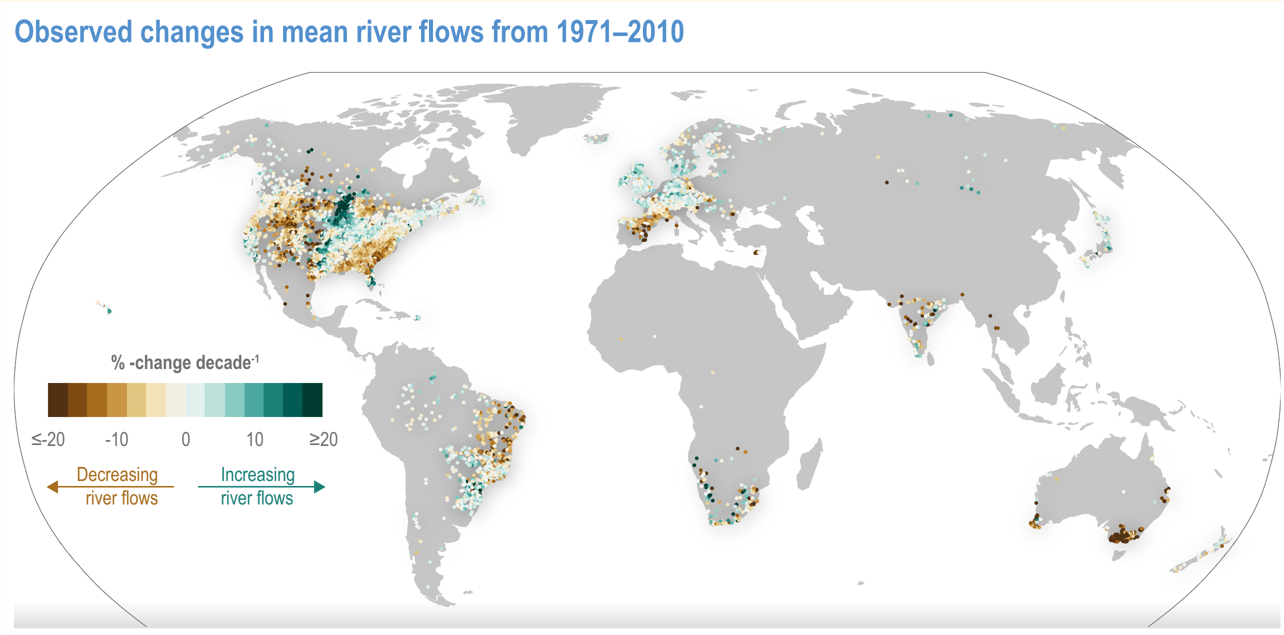


Figure FAQ4.2.2 | Observed changes in mean river flows from 1971 to 2010

Some of these changes are starting to have impacts on society. For example, increasing rainfall in the USA has led to increased crop yields. Heavy rainfall and long periods of rainfall lead to flooding, causing deaths, injuries, infrastructural damage, spread of disease, disruptions to employment and education, psychological trauma and territorial displacement. The weather conditions associated with many recent major flooding events were made *more likely* by climate change, although non-climatic factors remain the dominant driver of increased flooding.

Drier soils have made heatwaves more severe. A drying of the landscape has increased the length of the fire season across much of the world, contributing to unprecedented severity of wildfires in recent years. In recent years, several major drought events with impacts on agriculture were made *more likely* by climate change.

Overall, the general picture is of increased average precipitation and/or longer periods of precipitation in the mid and high latitudes, but decreased precipitation and/or longer times between precipitation across much of the tropics and subtropics. Where heavy precipitation is changing, this is mostly towards increasing intensity. Societal impacts and increased risks from both wetter and drier conditions are starting to emerge.

Frequently Asked Questions

FAQ 4.3 | How will climate change impact the severity of water-related disasters, such as droughts and floods?

Climate change will lead to populations becoming more vulnerable to floods and droughts due to an increase in the frequency, magnitude and total area affected by water-related disasters. Floods and droughts will also affect more people in the course of this century as a result of population growth and increased urbanisation, especially if warming cannot be limited to 1.5°C. The impact of floods and droughts are expected to increase across all economic sectors, resulting in negative outcomes for the global production of goods and services, industry output, employment, trade and household consumption. Floods will pose additional risks to people's lives and health through inundation, facilitating the further spread of waterborne diseases. At the same time, droughts can have adverse health impacts due to the limited availability of food and water for drinking and hygienic purposes. All losses, both in terms of lives and in economic terms, will be more limited in a 1.5°C than in a 3°C warmer world.

Anthropogenic land use changes and climate change will exacerbate the intensity, frequency and spatial extent of floods and droughts, leading to populations becoming more vulnerable. According to projections, these increases in extreme events will be more significant with higher levels of global warming. However, the location and severity of floods and droughts are context-dependent and complex phenomena.

The processes that lead to droughts include lack of or less frequent precipitation, increased evapotranspiration and decreased soil moisture, snow cover, runoff and streamflow. For example, warming temperatures may result in higher evapotranspiration, in turn leading to drier soils. In addition, reduced soil moisture diminishes the amount of water filtering into rivers in both the short and long term while also increasing the aridity that can foster the conditions for fire. Moreover, decreased snow cover represents less runoff supply to downstream areas during warmer seasons. Depending on this process and the propagation of a meteorological drought onto further systems, a drought can be defined as hydrological, agricultural or ecological. Agricultural drought threatens food production through crop damage and yield decreases, and consequent economic impacts, and therefore, can be the most impactful to humans. Geographically, the likelihood of agricultural drought is projected to increase across most of southern Africa, Australia, the majority of Europe, the southern and western USA, Central America and the Caribbean, northwest China, parts of South America, and the Russian Federation; but due to increased precipitation, it is projected to decline in southeastern South America, central Africa, central Canada, western India and the south of the Arabian Peninsula.

Flood hazard natural processes usually result from increases in heavy precipitation events, but they can also be caused by saturated soils, increased runoff and land use changes. A warming climate usually causes greater energy for the intense upward motion for storm formation and increases evapotranspiration, which leads to heavier precipitation. Many places around the world will experience more-than-average rainfall, which may increase soil moisture. Wetter soils saturate faster during precipitation events, resulting in increased runoff that can muddy the waters and lead to floods. Anthropogenic land use changes, such as urbanisation, deforestation, grasslands and agricultural extension, can also reduce the amount of water infiltrating the soil and leading to frequent flooding. Floods are expected to increase in Asia, the USA and Europe, particularly in areas dependent on glacier water where melting will lead to earlier spring floods. Additionally, fluvial floods are projected to be more frequent in some regions in central Africa and northern high latitudes and less frequent in the southern areas of North America, southern South America, the Mediterranean, parts of Australia and southern parts of Europe.

Globally, socioeconomic development will lead to heightened societal hazards. Due to population growth and increased urbanisation, floods and droughts will affect more people in the course of this century, especially if warming cannot be limited to 1.5°C. All losses, both in lives and in economic terms, will be more limited in a 1.5°C than in a 3°C warmer world. The impacts of floods and droughts are expected to increase across all economic sectors, from agriculture to energy production, resulting in negative outcomes for our global production of goods and services, industry output, employment, trade and household consumption. Landslides, sinkholes and avalanches arising from heavy rainfall events will increasingly threaten infrastructure and agricultural production. In cities, increased flood frequency could disrupt waste management systems, resulting in the clogging of waterways. In addition, unprecedented flood magnitudes could overwhelm hydraulic infrastructure, affecting the energy, industry and transportation sectors. An expansion in inundation area, coupled with urban sprawl, would increase flood damage. Floods will pose additional risks to people's lives and health through inundation, thus facilitating the spread of waterborne diseases. At the same time, drought can have adverse health impacts due to the limited availability of

FAQ 4.3 (continued)

food and water for drinking and hygienic purposes. Although there are no agreed-upon projections for migration and displacement due to water-related disasters, it is known that drought and desertification cause harvest failures, which may lead subsistence farmers to relocate to urban areas. Whether temporary or permanent, displacement is often mired with diminished safety, loss of social ties, and a weakened sense of place and cultural identity.

Finally, vulnerable groups such as people living in poverty, women, children, Indigenous Peoples, uninsured workers and the elderly will be the most affected by water-related disasters.

Frequently Asked Questions

FAQ 4.4 | Globally, agriculture is the largest user of water. How will climate change impact this sector, and how can farmers adapt to these changes?

Climate-induced changes in the global hydrological cycle are already impacting agriculture through floods, droughts and increased rainfall variability, which have affected yields of major crops such as maize, soybeans, rice and wheat. These changes are projected to continue in a warmer world, which will cause yields of rain-fed crops to decline and reduce the amount of water available for irrigation in water-stressed regions. Farmers already use adaptation and coping strategies to manage agricultural water use. Some of the most important adaptation responses are the application of irrigation, on-farm water and soil conservation; changing cropping patterns; adopting improved cultivars; and improved agronomic practices. In many parts of the world, farmers increasingly use Indigenous knowledge and local knowledge to inform their decisions of what to grow, when to grow and how much to irrigate. To offset the risks of market-related volatility coupled with climate change, farmers also adopt economic and financial instruments such as index-based crop insurance. Training and capacity-building programmes and social safety nets are other forms of adaptation that farmers are using to respond to these changes.

Worldwide, and especially in developing countries, agriculture (including crop cultivation and livestock and fisheries) is the largest water user, accounting for 50–90% of all water use. Moreover, a substantial part of the water used in agriculture is 'consumptive' use, which means that the water is 'consumed' for crop growth and is not immediately available for other uses. This is different from other sectors, such as energy production, where only a fraction of the water is consumed, and other downstream users can reuse the rest. Agriculture also accounts for a large share of employment in developing countries, with 60–80% of the rural population dependent on agriculture for their livelihoods. Agriculture provides food security for all. This makes farmers and agriculture particularly vulnerable to climate change.

Climate-induced changes in the global hydrological cycle are already impacting agriculture through floods, droughts and increased rainfall variability. For example, loss in yields has been reported for major crops such as maize (by 4.1%), soybeans (by 4.5%), rice (by 1.8%) and wheat (by 1.8%) due to changes in precipitation between 1981 and 2010. In addition, drought has affected both the area under cultivation and the yields of major crops. According to one estimate, globally, there has been a loss of 9–10% of total cereal production due to droughts and other weather extremes. Similarly, floods are one of the significant reasons for crop losses worldwide. Climate change-induced losses in livestock and fisheries have also been documented. In some parts of the world, especially in cold temperate zones, agro-climatic zones have become more conducive to yield growth in crops like maize and soybean due to increases in summer precipitation. Yet, negative impacts far outweigh positive impacts.

Projected impacts on agriculture due to changes in water availability are also severe. For example, yields of rain-fed crops such as maize are projected to decline by one fifth to one third by the end of the century. In contrast, many areas which currently support multiple crops may become unsuitable for rain-fed farming or support only one crop in a year. Irrigation, which is often one of the most effective adaptive strategies against water-induced stress, is also projected to be affected by a reduction of the amount of water available for irrigation in some parts of the world that are already water-stressed or as a result of groundwater depletion in places such as India, North China and the northwestern USA. Overall, future droughts and floods will pose a major risk to food security, and agriculture and impacts will be more severe on countries and communities that are already food insecure.

Given that farmers are already dealing with variability in the amount and timing of rainfall. In many places, demand for agricultural water is greater than supply, and farmers are using many adaptations and coping strategies to meet water demands for their crops, fish and livestock. Some of the most popular adaptation responses around crops and water include:

- changing cropping patterns to less water-intensive crops, and changes in the timing of sowing and harvesting to respond to unfamiliar trends in the onset of rains
- adoption of improved cultivars, such as drought and flood-resistant seed varieties
- improved agronomic practices, including conservation agriculture that helps reduce water application rates
- irrigation and water-saving technologies such as efficient irrigation and on-farm water management techniques
- on-farm water and soil moisture conservation

Most of these measures are beneficial across multiple indicators (water saving, increased incomes, etc.); however, whether they also reduce climate-related risks is not well understood and remains a knowledge gap. Irrigation and changes in crop choices and cultivars are also shown to be effective for future adaptation, especially at 1.5°C global warming, but much less effective at 2°C and 3°C when these responses will not mitigate a large part of the climate risk. Most of these adaptation measures mentioned above are autonomous. However, some, such as improved seeds

FAQ 4.4 (continued)

and cultivars, are supported by national agricultural research agencies, international research coalitions such as the CGIAR [Consultative Group on International Agricultural Research], and private seed companies. In many parts of the world, farmers are also increasingly using Indigenous knowledge and local knowledge to inform these decisions of what to grow, when to grow and how much to irrigate.

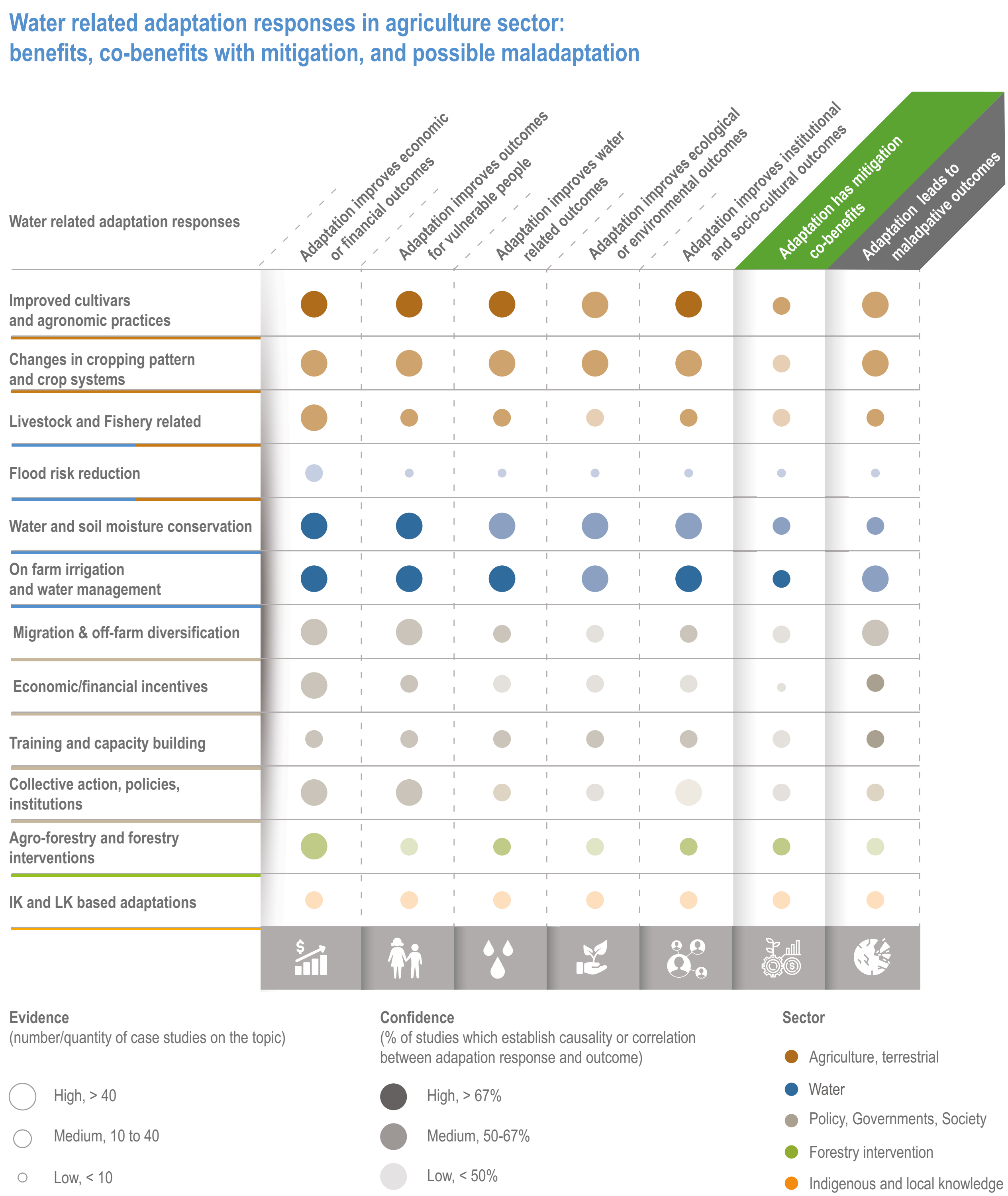


Figure FAQ4.4.1 | Water-related adaptation responses in agriculture sector: benefits, co-benefits with mitigation, and possible maladaptation

FAQ 4.4 (continued)

Given the predominance of market economies worldwide, most farmers also depend on the market to sell their produce, and market fluctuations affect their incomes. In addition, market-related volatility coupled with climate change is a source of increased risk for farmers. Several economic and financial instruments are being used with varying levels of success to offset some of these interlinked impacts. Index-based crop insurance is one such instrument that compensates farmers for losing crops due to hazards such as floods and droughts. However, several limitations in their implementation remain.

In cases of severe droughts and floods, which have debilitating impacts on already poor and vulnerable populations, national governments provide social safety programmes, such as food or cash-for-work programmes, which are shown to be successful in reducing risks for the most vulnerable people, even though there are often concerns with targeting efficiency. Providing training and capacity building of farmers to adopt new farming practices and technologies to manage risk better are also known to be effective when the training is conceptualised, targeted and implemented in consultation with farmers. Planned adaptation practices include managing weather and market risks through insurance products, social safety nets for vulnerable populations, and providing the right mix of training and capacity building. These adaptation practices are generally implemented by civil society, governments and the private sector.

Frequently Asked Questions

FAQ 4.5 | Which principles can communities implement to sustainably adapt to the ways that climate change is impacting their water security?

For communities to sustainably adapt to climate impacts on water security, their participation, cooperation and bottom-up engagement are critical in all stages of decision-making processes. In addition to enhancing the legitimacy of the decision-making process, the community's involvement can increase the equitability and effectiveness of the adaptation approach. As water insecurity disproportionately affects marginalised social groups, their participation in water governance and implementation can help improve their water security. Combining and integrating local, indigenous and traditional ecological knowledge with Western understandings of climate change can enhance the effectiveness of adaptation measures and strategies while ensuring that the adaptation is equitable and just. Improving water security is fundamental to achieving many of the 17 Sustainable Development Goals (SDGs).

For decades, communities worldwide have already been adapting to climate change-induced hydrological changes to maintain their livelihood and safety. Adaptation is a multi-faceted process that is implemented differently depending on the sector affected by changes in the hydrological cycle and the region where these changes happen. For instance, farmers in the semiarid areas might adapt to changing rain patterns through irrigation (see also FAQ4.4). At the same time, urban dwellers can adopt measures such as rainwater harvesting and other nature-based solutions. Several principles have been documented as crucial for achieving sustainable adaptation as they support communities in becoming more resilient to climate change. However, these principles can be implemented singularly or in tandem, and it is essential to acknowledge that long-term adaptation success is context-specific. Therefore, it is critical to involve local communities in co-designing effective adaptation responses.

For communities to sustainably adapt to climate impacts on water security, participation, cooperation and bottom-up engagement are critical in all stages of the decision-making processes, from planning to full implementation. Many of the countries and social groups most threatened by climate change have contributed least to global warming and do not have access to adequate resources to adapt. Effective participation of these actors in water-related climate change adaptation planning can contribute to more equitable adaptation actions. The involvement of the most vulnerable in the design of adaptation responses makes it more probable that these solutions will suit their needs and have therefore a higher chance of being effective. Accessible, inclusive and well-coordinated efforts to enhance water security will improve the legitimacy of water governance and work synergistically with reducing inequalities (UN SDG, SDG 10) and encouraging more sustainable communities (SDG 11). Communities can also be involved in sector-specific adaptation responses. These are often water-related and help ensure that climate action (SDG 13) is well aligned with clean water and sanitation (SGD 6).

The participation of traditionally excluded groups such as women and marginalised communities and Indigenous Peoples and ethnic minorities contributes to more equitable and socially just adaptation actions. Water insecurity disproportionately affects these marginalised groups, and their participation in water governance and implementation can help alleviate this burden.

Recognising the importance of Indigenous knowledge and local knowledge in improving water security is vital to ensuring that decisions and solutions align with the interests of Indigenous Peoples and local peoples and benefit their communities culturally and economically. Furthermore, the effectiveness of adaptation measures and strategies improves when Indigenous knowledge and local knowledge and traditional ecological knowledge are combined and integrated with technical understandings of climate change.

The climate adaptation plans led by national governments and local authorities will only be accepted and adequately implemented when supported by the community. Therefore, strong political and societal support is necessary to ensure effective policy changes, whether local or national. Significantly, access to financial assistance from private and public sources expands the range of strategies that communities can consider for enhancing their water security.

These principles are also conducive to the achievement of the United Nations SDGs. Actions that reduce climate risk and enhance water security can positively interact with sustainable development objectives (synergies). Therefore, improving water security is fundamental to achieving many of the 17 SDGs.

Frequently Asked Questions

FAQ 5.1 | How is climate change (already) affecting people's ability to have enough nutritious food?

Climate change has already made feeding the world's people more difficult. Climate-related hazards have become more common, disrupting the supply of crops, meat and fish. Rapid changes in weather patterns have put financial strain on producers, while also raising prices and limiting the choices and quality of produce available to consumers.

Most of our food comes from crops, livestock, aquaculture and fisheries. Global food supply increased dramatically in the last century, but ongoing climate change has begun to slow that growth, reducing the gains that would have been expected without climate change. Regionally, negative effects are apparent in regions closer to the equator, with some positive effects further north and south.

Climate impacts are also negatively affecting the quality of produce, from changes in micronutrient content to texture, colour and taste changes that reduce marketability. With warmer and more humid condition, many food pests thrive, food decays more quickly, and food contains more toxic compounds produced by fungi and bacteria.

Warming of the oceans has reduced potential fish catch. The increased carbon dioxide in the atmosphere has led to ocean acidification, which is already impacting the production of farmed fish and shellfish. Changes in local climate have forced producers to shift to new locations, changing what they grow or where they work (e.g., pole-ward shifting fishing grounds).

Climate hazards have increased over the past 50 years and are the major cause of sudden losses of production (food production shocks). Food shocks occur following droughts, heatwaves, floods, storms and outbreaks of climate-related pests and combine to cause multiplying impacts. Climate hazards sometimes disrupt food storage and transport, which impairs the food supply.

All of these negative impacts can lead to increased food prices, and reduced income for producers and retailers as there are fewer products to sell. Together, these impacts threaten to reduce the supply of varied, nutrient-rich foods to poor populations that already suffer ill health.

Box FAQ 5.1 (continued)

Trends in food production shocks in different food supply sectors from 1961-2013

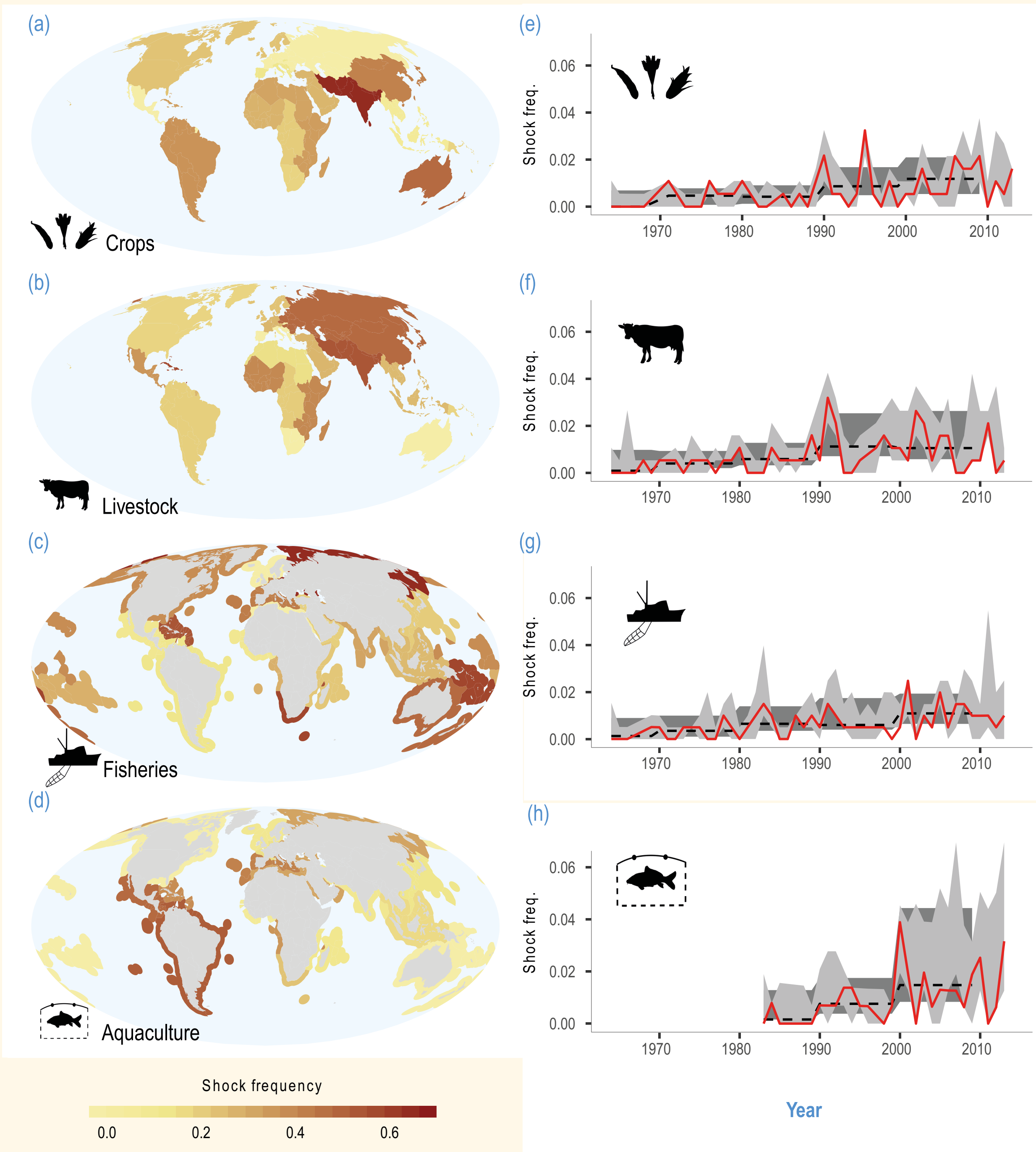


Figure FAQ5.1.1 | Trends in food production shocks in different food supply sectors from 1961 to 2013 (Cottrell et al., 2019). The red lines in the time series are the annual shock frequency, and the dashed line is the decadal mean.

Frequently Asked Questions

FAQ 5.2 | How will climate change impact food availability by mid and late century and who will suffer most?

Climate change impacts will worsen over time, with the period after mid-century seeing more rapid growth in negative impact than in the early part of this century. The impacts will be global, but people with fewer resources, and those who live in regions where impacts will worsen more rapidly, will be hurt the most.

Climate change impacts will worsen over time, but the extent depends on how rapidly greenhouse-gas emissions grow. If the current rate of emissions continues, the impacts will worsen, especially after mid-century, with rapid growth in the number and severity of extreme weather events. Yields of plants, animals and aquaculture will decline in most places, and marine and inland fisheries will suffer. Food production in some regions will become impossible, either because the crops or livestock there cannot survive in the new climatic conditions, or it is too hot and humid for farm workers to be in the fields.

After harvest, agricultural production passes through the agricultural value chain, supplying animal feeds, industrial uses and international markets, with some stored for use in the future. Each of these transitions will be affected by climate change. Food storage facilities will face more challenges in dealing with spoilage. Transportation of perishable fruits, vegetables and meats will become costlier to maintain quality. Households and food services will need to spend more on food preservation.

Low-income countries and poor people are at higher risk, as they have limited social safety nets and suffer more from rising food prices and an unstable food supply. But large famers will also be hurt. Rural communities, especially smallholder farmers, pastoralists and fishers, are extremely vulnerable because their livelihoods mainly depend on their production. The urban poor will have to spend more on food.

A flood, for example, may force low-income families out of their homes, affect their employment and reduce their access to food supplies, with prices often rising after natural disasters. Families will have less access to safe water supplies, and this combination of lower food supplies, uncertain employment, displacement from home and rising food costs will increase the number of children who are undernourished.

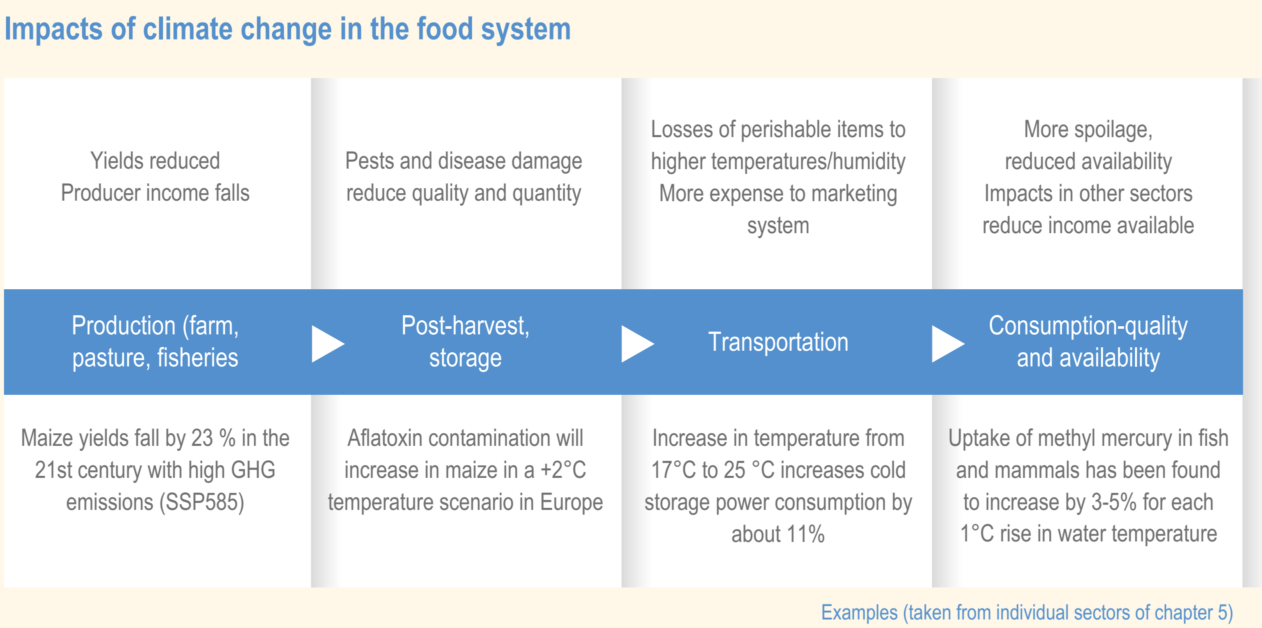


Figure FAQ5.2.1 | Impacts of climate change on the food system.

Frequently Asked Questions

FAQ 5.3 | Land is going to be an important resource for mitigating climate change: how is the increasing competition for land threatening global food security and who will be affected the most?

Climate change will affect food production. Meeting future food needs requires greater land shares unless we change what we eat and how we grow food. Additionally, large-scale land projects that aim to mitigate climate change will increase land competition. Less land will then be available for food production, increasing food insecurity. People at greater risk from land competition are smallholder farmers, Indigenous Peoples and low-income groups.

Why is land important?

Land is a limited resource on which humans and ecosystems depend on to grow plants, which capture carbon dioxide and release oxygen, and provide food, timber and other products. We also have cultural, recreational and spiritual connections to land.

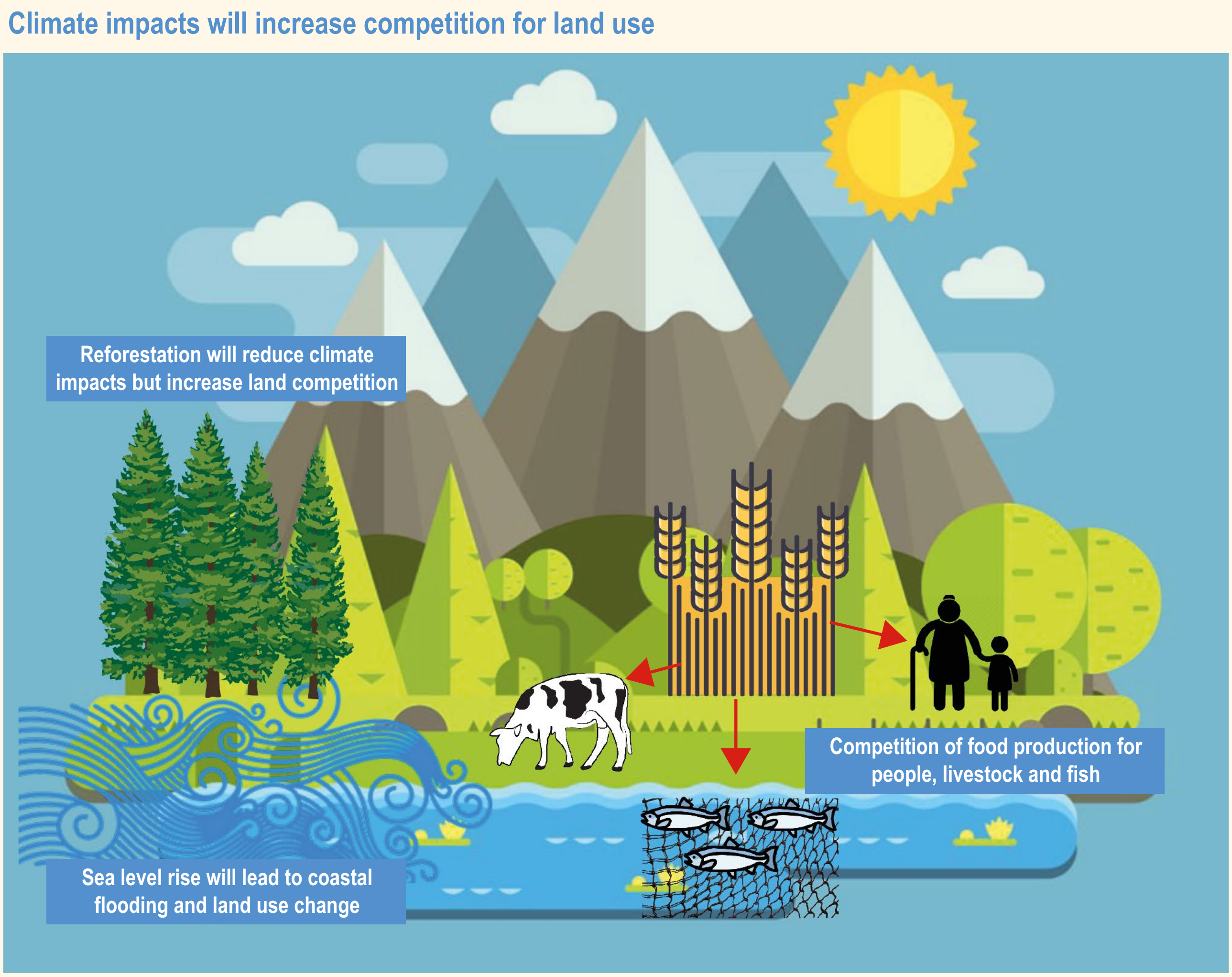


Figure FAQ5.3.1 | Climate impacts will increase competition for land use, reducing coastal land for crops and affecting food security for vulnerable groups. Adaptation methods like coastal aquaculture and mangrove reforestation reduce climate effects but may increase land competition.

Box FAQ 5.3 (continued)

Why will climate change affect land use?

Climate change results in more frequent heatwaves, extreme rainfall, drought and rising sea levels, which negatively affect crop yields. More land is thus needed to grow crops, increasing land competition with other food systems that use crops to feed their animals (e.g., livestock, fish). Where land will be flooded, humans cannot grow crops, but food production could be adapted to grow seafood instead. Extensive land allocations aiming at reducing carbon emissions, such as afforestation, reduce land availability for food. Unless carefully managed, competition for land will increase food prices and food security.

Solutions to reduce land competition and protect food security

Sustainable land management allows land to remain productive and support key functions. Other land practices include growing cover crops to improve soil quality. Governments can provide incentives to producers to grow alternative foods and use sustainable practices. Making sure that vulnerable groups (e.g., low-income communities, Indigenous people and small-scale producers) strengthen land tenure rights will help protect food security.

Food by-products used as alternative food sources and other products reduce waste and increase sustainability. Dietary changes are another important solution. People that eat high amounts of meat or unhealthy foods could reduce consumption of these foods and have more diverse diets. These dietary changes will benefit their health and reduce pressure on land. Regulated labelling, education and other policies which encourage healthy diets can support these shifts.

Frequently Asked Questions

FAQ 5.4 | What are effective adaptation strategies for improving food security in a warming world?

A variety of adaptation options exist to improve food security in a warming world. Examples of adaptation for crop production include crop management and livelihood diversification. For livestock-based systems, an example is matching number of animals with the production capacity of pastures. For fisheries, eliminating overfishing is an effective adaptation practice. For mixed cropping and nature-based systems, an appropriate adaptation is agroforestry.

Adaptation strategies to enhance food security vary from farm-level interventions to national policies and international agreements. They cover the following dimensions of food security: availability, access, utilisation (food quality and safety) and stability.

For the production of crops, adaptation strategies include field and farm-level options such as crop management, livelihood diversification and social protection such as crop insurance. The most common field management options are changes in planting schedules, crop varieties, fertilizers and irrigation. For example, farmers can shift their planting schedules in response to the early or late onset of the rainy season. Moreover, there are new crop insurance schemes that are based on changes in weather patterns.

