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4
RESILIENCE AND CLIMATE CHANGE

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In future, the risks and scale of natural disasters will be heightened and reshaped by climate change. Building resilience to disasters and adapting to climate change should therefore go hand in hand.

Climate change magnifies the risk of disasters and increases their costs.[1] As the climate system has warmed, the number of weather-related hazards globally has tripled, and the number of people living in flood-prone areas and cyclone-exposed coastlines has doubled – and this trend is expected to increase.[2]

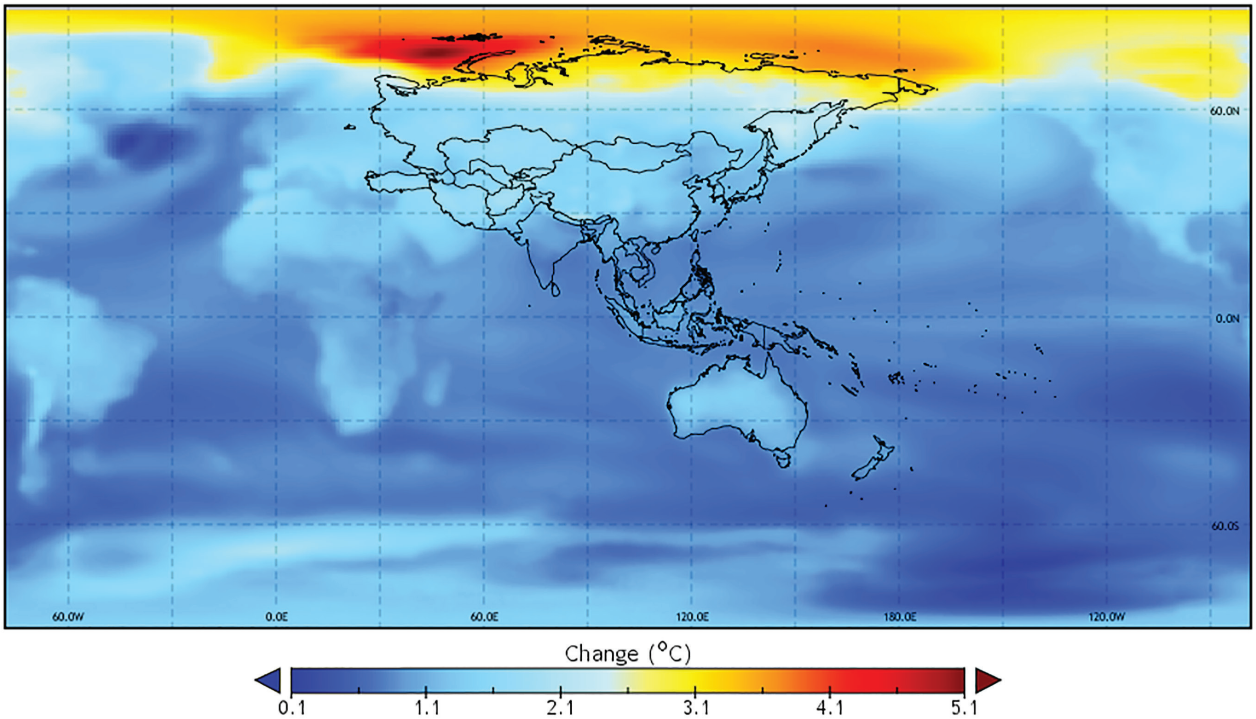
Over the past century, most of the Asia-Pacific region has seen warming trends and greater temperature extremes. The IPCC Synthesis Report 2014 assessed the risks and impacts of future climate change, applying different levels of confidence – from 'very low' to 'very high' – and assessing the likelihoods of various outcomes on a scale from 'exceptionally unlikely' to 'virtually certain'.[3] It concluded that future warming will increase the likelihood of extremely hot days and nights and result in greater evaporation that will exacerbate droughts as well as increase atmospheric moisture, resulting in more frequent heavy rainfall and snowfall.[4]

These changes will have a significant impact on human health. More frequent and intense heat waves will increase mortality and morbidity, particularly for vulnerable groups such as older people. Increases in heavy rain and temperature will also heighten the risk of diarrhoeal diseases, dengue fever, and malaria.

Climate change could also bring huge economic losses.[5] For South-East Asia, for example, it has been estimated that climate change may reduce the region's gross domestic product (GDP) by up to 11 per cent by 2100.[6] Increases in floods and droughts that affect rice crops will increase food prices. By 2030, climate change could force more than 100 million people into extreme poverty.

Figure 4-1

Projected temperature changes by the 2030s, RCP4.5



Source: RIMES, based on datasets from CMIP 5 Modelling Groups, 2017.

Note: Changes in maximum temperatures (°C) over the Asia-Pacific region by the 2030s as compared to baseline (1980s) using an ensemble of CMIP5 GCMs for future scenario RCP 4.5

Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

CHAPTER 4

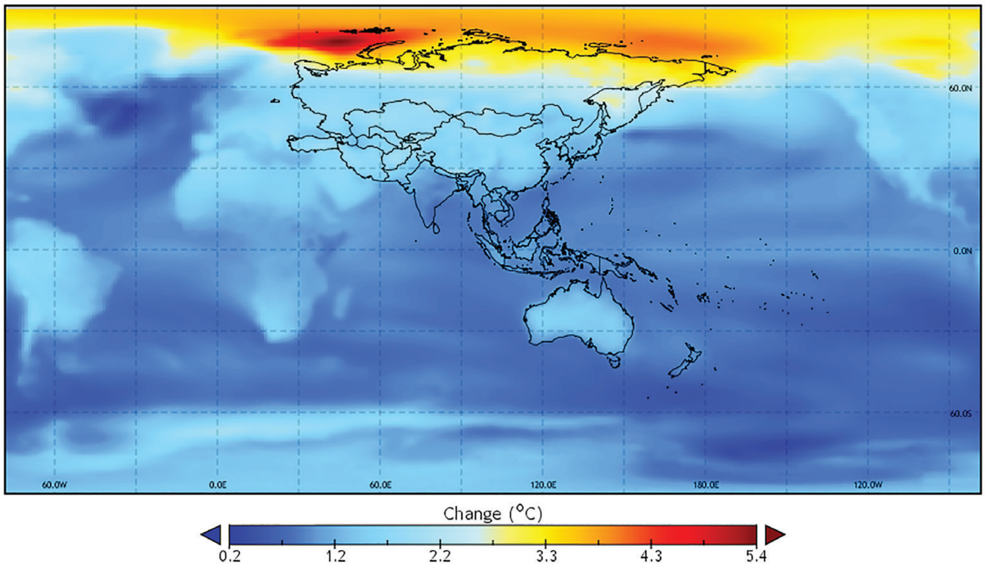
Risk scenarios

For estimates of future concentrations of greenhouse gases, the IPCC has developed five scenarios – referred to as 'representative concentration pathways' (RCPs). In conjunction with RIMES, ESCAP has developed climate risk scenarios for the 2030s for the Asia-Pacific region based on two of these – RCP 4.5 and RCP 8.5.[7] Both indicate increases in temperature of 1.5 to 2.0 degrees centigrade over most of the oceanic and land areas, with higher increases at higher latitudes. These will result is some hot and very hot days and periodic heat waves, with far-ranging impacts on agriculture, health, water and energy. For both scenarios, the increases are similar almost until the middle of the century (Figure 4-1 and Figure 4-2).

