Seizing the Moment

TARGETING TRANSFORMATIVE DISASTER RISK RESILIENCE

Asia-Pacific Disaster Report 2023

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Economic and Social Commission
for Asia and the Pacific

*The shaded areas of the map indicate ESCAP members and associate members.**

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Foreword

Nowhere is the escalating threat of climate change-induced disasters greater than in Asia and the Pacific. Over the past decades, floods, tropical cyclones, heatwaves, droughts and earthquakes have become more frequent and intense. They have brought a tragic loss of life, displaced communities, damaged people's health and pushed millions into poverty. The number of persons exposed to potential disasters is high and forecast to increase as new hotspots emerge and existing ones intensify. In the absence of immediate action, disaster risk could soon outstrip the limits of feasible adaptation. The region has a narrow window of opportunity to increase resilience.

The *Asia-Pacific Disaster Report 2023* aims to help the region seize this moment. It provides a comprehensive assessment of the current state of disaster risk, the upcoming challenges and the transformative adaptation needed in response. Strengthening early warning systems carries the potential to significantly reduce the impact of disasters and related losses. It must be prioritized, alongside sector-specific early warning systems, to shield key industries such as agriculture and energy from climate shocks. This report explores the contribution nature-based solutions can make to sustainably protect our ecosystems and build disaster resilience. Let us make these central to our region's climate adaptation strategies.

Now is the moment to work together, and through regional cooperation, to build on innovation and scientific breakthroughs that accelerate transformative adaptation across the region. Only together can we protect the human, economic and environmental developmental gains necessary to achieve the 2030 Agenda for Sustainable Development. Only together can we implement a regional strategy to support Early Warnings for All, aligned with global and country-level initiatives and resting on well-established regional cooperation mechanisms. Only together can we unlock the financing necessary to enhance preventative and anticipatory actions.

This report provides concrete recommendations in all these areas. I hope it can give momentum to our collective effort and imbue our actions with the ambition necessary to ensure disaster resilience is never outpaced by disaster risk in Asia and the Pacific.

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Executive Summary

A disaster emergency

Climate change-induced disasters pose an increasingly serious threat to Asia and the Pacific. The region remains the most disaster-prone region in the world where 2 million people have lost their lives to disasters since 1970. In 2022, over 140 disasters struck the Asia-Pacific region, leading to over 7,500 deaths, affecting over 64 million people and causing economic damage estimated at US$ 57 billion.

The impact and magnitude of disasters, over the past decade, indicate that climate change is making natural hazards even more frequent and intense, with floods, tropical cyclones, heatwaves, droughts and earthquakes resulting in tragic losses of life, displaced communities, damaged people's health and millions pushed into poverty. Moreover, food and energy systems are being disrupted, economies destabilized and societies undermined. Risks in existing disaster hotspots are forecasted to intensify, and new disaster hotspots will begin to appear. A riskscape of complex, compound and cascading disasters is emerging.

In particular, disaster fatalities and economic losses are unevenly distributed across the Asia-Pacific region, and the impact of disasters is particularly consequential in the least developed countries of Asia and the Pacific, as their pre-existing vulnerabilities make it challenging for these countries to prepare for and cope with natural hazards. Areas already vulnerable to transboundary disasters are expected to experience intensifying hazards, such as floods, drought and heatwaves.

Furthermore, climate-induced disaster risk is outpacing the region's resilience. With such an expanding and intensifying riskscape, continued investment is needed to strengthen disaster resilience locally and nationally, including to maintain effective early warning systems in existing hotspots. It is critical to respond to intensifying hotspots, strengthen regional and subregional cooperation mechanisms, and widely introduce nature-based solutions (NbS).

The cost of inaction

The Asia-Pacific region has a narrow window to increase its resilience and protect its hard-won development gains from the socioeconomic impacts of climate change. In the absence of immediate action, temperature rises of 1.5°C and 2°C will cause disaster risk to outpace resilience beyond the limits of feasible adaptation and imperil sustainable development. Furthermore, climate disaster-related losses are already enormous, but the future cost of inaction today is greater still, with average annual losses increasing from $924 billion to almost $1 trillion, or from 2.9 to 3 per cent of the regional GDP.

Current annual losses from drought, floods, heatwaves and tropical cyclones and related biological hazards, and tsunamis and earthquakes, are forecasted to increase. Such disasters and extreme weather events will undermine productivity and increase inequality. Indeed, in the broader Asia-Pacific region, there is a strong intersection between risks from disasters, inequalities of income and poverty because the population is more highly exposed to disaster risk. In the least developed and landlocked developing countries, disaster losses could become a driving force for persistent inequality.

Disaster-related losses are particularly dangerous in both the agriculture and energy sectors. Drought, intense rainfall, and floods are already contributing to decreasing agricultural produce and surging food prices. Those most impacted by a decline in agricultural productivity will be the many farming communities living on the brink of poverty and the urban poor who are vulnerable to food price inflation. Further, heatwaves and droughts are already putting existing energy generation under stress. If no action is taken, such disasters will affect energy supply and production, as well as the resilience of energy infrastructure.

Climate hazards will continue to drive environmental degradation and reduce biodiversity. The increase in hydro-meteorological hazards, caused by climate change, have already resulted in the loss of local species, increased diseases, and driven mass mortality of plants and animals, leading to the first climate-driven extinctions.

Protecting people and development gains

Multi-hazard early warning systems are one of the most effective ways to reduce mortality from natural hazards and protect people in multi-hazard risk hotspots. The share of people exposed to multi-hazard risk is forecast to increase to 85 per cent of the region's population under 1.5°C warming and 87 per cent under 2°C warming. Food and energy systems are exposed to increasingly intense and frequent shocks. The United Nations Office of Disaster Risk Reduction estimates that countries with limited to moderate multi-hazard early warning system coverage have nearly eight times the mortality rate of countries with substantial to comprehensive coverage.

Multi-hazard early warning systems could reduce disaster losses by up to 60 per cent. This is a cost-effective way of protecting people and assets and provides a tenfold return on investment. Countries with low multi-hazard early warning system coverage and high agricultural economic value exposure are highly vulnerable to the impacts of climate change and require the establishment of sector-specific early warning systems to protect agricultural assets. Countries with relatively low levels of multi-hazard early warning systems and high economic value exposure due to at-risk power plants also need to maintain and improve their early warning systems to protect power plants from the increasing risks posed by climate change and other hazards.

Thus, increased investments in multi-hazard early warning systems are urgent. Climate projections on emerging and intensifying risk hotspots make it possible to identify people that are exposed to higher risk. Existing multi-hazard early warning systems can take advantage of the climate projection to assess their existing and future status and capabilities to reach the most vulnerable populations. Observation, forecasting and building preparedness and response capabilities are also key areas which need strengthening. The biggest investments are needed in building local capacities to respond effectively and rapidly to early warning alerts, followed by investments to expand global satellite data use, and to strengthen networks and services which disseminate early warning messages. Finally, early warning systems need to be anchored in comprehensive risk management policies to build resilience, especially in the agriculture and energy sectors.

Champion innovation and scientific breakthroughs capable of advancing early warnings. It is critical to tighten the observation network at the global and regional level to strengthen risk knowledge, develop more accurate weather predictions, and increase lifesaving and damage reducing lead-times for early warnings. Building capacity at national and local levels is also critical for effective responses, underscoring the need to support the forecasting maturity of all high risk, low-capacity countries.

Invest in nature-based solutions which can deliver up to 40 per cent of needed climate actions. Nature-based solutions support the long-term sustainable management, protection and restoration of the degraded environment and thus reduce disaster risk. Such measures include: i) wetlands, flood plains and forests, that can reduce extreme weather events, such as flooding and drought; ii) mangroves and coral reefs as these are critical to guard against coastal flooding; and iii) urban planning for future urban resilience.

Implementing transformative adaptation

Transformative adaptation provides a major opportunity to build a resilient future as global temperatures rise. It considers the fundamental changes required of our societies, our economies, and the management of ecological systems, in anticipation of climate change and its impacts and is shaped by the principle of 'a just transition for climate change adaptation' and the 'think resilience' approach. This approach emphasizes the following:

Invest in sectoral to systems approach to provide a major opportunity to build a resilient future as temperatures rise. Such investments in adaptation catalyse change across systems and structures. The building blocks of transformational adaptation in multi-hazard risk hotspots include conducting comprehensive disaster and climate risk assessments, and transitioning from a sectoral to a systems approach, with the aim to leave no one behind at its core.

Align social protection and climate change interventions to help build the resilience of poor and climate-vulnerable households. Such 'adaptive social protection' interventions will strengthen the capacity of vulnerable populations to adapt, absorb and transfer risks. Together social protection and climate response measures have the potential to build resilience in poor and vulnerable households by protecting assets and capabilities, and providing sustainable, climate-resilient opportunities for graduation out of poverty.

Implement comprehensive disaster and Climate Risk Management (CRM) to strengthen synergies between disaster risk reduction and climate change adaptation. CRM identifies mutually beneficial opportunities across policies and programmes, while developing government capacity for cross-sectoral planning. By applying a full-spectrum analysis of risk, CRM shapes risk-informed development policies, investments, and risk governance frameworks, and integrates risk-centred approaches into national and subnational adaptation plans and strategies.

CRM is critical to make food systems, including agri-food production, more resilient. Transformative adaptation means prioritizing resilience-building in climate hotspots, such as semi-arid and arid regions and coasts, where systemic tipping points make fundamental changes urgent. Risk management strategies for shocks, such as droughts, floods and pests, including multi-risk assessments, timely forecasts, early warning systems and early action plans, are necessary to build resilient food systems.

Energy is the backbone of critical infrastructure networks, and it is critical to build its climate-resilience. To deliver resilient infrastructure, a framework for resilience is required. This can help anticipate future shocks and stresses better, improve actions to resist, absorb and recover from shocks and stresses by testing for vulnerabilities and addressing them before it is too late.

Invest in the Global Executive Action Plan on Early Warnings for All. Leveraging on emerging technologies, there is a need to invest in early warnings that leave no-one @ risk behind, at the global, regional and country levels. As climate change intensifies, the transboundary impacts of disasters are on the increase. A regional strategy is proposed that aligns to the global initiative will enhance the interoperability of early warning systems at country level. A regional approach will help improve the accuracy of predictions, how early warning messages are shared with users as well as the cost-effectiveness and long-term sustainability of early warnings.

The private sector and regional cooperation provide cost-effective avenues for low-capacity, or technologically poor countries to access advances in technology for disaster risk reduction. Much of the innovation of climate adaptation technology is happening in the global North, but most people in the firing line of climate change impacts are in the global South. It is important to develop, apply and transfer climate technologies to developing countries to protect people and development gains.

Financing Transformative Adaptation

Disaster and climate risk-informed adaptation and risk-reduction investments are far more cost-effective than post-disaster response and recovery, and these investments contribute to sustainable development. According to the ESCAP calculations, the current level of adaptation finance flow does not cover 91.96 per cent of the current adaptation costs in the Asia-Pacific region.

The investments needed for transformative adaptation stand at $144.74 billion for the region or 0.49 per cent of regional GDP. The adaptation cost in the Pacific SIDS is the greatest (1.41 per cent of GDP) followed by Southeast Asia (0.98 per cent), South and South West Asia (0.92 per cent), East and North East Asia (0.36 per cent) and North and Central Asia (0.30 per cent).

Countries that are most at risk from climate change also suffer from high debt burden. Consequently, a significant portion of their earnings go into external debt repayments leaving limited room for investing in transformative adaptation. However, there are opportunities in these countries to use the debt to build resilience. The augmented debt sustainability analytical approach can be a powerful tool for sustainable development, if used judiciously and with a long-term horizon. The approach can be used to finance evidence-based risk investments in disaster and climate resilient infrastructure, health care, and other areas that can not only promote economic growth and social development, but increase the future resiliency of economies.

Emerging innovations in financing mechanisms have the potential to play a significant role in helping finance climate change adaptation. Instruments such as thematic bonds, debt for adaptation, and ecosystem adaptation finance, including payment for ecosystem services and biodiversity credits can help to attract private investment, reduce risk and create new markets. However, for developing countries these innovations may not be accessible.

Official development assistance (ODA) and international cooperation is important for uptake of emerging financing innovations in developing countries to build disaster and climate resilience. ODA can provide financial resources and technical assistance to help less developed countries explore and access innovative financing mechanisms. International cooperation can foster knowledge sharing among countries, institutions, and stakeholders, enabling less developed countries to learn from the experiences of others who have successfully utilized innovative financing mechanisms.

Technological advances amplify financing adaptation. Digital technologies can greatly support financing for adaptation by improving efficiency, transparency, and accessibility in various aspects of the process. Digital platforms such as the ESCAP Asia Pacific Risk and Resilience Portal enable efficient collection and analysis of data, informing evidence-based decision-making and prioritizing evidence-based adaptation investments. Use of technology solutions can be bolstered by building economies of scale through existing institutions, such as the ESCAP's multi-doner Trust Fund, Tsunami, Disaster and Climate Preparedness.

Better understanding of loss and damage

Loss and Damage brought on by climate change are now a top priority on the international agenda. They also exhibit significant impacts to the Sustainable Development Agenda, to SDG Target 11.5 on reducing the number of deaths, the number of people affected, and decreasing the direct economic losses, and form the critical parts of Target A, B, C and D of the Sendai Framework for Disaster Risk Reduction. COP27, for the first time, considered funding arrangements responding to Loss and Damage associated with the adverse effects of climate change.

Estimates of disaster loss and damage are improving. Existing methodologies are being reviewed and new models to evaluate loss and damage are under continuous development. These models generally focus on post-disaster cost estimates, but increasingly can also forecast future loss and damage costs, with slow-onset disasters receiving more attention.

Greater use of the new science of climate attribution is underway. Climate attribution helps recognize a spectrum of climate impacts, differentiate between rapid- and slow-onset disasters and accurately gauge timeframes of impact and recovery. By determining the degree to which climate change is responsible for a certain occurrence, risks can be minimized. As new technology applications emerge, it can be expected that by integrating impact-based forecasting to estimate the time, the location and the likelihood of disaster impact, advanced preparations will minimize the socioeconomic costs.

The use of digital technologies and Smart Earth technology is assuming centre stage. Such technology has been used effectively in the Asia and Pacific region, connecting data sets, enhancing communication between environmental sensors and databases, improving the monitoring and tracking of ecosystem changes and strengthening the analysis of disaster risk management. During disasters, digital technologies have helped stabilize supply chains, decreasing transaction costs and data and information protection. The rapid expansion of sensing capabilities and big data analysis tools is opening new possibilities for anticipating, understanding, and visualizing disasters, and provides new means of recovering in their aftermath.

Contents

Boxes, figures and tables

Explanatory notes

Analyses in the *Asia-Pacific Disaster Report 2023* are based on data and information available up to 14 June 2023.

The Asia-Pacific region, unless otherwise specified, refers to the group of ESCAP members and associate members that are within the Asia and the Pacific geographic region. Groupings of countries and territories/areas referred to in the present edition of the Report are defined as follows:

ESCAP region: Afghanistan; American Samoa; Armenia; Australia; Azerbaijan; Bangladesh; Bhutan; Brunei Darussalam; Cambodia; China; Cook Islands; Democratic People's Republic of Korea; Fiji; French Polynesia; Georgia; Guam; Hong Kong, China; India; Indonesia; Iran (Islamic Republic of); Japan; Kazakhstan; Kiribati; Kyrgyzstan; Lao People's Democratic Republic; Macao, China; Malaysia; Maldives; Marshall Islands; Micronesia (Federated States of); Mongolia; Myanmar; Nauru; Nepal; New Caledonia; New Zealand; Niue; Northern Mariana Islands; Pakistan; Palau; Papua New Guinea; Philippines; Republic of Korea; Russian Federation; Samoa; Singapore; Solomon Islands; Sri Lanka; Tajikistan; Thailand; Timor-Leste; Tonga; Türkiye; Turkmenistan; Tuvalu; Uzbekistan; Vanuatu; and Viet Nam

East and North-East Asia: China; Democratic People's Republic of Korea; Hong Kong, China; Japan; Macao, China; Mongolia and Republic of Korea

North and Central Asia: Armenia; Azerbaijan; Georgia; Kazakhstan; Kyrgyzstan; Russian Federation; Tajikistan; Turkmenistan and Uzbekistan

Pacific: American Samoa; Australia; Cook Islands; Fiji; French Polynesia; Guam; Kiribati; Marshall Islands; Micronesia (Federated States of); Nauru; New Caledonia; New Zealand; Niue; Northern Marina Islands; Palau; Papua New Guinea; Samoa; Solomon Islands; Tonga; Tuvalu and Vanuatu

South and South-West Asia: Afghanistan; Bangladesh; Bhutan; India; Iran (Islamic Republic of); Maldives; Nepal; Pakistan; Sri Lanka and Türkiye

South-East Asia: Brunei Darussalam; Cambodia; Indonesia; Lao People's Democratic Republic; Malaysia; Myanmar; Philippines; Singapore; Thailand; Timor-Leste and Viet Nam

Developing ESCAP region: ESCAP region excluding Australia; Japan and New Zealand

Developed ESCAP region: Australia; Japan and New Zealand

COUNTRIES WITH SPECIAL NEEDS

Least developed countries: Afghanistan; Bangladesh; Bhutan; Cambodia; Kiribati; Lao People's Democratic Republic; Myanmar; Nepal; Solomon Islands; Timor-Leste and Tuvalu. Samoa was part of the least developed countries prior to its graduation in 2014. Vanuatu was part of the least developed countries prior to its graduation in 2020.

Landlocked developing countries: Afghanistan; Armenia; Azerbaijan; Bhutan; Kazakhstan; Kyrgyzstan; Lao People's Democratic Republic; Mongolia; Nepal; Tajikistan; Turkmenistan and Uzbekistan

Small island developing States: Cook Islands; Fiji; Kiribati; Maldives; Marshall Islands; Micronesia (Federated States of); Nauru; Niue; Palau; Papua New Guinea; Samoa; Solomon Islands; Timor-Leste; Tonga; Tuvalu and Vanuatu

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References to dollars ($) are to United States dollars, unless otherwise stated. The term “billion” signifies a thousand million. The term “trillion” signifies a million million.

In the tables, two dots (..) indicate that data are not available or are not separately reported; a dash (–) indicates that the amount is nil or negligible; and a blank indicates that the item is not applicable.

In dates, a hyphen (-) is used to signify the full period involved, including the beginning and end years, and a stroke (/) indicates a crop year, fiscal year or plan year.

COUNTRY PROFILE MAP

Map source: UNmap.
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.

Acronyms and Abbreviations

AAL	Average Annual Losses
ABC Waters	Active, Beautiful, Clean Waters
ACIAR	Australian Centre For International Agricultural Research
ADB	Asian Development Bank
AI	Artificial Intelligence
ARPA-AD	ASEAN Regional Plan Of Action For Adaptation To Drought
ASEAN	Association Of Southeast Asian Nations
CamDi	Cambodia Disaster Loss And Damage Information System
CAP	Common Alerting Protocol
CDRI	Coalition Of Disaster Resilience Infrastructure
CICERO	Centre For International Climate And Environmental Research
CMIP	Coupled Model Intercomparison Project
COP27	The 27th Conference Of The Parties To The United Nations Framework Convention On Climate Change
COVID-19	Coronavirus Disease 2019
CRM	Climate Risk Management
CSR	Corporate Social Responsibility
DaLA	Loss And Damage Methodology
DEM	Digital Elevation Model
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DT	Digital Technology
EECC	Essential Emergency And Critical Care
ENEA	East And North-East Asia (ESCAP Sub-Region)
ES	Ecosystem Services
ESCAP	Economic And Social Commission For Asia And The Pacific
ETC	Emergency Telecommunications Cluster
EW4ALL	Early Warnings For All
EWS	Early Warning Systems
FAO	Food And Agriculture Organization Of The United Nations
FbF	Forecast-Based Financing
G2P	Government-To-Person
GBM	Ganga-Brahmaputra-Meghna
GCA	Global Center On Adaptation
GCRMN	Global Coral Reef Monitoring Network
GDP	Gross Domestic Product
GEE	Google Earth Engine
GIS	Geographic Information Systems
GIZ	German Agency For International Cooperation
HDI	Human Development Index
HNAP	Health National Adaptation Plans
ICIMOD	International Centre For Integrated Mountain Development
ICT	Information And Communications Technology
IEA	International Energy Agency
IFRC	International Federation Of Red Cross And Red Crescent Societies
IIED	International Institute For Environment And Development
IISD	International Institute For Sustainable Development
IMF	International Monetary Fund
INAS	Nature-Based Actions And Solutions
INDC	Intended Nationally Determined Contributions
INFORM	Index For Risk Management
IoT	Internet Of Things
IOTWMS	Indian Ocean Tsunami Warning And Mitigation System
IPCC	Intergovernmental Panel On Climate Change
IPCC AR5	Intergovernmental Panel On Climate Change Assessment Report
IPCC WGI	Intergovernmental Panel On Climate Change Working Group I
ITU	International Telecommunication Union
IUCN	International Union For Conservation Of Nature
LDC	Least Developed Country
LLDC	Landlocked Developing Country
LMF	Loss Modelling Framework

MEIDECC	Ministry Of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change, And Communications
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MHEWS	Multi-Hazard Early Warning System
ML	Machine Learning
MWICCC	Melbourne Water Industry Climate Change Committee
NAP	National Adaptation Plan
NAPA	National Adaptation Programmes Of Action
NbS	Nature-Based Solutions
NCA	North And Central Asia (ESCAP Sub-Region)
NCCHAP	National Climate Change And Health Action Plans
NDC	Nationally Determined Contributions
NDHM	National Digital Health Mission
NDMA	National Disaster Management Authority
NETP	National Emergency Telecommunication Plan
NLP	Natural Language Processing
NMHS	National Meteorological And Hydrological Service
NWP	Numerical Weather Prediction
ODA	Official Development Assistance
PCRIC	Pacific Catastrophe Risk Insurance Company
PCVA	Participatory Capacity And Vulnerability Analysis
PDNA	Post-Disaster Needs Assessments
PEOC	Penama Emergency Operation Centre
PIF	Pacific Islands Forum
PNEA	Pacific Network For Environmental Assessment
PPP	Public-Private Partnerships
RI	Rapid Intensification
RIMES	Regional Integrated Multi-Hazard Early Warning System For Africa And Asia
RISCO	Restoration Insurance Service Company
SDG	Sustainable Development Goals
SEA	South-East Asia (ESCAP Sub-Region)
SEADRIF	Southeast Asia Disaster Risk Insurance Facility
SFDRR	Sendai Framework For Disaster Risk Reduction
SHDI	Sub-National Human Development Index
SIDS	Small Island Developing States
SOFF	Systematic Observations Financing Facility
SSP	Shared Socio-Economic Pathways
SST	Sea Surface Temperatures
SSWA	South And South-West Asia (ESCAP Sub-Region)
TEEB	The Economics Of Ecosystems And Biodiversity
TERI	The Energy And Resources Institute
UN	United Nations
UNDP	United Nations Development Programme
UNDRR	United Nations Office For Disaster Risk Reduction
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention On Climate Change
V20	Vulnerable Twenty
VSAT	Very Small Aperture Terminal
WHO	World Health Organization
WIM	Warsaw International Mechanism For Loss And Damage
WMO	World Meteorological Organization

CHAPTER 1

A disaster emergency

The texture of heatmaps, made to look like satellite-imagery, reflect the need to have a science-based, systems thinking approach to disaster and climate risk reduction.