For livestock-based systems, adaptation options include matching the number of animals with the production capacity of pastures; adjusting water management based on seasonal and spatial patterns of forage production; managing animal diet; more effective use of fodder, rotational grazing; fire management to control woody thickening of grass; using more suitable livestock breeds or species; migratory pastoralist activities; and activities to monitor and manage the spread of pests, weeds and diseases.

For ocean and inland fisheries, adaptation options are primarily concentrated in the socioeconomic dimension and governance and management. In general, eliminating overfishing could help rebuild fish stocks, reduce ecosystem impacts, and increase fishing's adaptive capacity. Aquaculture is often viewed as an adaptation option for fisheries declines. However, there are adaptation strategies specific to aquaculture, including proper species selections at the operational level, such as the cultivation of brackish species (shrimp, crabs) in inland ponds during dry seasons and rice–freshwater finfish in wetter seasons.

For so-called mixed farming systems that produce a combination of crops, livestock, fish and trees, these systems' inherent diversity provides a solid platform for adaptation. A good example is agroforestry, the purposeful integration of trees or shrubs with crop or livestock systems, which increases resilience against climate risks.

Overall, nature-based systems or ecosystem-based strategies in food systems, such as agroecology, can be a useful adaptation method to increase wild and cultivated food sources. Agroecological practices include agroforestry, intercropping, increasing biodiversity, crop and pasture rotation, adding organic amendments, integration of livestock into mixed systems, cover crops and minimising toxic and synthetic inputs with adverse health and environmental impacts.

Frequently Asked Questions

FAQ 5.5 | Climate change is not the only factor threatening global food security: other than climate action, what other actions are needed to end hunger and ensure access by all people to nutritious and sufficient food all year round?

Our food systems depend on many factors other than climate change, such as food production, water, land, energy and biodiversity. People's access to healthy food can be also be affected by factors such as poverty and physical insecurity. We are all stakeholders in food systems, whether as producers or consumers, and we can all contribute to the goal of a food-secure world by the choices we make in our everyday lives.

Today more than 820 million people are hungry, and hunger is on the rise in Africa. Two billion people experience moderate or severe food shortages, and another 2 billion suffer from overnutrition, a state of obesity or being overweight from unbalanced diets, with related health impacts such as diabetes and heart disease. The changing climate is already affecting food production. These effects are worsening, affecting food production from crops, livestock, fish and forests in many places where people already do not have enough to eat. Food prices will be affected as a result, with increasing risk that poorer people will not be able to buy enough for their families. Food quality will increasingly be affected too.

Our ability to grow and consume food depends on many factors other than climate change. There are tight connections between food production, water, land, energy and biodiversity, for example. Other factors like gender inequity, poverty, political exclusion, remoteness from urban centres and physical insecurity can all affect people's access to healthy food.

Food systems are complicated (Figure FAQ5.5.1). To improve food production, supply and distribution, we need to make changes throughout the food supply chain. For instance: improving the way farmers access the inputs needed to grow food; improving the ways in which food is grown, with climate and market information, training and technical know-how, water-saving and water-harvesting technologies; adopting new low-cost and less carbon-intensive storage and processing methods; and creating local networks of producers and processors For food consumers, we could consider shifts to different diets that are healthier and make more efficient use of natural resources; depending on context, these could involve rebalancing consumption of meat and highly processed foods, reducing food loss and waste, and preparing food in more energy-efficient ways. Policymakers can enable such actions through appropriate price and trade policies, implementing policies for sustainable and low-emission agriculture, providing safety nets where needed, and empowering women, youth and other socially disadvantaged groups.

Our food systems need to be robust and sustainable; otherwise we will not be able to manage the additional pressures imposed on them by climate change. We can all contribute to this goal.

Box FAQ 5.5 (continued)

Conceptual framework of food systems for diets and nutrition

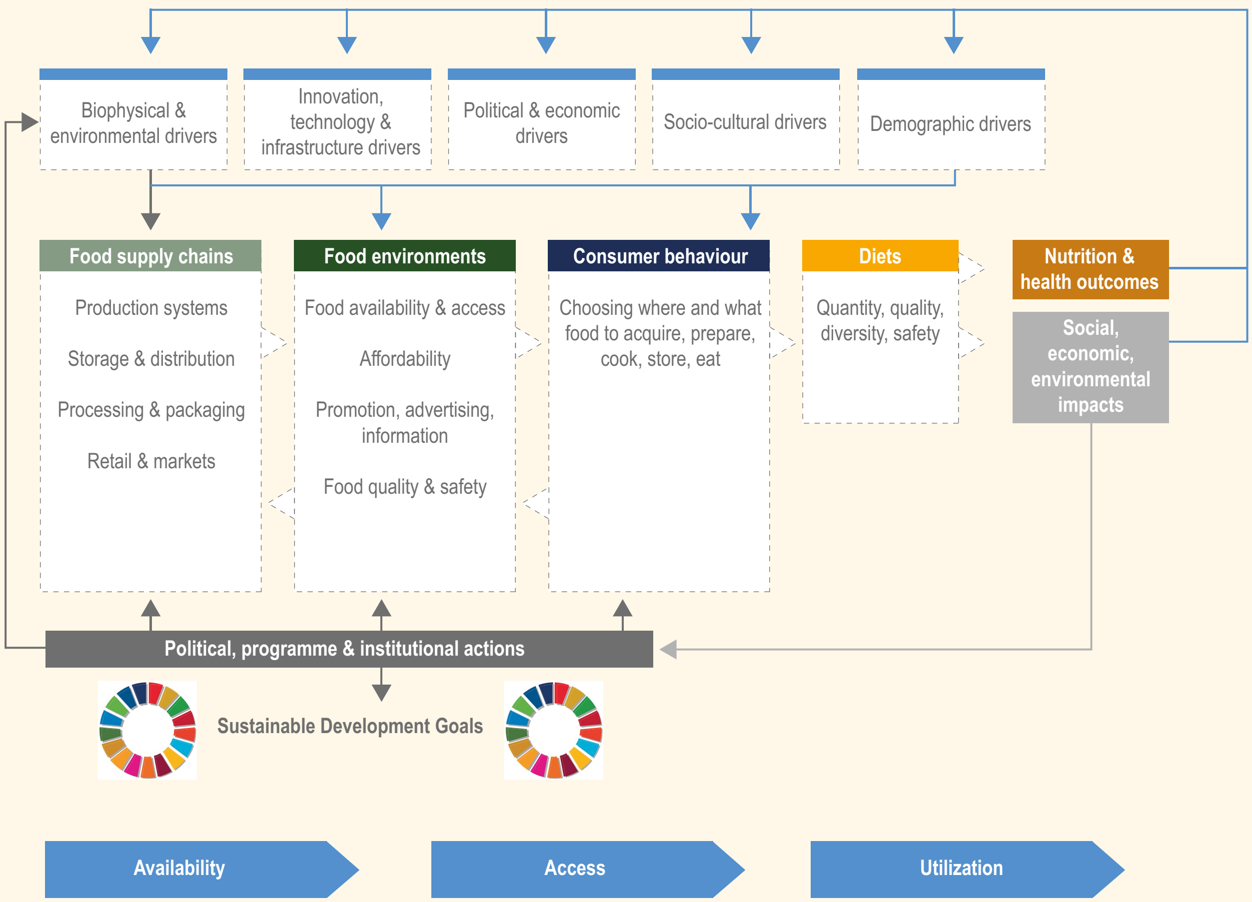


Figure FAQ5.5.1 | Conceptual framework of food systems for diets and nutrition (modified from HLPE, 2017a).

Frequently Asked Questions

FAQ 6.1 | Why and how are cities, settlements and different types of infrastructure especially vulnerable to the impacts of climate change?

Cities, settlements and infrastructure become vulnerable when investment decisions fail to take the risks of climate change fully into account. Such failures can result from a lack of understanding, competing priorities, a lack of finance or access to appropriate technology. Around the world, smaller cities and poorer populations are often most vulnerable and suffer the most over time, while large cities can register the greatest losses to individual events.

The world is urban. Billions of people live in towns and cities. Hardly anyone, even in remote rural locations, is separated from the flows of trade that connect the world and are held together by networks of transport and communication infrastructure systems. Connected networks once broken can cascade out, multiplying impacts across urban and rural areas. When major manufacturing centres or regionally important ports are impacted, global trade suffers. For example, flooding in Bangkok in 2011 led to a global shortage in semiconductors and a slowdown in global computer manufacturing.

Despite cities generating wealth, additional vulnerability to climate change is being created in urban areas every day. Demographic change, social and economic pressures, and governance failures that drive inequality and marginality mean that increasing numbers of people who live in towns and cities are exposed to flooding, temperature extremes and water or food insecurity. This leads to an adaptation gap, where rich neighbourhoods can afford strategies to reduce vulnerability while poorer communities are unable to do the same. Although this would be so even without a changing climate, climate change increases the variability and extremes of weather, exposing more people, businesses and buildings to floods and other events. The combination of rising vulnerability and increasing exposure translates to a growth in the number of people and properties at risk from climate change in cities worldwide.

Around the world, vulnerability is rising but differs considerably between and within urban areas. Settlements of up to 1 million people are the most rapidly expanding and also among the most vulnerable. These settlements often have limited community level organisation and might not have a dedicated local government. Coping with rapid population growth under conditions of climate change and constrained capacity is a major challenge. For large cities, multiple local governments and well-organised community-based organisations interact with large businesses and national political parties in a complicated cocktail of interests that can interfere with planning and action to reduce vulnerability.

For the poorest living in urban slums, informal settlements or renting across the city, lack of secure tenure and inadequate access to basic services compound vulnerability. But even the wealthy in large cities are not fully protected from climate change-related shocks. Just like breaks in infrastructure between towns and rural settlements, big city infrastructure can be broken by even local landslides, floods or temperature events, with consequences cascading across the city. Electricity blackouts are the most common and can affect water pumping, traffic regulation and streetlights, as well as hospitals, schools and homes. Still, it is the urban poor and marginalised who experience the greatest exposure, most vulnerability and least capacity to cope.

Rounds of exposure and impact can reduce the capacity of survivors to cope with future events. As a result, the already vulnerable and exposed become more vulnerable over time, increasing urban inequalities. But this need not be the case. Focussing on vulnerability reduction is not easy, it requires joined-up action across social and economic development sectors, together with critical infrastructure planning. It often also means partnering local government with informal and community-based actors. But there is considerable experience globally on what works and how to deliver reduced vulnerability for the urban poor and for cities as a whole. The challenge is to scale up this experience and accelerate its application to keep pace with climate change and address the adaptation gap.

Frequently Asked Questions

FAQ 6.2 | What are the key climate risks faced by cities, settlements and vulnerable populations today, and how will these risks change in a mid-century (2050) 2°C warmer world?

Climate change will interact with the changing physical environment in cities and settlements to create or exacerbate a range of risks. Rising temperatures and heatwaves will cause human illness and morbidity, as well as infrastructure degradation and failures, while heavy rainfall and sea level rise will worsen flooding. Low-income groups and other vulnerable populations will be affected most severely because of where they live and their limited ability to cope with these stresses.

Cities and settlements are constantly changing. Their populations grow and shrink, economic activities expand or decline, and political priorities shift. The risks that cities and their residents face are influenced by both urban change and climate change. The seriousness of these risks into the 21st Century will be shaped by the interactions between drivers of change including population growth, economic development and land use change.

In a warming world, increasing air temperature makes the urban heat island effect in cities worse. One key risk is heatwaves in cities that are *likely* to affect half of the future global urban population, with negative impacts on human health and economic productivity. Heat and built infrastructure such as streets and houses interact with each other and magnify risks in cities. For instance, higher urban temperatures can cause infrastructure to overheat and fail, as well as increase the concentration of harmful air pollutants such as ozone.

The density of roads and buildings in urban areas increases the area of impermeable surfaces, which interact with more frequent heavy precipitation events to increase the risk of urban flooding. This risk of flooding is greater for coastal settlements due to sea level rise and storm surges from tropical cyclones. Coastal inundation in the Miami-Dade region in Florida, USA, is estimated to have caused over USD 465 million in lost real estate value between 2005 and 2016, and it is *likely* that coastal flood risks in the region beyond 2050 will increase without adaptation to climate change.

Within cities, different groups of people can face different risks. Many low-income residents live in informal settlements alongside coasts or rivers, which greatly heightens exposure and vulnerability to climate-driven hazards. In urban areas in Ghana, for example, risks from urban flooding can compound health risks, and have resulted in outbreaks of malaria, typhoid and cholera. Those outbreaks have been shown to disproportionately affect poorer communities.

Severe risks in cities and settlements also arise from reduced water availability. As urban areas grow, the amount of water required to meet basic needs of people and industries increases. When increased demand is combined with water scarcity from lower rainfall due to climate change, water resource management becomes a critical issue. Low-income groups already face major challenges in accessing water, and the situation is *likely* to worsen due to growing conflicts over scarce resources, increasing water prices and diminishing infrastructure provisions in ever-expanding informal settlements.

These key risks already differ greatly between cities, and between different groups of people in the same city. By 2050, these discrepancies are likely to be even more apparent. Cities with limited financial resources, regulatory authority and technical capacities are less equipped to respond to climate change. People who already have fewer resources and constrained opportunities face higher levels of risk because of their vulnerability. As a result of this, key risks vary not only over time as climate change is felt more strongly, but also over space, between cities exposed to different hazards and with different abilities to adapt, and between social groups, meaning between people who are more or less affected and able to cope.

Frequently Asked Questions

FAQ 6.3 | What adaptation actions in human settlements can contribute to reducing climate risks and building resilience across building, neighbourhood, city and global scales?

Settlements bring together many activities, so climate action will be most effective if it is integrated and collaborative. This requires (i) embedding information on climate change risks into decisions; (ii) building capacity of communities and institutions; (iii) using both nature-based and traditional engineering approaches; (iv) working in partnership with diverse local planning and community organisations; and (v) sharing best practice with other settlements.

Settlements bring together people, buildings, economic activities and infrastructure services, and thus integrated, cross-sector, adaptation actions offer the best way to build resilience to climate change impacts. For example, actions to manage flood risk include installing flood proofing measures within and outside properties, improving capacity of urban drainage along roads, incorporating nature-based solutions (NbS) within the urban areas, constructing flood defences and managing land upstream of settlements to reduce runoff.

Adaptation actions will be more effective if they are implemented in partnership with local communities, national governments, research institutions, and the private and third sector. Climate action should not be considered as an additional or side action to other activities. Rather, climate action should be mainstreamed into existing processes, including those that contribute to the UN Sustainable Development Goals (2015) and New Urban Agenda adopted at the UN Conference on Housing and Sustainable Urban Development (Habitat III) in 2016. Cities are already coming together through international networks to share good practice about adaptation actions, speeding up the dissemination of knowledge.

This integrated approach to adaptation in human settlements needs to be supported by various other actions, including potential co-benefits with carbon emissions reductions, public health and ecosystem conservation goals. First, information on climate risks needs to be embedded into the architectural design, delivery and retrofitting of housing, transportation, spatial planning and infrastructure across neighbourhood and city scales. This includes making information on climate impacts widely available, updating design standards and strengthening regulation to avoid development in high-risk locations. Second, the capacity of communities needs to be strengthened, especially among those in informal settlements, the poorest and other vulnerable groups including minorities, migrants, women, children, elderly, disabled and people with serious health conditions such as obesity. This involves raising awareness, incorporating communities into adaptation processes, and strengthening regulation, policies and provision of infrastructure services. Third, nature-based solutions should be integrated to work alongside traditional 'grey' or engineered infrastructure. Vegetation corridors, greenspace, wetlands and other green infrastructure can be woven into the built environment to reduce heat and flood risks, whilst providing other benefits such as health and biodiversity.

Although even the largest city covers only a small area of the planet, all settlements are part of larger catchments from which people, water, food, energy, materials and other resources support them. Actions within cities should be mindful of wider impacts and avoid displacing issues elsewhere.

Frequently Asked Questions

FAQ 6.4 | How can actions that reduce climate risks in cities and settlements also help to reduce urban poverty, enhance economic performance and contribute to climate mitigation?

If carefully planned, adaptation actions can reduce exposure to climate risk and reduce urban poverty, advance sustainable development and mitigate greenhouse gas emissions. When adaptation responses are equitable, and if a range of voices are heard in the planning process, the needs of the disadvantaged are more likely to be addressed and wider societal benefits can be maximised.

Urbanisation is a global trend which is interacting with climate change to create complex risks in cities and settlements, especially for those that already have high levels of poverty, unemployment, housing informality and backlogs of services. Many cities and settlements are seeing increasing action to manage climate risks. On top of reducing communities' exposure to climate risk, adaptation actions can have benefits for reducing urban poverty and enhancing economic performance in ways that reduce inequality and advance sustainability goals. Adaptation actions, however, can also have unintended consequences. That is why care needs to be taken to ensure climate adaptation planning and development of new infrastructure does not exacerbate inequality or negatively impact other sustainable development priorities. Climate adaptation planning is most effective when it is sensitive to the diverse ways that low-income and minority communities are more *likely* to experience climate risk, including women, children, migrants, refugees, internally displaced peoples and racial/ethnic minority groups, among others.

Adapting to climate change can have benefits for reducing greenhouse gas (GHG) emissions and urban inequalities. In cities where growing numbers of people live in informal settlements, introducing risk-reducing physical infrastructure such as piped water, sanitation and drainage systems can enhance the quality of life of the community. At the same time, those measures can increase health outcomes and reduce urban inequalities by reducing exposure to flooding or heat impacts. In less developed countries, less than 60% of the urban population have access to piped water which, in turn, impacts their health and well-being. Increasingly, housing is being built better to manage heat risk through insulation or changing building orientation, or to flood risk by raising structures, which then contributes to well-being and ability to work. Improvements to early warning systems can help people evacuate rapidly in case of storm surges or flooding. Although the most vulnerable often do not get these warnings in time.

Carefully planned nature-based solutions (NbS), such as public green space, improved urban drainage systems and storm water management, can deliver both health and development benefits. When these adaptation actions succeed, water, waste and sanitation can be improved to better manage climate risk and provide households and cities with better services. Many nature-based solutions entail bringing back plants and trees into cities, which also helps to reduce the concentration of heat-trapping GHGs in the atmosphere.

When care is taken to ensure that adaptation responses are equitable, and that a range of voices are heard in planning, the needs of the disadvantaged are more likely to be addressed. For example, a study that looked at transport plans across 40 cities in Portugal saw that some urban communities have prioritised the needs of disadvantaged users such as the elderly and disabled, while at the same time reducing urban transport emissions and enhancing public well-being and equity of transport. On the other hand, in some cities, there is evidence of emerging trade-offs associated with climate adaptation actions where sea walls and temporary flood barriers were erected in economically valuable areas and not is less well-off areas. Going forward, it is important to ensure that vulnerable groups' needs are carefully considered, both in terms of climate and other risks, as this has not been sufficiently done in the past.

Frequently Asked Questions

FAQ 6.5 | What policy tools, governance strategies and financing arrangements can enable more inclusive and effective climate adaptation in cities and settlements?

Inclusive and effective climate adaptation requires efforts at all levels of governance, including the public sector, the private sector, the third sector, communities and intermediaries such as universities or think tanks. Inclusive and effective adaptation requires action fit for the diverse conditions in which it is needed. Collaborative dialogues can help to map both adaptation opportunities and potential negative impacts.

There is no one-size-fits-all approach to ensure that climate adaptation efforts have positive results and include the concerns of everyone affected. Cities and local communities are diverse, and thus they have diverse perspectives on what responses to prioritise. Moreover, adaptation efforts may impact people's lives in very different ways. Policy tools, strategies and financial arrangements for adaptation can include all society sectors and address socioeconomic inequalities. Planning and decision making must respond to marginalised voices and future generations (including children and youth).

Efforts to adapt to climate change can be incremental, reformist or transformational, depending on the scale of the change required. Incremental action may address specific climate impacts in a given place, but do not challenge the social and political institutions that prevent people from bouncing back better. Reformist action may address some of the social and institutional drivers of exposure and vulnerability, but without addressing the underlying socioeconomic structures that drive differential forms of exposure. For example, social protection measures may improve people's capacity to cope with climate impacts, but that improved capacity will depend on maintaining such protection measures. Transformative action involves fundamental changes in political and socioeconomic systems, oriented toward addressing vulnerability drivers (e.g., socioeconomic inequalities, consumption cultures). All forms of adaptation are relevant to deliver resilient futures because of the variability of conditions in which adaptation action is needed.

Local and regional governments play an essential role in delivering planning and institutional action suited to local conditions in cities and settlements. Potential strategies can span multiple sectors and scales, ranging from land use management, building codes, critical infrastructure designs and community development actions, to different legal, financial, participatory decision making and robust monitoring and evaluation arrangements. NGOs or third sector organisations can also play a coordinating role by building dialogues across governments, the private sectors and communities through effective communication and social learning. Local action tends to falter without the support of national governments as they are often facilitators of resources and finance. They can create institutional frameworks that facilitate (rather than impede) local action. National governments also play a crucial role in the development of large-scale infrastructures.

Private actors can also drive adaptation action. The evaluation of private-led infrastructure and housing projects suggests that the prioritisation of profit, however, may have a detrimental impact on the overall resilience of a place. New institutional models such as public–private partnerships respond to the shortcomings of both the public and private sectors. Still, the evidence of them facilitating the inclusion of multiple actors is mixed.

The private sector can mobilise finance. However, the forms of finance available for adaptation are limited and directed to huge projects that do not always address local adaptation needs. Private actors tend to join adaptation projects when there is an expectation of large profits, such as in interventions that increase real estate value. Private-led adaptation can lead to 'gentrification' whereby low-income populations are relocated from urban centres and safer settlements. Models that enable the collaboration between public, private and civil society sectors have greater potential to mobilise adaptation finance in inclusive ways.

Forms of collaborative planning and decision making can create dialogues for a sustainable future in cities, settlements and infrastructure systems. Adaptation action needs multiple approaches. For example, adaptation needs both actions that depend on dialogues between multiple actors (e.g., urban planning and zoning) and action that follows strong determination and leadership (e.g., declarations of emergency and target commitments). There are adaptation actions that depend on place-based conditions (e.g., flood defences) and those that require considering interactions across scales (e.g., regulatory frameworks). The growth of adaptation capacities, fostering dialogues, empowered communities, multi-scalar assessments and foresight within current institutions can support effective and inclusive adaptation action that is also sustained in the long term.

Frequently Asked Questions

FAQ 7.1 | How will climate change affect physical and mental health and well-being?

Climate change will affect human health and well-being in a variety of direct and indirect ways that depend on exposure to hazards and vulnerabilities that are heterogeneous and vary within societies, and that are influenced by social, economic and geographical factors and individual differences (see Figure FAQ7.1.1). Changes in the magnitude, frequency and intensity of extreme climate events (e.g., storms, floods, wildfires, heatwaves and dust storms) will expose people to increased risks of climate-sensitive illnesses and injuries and, in the worst cases, higher mortality rates. Increased risks for mental health and well-being are associated with changes caused by the impacts of climate change on climate-sensitive health outcomes and systems (see Figure FAQ7.1.2). Higher temperatures and changing geographical and seasonal precipitation patterns will facilitate the spread of mosquito- and tick-borne diseases, such as Lyme disease and dengue fever, and water- and food-borne diseases. An increase in the frequency of extreme heat events will exacerbate health risks associated with cardiovascular disease and affect access to freshwater in multiple regions, impairing agricultural productivity and increasing food insecurity, undernutrition and poverty in low-income areas.

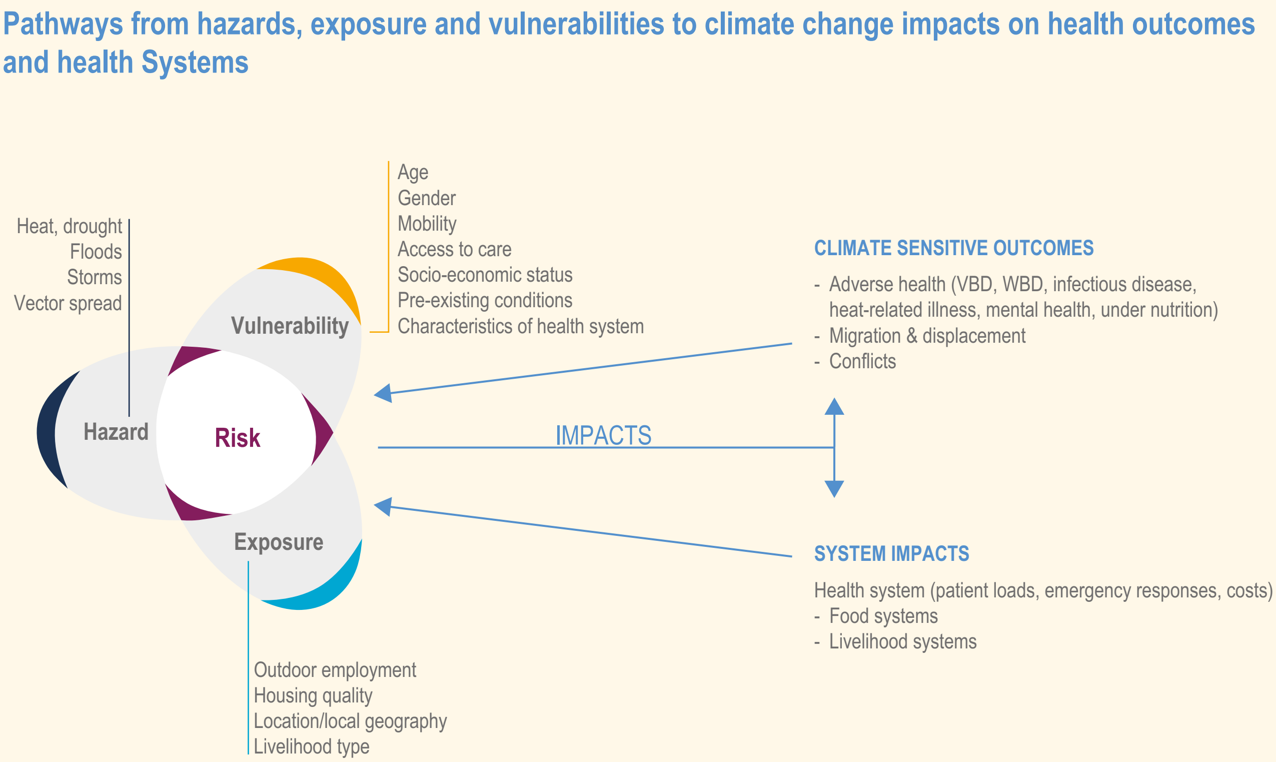


Figure FAQ7.1.1 | Pathways from hazards, exposure and vulnerabilities to climate change impacts on health outcomes and health systems. WBD: waterborne disease, VBD: Vector-borne disease, and FBD: Food-borne disease.

Box FAQ 7.1 (continued)

Climate change impacts on mental health and adaptation responses

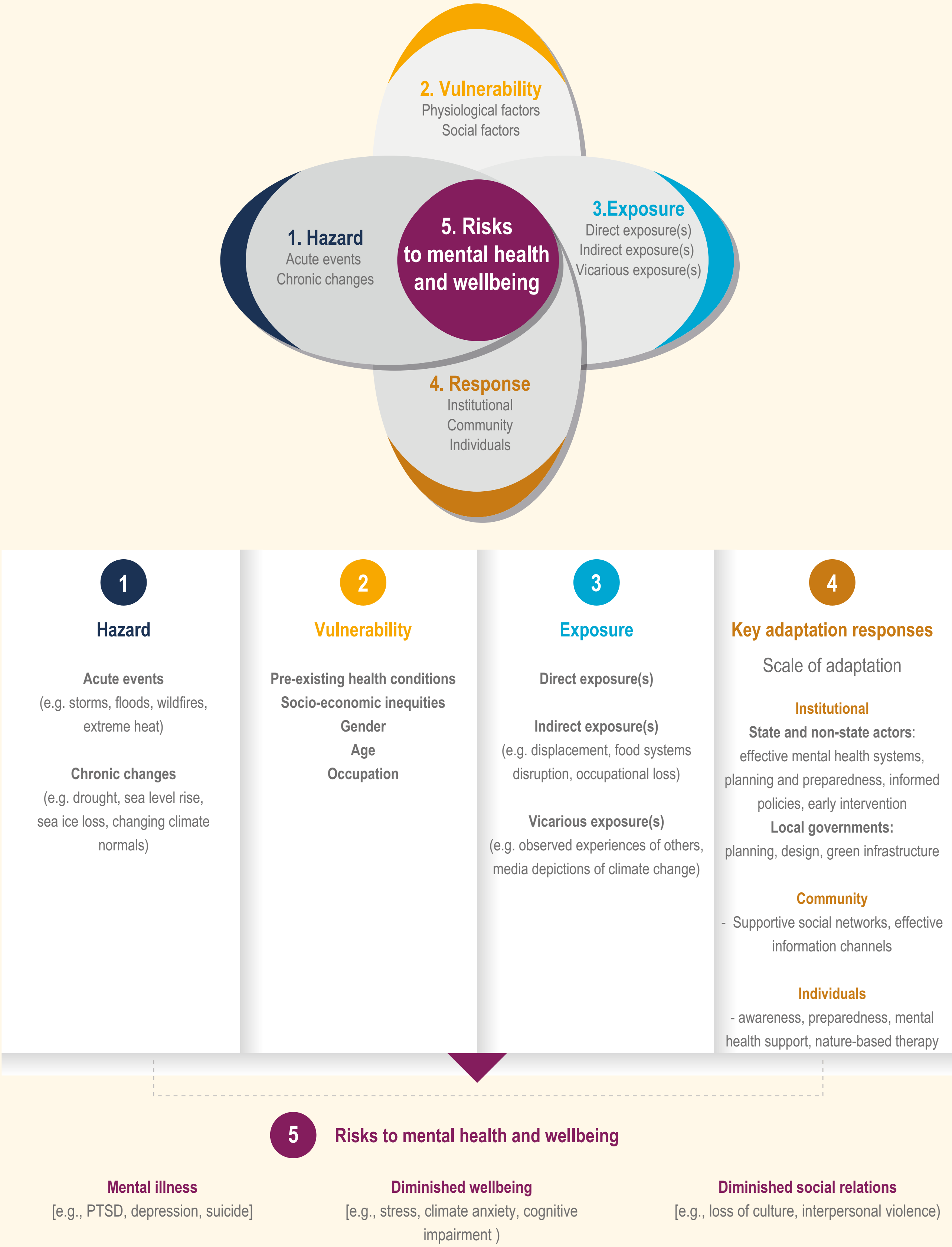


Figure FAQ7.1.2 | Climate change impacts on mental health and key adaptation responses.
PTSD: Post traumatic stress disorder.

Frequently Asked Questions

FAQ 7.2 | Will climate change lead to wide-scale forced migration and involuntary displacement?

Climate change will have impacts on future migration patterns that will vary by region and over time, depending on the types of climate risks people are exposed to, their vulnerability to those risks and their capacity—and the capacity of their governments—to adapt and respond. Depending on the range of adaptation options available, households may use migration as a strategy to adapt to climate risks, often through labour migration. The most common drivers of climate-related displacement are extreme weather events, floods and droughts, especially when these events cause severe damage to homes, livelihoods and food systems. Rising sea levels will present a new risk for communities situated in low-lying coastal areas and small island states. The greater the scale of future warming and extreme events, the greater the potential scale of future, involuntary climate-related migration and displacement.Progress towards achieving the Sustainable Development Goals (SDGs) has strong potential to reduce future involuntary climate-related migration and displacement.

Frequently Asked Questions

FAQ 7.3 | Will climate change increase the potential for violent conflict?

Climate hazards have affected armed conflict within countries but the observed influence of climate is small relative to socioeconomic, political and cultural factors. Adverse impacts of climate change threaten to increase poverty and inequality, undermine progress in meetings Sustainable Development Goals (SDGs) and place strain on civil institutions—all of which are factors that contribute to the emergence or worsening of civil unrest and conflict. Climate change impacts on crop productivity and water availability can function as a 'risk multiplier' for conflict in areas that are already politically and/or socially fragile and, depending on circumstances, could increase the length or the nature of an existing conflict. Institutional initiatives within or between states to protect the environment and manage natural resources can serve simultaneously as mechanisms for engaging rival groups and adversaries to cooperate in policymaking and peacebuilding.

Frequently Asked Questions

FAQ 7.4 | What solutions can effectively reduce climate change risks to health, well-being, forced migration and conflict?

The solution space includes policies, strategies and programmes that consider why, how, when and who should be involved to sustainably adapt to climate change. Effectively preparing for and managing the health risks of climate change requires considering the multiple interacting sectors that affect population health and effective functioning of health systems. Considering the close inter-connections between health, migration and conflict, interventions that address climate risks in one area often have synergistic benefits in others. For example, conflicts often result in large numbers of people being involuntarily displaced and facilitate the spread of climate-sensitive diseases; tackling the underlying causes of vulnerability and exposure that generate conflict reduces risks across all areas. A key starting point for health and well-being is strengthening public health systems so that they become more climate resilient, which also requires cooperation with other sectors (water, food, sanitation, transportation, etc.) to ensure appropriate funding and progress on sustainable development goals. Interventions to enhance protection against specific climate-sensitive health risks could reduce morbidity and mortality and prevent many losses and damages (Figure FAQ7.4.1). These range from malaria net initiatives, vector control programmes, health hazard (syndromic) surveillance and early warning systems, improving access to water, sanitation and hygiene (WASH), heat action plans (HAPs), behavioural changes and integration with disaster risk reduction (DRR) and response strategies. More importantly, climate resilient development pathways (CRDPs) are essential to improve overall health and well-being, reduce underlying causes of vulnerability and provide a framework for prioritising mitigation and adaptation options that support sustainable development. Transformative changes in key sectors including water, food, energy, transportation and built environments offer significant co-benefits for health.

Adaptation responses to climatic risks

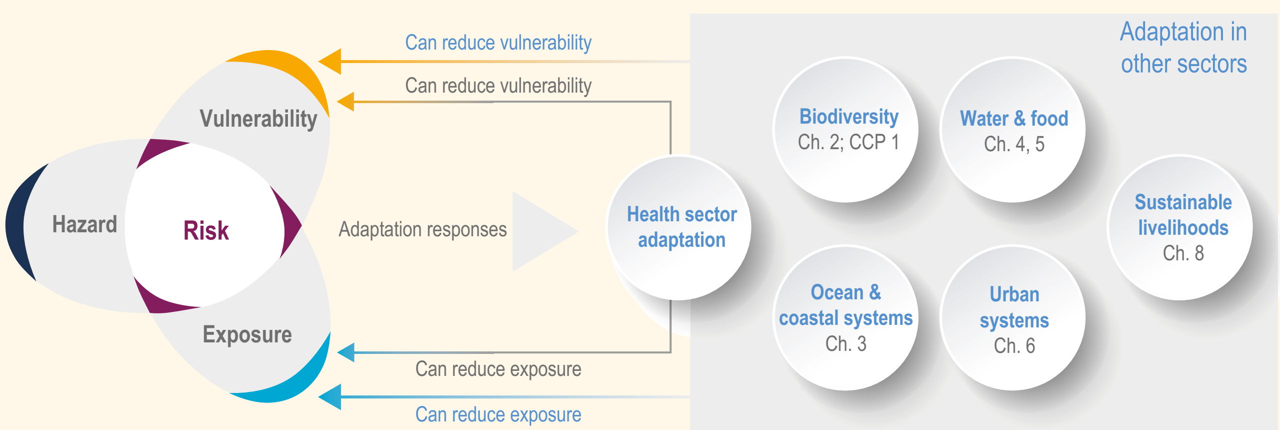


Figure FAQ7.4.1 | Solution space for adaptation to climate change in health and other sectors.

Frequently Asked Questions

FAQ 7.5 | What are some specific examples of actions taken in other sectors that reduce climate change risks in the health sector?

Many actions taken in other sectors to address the risks of climate change can lead to benefits for health and well-being. Adaptive urban design that provides greater access to green and natural spaces simultaneously enhances biodiversity, improves air quality and moderates the hydrological cycle; it also helps reduce health risks associated with heat stress and respiratory illnesses, and mitigates mental health challenges associated with congested urban living. Transitioning away from internal-combustion vehicles and fossil fuel-powered generating stations to renewable energy mitigates greenhouse gas emissions, improves air quality and lowers the risks of respiratory illnesses. Policies and designs that facilitate active urban transport (walking and bicycling) increase efficiency in that sector, reduce emissions, improve air quality and generate physical and mental health benefits for residents. Improved building and urban design that foster energy efficiency improve indoor air quality and reduce risks of heat stress and respiratory illness. Food systems that emphasise healthy, plant-centred diets reduce emissions in the agricultural sector while helping in the fight against malnutrition.

Frequently Asked Questions

FAQ 8.1 | Why are people who are poor and disadvantaged especially vulnerable to climate change and why do climate change impacts worsen inequality?

Poor people and their livelihoods are especially vulnerable to climate change because they usually have fewer assets and less access to funding, technologies and political influence. Combined, these constraints mean they have fewer resources to adapt to climate change impacts. Climate change impacts tend to worsen inequalities because they disproportionately affect disadvantaged groups. This in turn further increases their vulnerability to climate change impacts and reduces their ability to cope and recover.

Climate change and related hazards (e.g., droughts, floods, heat stress, etc.) affect many aspects of people's lives—such as their health, access to food and housing, or their source of income such as crops or fish stocks—and many will have to adapt their way of life in order to deal with these impacts. People who are poor and have few resources with which to adapt are thus much more seriously negatively affected by climate-related hazards. 'Vulnerability' is when a person or community is not able to cope and adapt to climate-related hazards. For example, if someone who is very rich has their house washed away in a flood, this is terrible, but they often have more resources to rebuild, have insurances that support recovery and maybe even build a house that is not in a flood-prone area. Whereas for someone who is very poor and who does not live in a state that provides support, the loss of their house in a flood could mean homelessness. This example shows that the same climate hazard (flood) can have a very different impact on people depending on their vulnerability (their capacity to cope and adapt to hazards).