The corresponding scenarios for rainfall are shown in Figure 4-3 and Figure 4-4. These indicate only slight increases by 2030.

Figure 4-2

Projected temperature changes by the 2030s, RCP8.5



Source: RIMES, based on datasets from CMIP 5 Modelling Groups, 2017.

Note: Changes in maximum temperatures (°C) over Asia and the Pacific region during the 2030s as compared to baseline (1980s) using an ensemble of CMIP5 GCMs for future scenario RCP 8.5

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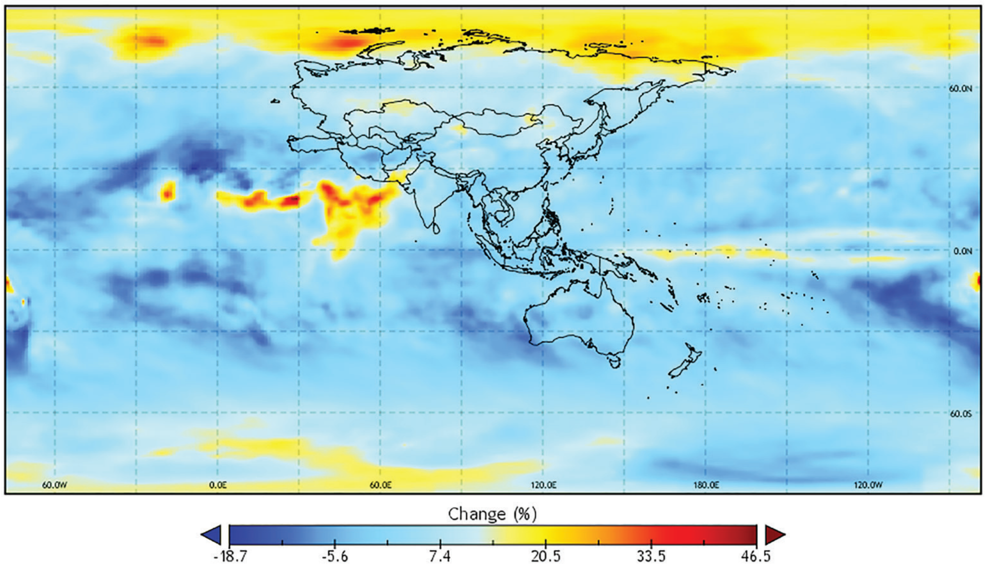
Figure 4-3

Projected rainfall changes by the 2030s, RCP 4.5



Source: RIMES, based on datasets from CMIP 5 Modelling Groups, 2017.

Note: Changes in annual rainfall (per cent change) over Asia and the Pacific region during the 2030s as compared to baseline (1980s) using an ensemble of CMIP5 GCMs for future scenario RCP 4.5

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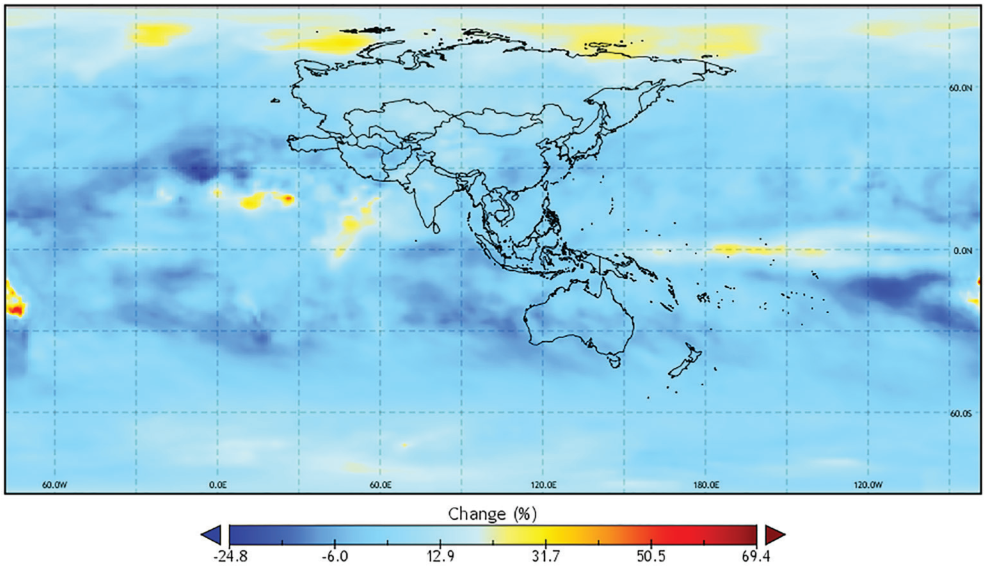
Figure 4-4

Projected rainfall changes by the 2030s, RCP 8.5



Source: RIMES, based on datasets from CMIP 5 Modelling Groups, 2017.

Note: Changes in annual rainfall (per cent change) over Asia and the Pacific region during the 2030s as compared to baseline (1980s) using an ensemble of CMIP5 GCMs for future scenario RCP 8.5

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Climate change and increasing disaster risk

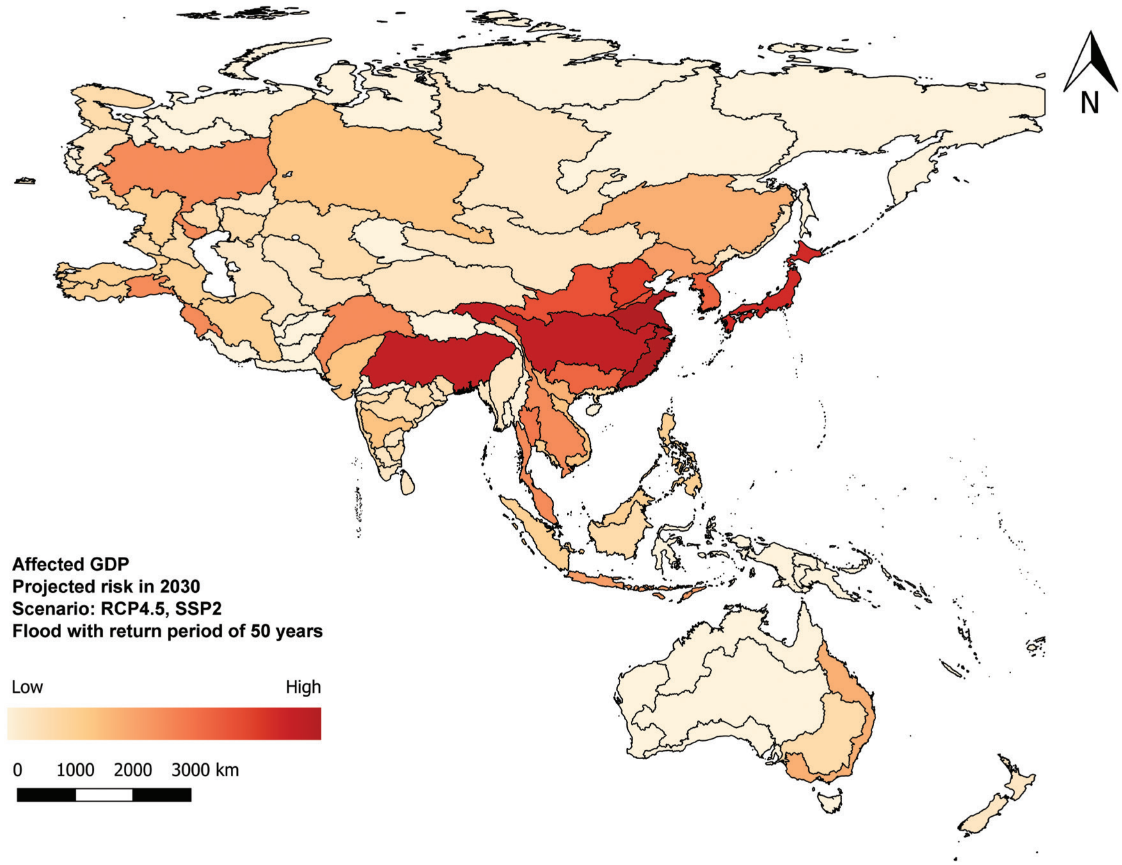
The impact of climate change will be felt particularly through periodic weather events that can be considered as climate risk fault-lines – monsoon rainfall and El Niño/La Niña events – as well as through heatwaves, sand and dust storms, floods, cyclones and droughts.