Climate change-induced disasters pose a threat more serious than previously assessed in Asia and the Pacific, which remains the most disaster-prone region in the world. A riskscape of complex, compound and cascading disasters has emerged. This chapter considers major recent disasters and disaster trends over the past fifty years to understand how disasters affect people, economies, and the environment, and forecasts their impact when the planet is 1.5°C and 2°C warmer. The research finds disasters have become more frequent and intense, and have brought tragic loss of life, displaced communities, damaged people's health and pushed millions into poverty. While fewer disasters struck in 2021 and 2022 compared to the previous decade, their impact is being made evermore devastating by climate change.

Disasters are unevenly distributed across the Asia-Pacific region. Their impacts are most consequential in the least developed countries where critical infrastructure, vulnerable urban dwellers, and populations dependent on subsistence agriculture are more exposed. Risks in existing disaster hotspots are forecasted to intensify, and new disaster hotspots are to appear, particularly in the north of the region. Areas vulnerable to transboundary disasters will see hazards, such as floods, drought and heatwaves, intensify, undermining populations' resilience, food security and energy systems. Climate-induced risk is outpacing the region's resilience. Increased investment is needed to strengthen this resilience nationally and locally, and to build and maintain effective early warning systems in Asia and the Pacific.

1.1 Disaster events: 2021-2022

Fewer disaster events occurred in 2022 compared to the recent ten-year period but their impact was devastating.[1] In 2022, over 140 disaster events occurred in the Asia-Pacific region which caused over 7,500 deaths, affected over 64 million people, and brought economic damage estimated to be over $57 billion (Table 1.1). Flooding led to the greatest loss of life and was the cause of over 4,800 fatalities primarily in India, Pakistan, Afghanistan, Nepal, and in Bangladesh. The two deadliest flooding events, in 2022, occurred in India and Pakistan, which alone accounted for almost 80 per cent of the total yearly mortality related to disasters. Flooding was also the disaster which affected the highest number of people in 2022, affecting 33 million people in Pakistan alone. Earthquakes also caused significant damage, with losses estimated at $12 billion, occurring primarily in Japan, China, Philippines, and the Islamic Republic of Iran. The following paragraphs describe the major disasters that swept across Asia and the Pacific in 2021 and 2022.

TABLE 1.1 Disaster impacts in Asia and the Pacific, 2022

Disaster type	Total number of fatalities	Total number of people affected	Total economic losses, adjusted (US$)
Flood	4,877	45,846,142	$34 billion
Earthquake	1,611	3,538,291	$12.1 billion
Tropical cyclone	605	7,297,397	$3.4 billion
Other	318	1,235,551	$0.2 billion
Heatwave	107	28,505	N/A
Drought	n/a	6,104,480	$7.6 billion
Total	7,518	64,050,366	$57.3 billion

Source: EM-DAT, The International Disaster Database, 2009. Available at https://www.emdat.be (accessed on 14 June 2023).
Note: some numbers are still under assessment, for example economic losses caused due to heat.

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[1] Historical disaster events from EM-DAT include flood, drought, tropical cyclone, heatwave, earthquake, and tsunami. Some disaster events, including cold wave, landslide, and glacial lake outbursts are grouped together under "other" category. Note: some disaster event types, such as animal accidents, epidemics, and insect infestation are not included as disaster events for this analysis.

HEATWAVES: INDIA AND PAKISTAN

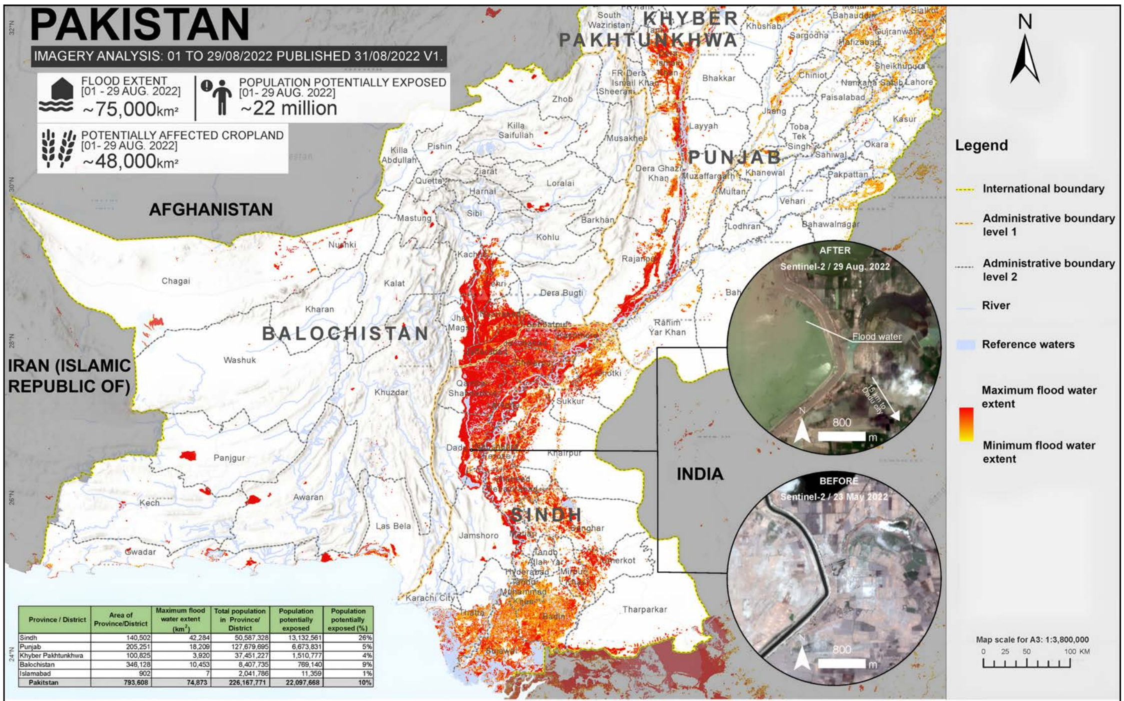
In April and May 2022, an unprecedented, early, prolonged and dry heatwave affected large parts of North India and Pakistan. India recorded its warmest March on record, with an average maximum temperature of 33.1°C. This was 1.86°C above the long-term average. Pakistan also recorded its warmest March in 60 years (Zachariah and others, 2022). Although the health-related economic impact from the heatwave will take time to assess, early reports have attributed at least 90 deaths to this heatwave in both countries, and an estimated 10-35 per cent reduction in crop yields in Haryana, Uttar Pradesh, and Punjab (Zachariah and others, 2022). Furthermore, the probability of a heatwave of such magnitude has increased by a factor of 30, and as global warming increases, heatwaves of this kind will become hotter and more common (Zacharia and others, 2022).

FLOODING: INDIA, BANGLADESH, PAKISTAN AND CHINA

In India, heavy rainfall from May to September 2022 triggered multiple landslides, river overflows and floods which resulted in casualties and damage. Heavy monsoon rains affected especially the north-eastern parts of India and Bangladesh (Reliefweb, 2023b). This disaster caused the highest number of fatalities between 2021 and 2022 (EM-DAT, 2009).

In Pakistan, flooding from sea-like waters, between June and September in 2022, affected millions of people and wreaked havoc. Pakistan received 60 per cent of its total normal monsoon rainfall in just three weeks at the start of the monsoon season in 2022. The heavy rains resulted in urban and flash floods, landslides, and glacial lake outburst floods across the country. The flooding was especially severe in Balochistan, Khyber Pakhtunkhwa, and Sindh provinces (Reliefweb, 2023d). According to National Disaster Management Authority (NDMA), more than 33 million people, almost 14 per cent of the 2022 population, were affected, over 1,730 people perished, and almost 8 million people were displaced. In addition to the direct impact on people, the flood caused widespread damage to critical infrastructure, houses, and livestock. Many of those affected have moved to places without infrastructure or adequate shelter, often in areas surrounded by flood waters (Reliefweb, 2023e). The total economic damage from this flooding is still under assessment, but the damage is estimated to be over $30 billion (UNDP, 2023b).

FIGURE 1.1 Satellite detected water extents between 1 and 29 August 2022 over Pakistan



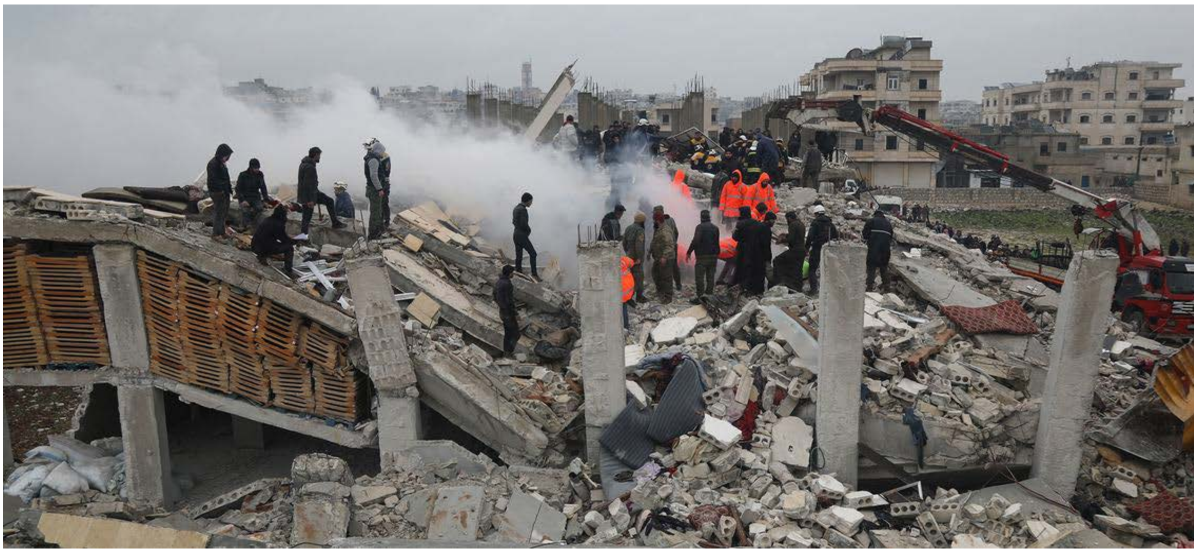
Province / District	Area of Province/District	Maximum flood water extent (km^2)	Total population in Province/ District	Population potentially exposed	Population potentially exposed (%)
Sindh	140,502	42,284	50,587,328	13,132,561	26%
Punjab	205,251	18,209	127,679,695	6,673,831	5%
Khyber Pakhtunkhwa	100,825	3,920	37,451,227	1,510,777	4%
Balochistan	346,128	10,453	8,407,735	769,140	9%
Islamabad	902	7	2,041,786	11,359	1%
Pakitstan	**793,608**	**74,873**	**226,167,771**	**22,097,668**	**10%**

Source: Analysis by UNITAR - UNOSAT on NOAA-20/VIIRS Sateliite Data, Imagery date: 01 to 29 August 2022; NOAA; Sentinel-2; OpenStreetMap; Worldpop (https://reliefweb.int/map/pakistan/satellite-detected-water-extents-between-01-and-29-august-2022-over-pakistan-imagery-analysis-01-29082022-published-31082022-v1)
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsment or acceptance by the United Nations.

Source: United Nations Satellite Centre (UNOSAT), "Satellite detected water extents between 01 and 29 August 2022 over Pakistan – Imagery Analysis: 01 to 29/08/2022", 31 August 2022. Available at https://reliefweb.int/map/pakistan/satellite-detected-water-extents-between-01-and-29-august-2022-over-pakistan-imagery-analysis-01-29082022-published-31082022-v1

Record rainstorms swept across central China, between June and August 2021, especially in the Henan province, but also in the inner Mongolia and Shaanxi provinces. The water levels of small- and medium-sized rivers and reservoirs in the Yellow River and Haihe River basins have risen rapidly, and large-scale urban waterlogging and farmland flooding have occurred (Xinhua, 202). This flooding caused over 350 deaths, affected 14.5 million people or over 1 per cent of the country's population in 2021. It caused an estimated economic damage of $17.8 billion, the highest economic losses in the Asia-Pacific region between 2021 and 2022 (EM-DAT, 2009).

BOX 1.1 2023 Türkiye-Syria Earthquake ("Kahramanmaraş earthquakes")



Source: Ali Haj Suleiman, "UN agencies launch emergency response after devastating Türkiye and Syria quakes", UNOCHA, 6 February 2023. Available at https://news.un.org/en/story/2023/02/1133177

Two earthquakes of magnitude 7.8 and 7.7 struck southern and central Türkiye, and northern and western Syria on 6 February 2023. The second shock came nine hours after the first, and both were followed by more than 7,500 aftershocks. The affected regions already had some of the highest poverty rates in Türkiye and hosted almost 50 per cent of the Syrian refugee population in the country.[a] In Türkiye, the 11 most impacted provinces have been designated by the authorities as "disaster areas", and these provinces are home to around 14 million people, or 16.5 per cent of the country's population. As of 4 March 2023, over 45,000 people lost their lives, and at least 115,000 people were injured. An estimated 2.7 million people have been displaced due to these earthquakes.[b]

Based on a Global Rapid Post-Disaster Damage Estimation Report, released on 20 February 2023, the direct damages in Türkiye are estimated to be US$ 34.2 billion, equivalent to 4 per cent of the country's GDP in 2021.[c] As this figure does not include estimated indirect and secondary impacts, the actual recovery and reconstruction costs are expected to be much larger, potentially twice as large. The GDP losses associated with economic disruptions will add to the cost of the disasters. The greatest portion of the estimated direct cost is attributable to damages of residential buildings (53 per cent), followed by damage in infrastructure (19 per cent).[d]

[a] World Bank, "Earthquake Damage in Türkiye Estimated to Exceed $34 billion: Work Bank Disaster Assessment Report", 27 February 2023a. Available at https://www.worldbank.org/en/news/press-release/2023/02/27/earthquake-damage-in-turkiye-estimated-to-exceed-34-billion-world-bank-disaster-assessment-report. (accessed on 6 March 2022).

[b] Reliefweb, "Türkiye – Earthquake: Emergency Situation Report, 3 March 2023", 2023g. Available at https://reliefweb.int/report/turkiye/turkey-earthquake-emergency-situation-report-03032023#:~:text=According%20to%20the%20latest%20statement,115%2C000%20people%20were%20injured. (accessed on 6 March 2023).

[c] Rashmin Gunasekera, and others, "Global Rapid Post-Disaster Damage Estimation (GRADE) Report: 6 February 2023 Kahramanmaraş Earthquakes – Türkiye Report (English)", (Washington D.C.: World Bank, 2023). Available at https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099022723021250141/p1788430aeb62f08009b2302bd4074030fb

[d] United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Our Work: ICT and Disaster Risk Reduction", n.d. Available at https://www.unescap.org/our-work/ict-disaster-risk-reduction

EARTHQUAKE: JAPAN

Off the coast of Fukushima Prefecture, a strong earthquake occurred on 16 March 2022. The epicentre was located about 50 km east of coastal Minamisoma City. A small tsunami of up to 0.3 m was recorded in the coastal areas in Miyagi and northern Fukushima (Reliefweb, 2023c). This event caused 3 deaths, affected over 740 people and caused an estimated economic loss of over $8.8 billion. This was the third highest level of economic damage in the Asia-Pacific region between 2011 and 2021 (EM-DAT, 2009).

VOLCANIC ERUPTION AND TSUNAMI: TONGA

The Hunga-Tonga-Hunga-Ha'apai volcano erupted on 15 January 2022 triggering tsunami waves of up to 15 km and ashfall which covered an area of at least 5 km^2. Although only three direct and one indirect fatality have been linked to the eruption and the tsunami, houses, roads and other infrastructure suffered severe damage, including international and domestic telecommunications and underwater infrastructure. According to an early government estimate, around 84 per cent of the population on Tongatapu, Ha'apai and 'Eua were affected, particularly by ashfall. Around 3,000 people were displaced in the immediate aftermath (Reliefweb, 2023f).

DROUGHT: AFGHANISTAN

Afghanistan has been experiencing below-normal rainfall since October 2020, which has continued throughout 2021 and 2022. The dry conditions have affected the winter season snow accumulation, which is critical for water access during the spring and summer agricultural seasons. On 22 June 2021, the Government of Afghanistan officially declared a drought in the country (Reliefweb, 2023a). The dry conditions are ongoing and the drought is estimated to have affected over 11 million people, or over 27 per cent of the country's population in 2021 (EM-DAT, 2009).

BOX 1.2 2023 Vanuatu Cyclone

Two destructive category 4 Tropical Cyclones, Judy and Kevin, and an earthquake with a magnitude of 6.6 impacted over 80 per cent of the Vanuatu population between 1-4 March 2023. The first storm, Tropical Cyclone Judy made landfall on the main island Efate in Vanuatu, damaging buildings, power lines and other infrastructure.[a] Over 167,000 people are estimated to be affected by Tropical Cyclone Judy and more than 50 per cent of houses were damaged in rural Efate Island.[b] Damage assessment had to be put on hold for the country as it braced itself for a second typhoon, Cyclone Kevin. In addition to the cyclones, the earthquake caused severe damage with its epicentre approximately 20 km west of the eastern coast of Espiritu Santo Island in the north of the country.[c] This was the first time that the island was struck by such cascading and compounding disaster events simultaneously. Cyclone hazards intensified and deviated from their traditional tracks due to climate change, hampering forecasts and adequate preparations.

The twin cyclones and an earthquake in just 48 hours are a reminder that seismic and climate risks are *converging and intensifying*. Indeed, no communities felt this more acutely than those in the Pacific region.[d]

[a] Reliefweb, "Vanuatu capital battered by hurricane force winds as Cyclone Judy intensifies and heads south", 1 March 2023h. Available at https://reliefweb.int/report/vanuatu/vanuatu-capital-battered-hurricane-force-winds-cyclone-judy-intensifies-and-heads-south. (accessed on 6 March 2023).

[b] International Federation of the Red Cross and Red Crescent Societies (IFRC), "Vanuatu Tropical Cyclone Judy and Kevin 2023 – DREF Application", 2023. Available at https://reliefweb.int/report/vanuatu/vanuatu-tropical-cyclone-judy-and-kevin-2023-dref-application-mdrvu010 and Global Disaster Alert and Coordination System (GDACS), "Overall Red alert Tropical Cyclone for Judy-23", 2023. Available at https://www.gdacs.org/Cyclones/report.aspx?eventtype=TC&eventid=1000965&system=JTWC

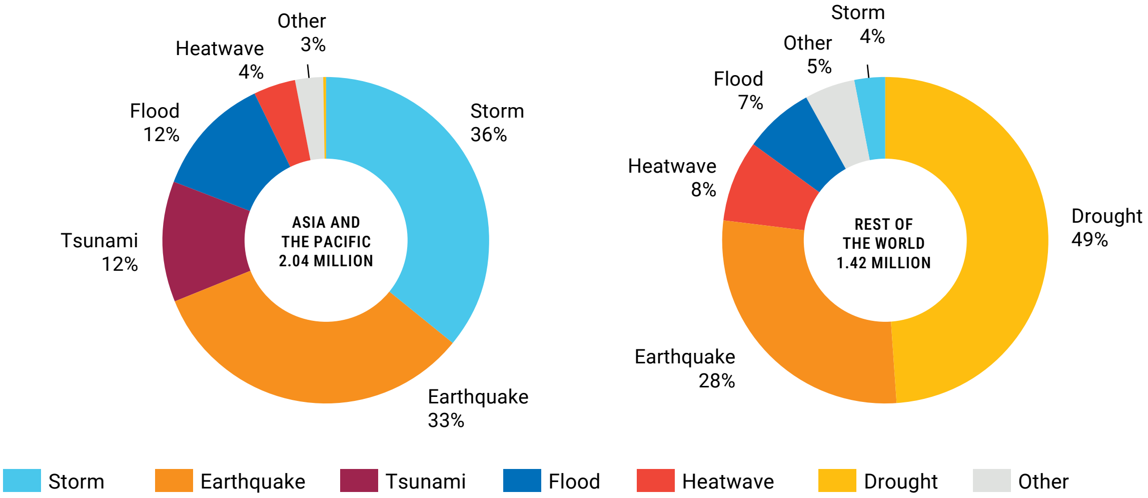
[c] Reliefweb, "Vanuatu – Tropical cyclones update and earthquakes", 3 March 2023i. Available at https://reliefweb.int/report/vanuatu/vanuatu-tropical-cyclones-update-and-earthquakes-gdacs-jtwc-vmgd-reliefweb-usgs-echo-daily-flash-03-march-2023. (accessed on 9 March 2023).

[d] United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Our Work: ICT and Disaster Risk Reduction", n.d. Available at https://www.unescap.org/our-work/ict-disaster-risk-reduction

Disaster trends: 1970-2022

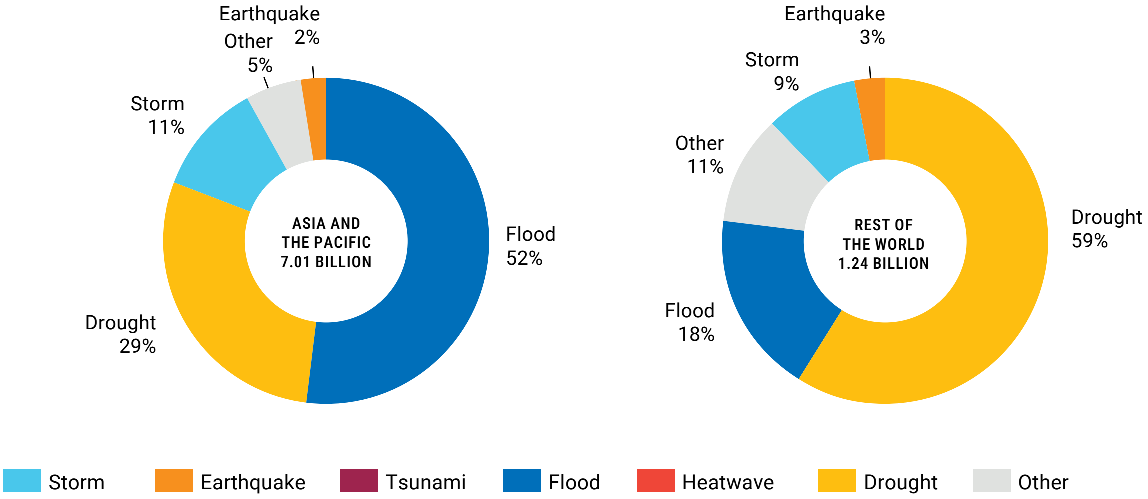
Asia and the Pacific remains the most disaster-prone region in the world.[2] Since 1970, disasters in Asia and the Pacific have resulted in over 2 million fatalities, which is almost 60 per cent of the global disaster death toll. This is equivalent to 105 lives being lost every day or one life every 13 minutes. In the rest of the world, the average number of fatalities per disaster is 191, whereas in Asia and the Pacific, this number is much higher at 338. As indicated in Figure 1.2, the principal causes of fatalities from natural hazards, in Asia and the Pacific, were storms and earthquakes, followed by tsunami and floods. In the rest of the world, the pattern was different, and the death toll lower. In Africa, drought was the most lethal disaster, followed by floods.

