CHAPTER 4

The scaled-up contours of a regional resilience response

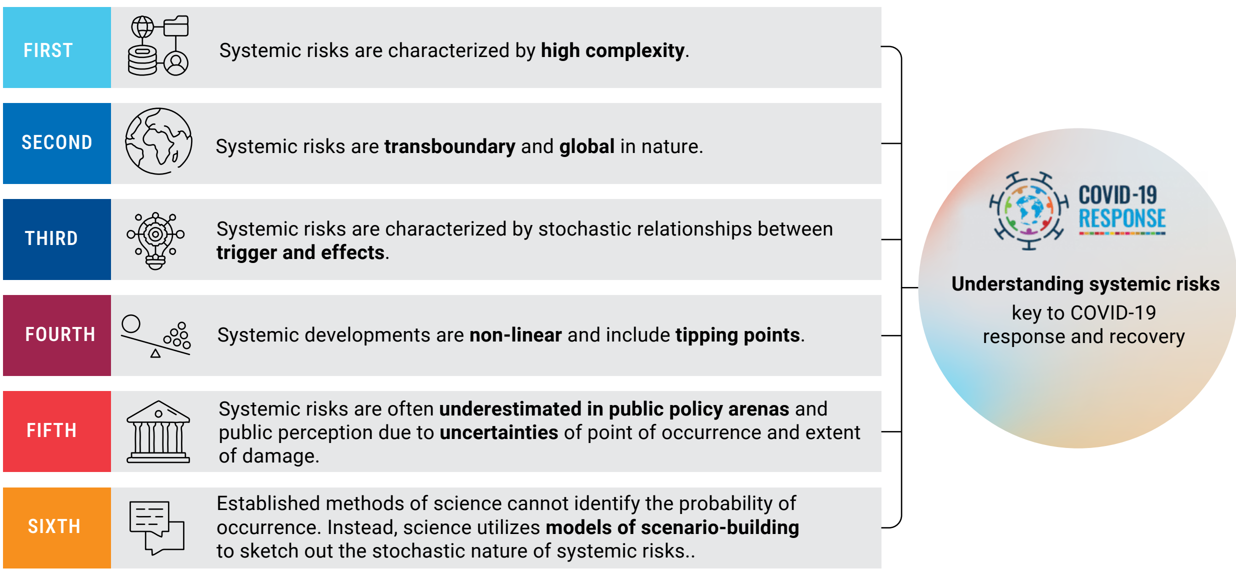
The COVID-19 pandemic has served as a wake-up call, a stark reminder that humanity will always remain vulnerable to powerful natural forces. How should countries in Asia and the Pacific respond? This report suggests four national priority action areas; envisage risk scenarios, investment in health and social protection, capitalize on frontier technologies, and target fiscal spending. It also highlights the importance of regional and subregional coordination and action.

Traditionally, risk is envisaged as the adverse effects resulting from the interaction between hazards, whether natural or caused by humans, with vulnerability, exposure, and adaptive capacity being included in risk assessments. But such traditional risk analyses do not take into account how, in our increasingly complex and fragile planet, all these hazards and impacts interconnect and overlap, with multiple cascading effects that spread across social, economic, and environmental domains, with potentially catastrophic outcomes.[120]

Indeed, most aspects of human societies can now better be considered in terms of systems. As the *Global Assessment Report on Disaster Risk Reduction*, 2019, notes, "In today's globalized economic system, networks of communication and trade have generated highly interdependent social, technical and biological systems." [121]

The COVID-19 pandemic is a dramatic example of a systemic risk, a hazard whose impacts have reverberated around the world bringing other systems close to collapse, with most of them being far removed from the biohazard origin.[122] Climate change too represents a huge risk to many systems, since it can cause extreme weather events and variations in climate that can trigger food and water shortages, forced migration, epidemics, and loss of biodiversity, all of which can even cascade into armed conflict. Characterized by deep uncertainties, systemic risks are both complex and heterogeneous and very unpredictable. They can be considered to have six unique characteristics (Figure 4-1).

FIGURE 4-1 **Six characteristics of systemic risk**



Source: Adapted from Ortwin Renn and others, "Systemic risks from different perspectives", *Risk Analysis*, vol. 0, No. 0, (2020). Available at https://onlinelibrary.wiley.com/doi/epdf/10.1111/risa.13657

120 *Global Assessment Report on Disaster Risk Reduction 2019* (United Nations publication, 2019). Available at https://www.undrr.org/publication/global-assessment-report-disaster-risk-reduction-2019#:~:text=The%202019%20Global%20Assessment%20Report,the%20global%20disaster%20risk%20landscape.

121 Ibid.

122 The Global Assessment Report 2019 defines a 'systemic risk' as a risk that is endogenous to, or embedded in, a system that is not itself considered to be a risk and is therefore not generally tracked or managed, but which is understood through system analysis to have a latent or cumulative risk potential to negatively impact overall system performance when some characteristics of the system change.

Preparing for pandemics

The first global agreement of its kind to include biological hazards and the need to prepare for pandemics is the Sendai Framework for Disaster Risk Reduction (Box 4-1). Nevertheless, most countries failed to include pandemic response and preparedness in their legal, regulatory and policy frameworks.[123] As a result, the response to the pandemic has been erratic, ad hoc and inadequate.[124]

The World Health Organization had already advised governments to prepare health national adaptation plans (HNAPs) to inform their national adaptation plans and programmes of action. Although progress in this direction has been mixed, nevertheless, 43 countries in the region have climate strategies that include the health sector. Figure 4-2 presents an overview of current national strategies that include health. Only three countries have a formal HNAP; Bangladesh, Nepal and Sri Lanka, and an HNAP is drafted and awaiting finalization in an additional four: Bhutan, India, Indonesia and Thailand. These plans will be submitted as part of the formal national adaptation plans (NAPs) under the Paris Agreement. In addition, 13 Pacific countries, 5 South-East Asian countries, and the Maldives have developed national strategies to address health and climate change. For most Pacific countries, these have been systematically drafted and follow the same structure, and are called the national climate change and health action plans (NCCHAPs). Additionally, 24 countries have submitted nationally determined contributions (NDCs) and intended nationally determined contributions (INDCs) that include health sector adaptation, 16 countries have submitted National Adaptation Plans (NAPs)/ National Adaptation Programmes of Action (NAPAs) which include health strategies, and 4 countries have submitted national communications to the United Nations Framework Convention on Climate Change (UNFCCC) that include health adaptation measures.

National adaption strategies have identified nine principal areas for health-care adaptation: malnutrition and food security; disease surveillance and control; health services and assessment; awareness-raising and behaviour change; health infrastructure resilience; governance and coordination; research and knowledge; capacity of health-care sector workers; and environmental impacts on health. These should ensure that the health sector is not only well integrated into climate adaptation, but also safeguards the lives, health and well-being of the people most impacted by natural hazards.

For their health sectors, 34 countries, across the region, have identified disease surveillance and control as a priority, while 26 countries have emphasized research and knowledge, 23 countries have highlighted awareness-raising and behaviour change, 18 countries have noted governance and coordination, 14 countries have identified health infrastructure resilience, and 12 countries have emphasized nutrition and food security as priorities. No country in the region identifies all components as priority areas, but 22 countries do note at least five of them as priorities.

In this respect, the countries performing best in their adaptation plans and strategies are those in the Pacific, where every country covers at least five health priorities. Countries in South-East Asia, and in South and South-West Asia also have disease surveillance and control as their highest priority; since, under both climate change scenarios, their people are at serious risk from natural and biological hazards.

123 *Official Records of the General Assembly, Seventy-fifth Session* (A/75/226).

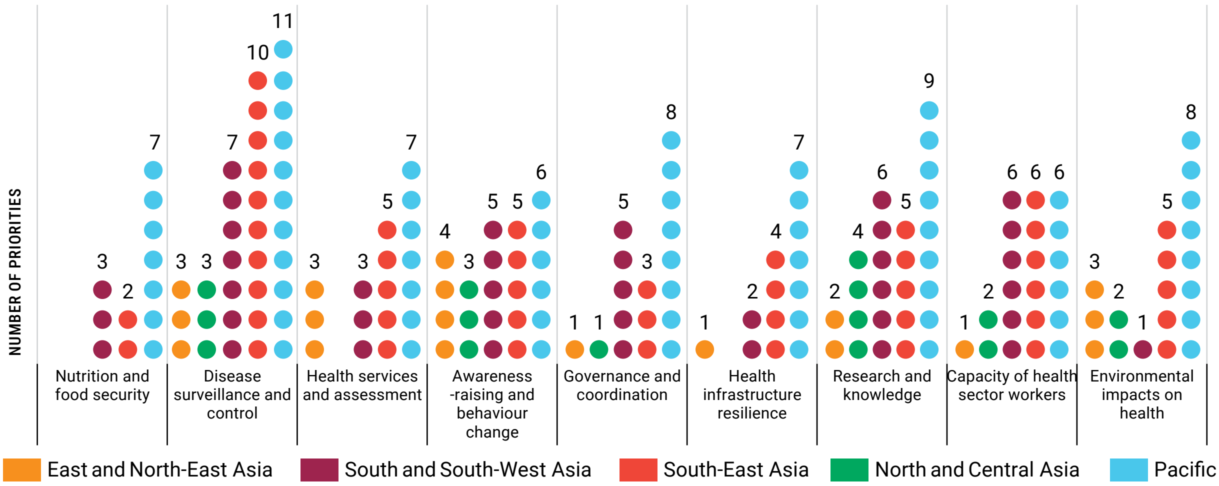
124 *Review of COVID-19 Disaster Risk Governance in Asia-Pacific: Towards MultiHazard and Multi-Sectoral Disaster Risk Reduction* (United Nations publication, 2020). Available at https://www.undrr.org/publication/review-covid-19-disaster-risk-governance-asia-pacific-towards-multi-hazard-and-multi.

The COVID-19 stimulus efforts offered a golden opportunity to simultaneously address disaster, climate and health and the underlying risk drivers. ESCAP has analysed these measures and found some emphasis on green priorities, 111 'sweet-spot' measures that addressed both economic recovery and environmental protection. These measures covered such issues as energy, surface transport, air travel and tourism, land-use, water and waste, and disaster risk management (DRM). However, these measures were not generally part of coherent national plans for building back better. More than half were unplanned, and they were outnumbered by those that purely focused on the economy.[125] In many countries, the financial commitment for the health sector has been less than 10 per cent of the total stimulus spending. In addition, there have been no specific forward-looking allocations for climate adaptation or environmental protection.[126]

FIGURE 4-2 National adaptation strategies that include the health sector, by subregion

Source: ESCAP analysis of national adaptation strategies.
Note: Includes strategies that are under development.
Note: HNAP = health national adaptation plans; NAP = National Adaptation Plans; NAPA = National Adaptation Programmes of Action; NDC = nationally determined contributions; INDC = intended nationally determined contributions;

FIGURE 4-3 Priorities for the health sector identified by countries in national adaptation strategies, by subregion



Source: ESCAP analysis of national adaptation strategies.
Note: The number of countries with available information is 5 for East and North-East Asia, 4 for North and Central Asia, 8 for South and South-West Asia, 11 for South-East Asia and 12 for the Pacific.

125 United Nations Economic and Social Commission of Asia and the Pacific (ESCAP), *Are countries in the Asia Pacific region initiating a 'green recovery'? What more can be done?* Policy Brief, December 2020a. Available at https://www.unescap.org/sites/default/d8files/knowledge-products/UNESCAP%20Green%20Recovery%20Policy%20Brief.pdf

126 United Nations Economic and Social Commission of Asia and the Pacific (ESCAP), *Policy responses to COVID-19: Combating COVID-19 in Asia and the Pacific: Measures, lessons and the way forward*, Policy Brief, 15 May 2020b. Available at https://www.unescap.org/resources/policy-responses-covid-19-combating-covid-19-asia-and-pacific-measures-lessons-and-way (accessed on 26 March 2021).

BOX 4-1 The Sendai Framework and the Bangkok Principles

Over recent decades, the world has gained a better understanding of disaster risk. A major impetus in 2005 was the *Hyogo Framework for Action (2005–2015): Building the Resilience of Nations and Communities to Disasters*, which introduced a model for understanding risk in terms of hazard, vulnerability and exposure.

This was succeeded, in 2015, by the *Sendai Framework for Disaster Risk Reduction 2015–2030*, which, rather than managing disasters, put more emphasis on managing risk, and underlined the importance of involving many stakeholders at local, national, regional and global levels.[a] It also broadened the scope of disaster risk reduction to focus on both natural and man-made hazards and the related environmental, technological and biological hazards and risks.[b] The Sendai Framework points out that the nature and scale of risk has changed to such a degree that it cannot be addressed by established risk management institutions and approaches. For addressing the root causes of the risks, it presents a systems approach from global, to national, to local scale.

In 2016, implementation of the Sendai Framework was reinforced by the 'Bangkok Principles', which emerged from the International Conference on the Implementation of the Health Aspects of the Sendai Framework for Disaster Risk Reduction 2015–2030.[c] The Bangkok Principles recommend the measures to prevent, and/or reduce the risk of, health emergencies, such as pandemics. The seven recommendations cover:

1 *Integration* – Promote systematic integration of health into national and sub-national disaster risk reduction policies and plans, and include emergency and disaster risk management programmes in national and sub-national health strategies.

2 *Cooperation* – Enhance cooperation between health authorities and other relevant stakeholders to strengthen country capacity for disaster risk management for health, implement the International Health Regulations (2005), and build resilient health systems.

3 *Investment* – Stimulate people-centred public and private investment in emergency and disaster risk reduction, including in health facilities and infrastructure.

4 *Training* – Integrate disaster risk reduction into health education and training, and strengthen capacity building of health workers in disaster risk reduction.

5 *Data* – Incorporate disaster-related mortality, morbidity and disability data into multi-hazard early warning systems, health indicators and national risk assessments

6 *Collaboration* – Advocate for, and support, cross-sectoral, transboundary collaboration including information sharing, and science and technology for all hazards, including biological hazards.

7 *Policies* – Promote coherence and further development of local and national policies and strategies, legal frameworks, regulations, and institutional arrangements.