It is not just poverty that can make people more vulnerable to climate change and climate-related hazards. Disadvantage due to discrimination, gender and income inequalities and lack of access to resources (e.g., those with disabilities or of minority groups) can mean these groups have fewer resources with which to prepare and react to climate change and to cope with and recover from its adverse effects. They are therefore more vulnerable. This vulnerability can then increase due to climate change impacts in a vicious cycle unless adaptation measures are supported and made possible.

Frequently Asked Questions

FAQ 8.2 | Which world regions are highly vulnerable and how many people live there?

A mix of multiple development challenges, such as poverty, hunger, conflict and environmental degradation, make countries and whole regions vulnerable to climate change. Many of the people in the most vulnerable situations and in the most vulnerable regions are also highly exposed to climate hazards, such as droughts, floods or sea level rise at present and will become increasingly so in the future. Studies estimate that around 3.3 to 3.6 billion people are living in regions classified as highly vulnerable to climate change impacts, which is significantly higher than the number of people who reside in regions classified as least vulnerable. The most vulnerable regions include East, Central and West Africa, South Asia, Micronesia and Melanesia, and Central America.

When a country or region is considered 'vulnerable' to climate change this means that climate hazards (e.g., drought, flood, heatwaves) have a very negative impact because there is a high number of people in these areas that lack the ability or opportunity to cope and adapt to such events, due to, for example, high average poverty, inequality and lack of institutional support. This vulnerability could be due to many different development challenges that all come together and influence each other, such as poverty, lack of access to basic infrastructure services, high numbers of uprooted people, state fragility, low or below average life expectancy and biodiversity degradation. These structural social issues often affect regions for many decades and make it difficult for the state and for individuals to respond to climate change and climate-related hazards.

For example, if a region is already characterised by poverty and struggling to feed its population and provide adequate access to basic infrastructure services, such as water and sanitation, this makes them vulnerable. If this region is then faced with an increased number of extremely dry years, this exposes them to drought and will make things even harder causing more hunger, poverty and worsened health—these are climate impacts.

Most vulnerable regions are in Africa, as well as in South Asia, the Pacific and the Caribbean. In these regions, there are often multiple neighbouring countries that all are highly vulnerable, for example in Central and West Africa. These regional clusters require special attention.

There are also highly vulnerable groups and individuals within less vulnerable regions. For example, marginalised, disadvantaged and poor minorities within highly affluent cities. Programmes that aim to support adaptation to climate change need to focus on reducing the vulnerability of individuals, groups, countries and regions.

Frequently Asked Questions

FAQ 8.3 | How does and will climate change interact with other global trends (e.g., urbanisation, economic globalisation) and shocks (e.g., COVID-19) to influence livelihoods of the poor?

A range of local, regional and global economic and political processes already underway have put the livelihoods of the poor at risk. These processes include urbanisation, industrialisation, technological transformation, monetisation of rural economies, increasing reliance on wages, and inequality at national and international levels. Climate change intersects with these processes.

The world's poorest already struggle to provide for themselves and their families in their pursuit of livelihoods. Despite hard work there are many factors beyond an individual's control that can make earning a living very difficult. Climate change is one problem among many that puts stress on livelihoods. Poor and marginal groups disproportionately bear impacts of climate change, in ways that accelerate transitions from traditional livelihoods, such as rural farming, to wage jobs in urban areas. Where adaptation measures are insufficient and where the poor are excluded from decision making, these livelihood transitions can be severely destabilising.

For example, climate change may alter the frequency or intensity of hazards that threaten the viability of a community's traditional farming or fishing livelihoods. Local farmers or fishers are then forced to adapt how they farm or fish or abandon livelihood practices entirely. The latter may mean migrating to a city to find work. As many communities face the same challenge, this intersects with a global trend that is affecting billions of lives and livelihoods—urbanisation—as seen in the rapid growth of informal settlements at the peripheries of cities around the world, particularly rapidly growing mega-cities in Africa, Asia and Latin America. These developments will be accelerated by negative impacts of climate change and increase risks that larger segments of the population enter conditions of persistent poverty.

At the same time, people whose livelihoods have been upended by climate change are subject to new threats, such as the global COVID-19 pandemic, which has shone a light on the plight of the most vulnerable people. For example, the elderly, Indigenous Peoples and Communities of Colour were disproportionately severely impacted by COVID-19; also the indirect economic consequences particularly hit the poor. Hence, COVID-19 demonstrates that the livelihoods of the poorest and most marginalised are vulnerable to other global trends beyond climate change. Also, most severe impacts are expected in regions that are already characterised by high levels of systemic human vulnerability.

Frequently Asked Questions

FAQ 8.4 | What can be done to help reduce the risks from climate change, especially for the poor?

Public and private investment in different types of assets can help reduce risks from climate change. Exactly which assets require investment depends on the specific situation. However, the provision of access to basic services, such as water and sanitation, education and health care as well as the importance of reducing inequity is shown within the assessment for many regions. The poor have fewer resources to invest, so in poorer countries greater public investment is needed. Legal, social, political, institution and economic interventions can alter human behaviour, though care must be taken that these do not amplify existing inequalities, create new inequalities or reduce future adaptation options.

Adaptation can help to reduce risks for the poor and requires both public and private investment in various natural assets (e.g., mangroves, farmland, wetlands), human assets (e.g., health, skills, Indigenous knowledge), physical assets (e.g., mobile phone connectivity, housing, electricity, technology), financial assets (e.g., savings, credit) and social assets (e.g., social networks, membership of organisations such as farmer cooperatives). Often, the poor have the least to invest, so poverty can reduce adaptation options. Sometimes people migrate as a reaction to floods or droughts, though the poorest groups often lack the resources to move. Exactly what needs investing in to reduce risks varies according to the scale and livelihood system in need of adaptation. In general, risks can be reduced through a range of different technological and engineering approaches (for example, building sea defences to reduce storm surge impacts), as well as ecosystem-based approaches (such as replanting mangroves, altering the types of crops grown, changing the timing of farming activities, or using climate-smart agriculture or agroforestry approaches).

At the same time, legal, social, political, institutional and economic solutions can alter human behaviour (e.g., through enforcement of building codes to prevent construction on low-lying land prone to flooding, timely provision of weather information and early warning systems, knowledge-sharing activities, including adaptation strategies grounded in Indigenous knowledge, crop insurance schemes, incentives such as payments to stop people cutting down trees or to enable them to plant them and social protection to provide a safety net in times of crisis).

The poorest groups often require greater public adaptation investments. Efforts to support adaptation need to be mindful of reinforcing existing inequalities and introducing new ones, making sure they are inclusive, culturally sensitive and that the voices of all groups of people are heard. It is also important that adaptations which reduce immediate risks for the poor do not rule out adaptation options that could help them later on or which could cause them to increase their emissions. Political will is needed to put people at the centre of climate change risk reduction efforts, including support for their livelihoods.

Frequently Asked Questions

FAQ 8.5 | How do present adaptation and future responses to climate change affect poverty and inequality?

Present adaptation can help to reduce the current and possibly future impacts of climate change. Future responses to climate change can reduce poverty and inequality, and even help transition toward climate-resilient livelihoods and climate resilient development. Pro-poor adaptation planning is necessary to ensure future risks for the poor are being accounted for and the inequality underlying the poverty is being addressed.

There are many ways in which poverty and inequality are influenced by climate change. The livelihood sources of the poor are likely to be affected and cumulative effects of losses and damages, and may influence future poverty. There are cases when present adaptation worsens future poverty and exacerbates inequality—this is called maladaptation. The risks of maladaptation are greater in societies characterised by high inequality, and in many cases the poor and most vulnerable groups are the ones most adversely affected.

Effective decision making in adaptation should be informed by past, present and future climate data, information and scenarios to cater for reliable plans and actions for climate-resilient livelihoods. Adaptation lessons from the past play an important role in decision making regarding responses to climate change. There is an emerging debate on the role of learning, particularly forward-looking (anticipatory) learning, as a key element or important aspect for adaptation and resilience in the context of climate change. Memory, monitoring of key drivers of change, scenario planning and measuring anticipatory capacity are seen as crucial ingredients for future adaptation and resilience pathways, and, hence overcoming maladaptation. Moreover, climate resilient development calls for ensuring synergies between adaptation, mitigation and development are maximised, while trade-offs, especially those affecting the poor, are minimised.

Frequently Asked Questions

FAQ 9.1 | Which climate hazards impact African livelihoods, economies, health and well-being the most?

Climate extremes, particularly extreme heat, drought and heavy rainfall events, impact the livelihoods, health, and well-being of millions of Africans. They will also continue to impact African economies, limiting adaptation capacity. Interventions based on resilient infrastructure and technologies can achieve numerous developmental and adaptation co-benefits.

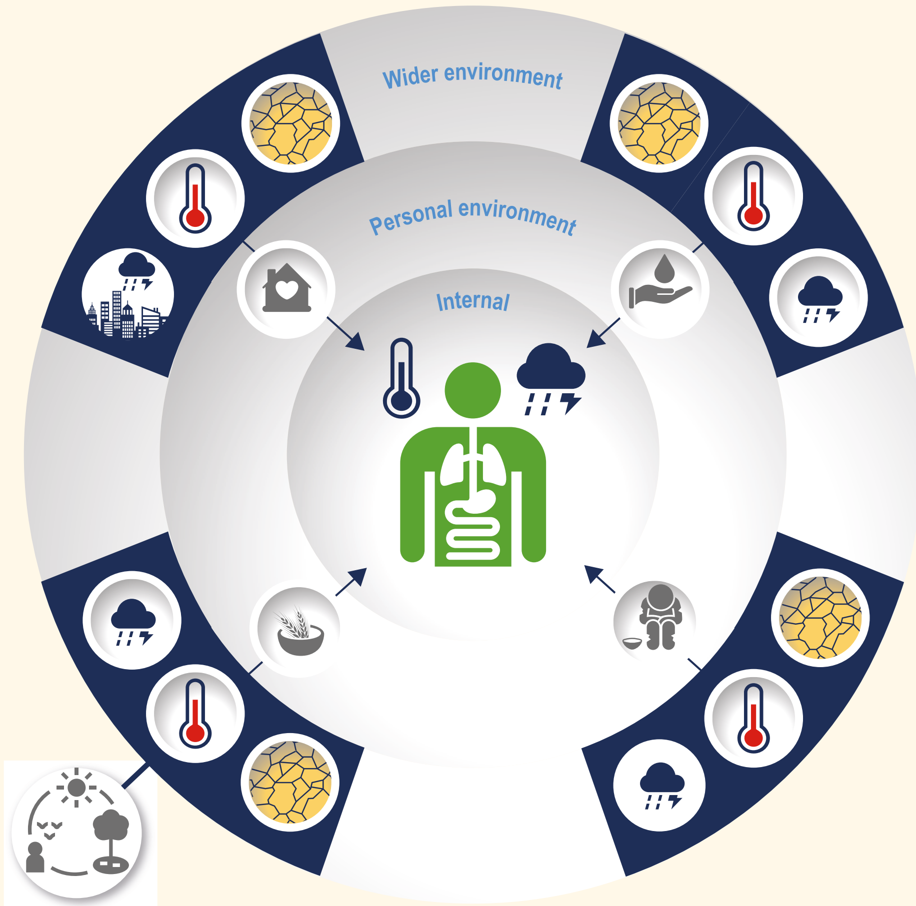
Multi-year droughts have become more frequent in west Africa, and the 2015–2017 Cape Town drought was three times more likely due to human-caused climate change. Above 2°C global warming, drought frequency is projected to increase, and duration will double from approximately 2 to 4 months over north Africa, the western Sahel and southern Africa. Estimates of increased exposure to water stress are higher than those for decreases. By 2050, climate change could expose an additional 951 million people in sub-Saharan Africa to water stress while also reducing exposure to water stress by 459 million people. Compared to population in 2000, human displacement due to river flooding in sub-Saharan Africa is projected to triple for a scenario of low population growth and 1.6°C global warming. Changing rainfall distributions together with warming temperatures will alter the distributions of disease vectors like mosquitoes and midges. Malaria vector hotspots and prevalence are projected to increase in east and southern Africa and the Sahel under even moderate greenhouse gas emissions scenarios by the 2030s, exposing an additional 50.6–62.1 million people to malaria risk.

Increases in the number of hot days and nights, as well as in heatwave intensity and duration, have had negative impacts on agriculture, human health, water availability, energy demand and livelihoods. By some estimates, African countries' Gross Domestic Product per capita is on average 13.6% lower since 1991 than if human-caused global warming had not occurred. In the future, high temperatures combined with high humidity exceed the threshold for human and livestock tolerance over larger parts of Africa and with greater frequency. Increased average temperatures and lower rainfall will further reduce economic output and growth in Africa, with larger negative impacts than on other regions of the world.

Resilient infrastructure and technologies are required to cope with the increasing climate variability and change (Figure FAQ9.1.1). These include improving housing to limit heat and exposure, along with improving water and sanitation infrastructure. Such interventions to ensure that the most vulnerable are properly protected from climate change have many co-benefits, including for pandemic recovery and prevention.

Box FAQ 9.1 (continued)

A schematic illustration of the interconnectedness of different sectors and impacts



Climate hazards

- Extreme weather
- Extreme temperatures, heat
- Reduced precipitation, drought

Direct influences on Health & wellbeing

- Food
- Shelter/housing
- Water
- Poverty
- Ecosystem
- Cities/community

Figure FAQ9.1.1 | A schematic illustration of the interconnectedness of different sectors and impacts that spillover to affect the health and well-being of African people.

Frequently Asked Questions

FAQ 9.2 | What are the limits and benefits of climate change adaptation in Africa?

The capacity for African ecosystems to adapt to changing environmental conditions is limited by a range of factors, from heat tolerance to land availability. Adaptation across human settlements and food systems are further constrained by insufficient planning and affordability. Integrated development planning and increasing finance flows can improve African climate change adaptation.

With increasing warming, there is a lower likelihood species can migrate rapidly enough to track shifting climates, increasing extinction risk across more of Africa. At 2°C global warming more than 10% of African species are at risk of extinction. Species ability to disperse between areas to track shifting climates is limited by fencing, transport infrastructure, and the transformation of landscapes to agriculture and urban areas. Many species will lose large portions of their suitable habitats due to increases in temperature by 2100. Coupled with projected losses of Africa's protected areas, higher temperatures will also reduce carbon sinks and other ecosystem services. Many nature-based adaptation measures (e.g., for coral reefs, mangroves, marshes) are less effective or no longer effective above 1.5°C of global warming. Human-based adaptation strategies for ecosystems reach their limits as availability and affordability of land decreases, resulting in migration, displacement and relocation.

The limits to adaptation for human settlements arise largely from developmental challenges associated with Africa's rapid urbanisation, poor development planning, and increasing numbers of urban poor residing in informal settlements. Further limits arise from insufficient consideration of climate change in adaptation planning and infrastructure investment and insufficient financial resources. There are also limits to adaptation for food production strategies. Increasing climate extreme events—droughts and floods—impose specific adaptation responses which poorer households cannot afford. For instance, the use of early maturing or drought-tolerant crop varieties may increase resilience, but adoption by smallholder farmers is hindered by the unavailability or unaffordability of seed.

Adaptation in Africa can reduce risks at current levels of global warming. However, there is very limited evidence for the effectiveness of current adaptation at increased global warming levels. Ambitious, near-term mitigation would yield the largest single contribution to successful adaptation in Africa.

Current adaptation finance flows are billions of USD less than the needs of African countries and around half of finance commitments to Africa reported by developed countries remain undisbursed. Increasing adaptation finance flows by billions of dollars (including public and private sources), removing barriers to accessing finance and providing targeted country support can improve climate change adaptation across Africa.

Frequently Asked Questions

FAQ 9.3 | How can African countries secure enough food in changing climate conditions for their growing populations?

Climate change is already impacting African food systems and will worsen food insecurity in sub-Saharan Africa in the future. An integrated approach to adaptation planning can serve as a flexible and cost-effective solution for addressing African food security challenges.

Maize and wheat yields have decreased an average of 5.8% and 2.3%, respectively, in sub-Saharan Africa due to climate change. Among the 135 million acutely food-insecure people in crisis globally, more than half (73 million) are in Africa. This is partly due to the growing severity of drought with increasing temperatures also a severe risk factor. Adding to these challenges, Africa has the fastest-growing population in the world that is projected to grow to around 40% of the world's population by 2100.

Sustainable agricultural development combined with enabling institutional conditions, such as supportive governance systems and policy, can provide farmers with greater yield stability in uncertain climate conditions. It is also widely acknowledged that an integrated approach for adaptation planning that combines (a) climate information services, (b) capacity building, (c) Indigenous and local knowledge systems and (d) strategic financial investment can serve as a flexible and cost-effective solution for addressing African food security challenges.

Frequently Asked Questions

FAQ 9.4 | How can African local knowledge serve climate adaptation planning more effectively?

A strong relationship between scientific knowledge and local knowledge is desirable, especially in developing contexts where technology for prediction and modelling is least accessible.

In many African settings, farmers use the local knowledge gained over time—through experience and passed on orally from generation to generation—to cope with climate challenges. Indigenous Knowledge systems of weather and climate patterns include early warning systems, agroecological farming systems and observation of natural or non-natural climate indicators. For instance, biodiversity and crop diversification are used as a buffer against environmental challenges: if one crop fails, another could survive. Local knowledge of seasons, storms and wind patterns is used to guide and plan farming and other activities.

Collaborative partnerships between research, agricultural extension services and local communities would create new avenues for the co-production of knowledge in climate change adaptation to better inform adaptation policies and practices across Africa.

Frequently Asked Questions

FAQ 10.1 | What are the current and projected key risks related to climate change in each sub-region of Asia?

Climate-change-related risks are projected to increase progressively at 1.5°C, 2°C and 3°C of global warming in many parts of Asia. Heat stress and water deficit are affecting human health and food security. Risks due to extreme rainfall and sea level rise are exacerbated in vulnerable Asia.

Climatologically, the summer surface air temperature in South, Southeast and Southwest Asia is high, and its coastal area is very humid. In these regions, heat stress is already a medium risk for humans. Large cities are warmer by more than 2°C compared with the surroundings due to heat island effects, exacerbating heat stress conditions. Future warming will cause more frequent temperature extremes and heatwaves especially in densely populated South Asian cities, where working conditions will be exacerbated and daytime outdoor work will become dangerous. For example, incidence of excess heat-related mortality in 51 cities in China is estimated to reach 37,800 deaths per year over a 20-year period in the mid-21st century (2041–2060) under the RCP8.5 scenario.

Asian glaciers are the water resources for local and adjacent regions. Glaciers are decreasing in Central, Southwest, Southeast and North Asia, but are stable or increased in some parts of the Hindu Kush Himalaya region. The glacier melt water in the southern Tibetan Plateau increased during 1998–2007, and the total amount and area of glacier lakes has increased during recent decades. In the future, maximum glacial runoff is projected in High Mountain Asia. Glacier collapses and surges, together with glacier lake outburst flood due to the expansion of glacier lakes, will threaten the securities of the local and down streaming societies.

With much of the Asian population living in drought-prone areas, water scarcity is a prevailing risk across Asia through water and food shortage leading to malnutrition. Populations vulnerable to impacts related to water are going to increase progressively at 1.5°C, 2°C and 3°C of global warming. Aggravating drought condition is projected in Central Asia. Water quality degradation also has profound impact on human health.

Extreme rainfall causes floods in vulnerable rivers. Observed changes in extreme rainfall vary considerably by region in Asia. Extreme rainfall events (such as heavy rainfall >100 mm per day) have been increasing in South and East Asia. In the future, most of East and Southeast Asia are projected to experience more intense rainfall events as soon as by the middle of the 21st century. In those regions, the flood risk will become more frequent and severe. It is estimated that over one-third of Asian cities and about 932 million urban dwellers are living in areas with high risk of flooding.

Sea level rise is continuing. Higher than the global mean sea level rise is projected on Asian coasts. Storm surge and high wave by tropical cyclones of higher intensity are high risk for a large number of Asian megacities facing the ocean: China, India, Bangladesh, Indonesia and Vietnam have the highest numbers of coastal populations exposed and thus are most vulnerable to disaster-related mortality.

Changes in terrestrial biome have been observed that are consistent with warming, such as an upward move of treeline position in mountains. Climate change, human activity, lightning and quality of forest governance and management have increased wildfire severity and area burned in North Asia in recent decades. Changes in marine primary production also have been observed: a decrease up to 20% over the past six decades in the western Indian Ocean, due to ocean warming and stratification, has restricted nutrient mixing. The risk of irreversible loss of many ecosystems will increase with global warming.

The likelihood of adverse impacts to agricultural and food security in many parts of developing Asia will progressively escalate with the changing climate. The potential of total fisheries production in South and Southeast Asia is also projected to decrease.

FAQ 10.1 (continued)

Figure FAQ10.1.1 | Key risks related to climate change in Asia.

Frequently Asked Questions

FAQ 10.2 | What are the current and emerging adaptation options across Asia?

Mirroring the heterogeneity across Asia, different countries and communities are undertaking a range of reactive and proactive strategies to manage risk in various sectors. Several of these adaptation actions show promise, reducing vulnerability and improving societal well-being. However, challenges remain around scaling up adaptation actions in a manner that is effective and inclusive while simultaneously meeting national development goals.

Asia exhibits tremendous variation in terms of ecosystems, economic development, cultures and climate risk exposure. Mirroring this variation, households, communities and governments have a wide range of coping and adaptation strategies to deal with changing climatic conditions, with co-benefits for various non-climatic issues such as poverty, conflict and livelihood dynamics.

Currently, Asian countries have rich evidence on managing risk, drawing on long histories of dealing with change. For example, to deal with erratic rainfall and shifting monsoons, farmers make incremental shifts such as changing what and when they grow or adjusting their irrigation practices. Communities living in coastal settlements are using Early warning systems to prepare for cyclones or raising the height of their houses to minimise flood impacts. These types of strategies, seen across all Asian sub-regions, based on local social and ecological contexts, are termed *autonomous adaptations* that occur incrementally and help people manage current impacts.

Currently and in the future, Asia is identified as one of regions most vulnerable to climate change, especially on extreme heat, flooding, sea level rise and erratic rainfall. All these climatic risks, when overlaid on existing development deficits, show us that incremental adaptation will not be enough; transformational change is required. Recognising this, at subnational and national levels, government and non-governmental actors are also prioritising *planned adaptation strategies* which include interventions like ‘climate-smart agriculture’ as seen in South and Southeast Asian countries, or changing labour laws to reduce exposure to heat as seen in West Asia. These are often sectoral priorities governments lay out through national or subnational policies and projects, drawing on various sources of funding: domestic, bilateral and international. Apart from these planned adaptation strategies in social systems, Asian countries also report and invest in adaptation measures in natural systems such as expanding nature reserves to enable species conservation or setting up habitat corridors to facilitate landscape connectivity and species movements across climatic gradients.

Overall, the fundamental challenges that Asia will see exacerbated under climate change are around water and food insecurity, poverty and inequality, and increased frequency and severity of extreme events. In some places and for some people, climate change, even at 1.5°C and more so at 2°C, will significantly constrain the functioning and well-being of human and ecological systems. Asian cities, villages and countries are rising to this current and projected challenge, albeit somewhat unevenly.

Some examples of innovative adaptation actions are China’s ‘Sponge Cities’ which are trying to protect ecosystems while reducing risk for people, now and in the future. Another example is India’s Heat Action Plans that are using ‘cool roofs’ technologies and awareness-building campaigns to reduce the impacts of extreme heat. Across South and Southeast Asia, climate-smart agriculture programmes are reducing GHG emissions associated with farming while helping farmers adapt to changing risks. Each country is experimenting with infrastructural, nature-based, technological, institutional and behavioural strategies to adapt to current and future climate change with local contexts shaping both the possibility of undertaking such actions as well as the effectiveness of these actions to reduce risk. What works for ageing cities in Japan exposed to heatwaves and floods may not work for pastoral communities in the highlands of Central Asia, but there is progress on understanding what actions work and for whom. The challenge is to scale current adaptation action, especially in the most exposed areas and for the most vulnerable populations, as well as move beyond adapting to single risks alone (i.e., adapt to multiple coinciding risks such as flooding and water scarcity in coastal cities across South Asia or extreme heat and flash floods in West Asia). In this context, funding and implementing adaptation is essential, and while Asian countries are experimenting with a range of autonomous and planned adaptation actions to deal with these multiple and often concurrent challenges, making current development pathways climate resilient is necessary and, some might argue, unavoidable.

FAQ 10.2 (continued)

Table FAQ10.2.1 | System transitions, sectors and illustrative adaptation options

System transitions	Sectors	Illustrative adaptation options
Energy and industrial systems	Energy and industries	Diversifying energy sources Improving energy access, especially in rural areas Improving resilience of power infrastructure Rehabilitation and upgrading of old buildings
Land and ecosystems	Terrestrial and freshwater ecosystems	Expanding nature reserves Assisted species migration Introducing species to new regions to protect them from climate-induced extinction risk Sustainable forest management including afforestation, forest fuel management, fire management
	Ocean and coastal ecosystems	Marine protected areas Mangrove and coral reef restoration Integrated coastal zone management Sand banks and structural technologies
	Freshwater	Integrated watershed management Transboundary water management Changing water access and use practices to reduce/manage water demand High-efficiency water-saving technology Aquifer storage and recovery
	Agriculture, fisheries and food	Changing crop type and variety, improving seed quality Water storage, irrigation and water management Climate-smart agriculture Early warning systems and use of climate information services Fisheries management plans (e.g., seasonal closures, limited fishing licenses, livelihood diversification)
Urban systems	Cities and settlements	Flood protection measures and sea walls sustainable land-use planning and regulation Protecting urban green spaces, improving permeability, mangrove restoration in coastal cities Planned relocation and migration Disaster management and contingency planning
	Key infrastructures	Climate-resilient highways and power infrastructure Relocating key infrastructure
Health systems		Reducing air pollution Changing dietary patterns

Frequently Asked Questions

FAQ 10.3 | How are Indigenous knowledge and local knowledge being incorporated in the design and implementation of adaptation projects and policies in Asia?

Indigenous People, comprising about 6% of the global population, play a crucial role in managing climate change for two important reasons. First, they have a physical and spiritual connection with land, water and associated ecosystems, thus making them most vulnerable to any environmental and climatic changes. Second, their ecological and local knowledge are relevant to finding solutions to climate change.

Indigenous knowledge and local knowledge (IKLK) play an important role in the formulation of adaptation governance and related strategies (IPCC 2007), and best quality, locality-specific knowledge can help address the serious lack of education on climate change and uncertainties surrounding quality, salience, credibility and the legitimacy of the available knowledge base.

Key findings across Asia underline the importance of building, sustaining and augmenting local capacity through addressing inadequacies in terms of resource base, climate-change awareness, government–community partnerships and vulnerability assessment. Furthermore, inclusion of Indigenous knowledge and local knowledge as well as related practices will improve adaptation planning and decision-making processes concerning climate change.

In climate-sensitive livelihoods, an integrated approach informed by science that examines multiple stressors, along with Indigenous knowledge and local knowledge, appears to be of immense value. For instance, in building farmers' resilience, enhancing climate-change adaptation, ensuring cross-cultural communication and promoting local skills, Indigenous People's intuitive thinking processes and geographic knowledge of remote areas are very important.

There is also a widespread recognition that Indigenous knowledge and local knowledge are important in ensuring successful ecosystem-based adaptation (EbA). However, this recognition requires more practical application and translation into IKLK-driven EbA projects. For instance, in the Coral Triangle region, creating historical timelines and mapping seasonal calendars can help to capture Indigenous knowledge and local knowledge while also feeding this information into climate science and climate adaptation planning. Identifying indigenous crop species for agriculture by using Indigenous knowledge and local knowledge is already identified as an important way to localise climate adaptation: an example is Bali's vital contribution of moral economies to food systems which have long built resilience among groups of communities in terms of food security and sovereignty, even with the challenges faced due to modernising of local food systems.

Many of the pressing problems of Asia, including water scarcity, rapid urbanisation, deforestation, loss of species, rising coastal hazards and agricultural loss can be effectively negated, or at least minimised, through proper adoption of suitable science and technological methods. Climate-change adaptation is greatly facilitated by science, technology and innovation. This ranges from application of existing science, new development on scientific tools and methods, application of Indigenous knowledge and local knowledge and citizen sciences. Deploying Knowledge Quality Assessment Tool found significant co-relation between science-based and IKLK framing would help to address, acknowledge and utilise by an integrated approach the wisdom of Indigenous knowledge and local knowledge, a valuable asset for climate adaptation governance. The IKLK-based environmental indicators need to be seen as part of a separate system of knowledge that coexists with, but is not submerged into, another conventional knowledge system.

In the context of education and capacity development of climate change, an integrated approach of embracing both the importance of climate science and IKLK is acknowledged. The Indigenous knowledge and local knowledge is increasingly recognised as a powerful tool for compiling evidence of climate change over time. Such as knowledge of climate-change adaptation and disaster risk reduction provide a range of complementary approaches in building resilience and reducing the vulnerability of natural and human systems. Developing knowledge and utilising existing Indigenous knowledge and local knowledge, skills and dispositions to better cope with already evident and looming climate impacts. Engaging communities in the process of documenting and understanding long-term trends and practices will enable both Indigenous knowledge and local knowledge as well as Western scientific assessments of climate change to contribute in designing appropriate climate adaptation measures.

Frequently Asked Questions

FAQ 10.4 | How can Asia meet multiple goals of climate-change adaptation and sustainable development within the coming decades?

Asian countries are testing ways to develop in a climate-resilient manner to meet the goals related to climate change and sustainable development simultaneously. Some promising examples exist, but the window of opportunity to put some of these plans in place is small and closing fast, highlighting the need for urgent action across and within countries.

In order to achieve the multiple goals of climate-change adaptation, mitigation and sustainable development, critical are rapid, system transitions across (a) energy systems, (b) land and ecosystems and (c) urban and infrastructural systems. This is especially important across Asia, which has the largest population exposed to current climate risks and high sub-regional diversity, and where risks are expected to rise significantly and unevenly under higher levels of global warming. However, such transformational change is deeply challenging because of variable national development imperatives; differing capacities and requirements of large, highly unequal and vulnerable populations; and socioeconomic and ecological diversity that requires very contextual solutions. Furthermore, issues such as growing transboundary risks, inadequate data for long-term adaptation planning, finance barriers, uneven institutional capacity and non-climatic issues, such as increasing conflict, political instability and polarization, constrain rapid, transformational action across systems.

Despite these challenges, there are increasing examples of actions across Asia that are meeting climate adaptation goals and Sustainable Development Goals (SDGs) simultaneously, such as through climate-smart agriculture, disaster risk management and nature-based solutions. To enable these system transitions, vertical and horizontal policy linkages, active communication and cooperation between multiple stakeholders, and attention to the root causes of vulnerability are essential. Furthermore, rapid systemic transformation can be enabled by policies and finances to incentivise capacity building, new technological innovation and diffusion. The effectiveness of such technology-centred approaches can be maximised by combining them with attention to behavioural shifts such as by improving education and awareness, building local capacities and institutions, and leveraging Indigenous knowledge and local knowledge.

Obviously, time is of the essence. If system transitions are delayed, there is *high confidence* that climatic risks will increase human and natural system vulnerability, as well as increase inequality and erode the achievements of multiple SDGs. Thus, urgent systemic change that is suited to national and subnational social–ecological contexts across Asia is imperative.

FAQ 10.4 (continued)

Adaptatation option	Mitigation impacts	Implications on SDGs: Positive	Implications on SDGs: Negative
Wetland protection, restoration	Medium synergy (carbon sequestration through mangroves)	8 DECENT WORK AND ECONOMIC GROWTH; 14 LIFE BELOW WATER; 15 LIFE ON LAND	
Solar drip irrigitation	High synergy (shift to cleaner energy)	2 ZERO HUNGER; 7 AFFORDABLE AND CLEAN ENERGY; 12 RESPONSIBLE CONSUMPTION AND PRODUCTION	10 REDUCED INEQUALITIES
Climate-smart agriculture	High synergy (no till practices and improved residue management can reduce soil carbon emissions)	2 ZERO HUNGER; 12 RESPONSIBLE CONSUMPTION AND PRODUCTION	
Integrated smart water grids	High synergy (reduced energy needs for supplying water)	6 CLEAN WATER AND SANITATION; 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE; 11 SUSTAINABLE CITIES AND COMMUNITIES	
Disaster risk management (including early warning systems)	Not applicable	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE; 11 SUSTAINABLE CITIES AND COMMUNITIES	5 GENDER EQUALITY; 10 REDUCED INEQUALITIES
Aquifer storage and recovery	Low synergy	6 CLEAN WATER AND SANITATION; 12 RESPONSIBLE CONSUMPTION AND PRODUCTION	
Nature-based solutions in urban areas: green infrstructure	High synergy (blue-green infrastructure act as carbon sinks)	3 GOOD HEALTH AND WELL-BEING; 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE; 11 SUSTAINABLE CITIES AND COMMUNITIES	
Coastal green infrastructure	High synergy	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE; 11 SUSTAINABLE CITIES AND COMMUNITIES; 14 LIFE BELOW WATER; 15 LIFE ON LAND	

Figure FAQ10.4.1 | Adaptation options, mitigation impacts and implications on Sustainable Development Goals.

Frequently Asked Questions

FAQ 11.1 | How is climate change affecting Australia and New Zealand?

Climate change is affecting Australia and New Zealand in profound ways. Some natural systems of cultural, environmental, social and economic significance are at risk of irreversible change. The socioeconomic costs of climate change are substantial, with impacts that cascade and compound across sectors and regions, as demonstrated by heatwaves, wildfire, cyclone, drought and flood events.

Temperature has increased by 1.4°C in Australia and 1.1°C in New Zealand over the last 110 years, with more extreme hot days. The oceans in the region have warmed significantly, resulting in longer and more frequent marine heatwaves. Sea levels have risen and the oceans have become more acidic. Snow depths have declined and glaciers have receded. Northwestern Australia and most of southern New Zealand have become wetter, while southern Australia and most of northern New Zealand have become drier. The frequency, severity and duration of extreme wildfire weather conditions have increased in southern and eastern Australia and northeastern New Zealand.

The impacts of climate change on marine, terrestrial and freshwater ecosystems and species are evident. The mass mortality of corals throughout the Great Barrier Reef during marine heatwaves in 2016–2020 is a striking example. Climate change has contributed to the unprecedented south-eastern Australia wildfires in the spring and summer of 2019–2020, loss of alpine habitats in Australia, extensive loss of kelp forests, shifts further south in the distribution of almost 200 marine species, decline and extinction in some vertebrate species in the Australian wet tropics, expansion of invasive plants, animals and pathogens in New Zealand, erosion and flooding of coastal habitats in New Zealand, river flow decline in southern Australia, increased stress in rural communities, insurance losses for floods in New Zealand, increase in heatwave mortalities in Australian capital cities and fish deaths in the Murray-Darling River in the summer of 2018–2019.

Frequently Asked Questions

FAQ 11.2 | What systems in Australia and New Zealand are most at risk from ongoing climate change?

The nine key risks to human systems and ecosystems in Australia and New Zealand from ongoing climate change are shown in Figure FAQ 11.2.1. Some risks, especially on ecosystems, are now difficult to avoid. Other risks can be reduced by adaptation if global mitigation is effective.

Risk is the combination of hazard, exposure and vulnerability. For a given hazard (e.g., fire), the risk will be greater in areas with high exposure (e.g., many houses) and/or high vulnerability (e.g., remote communities with limited escape routes). The severity and type of climate risk varies geographically (Figure FAQ11.2.1). Everyone will be affected by climate change, with disadvantaged and remote people and communities the most vulnerable.

The risks to natural and human systems are often compounded by impacts across multiple spatial and temporal scales. For example, fires damage property, farms, forests and nature with short- and long-term effects on biodiversity, natural resources, human health, communities and the economy. Major impacts across multiple sectors can disrupt supply chains to industries and communities and constrain delivery of health, energy, water and food services. These impacts create challenges for the adaptation and governance of climate risks. When combined, they have far-reaching socioeconomic and environmental impacts.