FIGURE 1.2 Number of fatalities from disasters in the Asia-Pacific region and the rest of the world, 1970-2022



Source: EM-DAT, The International Disaster Database, 2009. Available at https://www.emdat.be (accessed on 14 June 2023).

FIGURE 1.3 Number of people affected from disasters in the Asia-Pacific region and the rest of the world, 1970-2022



Source: EM-DAT, The International Disaster Database, 2009. Available at https://www.emdat.be (accessed on 14 June 2023).

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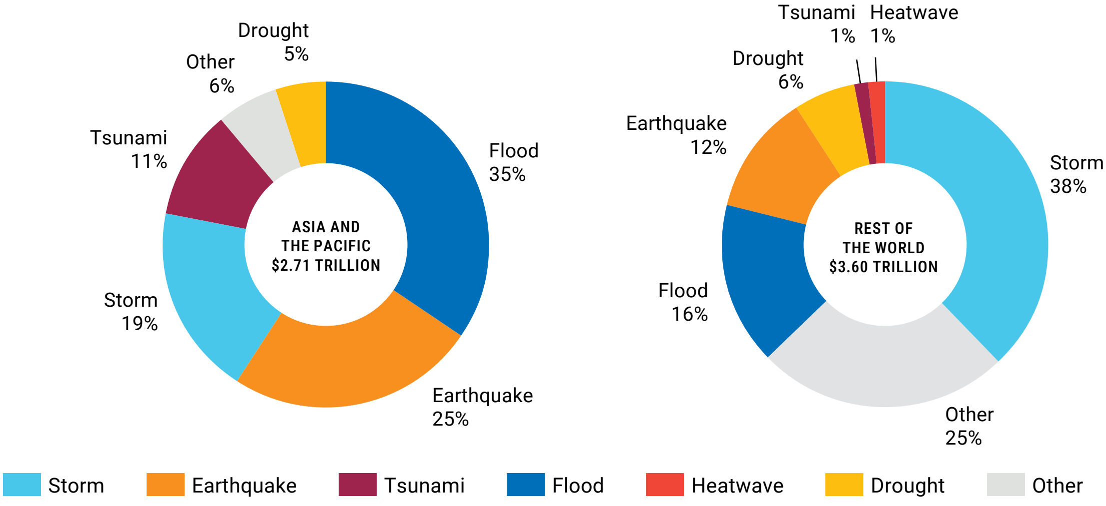
[2] EM-DAT data were used for historical climate impact calculations: www.emdat.be. EM-DAT is a global database on natural and technological disasters, containing essential core data on the occurrence and effects of more than 21,000 disasters in the world, from 1900 to the present. EM-DAT is maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at the School of Public Health of the Université catholique de Louvain located in Brussels, Belgium.

FIGURE 1.4 Economic damage from disasters in the Asia-Pacific region and the rest of the world, 1970-2022

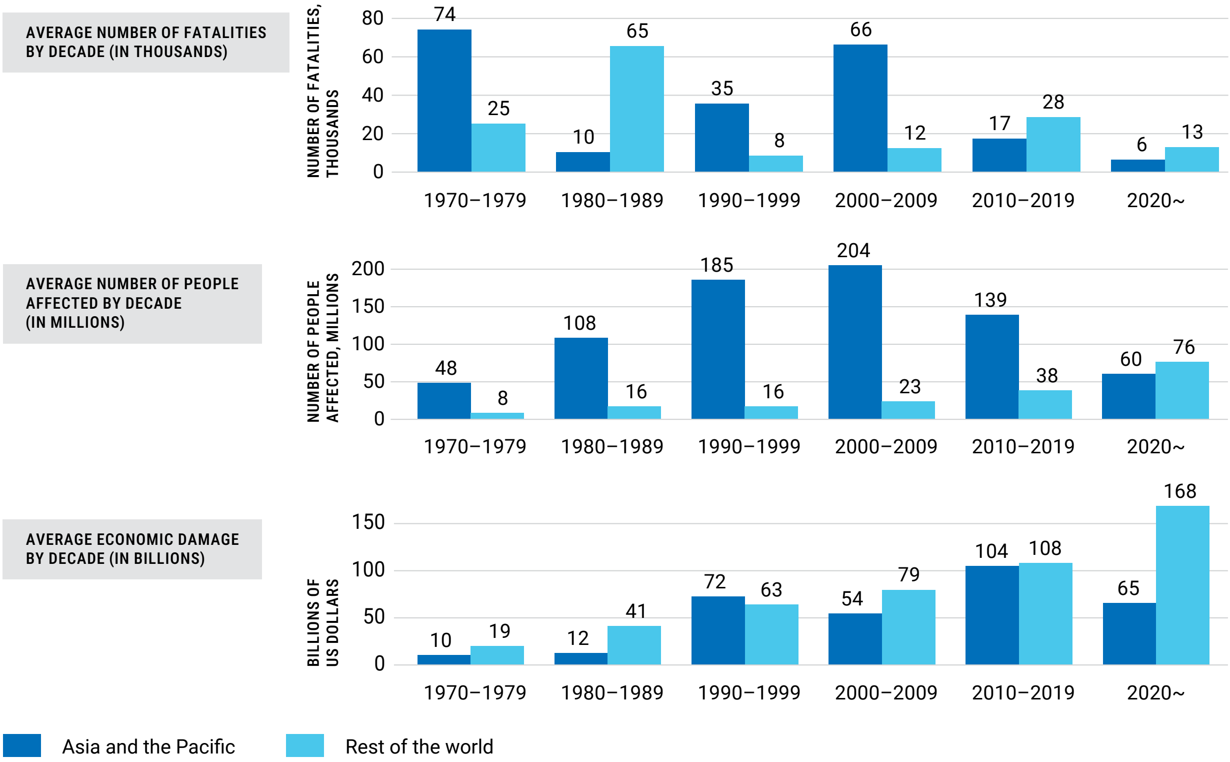


Source: EM-DAT, The International Disaster Database, 2009. Available at https://www.emdat.be. (accessed on 14 June 2023).
Note: some numbers are still under assessment, for example economic losses caused due to heat.

DECLINING DISASTER FATALITIES

Since 2020, the Asia-Pacific region has experienced a downward trend in the number of fatalities in recent decades and a declining number of people being affected by natural disasters. Comparing the average of the year 2020 onwards to the preceding decade, there has been a decrease of 63 per cent in the number of fatalities, 57 per cent in the number of people affected, and 38 per cent in economic damage. This decrease is a result of the efforts made to enhance forecasts, raise awareness and build resilience in the region. However, there is a great deal of variation between the different subregions of Asia and the Pacific.

FIGURE 1.5 Average number of fatalities, number of people affected, and economic damage by decade



Source: EM-DAT, The International Disaster Database, 2009. Available at https://www.emdat.be. (accessed on 14 June 2023).
Note: some numbers are still under assessment, for example economic losses caused due to heat.

MOST IMPACTED SUBREGIONS

Asia and the Pacific is a vast region exposed to complex and diverse risks. These risks are clustered in hotspots with fragile environments and critical vulnerabilities. Yet different areas have specific types of exposure.

South and South-West Asia is the subregion with the highest death toll as a share of population over the past fifty years. Across the region, disaster fatalities are unevenly distributed. More than 1 million, or 50 per cent of the fatalities, are from South and South-West Asia (SSWA), followed by East and North-East Asia (ENEA), South-East Asia (SEA), North and Central Asia (NCA), the Pacific small island developing States (SIDS), and lastly the Pacific countries of Australia and New Zealand (Table 1.2).

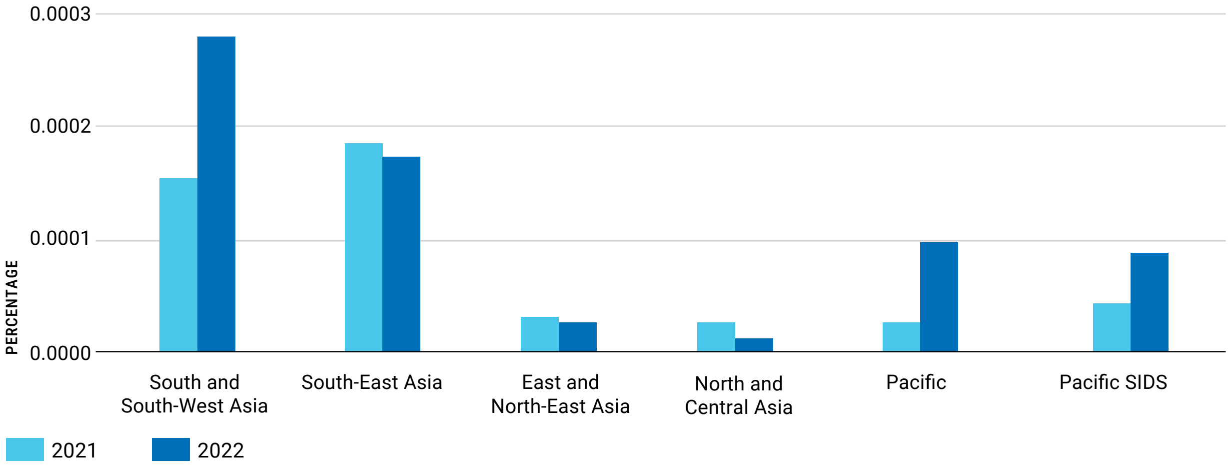
TABLE 1.2 Sum of disaster mortality in the Asia-Pacific subregions

Decades	East and North-East Asia	North and Central Asia	Pacific	Pacific small island developing States	South-East Asia	South and South-West Asia
1970	297,598	n/a	175	508	18,966	422,109
1980	24,376	n/a	230	431	17,352	57,697
1990	35,610	5,480	151	2,760	29,746	278,179
2000	101,102	2,312	601	685	340,471	216,145
2010	38,292	56,689	471	468	26,634	47,576
2020	1,614	95	40	119	3,420	13,362

Source: EM-DAT, The International Disaster Database, 2009. Available at https://www.emdat.be (accessed on 14 June 2023).

In 2021, and as a percentage of the population, the South-East Asia subregion had the highest number of fatalities, followed by South and South-West Asia (Figure 1.6).[3] In 2022, South and South-West Asia had the highest number of fatalities as a percentage of the population followed by the South-East Asia. These two subregions had significantly higher number of fatalities as a percentage compared to other subregions, where people in South and South-West Asia were more than two times more likely to perish due to natural hazards than people in the Pacific.

FIGURE 1.6 Number of fatalities as a percentage of population by subregion



Source: EM-DAT, The International Disaster Database, 2009. Available at https://www.emdat.be (accessed on 14 June 2023).

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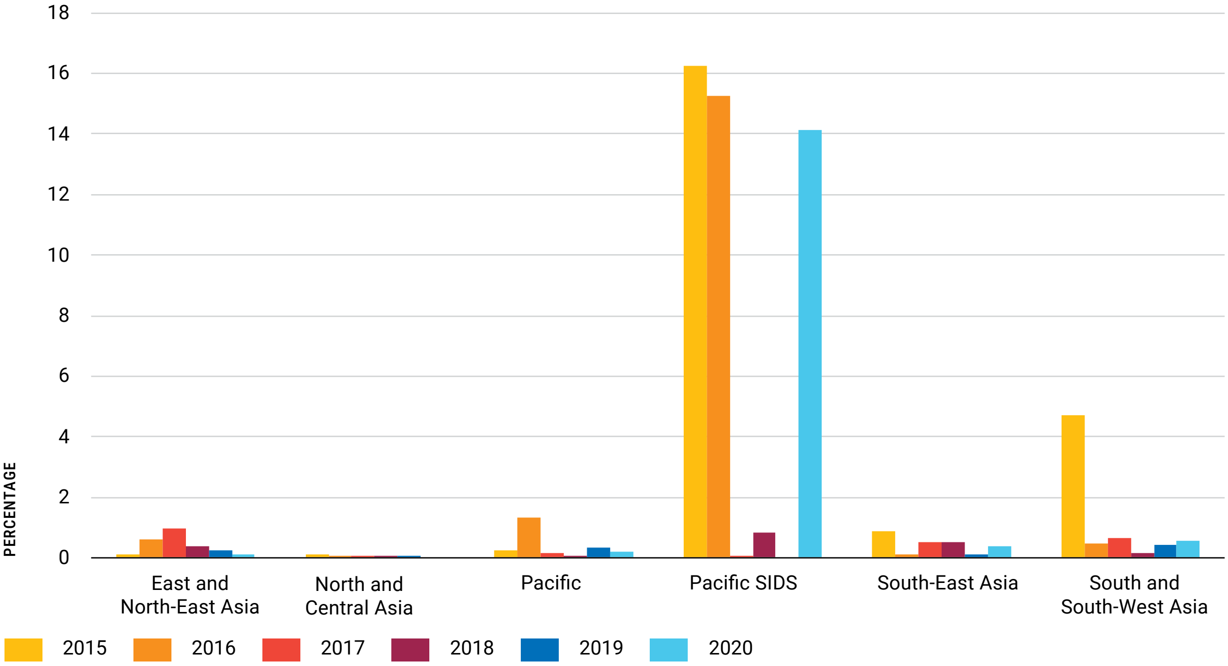
[3] Fatality numbers from EM-DAT, available at https://www.emdat.be and 2022 population numbers from SDG Gateway, available at https://data.unescap.org/home. Both data are for 2021.

Asia and the Pacific is the region which suffers the highest share of economic losses caused by disasters as a percentage of GDP, followed by Africa (UNDRR, 2022). Within the region, between 2015 and 2020, the subregion of the Pacific SIDS suffered the highest economic losses as a percentage of GDP,[4] with an average loss of almost 9 per cent of GDP. This was much higher than South and South-West Asia which had an average loss of 7 per cent. In most subregions, the average loss has been on a downward trend although there were yearly variations, often determined by big disaster events. For example, the Pacific SIDS saw a significant increase in average economic losses in 2020. This was largely due to Tropical Cyclone Harold in Tonga, which alone caused an estimated economic damage of over $125 million or almost 28 per cent of the country's GDP for that year.

FIGURE 1.7 Average economic loss as a percentage of GDP



Source: EM-DAT, The International Disaster Database, 2009. Available at https://www.emdat.be (accessed on 14 June 2023).

DISPROPORTIONAL IMPACTS IN LEAST DEVELOPED COUNTRIES (LDC)

Eleven of the world's 46 low-income countries are in Asia and the Pacific. These countries face severe structural impediments to sustainable development. Given their pre-existing vulnerabilities, it is particularly challenging for low-income countries to prepare for and cope with natural hazards. In 2021 and 2022, there were a total of 39 disaster events in these 11 low-income countries which caused over 2,400 deaths, affected over 22 million people and caused an estimated economic loss of $462 million. The three most deadly disaster events all occurred in Afghanistan followed by a flood in Bangladesh. The larger impact of natural hazards on the low-income countries is highlighted by the much higher percentage of mortality rates in the LDC populations in the Asia-Pacific region. In 2021 and 2022, mortality rates were up to five and eight times higher than in other countries.

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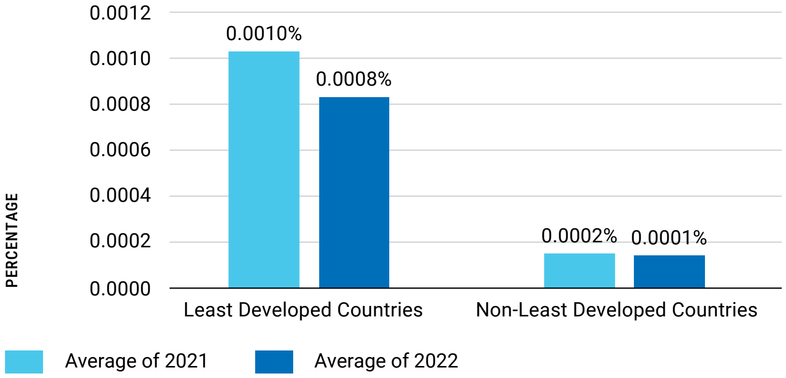
[4] Data on economic losses from EM-DAT, available at https://www.emdat.be and constant GDP numbers are from SDG Gateway, available at https://data.unescap.org/home. Note: average economic loss as a percentage of GDP is calculated first by taking the percentage of each country then by taking an average of the subregion, excluding countries with no available data.

FIGURE 1.8 Number of fatalities as a percentage of population in LDC and non-LDC in the Asia-Pacific region



Source: EM-DAT, The International Disaster Database, 2009. Available at https://www.emdat.be (accessed on 14 June 2023).

FOOD AND CRITICAL INFRASTRUCTURE MOST IMPACTED BY DISASTERS

The Post-Disaster Needs Assessments (PDNA) in Asia and the Pacific shows that almost 40 per cent of disaster impacts were on infrastructure and agriculture, with subsistence livelihoods most affected (ESCAP, 2019; UNDRR, n.d., a). In 2022, unprecedented floods in Pakistan demonstrated the vulnerability of food production and infrastructure. According to the PDNA on the Pakistan floods, the agriculture sector is projected to decline the most at 0.9 per cent of the 2022 GDP from the total projected 2.2 per cent decline (UNDP, 2023a). The direct damage to the agriculture sector is expected to have spillover effects in other areas. For example, decreased cotton production will impact the textile industry, which accounts for around a quarter of total industrial output and over half of the country's exported goods. To support the recovery, 33 per cent of the estimated $16 billion required is needed for infrastructure repair, in particular for transport, communication and energy.

CLIMATE CHANGE ATTRIBUTED TO EXTREME EVENTS

Attribution science is unequivocal: climate change has caused numerous extreme weather events and climatological disasters over the past decade. Attribution science is an emerging field of climate science which aims to understand and estimate the links between climate change and extreme weather events; how human-induced climate change affects the magnitude and probability of a disaster event. Research in this field can help understand whether climate change contributed to making some extreme events more severe and more likely to occur, and if so to what extent (UNDRR, n.d., b).

The World Weather Attribution study, released on 14 September 2022, revealed that climate change caused the extreme monsoon rainfall in Pakistan (World Weather Attribution, 2022). Bangladesh and India experienced floods in 2022, which affected 7.2 million and 1.3 million people, respectively. From June to August 2022, China experienced its most severe heatwave on record, dramatically lowering the water levels of the Yangtze river and adversely impacting the national energy sector. Events such as these demonstrate the systemic nature of risk and highlight the need for governance that is anticipatory; capable of preparing for future uncertainties, rather than reactionary and merely responding to what has already occurred.

The following section demonstrates how climate change will impact the riskscape of the Asia-Pacific region.

1.2 The riskscape of climate change under shared socioeconomic pathways

Given that a large share of the global population lives in the Asia-Pacific region, that the region is also responsible for a large share of greenhouse gas emissions, and is also highly vulnerable to the impacts of climate change, the global fight against climate change will be won or lost in the region (Deloitte, 2022). Transformative and forward-looking, risk-informed development and methods for working with alternative futures are needed in addition to the current risk models which are heavily based on hindsight.

ESCAP analysis therefore focuses on understanding the risks in the current context and future warming scenarios. New, sensitive climate models have emerged under "Shared Socioeconomic Pathways" which include information on how global society, demographics and economics might change over the next century.

Mitigation and adaptation lie at the heart of the Sharm-El-Sheikh Plan of the COP27. This *Asia-Pacific Disaster Report 2023* will therefore primarily focus on Shared Socioeconomic Pathway 3 (high challenges for adaptation and mitigation) and scenarios demonstrating how climate change of 1.5°C warming and 2°C warming in the Asia-Pacific region will: (i) shift exposures to key climate hazards of floods, drought, tropical cyclones and heatwaves; (ii) intensify or expand population, infrastructure and other key risk hotspots; and (iii) examine the cost of inaction if strategic foresight is not considered in development planning.