Monsoons – Increases in precipitation extremes are very likely in East, South, and South-East Asia. For East Asia, most models show an increase in mean precipitation in the summer monsoons and an increase in heavy precipitation events. For India, all models and scenarios project an increase in both mean and extreme precipitation in the summer monsoon.[8] There is also some evidence that climate change will affect the timing or seasonality of the monsoon.[9] In addition, the increase in heavy precipitation events could offset the shortening of the rainy season.[10]

El Niño and La Niña – On land in many tropical and subtropical areas, El Niño events favour drought while La Niña events promote wetter conditions. In a warming climate, these variations are expected to become more extreme.[11] It is not clear whether rising global and ocean temperatures will intensify the El Niño – though they could affect the frequency: some modelling suggests that over the next 100 years extreme El Niño events could occur roughly every 10 years instead of every 20.[12] A better understanding of the relationship with

Figure 4-5

Estimated flood risk in 2030



Source: ESCAP, based on data from World Resources Institute, Aqueduct Global Flood Analyzer, (http://floods.wri.org).

Note: The boundaries in this map are depicted from river catchment areas based on WRI data.

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climate changes should come from the World Climate Research Programme's Climate and Ocean: Variability, Predictability and Change projects.

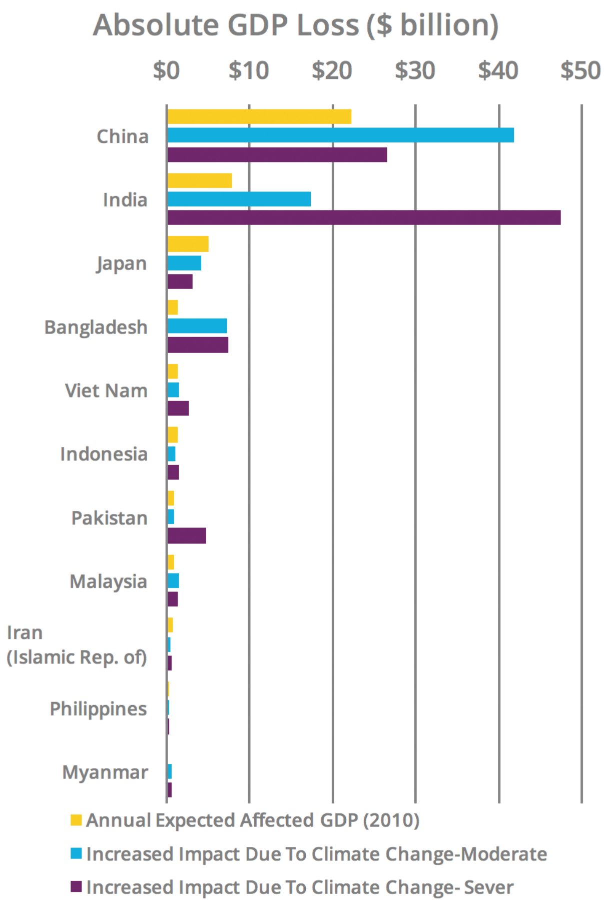
Heat waves – Climate change can increase the number of heat waves that cause substantial mortality.[13] In 2015–16, Pakistan and India were hit by an extreme heatwave, resulting in 3,765 deaths, mostly amongst the elderly, and manual labourers.[14] One cause was the unusual north-westerly wind movement, which spread hot air from the desert.[15]

Sand and dust storms – Higher temperatures reduce soil moisture which, combined with higher wind speeds, trigger large-scale sand and dust storms – especially in South-West Asia, and North and East Asia.

Floods – Using the World Resource Institute tools ESCAP has developed flood risk projections for moderate (RCP4.5) and severe (RCP8.5) scenarios.[16] Both indicate a substantial increase in flood losses, particularly in East, South, South-West and South-East Asia with the problems becoming worse by 2030 (Figure 4-5). China, India, Bangladesh