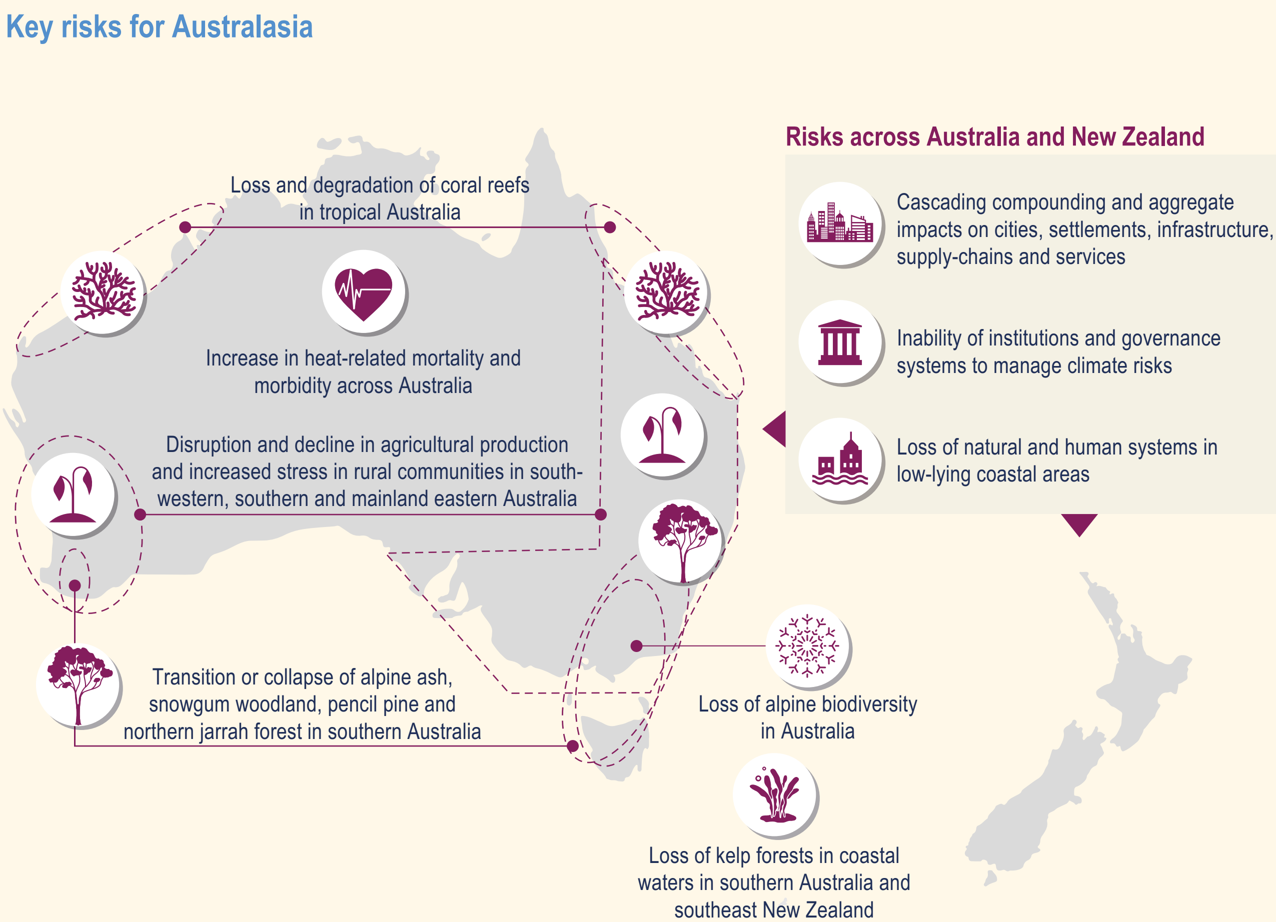


Figure FAQ11.2.1 | Key risks from climate change

Frequently Asked Questions

FAQ 11.3 | How can Indigenous Peoples' knowledge and practice help us understand contemporary climate impacts and inform adaptation in Australia and New Zealand?

In Australia and New Zealand, as with many places around the world, Indigenous Peoples with connections to their traditional country and extensive histories hold deep knowledge from observing and living in a changing climate. This provides insights that inform adaptation to climate change.

Indigenous Australians—Aboriginal and Torres Strait Islanders—maintain knowledge regarding previous sea level rise, climate patterns and shifts in seasonal change associated with the flowering of trees and emergence of food sources, developed over thousands of generations of observation of their traditional country. Knowledge of localised contemporary adaptation is also held by many Indigenous Australians with connections to traditional lands. With assured free and prior informed consent, this provides a means for Indigenous-guided land management, including for fire management and carbon abatement, fauna studies, medicinal plant products, threatened species recovery, water management and weed management.

Tangata Whenua Māori in New Zealand are grounded in Mātauranga Māori knowledge, which is based on human–nature relationships and ecological integrity and incorporates practices used to detect and anticipate changes taking place in the environment. Social-cultural networks and conventions that promote collective action and mutual support are central features of many Māori communities and these customary approaches are critical to responding to, and recovering from, adverse environmental conditions. Intergenerational approaches to planning for the future are also intrinsic to Māori social-cultural organisation and are expected to become increasingly important, elevating political discussions about conceptions of rationality, diversity and the rights of non-human entities in climate change policy and adaptation.

Frequently Asked Questions

FAQ 11.4 | How can Australia and New Zealand adapt to climate change?

There is already work under way by governments, businesses, communities and Indigenous Peoples to help us adapt to climate change. However, much more adaptation is needed in light of the ongoing and intensifying climate risks. This includes coordinated laws, plans, guidance and funding that enable society to adapt and the information, education and training that can support it. Everyone has a part to play working together.

We currently mainly react to climate events such as wildfires, heatwaves, floods and droughts and generally rebuild in the same places. However, climate change is making these events more frequent and intense, and ongoing sea level rise and changes in natural ecosystems are advancing. Better coordination and collaboration between government agencies, communities, Aboriginal and Torres Strait Islanders and Tangata Whenua Indigenous Peoples, not-for-profit organisations and businesses will help prepare for these climate impacts more proactively, in combination with future climate risks integrated into their decisions and planning. This will reduce the impacts we experience now and the risks that will affect future generations.

Some of the risks for natural systems are close to critical thresholds and adaptation may be unable to prevent ecosystem collapse. Other risks will be severe, but we can reduce their impact by acting now, for example coastal flooding from sea level rise, heat-related mortality and managing water stresses. Many of the risks have the potential to cascade across social and economic sectors with widespread societal impacts. In such cases, really significant system-wide changes will be needed in the way we currently live and govern. To facilitate such changes, new governance frameworks, nationally consistent and accessible information, collaborative engagement and partnerships with all sectors, communities and Indigenous Peoples and the resources to address the risks are needed (Figure FAQ11.4.1).

However, our ability to adapt to climate change impacts also rests on every region in the world playing its part in reducing greenhouse gas emissions. If mitigation is ineffective, global warming will be rapid and adaptation costs will increase, with worsening losses and damages.

Box FAQ 11.4 (continued)

Adaptation pathways for Australia and New Zealand

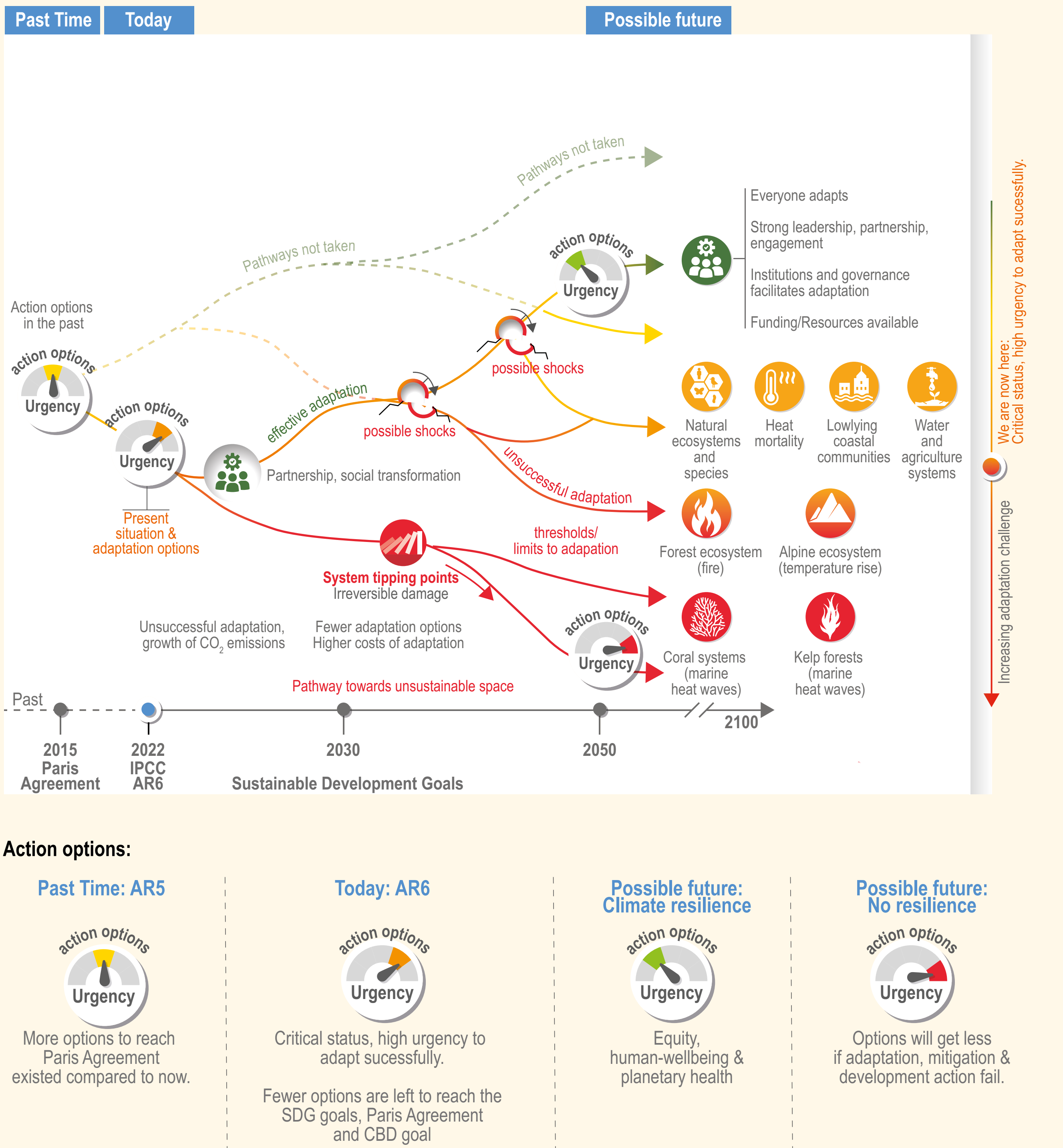


Figure FAQ11.4.1 | Developing adaptation plans in the solutions space showing system tipping points, thresholds and limits to adaptation, unsustainable pathways, critical systems and enablers to climate resilient development

Frequently Asked Questions

FAQ 12.1 | How are inequality and poverty limiting options to adapt to climate change in Central and South America?

Poverty and inequality decrease human capacity to adapt to climate change. Limited access to resources may reduce the ability of individuals, households and societies to adapt to the impacts of climate change and variability because of the narrow response portfolio. Inequality limits responses available to vulnerable segments as most adaptation options are resource-dependent.

Though poverty in Central and South America has decreased over the last 12 years, inequality remains as a historic and structural characteristic of the region. In 2018, 29.5% of Latin America's population (including Mexico) were poor (182 million) and 10.2% were extremely poor (63 million), more than half of them living in urban areas. In 2020, due to COVID crisis Gini coefficient projection of increases is ranging from 1.1% to 7.8%, poverty increased to 33.7% (209 millions) and extreme poverty to 12.5% (78 millions).

Poor populations have little or no access to good-quality education, information, health systems and financial services. They have fewer chances to access resources, such as land and water, good-quality housing, risk-reducing infrastructure, and services, such as running water, sanitation and drainage. Their lack of political clout and endowments limits their access to assets for withstanding and recovering from shocks and stresses. Poverty, inequality and high vulnerability to the impacts of climate change are interrelated processes. Poor populations are highly vulnerable to the impacts of climate change and are usually located in areas of high exposure to extreme events. The constant loss of assets and livelihoods in both urban and rural areas drives communities into chronic poverty traps, exacerbating local poverty cycles and creating new ones.

For instance, climate-related reduced yields in crops, fisheries and aquaculture have a substantial impact on the livelihoods and food security of families and affect their options for coping with and adapting to climate change and variability. The impact of climate change in agriculture for Central and South America depends on determinants such as the availability of natural resources, access to markets, diversity of inputs and production methods, quality and coverage of infrastructure and socioeconomic characteristics of the population. Impacts from climate change on small-scale farmers compromise the livelihoods and food security of rural areas and, consequently, the food supply for urban areas.

Governments in the region have implemented several poverty-reduction programmes. However, policies of income redistribution and poverty alleviation do not necessarily improve climate risk management, so complementary policies integrating both social and material conditions are required. A study in northern Brazil showed that risk management strategies for droughts and food insecurity did not change poverty rates between 1997–1998 and 2011–2012. Major shocks, such as climate and extreme weather events (e.g., floods, heavy rains, droughts, frost), reduce and destroy public and private property. For instance, the ENSO event of 2017 in Peru caused losses estimated between USD 6 and 9 billion, affected more than a million inhabitants and generated 370,000 new poor. In total, losses by unemployment, deaths, destruction and damage to infrastructure and houses were around 1.3% of the Gross Domestic Product of Peru.

Low government spending on social infrastructure (e.g., health, education), ethnic discrimination and social exclusion reduce healthcare access, leaving poor people in entire regions mostly undiagnosed or untreated. In a context of privatisation policies of healthcare systems, research shows that marginal people lack identifying documents needed to access public services in Buenos Aires (Argentina), Mexico City (Mexico) and Santiago de Chile (Chile), some of the most developed cities in the region. The consequences of this situation are underreporting, low diagnosis and low treatment of diseases such as vector-borne diseases such as dengue and risk of diarrhoeal diseases originating from frequent flooding in Amazonian riverine communities. Bias in reporting on access to healthcare and the incidence of diseases in marginal populations is usually region-dependent. For example, in Brazil's Amazonian north in 2018, there were 2.2 medical doctors per 1000 inhabitants, while 4.95 medical doctors per 1000 inhabitants and 9.52 doctors in São Paulo and Santa Catarina respectively. Another example is pregnant women in remote Amazonian municipalities, who receive less prenatal care than women in urban areas. These social inequities underlie systemic biases in health data quality, hindering reliable estimation of disease burdens such as the distribution of disease or birth and death registrations. For example, in Guatemala, alternative Indigenous healthcare systems are responding to local needs in Mayan communities. However, this remains unrecognised. The existence of health institutions based on IK can reinforce the lack of universal coverage by central government healthcare, addressing the miscalculation of morbidity, mortality and cause of death among disadvantaged groups.

FAQ 12.1 (continued)

Inequality, informality and precariousness are particularly relevant barriers to adaptation. A significant part of the construction sector in the region is informal and does not follow regulations for land use and construction safety codes, and there is a lack of public strategies for housing access. Adaptive construction is based on up-to-date regulation and codes, appropriate design and materials, and access to infrastructure and services. Decreasing inequality and eradicating poverty are crucial for achieving proper adaptation to climate change in the region. Some anti-poverty initiatives, such as savings groups, microfinance for improving housing or assets and community enterprises, may also support specific adaptive measures. These mechanisms should be widely accessible to poor groups and be complemented by comprehensive poverty alleviation programmes that include climate-change adaptation.

Frequently Asked Questions

FAQ 12.2 | How have urban areas in Central and South America adapted to climate change so far, which further actions should be considered within the next decades and what are the limits of adaptation and sustainability?

Cities are becoming focal points for climate-change impacts. Rapid urbanisation in Central and South America, together with accelerating demand for housing, resource supplies and social and health services, has put pressure on the already stretched physical and social infrastructure. In addition, migration is negatively affecting the opportunities of cities to adapt to climate change.

Central and South America is the second most urbanised region in the world after North America, with 81% of its population being urban. In addition, 129 secondary cities with 500,000 inhabitants are home to half of the region's urban population (222 million). Another 65 million people live in megacities of over 10 million each. The population migrates among cities, resulting in more secondary cities and creating mega regions and urban corridors.

Rapid growth in cities has increased the urban informal housing sector (e.g., slums, marginal human settlements and others), which increased from 6% to 26% of the total residences from 1990 to 2015. Coastal areas in Central and South America increasingly concentrate more urban centres. Researchers indicate that between 3 and 4 million inhabitants will experience coastal flooding and erosion from SLR in all emission scenarios by 2100 considering South America alone.

A study on cities with more than 100,000 inhabitants showed that the number of coastal cities significantly increased from 42 to 420 between 1945 and 2014; they are located close to fragile ecosystems such as bays, estuaries and mangrove forests, resulting in higher concentrations of population and economic activities. This process degraded the ability of coastal ecosystems, such as mangroves, to reduce risks and provide essential ecosystem services, which help to prevent coastal erosion or maintain fish stocks. Moreover, it reduced ports and tourism, along with income opportunities.

Climate-change impacts on cities in Central and South America are strongly influenced by ENSO, which is associated with an increase in more-extreme rainfall events. Urban areas are increasingly dealing with floods, landslides, storms, tropical cyclones, water stress, fires, spread of vector-borne and infectious diseases, damaging infrastructure, economic activities, built and natural environments and the population's overall well-being.

Glacier retreat in the mountains will affect water runoff and water provision to metropolitan areas such as Lima, La Paz, Quito and Santiago, which rely on rivers that originate in the high Andes. Lima, the second driest capital city in the world, is vulnerable to drought and heavy rain peak events associated with climate change. In Bogota, lower precipitation levels and a tendency towards increasing extreme events are expected in the coming decades. Hence, the protection of fragile ecosystems such as paramo (fields at 3000 to 4000 meters above sea level) will be crucial for supplying water to the city.

Sea level rise impacts cities located in low elevation coastal zones, not only because of direct coastal flooding, coastal erosion and subsidence, but also because it aggravates the impact of storm surges, heat wave energy and saltwater intrusion. In Suriname and Guyana 68% and 31% of the population respectively live below 5 metres above sea level, while many sectors of Georgetown, the capital of Guyana, are below sea level. Floods with increased frequency and severity of storm surges will also impact the River Plate estuary and lower delta of the Parana River where metropolitan Buenos Aires is located.

Over 80% of losses associated with climate-related risks are concentrated in urban areas, and between 40% and 70% of losses occur in cities with less than 100,000 inhabitants, most likely as a result of limited capacities to manage disaster risks and low levels of investment.

Despite consistent political and economic barriers, many cities in the region have adopted sustainable local development agendas, which work to bring about balanced urban development. The shortcomings of poor development patterns remain prominently on display in cities and present important obstacles to adaptation investment, as public investment in basic needs (mainly housing and sanitation) must be prioritised.

FAQ 12.2 (continued)

Cities struggle to address the immediate needs of their population while addressing longer-term needs associated with climate adaptation, emissions reduction and sustainable development. Some cities are moving forward to transformative adaptation, addressing drivers of vulnerability, building robust systems and anticipating impacts. Besides government-led adaptation planning and action, individuals, communities and enterprises have been incrementally adapting to climate change autonomously over time. Municipalities from Argentina, Peru, Chile, Equator, Brazil and Costa Rica are developing and implementing their Local Climate Action Plans, experimenting with and revealing best practices in adaptation. Both anticipatory adaptation measures—choosing safe locations, building structurally safe houses, choosing elevated places to store valuables, building on stilts—and reactive adaptation measures are used, the latter incorporating measures such as relocation, slope stabilisation, afforestation and greening of riverbanks. With variations, these cities have included mechanisms to work across sectors and actors on the understanding that it is collective planning and actions that will ensure that long-term programmes continue independently of particular city administrations.

Cities are interconnected systems operating beyond administrative boundaries. Improved collaboration and coordination are needed for integrated responses. Aside from good planning, cities need access to external adaptation funds. Climate-change adaptation requires long-term funding and investments, which are beyond cyclical political considerations. It is crucial to rethink how to ensure that international adaptation funds will reach cities and innovate. For example, member cities of Global Covenant of Mayors for Climate & Energy in the region, together with Cities for Life Forum in Peru, the Red Argentina de Municipios por el Cambio Climático (RAMCC), the Capital Cities of the Americas facing Climate Change (CC35) and others, are pursuing this goal and applying directly for international grants. New funding sources are required to help local governments and civil society. Cities and locally driven adaptation initiatives can be funded by national governments and international organisations.

Frequently Asked Questions

FAQ 12.3 | How do climatic events and conditions affect migration and displacement in Central and South America, will this change due to climate change, and how can communities adapt?

Migration and displacements associated with climatic hazards are becoming more frequent in CSA, and they are expected to continue to increase. These complex processes require comprehensive actions in their places of origin and reception, to improve both adaptation in more affected places and the conditions of mobilisation.

The migration, voluntary and involuntary, of individuals, families and groups is common in Central and South America. People migrate nationally and internationally, temporarily or permanently, predominantly from rural areas—often immersed in poverty—to urban areas. Common social drivers of migration in the region are the economy, politics, land tenure and land management change, lack of access to markets, lack of infrastructure, and violence; environmental drivers include loss of water, crops and livestock, land degradation and sudden or gradual onset of climate hazards.

The increasing frequency and magnitude of droughts, tropical storms, hurricanes and heavy rains producing landslides and floods have amplified internal movements, overall rural to urban. For instance, rural-to-urban migration in northern Brazil and international migration from Guatemala, Honduras and El Salvador to North America are partly a consequence of prolonged droughts, which have increased the stress of food availability in these highly impoverished regions. Diminished access to water is also a result of privatisation of that resource. In Central America, the majority of migrants are young men, reducing the labour force in their places of origin. However, the migrants send back substantial amounts of money, which have become the main source of foreign exchange for their countries and the main source of income for their families.

Because poor people have fewer resources to adapt to changing conditions, they are usually the most impacted by climate hazards since they are already struggling to survive under normal conditions. These populations are the most likely to migrate, chiefly because of the loss of their livelihoods, their precarious housing and settlements and the lack of money and international aid. Other important factors are the minimal governmental support and assistance through social safety nets and extension services, the scarcity and low quality of education and health services, their isolation and marginality and the insecurity of land rights. These same conditions, though, may hinder their mobility or even render them immobile. Nevertheless, in some cases, despite worsening conditions, people decide not to move.

The magnitude and frequency of droughts and hurricanes are projected to keep increasing by 2050, which may force millions of people to leave their homes. Climate models show some dry regions becoming even dryer in the coming decades, increasing the stress on small farmers who rely on rainfall to water their fields. Glacier retreat and water scarcity are becoming strong drivers of migration in the Andes. Sea level rise affects activities such as fishing and tourism, which will foster further migration. In Brazil, at least 0.9 million more people will migrate interregionally under future climate conditions.

Addressing migration and displacement requires diverse interventions: in dry regions it is recommended to improve water management in the places of origin of migration, including storage, distribution and irrigation. Wet regions, lowlands and floodplains will benefit from preventing construction in areas prone to landslides and flooding. Government and international aid are also important for improving people's options to adapt and enhance their resilience to climate impacts. In northern Brazil, for example, government financial support has significantly reduced drought-related migration. There exists between Guatemala and Canada a temporary migration programme to bring in migrant workers during the harvest season. The United States is also increasing these types of legal temporary migration.

Frequently Asked Questions

FAQ 12.4 | How is climate change impacting and how is it expected to impact food production in Central and South America in the next 30 years, and what effective adaptation strategies are and can be adopted in the region?

Agriculture is a fundamental sector in the development of societies from economic and social perspectives, and so it is a major component of Central and South American countries' adaptive strategies. Implementation of sustainable agriculture practices, such as improved management on native grasslands or agroforestry systems for crop and livestock production, can increase productivity while improving adaptability.

Over the last two decades, countries throughout Central and South American have been developing rapidly. The agricultural sector is fundamental to this development from economic and social perspectives. Some countries in the region are major global food exporters:

- Corn: three of the top 10 exporters are Brazil, Argentina and Paraguay;
- Soybean exports: Brazil and Argentina are among the top 5 and Paraguay and Bolivia rank in the top 12;
- Coffee exports: 5 of the top 10 export countries are Brazil, Colombia, Honduras, Peru and Guatemala;
- Fruits: 2 of the top 10 fresh fruit exporting countries are Chile and Ecuador;
- Fishmeal exports globally are led by Peru, Chile and Ecuador;
- Beef: four of the top exporting countries are from this region: Brazil, Argentina, Uruguay and Paraguay.

Central and South American is among the regions with the highest potential to increase food supplies, particularly to more densely populated regions in Asia, the Middle East and Europe. A better understanding of the impact of the economy on the environment and the contribution of the environment to the economy is critical for identifying opportunities for innovation and promoting activities that could lead to sustainable economic growth without depleting natural resources and increasing sensitivity to climate change and climate variability. The consideration of food as a commodity instead of a common resource leads to the accumulation of underpriced food resources at the expense of natural capital. Without serious emissions reduction measures, climate models project an average 1°C to 4°C increase in maximum temperatures and a 30% decrease in rainfall up to 2050, across CSA. Tropical South America is projected to warm at higher rates than the southern part of South America. Given these circumstances, some regions in Central and South America (Andes region and Central America) will just meet or fall below the critical food supply/demand ratio for their population. Meanwhile, the temperate southern-most region of South America is projected to have agricultural production surplus. The challenge for this region will be to retain the ability to feed and adequately nourish its internal population as well as make an important contribution to food supplies available to the rest of the world.

The Nationally Determined Contributions (NDCs) of most Central and South American countries expressly include agriculture as a major component of their adaptive strategy. From the recommendations presented, five general adaptive themes, or imperatives, emerge: (a) inclusion of climate-change projections as a key element for ministries of agriculture and research institutes in their decision-making processes, (b) support of research on and adoption of drought- and heat-tolerant crop varieties, (c) promotion of sustainable irrigation as an effective adaptive strategy, (d) recovery of degraded lands and sustainable intensification of agriculture to prevent further deforestation, and (e) implementation of climate-smart practices and technologies to increase productivity while improving adaptability.

Climate-smart practices provide a framework to operationalise actions aimed at understanding synergies among productivity, adaptation and mitigation. A significant amount of evidence supports the potential for climate-smart-practice technologies to produce such triple wins as natural pastoral systems in the southern region of South America. Such systems allow for the combination of food production and environmental sustainability. The production of meat based on native grasslands with grazing management that optimises forage allowance can achieve high production levels while providing multiple ecosystem benefits. Optimal forage allowance means offering animals enough forage in order to meet requirements while avoiding overgrazing. This management practice simultaneously increases productivity, reduces greenhouse gas emissions while improving soil carbon sequestration and minimises other environmental impacts such as excess of nutrients, fossil-based energy use and biodiversity loss. Pastoral farming systems that manage grazing and feeding efficiently are an example of the integration of food security, environmental conservation and nature-based adaptation to climate change.

FAQ 12.4 (continued)

Agroforestry systems are present in the tropical region of Central and South America. Trees are present in a large part of the agricultural landscape of this region, either dispersed or in lines, supporting the production of coffee, cocoa, fruits, pastures and livestock in various agroforestry configurations. In Central America, shade-grown coffee reduces weed control and improves the quality and taste of the product. Agroforestry uses nitrogen-fixing trees (*Leguminosae*), such as *Leucaena* in Colombia and *Inga* in Brazil, to restore soil nitrogen fertility. Tropical forest soils are generally nutrient-poor and unsuited to long-term agricultural use. Land converted to agriculture by cutting and burning natural vegetation tends to remain productive for only a few years. Agroforestry and so-called silvopastoral systems, which incorporate trees into crop and livestock systems, have been shown to have a dramatic impact on the maintenance and restoration of long-term productivity in agricultural landscapes, including degraded and abandoned land. Agroforestry systems can provide major benefits through enhanced food security, stronger local economies and increased ecosystem services such as carbon storage, regulation of climate and water cycles, control of pests and diseases and maintenance of soil fertility. Because of these multiple goods and services, agroforestry practices are considered one of the key strategies for the development of climate-smart agriculture.

Frequently Asked Questions

FAQ 12.5 | How can Indigenous knowledge and practices contribute to adaptation initiatives in Central and South America?

Indigenous Peoples have knowledge systems and practices that allow them to adapt to many climatic changes. Adaptation initiatives based on Indigenous knowledge and practices are more sustainable and legitimate among local communities. It is important to build effective and respectful partnerships among Indigenous and non–Indigenous researchers to co-produce climate-relevant knowledge to enhance adaptation planning and action in the region.

There are 28 million Indigenous Peoples in Central and South America (around 6.6% of the total population of the region). They belong to more than 800 groups living in territories covering a wide range of ecosystems—from drylands to tropical rainforests to savannahs, coasts to mountains—and that share the land with many other cultural and ethnic groups. In the region, Indigenous Peoples are often categorised as groups that are highly vulnerable to climate change because they are frequently affected by socioeconomic inequalities and the dominance of external powers. They often experience internal and external pressures on their communal lands in the forms of pollution, oil and mining, industrial agriculture and urbanisation. On the other hand, it is important to recognise that Indigenous Peoples have knowledge systems and practices that allow them to adapt to many climatic changes. Increasing scientific evidence shows that adaptation initiatives based on Indigenous knowledge and practices are more sustainable and legitimate among local communities.

The wide range of adaptation practices based on Indigenous knowledge in the region include, among others, increasing species and genetic diversity in agricultural systems through community seed exchanges; promotion of highly diverse crop systems; ancient systems to collect and conserve water; fire prevention strategies; observing and monitoring changes in communal ecological–agricultural calendar cycles; recognising changes in ecological indicators like migration patterns in birds, the behaviour of insects and other invertebrates and the phenology of fruit and flowering species; and systematisation and knowledge exchange among communities. These practices represent a valuable cultural and biological heritage.

The Kichwa in the Ecuadorian Amazon cultivate Chakras (plots) within the rainforest. These plots combine crops and medicinal herbs for both self-consumption and selling. Similar systems, like the Chakras in the high Andes, the Milpas in Central America, and the Conucos in northern South America, have been resilient to social and environmental disturbances due to their outstanding agrobiodiversity (more than 40 species and varieties can be present in one plot), microhabitat management and the associated knowledge and institutions.

Traditional fire management among Indigenous Peoples of Venezuela, Brazil and Guyana is another adaptation strategy based on a fine-tuned understanding of environmental indicators associated with their culture and worldviews. In these countries, Indigenous lands have the lowest incidence of wildfires, significantly contributing to maintaining and enhancing biodiversity. These traditional practices have helped to prevent large-scale and destructive wildfires, reducing the risks posed by rising temperature and dryness due to climate change.

The traditional agriculture of Mapuche Indigenous Peoples in Chile includes a series of practices that result in a system that is more resilient to climate and non-climate stressors. Practices include water management, native seed conservation and exchange with other producers (trafkintu), crop rotation, polyculture and tree–crop association. Similar practices can be found in Mayan communities in Guatemala at the other end of the sub-continent.

Despite the increasing recognition and integration of Indigenous knowledge in adaptation practices and policies in the region, important barriers for a more effective and transformative integration remain. Some of the most relevant barriers include limited participation of Indigenous Peoples and local communities in adaptation planning and the lack of sufficient consideration of non-climatic socioeconomic drivers of vulnerability such as poverty and inequality. Also, scientific knowledge is commonly prioritised over traditional Indigenous knowledge and local knowledge. However, some transformative efforts are emerging. Bolivian Indigenous organisations represent a notable example by contesting normative conceptions of development as economic growth and replacing them with more comprehensive views like harmony with Mother Earth and 'Sumak Kawsay' or 'Good Living'.

Several strategies have been proposed to overcome existing barriers, including building effective and respectful partnerships among Indigenous and non-Indigenous researchers, co-producing climate-change-relevant knowledge and recognising Indigenous Peoples as active participants in the continual development of autonomous strategies to preserve their practices, beliefs and knowledge. The implementation of these and other strategies can significantly enhance adaptation planning and action in the region.

Frequently Asked Questions

FAQ 13.1 | How can climate change affect social inequality in Europe?

The poor and those practising traditional livelihoods are particularly exposed and vulnerable to climate change. They rely more often on food self-provisioning and settle in flood-prone areas. They also often lack the financial resources or the rights to successfully adapt to climate-driven changes. Good practice examples demonstrate that adaptation can reduce inequalities.

Social inequalities in Europe arise from disparities in income, gender, ethnicity, age as well as other social categorisations. In the European Union (EU), about 20% of the population (109 million people) live under conditions of poverty or social exclusion. Moreover, poverty is unequally distributed across Europe, with higher poverty levels in Eastern Europe. The oldest and youngest in society are often most vulnerable.

The poor and those practising traditional livelihoods are particularly vulnerable and exposed to climate risks. Many depend on food self-provisioning from lakes, the sea and the land. With higher temperatures, the availability of these sources of food is *likely* to be reduced, particularly in Southern Europe. Poorer households often settle in flood-prone areas and are therefore more exposed to flooding. Traditional pastoralist and fishing practices are also negatively affected by climate change across Europe. Semi-migratory reindeer herding, a way of life among Indigenous and traditional communities (i.e., Komi, Sámi, Nenets) in the European Arctic, is threatened by reduced ice and snow cover. Almost 15% of the EU population (in some countries more than 25%) already cannot meet their health care needs for financial reasons, while they are at risk of health impacts from warming.

In addition to being more exposed to climate risks, socially vulnerable groups are also less able to adapt to these risks, because of financial and institutional barriers. More than 20% of people in Southern Europe and Eastern Europe live in dwellings that cannot be cooled to comfortable levels during summer. These people are particularly vulnerable to risks from increasing heatwave days in European cities (e.g., when they already face energy poverty). They may also lack the means to protect against flooding or heat (e.g., when they do not own the property). Risk-based insurance premiums, which are intended to help people reduce climate risks, are potentially unaffordable for poor households. The ability to adapt is also often limited for Indigenous people, as they often lack the rights and governance of resources, particularly when in competition with economic interests such as resource mining, oil and gas, forestry and expansion of bioenergy.

Adaptation actions by governments can both increase and decrease social inequality. The installation of new, or the restoration of existing, green spaces may increase land prices and rents due to a higher attractiveness of these areas, leading to potential displacement of population groups who cannot afford higher prices. On the other hand, rewilding and restoration of ecosystems can improve the access of less privileged people to ecosystem services and goods, such as the availability of freshwater. At city level, there are examples of good practice in climate resilient development that consider social equity which integrate a gender-inclusive perspective in its sustainable urban planning, including designing public spaces and transit to ensure that women, persons with disabilities and other groups can access, and feel safe using, these public amenities.

Frequently Asked Questions

FAQ 13.2 | What are the limits of adaptation for ecosystems in Europe?

Land, freshwater and ocean organisms and ecosystems across Europe are facing increasing pressures from human activities. Climate change is rapidly becoming an additional and, in the future, a primary threat. Ongoing and projected future changes are too severe and happen too fast for many organisms and ecosystems to adapt. More expensive and better implemented environmental conservation and adaptation measures can slow down, halt, and potentially reverse biodiversity and ecosystem declines, but only at low or intermediate warming.

Ecosystem degradation and biodiversity loss have been evident across Europe since 1950, mainly due to land use and overfishing; however, climate change is becoming a key threat. The unprecedented pace of environmental change has already surpassed the natural adaptive capability of many species, communities and ecosystems in Europe. For instance, the space available for some land ecosystems has shrunk, especially in Europe's polar and mountain areas, due to warming and thawing of permafrost. Across Europe, heatwaves and droughts, and their impacts such as wildfires, add further acute pressures, as seen in the 2018 heatwave, which impacted forest ecosystems and their services. In the Mediterranean Sea, plants and animals cannot shift northward and are negatively affected by marine heatwaves. Food-web dynamics of European ecosystems are disrupted as climate change alters the timing of biological processes, such as spawning and migration of species, and ecosystem composition. Moreover, warming fosters the immigration of invasive species that compete with–and can even out-compete–the native flora and fauna.

In a future with further and even stronger warming, climate change and its many impacts will become increasingly more important threats. Several species and ecosystems are projected to be already at high risk at 2°C global warming level, including fishes and lake and river ecosystems. At 3°C global warming level, many European ecosystems, such as coastal wetlands, peatlands and forests, are projected to be at much higher risk of being severely disrupted than in a 2°C warmer world. For example, Mediterranean seagrass meadows will *very likely* become extinct due to more frequent, longer and more severe marine heatwaves by 2050. Several wetland and forest plants and animals will be at high risk to be replaced by invasive species that are better adapted to increasingly dry conditions, especially in boreal and Arctic ecosystems.

Current protection and adaptation measures, such as the Natura 2000 network of protected areas, have some positive effects for European ecosystems; however, these policies are not sufficient to effectively curb overall ecosystem decline, especially for the projected higher risks above 2°C global warming level. Nature-based solutions, such as the restoration of wetlands, peatlands and forests, can serve both ecosystem protection and climate-change mitigation through strengthening carbon sequestration. Some climate-change mitigation measures, such as reforestation and restoration of coastal ecosystems, can strengthen conservation measures. These approaches are projected to reduce risks for European ecosystems and biodiversity, especially when internationally coordinated.

Not all climate-change adaptation options are beneficial to ecosystems. When planning and implementing adaptation options and nature-based solutions, trade-offs and unintended side effects should be considered. On one hand, engineering coastal protection measures (seawalls, breakwaters and similar infrastructure) in response to sea level rise reduce the space available for coastal ecosystems. One the other hand, nature-based solutions can also have unintended side effects, such as increased methane release from larger wetland areas and large-scale tree planting changing the albedo of the surface.

FAQ

Frequently Asked Questions

FAQ 13.3 | How can people adapt at individual and community level to heatwaves in Europe?

Heatwaves will become more frequent, more intense and will last longer. A range of adaptation measures are available for communities and individuals before, during and after a heatwave strikes. Implementing adaptation measures are important to reduce the risks of future heatwaves.

Heatwaves affect people in different ways; risks are higher for the elderly, pregnant women, small children, people with pre-existing health conditions and low-income groups. By 2050, about half of the European population may be exposed to high or very high risk of heat stress during summer, particularly in Southern Europe and increasingly in Eastern Europe and Western and Central Europe. The severity of heat-related risks will be highest in large cities, due to the UHI effect.

In Southern Europe, people are already aware of the risks of heat extremes. Consequently, governments and citizens have implemented a range of adaptation responses to reduce the impacts of heatwaves; however, there are limits to how much adaptation can be implemented. At 3°C global warming level, there will be substantial risks to human lives and productivity, which cannot be avoided. In the parts of Europe where heatwaves are a relatively new phenomenon, such as many parts of Northern Europe and Western and Central Europe, public awareness of heat extremes is increasing and institutional capacity to respond is growing.