BOX 1.3 SSP3 Regional Rivalry – A Rocky Road (High challenges to mitigation and adaptation)

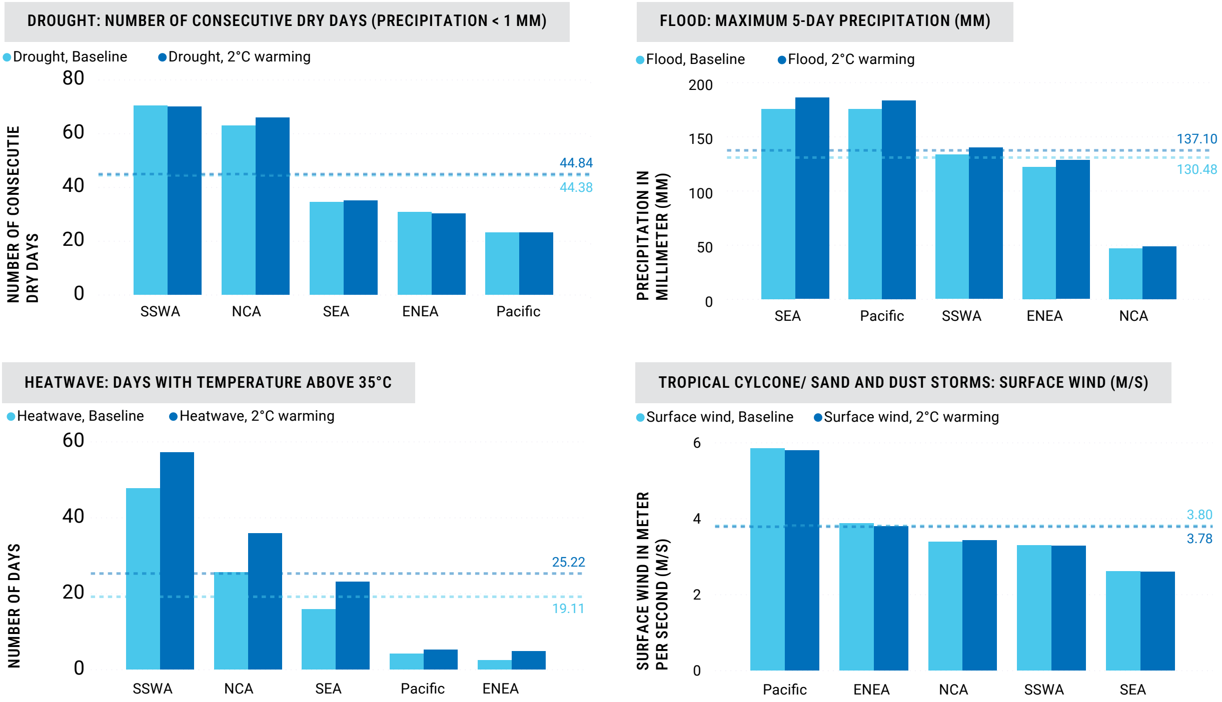
Resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own region at the expense of broader-based development. Investments in education and technological development are in decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialized countries and higher in developing countries. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.[a]

[a] Zeke Hausfather, "Explainer: How 'Shared Socioeconomic Pathways' explore future climate change", Carbon Brief, 19 April 2018. Available at https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change/

1.2.1 Current and future climate risk hotspots

The mean global surface temperature has risen by approximately 1.1°C since the beginning of the Industrial Revolution (IPCC, 2023). The last decade has been characterized by a surge in weather extremes (Rahmstorf and Coumou, 2011; Coumou and Rahmstorf, 2012). Robust evidence exists for a significant increase in the occurrence of heat waves and heavy rainfall events at the global scale (Coumou and Rahmstorf, 2013; Lehmann, Coumou and Frieler, 2015). Global warming has already been attributed to an exceptional number of unprecedented climate extremes in the Asia-Pacific region. The changes in extreme events from climate warming under 1.5°C and 2°C are displayed in Figure 1.9. The analysis reveals that heatwaves will increase in the region from the baseline period (1995-2015) to 2°C scenario with, on average, a 32 per cent increase in days with temperatures above 35°C. In the case of floods, up to 5 per cent increase in average rainfall can be expected.

FIGURE 1.9 Changes in extreme weather caused by global warming of 1.5°C and 2°C in the ESCAP subregions


DROUGHT: NUMBER OF CONSECUTIVE DRY DAYS (PRECIPITATION < 1 MM)

FLOOD: MAXIMUM 5-DAY PRECIPITATION (MM)

HEATWAVE: DAYS WITH TEMPERATURE ABOVE 35°C

TROPICAL CYLCONE/ SAND AND DUST STORMS: SURFACE WIND (M/S)

Source: ESCAP.

Note: ENEA = East and North-East Asia, NCA = North and Central Asia, SEA = South-East Asia, SSWA = South and South=West Asia, Pacific SIDS = Pacific small island developing States.

There is significant variation in the way in which changes and increases in extreme weather manifest themselves due to the complexity and multiple interacting factors caused by climate change, (Figure 1.11). The riskscape of hotspots is shifting under global warming of 1.5°C and 2°C. Under these scenarios, the risk of hazards in existing and known hotspots are likely to intensify, and entirely new risk hotspots could also emerge. The components and investments in long-term resilience required to respond to these new riskscapes differ vastly for countries in the region.

Using the global models (CMIP 6) from the Intergovernmental Panel on Climate Change (IPCC) (IPCC, n.d.), ESCAP analysed how the impact of 1.5°C and 2°C warming will change the region's climate hazard riskscape from its current state. Table 1.3 lists the areas of existing risk and areas of intensifying and emerging risks under 1.5°C and 2°C warming for four climate hazards: drought, floods, heatwaves, and surface winds (proxy for tropical cyclones in the coastal regions and, inland sand and dust storms). Each Asia-Pacific subregion has its own specific set of existing, intensifying, and emerging risks from hazards that are analysed in Table 1.3 in more detail. The multi-hazard analysis, however, highlights the following key points:

1. Existing areas vulnerable to transboundary disasters will see an intensification of hazards: floods, drought, heatwaves, in existing hotspots. These areas include the Ganges-Brahmaputra-Meghna basin, the Mekong River basin, the Indus basin and the Aral Sea basin.
2. Countries situated in the Ring of Fire, a string of volcanoes and sites of seismic activity around the edges of the Pacific Ocean, will experience risks of climate hazards, such as flooding and tropical cyclones under both 1.5°C and 2°C levels of warming, in addition to the existing risk of tectonic shifts and earthquakes.
3. Large swathes of the north of the Asia-Pacific region are poised to become areas of major emerging risk primarily because of heatwaves, with significant impacts on populations, food security and energy systems.

A foresight-based approach is needed to address the risk hotspots. Countries must continue to invest in building disaster resilience locally and nationally, including in the maintenance of early warning systems in existing risk hotspots. To respond to intensifying risk hotspots, such as in countries situated in the Ring of Fire, it is imperative to enhance current investments in early warning systems, strengthen existing regional and subregional cooperation mechanisms, and augment good practices in nature-based solutions. Where new risk hotspots are emerging, as in the north of the Asia-Pacific region, new investments are needed in early warning systems and nature-based solutions, and new multi-hazard regional and subregional cooperation mechanisms must be established to protect livelihoods and development gains.

TABLE 1.3 Existing, intensifying and emerging hotspots of multi-hazard risk

Subregion	Existing hotspots of multi-hazard risk (Baseline scenario)	Hotspots of intensifying multi-hazard risk (1.5°C)	Hotspots of intensifying multi-hazard risk (2°C)	Hotspots of emerging multi-hazard risk (1.5°C)	Hotspots of emerging multi-hazard risk (2°C)
South and South-West Asia	Medium to high risk in Ganges-Brahmaputra-Meghna basin, and Indus basin. High to very high risk in large parts of India, Pakistan, Afghanistan, the Islamic Republic of Iran, and some parts of Türkiye.	Parts of Ganges-Brahmaputra-Meghna basin, Afghanistan, the Islamic Republic of Iran, Türkiye	Parts of Ganges-Brahmaputra-Meghna basin, Indus basin, Afghanistan, Islamic Republic of Iran, Türkiye, Sri Lanka	Nepal, Türkiye, North India	Nepal, Türkiye, North India, Bhutan
East and North-East Asia	Medium risk in China, Japan, the Democratic People's Republic of Korea, the Republic of Korea, Mongolia, the Russian Federation	Parts of China	Parts of China	Ring of Fire; parts of China, Japan, the Russian Federation, Mongolia, the Democratic People's Republic of Korea, the Republic of Korea	Ring of Fire; parts of China, Japan, the Russian Federation, Mongolia, the Democratic People's Republic of Korea, the Republic of Korea
South-East Asia	Medium to high risk in the Mekong River basin, parts of Indonesia and Timor-Leste	Mekong River basin	Mekong River basin, Indonesia	Ring of Fire; Indonesia	Ring of Fire; Indonesia, Malaysia, Singapore
North and Central Asia	Medium to high risk in the countries in Aral Sea basin	Aral Sea basin	Aral Sea basin, Turkmenistan	Uzbekistan, northern parts of Kazakhstan, Kyrgyzstan	Uzbekistan, northern parts of Kazakhstan, Kyrgyzstan
Pacific	Medium to very high risk in Australia; medium risk in Papua New Guinea, New Caledonia, Vanuatu, Solomon Islands, Fiji	Australia	North and western parts of Australia, New Caledonia	Australia, New Zealand, Pacific SIDS- Papua New Guinea, Samoa	Australia, New Zealand; Pacific SIDS- Papua New Guinea, Kiribati, Samoa, Fiji, Nauru

Source: ESCAP.

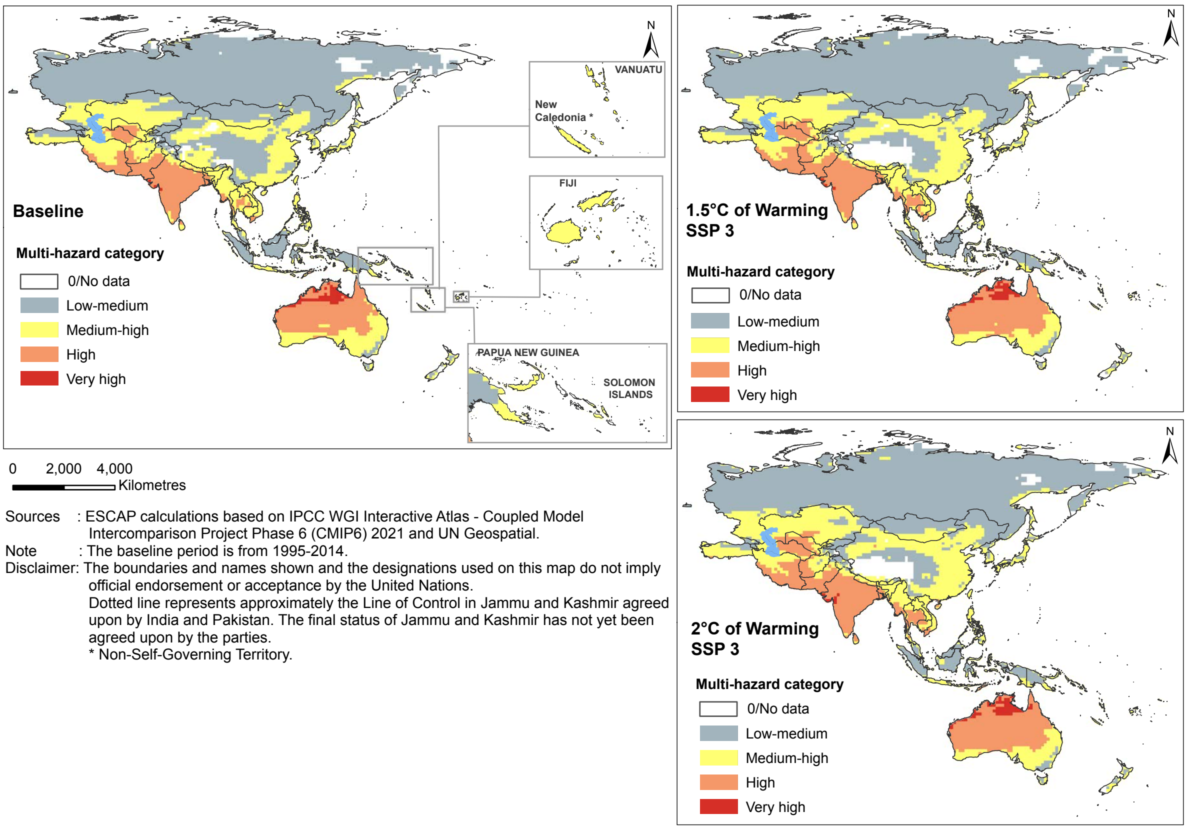
1.2.2 Multi-hazard risk hotspots under 1.5°C and 2°C SSP3 scenarios for drought, floods, heatwaves, and surface winds

Hotspots of <u>existing</u> multi-hazard risk: Figure 1.10 displays the hotspots of existing compounded risk from multiple climate hazards as compared to those under a 1.5°C and 2°C warming. The region is already under high risk from multiple hazards and many of these hotspots will continue under the 1.5°C and 2°C warming as well. These are hotspots where countries must continue to invest and maintain existing investments in multi-hazard early warning systems, and maintain the existing good practices in nature-based solutions.

Hotspots of <u>intensifying</u> multi-hazard risk under global warming of 1.5°C and 2°C SSP3 scenarios: Under 1.5°C and 2°C, some of these hotspots have intensifying risks. They will therefore fall into a higher risk category than under the baseline as demonstrated in Figure 1.11 In this case, countries must enhance current investments in regional and subregional cooperation to better integrate multi-hazard early warning systems and augment good practices in nature-based solutions and grey (infrastructures such as dams and seawalls), and green infrastructure (natural systems including forests, floodplains, wetlands and soils that provide benefits such as flood protection) (Conservation International, 2023).

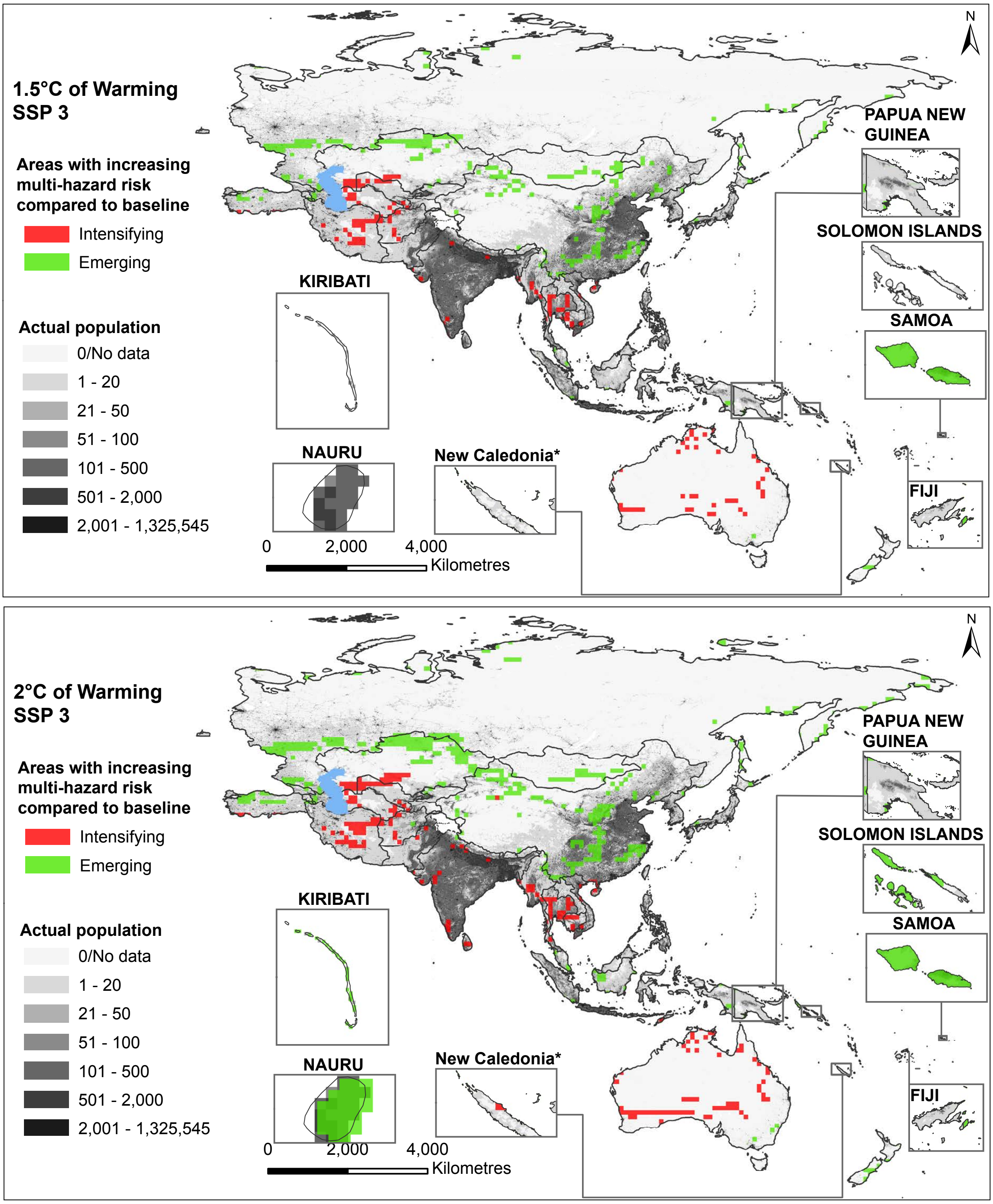
Hotspots of <u>emerging</u> multi-hazard risk under 1.5°C and 2°C SSP3 scenarios: As demonstrated in Figure 1.11, new risk hotspots will emerge under the 1.5°C and 2°C warming scenarios. These areas will shift from a low-risk category under the baseline to a medium, high, or very high-risk category under 1.5°C and 2°C warming. Here, new investments are needed in early warning systems and nature-based solutions to protect livelihoods and development gains. The emerging risk corridors are primarily driven by exposure to heatwaves.

FIGURE 1.10 Hotspots of climate-related multi-hazards – Recent baseline and climate projection under 1.5°C and 2°C SSP3 scenarios



Sources : ESCAP calculations based on IPCC WGI Interactive Atlas - Coupled Model Intercomparison Project Phase 6 (CMIP6) 2021 and UN Geospatial.
Note : The baseline period is from 1995-2014.
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.
* Non-Self-Governing Territory.

FIGURE 1.11 **Hotspots of emerging and intensifying multi-hazard risk hotspots of population under 1.5°C and 2°C, SSP3 scenarios compared to baseline**



Sources : ESCAP calculations based on IPCC WGI Interactive Atlas - Coupled Model Intercomparison Project Phase 6 (CMIP6) 2021, WorldPop 2020 Population Estimates, and UN Geospatial.

Note : The baseline period is from 1995-2014.

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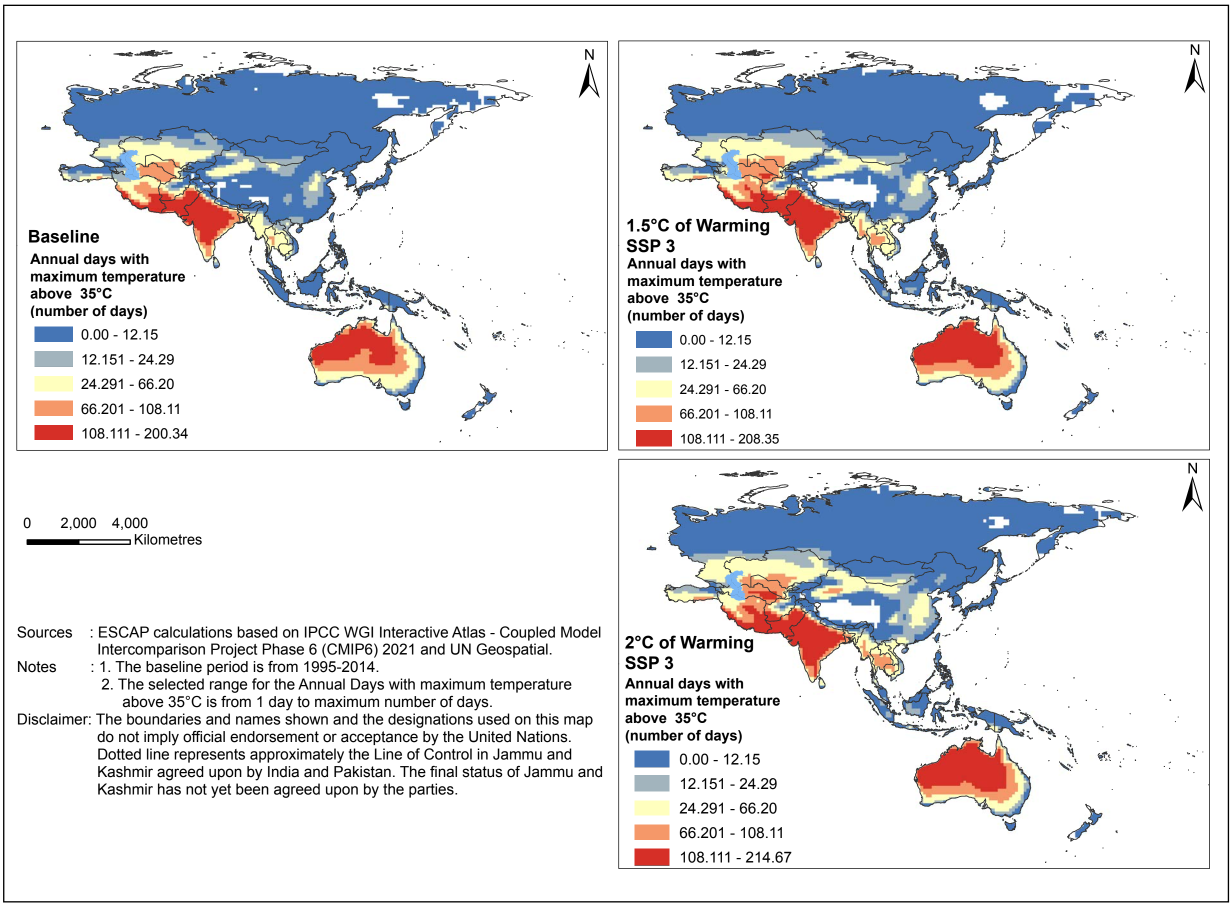
1.2.3 Targeted risk hotspots under 1.5°C and 2°C SSP3 scenarios for drought, floods, heatwaves and surface winds

Under multi-hazard scenarios, South and South-West Asia, as well as South-East Asia, will experience the greatest impact. However, it is crucial to focus on specific risk hotspots, for example, where heatwaves are emerging rapidly, as well as on those Pacific regions susceptible to potential tropical cyclones. To gain a comprehensive understanding, a detailed analysis of each hazard is conducted for the present conditions, as well as for warming scenarios of 1.5°C and 2°C (SSP3).

HEATWAVE (MAXIMUM ANNUAL DAYS WITH TEMPERATURES ABOVE 35°C)

ESCAP has examined the hotspots of existing heatwave risk under the baseline scenario and geolocated the areas of intensifying and emerging risk under the 1.5°C and 2°C warming scenarios. The baseline map in Figure 1.12 reveals hotspots of existing heatwave risk and where these risks will continue under 1.5°C and 2°C warming. These are hotspots where countries must continue to invest in and maintain support for people's livelihoods, health, and infrastructure, and begin to deploy additional investment in early warning systems for heatwaves if this has not already been done.

FIGURE 1.12 Heatwave risk (baseline, 1.5°C warming, 2°C warming)



Sources : ESCAP calculations based on IPCC WGI Interactive Atlas - Coupled Model Intercomparison Project Phase 6 (CMIP6) 2021 and UN Geospatial.

Notes : 1. The baseline period is from 1995-2014.
2. The selected range for the Annual Days with maximum temperature above 35°C is from 1 day to maximum number of days.