Figure 4-6

Projected GDP losses due to floods for the year 2030



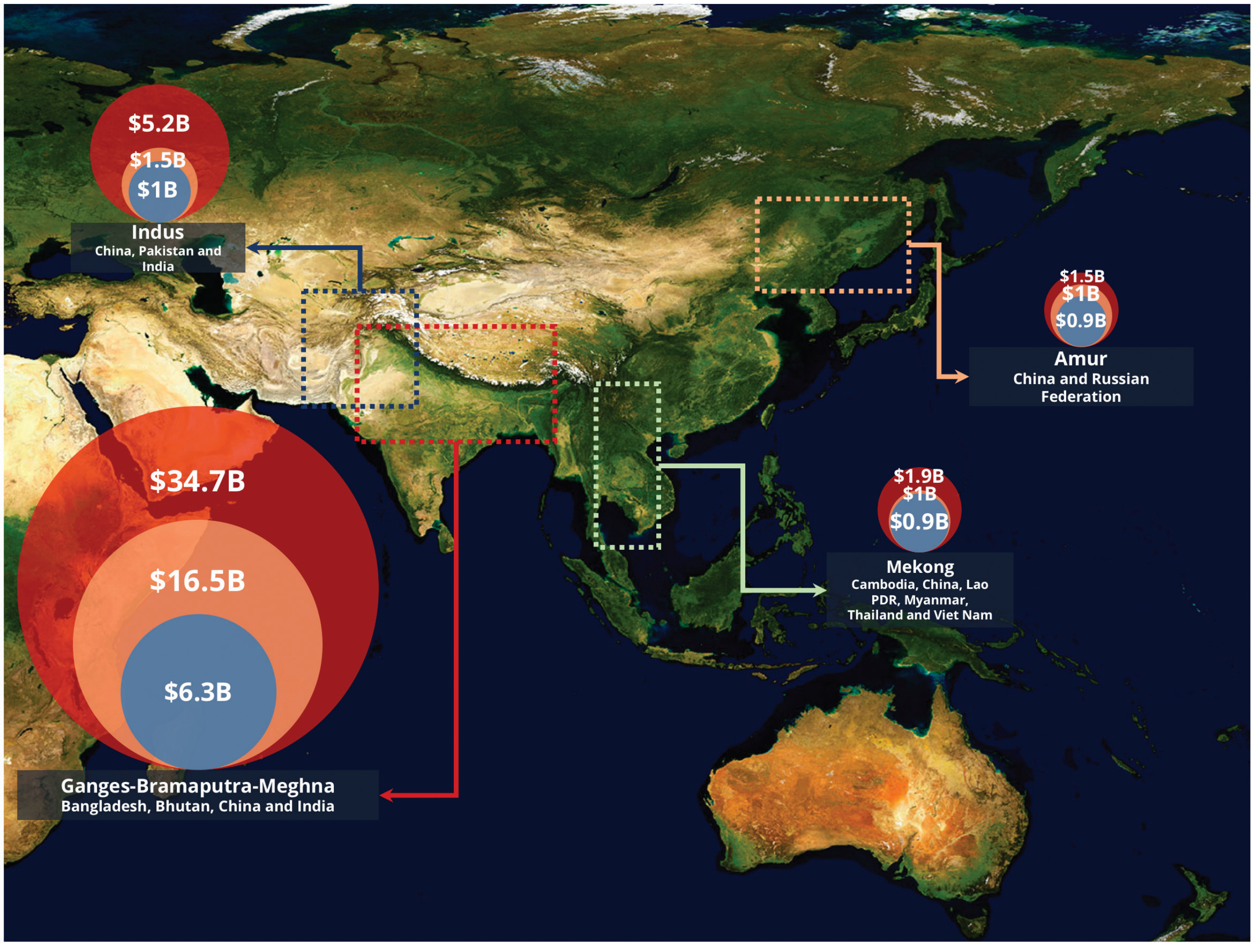
and Pakistan will experience losses two to three times greater than in the reference year of 2010. Under the severe scenario, India will be the country worst affected, with nearly $50 billion in annual losses, followed by China, Bangladesh and Pakistan (Figure 4-6).

While flooding can be considered by country, in fact much of the excess water spreads across the region's major river basins and over national frontiers. Under the moderate and severe climate change scenarios, the transboundary flood losses will be 2 to 6 times greater in the Ganga-Brahmaputra and Meghna basin; 1.5 to 5 times in the Indus basin: 1.1 to 2 times in the Mekong basin; and 1.1 to 1.6 times in the Amur basin (Figure 4-7).

Cyclone risk – The Global Assessment Report Atlas 2017 highlights the cyclone risk patterns in the Pacific and in the Indian Ocean basins Figure 4-8. This is based on the probabilistic cyclonic wind and storm surge hazards analysis in conjunction with the historical frequency and intensity of tropical cyclones. While cyclones are more frequent and intense in the Pacific, vulnerability is higher in the Indian Ocean basin (the Bay of Bengal and Arabian Sea).

Figure 4-7

Transboundary flooding costs in major river basins, 2010 and 2030



[Grey circle] 2010, actual losses, [light red]; 2030, moderate scenario; [dark red] 2030 severe scenario.

Source: ESCAP, based on data from World Resources Institute, Aqueduct Global Flood Analyzer, (http://floods.wri.org).

Background image created by Reto Stokli, NASA, (https://earthobservatory.nasa.gov/blogs/elegantfigures/2011/10/06/crafting-the-blue-marble/).

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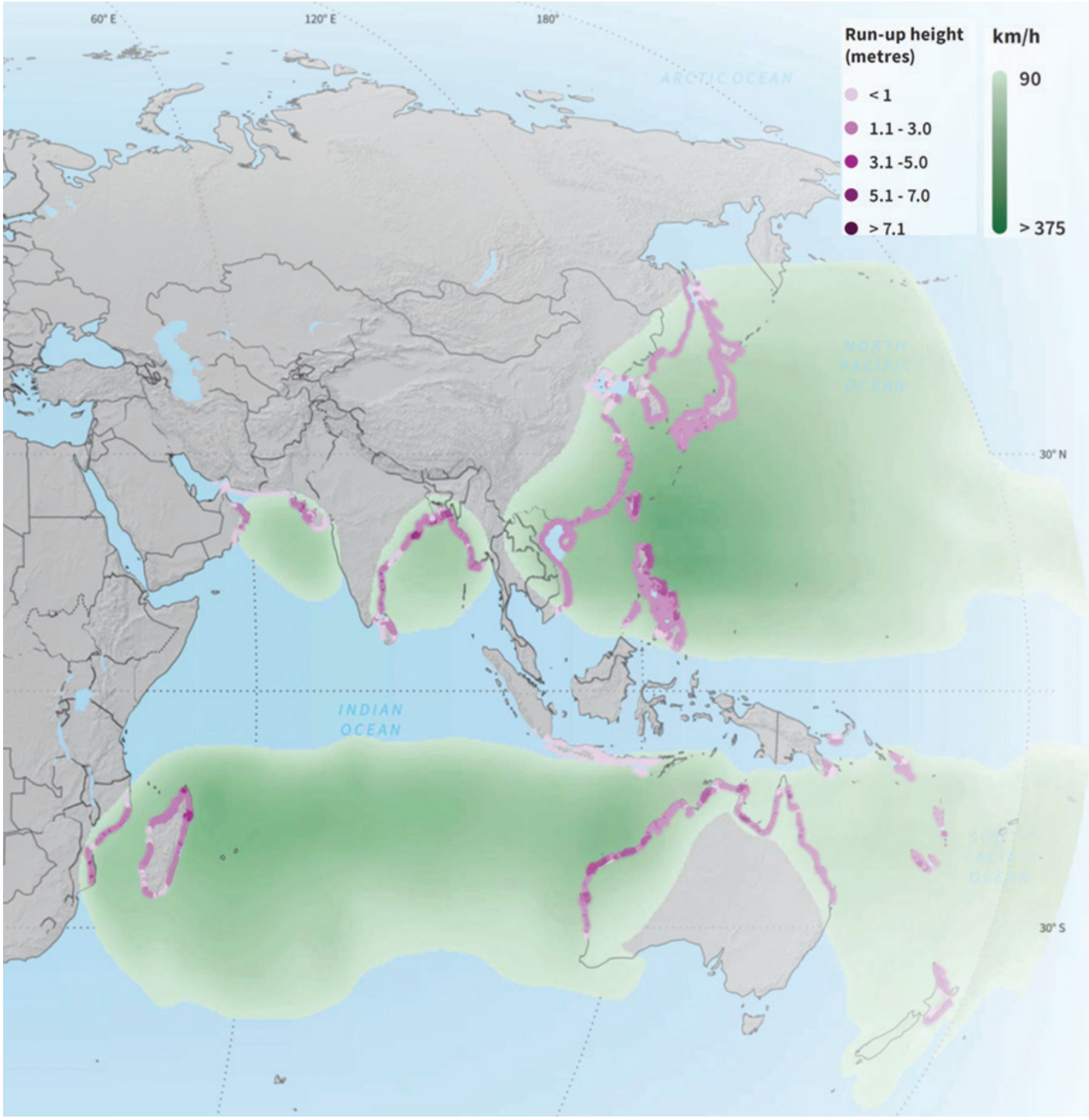
Climate change is predicted to increase the frequency of high-intensity storms in selected ocean basins depending on the climate model. The ESCAP/WMO Typhoon Committee has estimated that the occurrence of tropical cyclones could shift eastward or northward in the West and North Pacific basin, with the associated risk depending on changes in population density.[17] Future climate scenarios also suggest that tropical cyclones will have shorter return periods and be increasingly destructive.[18]

Figure 4-8

Regional tropical cyclones, wind and storm surge hazards



Source: ESCAP, based on UNISDR, Global Assessment Report on Disaster Risk Reduction, Atlas, March 2017.