The principles point out that health emergencies have many commonalities with other natural disasters, since they need to be addressed with assessments, surveillance and early warning systems, resilient infrastructure, and coordinated incident management that extends across national borders. The Bangkok Principles emphasize the need for coordination, calling for an interoperable, multi-sectoral approach to promote systematic cooperation that integrates health with other disaster risk management approaches.[d]

a United Nations, *Sendai Framework for Disaster Risk Reduction*, 2015. Available at https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf

b Marc Gordon and Scott Williams, "Shifting the Paradigm: Introducing Global Risk Assessment Framework (GRAF)", United Nations Office for Disaster Risk Reduction, 17 April 2020. Available at https://www.preventionweb.net/news/view/71352

c United Nations Office for Disaster Risk Reduction, World Health Organization and Royal Thai Government, The International Conference on the Implementation of the Health Aspects of the Sendai Framework for Disaster Risk Reduction 2015–2030, Bangkok, Thailand, 10–11 March 2016. Available at https://www.unisdr.org/conferences/2016/health

d Ibid.

National policy actions to address the new riskscape

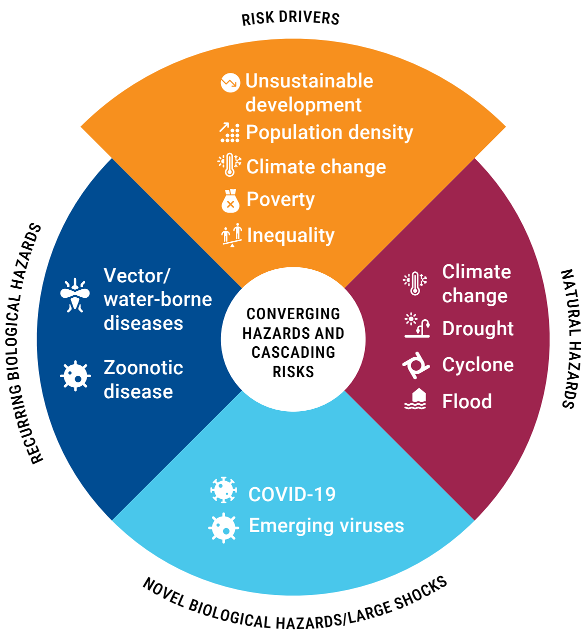
Faced with ongoing biological and other natural hazards, and the increasing impacts of climate change, how can governments in the region best respond? This report suggests four priorities for action: envisage risk scenarios; invest in health and social protection; apply emerging technologies; and target additional fiscal spending.

1. Envisage risk scenarios

Disaster risk management and early warning systems need to capture systemic risks. Given the correlations and dependencies of multiple risks and actors, the best approach is to envisage a series of scenarios, each with different interlinkages and relationships (Figure 4-4). Planners can develop composite risk matrices to identify and stratify vulnerable populations, and their varying needs and capacities, so as to arrive at comprehensive risk assessments and take targeted actions.

In 2020, ESCAP developed a prototype of composite matrices that placed districts or areas into appropriate risk zones, incorporating risks from endemic, natural, and biological hazards. The methodology, piloted for Bangladesh and India, integrated short-term, medium-term, and long-term risk data from diverse sources and highlighted the states that were most exposed to cascading disasters, including monsoon floods that occurred amid COVID-19, along with the endemic risk drivers of poverty, inequality, and population density.

FIGURE 4-4 **Planning scenarios for the intersection of converging hazards and cascading risks**



Source: United Nations, Economic and Social Commission of Asia and the Pacific, "Weaving a stronger fabric: Managing cascading risks for climate resilience", Policy Brief, 26 January 2021b. Available at https://www.unescap.org/kp/2021/weaving-stronger-fabric-managing-cascading-risks-climate-resilience

BOX 4-2 **Building back better after the Indian Ocean tsunami**

The 2004 Indian Ocean tsunami transformed disaster management worldwide by introducing the paradigm: *Build back better*. This had three key lessons:

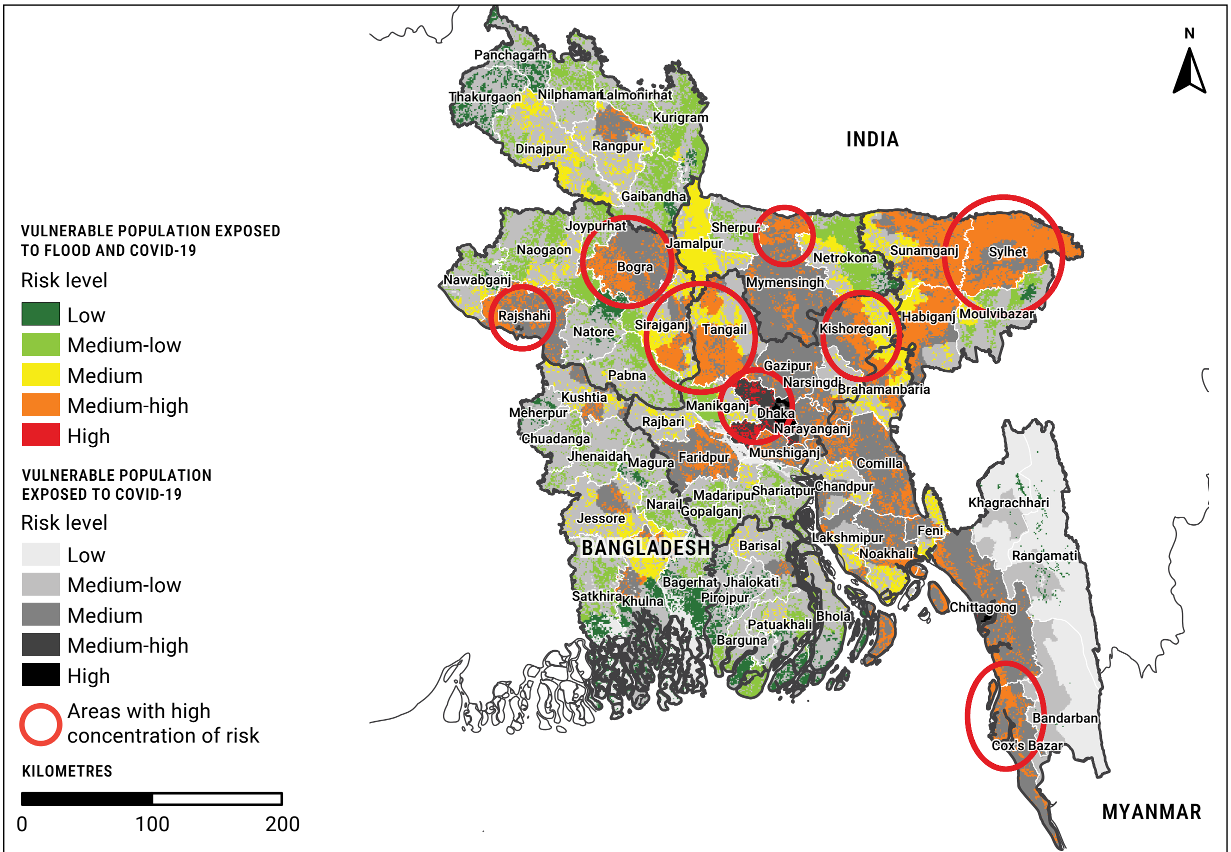
1 *Prepare better for future crises* – In this case, for example, through early warnings of tsunamis. It is estimated that over the next 100 years the Indian Ocean Tsunami Warning system will, on average, help save 1,000 lives per year.[a]

2 *Build dedicated institutions* – These include national disaster management authorities, ministries, and an exclusive department for disaster-related governance.

3 *Empower communities* – Communities should be at the centre of the recovery and reconstruction and be in a strong position to respond to disasters themselves.

a *Asia-Pacific Disaster Report 2015: Disasters Without Borders*, (United Nations publication, 2015). Available at https://www.unescap.org/publications/asia-pacific-disaster-report-2015-disasters-without-borders

FIGURE 4-5 **Vulnerable populations in Bangladesh**



Sources: ESCAP calculations based on UN WPP-Adjusted Population density 2020, v4.11; Sub-National Human Development Index (SHDI) 2018; Institute of Epidemiology, Disease Control and Research COVID-19 Cases, 9 August 2020; and UNOSAT-UNITAR analysis on NOAA-20 (VIIRS) Imagery, 20 June - 19 July 2020.
Map source:Coastline data from UNmap, 2020.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

The matrix for Bangladesh, for example, showed that, in 2020, 15 districts with a population of almost 12 million were at the highest risk from cascading disasters (Figure 4-5). The 12 million people who faced the highest risk were served by around 610 hospitals, almost 40 per cent of which were exposed to heavy floods in 2020. The matrix further predicted that immediate intervention would be needed for refugee settlements in Cox's Bazaar. Subsequently, the Government responded to these pressures and relocated many refugee camp families to a permanent settlement and, in partnership with local and international organizations, took the necessary precautions and ensured surveillance that helped contain the spread of the virus within the camps.

2. Capitalize on frontier technologies

In their race to control the COVID-19 epidemic and protect their people, countries have increasingly invested in 'frontier technologies', taking advantage of scientific advances and adapting innovation to local exigencies. The effectiveness has differed according to the spread of the infection and the timing, as the virus has typically been transmitted in waves, or centred around specific location clusters. Nevertheless, during the early stages of the pandemic, countries with past experience of the severe acute respiratory syndrome (SARS) appeared to be better prepared, basing their responses on surveillance, testing, contact tracing, and strict quarantine.

Throughout the course of the pandemic, artificial intelligence and the manipulation of big data have enabled better understanding of the transmission mechanisms. Advanced modelling techniques have been used for early detection, rapid diagnostics, and the prevention of virus spread, as well as for managing critical supplies and delivering equipment. While such technologies have been used effectively in Australia, China, New Zealand, the Republic of Korea, and Singapore, other less technologically advanced, middle-income countries have also been able to effectively use such technologies.

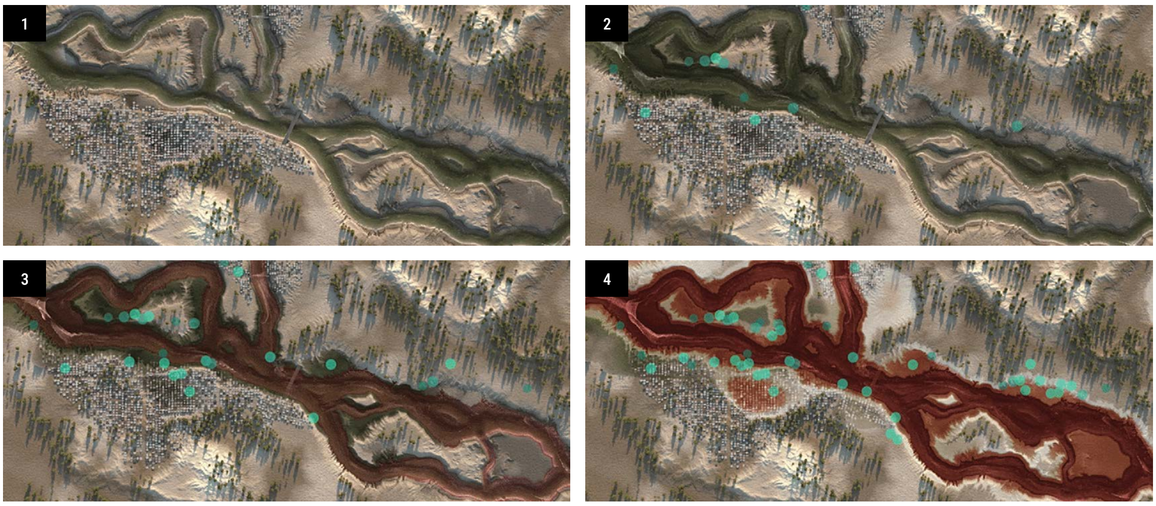
BOX 4-3

AI-based next generation flood forecasting

Building on the work on flood forecasting in previous years, Google extended, just in time for the 2020 monsoon season, its AI-based next generation flood forecasting work in India and Bangladesh. Using Google AI technology to optimize the targeting of every alert the two Governments send out, it is estimated that over 200 million people across more than 250,000 square kilometres will have benefitted from the early warning system. The new forecasting model allows to double the lead time of many of the alerts in the past by providing more notice to governments and giving tens of millions of people an extra day or so to prepare. It also provides people with information about flood depth; when and how much the flood waters are likely to rise. The information is provided through mobile phones in different formats, so that people can both read their alerts and see them presented visually and in their local languages.

An AI-enabled new approach for inundation modelling, called a *morphological inundation model*, which combines physics-based modelling with machine learning (ML) has been introduced to create more accurate and scalable inundation models in real-world settings. Additionally, a new *alert-targeting model* allows identifying areas at risk of flooding at unprecedented scale using end-to-end machine learning models and data that is publicly available globally. The next generation of flood forecasting systems, called Hydronet, presents a new architecture specially built for hydrologic modelling across multiple basins, while still optimizing for accuracy at each location. This is an important technological breakthrough that will enhance predictive capacity and overall outreach of flood forecasting.

FIGURE A **Inundation modelling estimates what areas will be flooded and how deep the water will be**



Source: Sella Nevo, "The technology behind our recent improvements in flood forecasting", Google AI Blog, 3 September 2020. Available at https://ai.googleblog.com/2020/09/the-technology-behind-our-recent.html.

New technologies need to be combined with social organization and mobilization, that is, promoting social distancing and hygiene combined with efficient test-isolate-treat regimes. In 2021, these techniques were difficult to apply in densely populated urban slums of many countries in the region. Nevertheless, frontier technologies were able to support official actions and local community surveillance by offering 'ears to the ground', for example, checking for unintended consequences of official action and taking corrective steps. The value of community action empowered by new technologies was also demonstrated in the early stages of the pandemic in Asia's largest slum, Dharavi in Mumbai. The Dharavi model takes a "chasing the virus" approach, through micro-mapping, robust surveillance, public-private partnerships, community engagement, and proactive leadership, that are key components of effective disaster management. The model was successful during the first wave of the virus in 2020.