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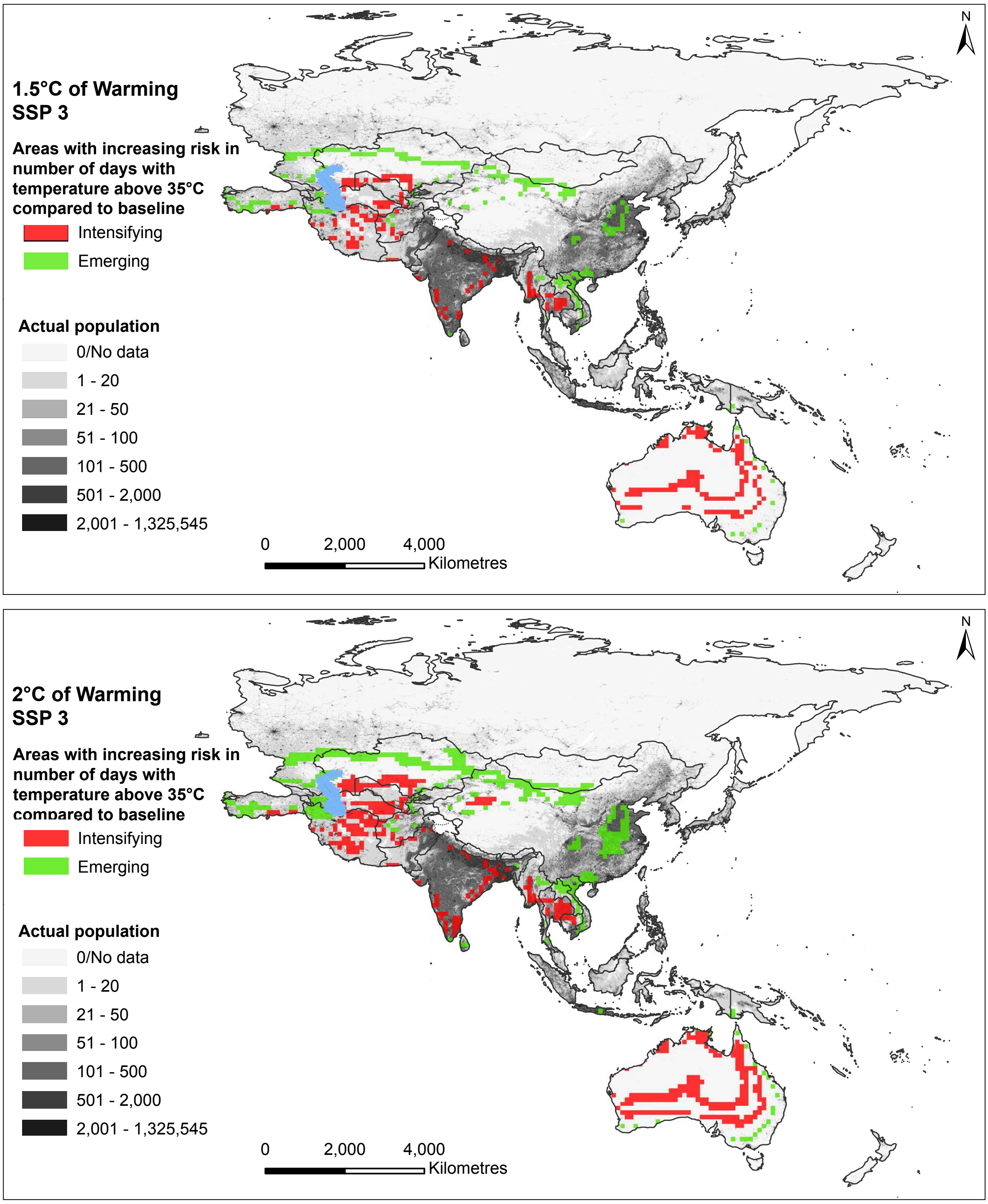
Figure 1.13 locates where heatwaves are intensifying and emerging under 1.5°C and 2°C warming and where the risk has shifted from a medium to a higher risk category. In areas of intensification, to support people's livelihoods and health, countries must enhance existing investments for heatwaves, establish early warning systems and augment good practices. In areas where heatwaves are emerging, new investments are needed in early warning systems and in social protection.

FIGURE 1.13 Hotspots of intensifying and emerging heatwave risk under 1.5°C and 2°C SSP3 scenarios from current scenario



Sources : ESCAP calculations based on IPCC WGI Interactive Atlas - Coupled Model Intercomparison Project Phase 6 (CMIP6) 2021, WorldPop 2020 Population Estimates, and UN Geospatial.
Note : The baseline period is from 1995-2014.
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TABLE 1.4 Hotspots of existing, intensifying and emerging heatwave risk under baseline and climate change scenarios (1.5°C and 2°C warming)

Subregion	Existing hotspots of heatwave risk (Baseline scenario)	Hotspots of intensifying heatwave risk (1.5°C)	Hotspots of intensifying heatwave risk (2°C)	Hotspots of emerging heatwave risk (1.5°C)	Hotspots of emerging heatwave risk (2°C)
South and South-West Asia	Medium to very high risk in large parts of India, Bangladesh, Pakistan, the Islamic Republic of Iran; medium to high risk in some parts of Türkiye and Afghanistan	Many parts of India and the Islamic Republic of Iran, some parts of Pakistan, Türkiye, Afghanistan	Indus basin (India, Pakistan, Afghanistan), other parts of India, large parts of the Islamic Republic of Iran, some parts of Türkiye.	Southern India, parts of Bangladesh, large parts of Türkiye, some parts of Afghanistan	Southern India, parts of Bangladesh, Sri Lanka
South-East Asia	Medium to high risk in Myanmar, Thailand, Cambodia, and parts of Lao People's Democratic Republic	Myanmar, Thailand	More intensification in Myanmar and Thailand than under 1.5°C warming, parts of Cambodia	Myanmar, Lao People's Democratic Republic, Viet Nam, Cambodia	More expansion in Myanmar, Lao People's Democratic Republic, Viet Nam, Cambodia than under 1.5°C; some parts of Indonesia
Pacific	Medium to very high risk in Australia, medium risk in few parts of Papua New Guinea	Australia	More intensification in Southern Australia	Eastern Australia, some parts of Papua New Guinea	More expansion Eastern Australia, some parts of Papua New Guinea than under 1.5°C
North and Central Asia	Medium to high risk in Aral Sea basin (Kazakhstan, Uzbekistan, Turkmenistan)	Aral Sea (Uzbekistan, Turkmenistan, Kazakhstan)	More intensification in the Aral Sea basin countries than under 1.5°C	Large swathes of land through Kazakhstan, Kyrgyzstan, Mongolia	More expansion in Kyrgyzstan, Kazakhstan and Mongolia than under 1.5°C
East and North-East Asia	Medium risk in some parts of China			The Russian Federation, large part of North-East China with potential impacts in Democratic People's Republic of Korea, the Republic of Korea and Japan	More expansion in Russian Federation, large part of North-East China with potential impacts in the Democratic People's Republic of Korea, the Republic of Korea and Japan than under 1.5°C

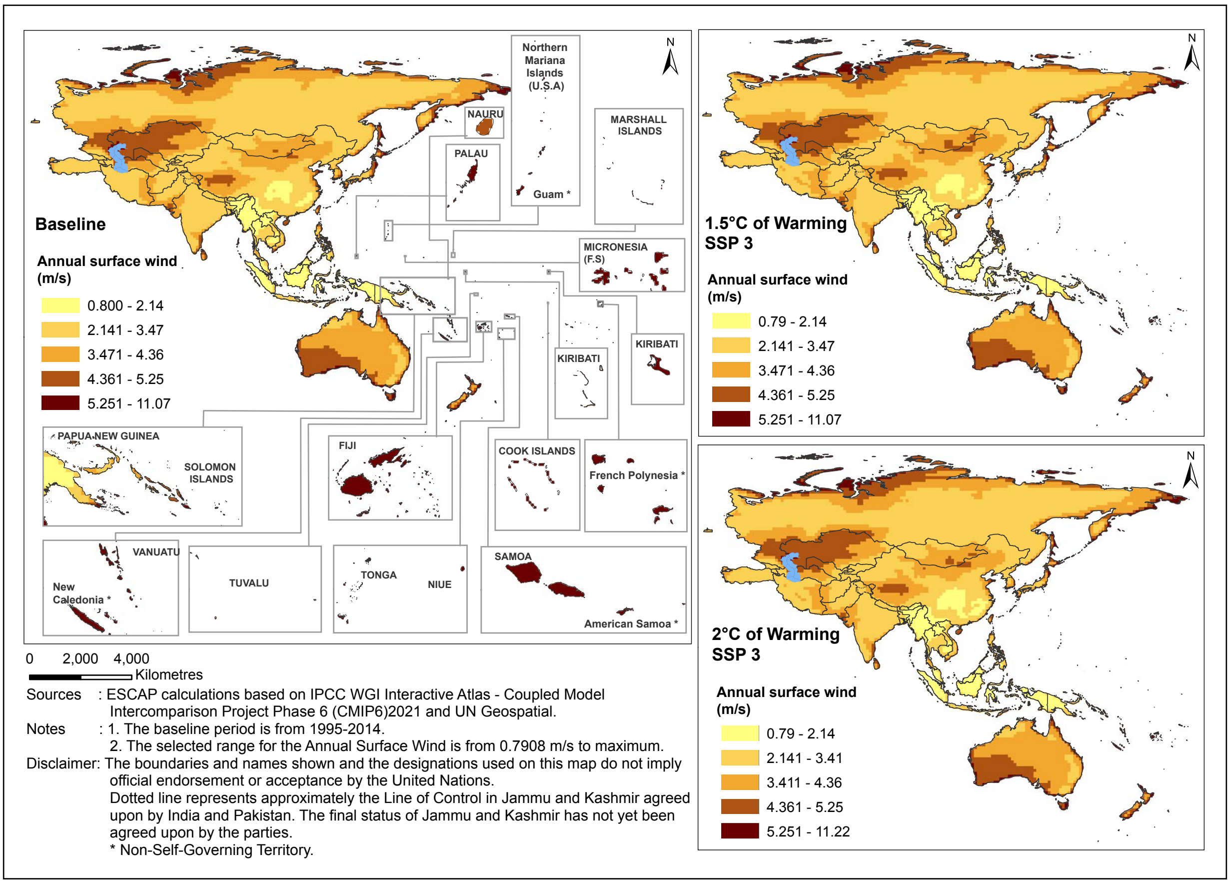
Source: ESCAP.

SURFACE WIND, RISK HOTSPOTS OF POTENTIAL TROPICAL CYCLONES

ESCAP examined the hotspots of existing surface wind risk under the baseline scenario and geolocated the areas of intensifying and emerging risk under 1.5°C and 2°C warming. Surface wind has been used in prior analysis as a proxy and determining factor in understanding tropical cyclones (Sasaki, 2021), as well as sand and dust storms (WMO, 2022b).

The baseline map in Figure 1.14 shows hotspots of existing risk of surface winds. These are hotspots of potential hazards, such as tropical cyclones in coastal areas and inland sand and dust storms, under the baseline and the two warming scenarios. Countries must continue to invest and maintain existing investments in early warning systems and maintain existing good practices in nature-based solutions, such as mangroves.

FIGURE 1.14 Surface wind risk (baseline, 1.5°C warming, 2°C warming)



Sources : ESCAP calculations based on IPCC WGI Interactive Atlas - Coupled Model Intercomparison Project Phase 6 (CMIP6)2021 and UN Geospatial.

Notes : 1. The baseline period is from 1995-2014.
2. The selected range for the Annual Surface Wind is from 0.7908 m/s to maximum.

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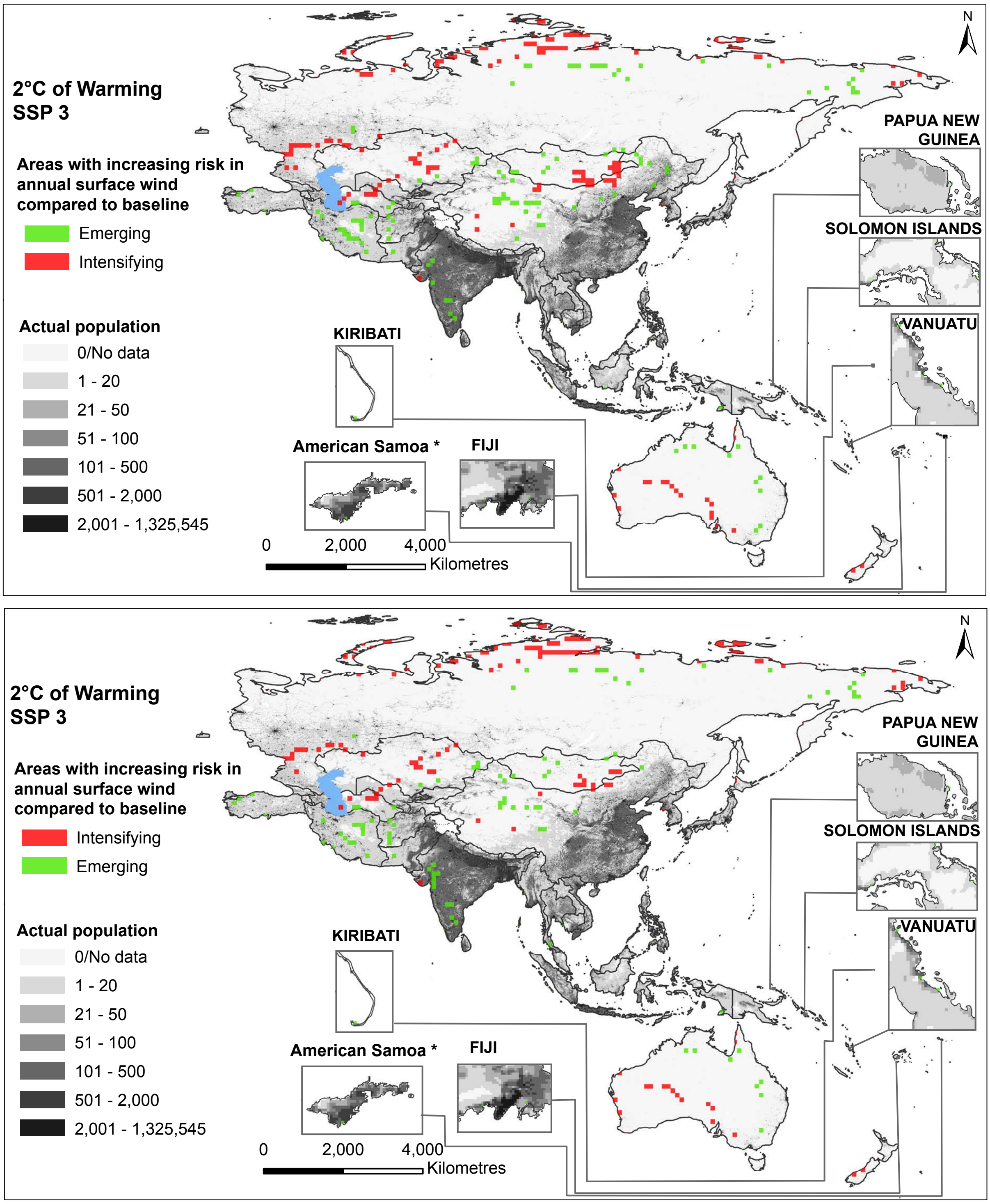
* Non-Self-Governing Territory.

Figure 1.15 locates where surface winds are intensifying under 1.5°C and 2°C warming scenarios, where the risk has shifted from a medium to a higher risk category. It displays emerging hotspots of tropical cyclones and dust storms under the warming scenarios, where the risk has shifted from a low risk to a higher risk category. Where risks are intensifying, countries must enhance current investments in early warning systems for tropical cyclones and sand and dust storms, and augment good practices in nature-based solutions. In areas of emerging risk, new investments are needed in early warning systems and nature-based solutions to protect lives and livelihoods. Table 1.5 presents the areas of existing, intensifying, and emerging risk of potential cyclones and dust storms for all ESCAP subregions.

FIGURE 1.15 **Hotspots of intensifying and emerging surface wind risk under 1.5°C and 2°C SSP3 scenarios from current scenario**



Sources : ESCAP calculations based on IPCC WGI Interactive Atlas - Coupled Model Intercomparison Project Phase 6 (CMIP6) 2021, WorldPop 2020 Population Estimates, and UN Geospatial.

Note : The baseline period is from 1995-2014.

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TABLE 1.5 Hotspots of existing, intensifying and emerging surface wind risk under baseline and climate change scenarios (1.5°C and 2°C warming)

Subregion	Existing hotspots of surface wind risk (Baseline scenario)	Hotspots of intensifying surface wind risk (1.5°C)	Hotspots of intensifying surface wind risk (2°C)	Hotspots of emerging surface wind risk (1.5°C)	Hotspots of emerging surface wind risk (2°C)
East and North-East Asia	Medium to very high risk in China, Democratic People's Republic of Korea, Japan and the Republic of Korea	Parts of China, the Russian Federation, Democratic People's Republic of Korea, the Republic of Korea, and Japan	Parts of China, the Russian Federation, Democratic People's Republic of Korea, the Republic of Korea, and Japan	Parts of the Russian Federation, China	Parts of the Russian Federation, China
North and Central Asia	High to very high risk in Aral Sea basin (Kazakhstan, Uzbekistan, Turkmenistan), Mongolia	Aral Sea basin (Kazakhstan, Uzbekistan, Turkmenistan), Mongolia	Aral Sea basin (Kazakhstan, Uzbekistan, Turkmenistan), Mongolia	Parts of Kazakhstan, Mongolia, Turkmenistan	Parts of Kazakhstan, Mongolia, Turkmenistan
Pacific	High to very high risk in Australia, Palau, parts of Papua New Guinea and Solomon Islands, New Caledonia, Vanuatu, Fiji, Samoa, Tuvalu, Kiribati, Cook Islands, Tonga, Niue, French Polynesia, Marshall Islands; Medium risk in New Zealand, Nauru	Parts of Australia, New Zealand	Parts of Australia, New Zealand	Parts of Australia, Papua New Guinea	Parts of Australia, Papua New Guinea
South-East Asia	Medium risk in parts of Thailand, Lao People's Democratic Republic, Cambodia; high risk in parts of Viet Nam, Philippines, Indonesia, Timor-Leste			Indonesia	Thailand
South and South-West Asia	Medium to high risk in parts of India, Bangladesh, Bhutan Pakistan, the Islamic Republic of Iran, Afghanistan, Sri Lanka; medium risk in Türkiye	Western part of India	Western part of India	South-West India, Southern Pakistan, parts of Afghanistan, the Islamic Republic of Iran and Türkiye	South-West India, Southern Pakistan, parts of Afghanistan, the Islamic Republic of Iran and Türkiye

Source: ESCAP.

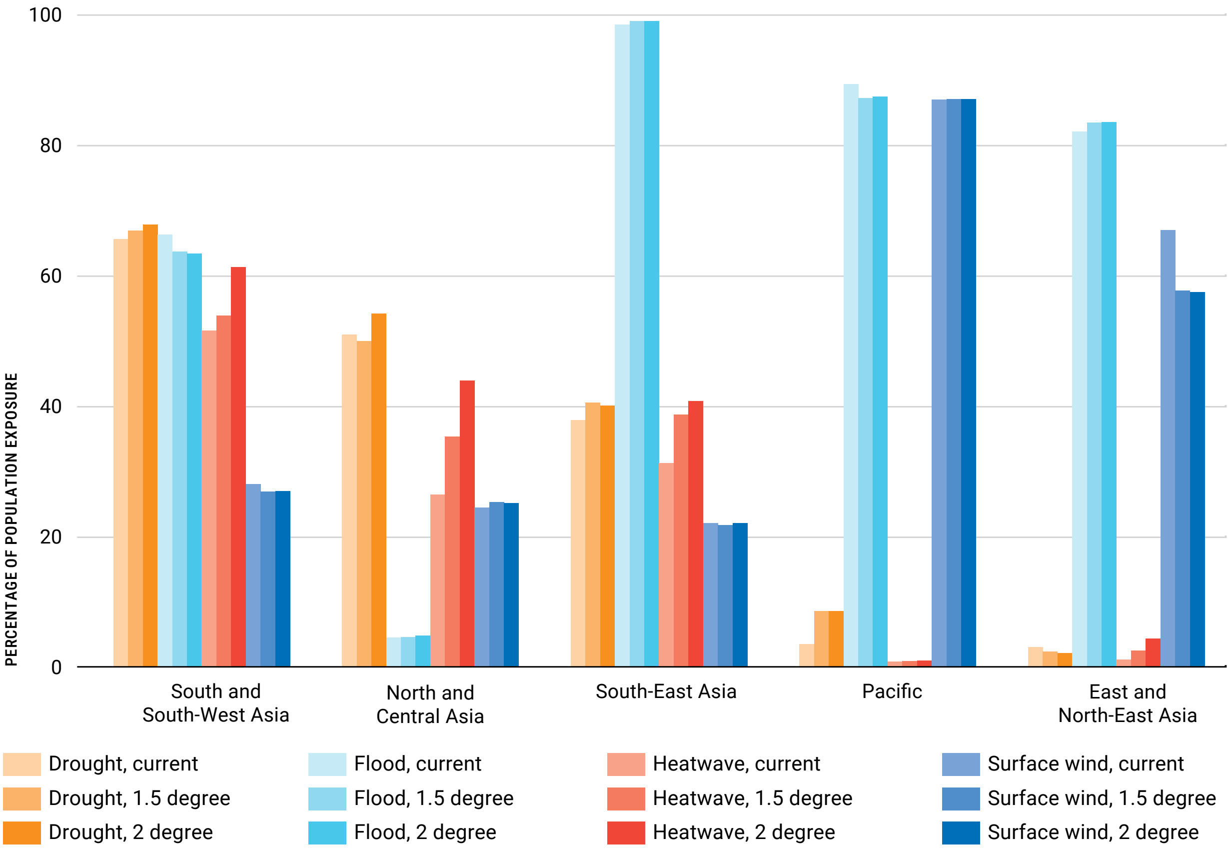
INCREASING POPULATION EXPOSURE UNDER WARMING SCENARIOS

Over half of the population of Asia and the Pacific is already exposed to multi-hazard risks and this is set to increase significantly as temperatures rise. Climate hazards have significant direct impacts on populations in the region, affecting lives, livelihoods, and health. ESCAP analysis estimates population exposure to multiple hazards, such as droughts, floods, heatwaves, and surface winds, under different warming scenarios under SSP3. Currently, 58 per cent of the region's population is exposed to these multi-hazard risks. Under 1.5°C and 2°C warming, the exposure increases to 59 per cent and 65 per cent, respectively.

Figure 1.16 reveals that the highest population exposure to multiple climate hazards, including droughts, floods, and heatwaves (more than 50 per cent of population exposed under 1.5°C and 2°C warming), is in South and South-West Asia. In South-East Asia, floods and droughts are the key risks. North and Central Asia faces a dominant risk of drought (more than 50 per cent of population is exposed under 1.5°C and 2°C warming), with an increasing impact from heatwaves under a 2°C warming scenario. East and North-East Asia is mainly exposed to floods (80 per cent of population exposure under 1.5°C and 2°C warming) as well as surface winds (tropical cyclones/sand and dust storms). The Pacific region is characterized by high exposure to floods and surface winds with close to 90 per cent of the population exposed to both hazards.