Note: Wind hazard - wind speed 100 years return period. Storm surge hazard – run-up height 100 years return period

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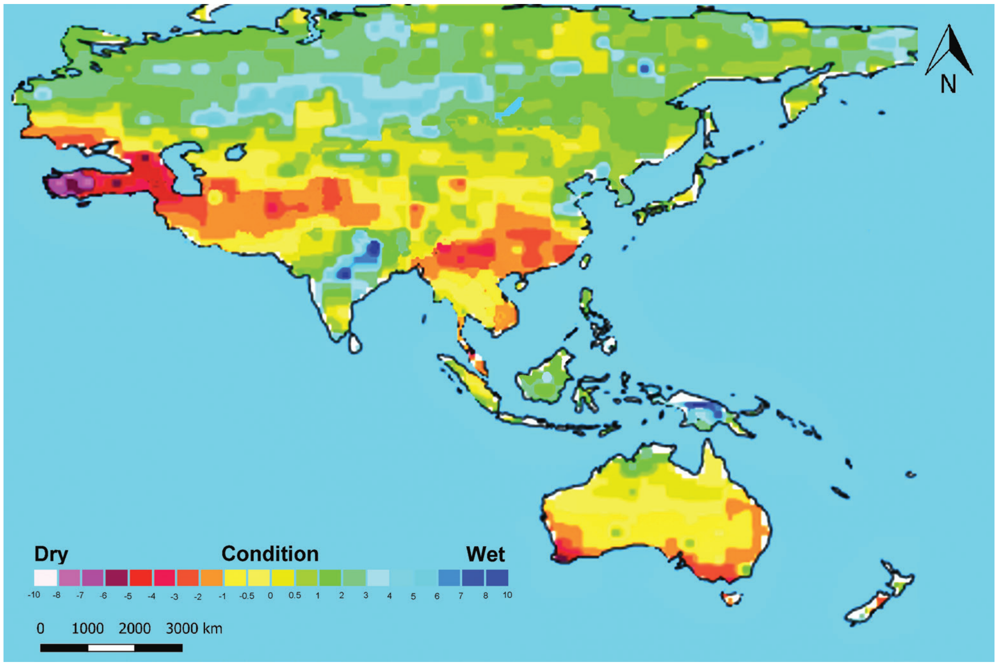
Figure 4-9

Drought severity by 2030



Source: ESCAP based on Dai, A. (2011)

Note: This is based on the Palmer Drought Severity Index. Lower values indicate more severe drought risk.

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Drought risk – Future drought risk scenarios are indicated in Figure 4-9.[19] This uses the Palmer Drought Severity Index – a measure of dryness based on precipitation and temperature-related parameters.[20] By 2030, drought risk will have increased substantially. There will also be a shift in the geography of drought: in South Asia towards the west; in South-East Asia towards the east.

Climate risks are widespread across the region, but there are also 'hotspots' where greater likelihood of change coincides with high concentrations of vulnerable, poor or marginalized people.[21] Generally, these cut across national boundaries (Figure 4-10).

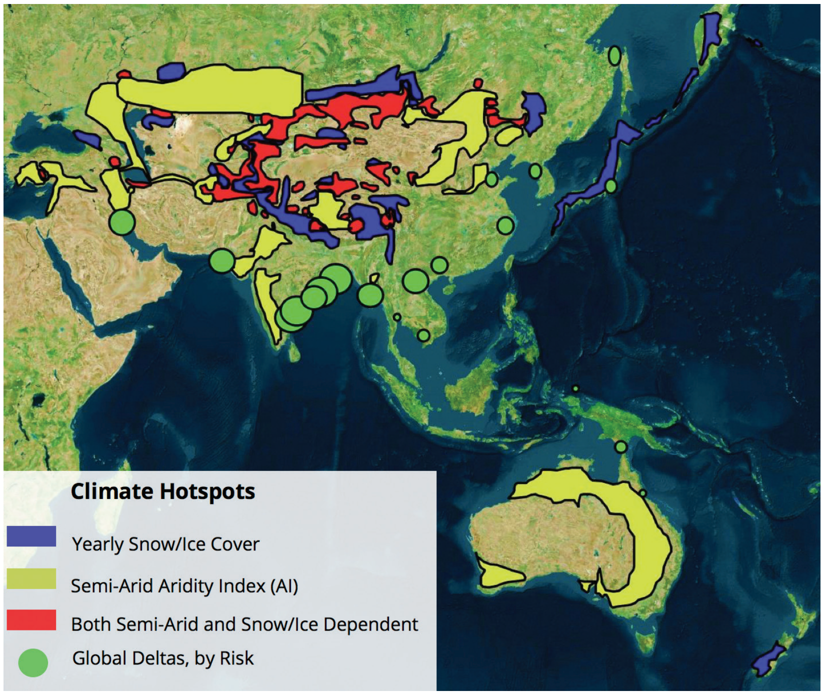
River deltas – The Mekong and the Ganges–Brahmaputra–Meghna deltas will be affected by sea-level rise due to subsidence, decreases in sediment supply, increase in groundwater salinity, and deteriorating water quality. They will also suffer loss and erosion because of floods, storm surges, and extreme cyclonic events, exacerbated by the loss of protection from mangrove forests and sand dunes.[22] All increase the risk of loss of life and economic losses and damages to economic activities such as fisheries,[23] along with reductions in biodiversity and species abundance.[24]

Semi-arid regions – Around 60 per cent of the cultivated areas in semi-arid regions are rain fed, in South Asia by the annual monsoon.[25] These areas are likely to experience more frequent and intense droughts – and as a result will become more extensive.[26]

Glacier- and snowpack-dependent river basins – More than 1.5 billion people living in

Figure 4-10

Climate change hotspots



Source: ESCAP, based on Szabo et al. (2016).

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the floodplains of the Ganges, Indus, and Brahmaputra depend on the Himalayan water system.[27] Based on a projected estimate of glacier area in 2050, declining water availability could eventually threaten some 60 million people with food insecurity.[28]

Adaptive capacity for climate resilience

A system's adaptive capacity is the set of resources available for adaptation, as well as the ability of that system to use these resources effectively. The IPCC's Fifth Assessment Report set out a range of interventions and policy responses:

Low-regrets measures – These provide large benefits but at low-cost – and thus cause low regrets should they prove unnecessary. They also have co-benefits in that they help address other development goals, such as improving livelihoods, human well-being, and biodiversity, and help minimize the scope for maladaptation. Measures include: early warning systems; risk communication between decision makers and local citizens; and sustainable land management and ecosystem management and restoration. Other measures are: improvements to health surveillance, water supply, sanitation, and irrigation and drainage systems; climate-proofing of infrastructure; development and enforcement of building codes; and better education and awareness.