In the complex risk environments during the pandemic, social media has helped improve communication between health experts, governments, and at-risk communities. In Indonesia, for example, particularly in rural and sub-urban areas, religious leaders have used social media to raise awareness about the risks of COVID-19 among their followers. Social media also helped authorities transmit real-time and actionable information. At the global level, this is available through the WHO's Situation Dashboard whose Arc Geographic Information System (ArcGIS) platform has provided the latest location-specific updates on the outbreak, including the numbers of infected people and deaths. The dashboard has also been adopted and modified at the country level in combination with relevant surveillance management systems.

Government agencies, across Asia and the Pacific, have also increasingly invested in the collection of big data and the production of integrated risk mapping of multiple hazards. This has proven to be effective in previous complex and dynamic disasters. With some adaptation, governments were then able to highlight the incidence of COVID-19 and predict the spread of the virus, thereby revealing the connections between cases and clusters of infections and identifying 'super-spreaders' or super-spreading events. With continued investments in these techniques, the ability of officials to make critical, risk-informed interventions, by imposing lockdowns in hotspots, for example, and insulating other provinces and cities from the spread of the virus, will increase in accuracy and timeliness. The resulting cluster-containment response strategies have proven effective in restricting the spread of COVID-19, especially within vulnerable communities.

3. Invest in health and social protection

Governments will want to select their own priorities for investing in health adaptation. In Asia and the Pacific, these include nutrition and food security, health infrastructure resilience, and governance and coordination. But, governments across the region will need to focus more on the health sector. India, for example, has announced a National Digital Health Mission (NDHM) as part of AatmaNirbhar Bharat Abhiyaan: A Campaign for Self-Reliant India. The NDHM aims to provide universal health cover, including digital services, to all citizens. This will involve gathering health-related data while ensuring confidentiality (Figure 4-6).[127] This system assigns a unique ID to each person and holds the individual's electronic medical records. It also holds registers of health facilities and doctors.[128] The pandemic has thus clearly demonstrated the value of digital health systems, though their legal and privacy issues need to be carefully addressed.

FIGURE 4-6 India's Digital Health Framework

1	Promoting medical research along with health data analytics.
2	Promoting the adoption of open standards by all the actors in national digital health ecosystem, for developing several digital health systems that span across the sector from wellness to disease management.
3	Creating and managing digital health data and the relevant infrastructure required.
4	Creating a system of individual patient digital health records which can be easily accessed by health professionals through patient consent.
5	Promoting and making use of the already existing health information systems.

Source: Adapted from Government of India, *National Digital Health Blueprint, Ministry of Health and Family Welfare*, 15 July 2019. Available at https://www.nhp.gov.in/NHPfiles/National_Digital_Health_Blueprint_Report_comments_invited.pdf

127 Government of India, *National Digital Health Blueprint, Ministry of Health and Family Welfare*, 15 July 2019. Available at https://www.nhp.gov.in/NHPfiles/National_Digital_Health_Blueprint_Report_comments_invited.pdf

128 Make in India, "National Digital Health Mission". Available at https://www.makeinindia.com/national-digital-health-mission.

The shock of the pandemic has also highlighted the importance of social protection that encompasses disaster preparedness. Over the years, governments have tried to ensure that social protection is more shock-responsive. But the scale of the economic impact of the pandemic, has brought to the fore the need for social protection that is not just shock-responsive but shock-prepared.

The measures needed to offer social protection that is shock-prepared include: (1) Using emerging technologies to support resilience, and ensuring that routine social protection programming is based on a solid understanding of the risks, shocks and stressors, including cascading hazards; (2) Preparing to scale up existing programmes or activating new emergency programmes to accommodate populations and needs; and (3) Aligning existing social protection programmes with scalable measures for disaster preparedness.

Such measures require a comprehensive portfolio of investments by promoting a culture of prevention that builds inclusiveness and resilience. The aim of building on existing achievements, should be on universal social protection throughout people's life cycles. Equally important are risk-informed investments in health and education infrastructure and service delivery.

For example, India's pioneering biometric ID system, Aadhaar, was used to digitally transfer $1.5 billion into the bank accounts of 30 million people, including many migrant workers who were forced to return to their villages when the country entered a sudden lockdown.[129] However, this does require the system to have been largely set up before the crisis. In this case, since 1 billion accounts were linked to people's Aadhaar identity numbers, the Government was able to transfer funds to those in need with remarkable efficiency. An Aadhaar-based biometric fingerprint is also mandatory for the drive to rapidly vaccinate India's 1.3 billion people.

During a pandemic, digital transfers have the further advantage of limiting personal contact and crowding while people collect their payments. Countries, such as India and Thailand, that have national IDs of citizens linked to their bank accounts, can implement government-to-person (G2P) rapid disbursements while observing social distancing.

4. Target additional fiscal spending

Government will need to boost resilience through targeted more forward-looking fiscal spending. How much will this cost? Prior to the pandemic there were a number of estimates of the costs of building greater resilience to climate change. However, the costs of protection from biological hazards must also be added to these cost estimates. Table 4-1 presents an overview of the earlier studies.

Previous studies have also explored how climate adaptation costs break down across different sectors. One clear finding from these studies is the importance of infrastructure spending. As indicated in Figure 4-7, studies by the UNFCCC and the IPCC report, *Economics of Adaptation to Climate Change*, both find that a high proportion of the costs of adaptation are for infrastructure, followed by measures in coastal zones, water supply and flood protection.

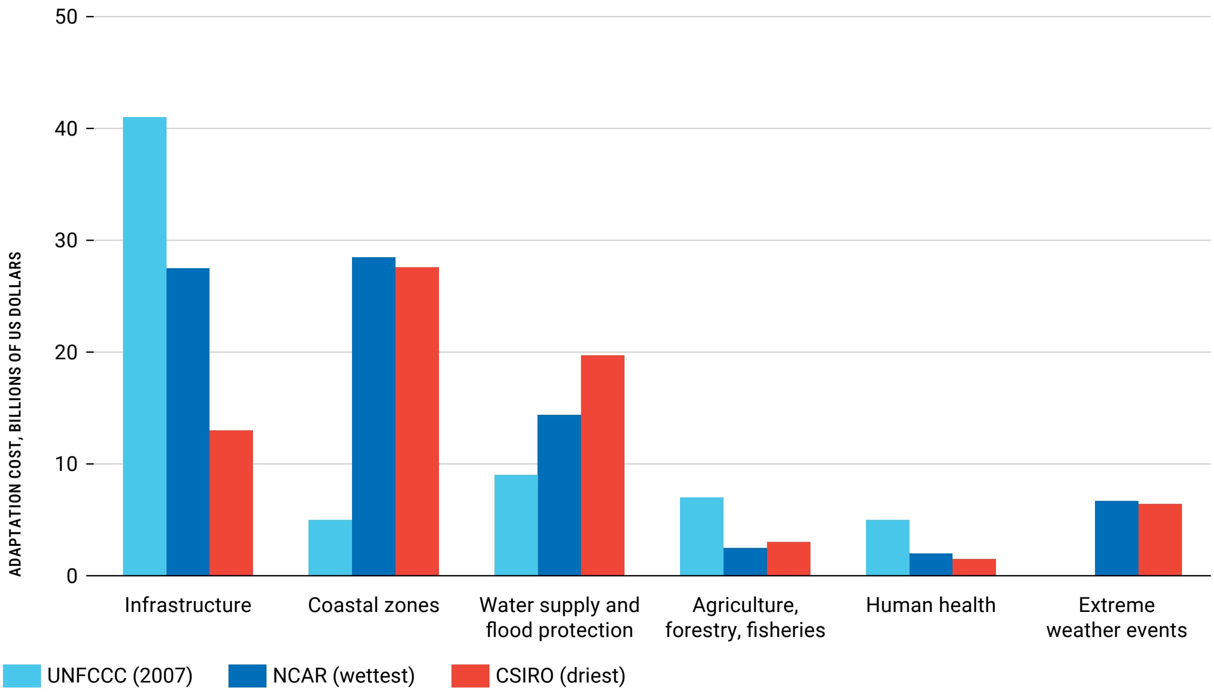
Investing in infrastructure resilience is particularly important in Asia and the Pacific, where critical infrastructure is often located in multi-hazard hotspots. 28 per cent of energy power plants, 34 per cent of ICT fibre-optic cables, 42 per cent of road infrastructure, 32 per cent of airports and 13 per cent of ports are located in multi-hazard hotspots.

129 "Covid-19 spurs national plans to give citizens digital identities", *The Economist* (7 December 2020). Available at https://www.economist.com/international/2020/12/07/covid-19-spurs-national-plans-to-give-citizens-digital-identities.

TABLE 4-1 Cost estimates for climate adaptation, infrastructure resilience and sustainable development

Study	Cost estimate	Scale
World Bank, Economics of Adaptation to Climate Change (2010)[130]	$70 - $100 billion a year for climate change adaptation	Global
World Bank, Economics of Adaptation to Climate Change (2010)	$17.9 - $25.7 billion	East Asia and the Pacific
Global Centre on Adaptation, State and Trends in Adaptation Report (2020)[131]	$300 billion a year by 2030 for climate change adaptation	Global
UNEP, Adaptation Finance Gap Report (2016)[132]	$280 - $500 billion a year by 2050 for climate change adaptation	Global, developing countries only
UNFCCC, Investment and Financial Flows to Address Climate Change (2007)[133]	$28 - $67 billion per year, up to 2030, for climate change adaptation	Global
Asian Development Bank, Meeting Asia's Infrastructure Needs (2017)[134]	$240 billion per year from 2016–2030 for climate-proofing infrastructure	45 developing member countries of ADB
ESCAP, Economic and Social Survey of Asia and the Pacific (2019)[135]	$182 billion per year up to 2030, for climate proofing infrastructure to meet the SDGs	Asia-Pacific region

FIGURE 4-7 Adaptation cost estimates by United Nations Framework Convention on Climate Change and the Intergovernmental Panel on Climate Change



Source: Adapted from Intergovernmental Panel on Climate Change, *AR5 Synthesis Report: Climate Change 2014* (Geneva, 2014).
Note: This figure compares the results from three models taken from UNFCCC and the IPCC report, *Economics of Adaptation to Climate Change*. From the IPCC report, NCAR and CSIRO are two models that present costs under a wetter or drier climate change scenario. CSIRO refers to the Commonwealth Scientific and Industrial Research Organization model; NCAR is the National Centre for Atmospheric Research model.

130 World Bank, *Economics of Adaptation to Climate Change: Synthesis Report* (Washington, D.C., World Bank, 2010).
131 Global Center on Adaptation, *State and Trends in Adaptation Report 2020*, vol. 1 (2020).
132 United Nations Environment Programme (UNEP), *Adaptation Finance Gap Report 2016* (Cophenhagen, 11 May 2016)
133 United Nations Framework Convention on Climate Change (UNFCCC), *Investment and Financial flows to Address Climate Change* (October 2007).
134 Asian Development Bank, *Meeting Asia's Infrastructure Needs* (Manila, February 2017).
135 *Economic and Social Survey of Asia and the Pacific 2019: Ambitions beyond Growth* (United Nations publication, 2019).

All studies emphasize the importance of infrastructure, but they vary significantly in indicating the total amount of investment required for strengthening resilience. Furthermore, none of these estimates have factored in the costs of addressing biological hazards. Based on methodologies in earlier studies, ESCAP has therefore used the calculations of the Average Annual Losses (AAL) for natural and biological hazards (Chapter 1), to estimate the full cost of adaptation under climate scenario RCP 8.5, for each country in Asia and the Pacific. Following a World Bank study, the cost of climate proofing, for example, is taken to be 20 per cent of the financial exposure to climate-related hazards.[136] The Pacific small island developing States are an exception where the exposure is taken to be 40 per cent, given the higher infrastructure losses during disasters.[137] Similarly, following a UNFCCC study, the health-related costs of adaptation are equivalent to one-third of health-related losses.[138] For financial exposure and total losses, the proxy used is the average annual loss.

On this basis, Table 4-2 presents the annual cost of adaptation for natural and other biological hazards under RCP 8.5. Even when biological hazards are added, the cost of adaptation under the most severe climate change scenario for the Asia-Pacific region is only one-fifth of the annualized losses from natural hazards for the region. The total cost is $270 billion, of which $68 billion is required for adapting to biological hazards. This is equivalent to 0.85 per cent of regional GDP for the total adaptation cost, and 0.22 per cent of GDP for the biological hazard adaption cost. Around 70 per cent of these costs are in East and North-East Asia at $190 billion. There are also clear differences between the costs of dealing with biological hazards and climate-related hazards. The greatest biological costs are in China.

TABLE 4-2 Annual adaptation cost under RCP 8.5 by subregion, billions of US dollars

Subregion	Climate-related hazard AAL (flood, tropical cyclone, drought)	Adaptation cost for climate-related hazards	Biological hazard AAL	Adaptation cost for biological hazards	Total climate adaptation cost
East and North-East Asia	640	130	180	61	190
North and Central Asia	9.2	1.8	0.66	0.22	2.1
South and South-West Asia	230	47	13	4.4	51
South-East Asia	102	20	5.9	2.0	22
Pacific	21	4.5	2.2	0.74	5.2
Total	1 000	200	200	68	270

These costs need to be considered alongside the capacities to pay. Figure 4-8 shows that the costs of adapting to climate change as a percentage of GDP varies from almost 1.4 per cent for the Pacific SIDS, to less than 1.0 per cent for South-East Asia, North and Central Asia, and the entire Pacific subregion. It also shows the variations investment in adaptation for biological hazards as a proportion of GDP. This additional new adaptation cost will be highest in East and North-East Asia, whereas in the Pacific SIDS the majority of investment should still go toward adapting to climate-related hazards.