Preparing for heatwaves is an important first step. Implementing and sustaining effective measures, such as national or regional early warning and information systems, heatwave plans and guidelines, and raising public awareness through campaigns, are successful responses. Evidence suggests that such measures have contributed to reduced mortality rates in Southern Europe and Western and Central Europe. At city level, preparing for heatwaves can sometimes require urban re-design. For example, green–blue spaces, such as recreational parks and ponds in cities, have been shown to reduce the average temperature in cities dramatically and to provide co-benefits, such as improved air quality and recreational space. The use of cool materials in asphalt, increasing reflectivity, green roofs and building construction measures are being considered in urban planning for reducing heat risks. Citizens can prepare themselves by using natural ventilation, using approaches to stay cool in heatwaves, green roofs and green façades on their buildings.

During heatwaves, public information that is targeted at people and social care providers is critical, particularly for the most vulnerable citizens. Governments and NGOs play an important role in informing people about how to prepare and what to do to avoid health impacts and reduce mortality. Coordination between vital emergency and health services is critical. Individuals can take several actions to effectively protect themselves from heat including (a) decrease exposure to high temperatures (e.g., avoid outdoor during hottest times of the day, access cool areas, wear protective and appropriate clothing), (b) keep hydrated (e.g., drink enough proper fluids, avoid alcohol, etc.) and (c) be sensitive to the symptoms of heat illness (dizziness, heavy sweating, fatigue, cool and moist skin with goosebumps when in heat, etc.).

Once the heatwave has ended, evaluation of what worked well and how improvements can be made is key to prepare for the *next* heatwave. Governments can, for example, evaluate whether the early warning systems provided timely and useful information, whether coordination went smoothly and assess the estimated number of lives saved, to determine the effectiveness of the measures implemented. Sharing these lessons learned is critical to allow other cities and regions to plan for heat extremes. After the heatwave, citizens can reflect if their responses were sufficient, whether investments are needed to be better prepared and draw key lessons about what (not) to do when the next heatwave strikes.

Frequently Asked Questions

FAQ 13.4 | What opportunities does climate change generate for human and natural systems in Europe?

Not all climate-change impacts across Europe pose challenges and threats to natural communities and human society. In some regions, and for some sectors, opportunities will emerge. Although these opportunities do not outweigh the negative impacts of climate change, considering these in adaptation planning and implementation is important to benefit from them. Nevertheless, Europe will face difficult decisions balancing the trade-offs between the adaptation needs of different sectors, regions and adaptation and mitigation actions.

Opportunities of climate change can be (a) positive effects of warming for specific sectors and regions, such as agriculture in Northern Europe, and (b) co-benefits of transformation of cities or transport measures that reduce the speed and impact of climate change while improving air quality, mental health and well-being. Windows of action for transformation opportunities for large-scale transitions and transformation of our society may be accelerated through new policy initiatives in response to the COVID-19 crisis, such as the European New Green Deal and Building Back Better.

As warming and droughts impact Southern Europe most strongly, direct opportunities from climate change are primarily in northern regions, thereby increasing existing inequalities across Europe. Across Europe, positive effects of climate change are fewer than negative impacts and are typically limited to some aspects of agriculture, forestry, tourism and energy sectors. In the food sector, opportunities emerge by the northward movement of food production zones, increases in plant growth due to CO_2 fertilisation and reduction of heating costs for livestock during cold winters. In the energy sector, positive effects include increased wind energy in the southwest Mediterranean and reduced energy demand for heating across Europe. While climatic conditions for tourist activities are projected to decrease for winter tourism (e.g., insufficient snow amount) and summer tourism in some parts of Europe (e.g., too much heat), conditions may improve during spring and autumn in many European locations. Fewer cold waves will reduce risks on transport infrastructure, such as cracking of road surface, in parts of Northern Europe and Eastern Europe particularly by the end of the century.

Indirect opportunities emerge from the co-benefits of implementing adaptation actions. Some of these co-benefits are widespread but need careful consideration in order to be utilised. For example, an nature-based solution approach to adaptation can make cities and settlements more liveable, increase the resilience of agriculture and protect biodiversity. Ecosystem-based adaptation can attract tourists and create recreational space. There are opportunities to mainstream adaptation into other developments and transitions, including the energy or agricultural transitions as well as COVID-19 recovery plans. Transformative solutions to achieve sustainability may be accelerated through larger changes of, for example, behaviour, energy, food or transport, to better exploit new opportunities and co-benefits. Implementation of adaptation actions can also help to make progress towards achieving the Sustainable Development Goals (SDGs).

Inclusive, equitable and just adaptation is critical for climate resilient development considering SDGs, gender as well as Indigenous knowledge and local knowledge and practices. Implementation requires political commitment, persistence and consistent action across scales of government. Upfront mobilisation of political, human and financial capital in implementation of adaptation actions is key, even when the benefits are not immediately visible.

Frequently Asked Questions

FAQ 14.1 | How has climate change contributed to recent extreme events in North America and their impacts?

Multiple lines of evidence indicate that climate change is already contributing to more intense and more frequent extreme events across North America. The impacts resulting from extreme events represent a huge challenge for adapting to future climate change.

Extreme events are a fundamental part of how we experience weather and climate. Exceptionally hot days, torrential rainfall and other extreme weather events have a direct impact on people, communities and ecosystems. Extreme weather can lead to other impactful events such as droughts, floods or wildfires. In a changing climate, people frequently ask whether extreme events are generally becoming more severe or more frequent, and whether an actual extreme event was caused by climate change.

Because really extreme events occur rarely (by definition), it can be very difficult to assess whether the overall severity or frequency of such events has been affected by changing climate. Nevertheless, careful statistical analysis shows that record-setting hot temperatures in North America are occurring more often than record-setting cold temperatures as the overall climate has gotten warmer in recent decades. The area burned by large wildfires in the western USA has increased in recent decades. Observed trends in extreme precipitation events are more difficult to detect with confidence, because the natural variability of precipitation is so large and the observational database is limited.

Our understanding of how individual extreme weather events have been influenced by climate change has improved greatly in recent years. Climate scientists have developed a formal technique ('event attribution', described in WGI FAQ 11.3) for assessing how climate change affects the severity or frequency of a particular extreme event, such as a record-breaking rainfall event or a marine heatwave. This is a challenging task, because any particular event can be caused by a combination of natural variability and climate change. Event attribution is typically carried out using models to compare the probability of a specific event occurring in today's climatic environment relative to the probability that the same event might have occurred in a modelled climate in which atmospheric greenhouse gases have not risen due to human activities. Using this strategy, multiple studies have estimated that the historically extreme rainfall amount that fell across the Houston area from Hurricane Harvey (2017) was three to ten times more *likely* as the result of climate change.

The *impacts* from extreme events depend not just on physical climate system hazards (temperature, precipitation, wind, etc.), but also on the exposure and vulnerability of humans or ecosystems to these events. For example, damage from land-falling hurricanes along the coast of the Gulf of Mexico is expected to increase as very strong hurricanes become more frequent and intense due to climate change. But damage would also increase with additional construction along the shoreline, because coastal development increases *exposure* to hurricanes. And if some structures are constructed to poor building standards, as was the case when hurricane Andrew made landfall in Florida in 1992, then *vulnerability* to hurricane-caused impacts is increased.

Climate change also contributes to impacts from extreme events by making some building codes and zoning restrictions inadequate or obsolete. Many North American communities limit development in areas known to be flood-prone, to minimise exposure to flooding. But as climate change expands the areas at risk of exposure to flooding beyond historical floodplains, the impacts of potential flooding are increased, as Hurricane Harvey demonstrated. Adapting to climate change may require retrofits for existing structures and revised zoning for new construction. Some structures and neighbourhoods may need to be abandoned altogether to accommodate expanded flooding risk.

Climate change can be an *added stress* that increases impacts from extreme events, combined with other non-climatic stressors. For example, climate change in western North America has contributed to more extreme fire weather. The devastating impacts of recent wildfire outbreaks, such as occurred across western Canada in 2016 and 2017, the western United States in 2018 and 2020, and both countries in 2021, are to some extent associated with expanded development and forest management practices (such as policies to suppress low-intensity fires, allowing fuel to accumulate). The effects of development and forest management have dramatically increased the exposure and vulnerability of communities to intense wildfires. Climate change has added to these stressors: warming temperature leads to more extreme weather conditions that are conducive to increasingly severe wildfires.

Biodiversity is affected by climate change in this way too. For example, numerous bird populations across North America are estimated to have declined by up to 30% over the past half-century. Multiple human-related factors, including habitat loss and agricultural intensification, contribute to these declines, with climate change as an added stressor. Increasingly extreme events, such as severe storms and wildfires, can decimate local populations of birds, adding to existing ecological threats.

Frequently Asked Questions

FAQ 14.2 | What can we learn from the North American past about adapting to climate change?

The archaeology and history of Indigenous Peoples and Euroamerican farmers show that climate variability can have severe impacts on livelihoods, food security and personal safety. Traditional societies developed numerous methods to cope with variability but have always expanded to the limits of what those adaptations permit. Current knowledge and technology can buffer societies from many negative effects of climate change already experienced but will be severely challenged by the novel conditions we are now creating.

People came into North America more than 15,000 years ago and have experienced both massive and minor shifts in climate ever since. At the end of the last very cold phase of the most recent Ice Age, about 11,500 years ago, temperatures rose extremely rapidly—as much as 10°C (18°F) in a decade in some regions. This undoubtedly contributed to the extinction of large mammals like mammoths and mastodons that people hunted alongside many other resources (see Cross-Chapter Box PALEO in Chapter 1). There were so few people on the land, though, and other resources were so abundant, that the long-standing human means of coping with climate variability—switching foods and moving on—were sufficient.

Following the end of the Ice Age, populations across North America grew for the next few thousand years, at a rate that increased once people began to domesticate corn (maize), beans and squash (the 'three sisters') as well as other crops. However, more people meant less mobility, and farmers traditionally are also more invested in their fields and remaining in place than foragers are to hunting grounds. Other means of coping with vulnerability to food shortage caused by climate variability included some continued hunting and gathering of wild resources, planting fields in multiple locations and with different crops, storage in good years, and exchange with neighbours and neighbouring groups.

According to archaeological evidence, however, these adaptation strategies were not always sufficient during times of climate-induced stress. Human remains showing the effects of malnutrition are fairly common, and conflict caused in part by climate-induced shortfalls in farming has left traces that include fortified sites, sites placed in defensible locations and trauma to human bone. Larger and more hierarchical groups emerged, first in Mesoamerica and then in the southwest and southeast USA as well as the Midwest USA. These groups offered the possibility of buffering poor production in one area with surplus from another, but they also tended to increase inequality within their borders and often attempted to expand at the expense of their neighbours, introducing new sources of potential conflict. Dense hierarchical societies also arose in other areas such as the northwest coast where agriculture was not practised but resources, such as salmon and roots, were abundant and either relatively constant or storable.

These societies were not immune to climate hazards despite their greater population and more formal organisation. Archaeological evidence strongly suggests that drought, or growing conditions that were too hot or cold, contributed to the decline of groups ranging from Classic-period Maya states in Mesoamerica, to the somewhat less hierarchical societies of Chaco in the southwest USA and Cahokia in the Midwest USA (Figure FAQ14.2.1). The usual pattern seems to be that climatic variability compounded social and environmental problems that were already challenging these societies.

If societies in North America prior to the Euroamerican colonisation were vulnerable to climate variability, surely were not the more recent and technologically advanced societies of North America at lower risk? The 20th century Dust Bowl created in the US and Canadian prairies suggests otherwise. Severe drought conditions throughout the 1930s—which, to make matters worse, peaked during the Great Depression—did not cause either the USA or Canada to collapse. But both countries suffered massive economic losses, regional loss of topsoil and regional human strife (including loss of crops, income and farms) leading to migration. Yet anthropogenic global climate change was of little or no consequence in the 1930s. While farming practices made climate stress worse, the climate variability itself was either completely, or mostly, within the envelope of historical climate variability that earlier human societies had experienced.

Indigenous Peoples and Euroamerican farmers and ranchers have a long history of mostly successful adaptation to changing weather patterns. The wisdom held by Indigenous Peoples deep knowledge of how plants, animals and atmospheric conditions provide early warning signals of approaching weather shifts, and stories about how past communities have tried to cope with climate-related resource shortfalls. Long-standing community-level management of resources also helps prevent shortfalls, and institutions such as kin groups, church groups, clubs and local governments (which exist in communities of both Euroamericans and Indigenous Peoples, in different forms) can be powerful aids in ameliorating shortfalls and resolving conflict.

FAQ

Box FAQ 14.2 (continued)

Examples of areas where past climate variability has contributed to crises

Figure FAQ14.2.1 | Examples of areas where past climate variability has contributed to crises. Climatic variability is most likely to lead to crisis when it is accompanied by social, demographic and political conditions or environmental mismanagement that compound climatic impacts on societies.

Box FAQ 14.2 (continued)

Still, Indigenous knowledge and traditional knowledge among Euroamerican farming communities provide guidelines for how to cope with *traditional* problems. Contemporary governmental restrictions (such as legal water-rights allocations, international borders and tribal-lands boundaries) have limited the adaptive capacity that Indigenous societies have developed over the centuries. Now human-caused climate forcing, if not mitigated by reducing heat-trapping greenhouse gases, is expected to produce climates in North America that have no local analogues in human history even as it destroys heritage sites that are sources of knowledge about palaeoclimates and the diverse ways of coping with them that past peoples have discovered. Just as past peoples often *avoided* local climate change by moving on, in a world where mobility options are severely limited, a lesson from archaeology and history is that we should use our hard-won knowledge of the causes of climate change to avoid creating futures with no past analogues to provide useful guidance.

Frequently Asked Questions

FAQ 14.3 | What impacts do changes in the North American Arctic have within and outside the region?

The North American Arctic is warming at nearly three times the global average, creating a cascading web of local, regional and global impacts within and beyond polar regions. Changes in the Arctic not only effect global ocean circulation and climate regulation, but also facilitate new Arctic transportation routes and support transboundary resources with geopolitical, environmental and cultural implications as conditions change.

Rapid warming and extreme temperatures in the Arctic is leading to unprecedented seasonal sea ice loss, permafrost thaw and increasing ocean temperatures. Cascading from these biophysical changes are cultural, socioeconomic and political consequences that are widespread and largely unprecedented in human history. Changes in sea ice create safety hazards for Indigenous Peoples and northerners who rely on frozen seas and rivers for transportation between remote communities and to subsistence hunting areas. Thawing permafrost, especially that of ice-rich permafrost, creates challenges and costs for a region with low population density and a small tax base to support major infrastructure investments. Warmer ocean temperatures induce large-scale distributional shifts and reduced productivity and access to the largest North American fisheries. Ice-associated marine mammals, such as polar bears, seals and walruses, have declined precipitously with decreasing sea ice in the Bering Sea, and widespread ecosystem changes from fish through birds and marine mammal species have altered the system with uncertain outcomes for these productive ice-driven ecosystems. Newly ice-free shipping routes are increasing regional and geopolitical tensions and may facilitate novel threats like the spread of invasive species and safety hazards to local hunters and fishers. The local and regional impacts of climate change in the North American Arctic are profound and span social, cultural, health, economic and political imperatives.

Although the region is remote, changes in the Arctic impact the rest of the world. The Arctic serves as a regulator of global climate and other ecological processes through large-scale patterns related to air and ocean circulation. These vitally important processes are nearing points beyond which rapid and irreversible (on the scale of multiple human generations) changes are possible. The magnitude of cascading changes over the next two centuries includes regional warming and temperature extremes, permafrost declines and sea ice loss beyond that experienced in human existence. This includes macro-scale risks related to sea level rise from the melting of glaciers and thermal expansion of oceans. Changes in the Arctic are more pronounced than elsewhere and portend climate-change impacts in other areas of the globe.

Adaptation in the Arctic is underway and lessons learned on what works and what is effective and feasible to implement can provide global insights. Successful adaptation in the North American Arctic region has been attributed, in part, to the explicit and meaningful inclusion of Indigenous knowledge and Indigenous self-determination, and diverse perspectives in decision-making processes, strong local leadership, co-management approaches, technological investment in integrated climate modelling and projections, and multilateral cooperation.

Frequently Asked Questions

FAQ 14.4 | What are some effective strategies for adapting to climate change that have been implemented across North America, and are there limits to our ability to adapt successfully to future change?

Climate adaptation is happening across North America. These efforts are differential across sectors, scale and scope. Without more integrative and equitable approaches across broad scales, known as transformational adaptation, the continent may face limits to the future effectiveness of adaptation actions.

Across North America, progress in introducing climate adaptation is steady, but incremental. Adaptation is typically limited to planning, while implementation is often hindered by 'soft' limits, such as access to financial resources, disparate access to information and decision-making tools, the existence of antiquated policies and management frameworks, lack of incentives and highly variable political perceptions of the urgency of climate change.

Cities and other state and local entities are taking the lead in adaptation efforts, particularly in terms of mainstreaming the use of many approaches to adaptation. These approaches include a suite of efforts ranging from assessment of impacts and vulnerability (relative to individuals, communities, jurisdictions, economic sectors, natural resources, etc.), planning processes, implementation of identified strategies and evaluation of the effectiveness of these strategies. Other institutions (e.g., NGOs, professional societies, private engineering and architecture businesses) also are making significant progress in the adaptation arena, particularly at local to regional levels.

The water management and utilities sectors have made significant progress towards implementation of adaptation strategies using broad-based participatory planning approaches. Consideration of climate change is now folded into some ongoing watershed-wide planning efforts. An example is provided by the One-Water-One-Watershed (OWOW) approach followed by the Santa Ana Watershed Project Authority (SAWPA) in southern California. SAWPA is a joint powers authority comprising five regional water districts that provide drinking water to more than 6 million people as well as industrial and irrigation water across the 2400-square-mile watershed. The OWOW perspective focuses on integrated planning for multi-benefit projects and explicit consideration of the impacts of any planning option across the entire watershed. Planning is supported by stakeholder-driven advisory bodies organised along themes that consider a full suite of technical, political, environmental and social considerations. SAWPA provides member agencies with decision-support tools and assistance to implement water conservation policies and pricing regimes, and one member agency is an industry leader on potable water recycling.

The marine and coastal fisheries sector also has shown considerable progress in climate adaptation planning, particularly in terms of assessing impacts and vulnerability of fisheries. Along the Pacific Northwest coast of the USA and Alaska, seasonal and sub-seasonal forecasts of ocean conditions exacerbated by warming (e.g., O_2, pH, temperature, sea ice extent) already have informed fisheries and aquaculture management. Similarly, forecasts and warnings have reduced human exposure to the increased risk of toxins from harmful algal blooms in the Gulf of Mexico, the Great Lakes, California, Florida, Texas and the Gulf of Maine.

Professional organisations and insurance play an important part in mainstreaming climate adaptation. Government and private-sector initiatives can help address adaptation efforts through building-design guidelines and engineering standards, as well as insurance tools that reflect the damages from climate impacts. Through the identification of climate risks and proactive adaptation planning, the private sector can contribute to reducing risks throughout North America by securing operations, supply chains and markets.

Indigenous Peoples and rural community efforts across the continent show great potential for enhancing and accelerating adaptation efforts particularly when integrated with Western-based natural resource management approaches, such as cultural burning and other traditional practices that reduce the buildup of fuels, in addition to prescribed fire and mechanical thinning. In the agricultural sector, examples include planting and cultivation of culturally significant plants, as a traditional practice of soil conservation, in addition to food crops or in lieu of synthetic or mechanical soil treatments.

Future changes in climate (e.g., more intense heatwaves, catastrophic wildfire and post-fire erosion, sea level rise and forced relocations) could exceed the current capacity of human and natural systems to successfully adapt (or 'hard limits'). The inclusion and equitable contribution of Indigenous Peoples and rural communities in decision-making and governance processes—including recognition of the interdependencies between cities and surrounding areas—increases the likelihood of building adaptive capacity at a pace that is commensurate with present and future climate-change risks.

Box FAQ 14.4 (continued)

Large-scale, equitable transformational adaptation likely will be required to respond to the growing rate and magnitude of changes before crossing tipping points where hard limits exist, beyond which adaptation may no longer be possible. Increasingly, there are calls for accelerating and scaling up adaptation efforts, in addition to aligning policies and regulatory legislation at multiple levels of government. Improved processes for adaptation decision making, governance and coordination, across sectors and jurisdictions, could enhance North America's capacity to adapt to rapid climatic change. These actions include a focused societal shift, across governments, institutions and transnational boundaries, from primarily technological approaches to NbS that help foster changes in perception of risk and, ultimately, human behaviour.

Frequently Asked Questions

FAQ 15.1 | How is climate change affecting nature and human life on small islands, and will further climate change result in some small islands becoming uninhabitable for humans in the near future?

Climate change has already affected and will increasingly affect biodiversity, nature's benefits for people, settlements, infrastructure, livelihoods and economies on small islands. In the absence of ambitious human intervention to reduce emissions, climate change impacts are likely to make some small islands uninhabitable in the second part of the 21st century. By protecting and restoring nature in and around small islands as well as implementing anticipatory adaptation responses, humans can help reduce future risks to ecosystems and human lives on most small islands.

Observed changes—including increases in air and ocean temperatures, increases in storm surges, heavy rainfall events, and possibly more intense tropical cyclones—are already reducing the number and quality of ecosystem services, thereby causing the disruption of human livelihoods, damage to buildings and infrastructure, and loss of economic activities and cultural heritage on small islands. Widespread observed impacts include severe coral reef bleaching events, such as that associated with the 2015–2016 El Niño season, the most damaging on record worldwide. Additionally, the 2017 Atlantic hurricane season was unusually characterised by sequential severe tropical cyclones that resulted in widespread cyclone-induced damage to ecosystems from the very interior of small islands to those of the ocean waters that surround them as well as damage to human settlements and economic activities within the whole Caribbean region. Although knowledge is limited regarding long-term increases in tropical cyclone intensity, studies have shown that heavy rainfall and intense wind speed of individual tropical cyclones were increased by climate change. The combination of various climate events, such as tropical cyclones, extreme ocean waves, and El Niño or La Niña phases, with sea level rise causes increased coastal flooding, especially on low-lying atoll islands of the Indian and Pacific oceans.

The expected increased risk of such impacts under further climate change is significant. For example, some low-lying islands and areas may be extensively flooded at every high tide or during storms. As a result, their freshwater supplies and soils would be repeatedly contaminated by saltwater, with adverse cascading consequences for freshwater and terrestrial food supplies, biodiversity and ecosystems, and economic activities. It is unlikely that these locations would remain habitable unless such impacts are mitigated through reduction of heat-trapping greenhouse gas emissions or adaptation solutions that are acceptable for the populations of these islands. Acceptable adaptation options may be limited in these locations. Additionally, drought intensity may challenge freshwater security in some regions such as the Caribbean. Likewise, remote atoll islands where inhabitants rely on reef-derived food and other resources and that are at high risk of widespread coral reef degradation may become uninhabitable. Strategies to reduce risk may include substituting the consumption of vulnerable inshore reef resources by developing onshore aquaculture (fish farming), or promoting access to tuna and other pelagic fish, and/or importing food to meet nutritional needs. However, adoption of these strategies will depend on the acceptance of their local populations.

The intensity and timing of such impacts will be more severe under high warming futures compared to low warming futures accompanied by ambitious adaptation. Tailored, desirable and locally owned adaptation responses that incorporate both short- and long-term time horizons would certainly help to reduce future risks to nature and human life in small islands. Among the short-term measures frequently employed to address sea level rise and flooding are seawalls. Long-term measures include ecosystem-based adaptation such as mangrove replanting, relocation of coastal villages to upland sites, creation of elevated land through reclamation, revised building codes as part of a broader disaster risk reduction strategy, shifting to alternative livelihoods and changes in farming and fishing practices.

Frequently Asked Questions

FAQ 15.2 | How have some small island communities already adapted to climate change?

Faced with rising sea levels and storm surges along their coastal areas which have significantly threatened people's safety, buildings, infrastructure and livelihoods, small island communities have already embarked on the use of different adaptation strategies. These include reactive adaptation, which deals with short-term measures, and anticipatory adaptation, which takes action in advance to lessen climate change impacts in the long run. Reactive measures have not always proven to be effective. By contrast, anticipatory measures hold much promise for future adaptation.

The majority of people living on small islands occupy coasts, and thus the most widespread threats to people's livelihoods are those from sea level rise, shoreline erosion, increased lowland flooding, and salinisation of groundwater and soil. Humans can either adapt reactively or anticipate coming changes and prepare for them. Given the diversity of small islands across the world, and their capacities to adapt, there is no single solution that fits all contexts.

Coastal livelihoods in particular are already affected by climate impacts. Coastal fishers have adapted to these changes in environmental conditions by diversifying livelihoods, expanding aquaculture production, considering weather insurance, building social networks to cope with reduced catches and availability during extreme storms, switching fishing grounds, and changing target species. Similarly, farmers have diversified livelihoods to more cash- and service-based activities such as tourism, changed plant species that thrive better in altered conditions, and shifted planting seasons according to changes in climate.

A typical reactive adaptation along small island coasts involves the construction of hard impermeable structures such as seawalls to stop the encroachment of the sea. Yet such structures, especially along rural island coasts, often fail to prevent flooding during extreme sea levels or extreme-wave impacts, and can inadvertently damage nearshore ecosystems such as mangroves and beaches. In the Caribbean, Indian Ocean islands and some Pacific islands, there are numerous examples of coastal engineering structures that have been destroyed already or are in grave danger from the encroaching sea. In many instances, citizens and governments are unable to access external advice or funding, communities have built such structures without assistance or knowledge of expected future SLR.

By contrast, anticipatory adaptation, which anticipates expected future impacts and acts in advance, requires a longer-term view as well as some understanding of future climate-change impacts in particular contexts. Along small island coasts, anticipatory adaptation typically involves recognising that sea level will continue rising and that problems currently experienced will be amplified in the future. One strategy for anticipatory adaptation in response to SLR and flooding is relocation, which is the movement of coastal communities away from vulnerable (coastal-fringe) locations to sites that are further inland. Coastal setback policies have been applied to hotels in some islands such as Barbados. In coastal locations where the risks of rising sea level, flooding and erosion are very high and cannot effectively be reduced, 'retreat' from the shoreline is the only way to eliminate or reduce such risks.

Where relocation is successful, it is most commonly driven and funded by governments and non-government organisations, often within a specially designed policy framework. The Government of Fiji, for example, has introduced a relocation framework that specifically develops guidance on relocation processes, with several villages already having relocated. Evaluations to date recommend thorough cost–-benefit analyses of relocation be undertaken before this strategy is pursued. Relocation is often viewed as a 'last resort' adaptation option because of high cost and because some sociocultural aspects of life cannot be maintained in locations separated from customary land. The Bahamas relocated a community on Family Island from the shoreline to an inland location and the community of Boca de Cachón in the Dominican Republic was relocated to higher ground. The Navunievu community (Bua, Fiji) has mandated that every young adult building their family home in the village should do so upslope rather than on the regularly flooded coastal flat where the existing village is located. Over the next few decades, this will result in the gradual upslope migration of the community, an example of autonomous adaptation. Such creative community-grounded solutions hold great promise for future adaptation on small islands, where they are undertaken inclusively.

FAQ 15.2 (continued)

Anticipatory adaptation has been aligned with disaster risk reduction in some small islands. For example, Jamaica adopted such an approach in relocating three communities. Recognising that a proactive approach is needed, Jamaica developed a Resettlement Policy Framework aligned with the National Development Plan and based on vulnerability assessments of communities at risk of climate change and disaster risk. A resettlement action plan was developed for the Harbour Heights community using community engagement to design successful planned relocation. In some islands revised building codes are implemented as an anticipatory adaptation measure. As part of the build-back-better strategy hurricane resistant roofs are being built to cope with strong winds associated with tropical cyclones.

Ecosystem-based adaptation can be a low-cost anticipatory adaptation measure that is often used in small islands. It is referred to as a 'no-regret' or 'low-regret' strategy because it is low-costing, brings co-benefits and requires less maintenance in contrast to hard engineering structures. Ecosystem-based adaptation is used at different scales and in different sectors such as to protect fisheries, farming and tourism assets, and integrates various stakeholders from national to local governments and non-governmental agencies. Many islands have implemented ecosystem-based adaptation such as watershed management, mangrove replanting and other nature-based solutions to strengthen coastal foreshore areas that are subjected to coastal erosion and flooding caused by sea level rise and changing rainfall patterns. For example, mangroves have been planted on several cays in Belize and pandanus trees have been planted near the coastlines of the Marshall Islands. Agroforestry is another example of ecosystem-based adaptation. Planting trees and shrubs in combination with crops has been used to increase resilience of crops to droughts or excessive rainfall run-off. Case studies show that people living on islands benefit even further from using ecosystem-based adaptation. Their health improves as well as their food and water supply, while risks of disasters caused by extreme events are reduced.

FAQ 15.2 (continued)

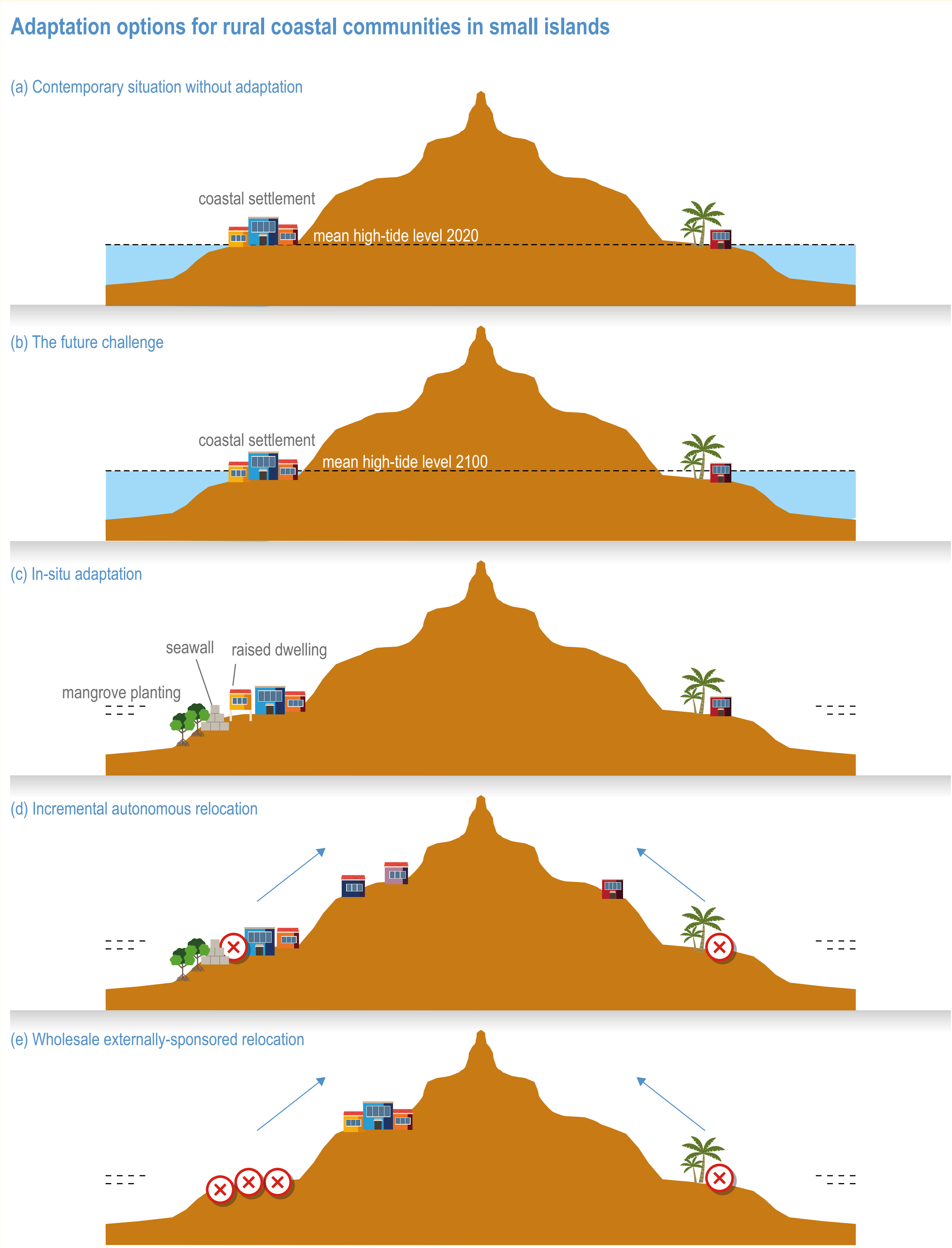


Figure FAQ15.2.1 | Adaptation options for rural coastal communities in small islands.

FAQ 15.2 (continued)

a: In many places today, coastal communities which have been established for hundreds of years are being more regularly inundated than ever before as a result of rising sea level.
b: By the end of this century, sea level in such places may have risen 1 m or more, making many such settlements (largely) uninhabitable, underscoring the need for effective (anticipatory) adaptation.
c: One option is in situ adaptation, popular because it is cheaper and less disruptive than other options; it is typically characterised by mangrove replanting, seawall construction and raising of dwellings.
d: A second option is for communities to incrementally relocate upslope by building all new houses further inland.
e: A third option is complete relocation of a vulnerable coastal community with external support upslope and inland.

Frequently Asked Questions

FAQ 15.3 | How will climate-related changes affect the contributions of agriculture and fisheries to food security in small islands?

Agriculture and fisheries are heavily influenced by climate, which means a change in occurrence of tropical cyclones, air temperature, ocean temperature and/or rainfall can have considerable impacts on the production and availability of crops and seafood and therefore the health and welfare of island inhabitants. Projected impacts of climate change on agriculture and fisheries in some cases will enhance productivity, but in many cases could undermine food production, greatly exacerbating food insecurity challenges for human populations in small islands.

Small islands mostly depend on rain-fed agriculture, which is likely to be affected in various ways by climate change, including loss of agricultural land through floods and droughts, and contamination of freshwater and soil through salt-water intrusion, warming temperatures leading to stresses of crops, and extreme events such as cyclones. In some islands, crops that have been traditionally part of people's diet can no longer be cultivated due to such changes. For example, severe rainfall during planting seasons can damage seedlings, reduce growth and provide conditions that promote plant pests and diseases.

Changes in the frequency and severity of tropical cyclones or droughts will pose challenges for many islands. For example, more pronounced dry seasons, warmer temperatures and greater evaporation could cause plant stress reducing productivity and harvests. The impacts of drought may hinder insects and animals from pollinating crops, trees and other vegetative food sources on tropical islands. For instance, many agroforestry crops are completely dependent on insect pollination, and it is, therefore, important to monitor and recognise how climate change is affecting the number and productivity of these insects. Coastal agroforest systems in small islands are important to national food security but rely on biodiversity (e.g., insects for pollination services). Biodiversity loss from traditional agroecosystems has been identified as one of the most serious threats to food and livelihood security in islands. Ecosystem-based adaptation practices and diversification of crop varieties are possible solutions.

The continuous reduction of soil fertility as well as increasing incidences of pests, diseases and invasive species contribute to the growing vulnerability of the agricultural systems on small islands. Higher temperatures could increase the presence of food- or water-borne diseases and the challenge of managing food safety. Changes in weather patterns can also disrupt food transportation and distribution systems on islands where indigenous communities are often located in remote areas.

Impacts of climate change on fisheries in small islands result from ocean temperature change, sea level rise, extreme weather patterns such as cyclones, reducing ocean oxygen concentrations and ocean acidification. These combined pressures are leading to the widespread loss or damage to marine habitats such as coral reefs but also mangroves and seagrass beds and consequently of important fish species that depend on these habitats and are crucial both to the food security (a high proportion of dietary protein is derived from seafood) and incomes of island communities. Shifting ocean currents and warming waters are also changing the distribution of pelagic fish stocks, especially of open-water tuna, with further consequences for both local food security and national economies, where they are often highly dependent on income from fishing licenses (e.g., 98% of Gross Domestic Product in Tokelau, 66% of national income in Kiribati).

Climate change is projected to have profound effects on the future status and distribution of coastal and oceanic habitats, and consequently of the fish and invertebrates they support. High water temperature causes changes in the growth rate of fish species as well as the timing of spawning and migration patterns, with consequences for fisheries catch potential. Some small island countries and territories are projected to experience more than 50% declines in fishery catches by 2100. Other small islands such as Easter Island (Chile), Pitcairn Islands (UK), Bermuda, and Cabo Verde may actually witness increases in catch potential under certain climate scenarios. Food shortages are often apparent in small islands, following the passage of catastrophic tropical cyclones. Access to pelagic fisheries can help to alleviate immediate food insecurity pressures in some circumstances, whereas aquaculture (fish farming) is being viewed as a longer-term means of diversifying incomes and enhancing resilience in many Caribbean and Pacific islands.

Frequently Asked Questions

FAQ CCP1.1 | Why are biodiversity hotspots important?

Biodiversity hotspots are regions that are exceptionally rich in species, ecologically unique and which may contain geographically restricted species. They are thus priority targets for nature conservation.

Recognising that the Convention on Biological Diversity definition of biodiversity includes the variation within and between species and of ecosystems, different schemes have been applied to define hotspots, leading to hundreds of different areas being proposed as hotspots. However, all identify a set of priority areas that cover a small portion of the Earth, but house an exceptionally high proportion of its biodiversity. Because biodiversity underpins all life on Earth, these hotspots have significant global value as they contain species and habitats that are found nowhere else. Their loss would mean loss of species and habitats that provide wild and farmed food, medicine and other materials, and services such as climate regulation, pollination and water purification, all of which maintain the health of the ecosystems we depend upon.

Healthy ecosystems, with flourishing biodiversity in natural conditions, are more resilient to disturbances, whether natural or human in origin. Environmentally sustainable development inside and outside hotspots could help reverse human impacts on biodiversity. The hotspots also capture and store carbon, thereby helping to mitigate climate change. Prioritisation of protecting biodiversity in hotspots thus benefits nature conservation and helps mitigate climate change. A global network of protected areas and restoration initiatives inside biodiversity hotspots can also help increase resilience to the effects of climate change on biodiversity.