Integrated approaches – These involve a portfolio of actions that are most effective when customized to local circumstances. They could involve hard infrastructure combined with building individual and institutional capacity and improving ecosystems.

Multi-hazard risk management – Considering multiple types of hazards together lowers the likelihood that reducing the risk for one type will increase exposure and vulnerability to others.

Synergies with disaster risk management – Greater coordination is needed between technology transfer and cooperation on disaster risk reduction and climate change adaptation.

Community-based adaptation – Local populations can document their experiences with the changing climate, particularly extreme weather events. This will reveal existing community capacity as well as shortcomings. Community-based adaptation can be supported with human and financial capital and information that is customized for local stakeholders.

Effective risk communication – Perceptions of risk are driven by psychological and cultural factors, values, and beliefs. Appropriate and timely risk communication among all stakeholder groups should also clarify the degrees of uncertainty and complexity.

Iterative management – The complexity and uncertainties, and the length of the time frames associated with climate change, require iterative processes of monitoring, research, evaluation and learning.

Table 4-3 summarises key areas of climate risk and the potential for adaptation, with corresponding levels of confidence. This indicates critical gaps in adaptive capacity for all hazards, particularly for the near term – 2030–2040 – and for heat-related hazards and drought in semi-arid regions, as well as for water-related disasters in deltas and snow-pack-dependent river-basins.

Coherence between climate change adaptation and disaster risk reduction

The aim should be to build climate resilience while adapting to climate changes and treat these as complementary processes (Figure 4-11). At present, these activities diverge in many respects: they often, for example, have different institutional structures, with experts and functionaries who respond to different constituencies. There are also structural barriers at international and regional levels. In addition, policies, planning and programmes may be disconnected: DRR projects tend to be more ad hoc, with shorter timescales and narrower information bases that do not take full account of climate change risks. For some programmes however, there has been greater convergence, particularly at the regional level – in such areas as the management of coastal zones and river-basin floodplains, and watershed development, as well as in measures for land-use planning and drought mitigation.

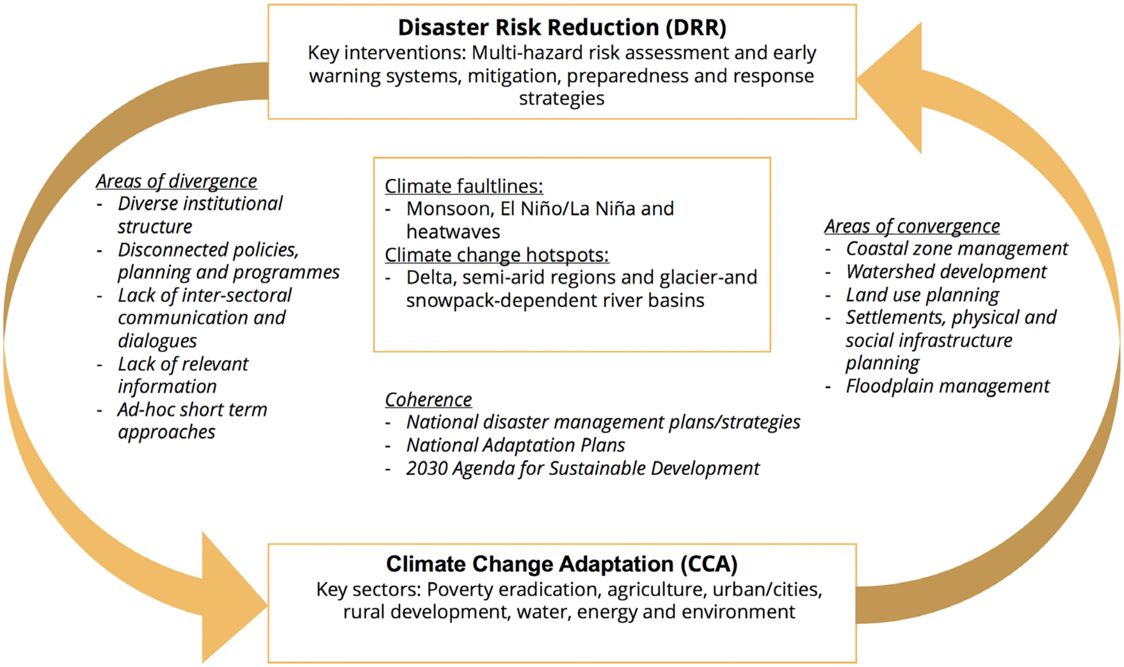
There are already well-established tools and techniques used for DRR such as multi-hazard early warning systems, hazard, risk and vulnerability analysis, risk assessment and monitoring, and risk mitigation, as well as response strategies. These can be integrated with climate change adaptation in sectors such as poverty eradication, agriculture, urban, rural, water and energy.

From 'conceptual framework' to 'actionable strategies', the following steps can help build regional climate resilience:

- *Step I: Managing climate fault-lines* – through better understanding of the climate risks associated with monsoon, El Niño/La Niña and heatwaves.

Figure 4-11

Coherence of climate change adaptation and disaster risk reduction



- *Step II: Forging resilient strategies for climate change hotspots* – including deltas, semi-arid regions, glacial and snow-pack-dependent river-basins with multi-hazard and transboundary approaches. Coastal zone management programmes and watershed development programmes in semi-arid regions, for example, address vulnerabilities through strategic planning for climate change adaptation.

- *Step III: Increasing coherence of climate change adaptation and DRR at global, regional, national and local levels* – to directly address climate change adaptation issues. Priority should be given to developing National Adaptation Plans of Action and integrating disaster risk reduction.

The gaps between adaptation and resilience can also be narrowed by improving meteorological, hydrological and climate information. The LDCs often have weak national meteorological and hydrological services and agencies for disaster risk management. They need to significantly upgrade their observation networks and build the capacity of government professionals. The SIDS face many of the same issues, including the need to improve network equipment, information technology infrastructure, and professional staff capacity, as well as to prepare for hazards beyond tropical cyclones. National agencies should also link better with global and regional support centres. Two initiatives to increase the capacity in LDCs and SIDS are the Climate Risk and Early Warning Systems (CREWS) initiative (Box 4-1) and the Regional Integrated Multi-hazard Early Warning System for Asia and Africa (RIMES) (Box 4-2). Another key initiative for improving the accuracy of early warning systems and climate risk information is the Global Framework for Climate Services.[29]

Box 4-1

Climate Risk and Early Warning Systems Initiative

The Climate Risk and Early Warning Systems initiative (CREWS) aims to mobilize $100 million to increase the capacity for Multi-Hazard Early Warning Systems in more than 50 LDCs and SIDS. By 2020, all are expected to have weather stations, radar facilities, and at least moderate early warning system and risk information capacities.