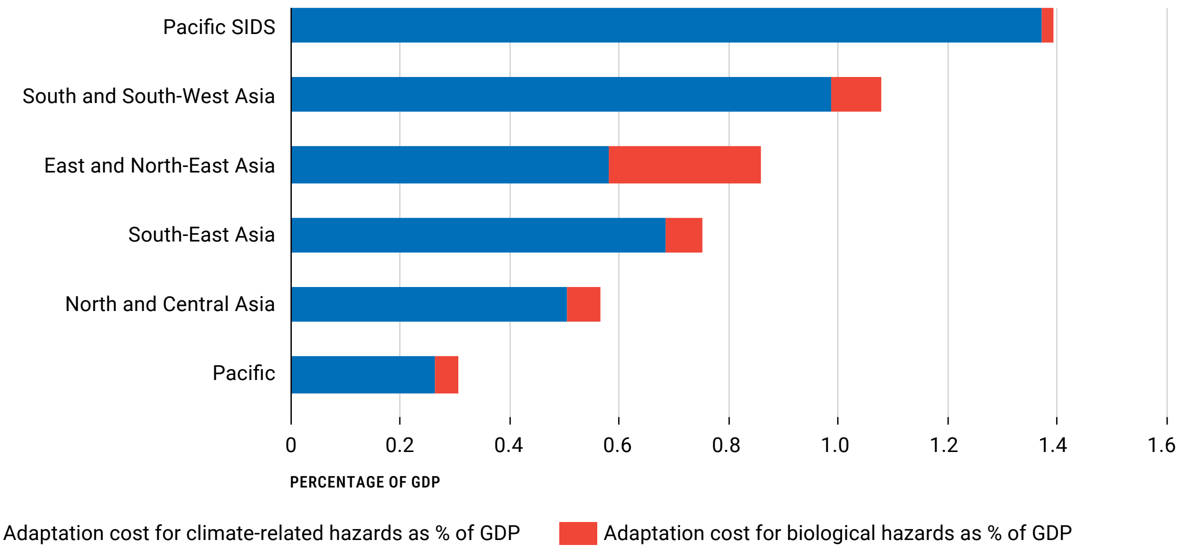
136 World Bank, *An Investment Framework for Clean Energy and Development* (Washington, D.C., World Bank, 2006).

137 *Economic and Social Survey of Asia and the Pacific 2019: Ambitions beyond Growth* (United Nations publication, 2019).

138 Brian Lipinski and Heather McGray, "Summary of studies estimating the cost of climate change adaptation in the developing world", World Resources Institute (WRI), January 2010. Available at https://pdf.wri.org/cost_of_adaptation_in_the_developing_world.pdf

Figure 4-8 and Figure 4-9 show how the results break down for individual Pacific SIDS, and for the least developed countries (LDCs), where economic assets are very exposed to natural hazards. Vanuatu has the region's highest cost at more than 8 per cent of GDP. But the costs are also high in Tonga, Micronesia and Palau. For each of these countries, the highest costs are for adapting to climate-related hazards. Of the LDCs, Vanuatu stands out as having the highest cost, but all except Timor-Leste have an adaptation cost that exceeds 1 per cent of GDP.

FIGURE 4-8 **Subregional adaptation costs for climate-related hazards and biological hazards, percentage of GDP**



Source: ESCAP calculations based on the Asia-Pacific SDG Gateway. Available at https://data.unescap.org/home.
Note: Pacific SIDS = Pacific small island developing States.

Given these new adaptation cost estimates, governments need to revise their own calculations and correspondingly modify their nationally determined contributions (NDCs) and intended national determined contributions (INDCs). Table 4-3 compares new estimates with the submitted NDCs and INDCs, which include cost estimates for climate change adaptation, for the 11 Asia-Pacific countries. The data indicates that Bangladesh, Cambodia, the Lao People's Democratic Republic, Solomon Islands and Vanuatu would all need to increase their estimates. The analysis is limited, but does suggest that a number of governments will need to increase their fiscal spending.

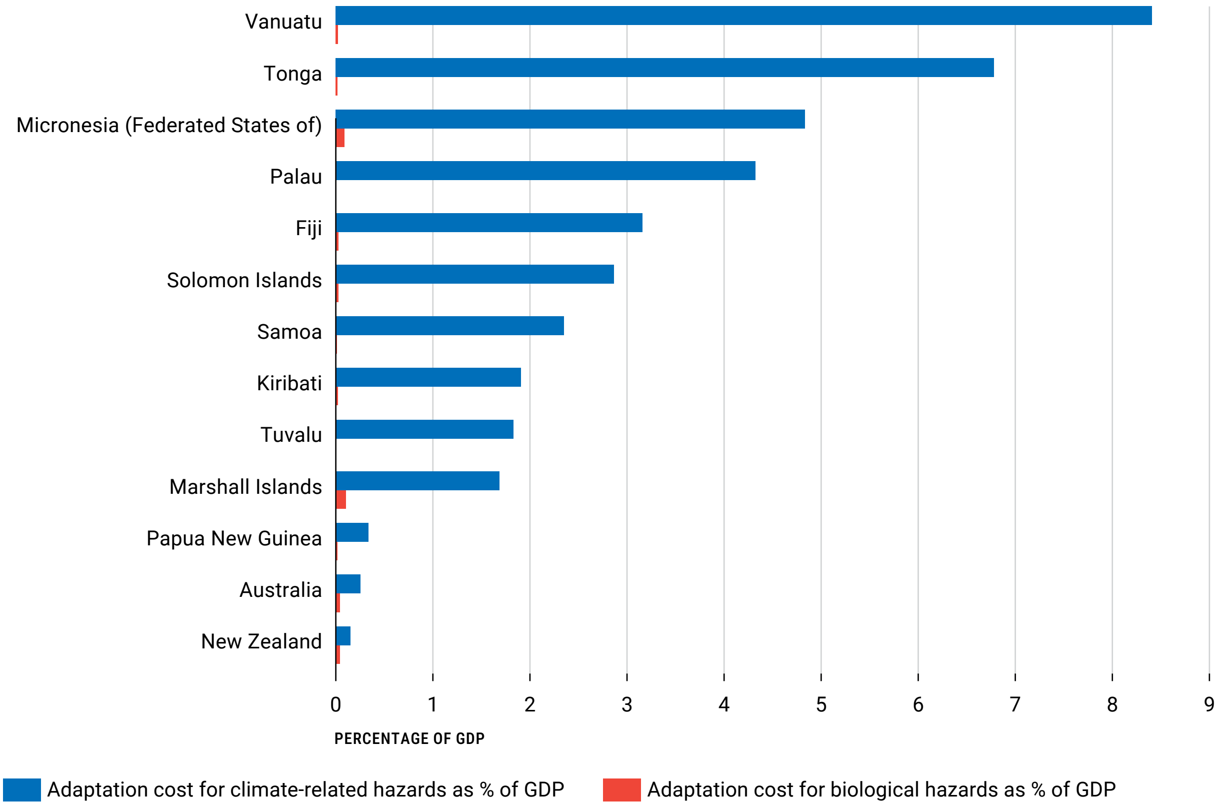
BOX 4-4 **The Pacific Disaster Risk Financing and Insurance Program**

To build financial resilience to disasters in Pacific island States, the Pacific Disaster Risk Financing and Insurance Program implements market-based, sovereign, catastrophe risk insurance solutions. These instruments cover liquidity during tropical cyclones, earthquakes and tsunamis. In addition, the Program provides technical assistance on public finance management of natural disasters, especially on post-disaster budget mobilization and execution.

This is a joint initiative of the World Bank Group, and the Secretariat of the Pacific Community with funding support from the Government of Japan. A milestone achievement by the Program was the catastrophe risk insurance received by Tonga following tropical Cyclone Ian in January 2014. Within two weeks of the event, Tonga received $1.27 million from the insurance policy. The amount was equivalent to nearly half of the Tonga National Reserve Funds, providing substantial support for disaster recovery.[a]

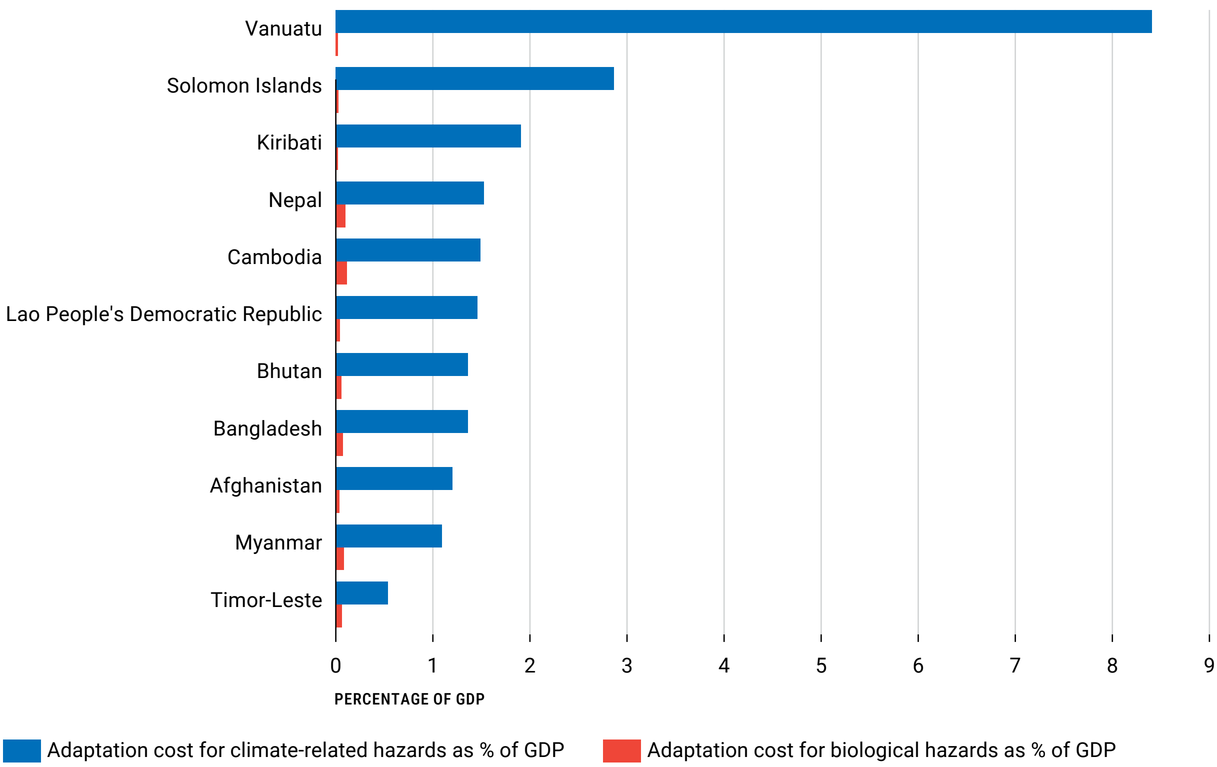
a World Bank Group and others, Pacific Catastrophe Risk Financing and Insurance Program. Available at https://www.gfdrr.org/sites/default/files/publication/PCRAFI_Program%20Pager_FINAL%20VERSION.pdf

FIGURE 4-9 **Adaptation costs under RCP 8.5 for countries in the Pacific, as a percentage of GDP**



Source: ESCAP calculations based on the Asia-Pacific SDG Gateway. Available at https://data.unescap.org/home.

FIGURE 4-10 **Adaptation costs under RCP 8.5 for the Least Developed Countries, percentage of GDP**



Source: ESCAP calculations based on the Asia-Pacific SDG Gateway. Available at https://data.unescap.org/home.

TABLE 4-3 **Estimated adaption costs compared with intended national determined contributions (INDCs)**

Country	Adaptation cost per year in INDCs, billions of US dollars	Adaptation cost per year in ESCAP analysis, billions of US dollars
Afghanistan	1.08	0.25
Bangladesh	2.67	3.86
Cambodia	0.20	0.40
Georgia	0.20	0.11
Kiribati	0.01	0.00
Kyrgyzstan	0.13	0.07
Lao People's Democratic Republic	0.19	0.27
Mongolia	0.52	0.10
Solomon Islands	0.01	0.04
Turkmenistan	0.70	0.08
Vanuatu	0.01	0.07

Source: ESCAP calculations based on World Bank INDC portal data.
Note: The higher cost estimates for each country are shown in grey.

Governments should pay particular attention to the health sector. Numerous measures indicate that there is a significant investment gap in this sector, even without taking into account the impacts of climate change and biological hazards. For example, ESCAP calculated, in 2019, that an additional investment of $158 billion per year over the period 2016–2030,[139] will be required to achieve universal health coverage (a target of SDG 3) across 19 Asia-Pacific countries. Once the need to climate-proof this investment is added, the investment gap will increase even further. As indicated earlier in this chapter, the total costs for adapting to biological hazards, under an RCP 8.5 climate scenario, were estimated to be $68 billion a year for the region.

To increase adaptation spending, governments will need to diversify their sources of finance. In addition to those used for normal public spending, these can include new climate finance instruments, such as climate resilience bonds, debt-for-resilience swaps, and debt relief initiatives. Governments can also share the costs with the private sector through public-private partnerships, and here innovative instruments of parametric insurance have gained some traction.

The financial sector can support such investment with risk-sharing instruments, like parametric insurance, which are issued rapidly and automatically once a pre-defined physical or meteorological parameter is reached.[140] Examples of parametric insurance are in Box 4-4 for Pacific small island developing States and Box 4-6 for the Philippines.

In addition, private- and public-sector investors must take into account disaster and climate risks as contingent liabilities in their balance sheets and financial planning on an annualized basis.[141] This need was highlighted at the International Workshop on Disaster Resilient Infrastructure 2019, organized in New Delhi by the India National Disaster Management Authority.[142]

139 *Economic and Social Survey of Asia and the Pacific 2019: Ambitions beyond Growth* (United Nations publication, 2019).