Understanding the specific risks faced by each subregion is crucial for effective climate adaptation and disaster risk reduction. This analysis highlights the urgent need for comprehensive strategies to mitigate the impacts of these hazards and protect vulnerable populations across the Asia-Pacific region.

FIGURE 1.16 Population exposure of ESCAP subregions for droughts, floods, heatwaves and surface winds under current, 1.5°C and 2°C warming (SSP3 scenario)



Source: ESCAP.

Note: ENEA = East and North-East Asia, NCA = North and Central Asia, SEA = South-East Asia, SSWA = South and South=West Asia, Pacific SIDS = Pacific small island developing States.

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CHAPTER 2

The cost of inaction

The Asia and Pacific region faces a widening gap between risk and resilience, with temperatures of 1.5°C or 2°C projected to surpass the limits of feasible adaptation, jeopardizing sustainable development.

Inaction and insufficient resilience-building efforts will result in significant economic costs, with future costs estimated to increase from US$ 924 billion to nearly $1 trillion. The Pacific region, including the Pacific small island developing States (SIDS), will experience the highest losses as a share of GDP, impacting productivity and exacerbating inequality.

Climate change-induced disasters and hazards pose a growing threat to food and energy security, impacting people's lives and livelihoods. Failure to take decisive action will contribute to environmental degradation and biodiversity loss, particularly in South and South-West Asia and the Pacific, where the need for urgent action is evident.

The above key messages reflect the urgent need for proactive measures to bridge the risk-resilience gap, mitigate economic costs, and address the environmental and social implications of climate change in the Asia and Pacific region.

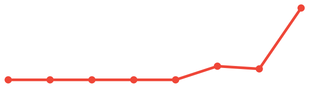
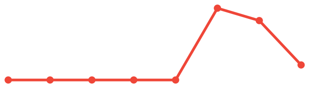
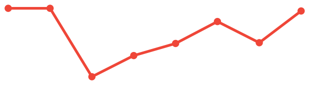
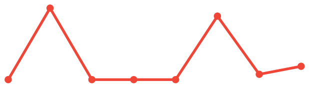
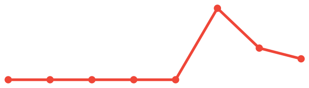
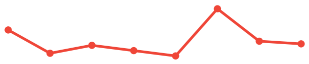
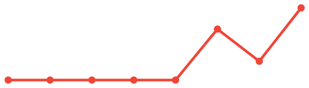
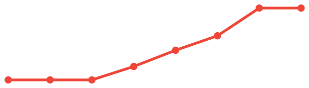
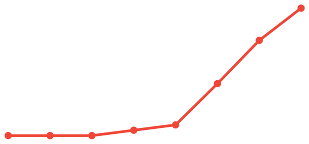
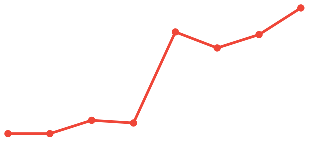
2.1 Sendai Framework and the Sustainable Development Goals imperilled

The Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR) and the United Nations 2030 Agenda for Sustainable Development and its Sustainable Development Goals (SDGs) are inextricably linked. Sustainable development cannot be attained while disasters and climate change continue to undermine economic growth and social progress. The transformative potential of the SDGs can only be achieved if the implementation of the SFDRR is at the core of the region's sustainable development effort.

2.1.1 Inadequate progress in disaster and climate action

The mid-term review of the Sendai Framework highlights concerning trends in its targets, with many regressing and revealing insufficient global access to disaster data and risk knowledge. Inadequate financing for disaster risk reduction fails to match the rising economic costs of disasters. Utilizing data from the ESCAP Risk and Resilience Portal, the analysis in Table 2.1 identifies regressing trends among Sendai Framework targets in the Asia-Pacific region. Over half of the subtargets related to disaster impacts in various sectors demonstrate uneven or regressing trends, particularly in critical infrastructure and basic services, like education and health care. Despite positive progress in adopting disaster risk reduction policies, achieving the goals of the Sendai Framework appears unlikely due to these regressing trends. Addressing the drivers behind these gaps is crucial for reversing the trends and preventing their undermining impact on efforts to achieve the Sustainable Development Goals (SDGs).

TABLE 2.1 Trends in Sendai Framework targets for the Asia-Pacific region

Sendai Target	Sendai Sub-target	SDG Indicator	Regressing trends from 2005-2023
Target A: Substantially reduce global disaster mortality by 2030	A-1: Number of deaths and missing persons attributed to disasters, per 100,000 population	1.5.1	
	A-2: Number of deaths attributed to disasters, per 100,000 population	1.5.1	
Target B: Substantially reduce the number of affected people globally	B-1: Number of directly affected people attributed to disasters, per 100,000 population	1.5.1	
	B-3: Number of people whose damaged dwellings were attributed to disasters	1.5.1	
	B-5: Number of people whose livelihoods were disrupted or destroyed, attributed to disasters	1.5.1	
Target C: Reduce direct disaster economic losses in relation to global gross domestic product (GDP).	C-4: Direct economic loss in the housing sector attributed to disasters	1.5.2	
	C-5: Direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters	1.5.2	
	C-6: Direct economic loss to cultural heritage damaged or destroyed attributed to disasters	1.5.2	
Target D: Reduce disaster damage to critical infrastructure and basic services disruptions	D-2: Number of destroyed or damaged health facilities attributed to disasters	11.5.2	
	D-4: Number of other destroyed or damaged critical infrastructure units and facilities attributed to disasters	11.5.2	
	D-5: Number of disruptions to basic services attributed to disasters	11.5.2	
	D-6: Number of disruptions to educational services attributed to disasters	11.5.2	
	D-8: Number of disruptions to other basic services attributed to disasters	11.5.2	
Target E: Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020	E-1: Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015-2030	13.1.2	
	E-2: Percentage of local governments that adopt and implement local disaster risk reduction strategies in line with national strategies	13.1.3	

Source: SDG Gateway Asia Pacific (2023a). Available at https://data.unescap.org/home

BOX 2.1 Sendai Framework Mid-term Review Political Declaration

The Midterm Review of the Sendai Framework for Disaster Risk Reduction 2015-2030 provided an opportunity to assess progress and identify necessary changes to effectively address the systemic nature of risk and achieve the goals of the Framework. The Political declaration of the Midterm Review of the Sendai Framework for Disaster Risk Reduction 2015-2030, adopted by the United Nations General Assembly on May 2023 calls for a broader and more people-centred approach to disaster risk reduction and expresses concerns over the insufficient pace of implementation and the increasing frequency and intensity of disasters.

STRENGTHENING RISK AWARENESS AND UNDERSTANDING

Efforts are needed to bridge data gaps and collect more comprehensive and disaggregated disaster loss and risk data. This includes considering income, sex, age, and disability in data collection and sharing. The use of traditional, indigenous, and local knowledge is crucial, as is promoting disaster risk education. Adequate resources and capacity building are essential to understanding risk and implementing the Sendai Framework.

ENHANCING RISK GOVERNANCE AND STAKEHOLDER ENGAGEMENT

Multi-hazard and multi-stakeholder risk governance should be strengthened, involving legal and regulatory frameworks. The participation of various groups, such as women, older persons, persons with disabilities, indigenous peoples, local communities, youth, academia, and the private sector, is crucial. Local authorities and civil society organizations in developing countries need greater support and engagement. Nature-based solutions and collaboration with global and regional organizations are also important.

INCREASING INVESTMENTS AND FINANCING

Investments in disaster risk reduction and efforts to de-risk investments remain inadequate. Official development assistance for disaster risk reduction has seen little increase since 2015. Sustainable and predictable investment is needed, including involvement from the private sector. The impact of disasters on the debt sustainability of least developed countries should be recognized, and domestic resources should be allocated to mainstream disaster risk reduction into public budgeting. Comprehensive national and local financing strategies aligned with disaster risk reduction plans are necessary, and international financial institutions should consider integrating disaster risk reduction into their work.

STRENGTHENING EARLY WARNING SYSTEMS AND PREPAREDNESS

Build back better principles should be applied systematically, and access to early warning systems needs improvement. Investment in people-centred and multi-hazard early warning systems is essential. The Political Declaration welcomes the call for universal coverage of early warning systems and emphasizes the need for inclusive disaster preparedness and response, particularly in countries facing protracted humanitarian crises and emergencies.

LEVERAGING SCIENCE, TECHNOLOGY, AND INNOVATION

Science, technology, and innovation play a vital role in disaster risk reduction. An inclusive approach is encouraged to implement strategies and increase dedicated investment in this area.

The Midterm Review highlights the need for a people-centred preventive approach to disaster risk reduction, increased investment and financing, and strengthened early warning systems. It emphasizes the importance of stakeholder engagement, including marginalized groups, and the role of science, technology, and innovation in achieving the goals of the Sendai Framework.

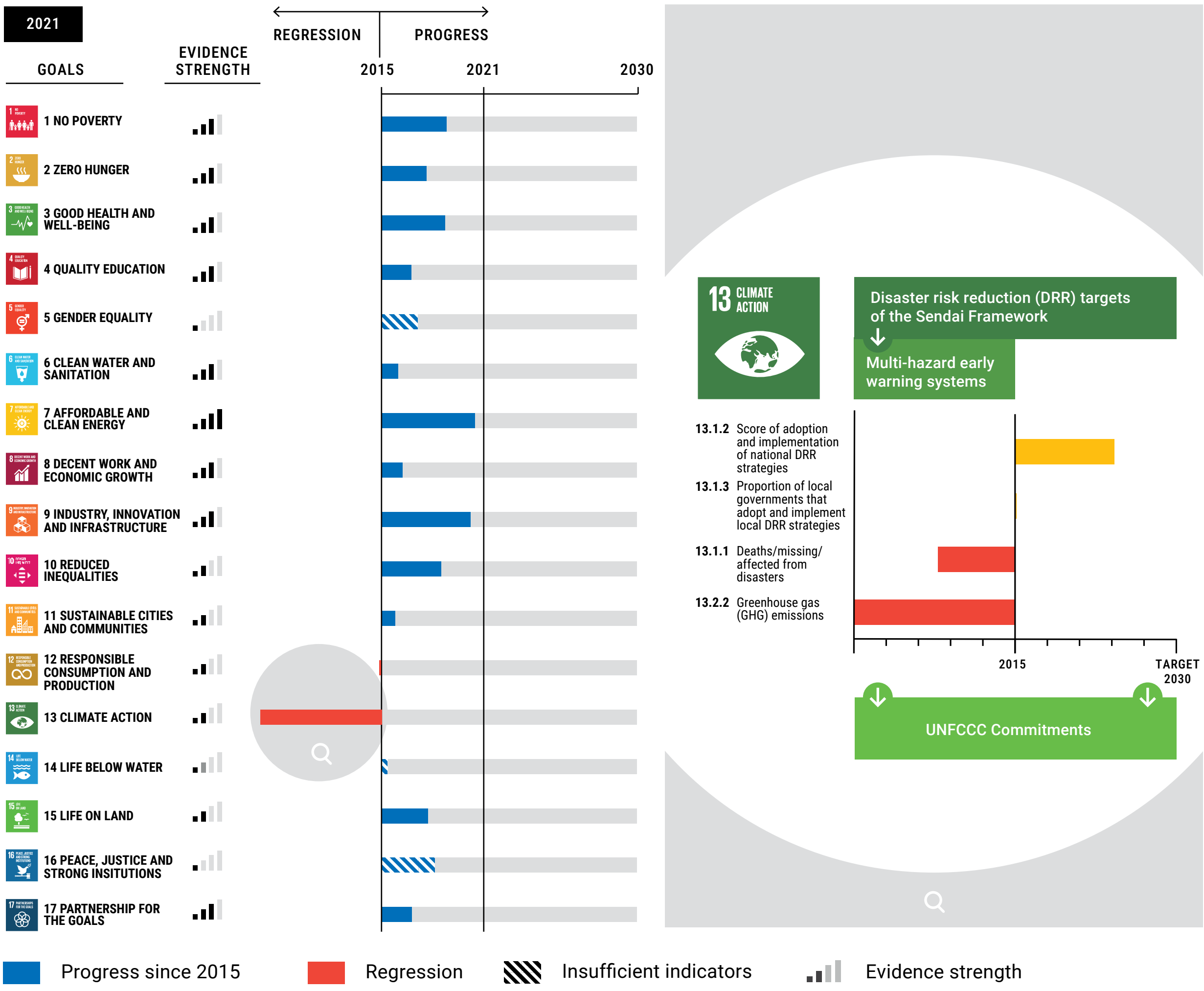
2.1.2 Inaction in disaster and climate-related SDGs have knock on regressive impacts

The regressing trends in SFDRR targets and related SDG indicators are posing a significant obstacle to achieving the Sustainable Development Goals (SDGs) in the region. The *Asia and the Pacific SDG Progress Report 2022* indicates an overall deceleration in SDG progress, with Figure 2.1 highlighting the reversal of trends in SDG13, primarily due to increased disaster-related fatalities and a widening gap in climate change mitigation and adaptation efforts in the region (ESCAP, 2022).

Several SDG goals, including SDG 1, 2, 3, 4, 6, 9, 14, and 15, have a direct correlation with disaster and climate-related SDGs. Figure 2.2 demonstrates that the progress towards these targets is either regressing or has made minimal advancements, particularly in SDG 2.1 (undernourishment and food security), SDG 6.1 (safe drinking water), SDG 6.4 (water-use efficiency), and SDG 6.6 (water-related ecosystems), which are regressing across all subregions. Strengthening disaster risk reduction and climate adaptation strategies, and effectively implementing them at the local level are crucial to supporting the achievement of these SDGs.

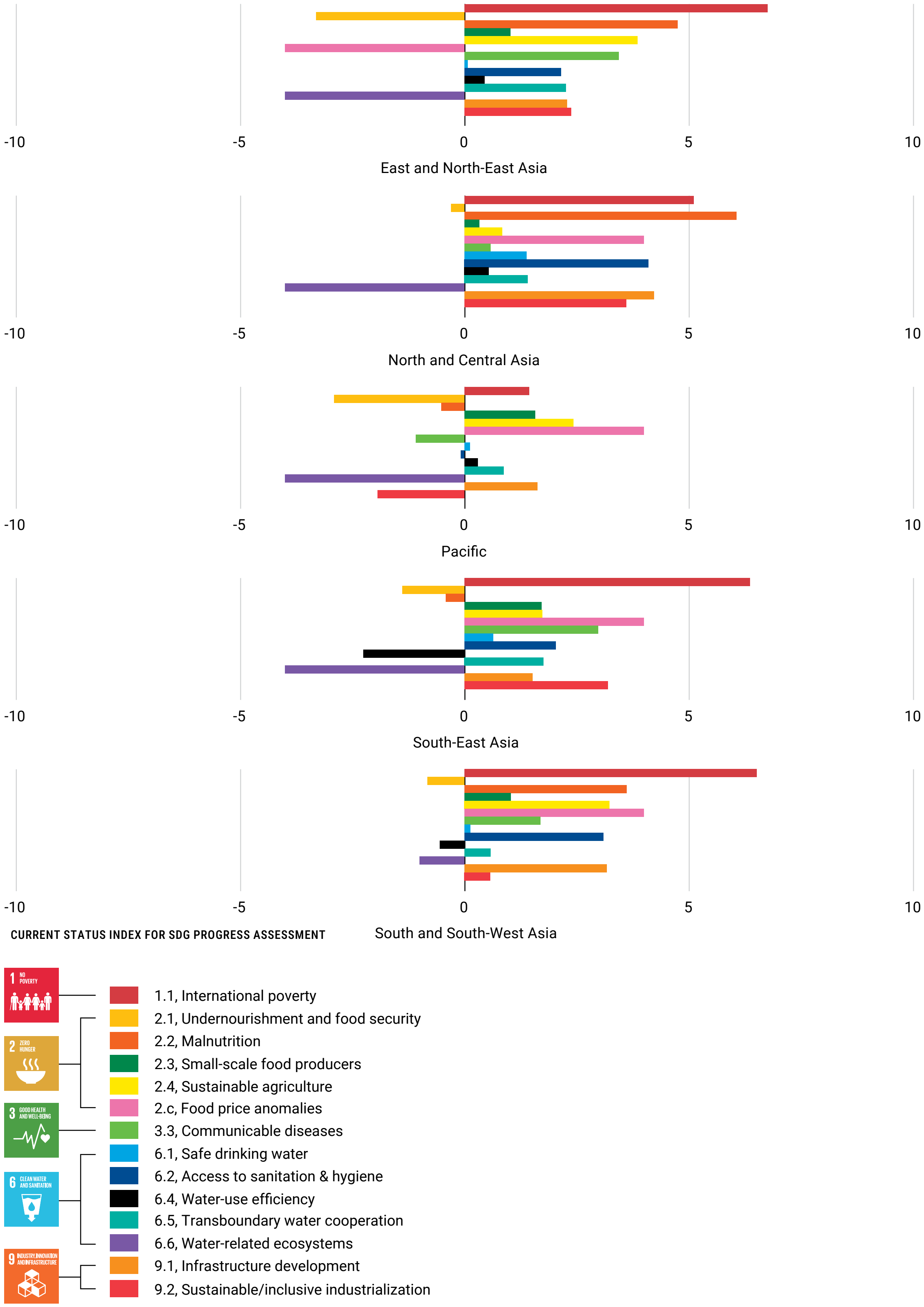
Addressing the regressing trends, enhancing local-level implementation, and bolstering disaster risk reduction and climate adaptation efforts are essential for restoring progress towards the SDGs and ensuring the resilience and sustainability of the region.

FIGURE 2.1 Progress on the SDGs in the Asia-Pacific region



Source: *Asia and the Pacific SDG Progress Report 2022: Widening disparities amid COVID-19* (United Nations publication, 2022). Available at https://www.unescap.org/kp/2022/asia-and-pacific-sdg-progress-report-2022

FIGURE 2.2 Progress towards achieving SDGs for disaster and climate resilience



Source: *Asia and the Pacific SDG Progress Report 2022: Widening disparities amid COVID-19* (United Nations publication, 2022). Available at https://www.unescap.org/kp/2022/asia-and-pacific-sdg-progress-report-2022

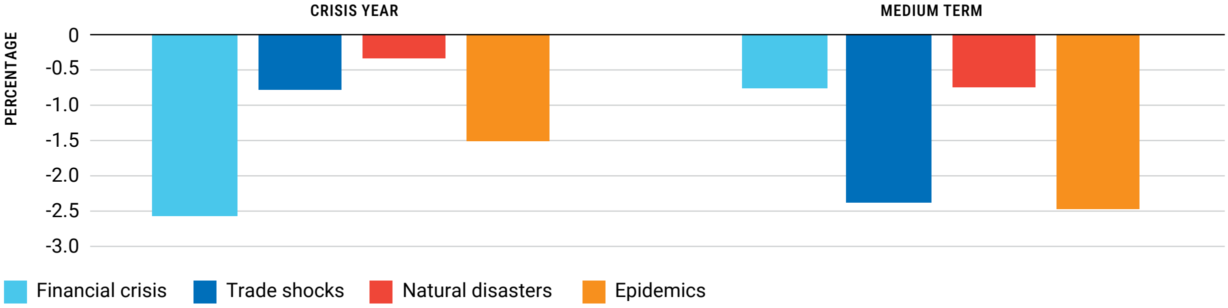
Note: ENEA = East and North-East Asia, NCA = North and Central Asia, PAC = Pacific, SEA = South-East Asia, SSWA = South and South-West Asia.

2.2 Inaction increases impact on economic, social and environment sectors

2.2.1 Disaster and climate-related losses destroy development gains

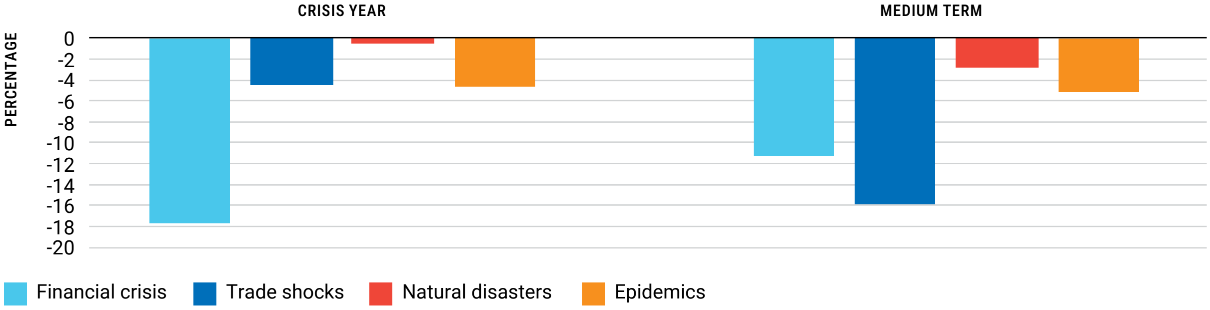
Climate disasters are economic risks that reverse hard-won developmental gains. The world economy is poised to lose more than 18 per cent of current gross domestic product (GDP) by 2048 if no action on climate change is taken (Gray and Varbanov, 2021). The *Economic and Social Survey of Asia and the Pacific 2021: Towards Post-Covid-19 Resilient Economies* notes that disaters have very high long-term impacts on GDP, investment and consumption (ESCAP, 2021). Figure 2.3 shows that disasters over a longer period of time have high regressive impacts on GDP, followed by consumption and investment.

FIGURE 2.3 Economic impacts of natural hazards – GDP per capita



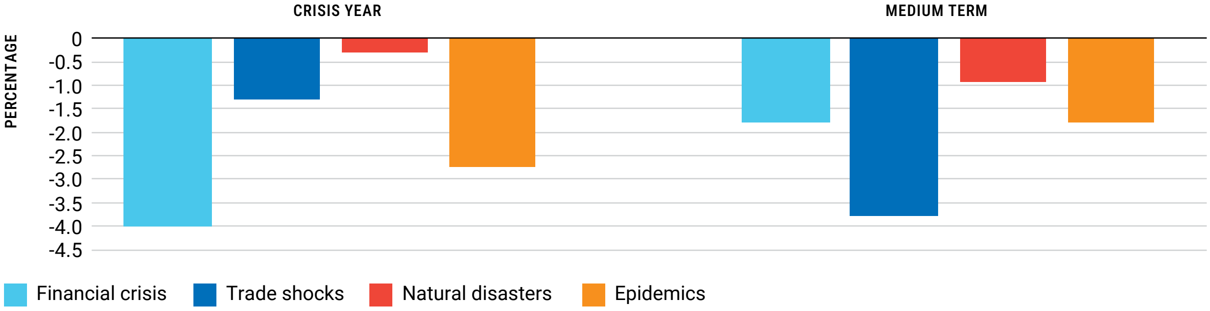
Source: ESCAP, based on the Penn World Table.
Note: "Medium term" refers to the three-year cumulative response.