The CREWS coalition is led by France, with support from Australia, Germany, Luxembourg, the Netherlands, Japan and Canada. It is being implemented by the World Meteorological Organization (WMO), the United Nations Office for Disaster Risk Reduction (UNISDR), the World Bank, and the Global Facility for Disaster Reduction and Recovery (GFDRR).

Source: Global Facility for Disaster Risk Reduction, the World Bank (https://www.gfdrr.org/crews-climate-risk-early-warning-systems).

Box 4-2

Regional Integrated Multi-Hazard Early Warning System

The Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) is an intergovernmental institution, owned and managed by its more than 30 Member States and collaborating countries. Established in 2009 with the support from ESCAP Multi-donor Trust Fund on Tsunami, Disaster and Climate Preparedness, RIMES allows Member States to gather information at much lower costs than individual early warning systems, particularly for high-impact, low frequency hazards.

RIMES services include localized and customized severe weather and short-term weather information that can be used for contingency planning. It also offers medium-term weather information for logistics planning, as well as longer-term climate outlooks for resource planning and management. In addition, it analyses risks of climate variability and change, identifies risk management and adaptation options, and develops new-generation risk information products. It also offers decision support tools including risk assessment, interpretation and translates early warning information into impact outlooks and response options.

For climate change adaptation, RIMES produces customized climate change information to inform national planning processes. To generate climate change scenarios for countries, RIMES uses a sub-set of eight Global Circulation Model (GCMs), downscaling the coarser resolution statistical models, analogue methods, and climate control correlations.

Source: Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES), http://www.rimes.int/cc/model-product

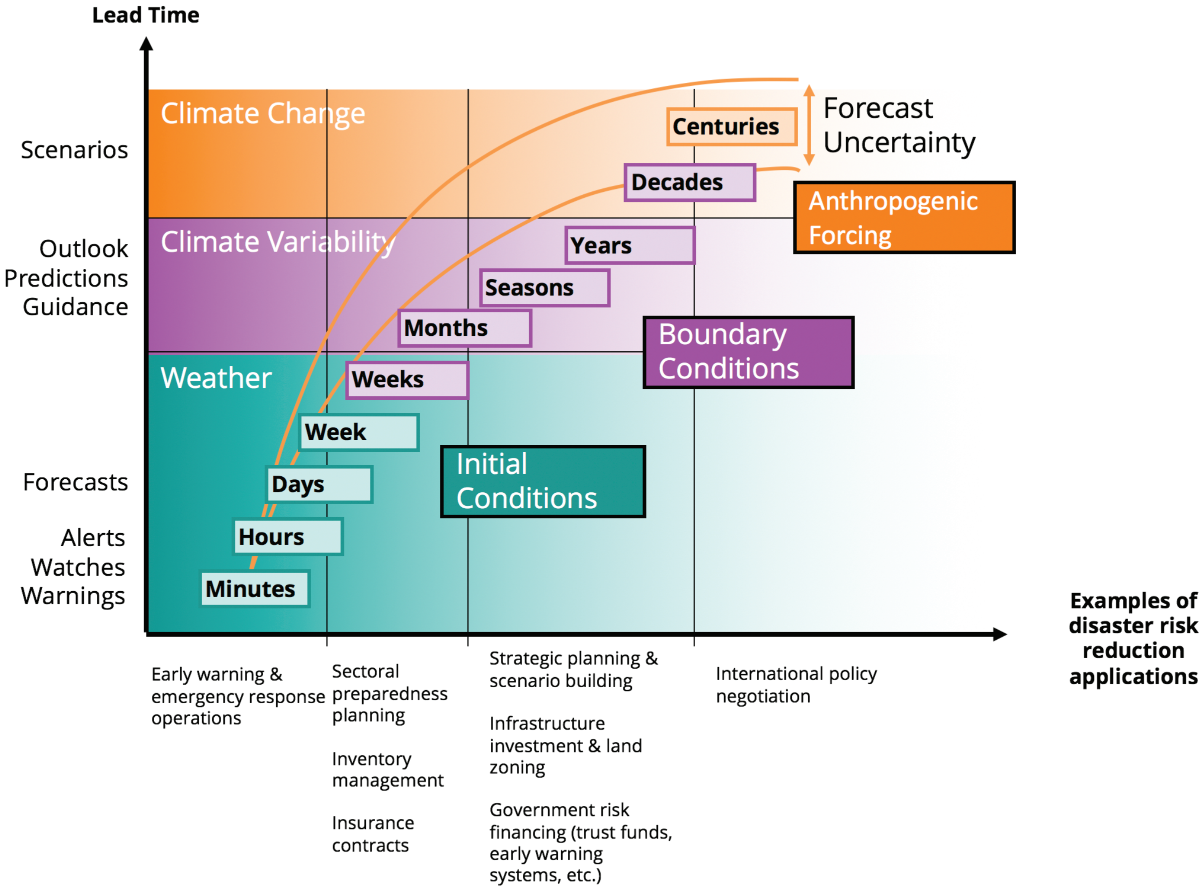
Policy decisions and deep uncertainty

For DRR to be successful, it needs to take account of the shifting risks associated with climate change and ensure that measures do not increase vulnerability to climate change in the medium to long term.[30] Traditionally hazard analysis has been based on historical data, but this is no longer sufficient, because hazard characteristics are changing as a result of climate change. For instance, a 100-year flood or drought may become a 30-year flood or drought.[31] Climate scenarios inevitably have ranges of uncertainty which increase as they project further into the future (Figure 4-12 and Table 4-1).[32] There are also issues of resolution, since the projections may be for areas broader than those required for local policy decisions.

Many buildings and critical infrastructure will have to cope in 2100 with conditions that, according to most climate models, will be radically different from current ones. Table 4-2 indicates the likely timeframes and degrees of exposure for different sectors. Many methodologies have been proposed for making decisions under deep uncertainty, often using a mix of methodologies.[33]

Figure 4-12

Uncertainties associated with climate change scenarios, outlooks, and forecasts



Source: WMO (2011).

Table 4-1

State of science and models for different event types

H = high M = medium L = low	Capabilities of climate models to simulate event type	Quality/length of the observational record	Understand that lead to changes in extremes and result of climate change
Extreme cold events	H	H	H
Extreme heat events	H	H	H
Droughts	M	M	M
Extreme rainfall	M	M	M
Extreme snow and ice storms	M	L	M
Tropical cyclones	L	L	M
Extratropical cyclones	M	L	L
Wildfires	L	M	L
Severe convective storms	L	L	L

Source: National Academies of Sciences, Engineering, and Medicine. 2016.

Note: The assessments of the capabilities of climate models apply to those models with spatial resolutions (100km or coarser) that are representative of most models participating in the Coupled Model Inter-comparison Project Phase 5.

Table 4-2

Selected sectors that require long-term planning for climate change

Sector	Time scale	Exposure
Water infrastructures (e.g., dams, reservoirs)	30-200 yr.	+++
Land-use planning (e.g., in flood plain or coastal areas)	>100 yr.	+++
Coastline and flood defences (e.g., dikes, sea walls)	>50 yr.	+++
Building and housing (e.g., insulation, windows)	30-150 yr.	++
Transportation infrastructure (e.g., port, bridges)	30-200 yr.	+
Urbanism (e.g., urban density, parks)	>100 yr.	+
Energy production (e.g., nuclear plant cooling system)	20-70 yr.	+

Source: Illustrative list of sectors with high inertia and high exposure to climate conditions (from Hallegatte, 2009).