140 Marsh and McLennan Companies, *Global Risks for Infrastructure: The Climate Challenge*, 2020. Available at https://www.mmc.com/content/dam/mmc-web/insights/publications/2020/august/Global-Risks-for-Infrastructure_The-Climate-Challenge_Final.pdf

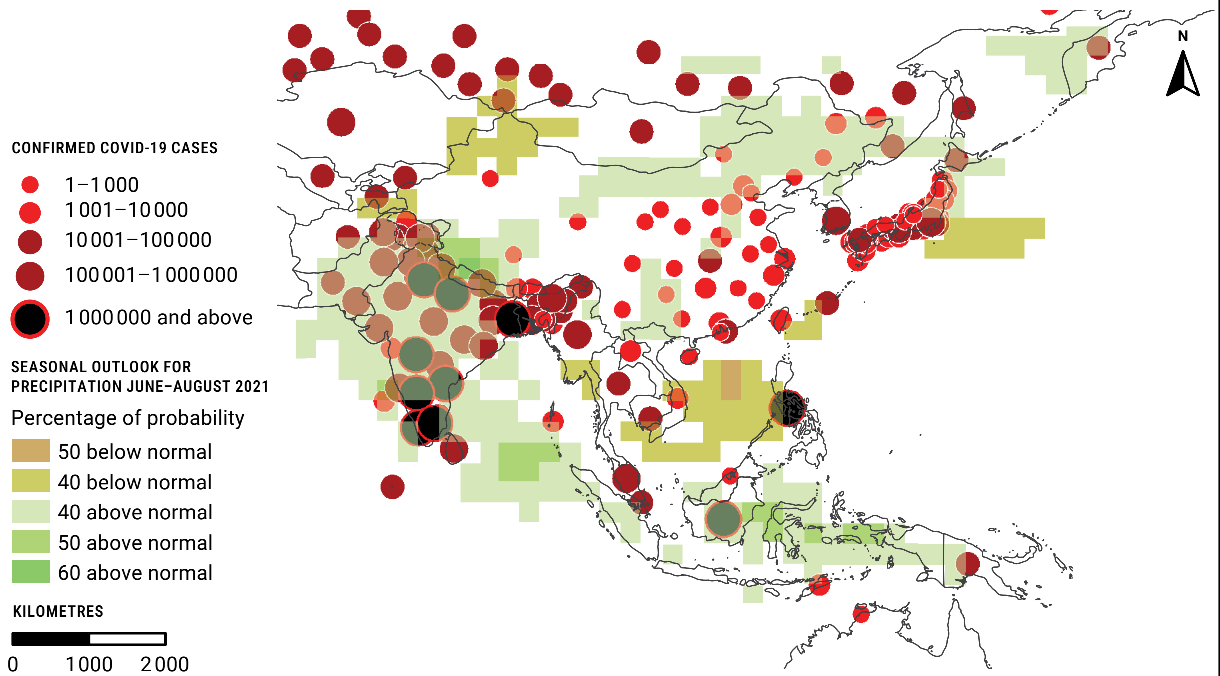
141 Coalition for Disaster Resilient Infrastructure, "Second International Workshop on Disaster Resilient Infrastructure", Workshop Summary, New Delhi, 19–20 March 2019. Available at https://cdri.world/node/155

142 The workshop was organized by National Disaster Management Authority of India in collaboration with the United Nations Office for Disaster Risk Reduction (UNDRR), in partnership with the Global Commission on Adaptation, The World Bank and United Nations Development Programme (UNDP).

BOX 4-5 Forecasting cascading risk scenarios at different time scales

The Asia-Pacific Disaster Resilience Network's (APDRN) predictive analytics solution, for example, captures cascading risk scenarios at the regional level as well as zooms in on South Asia where the intersection of the COVID-19 pandemic and extreme weather events is likely to intensify in the coming months. The solution is derived from integration of the WMO seasonal outlook for June, July and August 2021, issued in April with the COVID-19 cases on the ground (Figure A). During this period, above-normal precipitation is expected in Pakistan, India, Nepal, and in the north-eastern parts of China near the border with the Russian Federation.

FIGURE A Convergence of precipitation anomaly with COVID-19 in Asia for June–August 2021



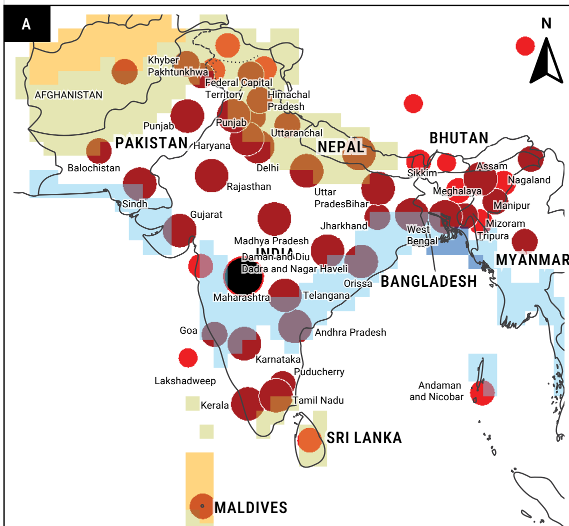
Sources: ESCAP, based on Johns Hopkins University Coronavirus COVID-19 Cases V2, 12 May 2021 and WMO Asia Pacific Seasonal Outlook Precipitation Data for June to August 2021.Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance 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.

Further, in South Asia in mid-2020 when COVID-19 was spreading rapidly, the most immediate concern was the June–September monsoon. The APDRN indicated the hotspots for floods and droughts. Climate-related disasters have different risk pathways than COVID-19 but can intersect and converge with the pandemic in complex and destructive ways. Many communities are exposed to both, with extensive long-term consequences, in particular, causing damage to people's health and livelihoods and limiting their prospects of escaping poverty.[a]

Several flood-prone areas of the subregion were expected to receive above-normal precipitation (north-western and southern parts of the subregion during the summer monsoon season of 2020, northern Bay of Bengal last winter, and upstream of the Ganges River Basin, in Nepal, from June to September this year). Some of these areas coincide with where the COVID-19 pandemic has rapidly increased, and thus potential convergence of water-related hazards with the pandemic were identified. The analysis of possible convergence of hazards provides advance information for all stakeholders to be better prepared. *Box continues on next page…*

FIGURE B **Convergence of precipitation anomaly with COVID in South Asia for (a) June-September 2020, (c) October–December 2020, and (d) June–September 2021**

A



CONFIRMED COVID-19 CASES

- 1–1 000
- 1 001–10 000
- 10 001–100 000
- 100 001–1 000 000
- 1 000 000 and above

SEASONAL OUTLOOK FOR PRECIPITATION

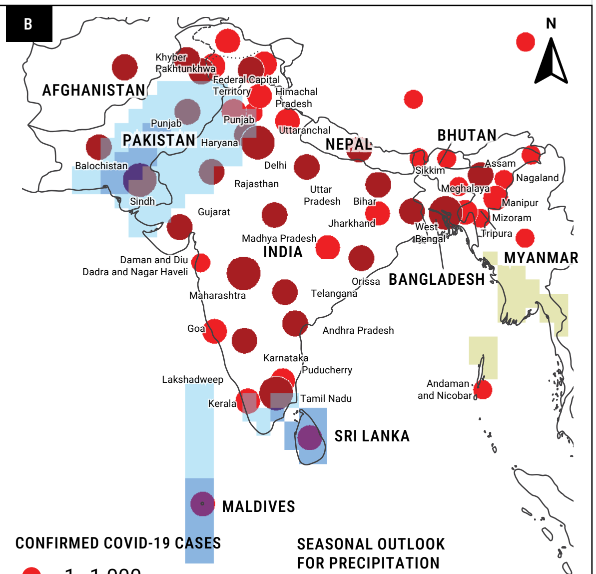
Percentage of probability

- 50 below normal
- 40 below normal
- 40 above normal
- 50 above normal

Sources: ESCAP, based on ESRI and John Hopkins University Coronavirus COVID-19 Cases V2, 19 October 2020 and SASCOF Seasonal Outlook Precipitation Data for October, November and December 2020.

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.

B



CONFIRMED COVID-19 CASES

- 1–1 000
- 1 001–10 000
- 10 001–100 000
- 100 001–1 000 000

SEASONAL OUTLOOK FOR PRECIPITATION

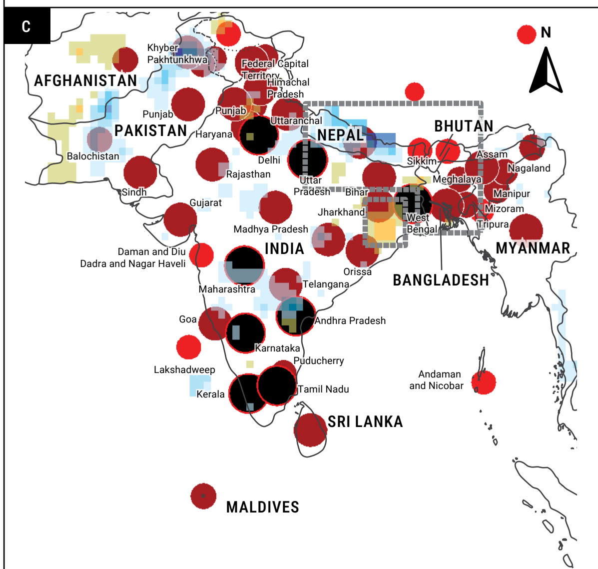
Percentage of probability

- 40 below normal
- 40 above normal
- 50 above normal

Sources: ESCAP, based on ESRI and John Hopkins University Coronavirus COVID-19 Cases V2, 14 July 2020 and SASCOF Seasonal Outlook Precipitation Data for June, July, August and September 2020.

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.

C



CONFIRMED COVID-19 CASES

- 1–1 000
- 1 001–10 000
- 10 001–100 000
- 100 001–1 000 000
- 1 000 000 and above

SEASONAL OUTLOOK FOR PRECIPITATION

Percentage of probability

BELOW NORMAL

- 40.1–50
- 50.1–60
- 60.1–70

ABOVE NORMAL

- 40.1 - 50
- 50.1 - 60
- 60.1 - 70
- 70.1 - 80
- 80.1 - 90
- 90.1 - 100

Areas need attention

KILOMETRES

0 1 000 2 000

Sources: ESCAP, based on SASCOF Seasonal Outlook Precipitation Data for June to September 2021; ESRI and John Hopkins University Coronavirus COVID-19 Cases V2, 12 May 2021.

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.

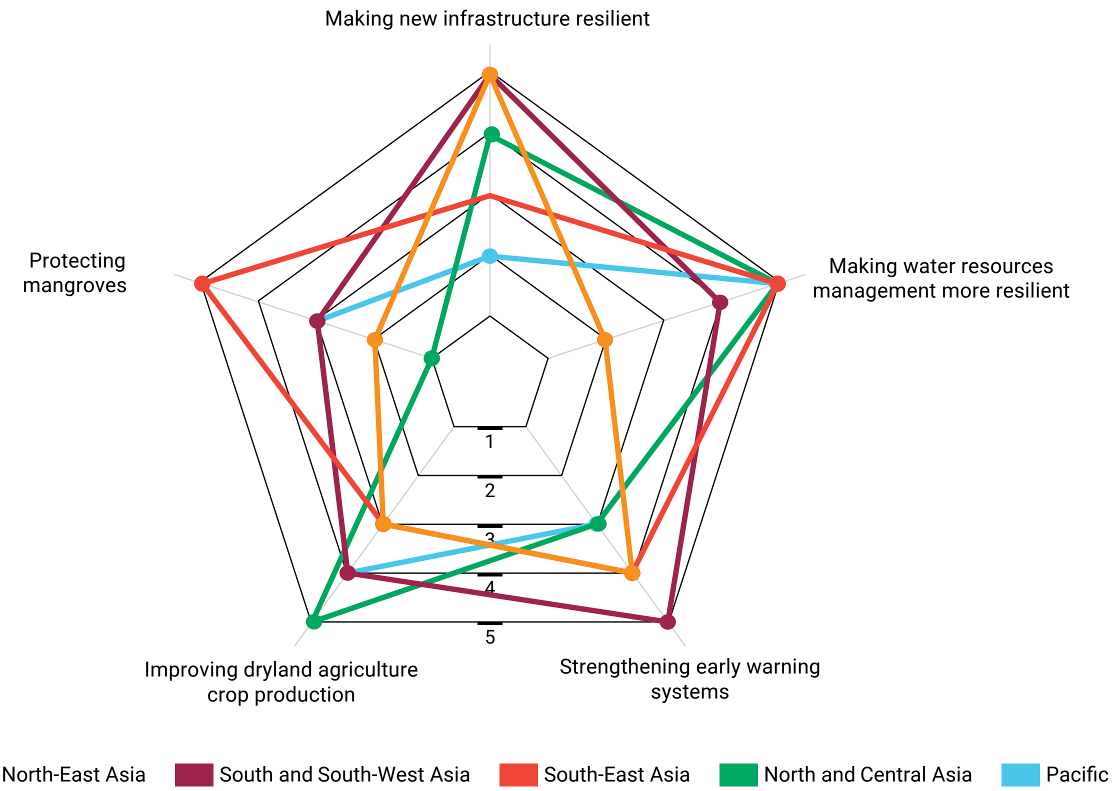
a United Nations, Economic and Social Commission of Asia and the Pacific, "Weaving a stronger fabric: Managing cascading risks for climate resilience", Policy Brief, 26 January 2021b. Available at https://www.unescap.org/kp/2021/weaving-stronger-fabric-managing-cascading-risks-climate-resilience

Scaling up subregional cooperation

To support the above mentioned four national policy actions, there are also opportunities to facilitate and reinforce these efforts at the subregional and regional levels. For example, policy coherence, integrated multi-hazard early warning systems, climate adaptation and resilience and investing in health infrastructure form the key components of climate disaster and health resilience. Given the diversity and specific risk profiles, each subregion will have its own adaptation priorities, as illustrated in Figure 4-10 based on categories established by the Global Commission on Adaptation: early-warning systems; climate-resilient infrastructure; improved dryland agriculture crop production; mangrove protection, and water security.[143] This prioritization of adaptation measures should take into account the specific risk profiles while making decisions on adaptation investments (Table 4-4).

In East and North-East Asia, the adaptation priorities are to make new infrastructure more resilient and strengthen early warning systems. In South and South-West Asia, the highest priorities are to strengthen early warning systems and make new infrastructure more resilient, followed by resilient water resource management by improving drylands and protecting mangroves. In South-East Asia, however, the key priorities are to protect mangroves and make water resource management more resilient, thereby reflecting the increasing impacts of drought, floods and cyclones in the region.[144] In North and Central Asia, the key priorities are to make water resource management more resilient and to improve dryland agriculture. For the Pacific subregion, making water resource management more resilient, improving dryland agriculture crop production and as protecting mangroves are identified as high priority adaptation measures.