FIGURE 2.4 Economic impacts of natural hazards – Investment



Source: ESCAP, based on the Penn World Table.
Note: "Medium term" refers to the three-year cumulative response.

FIGURE 2.5 Economic impacts of natural hazards – Consumption



Source: ESCAP, based on the Penn World Table.
Note: "Medium term" refers to the three-year cumulative response.

FUTURE ECONOMIC COST OF CURRENT INACTION

ESCAP has estimated the potential losses to GDP caused by climate hazards to understand the future cost of inaction. Currently, the average annual losses from various hazards, such as droughts, floods, heatwaves, tropical cyclones, tsunamis, and earthquakes, amount to approximately $924 billion, or 2.9 per cent of the regional GDP. Under a 1.5°C climate warming scenario, these losses are projected to increase to $953 billion, or 3 per cent of the regional GDP, and under a 2°C warming scenario, they could reach nearly $1 trillion ($980 billion, or 3.1 per cent of the regional GDP) (Table 2.2).

When looking at specific hazards, heatwaves and cyclones show an increasing trend of losses under both the 1.5°C and 2°C climate scenarios, as depicted in Figure 2.4 In terms of absolute value, East and North-East Asia experience the highest losses, followed by South and South-West Asia, South-East Asia, North and Central Asia, and the Pacific. However, as a share of GDP, the Pacific region, particularly the Pacific small island developing States (SIDS), faces the most substantial losses, accounting for around 8 per cent of their GDP. This is almost double the percentage of average loss in the rest of Asia and the Pacific.

Among the specific subregions, South-East Asia would face a 5 per cent loss of GDP under the current scenario, which would increase to 6 per cent under 2°C warming. South and South-West Asia would also face a 5 per cent loss of GDP across all scenarios. North and Central Asia would experience a 3 per cent loss of GDP, and East and North-East Asia would encounter a 2 per cent loss of GDP across all scenarios (Figure 2.6). While China, India, and Japan would suffer the highest absolute losses, the Pacific SIDS would bear the most significant losses as a percentage of their GDP.

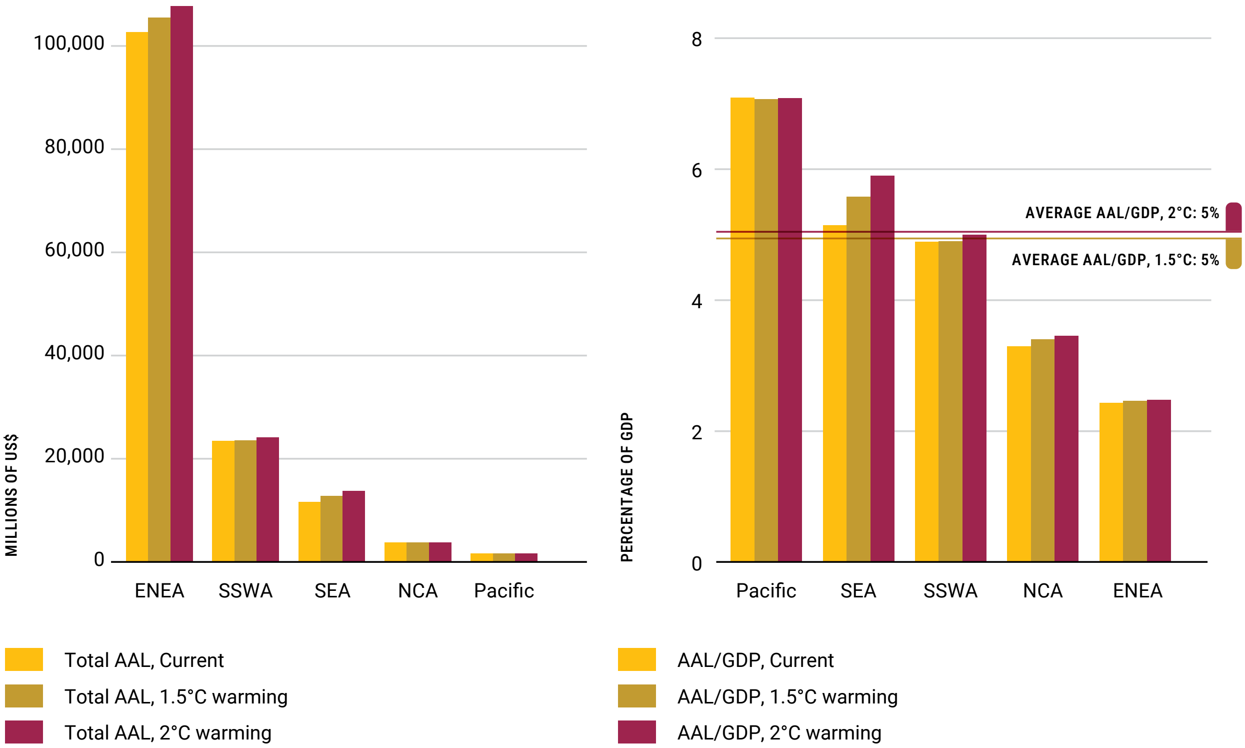
Figure 2.7 highlights the 15 countries that experience the highest losses as a percentage of their GDP.

TABLE 2.2 **Average Annual Loss under the current scenario and two warming scenarios under SSP2-SSP3**

Hazards	Average annual loss, Current scenario (USD million)	Average annual loss, 1.5 degree warming, SSP2-SSP3 (USD million)	Average annual loss, 2 Degree warming, SSP2-SSP3 (USD million)
Biological	104,702.45	104,702.45	104,702.45
Drought	404,479.17	396,260.89	393,971.46
Earthquakes	90,904.27	90,904.26	90,904.26
Flood	87,965.62	90,919.60	93,134.25
Heatwaves	144,136.67	178,760.18	205,966.54
Tropical cyclones	86,043.47	85,462.39	85,279.68
Tsunami	6,022.18	6,022.18	6,022.18
Total	**924,253.83**	**953,031.95**	**979,980.82**

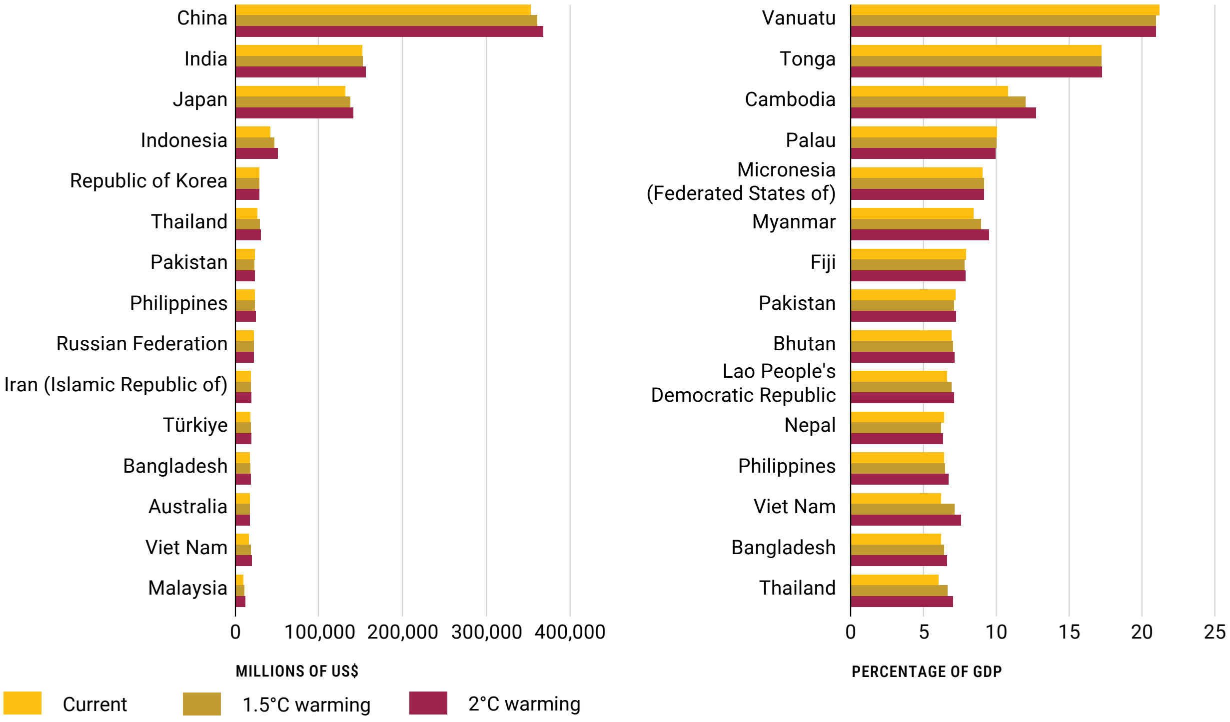
Source: ESCAP.

FIGURE 2.6 Absolute Average Annual Loss vs. Average Annual Loss as a percentage of GDP under current scenario, 1.5°C warming scenario (SSP2-SSP3), 2°C warming scenario (SSP2-SSP3)



Source: ESCAP.
Note: ENEA = East and North-East Asia, NCA = North and Central Asia, SEA = South-East Asia, SSWA = South and South-West Asia.

FIGURE 2.7 Top 15 countries in the Asia-Pacific region: Comparison of absolute Average Annual Loss vs. Average Annual Loss as a percentage of GDP under current scenario, 1.5°C warming scenario (SSP2-SSP3), 2°C warming scenario (SSP2-SSP3)



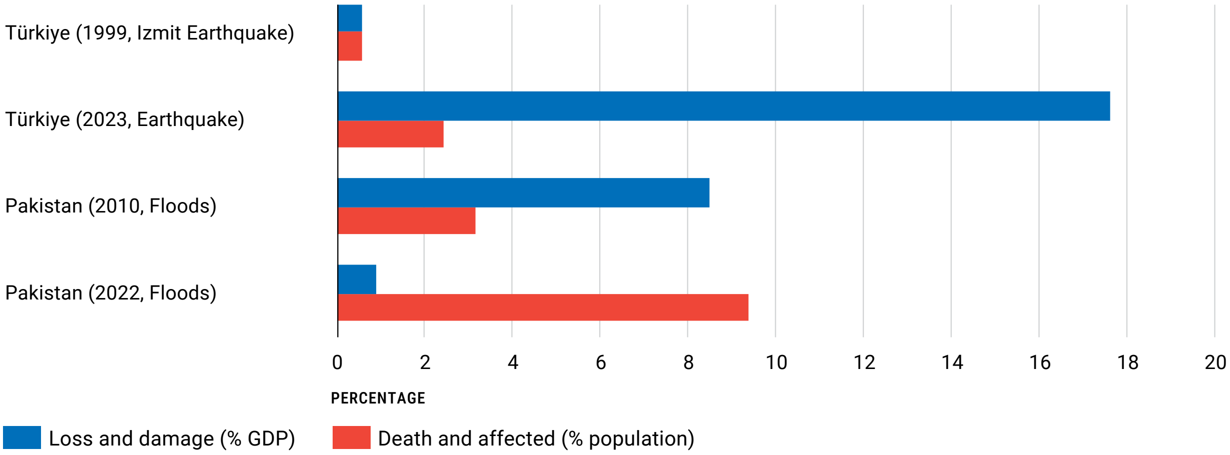
Source: ESCAP.

2.2.2 Disaster and climate losses increase inequalities, drive food and energy insecurity, and erode human health

The ongoing large-scale disasters and climate change in the region will continue to heavily impact the social sector if the region continues on its current trajectory.

For example, in 1999 the Izmit earthquake in Türkiye killed 17,000 people and affected 500,000. At the time, the Post-Disaster Needs Assessment of Izmit earthquake estimated the total damage and loss in social, economic, and productive sectors to be around $6.4 billion. A key recommendation of the PDNA was to invest in risk mitigation, preparedness, and resilient infrastructure and the Government of Türkiye introduced new building codes and a compulsory earthquake insurance system. Yet, when the most recent earthquake – Kahramanmaras - hit Türkiye, it took the lives of an estimated 50,000 people, almost a twofold increase compared to Izmit. The economic losses are estimated at $25 billion, almost a threefold increase compared to Izmit (Figure 2.8). Similarly, in 2010, Pakistan was hard hit by floods with losses of $10 billion estimated in the PNDA. In 2022, Pakistan was hit by even more severe floods with an estimated $30 billion in losses estimated in the PDNA (Figure 2.8). Inaction to mitigate these disasters rapidly carries negative consequences for sectors that most impact people. It increases inequality and makes food and energy systems more insecure and leads to erosion in human health.

FIGURE 2.8 Inaction in risk reduction and adaptation measures (Türkiye, Earthquakes; Pakistan, Floods)



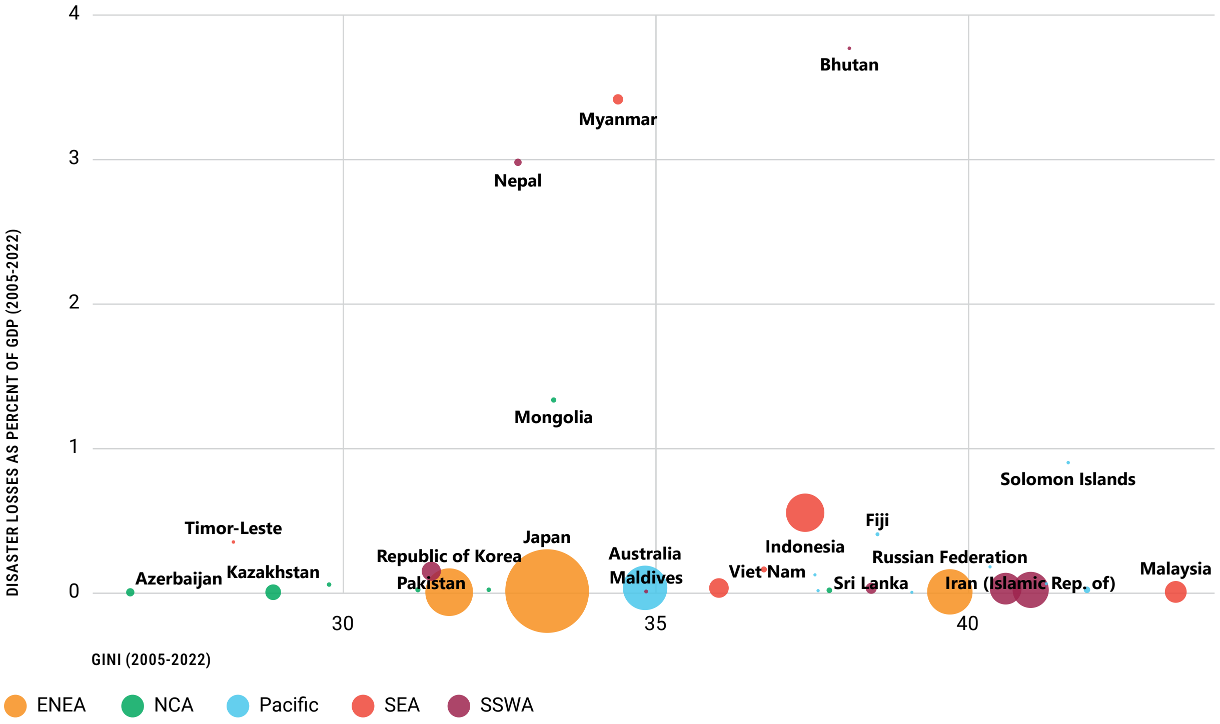
Source: International Recovery Platform, "Post-Disaster Needs Assessments (PDNA)", n.d. Available at https://recovery.preventionweb.net/build-back-better/post-disaster-needs-assessments/country-pdnas#tabs-13869-3

IMPACTS ON INEQUALITY

In the Asia-Pacific region, there is a greater intersection between risks from disasters, inequalities of income and poverty than elsewhere, because the population is more highly exposed to disaster risk than that of other regions (ESCAP, 2019).

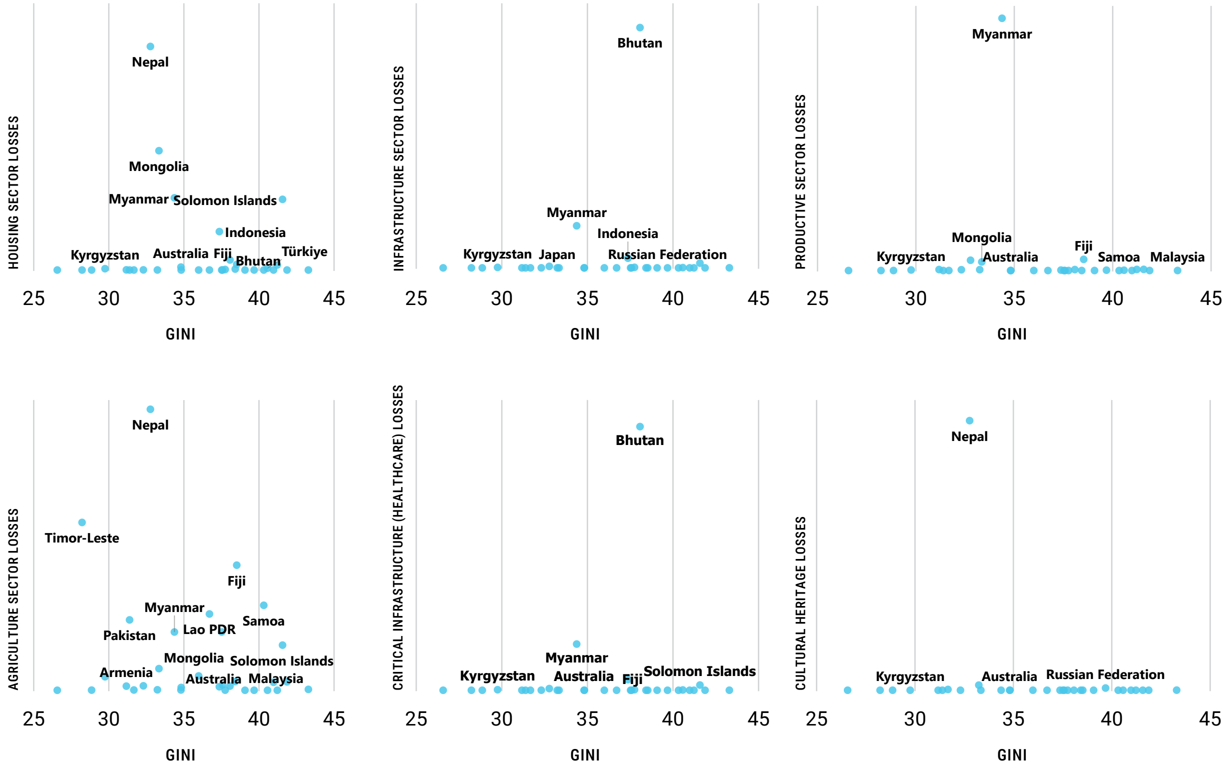
While inequality is caused by multiple factors, there are countries where disasters losses could be a driving force for persistent inequality (UNDRR, n.d., a). Figure 2.9 uses the SFDRR subtargets and the related SDG indicators to demonstrate how and where disasters can be a driving force for continuing inequality measured by the GINI coefficient. Multiple least developed countries (LDCs) and landlocked developing countries (LLDCs) are particularly impacted, especially Bhutan, Myanmar, Nepal, Mongolia, the Solomon Islands and Timor-Leste. Nepal has the greatest intersection between inequality and loss of cultural heritage from disasters, pointing to the permanent losses in social sectors that occurred as a result of the 2015 earthquake. Additionally, in a number of Pacific islands there is a strong relationship between disaster losses in the agriculture sector and rising inequality. These inequalities will be further exacerbated in 1.5°C and 2°C warming scenarios.

FIGURE 2.9 Relationship between inequality (GINI) and disaster losses



Source: SDG Gateway Asia Pacific (2023a). Available at https://data.unescap.org/home
Note: ENEA = East and North-East Asia, NCA = North and Central Asia, SEA = South-East Asia, SSWA = South and South-West Asia. Lao PDR = Lao People's Democratic Republic.

FIGURE 2.10 Relationship between inequality (GINI) and disaster losses disaggregated by sectors



Source: SDG Gateway Asia Pacific (2023a). Available at https://data.unescap.org/home

IMPACTS ON FOOD SECURITY AND HUMAN HEALTH

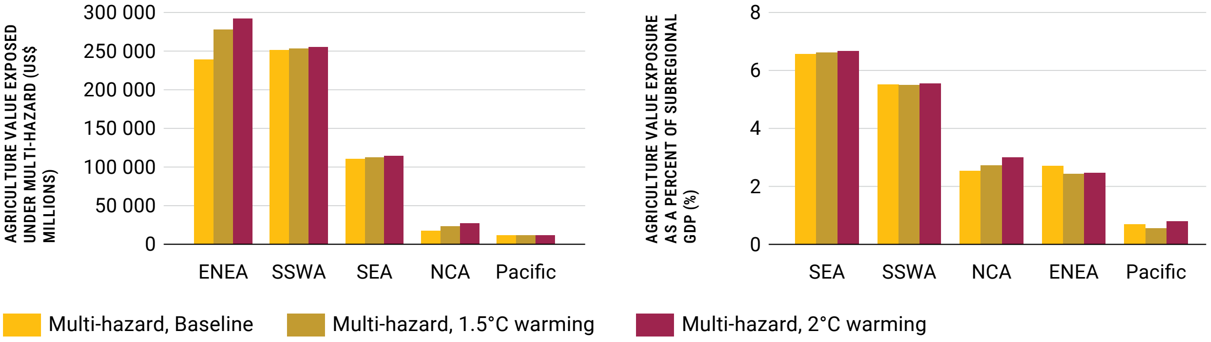
Climate change poses a significant threat to food security in Asia, impacting the agriculture sector and exacerbating inequalities. Despite progress in reducing income poverty, Asia still houses 67 per cent of the world's hungry population, approximately 552 million people (ADB, 2023).

Climate change is already affecting agriculture, including fisheries and livestock, across various economies and farming systems (Habib-Ur-Rahman and others, 2022; Pandey, 2022). Rice and wheat, the region's staple crops, are particularly vulnerable due to their high water dependency (Aryal and others, 2019). Heat stress and water scarcity resulting from climate change increases the risk of drought and crop loss, leading to higher food prices. Furthermore, climate variability, such as intense rainfall, floods, and droughts, has also contributed to surging food prices (ADB, 2022).