Figure 4-13

Seamless integration of climate scenarios, seasonal forecasts and medium/short term forecasts for a range

Climate risk exists in different time scales ranging from decades to weeks to days. As shown in Figure 4-13, risk-sensitive activities and decisions ranging from operational, strategic, to tactical – are being managed using different weather and climate information products.

Managing risks from long-term climate change should be viewed as part of a broader strategy for managing climate risks for all timescales. Since climate risks develop and accumulate over time, building plausible scenarios can be useful to help decision-makers identify adaptation measures against a range of climate change outcomes. Climate scenarios can be customized to support long-term policy decisions.

Opportunities for low-cost adaptation

Many adaptations can be implemented at low cost. It has been estimated that transitioning to a low-carbon pathway (under a 2°C scenario) would cost the region 1.4 to 1.8 per cent of GDP by 2050 and 2 per cent of GDP by 2100. This is lower than the costs of inaction; without action, the region could see GDP decrease by as much as 3.3 per cent by 2050 and 10 per cent by 2100.

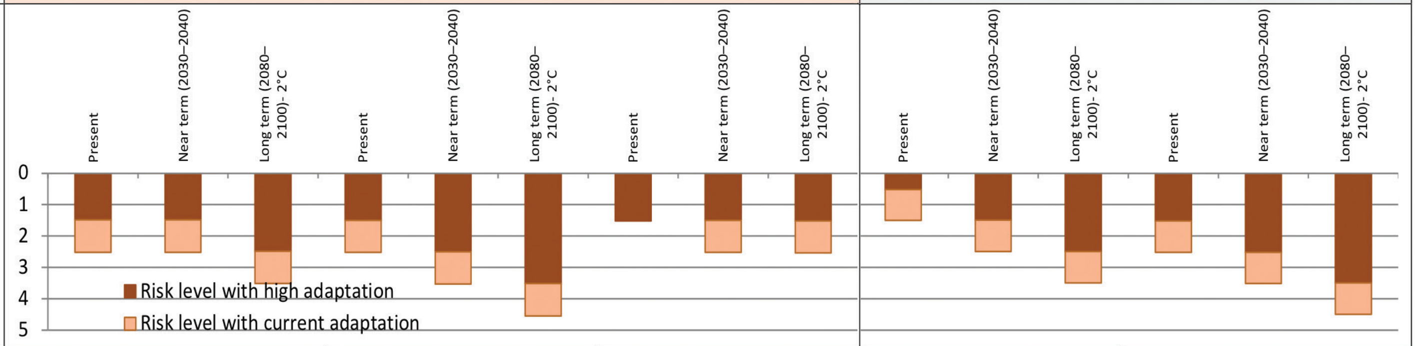
The costs are modest partly because of the steep drop in the cost of green technologies, but also because of the potential for large efficiency savings and significant co-benefits.[34] There are four priority areas to promote climate change adaptation and improve resilience: implement effective carbon pricing; phase out fossil fuel subsidies; encourage renewable energy and energy efficiency; and expand climate finance. All these efforts can take advantage of new tools that are becoming available. These are the subject of Chapter 6.

CHAPTER 4

Table 4-3

Key areas of climate risk and potential for adaptation

Risk Level



Region	Climatic drivers	Key risk	Adaptation issues & prospects
Asia	• Extreme precipitation • Damaging cyclone • Sea level	Increased riverine, coastal, and urban flooding leading to widespread damage to infrastructure, livelihoods, and settlements in Asia (medium confidence)	• Exposure reduction via structural and non-structural measures, effective land-use planning, and selective relocation • Reduction in the vulnerability of lifeline infrastructure and services (e.g., water, energy, waste management, food, biomass, mobility, local ecosystems, e-communications) • Construction of monitoring and early warning systems; Measures to identify exposed areas, assist vulnerable areas and households, and diversify livelihoods • Economic diversification
Asia	• Warming trend - heatwaves • Extreme temperature	Increased risk of heat-related mortality (high confidence)	• Heat health warning systems • Urban planning to reduce heat islands; Improvement of the built environment; Development of sustainable cities • New work practices to avoid heat stress among outdoor workers
Asia	• Warming trend - drought • Extreme temperature • Drying trend	Increased risk of drought-related water and food shortage causing malnutrition (high confidence)	• Disaster preparedness including early warning systems and local coping strategies • Adaptive/integrated water resource management • Water infrastructure and reservoir development • Diversification of water sources including water re-use • More efficient use of water (e.g., improved agricultural practices, irrigation management, and resilient agriculture)
Pacific Islands	• Drying trend • Damaging cyclone • Ocean acidification • Sea level • Extreme precipitation	Loss of livelihoods, coastal settlements, infrastructure, ecosystem services, and economic stability (high confidence)	• Significant potential exists for adaptation in islands, but additional external resources and technologies will enhance response. • Maintenance and enhancement of ecosystem functions and services and of water and food security • Efficacy of traditional community coping strategies is expected to be substantially reduced in the future.
Pacific Islands	• Damaging cyclone • Sea level	The interaction of rising global mean sea level in the 21st century with high-water-level events will threaten low-lying coastal areas (high confidence)	• Evolutionary adaptation potential of fish and invertebrate species to warming is limited as indicated by their changes in distribution to maintain temperatures. • Human adaptation options: Large-scale translocation of industrial fishing activities following the regional decreases (low latitude) vs. possibly transient increases (high latitude) in catch potential; Flexible management that can react to variability and change; Improvement of fish resilience to thermal stress by reducing other stressors such as pollution and eutrophication; Expansion of sustainable aquaculture and the development of alternative livelihoods in some regions.

ENDNOTES

1 IPCC, 2012.
2 UNISDR, 2015a.
3 IPCC, 2014b
4 National Academies of Sciences, Engineering, and Medicine, 2016.
5 ESCAP, 2016b.
6 ADB, 2015.
7 ESCAP & RIMES, 2017.
8 IPCC, 2012.
9 Loo et al., 2015.
10 Sabeerali et al., 2017.
11 Cai et al., 2014.
12 Cho, 2016.
13 Campbell-Lendrum et al., 2005.
14 Reliefweb, 2015.
15 NOAA, 2015.
16 Representative Concentration Pathways (RCPs) are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its fifth Assessment Report (AR5) in 2014. The RCPs are consistent with a wide range of possible changes in future anthropogenic greenhouse gas (GHG) emissions. RCP 4.5 assumes that global annual GHG emissions (measured in CO_2-equivalents) peak around 2040, then decline. In RCP 8.5, emissions continue to rise throughout the 21st century.
17 Ying et al., 2012.
18 Ibid.
19 Dai, 2011.
20 PDSI is a measurement of dryness based on recent precipitation and temperature. The index has proven most effective in determining long-term drought, a matter of several months.
21 Souza et al., 2015.
22 Gopal, 2013.
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