FIGURE 4-11 Adaptation priorities for ESCAP subregions



Source: ESCAP calculations based on data from EM-DAT – The International Disaster Database. Available at https://www.emdat.be; World Bank, "World Bank Open Data". Available at https://data.worldbank.org/ ; Asia-Pacific SDG Gateway. Available at https://data.unescap.org/home.

143 Global Commission on Adaptation, *Adapt now: A global call for leadership on climate resilience*, 13 September 2019. Available at https://gca.org/reports/adapt-now-a-global-call-for-leadership-on-climate-resilience/ (accessed on 26 March 2021).

144 *Ready for the Dry Years: Building resilience to drought in South-East Asia* (United Nations publication, 2021a).

TABLE 4-4 **Adaptation costs and priorities by ESCAP subregions**

Subregions	Adaptation Cost (billions of US dollars, percentage of GDP)	Adaptation Priorities (highest to lowest, 5 being highest priority)
East and North-East Asia	190 (0.9%)	5 - Making new infrastructure resilient 4 - Strengthening early warning systems 3 - Improving dryland agriculture crop production 2 - Making water resources management more resilient, protecting mangroves
North and Central Asia	2.1 (0.6%)	5 - Making water resources management more resilient, Improving dryland agriculture crop production 4 - Making new infrastructure resilient 3 - Strengthening early warning systems
South and South-West Asia	51 (1.1%)	5 - Making new infrastructure resilient, and strengthening early warning systems 4 - Making water resources management more resilient, and improving dryland agriculture crop production 3 - Protecting mangroves
South-East Asia	22 (0.8%)	5 - Making water resources management more resilient, and protecting mangroves 4 - Strengthening early warning systems 3 - Making new infrastructure resilient and improving dryland agriculture crop production
Pacific small island developing States	0.5 (1.4%)	5 - Making water resources management more resilient 4 - Improving dryland agriculture crop production 3 – Strengthening early warning systems, and protecting mangroves 2 - Making new infrastructure resilient

The opportunities for scaling up subregional cooperation are considered below.

South-East Asia

In South-East Asia, 110 million people are exposed to drought and the biological hazards related to it. As of 2020, five of the ten ASEAN member states have more than 30 per cent of the total employed population working in the agricultural sector. In these circumstances, droughts generally have a major impact, so it is important to build resilient water resources and improve dryland agriculture. Furthermore, with 42 million people exposed to cyclones and its related biological hazards, it is also vital to have robust early warning systems.

As part of the effort to mobilize region-wide action, ASEAN and ESCAP has jointly produced the *Ready for the Dry Years* publication series. This publication provided the evidence base for the negotiations of the Association of Southeast Asian Nations Declaration on the Strengthening of Adaptation to Drought, which was adopted at the 37th Association of Southeast Asian Nations Summit.

In follow-up, the two secretariats working in partnership are supporting the development of a regional roadmap/regional action plan. National case studies will be prepared for two pilot countries: Cambodia and Thailand. In addition, the secretariat is working with the Brunei Climate Change Secretariat on a joint secretariat/Regional Integrated Early Warning System for Africa and Asia; a technical assistance project with a focus on improving climate adaptation, resilience and disaster preparedness in Brunei Darussalam.

The ASEAN Committee on Disaster Management and the ESCAP secretariat reinforced this cooperation by using the *Ready for the Dry Years* publication series to mobilize cross-sectoral support for drought action across agriculture, disaster management, energy, environment, finance, planning, science, and technology. Additionally, the adoption of the Declaration at the 37th ASEAN Summit was facilitated by strong partnerships in South-East Asia between the United Nations, ASEAN, national governments and other stakeholders, and structured through the Comprehensive Partnership and the Plan of Action.

BOX 4-6 **Philippines Natural Disaster Risk Insurance Policy**

The Philippines Natural Disaster Risk Insurance policy, supported by the World Bank, was started in 2017 and was renewed and boosted in 2018. Under this policy, the World Bank has entered into an agreement with private investors to provide cover against disaster and severe climate events to government agencies in 25 participating provinces. These provinces are provided with $390 million in insurance against typhoon and earthquake events. Insurance payouts are initiated by pre-defined parametric triggers. The Philippines Government Service Insurance System provides the insurance coverage. In effect, the policy provides prompt liquidity support to the Government to catalyse disaster recovery measures.[a]

a World Bank, "World Bank doubles Philippines natural disaster risk insurance with US$ 390 million in coverage", press release, Manila/Washington D.C., 16 January 2019. Available at https://www.worldbank.org/en/news/press-release/2019/01/14/world-bank-doubles-philippines-natural-disaster-risk-insurance-with-us390-million-in-coverage.

East and North-East Asia

In East and North-East Asia, around 260 million people are vulnerable to heatwaves, 196 million to cyclones and 68 million to drought and its associated biological hazards. In March 2021, amid the COVID-19 pandemic, North and East Asia was hit by the worst sand and dust storms (SDS) in a decade. In East Asia, a global temperature rise of 1.5°C, above pre-industrial levels between 2030 and 2052, will expose 48 million people to water scarcity. These climate hazards will severely impact countries, such as the Republic of Korea, where more than half the employed population works in agriculture. Hence, the importance of investing in early warning systems, appropriate land management for improved agricultural production and water resource management.

Since 1993, the North-East Asian Subregional Programme for Environmental Cooperation has served as a comprehensive intergovernmental cooperation framework in North-East Asia with membership of six countries: China, the Democratic People's Republic of Korea, Japan, Mongolia, the Republic of Korea and the Russian Federation. The framework has pursued a multi-disciplinary and multi-sectoral approach to address subregional environmental challenges. In this regard, desertification and land degradation is one of the five programmatic areas of the Strategic Plan 2021–2025.

There is thus scope to scale up the programme's work on desertification and land degradation and its interlinkage with climate change through strengthened subregional cooperation. As a first step, a study will contribute to enhanced scientific understanding of risk management and implementation of early warning systems. The study will also provide pathways for the necessary acceleration of adaptation actions. This includes building individual and institutional capacity to address implementation gaps and accelerating knowledge transfer on enabling financial mechanisms.

South and South-West Asia

As the subregion became the world's epicentre of the pandemic, the intersection of the COVID-19 pandemic with extreme climate events, acutely highlighted the urgency of subregional actions. Although the respective frameworks of the South Asian Association of Regional Co-operation and Economic Co-operation Organization frameworks are already aligned with the Sendai Framework for Disaster Risk Reduction, they do not address cascading risks.

Recognizing the need to do so, Ministers dealing with environment and disaster management in five South Asian countries, namely Afghanistan, Bangladesh, India, the Maldives, and Pakistan met at a Special High-Level Event on Disaster and Climate Resilience in South Asia, held virtually on 4 December 2020. In the meeting, they called on the secretariat to shape a longer-term, holistic, coordinated and more strategic approach to building disaster and climate resilience and to develop a new regional framework for managing cascading risks from natural and other biological hazards through cooperation with subregional bodies. Accordingly, and working in partnership with the relevant subregional organizations, the secretariat plans to provide support for a scale-up of the subregion's frameworks to encompass cascading risks.

North and Central Asia

In North and Central Asia, where large proportions of the populations depend on agriculture, around 22 million people are exposed to heatwaves and related biological hazards and 5 million are exposed to drought and food insecurities. Furthermore, a global temperature rise of 1.5°C above pre-industrial levels would expose many more people to water shortages.

The drying up of the Aral Sea as the biggest lake in Central Asia, shared by Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan, and Turkmenistan is often considered as the world's worst environmental catastrophe. The Aral Sea catastrophe has also contributed to the spread of drought, land degradation, desertification and sand and dust storms. With the emerging threat from climate change, along with increasing demands for food and water, exacerbated by a growing population, there are risks of other water-related disasters in inland basin systems.

While these phenomena have been studied extensively from the perspective of the sustainable management of natural resources, less work has been undertaken on the disaster-risk reduction and associated climate change adaptation perspectives of inland water basins. Consequently, the secretariat is undertaking a study on the risk drivers of water-related disasters in inland water-basins, including the impacts of climate change, through advances in Earth observation, digital elevation modelling, geospatial techniques and high-resolution climate modelling. This should support regional cooperation on the Aral Sea catastrophe from multi-sectoral risk management perspectives, and provide lessons for disaster risk reduction in other inland water basins.

The work underway is also designed to provide support to a resolution drafted by the Government of Turkmenistan, entitled 'Creating regional mechanisms to study, mitigate and minimize disasters in endorheic (inland) water basins and to prevent them, in particular considering modalities for establishment of the United Nations special programme for the Aral Sea basin'.

Pacific small island developing States

A high proportion of the population of the Pacific small island developing States are exposed to drought, heatwaves and cyclones, which, together with exposure to biological hazards, makes this subregion a risk hotspot (Box 4-7).

With funding from the Joint Sustainable Development Goals Fund, the ESCAP secretariat, together with the Government of Samoa and the United Nations system, is implementing a project on strengthening the resilience of Pacific island States through the universal social protection programme. The programme offers a strategic opportunity to consider disaster risk in the design and implementation of social protection systems. This policy brief series by the secretariat and the United Nations Joint Programme in Samoa, Cook Islands, Niue and Tokelau provides practical suggestions on how to design social protection schemes that build resilience to disasters. The first edition of the policy brief series is co-published by the secretariat with the Ministry of Natural Resources and the Environment of Samoa. The secretariat is partnering with the Secretariat of the Pacific Regional Environmental Programme and the Secretariat of the Pacific Community to scale up regional cooperation related to disaster, climate and health resilience.

Overall, the ongoing and forthcoming policy deliberations and engagements with various regional and subregional organizations as well as with ministers and government officials at the national level pave the way for strengthening and scaling up regional and subregional cooperation.

BOX 4-7 Adaptation Priorities in the Pacific small island developing States

In the Pacific small island developing States the top adaptation priorities are to make water resource management more resilient and improve dryland agriculture crop production followed by protecting mangroves, strengthening early warning systems and making new infrastructure resilient.

While most people have access to basic drinking water services, access is low in some countries like Papua New Guinea (PNG). PNG also has 58 per cent of its employed population working in agriculture, hence the importance of better water resources management and dryland agriculture.[a]

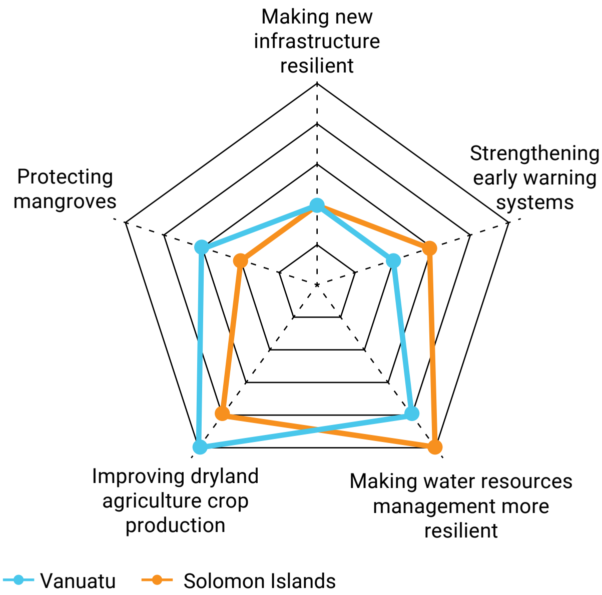
These adaptation measures also respond to the subregion's vulnerability to cyclones and related biological hazards. In some areas, protective green infrastructure is provided by mangrove forests. In 2019, total mangrove cover across 13 countries in the Pacific was 3.7 million hectares, one of the highest figures being in PNG with 728,477 hectares.[b]

Adaptation priorities at country-level: Vanuatu and Solomon Islands

Vanuatu and Solomon Islands, in the Pacific small island developing States, are also LDCs that record the highest Adaptation Costs as a percentage of GDP. For both countries, the highest adaptation priority is attributed to improving dryland agriculture crop production and resilient water resource management followed by protecting mangroves, strengthening early warning systems and making new infrastructure resilient (Figure A).

This can be attributed to high exposure to cyclones in both countries, and drought in Vanuatu, which contributes majorly to the total AAL ($204.6 million in Vanuatu and $100.5 million in the Solomon Islands under the RCP 8.5 climate change scenario). Further, a major share of employed population also works in the agriculture sector, 55 per cent in Vanuatu and 37 per cent[c] in Solomon Islands, reiterating the need for these adaptation measures.

FIGURE A Adaptation priorities for Vanuatu and Solomon Islands



Source: ESCAP calculations based on data from EM-DAT – The International Disaster Database. Available at https://www.emdat.be; World Bank, "World Bank Open Data". Available at https://data.worldbank.org/ ; Asia-Pacific SDG Gateway. Available at https://data.unescap.org/home

a Asia-Pacific SDG Gateway. Available at https://data.unescap.org/home
b European Space Agency, "Land cover map 2019". Available at http://maps.elie.ucl.ac.be/CCI/viewer/?fbclid=IwAR19v_VeH6O3M661uhBScPHNj_z4l-1lmxHlTmHEbAPlbMPclMc81UHocvU
c Asia-Pacific SDG Gateway. Available at https://data.unescap.org/home

Asia and the Pacific

Disaster risks know no borders, so countries across Asia and the Pacific need to work together through overarching regional initiatives. Subregional initiatives serve as the building blocks for regional approaches. The risks in the steppes of Central Asia may be very different from those of the small island States in the Pacific, but what countries across the region should have in common, however, are sound principles for managing disaster risks in a more coherent and systematic way; principles that are applied with political commitment and strengthened through regional and subregional collaboration.

In this regard, there is a need for a regional strategy on building back better with disaster, climate and health resilience. It is recommended that the strategy incorporate the analytical components and policy recommendations presented in this report, with four work streams proposed: (a) policy coherence, (b) multi-hazard and integrated early warning systems, (c) climate change adaptation, and (d) investing in resilient health infrastructure.