Frequently Asked Questions

FAQ CCP1.2 | How can society ensure conservation of biodiversity in climate policies?

To reduce the effects of climate change on biodiversity, it is first essential to address direct human impacts that are already leading to a loss of biodiversity. This can be achieved by protecting biodiversity in conservation areas, restoring biodiversity everywhere possible and promoting sustainable development. Climate policies should thus integrate with policies to protect and restore nature.

Avoiding further loss of biodiversity is implicit in sustainable development. This needs to happen on land, rivers, lakes and in the oceans. It is especially important in 'biodiversity hotspots' (FAQ 1.1) and protected areas to minimise species losses. Hence calls by the International Union for the Conservation of Nature, Convention on Biological Diversity, United Nations Sustainable Development Goals (SDGs) to increase the size and connectivity of fully protected areas (which aim to have biodiversity in a near natural condition) and include in them the biodiversity hotspots, need to be immediately implemented.

Five of the SDGs are life on land, life below water, good health and well-being, food security and climate action. They underpin and interact with many other SDGs. Healthy ecosystems play a role in mitigating greenhouse gas emissions, not only protecting areas to prevent the release of carbon through land conversion activities but also restoring otherwise degraded land. The United Nations has declared 2021–2030 as the Decade on Ecosystem Restoration and the Decade of Ocean Science for Sustainable Development. Restoration means actively or passively allowing habitat to return to its natural state (e.g., grassland, forest, peatland, oyster beds), including replanting native vegetation. This can benefit the recovery of biodiversity, help remove carbon dioxide from the atmosphere and improve the delivery of nature's contributions to people, such as climate regulation, water purification, pollination, and pest and disease control. Thus, protecting biodiversity helps to meet two SDGs directly, and three indirectly.

On land, the loss of natural forests and grasslands not only means a loss of carbon and many of their associated species, but exposes soils to erosion, affecting food production, and can affect the climate by altering the water cycle. Sustainable development, even within hotspots, involves active restoration of natural biodiversity, reducing poaching and trafficking of wildlife (UN SDG 15), and needs to include agriculture. This includes working to ensure biodiverse soils and supporting healthy pollinator populations. Biodiversity includes not only wild species but also genetic diversity, including crops and wild crop relatives. These wild relatives may contain important genes that could help farmed crops survive better in a changed climate. At least some of these wild relatives come from areas designated as hotspots. In the ocean, sustainable development means reducing pollution, carefully managed aquaculture development, increased protected areas (from the present 2.5% of the ocean area), enforcement of fisheries regulations, and removal of fishery subsidies that perpetuate overfishing within Exclusive Economic Zones and on the High Seas (UN SDG 14). Generally, the use of freshwaters, rivers, lakes and groundwaters, has not been sustainable and there is a need to restore biodiversity and water quality by eliminating pollution and to better manage abstraction, river flows, fishing and invasive species. Thus, as is the case with land and oceans, climate policies must prioritise the restoration of freshwater biodiversity, and reduction of the current negative impacts of human activities.

Frequently Asked Questions

FAQ CCP2.1 | Why are coastal cities and settlements by the sea especially at risk in a changing climate, and which cities are most at risk?

Coastal cities and settlements (C&S) by the sea face a much greater risk than comparable inland cities and settlements because they concentrate a large proportion of the global population and economic activity, whilst being exposed and vulnerable to a range of climate- and ocean-compounded hazard risks driven by climate change. Coastal cities and settlements range from small settlements along waterways and estuaries, to small island states with maritime populations and/or beaches and atolls that are major tourist attractions, large cities that are major transport and financial hubs in coastal deltas, to megacities and even megaregions with several coastal megacities.

The concentration of people, economic activity and infrastructure dynamically interacts with coast-specific hazards to magnify the exposure of these cities and settlements to climate risks. While large inland cities and coastal settlements can be exposed to climate-driven hazards, such as urban heat islands and air pollution, the latter are also subject to distinctive ocean-driven hazards, such as sea level rise (SLR), exposure to tropical cyclones and storm surges, flooding from extreme tides and land subsidence from decreased sediment deposition along coastal deltas and estuaries. With climate change increasing, the intensity and frequency of hazards under all future warming levels and thus the risks to lives, livelihoods and property are especially acute in cities and settlements by the sea.

Coastal cities are diverse in shape, size, growth patterns and trajectories, and in terms of access to cultural, financial and ecosystem resources and services. Along deltaic and estuarine archetypes, cities most vulnerable to a changing climate have relatively high levels of poverty and inequality in terms of access to resources and ecosystem services, with large populations and dense built environments translating into higher exposure to coastal climate risks.

These climate risks at the coast can also be magnified by compounding and cascading effects due to non-climate drivers directly affecting vulnerable peri- and ex-urban areas inland. These risks include disruption to transport supply chains and energy infrastructure from airports and power plants sited along the coastline, as occurred in New York City, USA, during Hurricane Sandy in 2012. The impacts can be felt around the world through globalised economic and geopolitical linkages, for example through maritime trade and port linkages.

For open coasts, settlements on low-lying small island states and the Arctic are especially vulnerable to climate change, and sea level rise impacts in particular, well before 2100. While the economic risks may not compare to the scale of those faced in coastal megacities with high per capita Gross Domestic Product, the existential risks to some nations and an array of distinctive livelihoods, cultural heritage and ways of life in these settlements are great, even with modest sea level rise.

Frequently Asked Questions

FAQ CCP2.2 | What actions can be taken by coastal cities and settlements to reduce climate change risk?

Sea level rise (SLR) responds to climate change over long timeframes and will continue even after successful mitigation. However, rapid global mitigation of greenhouse gases significantly reduces risks to coastal cities and settlements (C&S), and, crucially, buys time for adaptation.

Appropriate actions to reduce climate change risks in coastal cities and settlements depend on the scale and speed of coastal change interacting with unfolding local circumstances, reflecting the hazards, exposure, vulnerability and response to risks.

'Hard' protection, like dikes and seawalls, can reduce the risk of flooding for several metres of sea level rise in some coastal cities and settlements. These are most cost effective for densely populated cities and some islands, but may be unaffordable for poorer regions. Although these measures reduce the likelihood of coastal flooding, residual risk remains, and hard protection typically has negative consequences for natural systems. In low-lying protected coastal zones, draining river and excess water will increasingly be hampered, eventually requiring pumping or transferring to alternative strategies.

Whereas structures can disrupt natural beach morphology processes, sediment-based protection replenishes beaches. These have lower impact on adjacent beaches and coastal ecology and lower costs for construction and maintenance compared to hard structures. Another form of 'soft' protection involves establishing, rehabilitating and preserving coastal ecosystems, like marshes, mangroves, seagrass, coral reefs and dunes, providing 'soft' protection against storm surges, reducing coastal erosion and offering additional benefits including food, materials and carbon sequestration. However, these are less effective where there is limited space in the coastal zone, limited sediment supply and under higher rates of sea level rise.

Coastal settlements can 'avoid' new flood and erosion risks by preventing development in areas exposed to current and future coastal hazards. Where development already exists, settlements can 'accommodate' climate change impacts through, among other things, land-use zoning, raising ground or buildings above storm surge levels, installing flood-proofing measures within and outside properties, and early warning systems. Improving the capacity of urban drainage, incorporating nature-based solutions within urban areas and managing land upstream of settlements to reduce runoff from the hinterland reduces the risk of compound flood events. More radically, land can also be reclaimed from the sea, which offers opportunities for further development but has impacts on the natural system and wider implications for the trajectory of development.

Coastal risks and impacts such as floods, loss of fisheries or tourism, or salinization of groundwater require people to change behaviour to adapt, such as diversifying livelihoods or moving away from low-lying areas. Currently, most of these practices are reactive and help people adjust to/cope with current impacts. While a critical part of coastal adaptation, changing behaviour can be enabled by supportive policies and financial structures aligned with sociocultural values and worldviews.

Where risks are very high or resources are insufficient to manage risks, submergence or erosion of coastal cities and settlements will be inevitable, requiring 'retreat' from the coastline. This is the outlook for millions of people in the coming decades, including those living in river deltas, Arctic communities, small islands and low-lying small settlements in poor and wealthy nations. Whilst the impacts of retreat on communities can be devastating, the prospect of many cities and settlements and even whole nations being permanently inundated in the coming centuries underscores the imperative for urgent action.

Crucial to making choices about how to mitigate greenhouse gas emissions and adapt to climate change in coastal cities and settlements is to establish institutions and governance practices supporting climate resilient development—a mix and sequence of mitigation and adaptation actions—that are fair, just and inclusive as well as technically and economically effective across successive generations.

Frequently Asked Questions

FAQ CCP2.3 | Considering the wide-ranging and interconnected climate and development challenges coastal cities and settlements face, how can more climate resilient development pathways be enabled?

Coastal cities and settlements (C&S) are on the frontline of the climate change challenge. They are the interface of three interconnected realities. First, they are critical nodes of global trade, economic activity and coast-dependent livelihoods, all of which are highly and increasingly exposed to climate- and ocean-driven hazards (FAQ CCP2.1). Second, coastal C&S are also sites where some of the most pressing development challenges are at play (e.g., trade-offs between expanding critical built infrastructure while protecting coastal ecosystems, high economic growth coupled with high inequality in some coastal megacities). Third, coastal C&S are also centres of innovation and creativity, thus presenting a tremendous opportunity for climate action through a range of infrastructural, nature-based, institutional and behavioural solutions (FAQ CCP2.2). Given these three realities of high climate change risks, rapid but contested and unequal development trajectories, and high potential for innovative climate action, C&S are key to charting pathways for climate resilient development (CRD).

Three key levers can enable pathways that are climate resilient and meet goals of inclusive, sustainable development. One key enabler involves flexible, proactive, and transparent governance systems, built on a bedrock of accountable local leadership, evidence-based decision-making—even under uncertainty—and inclusive institutions that consider different stakeholder voices and knowledge systems. Another key enabler is acknowledging the sociocultural and psychological barriers to climate action and incentivising people to change to lifestyles and behaviours that are pro-climate and aligned with community-oriented values and norms. In practice, coastal cities and settlements are experimenting with different strategies to change practices and behaviours, such as using subsidies and zoning policies, tax rebates and public awareness campaigns to promote individual and collective action. Finally, enabling climate resilient development needs dedicated short- and long-term financing to reorient current trajectories of unsustainable and unequal development towards climate mitigation and adaptation action that reduces current and predicted losses and damages, especially in highly vulnerable coasts such as the small island states, the Arctic and low-lying cities and settlements. Currently, adaptation finance is concentrated in coastal megacities and tends to be deployed for risk-proofing high-value waterfront properties or key infrastructures. Addressing these financial imbalances (globally, regionally and sub-nationally) remains a critical barrier to inclusive climate resilient coastal development.

Notwithstanding the many interconnected challenges faced, from more frequent and intense extreme events to the COVID-19 pandemic, many coastal cities and settlements are experimenting with ways to pivot towards climate resilient development. Critical enablers have been identified and lesson learned, which, if translated into practice, will enhance the prospects for advancing the Sustainable Development Goals and charting pathways for climate resilient development that are appropriate to local contexts and foster human well-being and planetary health.

Frequently Asked Questions

FAQ CCP3.1 | How has climate change already affected drylands and why are they so vulnerable?

Human-caused climate change has so far had mixed effects across the drylands, leading to fewer trees and less biodiversity in some areas and increased grass and tree cover in others. In those dryland areas with increasing aridity, millions of people face difficulties in maintaining their livelihoods, particularly where there is water scarcity.

Drylands include the hottest and most arid areas on Earth. Human-caused climate change has been intensifying this heat and aridity in some places, increasing temperatures more across global drylands than in humid areas. In areas which are hotter and drier, tree death has occurred and in some locations bird species have been lost. Climate change has reduced rainfall in some dryland areas and increased rainfall in other areas. Increased rainfall, combined with the plant-fertilizing effect of more carbon dioxide in the atmosphere, can increase grass and shrub production in dryland areas. Because water is scarce in drylands and aridity limits the productivity of agriculture, millions of people living in drylands have faced severe difficulties in maintaining their livelihoods. This challenge is exacerbated by non-climate change factors, such as low levels of infrastructure, remoteness and limited livelihood options that are less dependent on scarce natural resources. High temperatures in drylands increase the vulnerability of people to potential heat-related illnesses and deaths from heat under continued climate change.

Frequently Asked Questions

FAQ CCP3.2 | How will climate change impact the world's drylands and their people?

Climate change is projected to lead to higher temperatures across global drylands. Many drylands also risk more irregular rainfall leading to increased irregularity in crop yields and increased water insecurity where less rainfall is projected, which may have profound implications for both dryland ecosystems and their human inhabitants.

There is, however, considerable uncertainty about the changes that may occur in drylands in the future and how people and ecosystems will be affected. In some drylands, higher temperatures and declining rainfall have increased aridity. However, this is not a global trend as many drylands are experiencing increases in vegetation cover and rainfall. Both the amount of rainfall and its seasonality have changed in many dryland areas, associated with natural variability and warming.

Most climate models project increased rainfall in tropical drylands, but more variability. High natural climatic variability in drylands makes predictions uncertain. Understanding future impacts is further complicated by many interacting factors such as land use change and urbanisation that affect the condition of drylands. Future trends in sand and dust storm activity are also uncertain and will not be the same everywhere, but there will likely be increases in some regions (e.g., the USA) in the long term. The impacts of climate change in deserts and semiarid areas may have substantial implications globally: for agriculture, biodiversity, health, trade and poverty, as well as potentially, for conflicts and migration. Increasing temperatures and more irregular rainfall are expected to affect soil and water and contribute to tree death and loss of biodiversity. In other places, woody encroachment onto savannas may increase, in response to the combination of land use change, changes in rainfall, fire suppression and CO_2 fertilization. Crop yields are projected to decline in some areas, with adverse impacts on food security. The potential for conflicts and migration is primarily associated with socioeconomic development, while links to climate change remain uncertain and lack evidence.

Frequently Asked Questions

FAQ CCP3.3 | What can be done to support sustainable development in desert and semiarid areas, given projected climate changes?

Water is a major limiting factor in drylands. Many efforts to support sustainable development aim to improve water availability, access and quality, ranging from large engineering solutions that move or desalinise water, to herders' migrations with their animals to locations that have water, to land management and water harvesting practices that conserve water and support land cover. These solutions draw on IKLK and innovative science, and can help to address multiple Sustainable Development Goals.

Different desert and semiarid areas can benefit from different incremental and transformational solutions to move toward sustainable development under climate change. In some dryland areas facing critical water shortages, transformational adaptations may be needed; for example, large-scale water desalination when they have access to sea water, despite high energy use and negative environmental impacts of waste brine. In dryland agricultural areas across the world, incremental adaptations include water conservation measures, use of improved crop varieties or increasing herd mobility. What counts as a transformational change in some places may be incremental in others.

Often solutions can target multiple development goals. For example, water harvesting can make water available during drought, buffering water scarcity impacts, while also supporting food production, agricultural livelihoods and human health. Land-based approaches, e.g. restoration of grassland, shrubland, and savanna ecosystems, are important for ensuring ecological integrity, soil protection and preventing livelihoods from being undermined as a result of growing extreme weather events.

It is important that policies, investments and interventions that aim to support sustainable development take into account which groups are likely to be most affected by climate change. Those people directly dependent on natural resources for their survival are generally most vulnerable but least able to adapt. The capacity to translate Indigenous knowledge and local knowledge and experience into actions can require external support. Governments and other stakeholders can help by investing in early warning systems, providing climate information, realigning policies and incentives for sustainable management, investing in supporting infrastructures, alongside developing alternative livelihood options that are less exposed and sensitive to climate change. Involving all relevant stakeholders is important. For example, in China, the Grain for Green programme secured local engagement by paying people to manage the environment more sustainably. At a global level, important groups have emerged to cooperate and offer solutions around issues such as sand and dust storms, and integrated drought management. Efforts are needed across all scales from local to global to support sustainable development in desert and semiarid areas, given projected climate changes.

Frequently Asked Questions

FAQ CCP4.1 | Is the Mediterranean Basin a 'climate change hotspot'?

Is the Mediterranean 'a geographical area characterised by high vulnerability and exposure to climate change'? Climate change projections for the Mediterranean Basin indicate with very high consistency that the region will experience higher temperatures, less rainfall and continued sea level rise during the coming decades. Given that summers are already comparatively dry, these factors together will likely cause substantially drier and hotter conditions as well as coastal flooding, impacting people directly but also harming ecosystems on land and in the ocean.

For the Mediterranean Basin, climate models consistently project regional warming at rates about 20% above global means and reduced rainfall (–12% for global warming of 3°C). While it is not the region with the highest rate of expected warming on Earth, the Mediterranean Basin is considered particular in comparison to most other regions due to the high exposure and vulnerability of human societies and ecosystems to these changes: a 'climate change hotspot'.

Rising temperatures trigger extensive evaporation of water from all wet surfaces, notably the sea, lakes and rivers, but also from soils. Along with decreasing rainfall, this evaporation leads to shrinking water resources on land, drier soils, reduced river flow, and significantly longer and more intensive drought spells. Since the Mediterranean climate is already relatively dry and warm in the summer, any additional drought (and also heat) will affect plants, animals and people significantly, and ultimately entire societies and economies.

In general, increasing temperatures and more intensive heat waves in the basin threaten human well-being, economic activities, and also many ecosystems on land and in the ocean. Extreme rainfall events, which despite the lower total rainfall are expected to increase in intensity and frequency in some regions, generate significant risks for infrastructure and people through flash floods. Warming also affects the ocean and its ecosystems, jointly with acidification caused by atmospheric carbon dioxide. Finally, sea level rise, currently accelerating because of global ice loss, threatens coastal ecosystems, historical sites and a growing human population.

Key risks in the Mediterranean and their location for SSP5-RCP8.5 by 2100

Figure FAQ CCP4.1.1 | Key risks across the Mediterranean region by 2100. The symbols above the map highlight risks enhanced by climate change which apply to the entire region with *high confidence*. Other risks are localised in the map.

FAQ CCP4.1(continued)

Risks associated with projected climate change are particularly high for people and ecosystems in the Mediterranean Basin due to the unique combination of many factors, including:

- A large and growing urban population exposed to heat waves, with limited access to air conditioning
- A large and growing number of people living in settlements impacted by rising sea level
- Important and increasing water shortages, already experienced by 180 million people today
- Growing demand for water by agriculture for on irrigation
- High economic dependency on tourism, which is likely to suffer from increasing heat but also from the consequences of international emission reduction policies on aviation and cruise-ship travel
- Loss of ecosystems in the ocean, wetlands, rivers and also uplands, many of which are already endangered by unsustainable practices (e.g., overfishing, land use change).

Frequently Asked Questions

FAQ CCP4.2 | Can Mediterranean countries adapt to sea level rise?

The rates of observed and projected sea level rise in the Mediterranean are similar to the Northeast Atlantic, potentially reaching 1.1 metres at the end of the present century. Erosion, flooding and the impacts of salinisation are projected to be particularly severe due to the special conditions of the coastal zones in the region. Beyond a few tens of centimetres, adaptation to sea level rise will require very large investments and may be impossible in some regions.

Sea level in the Mediterranean has been rising by only 1.4 mm yr^{-1} during the 20th century, more recently by 2.4±0.5 mm yr^{-1} from 1993 to 2012, and it is bound to continue rising in the future. Future rates are projected to be similar to the global mean (within an uncertainty of 10–20 cm), potentially reaching 1.1 m or more around 2100 in the event of 3°C of global warming (Figure FAQ CCP4.2; Table SMCCP4.4). Due to the ongoing ice loss in Greenland and Antarctica, this trend is expected to continue in coming centuries. Sea level rise already impacts extreme coastal waters around the Mediterranean and it is projected to increase coastal flooding, erosion and salinisation risks. These impacts would affect agriculture, fisheries and aquaculture, urban development, port operations, tourism, cultural sites and many coastal ecosystems.

Most of the Mediterranean Sea is a micro-tidal environment, which means that the difference between regular high and mean water levels (astronomical tides) is very small. Storm surges and waves can produce coastal floods that persist for several hours, causing particularly large impacts on sandy coasts and eventually also on coastal infrastructure. Mediterranean coasts are also characterised by narrow sandy beaches that are highly valuable for coastal ecosystems and tourism. These beaches are projected to be increasingly affected by erosion and eventually disappear where sedimentary stocks are small.

Overall, Mediterranean low-lying areas of significant width occur along 37% of the coastline and currently host 42 million inhabitants. The coastal population growth projected until 2050 mostly occurs in southern Mediterranean countries, with Egypt, Libya, Morocco and Tunisia being the most exposed countries to future sea level rise. The area at risk also hosts 49 cultural World Heritage sites, including the city of Venice and the early Christian monuments of Ravenna. The Mediterranean also includes areas subjected to sinking of the land (subsidence), including the eastern Nile Delta (Egypt) and the Thessaloniki flood plain (Greece), where local relative sea level rise can exceed 10 mm yr^{-1} today.

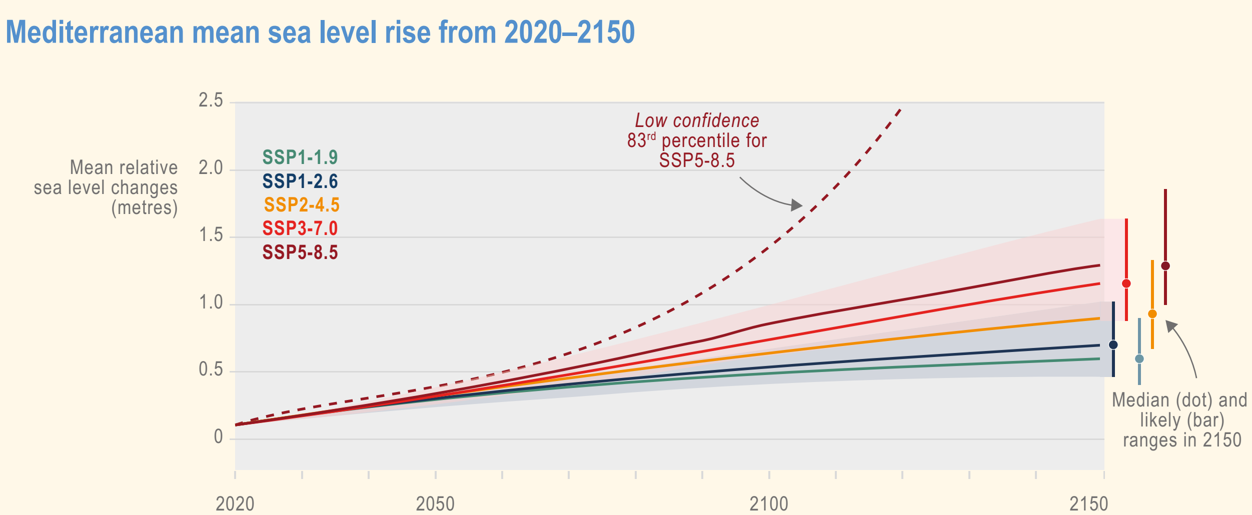


Figure FAQ CCP4.2.1 | Mediterranean Sea level projections. These projections translate the global estimates in WGI AR6 Chapter 9 to the Mediterranean Basin (Fox-Kemper et al., 2021). They assume that sea level change in the Mediterranean continues to be forced by Atlantic Sea level change seen at the Gibraltar Strait (Section CCP4.1) and thus follow the global mean beyond 2100. Vertical ground motions induced by glacial isostatic adjustments are also included, but not those due to other natural or anthropogenic processes such as tectonics or groundwater extractions. Intra-basin sea level changes are not included. Data available as supplementary material.

FAQ CCP4.2 (continued)

Adaptation to sea level rise in the Mediterranean includes engineering or soft/ecosystem-based protection, accommodation, and retreat or managed realignment. Despite various limitations, adaptation already happens today to some extent, as for example the coastal flood and erosion protections along the subsiding Nile Delta coast. Only massive coastal protection and other sustainable development policies could reduce the growing number of people exposed to sea level rise by 20%. It appears therefore *likely* that the number of people exposed could increase by up to 130% by 2100.

Without drastic mitigation of climate change, sea level rise is projected to accelerate and will require additional coastal engineering protection projects (e.g., dykes or groynes). Despite their efficiency for the few next decades, these engineering options have also adverse impacts for coastal ecosystems and may not ensure that the recreative value of Mediterranean coasts can be sustained (see Box 13.1 on Venice on the movable barriers protecting the Venice Lagoon). Among nature-based solutions, there are immediate benefits of restoring dunes and coastal wetlands to restore a buffer zone between coastal infrastructure and the sea and therefore reduce coastal risks (Cross-Chapter Box SLR in Chapter 3). Yet, this kind of protection is not feasible everywhere, particularly in urbanised areas, where it faces its limits. The limits for adaptation in the Mediterranean to further acceleration of sea level rise have stimulated ideas of large-scale geoengineering projects such as surface height control dams at Gibraltar. However, such projects come with unknown risks for humans and ecosystems.

Frequently Asked Questions

FAQ CCP4.3 | What is the link between climate change and human migration in the Mediterranean Basin?

Climate change already influences conflict and migrations occurring within countries or regions. However, climate is only one of the multiple factors affecting conflict and migration decisions across countries and regions. It is currently not possible to attribute particular conflicts or migrations to climate change and also in the future migration will most likely depend on the economic, social and governance context.

The Mediterranean Sea is the world's most dangerous place for migrants, with more than 20,000 deaths reported since 2014. Although empirical evidence indicates that migration related to climate impacts is mostly internal to national borders, climate change is likely to contribute to migration in the Mediterranean Basin as one out of several factors. Climate impacts contribute to migration flows particularly by affecting the economic and political drivers of migration.

Many migrants attempting to cross the Mediterranean to Europe originate from sub-Saharan Africa, a region heavily affected by climate change. In West Africa, for example, migration decisions are heavily influenced by perceptions of climate change and of its economic impact on resources and income. However, projections are uncertain, because climate impacts in Africa might both increase human suffering and thus enhance mobility, but they could also limit mobility of people through lack of financial resources.

The impacts of climate change on conflicts and security are increasingly documented, especially in Africa. Climate impacts may not in itself have caused social and political unrest but can contribute to them. The conflict in Syria has occurred after the drought that marred the country in the years before, but there is no evidence for direct causal linkage. There is, however, high agreement that food insecurity and land degradation, which can be induced by climate change, are major drivers of political upheavals and instability in northern and sub-Saharan Africa.

Frequently Asked Questions

FAQ CCP5.1 | How is freshwater from mountain regions affected by climate change, and what are the consequences for people and ecosystems?

Sources of freshwater from mountains, such as rainfall, snow and glacier melt, and groundwater are strongly affected by climate change, leading to important changes in water supply in terms of quantity and, partly, quality and timing (e.g., shifts and changes in seasonality). In many cases, the effects on ecosystems and people are negative, e.g., creating or exacerbating ecosystem degradation, water scarcity or competition or conflict over water.

River flow is a main source of freshwater both in mountain regions and downstream areas. Various sources contribute to it, including rainfall, snow and glacier melt and groundwater. Climate change affects these different sources in different ways. Climate change affects rainfall patterns, such as long-term increase or decrease, seasonal shifts or changes in rainfall intensity. Rising temperatures strongly influence snowmelt- and glacier-melt-generated river discharge; the snowmelt season starts earlier, less snow mass is available for melt, and snowmelt contribution to river flow thus decreases over the year. Whether rising temperatures produce meltwater from glaciers depends on the state and characteristics of the glaciers and the catchment basin. The concept of 'peak water' implies that, first, as glaciers shrink in response to a warmer climate, more meltwater is released until a turning point (peak water), after which glaciers melt, and so its contribution to river flow decreases. In many mountain regions worldwide, glaciers and their basins have already passed peak water, and the runoff contribution of glaciers is on the decline. Glacier shrinkage not only influences river discharge but also water quality. In the Andes of Peru, for instance, it has been observed that retreating glaciers expose bedrock, resulting in more acid water because of minerals that dissolve from the rock. Mountain ecosystems are also affected by changing freshwater availability. For instance, high-elevation wetlands in the tropical Andes critically depend on glacier meltwater during the dry season, and the disappearance of this freshwater source results in ecosystem degradation.

The effect of climate change on groundwater in mountains is insufficiently understood. Infiltrating water from glaciers and snowmelt plays an important role in groundwater recharge. Groundwater recharge is expected to decrease with continued climate change in several mountain regions. In the Himalaya many springs have already been observed to be in decline.

The availability of freshwater is a function of water supply and water demand, with the latter being determined by sectors such as agriculture, energy, industry or domestic use, as well as by competition among these sectors. Formal and informal water extraction and use prevail, and competition includes issues of inequality, power relations and asymmetry. Consequently, the effects of climate change on water resources, people and ecosystems are strongly modulated and often exacerbated by socioeconomic development and related water resource management. For example, the increasing frequency and intensity of droughts in the European Alps, combined with declines and seasonal shifts of river runoff from snowmelt and glacier melt, are expected to result in growing competition among different sectors, such as hydropower, agriculture and tourism. Similar developments are projected or have already been observed in many other mountain regions. This situation calls for strengthening and improving negotiation formats for water management that are transparent, equitable and socially and environmentally just. Management of water demand and strategies that entail multiple uses of water will become increasingly important in this context.

Frequently Asked Questions

FAQ CCP5.2 | Do people in mountain regions, and further downstream, face more severe risks to water-related disasters due to climate change, and how are they coping?

Mountain regions have always been affected by either too much or too little water. Because of climate change, hazards are changing rapidly and becoming even more unpredictable. Whether or not these changes will result in more disasters locally and further downstream depends on several factors, not least the fact that more people are settling in exposed locations. People in mountains have a history of developing skills to live in a dangerous and dynamic environment, which will be invaluable in the future when combined with inclusive and long-term disaster risk reduction measures.

Water-related hazards in mountains include rainfall (pluvial) and river (fluvial) floods, extreme rainfall-induced landslides, debris flows, ice and snow avalanches and droughts. When people are exposed and vulnerable to these hazards, disasters can result. Floods and landslides in mountains contribute to and count among the most devastating disasters globally, often resulting in significant losses such as high numbers of fatalities and economic and property damage. Climate change may alter rainfall frequency/intensity distributions, potentially leading to floods and droughts. Climate change may also lead to shifts in precipitation type, with more precipitation falling as rain rather than snow in the future, which will further impact both short- and long-term water storage and, therefore, will impact downstream ecosystems and cities.

Although climate change directly affects water-related hazards, studies indicate that above and beyond natural hazards, disaster risk and disasters are influenced to a major extent by vulnerability and exposure. This is of relevance in mountains, where disaster risk is influenced by population growth, induced displacements, land use changes and inefficient water distribution systems. For example, current trends suggest that more people are settling in exposed locations, with more infrastructure being built and activities such as tourism and recreation being promoted, exacerbating this exposure.

Experiences in dealing with water-related disasters provide a basis on which to build adequate responses to increasing risks in the future. For example, upgrading infrastructure like dams and embankments can help address water shortages, but diversification of income-generating activities, such as subsistence farming moving away from certain drought-sensitive crops, can also help.

The risk perceptions of people also shape their behaviours in coping with disaster risks. For example, based on their longstanding observations and local knowledge, communities in the southern part of the Peruvian Andes identified the shrinking of glaciers, more frequent and intense extreme weather events, more extreme temperatures and shortened rainy seasons as key challenges. The recognition of local knowledge is key to addressing these challenges, as well as providing a basis for the transformation of current systems. A lack of community involvement and participation in decision making on how to address disaster risk can contribute to mismatches between perceptions and behaviours in face of those risks, and the actions needed to reduce losses. Therefore, measures which are flexible, address the objectives and needs of all those affected by disasters and bring long-term benefits have more chances of being successful in dealing with future disaster risks.

Frequently Asked Questions

FAQ CCP5.3 | Does climate change pose a risk to mountain species and ecosystems, and will this affect people?

Treeline position, bioclimatic zones and species ranges move up in elevation as the climate warms, increasing the risk of extinction for species isolated on mountain tops as a result of exceeding their physiological limits, loss of habitat or competition from colonising species. Additionally, climate change may alter the quality and quantity of food and natural products on which the livelihood of many mountain communities depends.

Mountain regions cover about a quarter of the Earth's land surface, are scattered around the globe and may support a wide range of climates within short horizontal distances. Mountains have experienced above-average warming, and this trend is expected to continue. Mountains provide a variety of goods for people, are home to many Indigenous Peoples and are attractive for tourism and recreational activities. Mountain regions support many different ecosystems, and some are very species rich. Mountain regions can be vast and diverse, and climate change and its impacts on ecosystems vary greatly from location to location.

With increasing average global temperatures, the climatic conditions under which plants and animals can thrive are shifting to higher elevations. The movement of some plant taxa towards mountain tops has been observed in recent decades. However, for species restricted to the highest elevations, there is nowhere to move to, meaning they are increasingly at risk of extinction. Climatic conditions may exceed the physiological limits for species and habitats may become unsuitable for others. There is also a risk from competition with colonising native species and invading non-native species, spreading to higher elevations, and some species cannot move quickly enough to keep pace with changes in the climate. The most vulnerable species are those that reproduce and disperse slowly and those that are isolated on mountain tops, including endemic species, which may face global extinction. In other cases, species will be lost from some parts of their current range. Mountains can, however, allow other species to survive in areas where they otherwise would not because of small-scale variations in climate with elevation or different aspects of slopes.

Changes in snow cover and snow duration are related to changes in temperature and precipitation and are also critical for plants and animals. In particular, glacier retreat and changing snow patterns affect both streamflow dynamics (including extremes) and soil moisture conditions and can cause moisture shortages during the growing season. A change in snow patterns can critically affect animal movements in mountains. Other processes creating stresses on mountain ecosystems are direct human impacts, such as the influence of grazing, tourism, air pollution and nitrogen deposition on alpine vegetation. In some cases, these impacts can be so large on the goods and services provided by alpine ecosystems that they can overshadow the effects of climate change or exacerbate its effects.

In many mountain regions, multiple sources of evidence point to tree expansions into treeless areas above (and in some cases below) the forest belt. This may increase forest productivity at the upper treeline. Treelines have moved up in the last 30–100 years in many mountain regions, including, for example, the Andes, Urals and Altai. At the same time, since the 1990s, treeline responses in different parts of the Himalaya have been highly variable, in some places advancing upslope, in others demonstrating little change and in yet others moving downwards. This can be explained by site-specific complex interactions of the positive effects of warming on tree growth, drought stress, change in snow precipitation, land use change, especially grazing, and other factors. Treelines are affected by land use and management around the globe, and changing land use practices can supersede climate change effects in some mountain regions. An upward shift in the elevation of bioclimatic zones, decreases in the area of the highest elevation zones and an expansion of the lower zones can be expected by mid-century, for example in regions such as the Himalaya.

In some regions, the livelihoods of many local mountain communities depend on access to firewood, pastures, edible plants and mushrooms, and medicinal and aromatic plants. Climate change can alter the quality and quantity of these ecosystem services; however, the degree and direction of change are context specific. The appeal and feasibility of mountains for tourism and recreational activities are also affected by climate change.

Frequently Asked Questions

FAQ CCP5.4 | What types of adaptation options are feasible to address the impacts of climate change in mountain regions under different levels of warming, and what are their limits?

The feasibility of adaptation to address risks in mountain regions is influenced by numerous factors, many of which are unique to mountain people and their environment. Adaptation efforts in mountains mainly consist of small, largely autonomous steps. Robust and flexible adaptation measures have a better chance of addressing risks, but eventually large systemic transformation will be needed in the face of higher levels of warming. Empirical evidence on what works and what does not is largely absent but urgently needed.

The term feasibility refers to climate goals and adaptation options that are possible and desirable. Feasibility is influenced by factors such as economic viability, availability of technical resources, institutional support, social capital, ecological and adaptive capacity and biophysical conditions. Establishing the feasibility of options under changing climatic and socioeconomic conditions is not an easy task, mostly because even present feasibility is difficult to assess in mountains due to a lack of systematic information on opportunities and challenges of adaptation in practice.

Underlying environmental conditions, such as limited space, shallow soils, exposure to numerous hazards, climate-sensitive ecosystems and isolation, make it particularly difficult to implement adaptation at scales relevant for implementation. Common adaptation options are often implemented at the individual, household or community level. These options are incremental and have generated observable results and outcomes. Adaptation actions that involve partial changes that do not dramatically alter established practices and behaviours seem to have better chances of being implemented than systemic or structural changes. Formal or planned adaptation efforts that are more institutionally driven constitute only a small proportion of observed adaptation in mountain regions. Where adaptation options are implemented, they often target not only climate change but an array of other issues, priorities and pressures experienced by and in those communities (e.g., livelihood diversification in farming practices).

Whether or not adaptation options are feasible says little about their effectiveness, i.e., the degree to which adaptation has been or will be successful in reducing the risks of negative impacts. Adaptation is difficult to disentangle from other factors that contribute to both increasing and decreasing risks. Since adaptation in mountains is often autonomous and unplanned, measuring its effectiveness is complex and missed by more conventional, formal or structured monitoring and evaluation frameworks.

Evidence suggests that promising measures undertaken in mountains are those that are robust under uncertain futures, allow for adaptive planning and management and respond to multiple interests and purposes. For example, multi-purpose water reservoirs can alleviate multiple stressors and address several risks, such as those from natural hazards and water shortages. Capacity-building and awareness-raising can go a long way towards ensuring that these measures are also socially acceptable if combined with more structural and systemic changes. Indeed, transformations happen slowly in mountains and it is unlikely that small steps and incremental measures will be able to cope with more severe and pervasive risks.