Building resilience in a riskier world

The Asia-Pacific region, like any other in the world, is regularly exposed to geophysical hazards, such as earthquakes, droughts, cyclones and floods. With climate change, these hazards are occurring with greater intensity and higher frequency. As the COVID-19 pandemic continues to wreak havoc, the region faces multiple challenges as biological and natural hazards are converging to reshape and redefine the contours of the Asia-Pacific disaster riskscape. Given the underlying stresses of poverty and inequality, the life prospects of millions of people across the region are at stake.

Indeed, the Asia-Pacific region has made remarkable progress in managing disaster risk. Risk communication and multi-hazard early warning systems have been effective in response and recovery programmes. But, there is still much more to be done and it is clear that countries can never relax their guard. The COVID-19 pandemic, with all its tragic consequences and huge economic losses, has exposed the frailties of human society in the face of powerful natural forces. Thus, this report encourages social protection programmes to move from being shock-responsive to being shock-prepared. Protection does not simply mean responding with relief packages, but anticipating emergencies and creating robust systems of social protection that will make the poorest communities safer and more resilient. Vulnerable groups, such as the urban poor, women, children, and people with disabilities need to be identified and health and social protection needs to be integrated into health and disaster risk management.

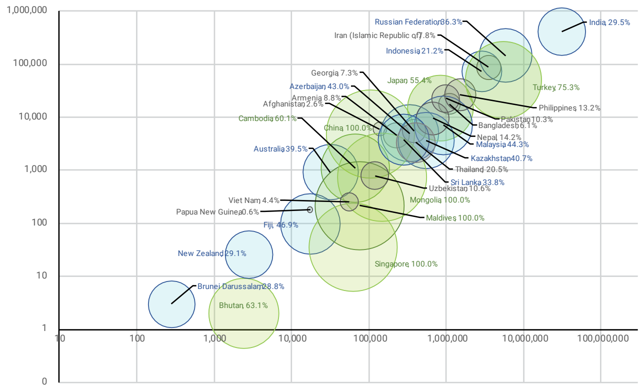
However, disaster risk management cannot function in silos. Following the Sendai Framework for Disaster Risk Reduction 2015–2030, countries in Asia and the Pacific had already come to a greater understanding of the need for a more integrated approach to disaster risk management, for treating these risks as indivisible, and for addressing them as a whole rather than one at a time. The COVID-19 pandemic has brought to the forefront, yet again, how risks interconnect; a natural hazard converging with a public health crisis can rapidly trigger an economic disaster. To address such 'systemic risks', this report suggests four priority areas for action; envisage risk scenarios; invest in health and social protection; apply emerging technologies; and target additional fiscal spending. However, given that disaster risks know no borders, subregional and regional cooperation to build disaster, climate and health resilience that incorporate the analytical findings and policy recommendations of this report can serve to truly help the region to *build forward better*.

BOX 4-8 COVID-19 vaccination in Asia and the Pacific

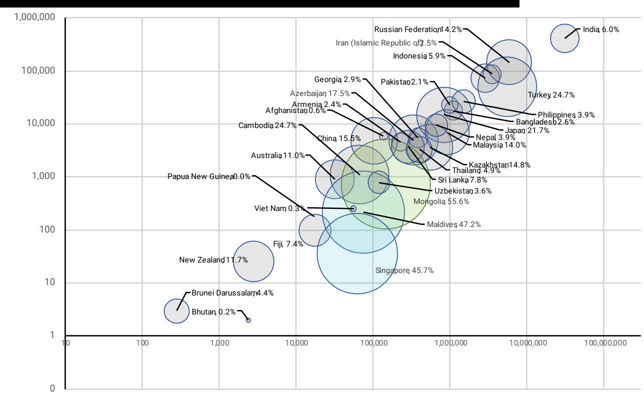
Countries in Asia and the Pacific have been efficiently managing the Covid-19 vaccination programme. As of 19 July 2021, the percentage of population fully vaccinated in Mongolia was more than 50 per cent, and more than 40 per cent in Maldives and Singapore, followed by around 25 per cent in Cambodia and Turkey. China, Maldives, Mongolia and Singapore also distributed at least first doses of vaccines to 100 per cent of their population, followed by Turkey, at around 75 per cent of population, Bhutan and Cambodia at around 60 per cent, and Japan at around 55 per cent.[a]

FIGURE Administered doses of the COVID-19 vaccine as a proportion of the total population, number of confirmed cases, and number of deaths[b]

PERCENTAGE OF ADMINISTERED DOSES OVER TOTAL POPULATION



PERCENTAGE OF FULLY VACCINATED PEOPLE OVER TOTAL POPULATION



Source: Johns Hopkins University. Coronavirus Resource Center – COVID-19 Overview and Vaccine tracker. Available at https://coronavirus.jhu.edu/region (accessed on 19 July 2021).
Notes: Some countries are not presented in the diagram due to data unavailability.

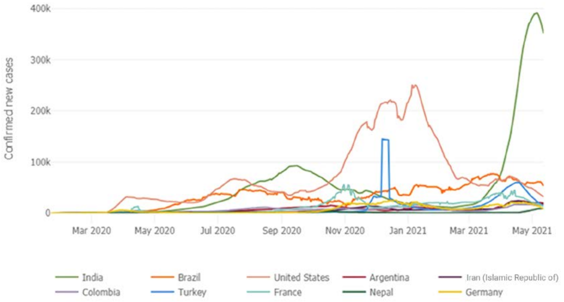
This chart indicates that India accounts more than 31 million confirmed COVID-19 cases and more than 400,000 deaths, and has vaccinated 30 per cent of its population, where 6 per cent have been fully vaccinated. The Russian Federation, recording the second highest confirmed cases at more than 5.8 million and more than 140,000 COVID-19 deaths, is currently preparing vaccine doses for more than 35 per cent of its population, where 14 per cent have been fully vaccinated. Third, Turkey, with 5.5 million cases, has administered vaccine doses for 75 per cent of its total population. It is followed by Islamic Republic of Iran with more than 3.5 million cases and 87,000 deaths, with vaccine doses at 8 per cent of its population, and Indonesia with more than 2.8 million cases and vaccine doses to cover 21 per cent of its population.

a Johns Hopkins University, Coronavirus Resource Center – COVID-19 Overview and Vaccine tracker. Available at: https://coronavirus.jhu.edu/region (accessed on 19 July 2021).
b Ibid.

BOX 4-9 Critical infrastructure services: key policy innovations for future pandemic

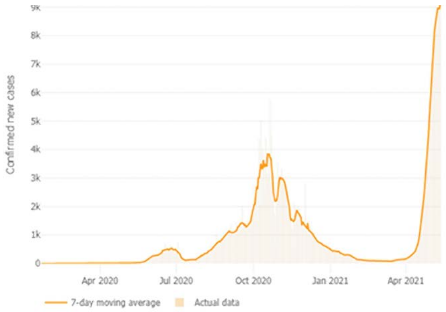
India's second COVID-19 wave was devastating, reaching world records for the total numbers of cases and deaths, and overwhelming the health-care system. The most striking aspect of the second wave was the speed with which it grew, with daily caseloads rising from about 12,000 in mid-March to 412,000 by the first week of May. The rapid speed with which the virus spread during the second wave is unique, with over 3,200 per cent growth in cases (Figure A), a similar speed is being seen in neighbouring Nepal.

FIGURE A **Daily confirmed new cases (7-day moving average): outbreak evolution for the current most affected countries**



Source: Johns Hopkins University. Coronavirus Resource Center – COVID-19 Overview and Vaccine tracker. Available at https://coronavirus.jhu.edu/region (accessed on 14 May 2021).

FIGURE B **Daily confirmed new cases (7-day moving average) in Nepal**



Source: Johns Hopkins University. Coronavirus Resource Center – COVID-19 Overview and Vaccine tracker. Available at https://coronavirus.jhu.edu/region (accessed on 14 May 2021).

Oxygen is vital for patients of COVID-19, which is a respiratory disease that attacks the lungs and leads to dangerously low levels of oxygen in the body. It is listed in the WHO's model list of essential medicines. Before the second wave, 700–800 tons per day of medical oxygen were required. This increased to 3,500–4,000 tons per day by the second week of April; a jump of over 400 per cent that put immense pressure on oxygen manufacturing units in the country. A large proportion of the 238,000 deaths in the second wave (by the first week of May only), are attributed to overstretched basic health-care facilities, particularly the supply of medicinal oxygen. The crisis reveals three key lessons for preparing for future pandemics:

Anticipatory actions – While the evidence indicates that a more contagious COVID-19 variant is spreading in India, the spread of the second wave is also driven by gaps in policy responses that emanate from a lack of anticipatory actions. So far mathematical models have been used to inform public policies and many of the social distancing measures implemented worldwide. All models, however, face challenges due to availability of data, the rapid evolution of the pandemic and unprecedented control measures put in place. It is therefore essential to strengthen mathematical modelling research capacity for pandemic planning forecast response and early warning systems to support risk-informed anticipatory actions.

Health infrastructure services – Basic, and scalable services for essential emergency and critical care (EECC), including oxygen, must be prioritized. The key lesson from this pandemic is that the capacities of public health systems must be scaled up and re-purposed, using systemic approaches for strengthening disaster resilience across all sectors. Otherwise, disruptions to the supply chain systems on which various facilities and undisrupted services depend will have fatal consequences.

Regional cooperation – As the world responds to the pandemic and many countries begin to roll out vaccination programmes, there is a unique opening to develop a resilient, accessible, inclusive, and affordable health and supply chain system for all by building regional cooperation.

BOX 4-10 Scenario planning in the coastal city of Visakhapatnam, India

The city of Visakhapatnam lies on the eastern coast of India. It is vulnerable to sea-level rise as well as climate change-induced extreme events like cyclones and storm surges. To assess the vulnerability of infrastructure services and support climate resilience planning, scenario planning was conducted by the Energy and Resources Institute (TERI) and submitted to the city government, municipal corporation, and the urban development authority. Following is an example of the scenario planning conducted for the city of Visakhapatnam.

Scenario planning steps	Details
1. Preparing an urban infrastructure inventory	Inventory of information on infrastructure assets
2. Preparing spatial inventory of urban infrastructure services	Sector-wise assets and services networks mapped using GIS platform (see Figure A)
3. Developing climate knowledge	Climate exposure assessments on precipitation, cyclones and sea-level rise. Four climate change scenarios considered for vulnerability assessment of the city based on sea-level rise model projections of 0.2 mm/year, 1.09 mm/year, 1-metre sea-level rise in 100 years and the case of cyclonic events with surge height of 4 metres.
4. Vulnerability assessment	The four scenarios overlayed on a digital elevation model (DEM) to identify hotspots, areas and assets likely to face climate hazard impacts
5. Sensitivity Analysis	Sea-level rise scenarios, sector-wise assets superimposed on the DEM to identify the most sensitive assets and areas. For example, in Visakhapatnam Airport area, airport infrastructure, storm-water drainage systems are exposed to potential sea-level rise, storm surges and floods
6. Understanding adaptive capacity	Assessment of entire systems to cope with climate-induced hazards, continuous assessment based on review of city plans, state-level policies, stakeholders, and expert group consultations.

Overall, based on the six levels of assessment, the project derived sector-wise recommendations for building resilient infrastructure. For the energy and telecommunications sector, for example, these were:

- Building design solutions to reduce flood damage
- On-site drainage in production and refuelling stations
- New infrastructure planning: avoiding vulnerable hotspots for siting
- Data collection on details of transmission lines: tower locations, networks, underground cabling details for flood prone and low-lying areas

FIGURE A Telecommunications sector, Visakhapatnam, cell phone towers mapped across the city

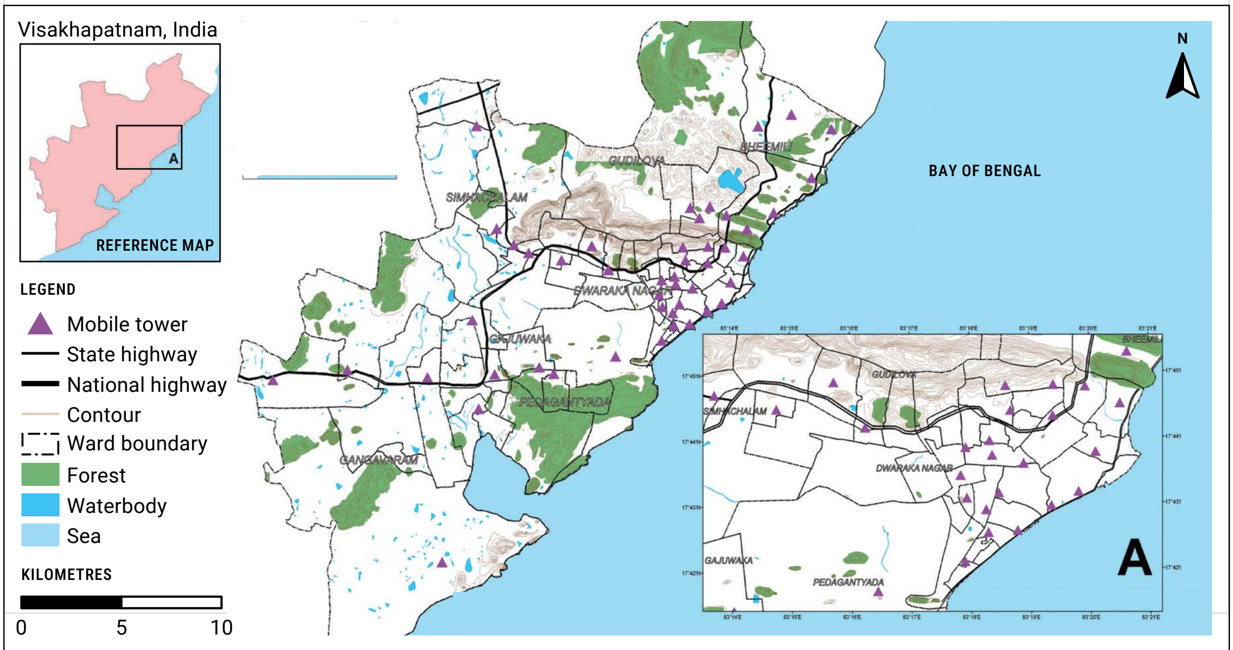
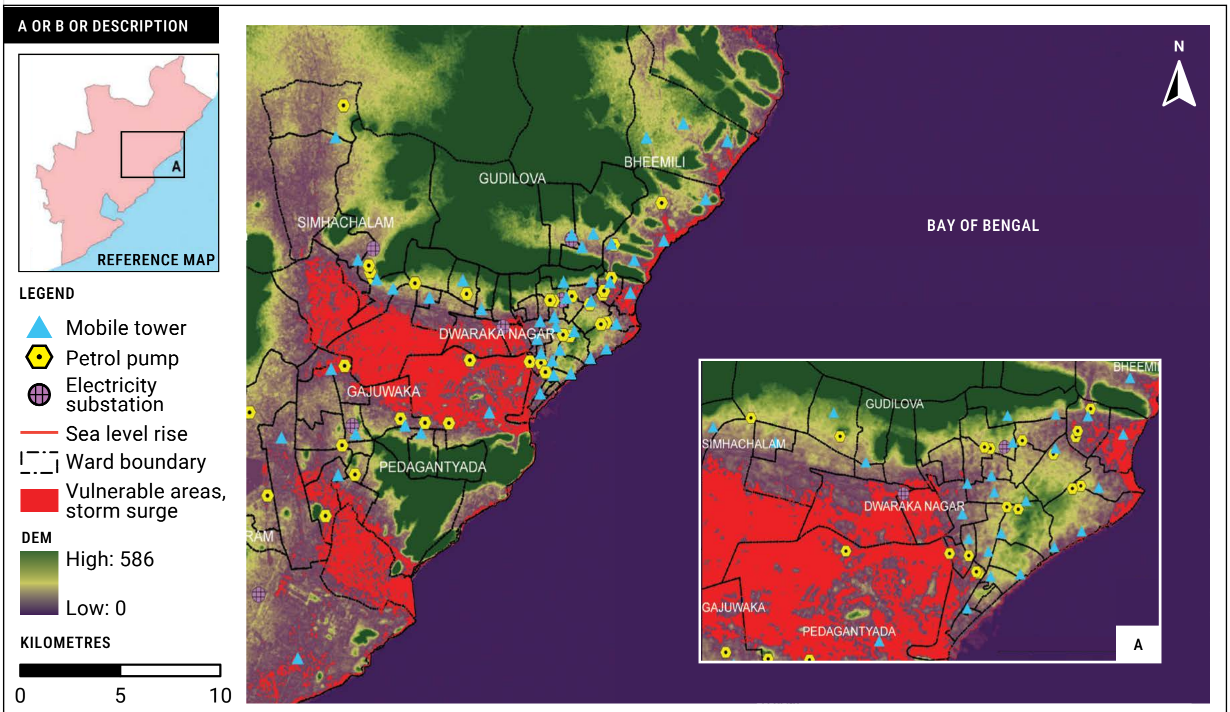


FIGURE B **Energy and telecommunication assets at risk of flooding during sea-level rise and storms**



Source: Chapter 3 – Preparing For The Future, The Energy and Resources Institute (TERI), 2021
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Source: The Energy and Resources Institute (TERI), "Climate Resilient infrastructure services, Case study brief: Visakhapatnam". Available at https://www.teriin.org/eventdocs/files/Case-Study-Vishakhapatnam.pdf

BOX 4-11 **Melbourne Water's Industry Climate Change Committee**

Melbourne is Australia's second-largest city with a population of over 4.5 million. The city is often exposed to climate change impacts like droughts, intense rainfall, high-speed winds, and heatwaves as well as sea-level rise.

Melbourne Water is a primary state-owned authority with responsibility for providing drinking water, recycled water, and waste treatment and for managing floods. To address shared risks, Melbourne Water established the Melbourne Water Industry Climate Change Committee (MWICCC) with three local water retailers for sharing information and lessons on climate risks and adaptation. Some overlapping risks and concerns include management of water during droughts, and tackling overflows from sewer networks during high-rainfall events.

The committee shares climate science inputs and risks to improve understanding of implications for businesses, identifies areas of joint research and work on developing consistent datasets as well as risk assessments. MWICCC has, for example, developed an industry risk register that records common risks facing these organizations.[a]

a C40 Cities, "C40 Infrastructure Interdependencies and Cascading Climate Impacts Study", Spring 2017. Available at https://assets.locomotive.works/sites/5ab410c8a2f42204838f797e/content_entry5ab410fb74c4833febe6c81a/5ad4fd8574c4837def5d3f8a/files/C40_Interdependencies_TOOL.pdf?1528290641

References

Asia-Pacific Disaster Report 2015: Disasters Without Borders (2015). United Nations publication. Available at https://www.unescap.org/publications/asia-pacific-disaster-report-2015-disasters-without-borders.

Asia-Pacific SDG Gateway. Available at https://data.unescap.org/home.

Asian Development Bank (2017). *Meeting Asia's Infrastructure Needs.* Manila (February).

Assel Satubaldina (2018). Kazakhstan's first robotic surgery performed in Ust-Kamenogorsk. *The Astana Times*, 30 March. Available at https://astanatimes.com/2018/03/kazakhstans-first-robotic-surgery-performed-in-ust- kamenogorsk/#:~:text=Kazakhstan's%20first%20robotic%20surgery%20performed%20in%20Ust%2DKamenogorsk,-By%20Assel%20Satubaldina&text=ASTANA%20%E2%80%93%20Kazakhstan's%20robot%20surgery%20and,woman%2C%20reported%20inform.kz.

C40 Cities (2017). C40 Infrastructure Interdependencies and Cascading Climate Impacts Study. Spring. Available at https://assets.locomotive.works/sites/5ab410c8a2f42204838f797e/content_entry5ab410fb74c4833febe6c81a/5ad4fd8574c4837def5d3f8a/files/C40_Interdependencies_TOOL.pdf?1528290641.

Coalition for Disaster Resilient Infrastructure (2019). Second International Workshop on Disaster Resilient Infrastructure. Workshop Summary. New Delhi, 19–20 March. Available at https://cdri.world/node/155.

"Covid-19 spurs national plans to give citizens digital identities" (2020). *The Economist* (7 December). Available at https://www.economist.com/international/2020/12/07/covid-19-spurs-national-plans-to-give-citizens-digital-identities.

European Space Agency. Land cover map 2019. Available at http://maps.elie.ucl.ac.be/CCI/viewer/?fbclid=IwAR19v_VeH6O3M661uhBScPHNj_z4l-1ImxHlTmHEbAPIbMPcIMc81UHocvU.

Global Center on Adaptation (2020). *State and Trends in Adaptation Report 2020*, vol. 1.

Global Commission on Adaptation (2019). *Adapt now: A global call for leadership on climate resilience*, 13 September. Available at https://gca.org/reports/adapt-now-a-global-call-for-leadership-on-climate-resilience/. Accessed on 26 March 2021.

Global Data Lab and United Nations Development Programme (UNDP) (2020). Subnational Human Development Index (HDI) Version 4.0. Available at http://hdr.undp.org/en/content/human-development-index-hdi and https://globaldatalab.org/shdi/download_files/.

Government of India (2019). *National Digital Health Blueprint, Ministry of Health and Family Welfare*. 15 July. Available at https://www.nhp.gov.in/NHPfiles/National_Digital_Health_Blueprint_Report_comments_invited.pdf.

Institute of Epidemiology, Disease Control and Research (2020). Bangladesh COVID-19 Cases. 9 August. Available at https://iedcr.gov.bd/covid-19/covid-19-general-information. Accessed on 10 August 2020.

Intergovernmental Panel on Climate Change (2014). *AR5 Synthesis Report: Climate Change 2014*. Geneva.

Johns Hopkins University. Coronavirus Resource Center – COVID-19 Overview and Vaccine tracker. Available at https://coronavirus.jhu.edu/region. Accessed on 14 May 2021.

Johns Hopkins University and Environmental Systems Research Institute (ESRI) (2020). Coronavirus COVID-19 Cases V2. Available at https://coronavirus-resources.esri.com/maps/1cb306b5331945548745a5ccd290188e/about.

Lipinski, Brian and Heather McGray (2010). Summary of studies estimating the cost of climate change adaptation in the developing world. World Resources Institute (WRI). January. Available at https://pdf.wri.org/cost_of_adaptation_in_the_developing_world.pdf.

Make in India. National Digital Health Mission. Available at https://www.makeinindia.com/national-digital-health-mission.

Marc Gordon and Scott Williams (2020). Shifting the Paradigm: Introducing Global Risk Assessment Framework (GRAF). United Nations Office for Disaster Risk Reduction. 17 April. Available at https://www.preventionweb.net/news/view/71352.

Marsh and McLennan Companies (2020). Global Risks for Infrastructure: The Climate Challenge. Available at https://www.mmc.com/content/dam/mmc-web/insights/publications/2020/august/Global-Risks-for-Infrastructure_The-Climate-Challenge_Final.pdf.

Nevo, Sella (2020). The technology behind our recent improvements in flood forecasting. Google AI Blog, 3 September. Available at https://ai.googleblog.com/2020/09/the-technology-behind-our-recent.html.

Renn, Ortwin, and others (2020). Systemic risks from different perspectives. *Risk Analysis*, vol. 0, No. 0 (2020). Available at https://onlinelibrary.wiley.com/doi/epdf/10.1111/risa.13657.

Review of COVID-19 Disaster Risk Governance in Asia-Pacific: Towards MultiHazard and Multi-Sectoral Disaster Risk Reduction (2020). United Nations publication. Available at https://www.undrr.org/publication/review-covid-19-disaster-risk-governance-asia-pacific-towards-multi-hazard-and-multi.

Socioeconomic Data and Applications Center (SEDAC). Gridded Population of the World (GPW), v4. UN WPP-Adjusted Population Count 2020, v4.11. Available at https://sedac.ciesin.columbia.edu/data/collection/gpw-v4/sets/browse. Accessed in May 2020.

South Asian Climate Outlook Forum (SASCOF) (2020). Seasonal Outlook Precipitation Forecast for South Asia for June, July, August and September 2020. Received from RCC of Indian Meteorological Department in Pune, India. Available at http://rcc.imdpune.gov.in/SASCOF17/concensus.html

South Asian Climate Outlook Forum (SASCOF) (2020). Seasonal Outlook Precipitation Forecast for South Asia for October, November and December 2020. Received from RCC of Indian Meteorological Department in Pune, India.

South Asian Climate Outlook Forum (SASCOF) (2021). Seasonal Outlook Precipitation Forecast for South Asia for June, July, August and September 2021. Received from RCC of Indian Meteorological Department in Pune, India.

The Energy and Resources Institute (TERI). Climate Resilient infrastructure services, Case study brief: Visakhapatnam. Available at https://www.teriin.org/eventdocs/files/Case-Study-Vishakhapatnam.pdf.

United Nations (2020). *Official Records of the General Assembly, Seventy-fifth Session* (A/75/226).

United Nations Economic and Social Commission of Asia and the Pacific (ESCAP) (2019). *Economic and Social Survey of Asia and the Pacific 2019: Ambitions beyond Growth*. United Nations publication, 2019.

__________ (2020a). *Are countries in the Asia Pacific region initiating a 'green recovery'? What more can be done?* Policy Brief, December 2020. Available at https://www.unescap.org/sites/default/d8files/knowledge-products/UNESCAP%20Green%20Recovery%20Policy%20Brief.pdf.

__________ (2020b). Policy responses to COVID-19: Combating COVID-19 in Asia and the Pacific: Measures, lessons and the way forward. Policy Brief. 15 May. Available at https://www.unescap.org/resources/policy-responses-covid-19-combating-covid-19-asia-and-pacific-measures-lessons-and-way (Accessed on 26 March 2021).

__________ (2021a) *Ready for the Dry Years: Building resilience to drought in South-East Asia*. United Nations publication.

__________ (2021b). Weaving a stronger fabric: Managing cascading risks for climate resilience", Policy Brief. 26 January. Available at https://www.unescap.org/kp/2021/weaving-stronger-fabric-managing-cascading-risks-climate-resilience.

United Nations Environment Programme (UNEP) (2016). *Adaptation Finance Gap Report 2016* (Cophenhagen, 11 May).

United Nations Framework Convention on Climate Change (UNFCCC) (2007). *Investment and Financial flows to Address Climate Change* (October).

United Nations Satellite Centre (UNOSAT) (2020). United Nations Institute for Training and Research (UNITAR) analysis on National Oceanic and Atmospheric Administration (NOAA)-20 Visible Infrared Imaging Radiometer Suite (VIIRS) Imagery, 20 June – 19 July 2020.

United Nations Office of Disaster Risk Reduction (UNDRR) (2019). *Global Assessment Report on Disaster Risk Reduction 2019*. United Nations publication. Available at https://www.undrr.org/publication/global-assessment-report-disaster-risk-reduction-2019#:~:text=The%202019%20Global%20Assessment%20Report,the%20global%20disaster%20risk%20landscape.

United Nations Office for Disaster Risk Reduction, World Health Organization and Royal Thai Government (2016). The International Conference on the Implementation of the Health Aspects of the Sendai Framework for Disaster Risk Reduction 2015–2030. Bangkok, Thailand, 10–11 March. Available at https://www.unisdr.org/conferences/2016/health.

United Nations, *Sendai Framework for Disaster Risk Reduction*, 2015. Available at https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf.

World Bank. World Bank Open Data. Available at https://data.worldbank.org/.

__________ (2006). *An Investment Framework for Clean Energy and Development*. Washington, D.C., World Bank.

__________ (2010). *Economics of Adaptation to Climate Change: Synthesis Report*. Washington, D.C., World Bank.

__________ (2019). World Bank doubles Philippines natural disaster risk insurance with US$ 390 million in coverage. Press release. Manila/Washington D.C., 16 January. Available at https://www.worldbank.org/en/news/press-release/2019/01/14/world-bank-doubles-philippines-natural-disaster-risk-insurance-with-us390-million-in-coverage.

World Bank Group and others. Pacific Catastrophe Risk Financing and Insurance Program. Available at https://www.gfdrr.org/sites/default/files/publication/PCRAFI_Program%20Pager_FINAL%20VERSION.pdf.

World Meteorological Organization (WMO) (2020). Asia-Pacific Seasonal Outlook for June, July, August and September 2020. April.