Overall, empirical evidence on the effectiveness of adaptations at reducing risk is largely lacking but is urgently needed to better understand what works and what does not under certain circumstances.

Frequently Asked Questions

FAQ CCP5.5 | Why are regional cooperation and transboundary governance needed for sustainable mountain development?

Regional cooperation and transboundary governance are key to managing our vast mountain resources because they do not necessarily share political boundaries. Mountain countries need to come together, share data and information, form joint management committees, jointly develop policies and take decisions that benefit all countries equitably. A lack of cooperation may lead to missed opportunities to address climate risks and adequately manage mountain resources, which could cause social unrest and spark conflict within and between countries.

Mountains are climate change hotspots that are highly susceptible to climate change. Due to rapidly changing climatic conditions, climate change is one of the major issues that would benefit from regional cooperation. The transboundary management of mountains means shared legal and institutional frameworks for sharing the benefits and costs of managing mountain ranges across boundaries, whether local or district jurisdictions within countries or indeed across national boundaries.

The IPCC's Special Report on Oceans and Cryosphere refers to governance as an 'effort to establish, reaffirm or change formal and informal institutions at all scales to negotiate relationships, resolve social conflicts and realise mutual gains'. Governance is an act of governments, NGOs, private-sector institutions and civil society in establishing rules and norms for restricting the use of common goods. Institutions can guide, constrain and shape human interaction through direct control, incentives, and processes of socialisation. How do we apply the definitions of governance and institutions in the context of mountains? Since governance not only refers to government, which is a formal arm of the state, the report also talks about other agencies such as community organisations, non-profit organisations or businesses that play a vital role in society and influence individual or collective decisions and help in preventing the overexploitation of resources.

To comprehend the processes of governance in mountain areas, we need to recognise how each of these agencies adds to the enduring task of enabling and managing change at the system level but also to preserving social structures and reconciling disputes. For the sustainable and resilient development of mountain regions, governance mechanisms may be different than those applied to the management of other resources, such as coastal zones or rivers. Mountains are also mostly transboundary and do not necessarily follow political boundaries. Mountain governance, therefore, is about managing resources across political boundaries for the benefit of all countries. This includes downstream countries that also rely on resources such as water, silt and others from these mountain regions. These include high rangelands, biodiversity hotspots, forests and glaciers, for example.

There are several examples of regional cooperation in connection with the governance of shared resources in mountains. Some examples come from the Arctic (bottom-up and science-based evolution of Arctic cooperation), Southeast Europe (regionalisation of environmental benefits) and the Hindu Kush Himalaya region (intergovernmental scientific institution for research and data sharing). Mountains share resources, so their management will benefit from cooperation among countries. Transboundary cooperation is needed not only to address transboundary climate risks and regional adaptation to climate change in mountains but also to work across countries to reduce greenhouse gas emissions.

Frequently Asked Questions

FAQ CCP6.1 | How do changes in ecosystems and human systems in the polar regions impact everyone around the globe? How will changes in polar fisheries impact food security and nutrition around the world?

Polar regions are commonly known to be experiencing particularly fast and profound climate change, which strongly affects areas and people all around the world in several ways. Physical processes taking place in these regions are critically important for the global climate and sea level. Less known is that regional climate-driven changes of ecosystems and human communities will also have far-reaching impacts on a number of sectors of human societies at lower latitudes.

Climate change has triggered rapid, unprecedented and cascading changes in polar regions that have profound implications for ecosystems and people globally. Although physically remote from the largest population centres, polar systems are inextricably linked to the rest of the world through interconnected ocean currents, atmospheric interactions and weather, ecological and social systems, commerce and trade. The nutrient-rich waters of the polar regions fuel some of the most productive marine ecosystems on earth, which in turn support fisheries for species packed with vital macronutrients that are essential for human health and well-being. The largest most sustainable fisheries in the world are located in polar waters, where a mix of ice, seasonal light and cold nutrient-rich waters fuel schools of millions of fish that swell and retract in numbers across the years, reflecting interlaced cycles of icy cold waters, lipid-rich prey and abundant predators. Polar systems thus exist in a productive balance that has supported vibrant ecocultural connections between Indigenous Peoples and the Arctic for millennia and has supported global food production and trade for centuries.

Climate change increasingly destabilises this balance with uncertain outcomes for Indigenous Peoples and local residents in the Arctic as well as for the rest of the world. Triggered by warming oceans and air temperatures, accelerated melting of sea ice, glaciers and IS in polar regions in turn impacts ocean salinity, sea levels and circulation throughout the global ocean. Warming waters have also pushed cold-adapted species poleward, eroded the cold barrier between boreal and Arctic species, and induced rapid reorganisation of polar ecosystems. Studies increasingly indicate that the complex web of physical and biological connections that have fuelled these productive regions will falter without the strong regulating influence of cryospheric change. At the same time, the global demand for food is increasing, particularly the demand for highly nutritious marine protein, placing increasing importance on stabilising polar ecological systems and minimising climate change impacts and risks.

Frequently Asked Questions

FAQ CCP6.2 | Is sea ice reduction in the polar regions driving an increase in shipping traffic?

The polar seas have captured the imagination of global nations for centuries for its natural resource, tourism, scientific, and maritime trade potential. As the polar regions are warming at two to three times the rate of the global average leading to rapid reductions in sea ice extent and thickness, international attention has been reinvigorated and investments are being made by Arctic and non-Arctic nations alike with a view to utilise newly accessible seaways. Between 2013 and 2019, ship traffic entering the Arctic grew by 25% and the total distance travelled increased by 75%. Similar shipping growth trends are evident in the Antarctic, albeit to a lesser extent. Expected growth in Arctic shipping will influence a suite of cascading environmental and cultural risks with implications for Indigenous Peoples.

There has been debate among shipping stakeholders, rightsholders and experts about the extent to which climate change and sea ice change is directly influencing increases in shipping activity in the polar regions relative to other social, technological, political and economic factors such as commodity prices, tourism demand, global economic trends, infrastructure support and service availability. Understanding the connection between climate change and polar shipping activity will allow for more reliable projections of possible future traffic trends and will aid in identifying appropriate adaptation and infrastructure needs required to support future management of the industry.

Recent studies have observed increasing statistical correlations between sea ice change and shipping trends in the polar regions, and many have concluded that although economic factors remain the main driver of shipping activities, followed by infrastructure availability, climate change does indeed play a varying but important role in influencing operator intentions. The ‘opening of polar seaways’ due to sea ice reduction is indeed ‘enabling’ opportunities for polar shipping among all types of vessels due to increasingly accessible areas that were previously covered by multi-year ice, but the extent to which climate change will specifically ‘drive’ an increase in shipping demand remains highly dependent on the vessel type and the reasons for operation.

There are certain vessel types, such as those supporting international trade, mining operations or community re-supply, where analysis shows no correlation or weak correlations with sea ice change, suggesting that climate change is enabling these types of ships via increased open water areas and season lengths but that it is not necessarily driving demand. Conversely, there are certain vessel types, such as yachts and cruise ships, where correlations between sea ice change and traffic increases are stronger, and where there is evidence to suggest that these vessels are indeed driven to visit the polar regions because they perceive waterways as exotic and exciting due to being newly accessible or they want to have a Polar experience before it disappears or is irreversibly changed as is the case with last chance tourists. As sea ice recedes and polar shipping opportunities grow, there will be an increased need to better identify and implement Indigenous self-determined and equitable shipping governance frameworks that facilitate benefits and minimise risks.

Box FAQ CCP6.2 (continued)

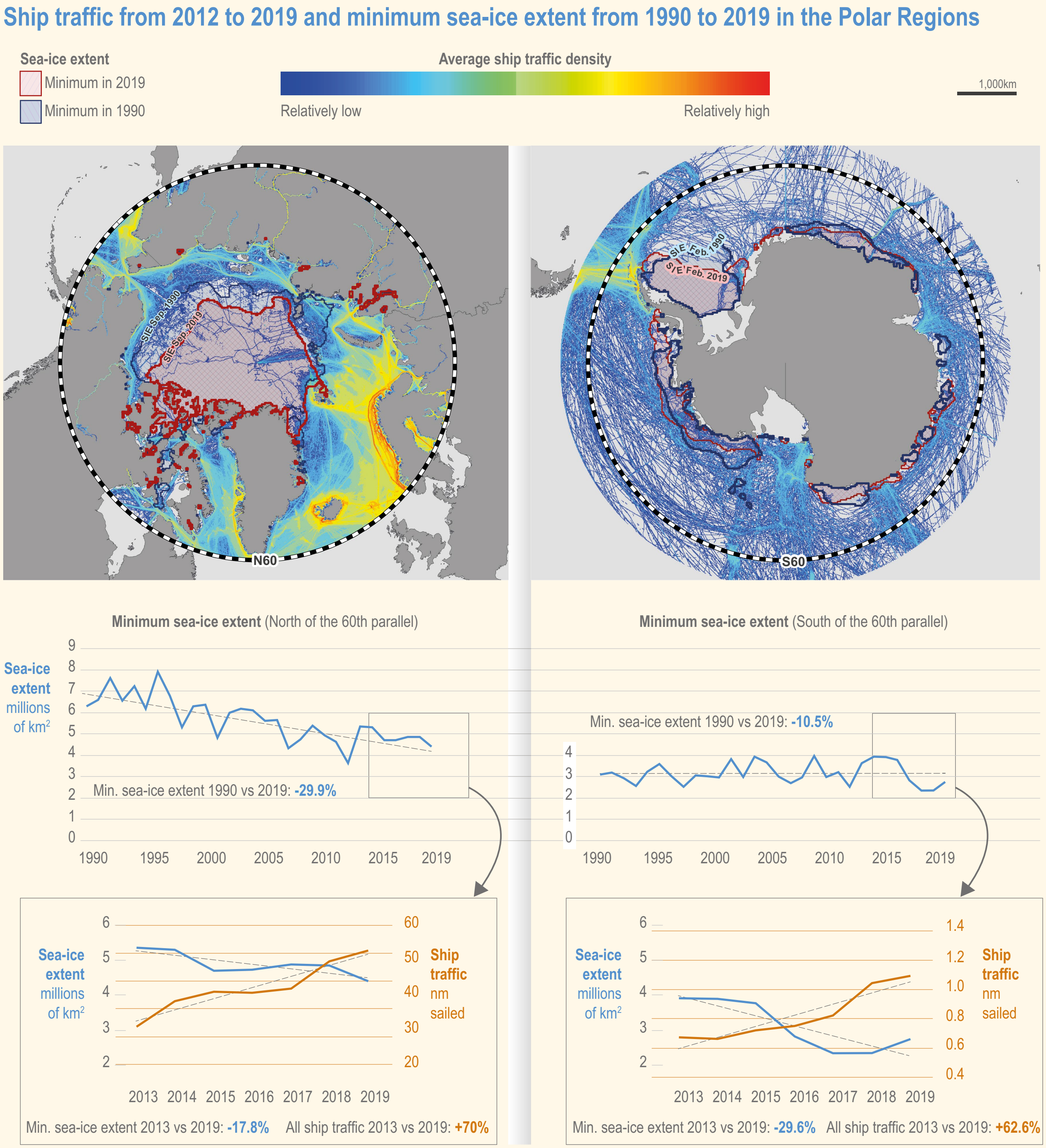


Figure FAQ CCP6.2.1 | Projected operational accessibility along Arctic maritime trade routes (Northwest Passage, Transpolar Route and Northern Sea Route) under future warming (left) and observed increases in commercial ship traffic along the routes from 2012 to 2019.

Frequently Asked Questions

FAQ CCP6.3 | How have arctic communities adapted to environmental change in the past and will these experiences help them respond now and in the future?

For thousands of years, Arctic Indigenous Peoples and local communities have survived several major changes to the ecosystems on which they rely; however, the present changes in climate are more challenging than pre- and early historic changes in the Arctic, and polar communities will now face new unprecedented risks.

The challenges for responding to present change are due to the multiple imposed and simultaneous drivers combined with elimination and/or removal of endemic capacity to respond in culturally and locally appropriate ways. Adapting in the past may therefore inform and produce novel solutions for the present and convey baselines of important contextual information on significance of change. Arctic communities, especially Indigenous Peoples, have been marginalised in terms of their autonomous responses spaces and self-assessment that could be made without external pressures. Therefore, to increase the possibility of community-led adaptation, colonialism and the resultant lack of upheld rights, resources and equity need to be solved simultaneously with the present climate change impacts. New research, governance, policy and collaborations are needed to effectively adapt to risks that are projected to emerge in the polar regions as a result of rapid climate change.

Frequently Asked Questions

FAQ CCP6.4 | When will climate change impacts in polar regions surpass our ability to adapt?

When environmental variability is within the range of the current adaptive management approaches, the social–ecological system can thrive. However, the rapidly changing polar systems are causing disruptions to societies, economies and ecosystems. The current management systems are yet to develop procedures for managing rapid change being experienced in warming waters, sea ice declines, permafrost thaw and erosion, and poleward shifts in species. These challenges are expected to become more pronounced within a few decades rather than later this century.

Polar regions are naturally dynamic environments. Ecosystems in polar regions, and the people who rely on them, have adapted to natural variability and dynamic nature of polar environments. Fish populations in polar regions are known to exhibit cycles of productivity, and shift their distribution across hundreds of kilometres in response to changes in winter sea ice cover and concomitant summer ocean conditions. Management of the productive fisheries in polar regions is also designed to allow for these changes, using adaptive and ecosystem-based approaches that buffer populations from overexploitation and also stabilise fisheries, livelihoods and food resources. Indigenous Peoples diversify their subsistence harvest across species and resources and, therefore, similarly stabilise food and nutritional security.

When environmental variability is within the range of these adaptive measures, the social–ecological system can thrive. Thus, there are fundamental components in place in polar regions already to help ecosystems and people adapt to some degree of climate change. However, as climate change impacts like warming waters, sea ice loss, permafrost thaw and erosion systematically alter components of the system, shift species increasingly poleward, and disrupt linkages between species and people, the ability to adapt is reduced. There are critical tipping points (e.g., sea ice melt, permafrost thaw) where changes may cascade, self-reinforce and accelerate, outpacing adaptation actions and force natural and human systems irreversibly (on the scale of human existence) into novel regimes. The risk of crossing tipping points is greater and the probability much increased after mid-century under scenarios without global carbon mitigation (SSP5 8.5), where changes are largest and most rapid.

Frequently Asked Questions

FAQ CCP7.1 | How is climate change affecting tropical forests and what can we do to protect and increase their resilience?

Global warming, droughts, extreme rainfalls and sea level rise cause significant impacts on tropical forests.

In addition to climate change, tropical forests are experiencing non-climatic stressors. Conversion of forest into large-scale agriculture land and exploitation of timber and non-timber forest products are increasing pressure and amplifying the impacts of climate change on the remaining areas of tropical forests. These include biodiversity decline, increases of fires, large-scale ecosystem transformation (e.g., into savannah in southeastern Amazon) and increasing carbon emissions due to deforestation, forest conversion and forest degradation. Further, loss of forest resources leads to the decline of livelihoods of Indigenous Peoples and local communities. All nations need to collaborate to implement collective actions to protect tropical forests.

Tropical forests are essentially important for the health of planet Earth. Tropical forests in Asia, Africa and South America regulate carbon, water and chemical cycles, which maintain a healthy climate and nutrient cycles for supporting life. Tropical forests are home to two-thirds of our world's biodiversity, although they cover only about 13% of the land on Earth, but it is not known exactly how many millions of living creatures, such as microorganisms, insects, amphibians, snakes, fish, birds, mammals and primates, live in tropical forests.

Approximately 1.3 billion people directly depend upon tropical forest resources to survive. Others are indirectly dependent upon the health and provisioning of ecosystem services and goods from tropical forests. The forests provide many kinds of economic products, such as timber, medicines and food, and recreational services, such as nature trekking, bird and wildlife watching, to mention a few. Indigenous People and other forest-dependent communities have shown extraordinary knowledge on how to manage forest resources to meet their subsistence needs without causing forest degradation. This forest culture and wisdom are broken when the rate of forest extraction changes into unplanned and unsustainable large-scale transformation.

Deforestation and land-use changes in tropical forests cause not only physical and biological changes on flora and fauna, but also rapid changes in cultures harming forest peoples. A degraded tropical forest is prone and more vulnerable to climate change. An increase in temperature in lowlands creates an unfavourable condition for optimum growths of many kinds of plant species which also affects several agricultural plants. Coffee farmers, for example, are forced to open new forest frontiers in highland areas to meet an optimum temperature for the growth of coffee.

The onset and duration of dry and rainy seasons also changes. A prolonged wet season has excessive rains which cause flash floods and substantially disturbs the fruiting cycle of many plant species. Due to high rainfall and high humidity, most flowers of forest trees fail to mature, and hence essentially deplete fruit production. Most trees in tropical forests require a short period of a dry season to have a mass fruiting season. On the other hand, a prolonged dry season causes soils to dry in deeper layers, higher atmospheric demand for water vapour and enhanced forest fires. In the tropical humid forests, the majority of forest fires are anthropogenic. In Southeast Asia, peat fires cause large carbon emissions and haze pollution which harms locals and people in neighbouring countries. The impact on tropical forest comes also from the sea level rise which is due to changes in salinity and sedimentation rates, and the expansion of inundated areas leads to the decline of mangrove productivity.

Projected impacts of climate change on the tropical forest might be detrimental to safeguards of local communities and a significant number of flora and fauna in the tropics. In southeastern Amazon, reduction in precipitation, due to changes in the climate pattern, associated with intense deforestation and land cover change are leading to reduction of productivity in the remaining forest areas, and might lead to a large-scale change in the forest structure which can become a savannah. In Southeast Asia, in particular in Indonesia and Malaysia, prolonged dry seasons associated with the El Niño phenomenon cause extensive peat fires, releasing large amounts of carbon dioxide and creating various health problems related to haze pollution. Furthermore, climate change interacts with deforestation for agriculture (crops, livestock and plantation forestry), logging, mining or infrastructure development, exacerbating temperature and rainfall changes resulting in more degradation.

Box FAQ CCP7.1 (continued)

Climate change, together with forest fragmentation and deforestation, also harms wildlife. For example, the orangutan, an endemic species to tropical peat forests in Kalimantan and Sumatra, is classified as critically endangered. Many other endemic and unknown species of flora in tropical forests are in the same condition and could experience a mass extinction at a more rapid rate than the previous five mass extinctions on Earth. About 1.3 million Indigenous Peoples depending on the natural resources of the tropical forest would suffer from cultural disruption and livelihood change due to forest loss.

To protect tropical forests a collective action of all nations is needed. It requires a global effort to stop deforestation and the conversion of tropical forests. The role of Indigenous Peoples and local communities as forest keepers must be strengthened. Economic incentives for protecting tropical forests, among other strategies, could facilitate collective actions towards a sustainable management of tropical forests. Sustainable, effective and just strategies to increase the resilience of tropical forests need to consider the complex political, social and economic dynamics involved, including the goals, identity and livelihood priorities of Indigenous Peoples and local communities beyond natural resource management. Strategies can benefit from integrating knowledge and know-how from traditional cultures, fostering transitions towards more sustainable systems.

Frequently Asked Questions

FAQ 16.1 | What are key risks in relation to climate change?

A few clusters of key risks can be identified which have the potential to become particularly severe and pose significant challenges for adaptation worldwide. These risks, therefore, deserve special attention. They include risks to important resources such as food and water, risks to critical infrastructures, economies, health and peace, as well as risks to threatened ecosystems and coastal areas.

The IPCC defines key risks related to climate change as potentially severe risks that are relevant to the primary goal of the United Nations Framework Convention on Climate Change treaty to avoid 'dangerous human interference with the climate system', and whatever the scale considered (global to local). What constitutes 'dangerous' or 'severe' risks is partly a value judgement and can therefore vary widely across people, communities or countries. However, the severity of risks also depends on criteria like the magnitude, irreversibility, timing, likelihood of the impacts they describe, and the adaptive capacity of the affected systems (species or societies). The Working Group II authors use these criteria in various ways to identify those risks that could become especially large in the future owing to the interaction of physical changes to the climate system with vulnerable populations and ecosystems exposed to them. For example, some natural systems may be at risk of collapsing, as is the case for warm-water coral reefs by mid-century, even if global warming is limited to +1.5°C. For human systems, severe risks can include increasing restriction of water resources that are already being observed; mortality or economic damages that are large compared with historical crises; or impacts on coastal systems from sea level rise and storms that could make some locations uninhabitable.

More than 120 key risks across sectors and regions have been identified by the chapters of this report, which have then been clustered into a set of 8 overarching risks, called representative key risks, which can occur from global to local scales but are of potential significance for a wide diversity of regions and systems globally. As shown in Figure 16.1.1, the representative key risks include risks to (a) low-lying coastal areas, (b) terrestrial and marine ecosystems, (c) critical infrastructures and networks, (d) living standards, (e) human health, (f) food security, (g) water security and (h) peace and human mobility.

These representative key risks are expected to increase in the coming decades and will depend strongly not only on how much climate change occurs, but also on how the exposure and vulnerability of society changes, as well as on the extent to which adaptation efforts will be effective enough to substantially reduce the magnitude of severe risks. The report finds that risks are highest when high warming combines with development pathways with continued high levels of poverty and inequality, poor health systems, lack of capacity to invest in infrastructure, and other characteristics making societies highly vulnerable. Some regions already have high levels of exposure and vulnerability, such as in many developing countries as well as communities in small islands, Arctic areas and high mountains; in these regions, even low levels of warming will contribute to severe risks in the coming decades. Some risks in industrialised countries could also become severe over the course of this century, for example if climate change affects critical infrastructure such as transport hubs, power plants or financial centres. In some cases, such as coral reef environments and areas already severely affected by intense extreme events (e.g., recent typhoons or wildfires), climate risks are already considered severe.

Box FAQ 16.1 (continued)

Presentation of the 8 representative key risks assessed in this report (and their underlying main key risks)

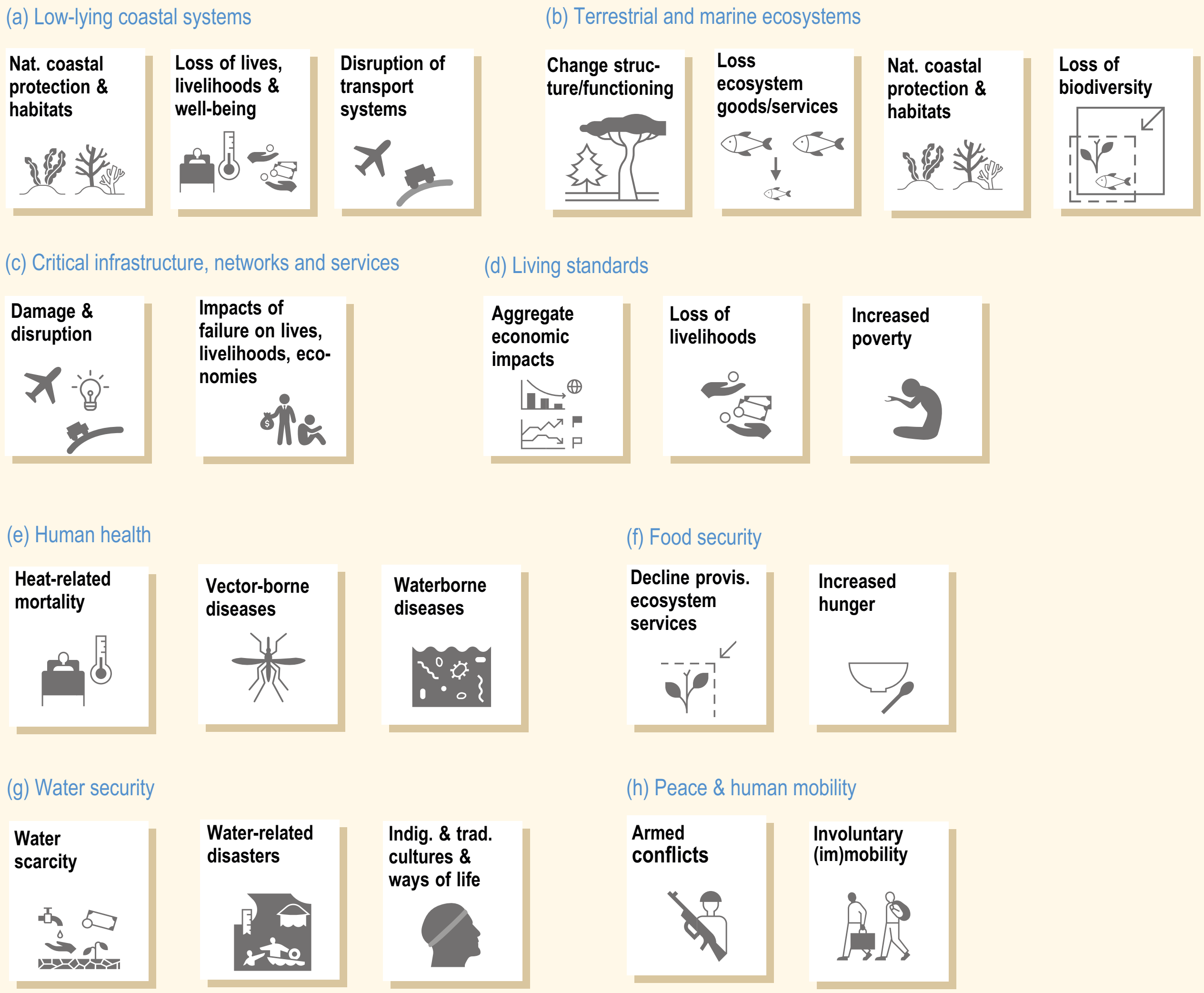


Figure FAQ16.1.1 | Presentation of the eight representative key risks assessed in this report (and their underlying main key risks).

Frequently Asked Questions

FAQ 16.2 | How does adaptation help to manage key risks and what are its limits?

Adaptation helps to manage key risks by reducing vulnerability or exposure to climate hazards. However, constraining factors make it harder to plan or implement adaptation and result in adaptation limits beyond which risks cannot be prevented. Limits to adaptation are already being experienced, for instance by coastal communities, small-scale farmers and some natural systems.

Adaptation-related responses are actions that are taken with the intention of managing risks by reducing vulnerability or exposure to climate hazards. While mitigation responses aim to reduce greenhouse gas emissions and slow warming, adaptations respond to the impacts and risks that are unavoidable, either due to past emissions or failure to reduce emissions. However, while these responses intend to reduce risks, it is difficult to determine precise levels of risk reduction that can be attributed to adaptation. Changing levels of risk as well as other actions—such as economic development—make it challenging to definitively connect specific levels of risk reduction with adaptation. Although it is not feasible to assess the adequacy of adaptation for risk reduction at global or regional levels, evidence from specific localised adaptation projects do show that adaptation-related responses reduce risk. Moreover, many adaptation measures offer near-term co-benefits related to mitigation and to sustainable development, including enhancing food security and reducing poverty.

Adaptation responses can occur in natural systems without the intervention of humans, such as species shifting their range, time of breeding, or migration behaviour. Humans can also assist adaptation in natural systems through, for example, conservation activities such as species regeneration projects or protecting ecosystem services. Other adaptation-related responses by humans aim to reduce risk by decreasing vulnerability and/or exposure of people to climate hazards. This includes infrastructural projects (e.g., upgrading water systems to improve flood control), technological innovation (e.g., early-warning systems for extreme events), behavioural change (e.g., shift to new crop types or livelihood strategies), cultural shifts (e.g., changing perspectives on urban greenspace, or increased recognition of Indigenous knowledge and local knowledge) and institutional governance (e.g., adaptation planning, funding and legislation).

While adaptation is important to reduce risk, adaptation cannot prevent all climate impacts from occurring. Adaptation has soft and hard limits, points at which adaptive actions are unable to prevent risks. Soft limits can change over time as additional adaptation options become available, while hard limits will not change as there are no additional adaptive actions that are possible. Soft limits occur largely due to constraints—factors that make it harder to plan and implement adaptation, such as lack of financial resources or insufficient human capacity. Across regions and sectors, the most challenging constraints to adaptation are financial and those related to governance, institutions and policy measures. Limited funding and ineffective governance structures make it difficult to plan and implement adaptation-related responses which can lead to insufficient adaptation to prevent risks. Small-scale farmers and coastal communities are already facing soft limits to adaptation as measures that they have put in place are not enough to prevent loss. If constraints that are limiting adaptation are addressed, then additional adaptation can take place and these soft limits can be overcome. Evidence on limits to adaptation is largely focused on terrestrial and aquatic species and ecosystems, coastal communities, water security, agricultural production, and human health and heat.

Adaptation is critical for responding to unavoidable climate risks. Greater warming will mean more and more severe impacts requiring a high level of adaptation which may face greater constraints and reach soft and hard limits. At high levels of warming, it may not be possible to adapt to some severe impacts.

Frequently Asked Questions

FAQ 16.3 | How do climate scientists differentiate between impacts of climate change and changes in natural or human systems that occur for other reasons?

We can already observe many impacts of climate change today. The large body of climatic impact data and research confirms this. To decide whether an observed change in a natural or human system is at least partly an impact of climate change, we systematically compare the observed situation with a theoretical situation without observed levels of climate change. This is detection and attribution research.

Global mean temperature has already risen by more than 1°C, and that also means that the impacts of climate change become more visible. Many natural and human systems are sensitive to weather conditions. Crop yields, river floods and associated damages, ecosystems such as coral reefs, or the extent of wildfires are affected by temperatures and precipitation changes. Other factors also come into play. So, for example, crop yields around the world have increased over the last decades because of increasing fertilizer input, improved management and varieties. How do we detect the effect of climate change itself on these systems, when the other factors are excluded? This question is central for impact attribution. 'Impact of climate change' is defined as the difference between the observed state of the system (e.g., level of crop yields, damage induced by a river flood, coral bleaching) and the state of the system assuming the same observed levels of non-climate-related drivers (e.g., fertilizer input, land use patterns or settlement structures) but no climate change.

So:

'Impact of climate change' is defined as the difference between the observed state of the system and the state of the system assuming the same observed levels of non-climate-related drivers but no climate change. For example, we can compare the level of crop yields, damage induced by a river flood, and coral bleaching with differences in fertilizer input, land use patterns or settlement structures, without climate change and with climate change occurring.

While this definition is quite clear, there certainly is the problem that, in real life, we do not have a 'no climate change world' to compare with. We use model simulations where the influence of climate change can be eliminated to estimate what might have happened without climate change. In a situation where the influence of other non-climate-related drivers is known to be minor (e.g., in very remote locations), the non-climate-change situation can also be approximated by observation from an early period where climate change was still minor. Often, a combination of different approaches increases our confidence in the quantification of the impact of climate change.

Impacts of climate change have been identified in a wide range of natural, human and managed systems. For example, climate change is the major driver of observed widespread shifts in the timing of events in the annual cycle of marine and terrestrial species, and climate change has increased the extent of areas burned by wildfires in certain regions, increased heat-related mortality, and had an impact on the expansion of vector-borne diseases.

In some other cases, research has made considerable progress in identifying the sensitivity of certain processes to weather conditions without yet attributing observed changes to long-term climate change. Two examples of weather sensitivity without attribution are observed crop price fluctuations and waterborne diseases.

Finally, it is important to note that 'attribution to climate change' does not necessarily mean 'attribution to anthropogenic climate change'. Instead, according to the IPCC definition, climate change means any long-term change in the climate system, no matter where it comes from.

Frequently Asked Questions

FAQ 16.4 | What adaptation-related responses to climate change have already been observed, and do they help reduce climate risk?

Adaptation-related responses are the actions taken with the intention of managing risks by reducing vulnerability or exposure to climate hazards. Responses are increasing and expanding across global regions and sectors, although there is still a lot of opportunity for improvement. Examining the adequacy and effectiveness of the responses is important to guide planning, implementation and expansion.

The most frequently reported adaptation-related responses are behavioural changes made by individuals and households in response to drought, flooding and rainfall variability in Africa and Asia. Governments are increasingly undertaking planning, and implementing policy and legislation, including, for example, new zoning regulations and building codes, coordination mechanisms, disaster and emergency planning, or extension services to support farmer uptake of drought tolerant crops. Local governments are particularly active in adaptation-related responses, particularly in protecting infrastructure and services, such as water and sanitation. Across all regions, adaptation-related responses are strongly linked to food security, with poverty alleviation a key strategy in the Global South.

Overall, however, the extent of adaptation-related responses globally is low. On average, responses tend to be local, incremental, fragmented, and consistent with Business-As-Usual practices. There are no global regions or sectors where the overall adaptation-related response has been rapid, widespread, substantial and has overcome or challenged key barriers. The extent of adaptation thus remains low globally, with significant potential for increased scope, depth, speed and the challenging of adaptation limits. Examples of low-extent adaptations include shifts by subsistence farmers in crop variety or timing, household flood barriers to protect houses and gardens, and harvesting of water for home and farm use. In contrast, high-extent adaptation means that responses are widespread and coordinated, involve major shifts from normal practices, are rapid, and challenge existing constraints to adaptation. Examples of high-extent adaptations include planned relocation of populations away from increasingly flood-prone areas, and widely implemented social support to communities to prevent migration or displacement due to climate hazards.

Increasing the extent of adaptation-related responses will require more widespread implementation and coordination, more novel and radical shifts from Business-As-Usual practices, more rapid transitions, and challenging or surmounting limits—key barriers—to adaptation. This might include, for example, best-practice programmes implemented in a few communities being expanded to a larger region or country, accelerated implementation of behaviours or regulatory frameworks, coordination mechanisms to support deep structural reform within and across governments, and strategic planning that challenges fundamental norms and underlying constraints to change.

We have very little information on whether existing adaptation-related responses that have already been implemented are reducing climate risks. There is evidence that risks due to extreme heat and flooding have declined, though it is not clear if these are due to specific adaptation-related responses or general and incremental socioeconomic development. It is difficult to assess the effectiveness of adaptation-related responses, and even more difficult to know whether responses are adequate to adapt to rising climate risk. These remain unknown but important questions in guiding implementation and expansion of adaptation-related responses.

Frequently Asked Questions

FAQ 16.5 | How does climate risk vary with temperature?

Climate risk is a complex issue, and communicating it is fraught with difficulties. Risk generally increases with global warming, though it depends on a combination of many factors such as exposure, vulnerability and response. To present scientific findings succinctly, a risk variation diagram can help visualise the relationship between warming level and risk. The diagram can be useful in communicating the change in risk with warming for different types of risk across sectors and regions, as well as for five categories of global aggregate risk called 'Reasons for Concern'.

A picture speaks a thousand words. The use of images to share ideas and information to convey scientific understanding is an inclusive approach for communicating complex ideas. A risk variation diagram is a simple way to present the risk levels that have been evaluated for any particular system. These diagrams take the form of bar charts where each bar represents a different category of risk. The traffic light colour system is used as a basis for doing the risks, making it universally understandable. These diagrams are known colloquially as 'burning ember' diagrams, and have been a cornerstone of IPCC assessments since the Third Assessment Report, and further developed and updated in subsequent reports. The fact that the diagrams are designed to be simple, intuitive and easily understood with the caption alone has contributed to their longstanding effectiveness. Here, in Figure FAQ16.5.1 below, we provide a simplified figure of this chapter's burning embers for five categories of global aggregate risk, called Reasons for Concern (RFCs), which collectively synthesise how global risk changes with temperature. The diagram shows the levels of concern that scientists have about the consequences of climate change (for a specified risk category and scope), and how this relates to the level of temperature rise.

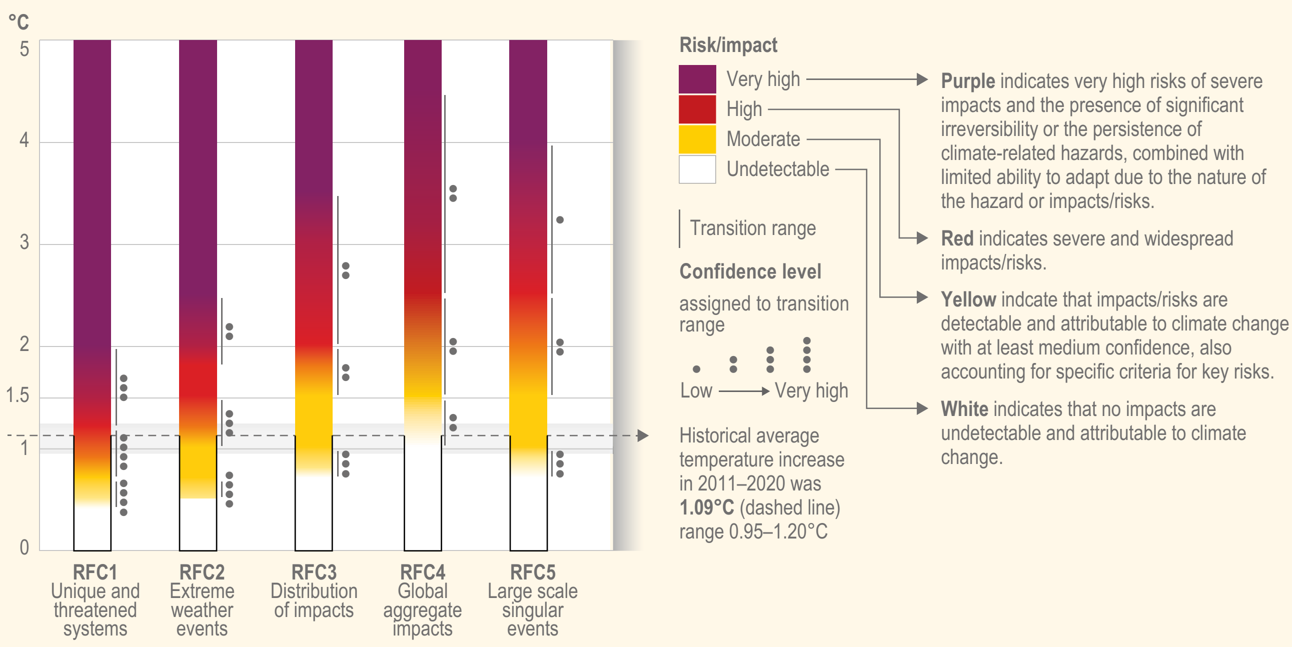


Figure FAQ16.5.1 | Simplified presentation of the five Reasons for Concern burning ember diagrams as assessed in this report (adapted from Figure 16.15). The colours indicate the level of risk accrual with global warming for a low-adaptation scenario. RFC1 Unique and threatened systems: ecological and human systems that have restricted geographic ranges constrained by climate-related conditions and have high endemism or other distinctive properties. Examples include coral reefs, the Arctic and its Indigenous People, mountain glaciers and biodiversity hotspots. RFC2 Extreme weather events: risks/impacts to human health, livelihoods, assets and ecosystems from extreme weather events such as heatwaves, heavy rain, drought and associated wildfires, and coastal flooding. RFC3 Distribution of impacts: risks/impacts that disproportionately affect particular groups owing to uneven distribution of physical climate change hazards, exposure or vulnerability. RFC4 Global aggregate impacts: impacts to socio-ecological systems that can be aggregated globally into a single metric, such as monetary damages, lives affected, species lost or ecosystem degradation at a global scale. RFC5 Large-scale singular events: relatively large, abrupt and sometimes irreversible changes in systems caused by global warming, such as ice sheet disintegration or thermohaline circulation slowing.

Box FAQ 16.5 (continued)

In this diagram, the risk variation bars or embers are shown with temperature on the *y*-axis, and the base of the ember corresponds to a baseline temperature. Typically, this baseline temperature is that before global warming started (i.e., average temperatures for the pre-industrial period of 1850–1900). This area of the ember appears white, which indicates no to negligible impacts due to climate change. Moving up the ember bar, changing colours show the increase in risk as the Earth warms globally in terms of degrees Celsius—yellow for moderate risk, red for high risk, and purple for very high risk. Definitions of the risk levels are presented in Figure FAQ16.5.1 The risk transitions are informed by the latest literature and scientific evidence, and developed through consultation and development of consensus among experts. The bars depict an averaged assessment across the world, which has the disadvantage of hiding regional variation. For example, some locations or regions could face high risk even when the global risk level is moderate.

When the embers for different risk categories are placed next to each other, it is possible to compare risk levels at different levels of global warming. For example, at 1°C warming all embers appear yellow or white, so it is possible to say that keeping global warming below that particular temperature would help ensure risks remain moderate for all five categories of concern assessed. In contrast, at 2°C warming, risk levels have transitioned to high for all categories assessed, and even reach a very high level of risk in the case of unique and threatened systems.

Frequently Asked Questions

FAQ 16.6 | What is the role of extreme weather events in the risks we face from climate change?

Climate change has often been perceived as a slow and gradual process, but by now it is abundantly clear that many of its impacts arise through shocks, such as extreme weather events. Many places are facing more frequent and intense extremes, and also more surprises. The impact of such shocks is shaped by exposure and vulnerability, where we live, and how we are prepared for and able to cope with shocks and surprises.

The rising risk of extreme events is one of the major Reasons for Concern about climate change. It is clear that this risk has already increased today. Many recent disasters already have a fingerprint of climate change.

There are large differences in such risks from country to country, place to place, and person to person. This is of course partly due to differences in hazards such as heatwaves, floods, droughts, storms, storm surges, etc., and the way those hazards are influenced by climate change. However, an even more important aspect is people's exposure and vulnerability: do these hazards occur in places where people live and work, and how badly do they affect people's lives and livelihoods? Some groups are especially vulnerable, for instance elderly in the case of heatwaves, or people with disabilities in the case of floods. In general, poor and marginalised people tend to be much more affected than rich people, partly because they have fewer reserves and support systems that help them to prepare for, cope with and recover from a shock. On the other hand, absolute economic losses are generally higher in richer places, simply because more assets are at risk there.

Many problems caused by extreme weather do not just appear because of one weather extreme, but due to a combination of several events. For instance, dryness may increase the risk of a subsequent heatwave. But the increased risk may also cascade through human systems, for instance when several consecutive disasters erode people's savings, or when a heatwave reduces the ability of power plants to produce electricity, which subsequently affects availability of electricity to turn on air conditioning to cope with the heat. Many shocks also have impacts beyond the place where they occur, for instance when a failed harvest affects food prices elsewhere. Climate risks can also be aggravated by other shocks, such as in the case of coronavirus disease 2019 (COVID-19), which not only had a direct health impact, but also affected livelihoods around the world and left many people much more vulnerable to weather extremes.

Understanding the risks we face can help in planning for the future. This may be a combination of short-term preparation, such as early-warning systems, and longer-term strategies to reduce vulnerability, for instance through urban planning, as well as reducing greenhouse gases to avoid longer-term increases in risk. Many interventions to increase people's resilience are effective in the face of a range of shocks. For instance, social safety nets can help mitigate the impact of a drought on farmers' livelihoods, but also of the economic impacts of COVID-19.

Climate-related shocks are threats to society, but they can also offer opportunities for learning and change. Recent disasters can motivate action during a short window of opportunity when awareness of the risks is higher and policy attention is focused on solutions to adapt and reduce risk. However, those windows tend to be short, and attention is often directed at the event that was recently experienced, rather than resilience in the face of a wider range of risks.

Frequently Asked Questions

FAQ 17.1 | Which guidelines, instruments and resources are available for decision makers to recognise climate risks and decide on the best course of action?

Guidelines, instruments and resources to identify options for managing risks, and support decisions on the most suitable course of actions to take, can be collectively referred to as decision-support frameworks. These can include data services, decision-support tools, processes for making decisions and methods for monitoring and evaluating progress and success. Data services enable the identification, location and timing of risks that could manifest with negative impacts, as well as potential opportunities. Often, these are termed 'climate services' and assist with mapping hazards and how they are changing. Decision-support tools range from qualitative approaches to determining overlap of areas of concern with those hazards in the future, to more quantitative and dynamic simulation approaches that enable dynamic stress-testing of adaptation options and strategies to determine if proposed plans for adapting to the future could be successful. An important consideration is whether options for risk management or capitalisation on opportunities will limit options and flexibility for responding to unforeseen events in the future. If these options have a negative effect on other areas of concern, then they could be identified in these planning scenarios as maladaptations, and therefore avoided.

A great challenge for decision makers is how to choose effective options when the future is uncertain. Uncertainty can arise not just in the statistical error of the magnitude of risk but also in the nature and consequence of risk from uncertainty about mechanisms that link areas of concern to hazards, uncertainty in the decision processes themselves and so on. Methods are available to help develop no-regret options, commonly referred to as decision-making under conditions of deep uncertainty'.

Decision-support frameworks are most successful when they are iterative, integrative and consultative. Rather than a single decision be made, and an action taken, there are processes for making the best decision possible, then monitoring progress towards delivering a successful outcome. Given a set of suitable indicators with regular monitoring, decisions can be revised, updated or changed as the future unfolds and foundations for the original decision tested. This is important because climate responses need to be initiated well in advance of them being needed due to the time required to implement suitable responses. These forward-looking approaches allow errors to occur and corrections made before problems arise. They also enable action to be taken without having to wait for the circumstances to arise, which if this were to occur could result in only limited reactions being available and the outcomes then dependent upon recovery from events rather than proactive planning and avoidance of events. Integrated approaches to risk management are available to help manage portfolios of interacting risks, including the potential for compounding and cascading risks when climate-related events arise.

Managing uncertainty with forward-looking processes needs to be more deliberative and oriented towards building trust in a collaborative process. Building relationships through informal, bottom-up processes enables this to occur. Top-down planning processes are important for ensuring that the management of risks and opportunities do not end up with maladaptations and that the approaches are equitable and proportional to that which is needed to manage the risks.

Frequently Asked Questions

FAQ 17.2 | What financing options are available to support adaptation and climate resilience?

What do we mean by 'climate finance'?

The UNFCCC has no formally agreed upon definition of climate finance. The current IPCC definition is: '*the financial resources devoted to addressing climate change by all public and private actors from global to local scales, including international financial flows to developing countries to assist them in addressing climate change*' (see Annex II: Glossary).

What needs to be financed?

Financial resources might be needed for a range of adaptation and resilience building activities. These include research, education and capacity building; development of laws, regulations and standards; provision of climate services and other information; reducing the vulnerability of existing assets, activities and services; and ensuring future development—such as new infrastructure, settlements, health services and business activities—is climate resilient. Finance is also needed to recover and rebuild from the damage of climate hazards that cannot be completely avoided through adaptation. Adaptation actions can be undertaken by many different actors, alone or in partnership, including national and sub-national governments, public and private utilities, businesses of varying size, communities, households and individuals.

Table FAQ17.2.1 | Examples of adaptation and resilience activities that might need to be financed

Training of agricultural extension officers so that their advice to small-holder farmers can support implementation of climate adapted agriculture. Additional financial support is needed for the costs of farmers transitioning to climate-resilient agricultural practices.	A new urban development requires higher standards (and up-front costs) for buildings, roads, stormwater systems and water re-use and to be resilient to expected changes in heavy rainfall, runoff, temperature and water supply reliability.
A water utility requires capital expenditure to increase supply through a desalination plant and to reduce leakage from its reticulation system in response to a scenario of reduced surface water availability and an increase in customers.	A catastrophe risk insurance facility is established to provide post-disaster (drought, hurricane, flooding, pest outbreaks) recovery finance to national governments. The facility requires capital to be able to underwrite the insurance products it offers.

How much finance is needed?

The amount of adaptation finance depends on global, regional and local factors, including: the amount and timing of global warming, and how this translates into impacts and adaptation needs across the world; the levels of adaptation already in place; the type of risk being adapted to; and the adaptation options being chosen, including whether the adaptation required is incremental or transformational.

The most-mentioned figure for finance need is the developed countries' commitment to provide USD 100 billion per year by 2020 to support developing countries' efforts in mitigation and adaptation. Negotiations will start in 2021 on updating this amount for 2025. While sometimes thought to represent the actual cost of responding to climate change in developing countries, this is not the case. More recent estimates of the global cost of adaptation by 2030 across developed and developing countries range between about USD 80 and 300 billion per year.

What types of finance are available?

Four main types (or instruments) of finance are currently being used to support adaptation. These different types are not mutually exclusive; grants can be combined with loans to provide blended finance.

Box FAQ 17.2 (continued)

Table FAQ17.2.2 | The main instruments through which adaptation is being financed.

Grants provide finance without any repayment requirements. Most grants for adaptation have been provided by multi-lateral funds such as the Green Climate Fund or a fund managed by a single OECD country such as Germany's International Climate Initiative. Some countries have national climate or environment funds that provide grants for their own climate adaptation actions. Grants are also provided by philanthropic foundations and sometimes by companies as part of their environmental and social responsiveness mandate.	**Concessional loans** require partial repayment of the finance provided. These involve either capital repayment coupled to below-market interest rates or capital repayment only. Concessional finance is almost entirely provided through multi-lateral development banks such as the World Bank. This finance is particularly important for developing countries where market interests are high due to poor credit ratings or other risk factors, or where the return on investment is too low make a commercial loan viable.
Non-concessional loans (or debts) are commercial instruments, where capital repayment and market interest rates apply. These may be provided through development banks or private banks. Green bonds are a relatively new form of market loan, designed to meet climate and other environmental sustainability criteria in terms of how the proceeds are used. In recent years, green bonds have offered better interest than ordinary bonds owing to oversubscription by investors who are looking to move towards environmentally sustainable investment portfolios.	**Budget re-allocation** does not require raising of new finance; rather, it involves moving funds already secured away from other purposes towards adaptation. In government, this might involve re-allocation towards flood defence. In the private sector, a company might move budget from marketing, research and development, or perhaps dividends, towards increasing the climate resilience of operation, infrastructure or their value chain.

Where are different types of finance most useful?

Grants are useful for a range of adaptation actions where it is hard to generate a financial return. These include capacity-building activities, piloting new adaptation innovations, high-risk investment settings or projects where there are considerable non-financial benefits. In contrast, loans and other debt instruments can often support larger investments, for example for scaling out of successful pilot projects or for building adaptation and resilience into general development investment. To date, a large proportion of international climate finance for adaptation in developing countries, especially in Sub-Saharan Africa and Oceania, has been grant led, sourced from OECD public funds, indicating that in many instances financing via loans is either considered too risky by the commercial investment sector or it has been hard to demonstrate sufficient return on investment.

Distribution of adaptation finance across different regions and different types of finance in 2015–2016

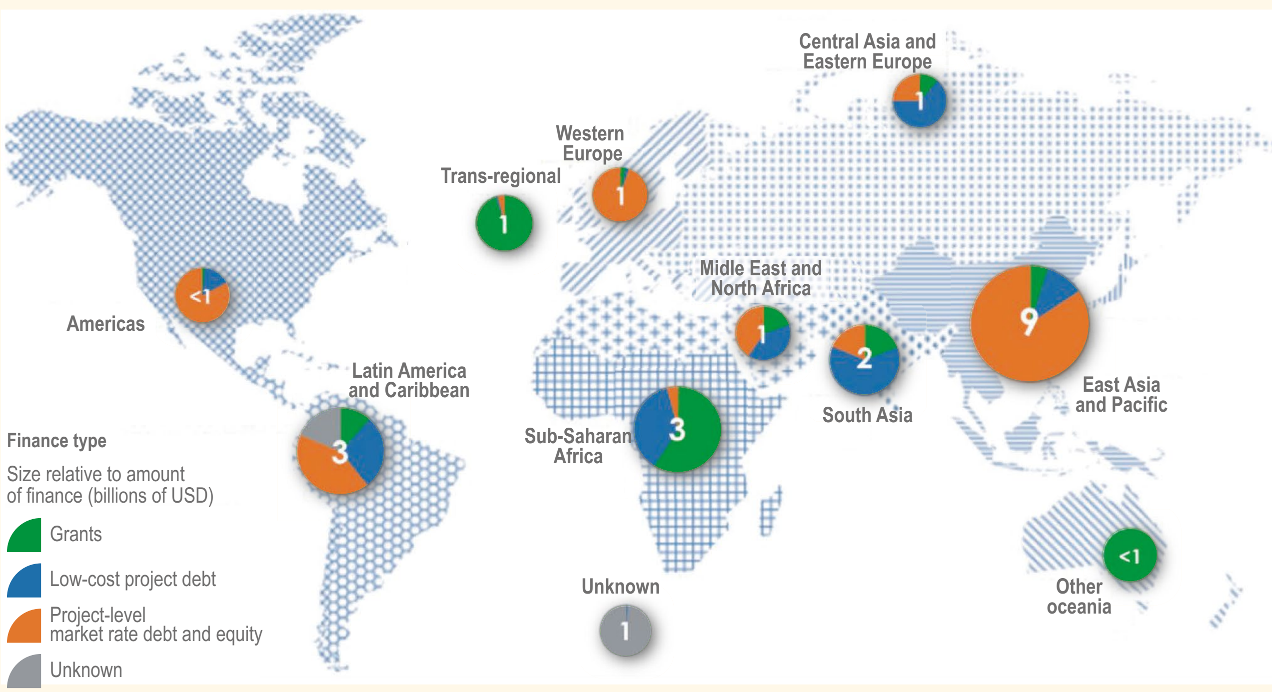


Figure FAQ17.2.1. | The distribution of adaptation finance across different regions and different types of finance in 2015–2016, as tracked by the Climate Policy Initiative. The size of each circle represents the amount of finance, with amount in billions USD superimposed.

Frequently Asked Questions

FAQ 17.3 | Why is adaptation planning along a spectrum from incremental to transformational adaptation important in a warming world?

In a warming world, incremental adaptation, that is, proven standard measures of adaptation, will not always suffice to adjust to the negative impacts from climate change leading to substantial residual risks and, in some cases, the breaching of adaptation limits; transformational adaptation, involving larger system-wide change (as compared with in-system change), will increasingly be necessary as a complement for helping individuals and communities to cope with climate change.

As an example of incremental adaptation, a farmer may decide to use drought-tolerant crops to deal with increasing occurrences of heatwaves. With further warming and increases in heatwaves and drought, however, the impacts of climate change may necessitate the consideration of system-wide change, such as moving to an entirely new agricultural system in areas where the climate is no longer suitable for current practices, or switching to livestock rearing. Where on-site adaptation becomes infeasible and pull factors exist, the farming households may decide to seek employment in other sectors, which may also lead to migration for work.

As another example, physical protection through sea walls to stop coastal flooding is a proven adaptation measure. With further projected flooding due to increasing sea level rise attributable to climate change transformational city planning, that would systemically change how flood water is managed throughout the whole city, potentially requiring deeper institutional, structural and financial support. Also, the deliberate relocation of settlements (managed retreat) is seeing attention in the face of increasingly severe coastal or riverine flooding in some regions. While transformational adaptation is increasingly being considered in theory and planning, implementation is only beginning to see attention.

Frequently Asked Questions

FAQ 17.4 | Given the existing state of adaptation, and the remaining risks that are not being managed, who bears the burden of these residual risks around the world?

A warming climate brings along increasing risks, part of which can be reduced or insured. What remains is called residual risks and needs to be retained by households, the private and public sectors. People living in conflict-affected areas benefit only marginally from adaptation investments by governments, private sector or other institutions. These people bear most of the changing climate risks themselves. Higher-income countries generally have invested heavily in structural adaptation to make sure people are not exposed to extreme events (e.g., dykes) and have developed a variety of private or public insurance systems to finance the risk of the most rare or extreme events. In other, middle- or lower-income countries, these very extreme events are less likely to be insured, and the impacts are borne by the most vulnerable people. Absent risk reduction or insurance, coping with residual risks generally means reducing consumption (e.g., food) or drawing down assets (selling machinery, houses, etc.), which all can bring along longer-term adverse developmental implications. Adaptation investments in low-income countries tend to focus more heavily on increasing capacity and reducing vulnerability; people remain exposed to the changing climate risks and bear the burden of reacting and responding.

Frequently Asked Questions

FAQ 17.5 | How do we know whether adaptation is successful?

Adaptation aims to reduce exposure and vulnerability to climate change by responding to dynamic and multi-scalar combinations of climatic risks. What might be seen as successful at one scale or at one point in time might not be at another, particularly if climate risks continue to rise. Moreover, the benefits of adaptation interventions may not reach all intended beneficiaries or everyone affected by climate impact and risk, causing different people to have different views on how successful adaptation has been.

There is, therefore, no universal way to measure adaptation success, but there is *high agreement* that success is associated with a reduction of climate risks and vulnerabilities (for humans and ecosystems) and an equitable balancing of synergies and trade-offs across diverse objectives, perspectives, expectations and values. Adaptation that is successful is also commonly expected to be inclusive of different socioeconomic groups, especially the most vulnerable, and to be based on flexible and integrative planning processes that take into account different climate scenarios.

Conceptually, the opposite of successful adaptation is maladaptation, that is, when adaptation responses produce unintended negative side effects such as exacerbating or shifting vulnerability, increasing risk for certain people or ecosystems, or increasing greenhouse gas emissions. Among the adaptation options assessed in this report (Figure FAQ17.5.1), physical infrastructure along coasts (e.g., sea walls) has the highest risk for maladaptation over time through negative side effects on ecosystem functioning and coastal livelihood opportunities. However, such adaptations may appear valuable in the short and even longer term for already densely populated urban coasts, demonstrating that an adaptation can be differently judged based on the context it is implemented in (Figure FAQ17.5.1). Many other adaptation options have a larger potential to contribute to successful adaptation (Figure FAQ17.5.1), such as nature restoration, providing social safety nets and changing diets/minimising food waste.

Assessments of adaptation need to be transparent about how they are measuring success. Monitoring and Evaluation (M&E) can be used to track progress and evaluate success and to identify if course corrections during adaptation implementation are needed to achieve the envisaged objectives. Given the diversity of adaptation actions and contexts, no one-size-fits-all approach to M&E and no common reference metrics for adaptation exist. To date, assessments of progress of adaptation have often focused on processes and outputs (i.e., actions taken, such as adaptation plans adopted) that are easier to measure than the effects of these actions in terms of long-term reduction of risks and vulnerabilities. However, knowledge about the outcomes in terms of reducing climate risk, impact and vulnerability is critically required to know if adaptation has been successful.

Tracking progress, in particular outcomes and impacts of adaptation, involves a number of challenges. First, to determine progress over time, risk and vulnerability assessments need to be repeated at least once after starting an adaptation process. This is rarely done, as it demands resources that are usually not factored into the adaptation response. Second, attributing changes in climate risks and vulnerabilities to the adaptation response is often difficult due to other influencing factors, such as socioeconomic development over time. Expected causal relationships between responses and their outcomes should already be outlined during the adaptation planning phase, for example by mapping the way from activities to outcomes, and they should be monitored during implementation. Third, as adaptation can occur in multiple forms and target multiple temporal and spatial scales, the engagement of a diversity of stakeholders is vital to understanding how responses enable adaptation and adaptation success across vulnerable groups. Although stakeholder engagement can be time intensive and costly, in particular when reaching out to populations that are usually not part of policy and planning processes, it can support evaluating co-benefits and trade-offs of adaptation responses. Consideration and analysis of co-benefits and trade-offs along with a focus on short, medium and long time horizons of adaptation goals, which is usually possible through flexible and strong institutions, facilitate successful adaptation and reduce the likelihood of maladaptation.

Box FAQ 17.5 (continued)

Contribution of adaptation options to potentially successful adaptation and to the risk of maladaptation

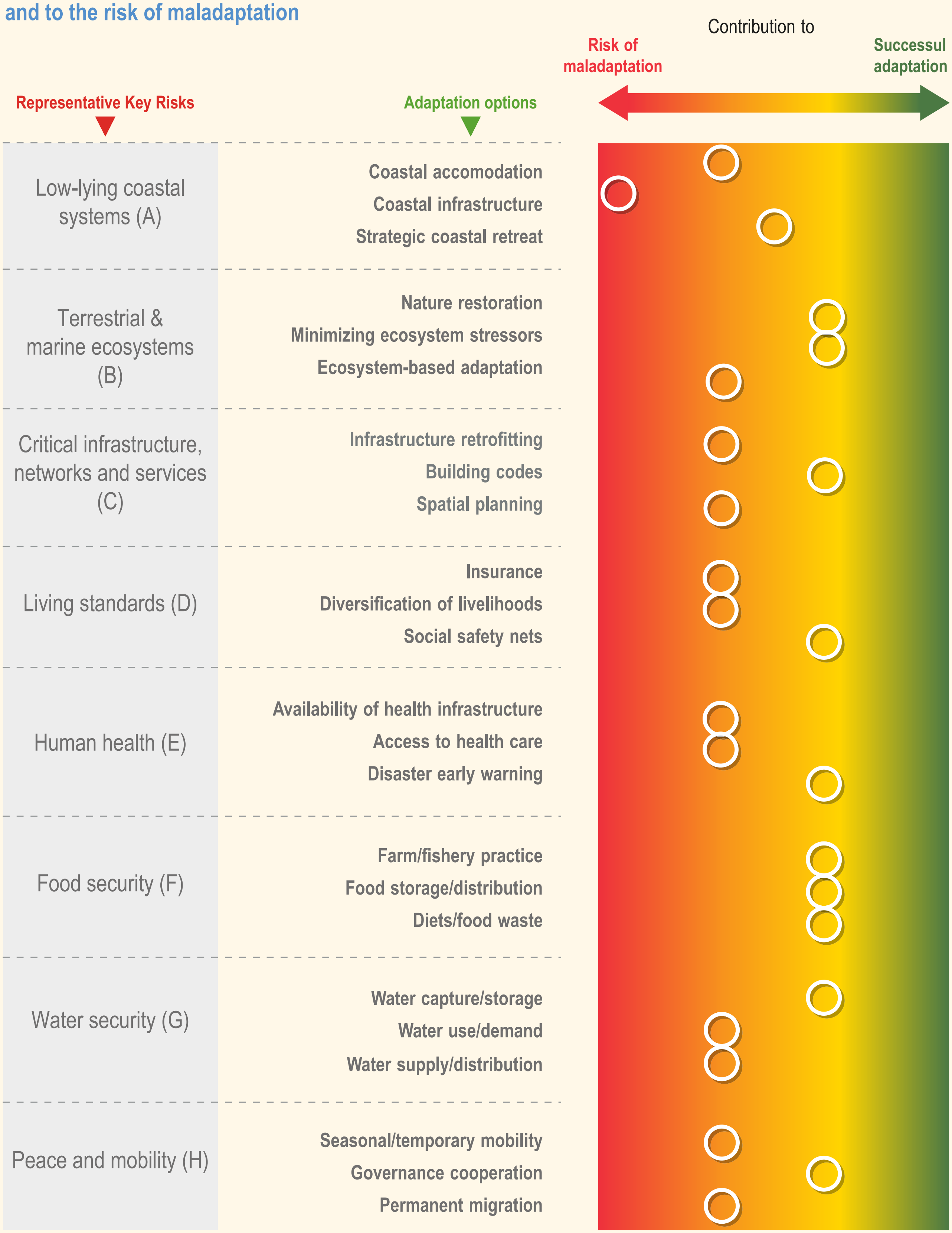


Figure FAQ17.5.1 | Contribution of adaptation options to potentially successful adaptation and to the risk of maladaptation. Note: A similar figure is part of Section 17.5.1.

Frequently Asked Questions

FAQ 18.1 | What is a climate resilient development pathway?

A pathway is defined in IPCC reports as a temporal evolution of natural and/or human systems towards a future state. Pathways can range from sets of scenarios or narratives of potential futures to solution-oriented decision-making processes to achieve desirable societal goals. Climate resilient development pathways (CRDPs) are therefore trajectories for the pursuit of climate resilient development (CRD) and navigating its complexities. They involve ongoing processes that strengthen sustainable development, eradicate poverty and reduce inequalities while promoting fair adaptation and mitigation across multiple scales. As the pursuit of CRDPs is contingent on achieving larger-scale societal transformation, CRDPs invariably raise questions of ethics, equity and feasibility of options to drastically reduce emission of greenhouse gasses (mitigation) that limit global warming (e.g., to well below 2°C) and achieve desirable and liveable futures and well-being for all.

There in no one, correct pathway for CRD, but rather multiple pathways depending on factors such as the political, cultural and economic contexts in which different actors find themselves. Some development pathways are more consistent with CRD, while others move society away from CRD. Moreover, CRDPs are not one single decision or action. Rather, CRDPs represent a continuum of coherent, consistent decisions, actions and interventions that evolve within individual communities, nations, and the world. Different actors, the private sector, and civil society, influenced by science, local and Indigenous knowledges, and the media play a role in designing and navigating CRD pathways.

While dependent on past patterns of development and their socio-ethical, political, economic, ecological and knowledge-technology outcomes at any point in time, transformation, ecological tipping points and shocks can create sudden shifts and unexpected nonlinear development pathways. Actions taken today can enable or foreclose some future potential CRDPs. The differentiated impacts of hurricanes and COVID-19 on nations and communities around the world illustrate how the character of societal development such as equity and inclusion have enabled some societies to be more resilient than others.

Frequently Asked Questions

FAQ 18.2 | What is climate resilient development and how can climate change adaptation (measures) contribute to achieving this?

Climate resilient development (CRD) is a process of implementing greenhouse gas mitigation and adaptation options to support sustainable development for all in ways that support human and planetary health and well-being, equity and justice. CRD combines adaptation and mitigation with underlying development choices and everyday actions, carried out by multiple actors within political, economic, ecological, socio-ethical and knowledge-technology arenas. The character of processes within these development arenas are intrinsic to how social choices are made and they determine whether development moves society along pathways toward CRD or away. For example, inclusion, agency and social justice are qualities within the political arena that underpin actions that enable CRD.

CRD addresses the relationship between greenhouse gas emissions, levels of warming and related climate risks. However, CRD involves more than just achieving temperature targets. It considers the possible transitions that enable those targets to be achieved as well as the evaluation of different adaptation strategies and how the implementation of these strategies interact with broader sustainable development efforts and objectives. This interdependence between patterns of development, climate risk and the demand for mitigation and adaptation action is fundamental to the concept of CRD. Therefore, climate change and sustainable development cannot be assessed or planned in isolation of one another.

Hence, CRD represents development that deliberately adopts mitigation and adaptation measures to secure a safe climate on earth, meet basic needs for each human being, eliminate poverty and enable equitable, just and sustainable development. It halts practices causing dangerous levels of global warming. CRD may involve deep societal transformation to ensure well-being for all. CRD is now emerging as one of the guiding principles for climate policy, both at the international level, reflected in the Paris Agreement (UNFCCC, 2015), and within specific countries.

FAQ 18.2 (continued)

Multiple intertwined climate resilient development pathways

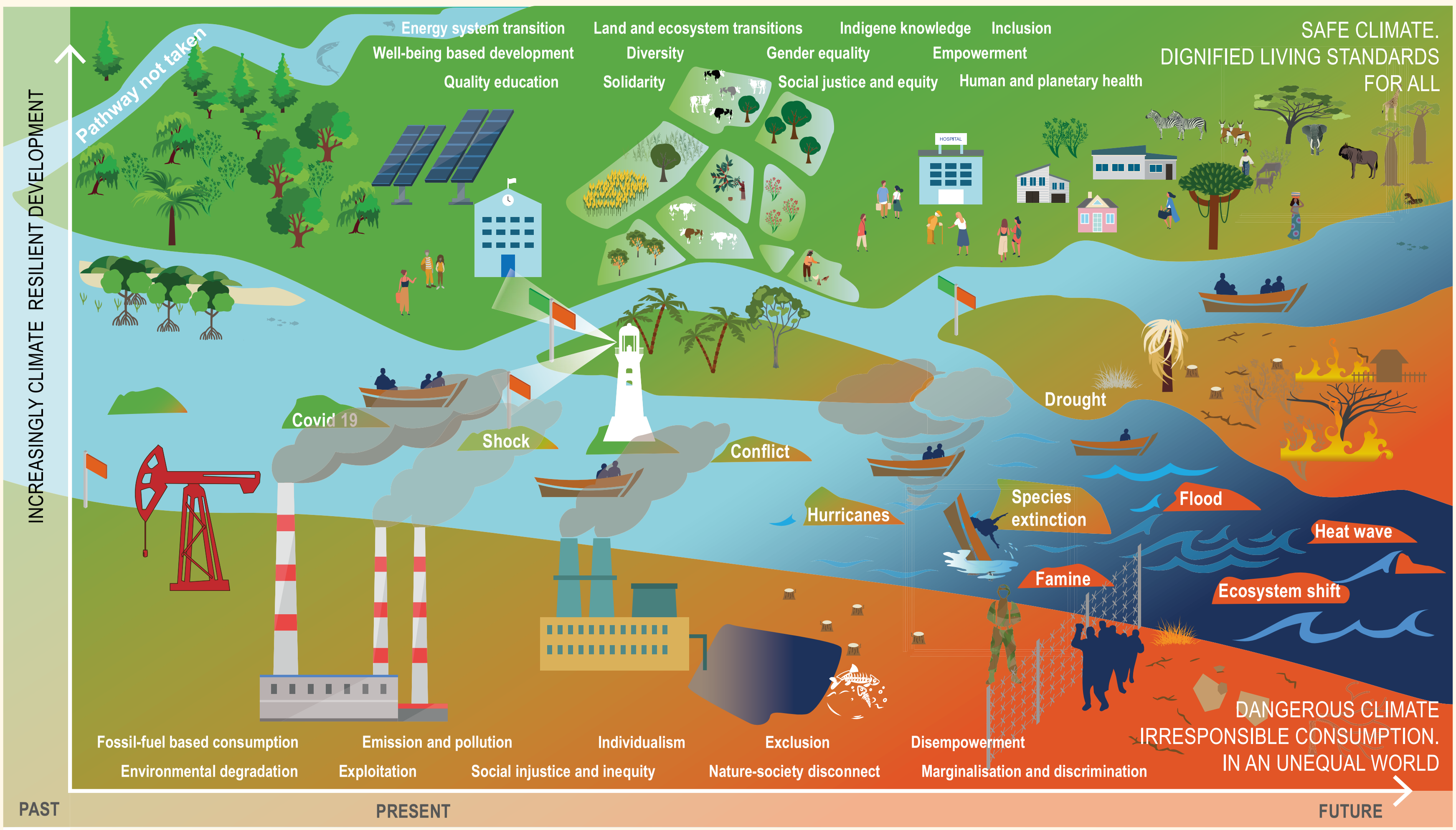


Figure FAQ18.2.1 | Multiple intertwined climate resilient development pathways. Climate change adaptation is one of several climatic and non-climatic measures carried out through decision making by multiple actors that may drive a pathway in a CRD or non-CRD direction. Adaptation, mitigation and sustainable development actions can push a society in a CRD direction, but only if these measures are just and equitable. There are multiple simultaneous pathways in the past, present and future. Societies (illustrated as boats) move on different pathways, towards CRD and non-CRD, with some pathways more dominant than others. The direction of pathways is emergent, taking place through contestations and social choices, through social transformation as well as through surprises and shocks (illustrated as rocks). Path dependency means it is possible but often turbulent to shift from a non-CRD to a CRD pathway. Such a shift becomes more difficult as risks/shocks increase (more rocks) and non-CRD processes and outcomes progress, limiting future options. Low CRD processes and outcomes at the bottom are characterised by inequity, exclusion, polarisation, environmental and social exploitation, entrenchment of Business-As-Usual, with increasing risks/shocks. High CRD processes and outcomes (at the top of the figure) are characterised by equity, solidarity, justice, human well-being, planetary health, stewardship/care and system transitions.

Frequently Asked Questions

FAQ 18.3 | How can different actors across society and levels of government be empowered to pursue climate resilient development?

CRD entails trade-offs between different policy objectives. Governments as well as political and economic elites may play a key role in defining the direction of development at a national and sub-national scale; but in practice, these pathways can be influenced and even resisted by local people, non-governmental organisations (NGOs) and civil society.

Given such tensions, contestation and debate are inherent to the definition and pursuit of climate resilient development (CRD). An active civil society and citizenship create the enabling conditions for deliberation, protest, dissent and pressure, which are fundamental for an inclusive participatory process. These enable a multiplicity of actors to engage across multiple arenas including governmental, economic and financial, political, knowledge, science & technology, and community. Decisions and actions may be influenced by uneven interactions among actors, including socio-political relations of domination, marginalisation, contestation, compliance and resistance, with diverse and often unpredictable outcomes.

In this way, recent social movements and climate protests reflect new modalities of action in response to social, economic, and political inaction. The new climate movement, led mostly by youth, seeks science-based policy and, more importantly, rejects a reformist stance toward climate action in favour of radical climate action. This is mostly pursued through collective disruptive action and non-violent resistance to promote awareness, a regenerative culture and ethics of care. These movements have resulted in notable political successes, such as declarations of climate emergency at the national and local level, as well as in universities. Also, their methods have proven effective to end fossil fuel sponsorship.

The success and importance of recent climate movements also suggest a need to rethink the role of science in society. On one hand, the new climate movements demanding political action were prompted by the findings of scientific reports, mainly the IPCC (2018a) and IPBES (2019) reports. On the other hand, these movements have increased public awareness and stimulated public engagement with climate change at unprecedented levels beyond what the scientific community can do alone.

Frequently Asked Questions

FAQ 18.4 | What role do transitions and transformations in energy, urban and infrastructure, industrial, land and ocean ecosystems, and in society, play in climate resilient development?

The IPCC SR1.5 report identified transitions in four key systems, including energy, land and ocean ecosystems, urban and infrastructure, and industry, as being fundamental to the pursuit of climate resilient development (CRD). In addition, this report identifies societal transitions, in terms of values and worldviews that shape aspirations, lifestyles and consumption patterns, as another key component of CRD. Acknowledging societal transitions has implications for how one assesses options and values different outcomes from the perspectives of ethics, equity, justice and inclusion. Collectively, these system transitions can widen the solution space and accelerate and deepen the implementation of sustainable development, adaptation, and mitigation actions by equipping actors and decision-makers with more effective and more equitable options. However, the way they are pursued may not necessarily be perceived as ethical or desirable to all actors. Moreover, system transitions are necessary precursors for more fundamental climate and sustainable-development transformations. Yet, these transitions can themselves be outcomes of transformative actions.

Frequently Asked Questions

FAQ 18.5 | What are success criteria in climate resilient development and how can actors satisfy those criteria?

Climate resilient development (CRD) is not a predefined goal to be achieved at a certain point or stage in the future. It is a constant process of evaluating, valuing, acting and adjusting various options for mitigation, adaptation and sustainable development, shaped by societal values as well as contestations of those values. Any achievement or success is always a work in progress driven by with continuous, directed, intentional actions. These actions will vary according to the priorities and needs of each population or system; therefore, specific criteria for, and indicators of, CRD will vary according to each specific context. This respect for context ensures the pursuit of CRD prioritizes people, planet, prosperity, peace and partnership, per the broad goals of the Agenda 2030 on sustainable development.

If CRD is defined as a process of implementing greenhouse gas mitigation and adaptation options to support sustainable development for all, this implies various potential criteria for success. These include the adoption of mitigation and adaptation measures to secure a safe climate, meet basic needs, eliminate poverty and enable equitable, just and sustainable development for all. Therefore, the 17 United Nations' Sustainable Development Goals provide a good (although limited) measure of progress toward CRD. The Sustainable Development Goals aim at ending poverty and hunger globally and protect life on land and underwater until the year 2030. Although there are proven synergies between the Sustainable Development Goals and mitigation, there remain synergies between the SDGs and adaptation that need to be explored further.