The decline in agricultural productivity due to climate-related hazards will have severe consequences for food security, particularly for vulnerable farming communities and urban poor populations already living in poverty. In 2021, 418 million Asians experienced extreme hunger, indicating a rise from the previous year. Asia also witnessed the highest food inflation rate in 2022 among all subregions (World Bank, 2022; FAO, 2022).

Figure 2.11 provides insights into the potential agricultural losses under different warming scenarios. East and North-East Asia face the highest absolute value of potential agriculture loss, with over $250 million at stake in all scenarios. South-East Asia is projected to suffer the most in terms of GDP loss, with potential agriculture losses amounting to 6 per cent of GDP. North and Central Asia and the Pacific also show increasing potential GDP losses.

FIGURE 2.11 Exposure of agriculture value under current, 1.5°C and 2°C warming (SSP3 scenario): Comparing absolute agriculture value vs. agriculture value/GDP, ESCAP subregions



Source: ESCAP.
Note: ENEA = East and North-East Asia, NCA = North and Central Asia, SEA = South-East Asia, SSWA = South and South-West Asia.

Countries with high potential exposure to losses from agriculture that already have high food insecurity will be the most affected by the warming climate.[5] Figure 2.12 illustrates the countries that are in the high-risk category under current and under 2°C climate warming scenarios. Countries in South and South-West Asia, such as Afghanistan, and in South-East Asia, such as Cambodia, will be at high risk of food insecurity under both climate scenarios. Countries, such as Bangladesh, Pakistan, the Islamic Republic of Iran, Sri Lanka, and Indonesia will be at higher risk under the 2°C warming scenario.

Under a 2°C warming, people in the Pacific SIDS (Vanuatu, Solomon Islands, Papua New Guinea) will be at a much higher risk of undernourishment due to potential agriculture losses from increasing floods and drought (Figure 2.13). This can have major impacts on increasing overall inequalities as agriculture has a high correlation with inequality in the Pacific region.

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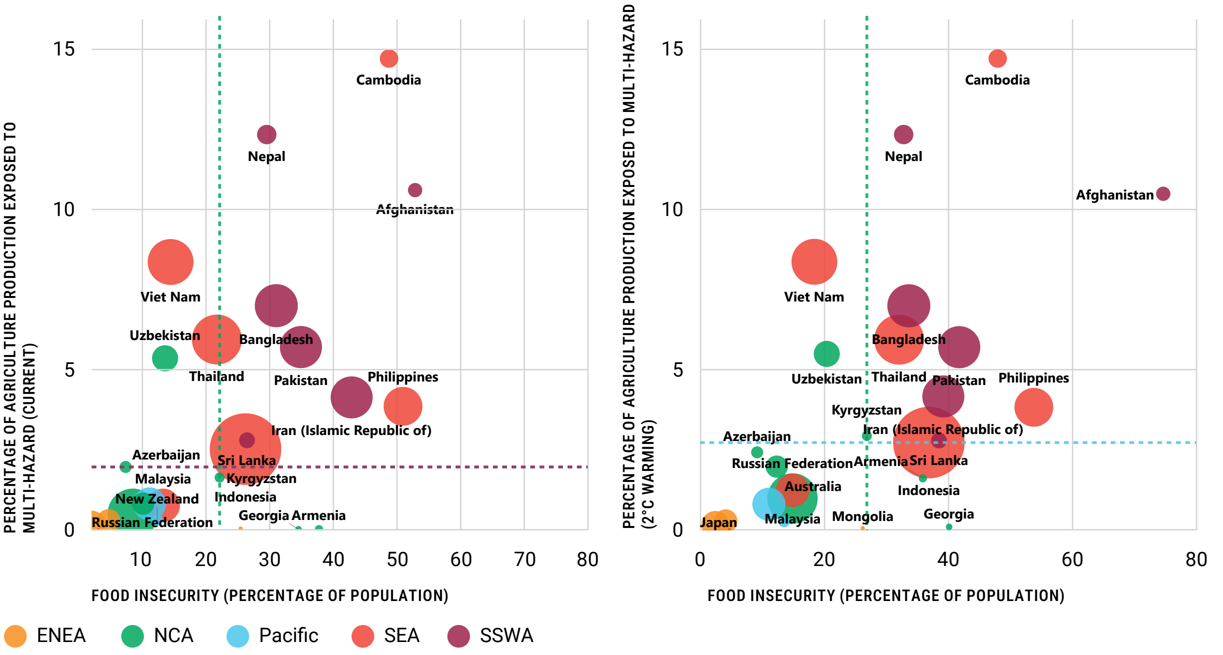
[5] This analysis is based on country data availability in the SDG Gateway. Available at https://dataexplorer.unescap.org/

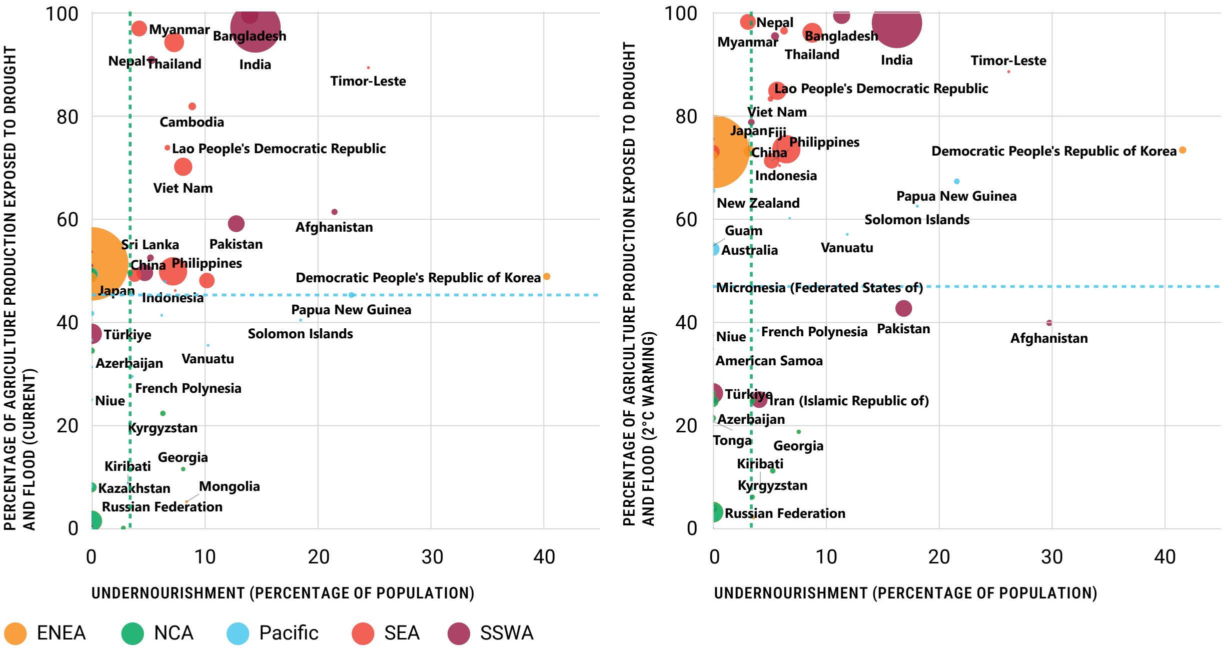
These findings highlight the urgency to address the impacts of climate change on agriculture to safeguard food security and reduce inequalities in the region.

FIGURE 2.12 **Food insecurity and risk exposure of agriculture sector under 1.5°C and 2°C warming**



Source: ESCAP.
Note: Size of bubbles indicate total agriculture value of country (US$); dotted lines denote the 50th percentile of food insecurity and agriculture production exposure.
Note: ENEA = East and North-East Asia, NCA = North and Central Asia, SEA = South-East Asia, SSWA = South and South-West Asia.

FIGURE 2.13 **Undernourishment and exposure of agriculture sector to floods and drought under current and 2°C warming scenarios: countries at risk**



Source: ESCAP.
Note: Size of bubbles indicate total agriculture value of country (US$); dotted lines denote the 50th percentile of undernourishment and agriculture production exposure.
Note: ENEA = East and North-East Asia, NCA = North and Central Asia, SEA = South-East Asia, SSWA = South and South-West Asia.

IMPACTS ON ENERGY SECURITY

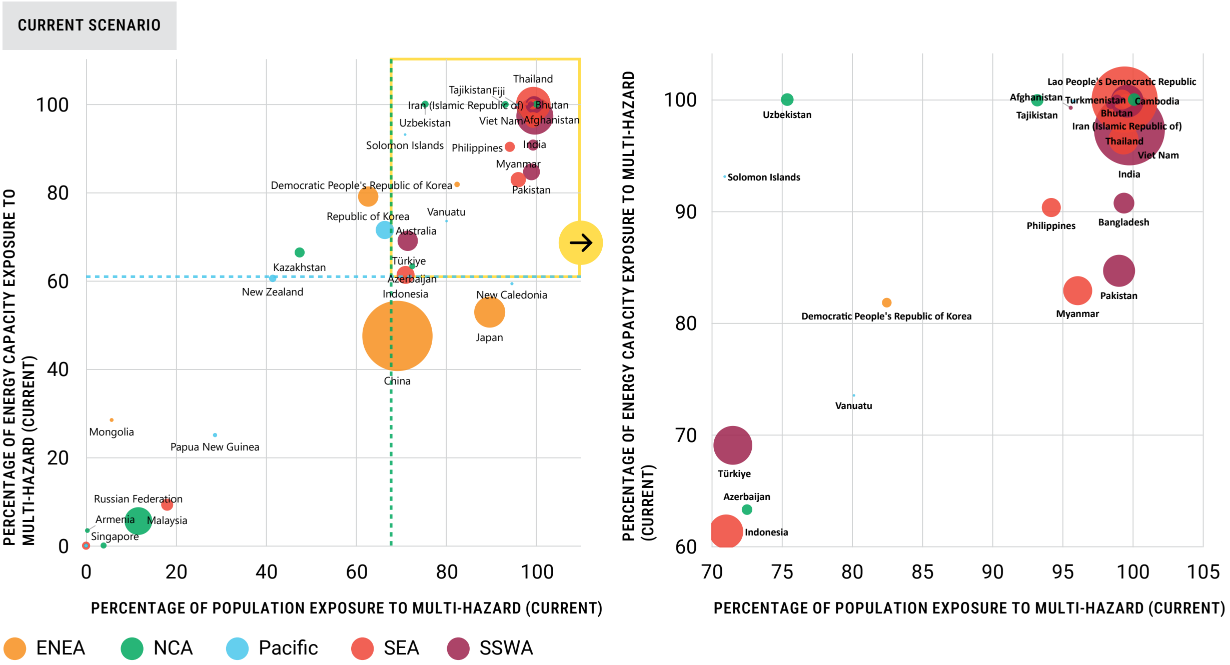
Disasters pose a significant risk to critical infrastructures, including energy systems, and climate change will further exacerbate these threats. Without action, climate change will impact fuel supply, energy production, and the resilience of energy infrastructure, jeopardizing lives and livelihoods. Heatwaves and droughts are already straining existing energy generation capabilities, highlighting the need to protect energy access (Winzenried and Purdie, 2022).

Hydropower generation is particularly vulnerable to climate change as it affects water availability. Thermal power plants, which require cooling water, are also at risk. Although dams can help mitigate climate change impacts through drought management and flood control, their reliance on climatic and hydrological conditions makes them susceptible. According to the International Energy Agency (IEA), in a 1.5°C warming scenario, the regional mean hydropower capacity factor in Asia and the Pacific is projected to decrease by 3.9 per cent, increasing to 5 per cent in a 2°C and above warming scenario (IEA, 2021).

As the demand for energy rises with population growth, the energy sector will face increasing stress. Figure 2.14 highlights countries with populations already exposed to high levels of climate hazards, which will experience significant stress on their energy capacity under current and 2°C warming scenarios. Least developed countries (LDCs) and landlocked developing countries (LLDCs) face a particularly challenging outlook, including Cambodia, the Lao People's Democratic Republic, Myanmar, Timor-Leste, Afghanistan, Bangladesh, Bhutan, Nepal, Solomon Islands, Azerbaijan, Tajikistan, Turkmenistan, and Uzbekistan.

Water stress also poses a threat to energy security. The availability of water directly impacts electricity generation from thermal, nuclear, and hydroelectric systems. In 2020, 87 per cent of global electricity from these sources depended on water availability. Thermal power plants and nuclear power plants located in high water stress areas face challenges, and the situation is expected to worsen in the coming years. Moreover, a significant portion of hydropower capacity is situated in river basins at medium to very high risk of water scarcity.

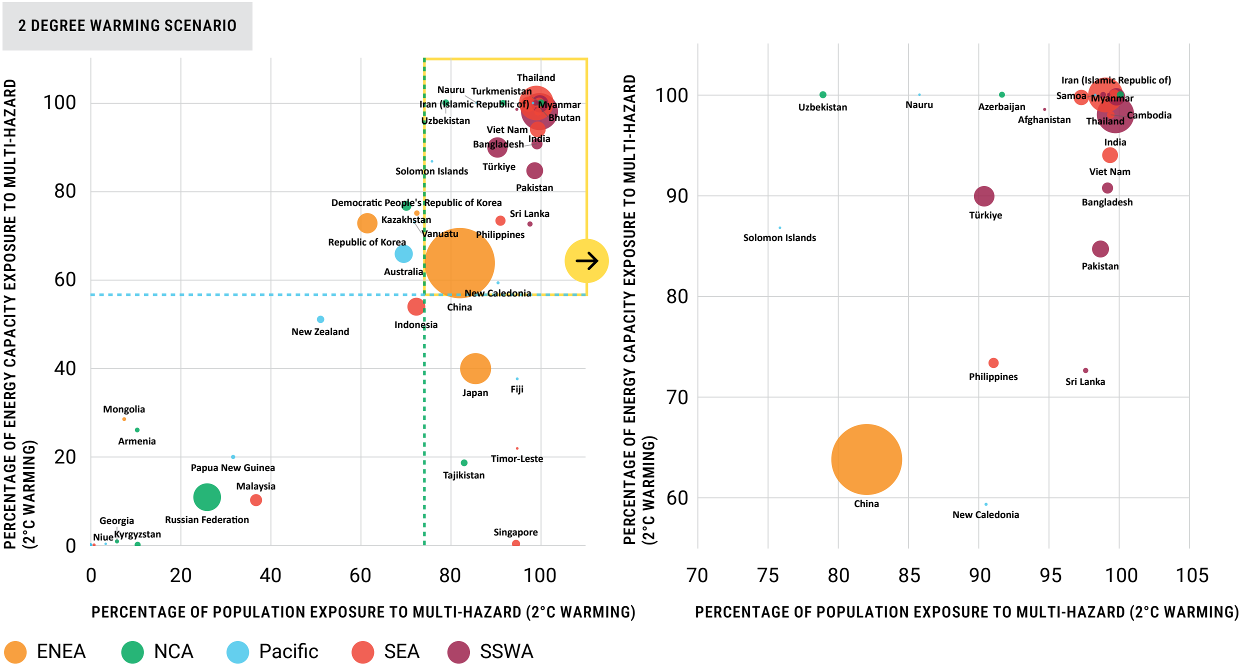
FIGURE 2.14 Total energy capacity exposure by population exposure to multi-hazard climate risk under current scenario



Source: ESCAP.
Note: ENEA = East and North-East Asia, NCA = North and Central Asia, SEA = South-East Asia, SSWA = South and South-West Asia.

Despite these risks, only 40 per cent of climate action plans submitted to the United Nations Framework Convention on Climate Change prioritize adaptation in the energy sector, indicating a lack of investment and attention. Figure 2.15 identifies countries at high risk due to the intersection of high water stress and exposure of energy capacity to climate hazards. Notably, LDCs and LLDCs feature prominently among the 18 countries at the highest risk, including those in North and Central Asia, the Pacific, South-East Asia, South and South-West Asia, East and North-East Asia (China), and Uzbekistan.

FIGURE 2.15 **Total energy capacity exposure by population exposure to multi-hazard climate risk under 2°C warming scenario**



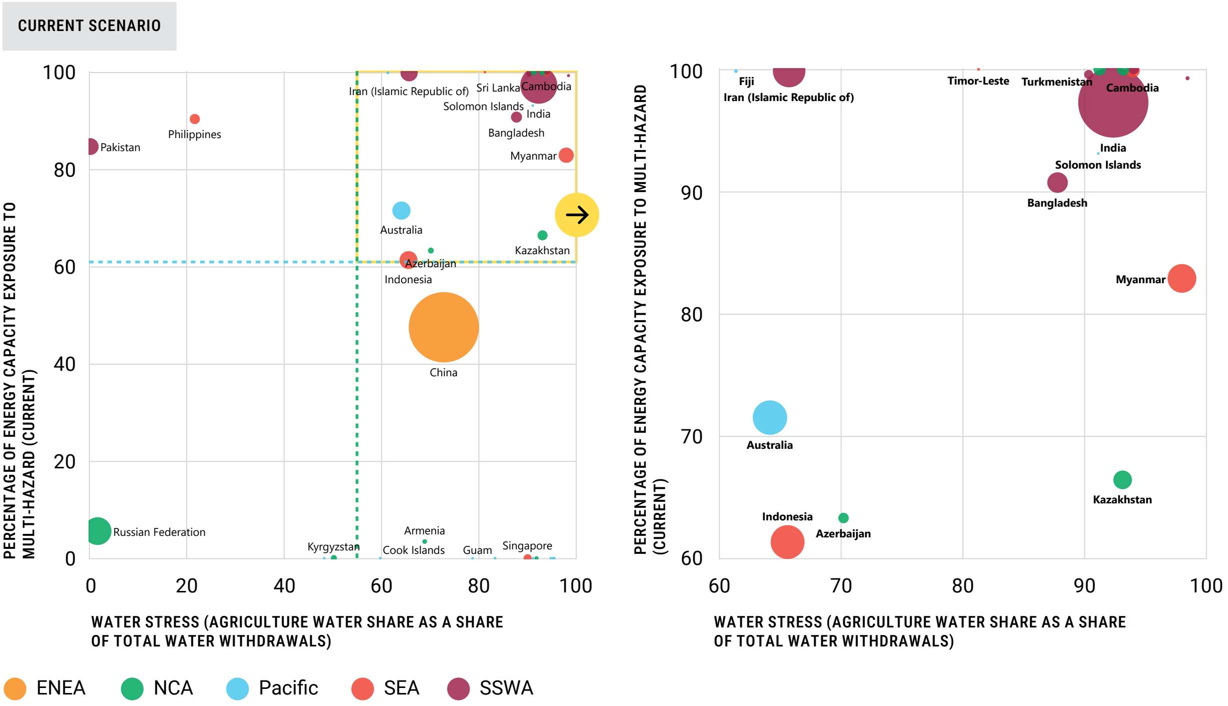
Source: ESCAP.
Note: ENEA = East and North-East Asia, NCA = North and Central Asia, SEA = South-East Asia, SSWA = South and South-West Asia.

Water stress poses a significant threat to energy security. According to the International Atomic Agency, in 2020, 87 per cent of global electricity generated from thermal, nuclear, and hydroelectric systems relied on water availability. Of the thermal power plants that depend on freshwater for cooling, 33 per cent are in high water stress areas. The same applies to 15 per cent of existing nuclear power plants, and this proportion is expected to rise to 25 per cent within the next two decades. Furthermore, 11 per cent of hydroelectric capacity is situated in highly water-stressed regions. River basins with a medium to very high risk of water scarcity contain approximately 26 per cent of existing hydropower dams, and 23 per cent of planned dams (WMO, 2022).

Despite these risks, only 40 per cent of climate action plans submitted to the United Nations Framework Convention on Climate Change prioritize adaptation in the energy sector, indicating limited investment in addressing these vulnerabilities (WMO, 2022).

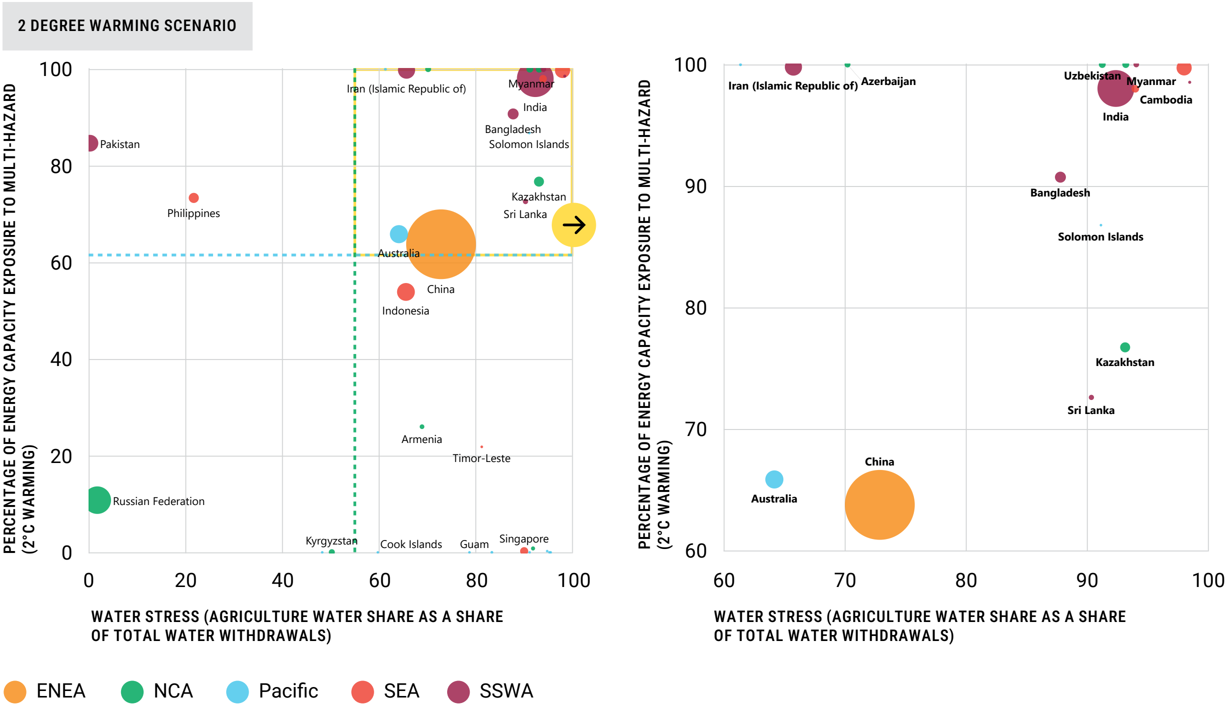
Figure 2.16 identifies countries facing the highest risk due to the intersection of high-water stress and exposure of energy capacity to climate hazards. At the 50th risk percentile in the current scenario, countries, such as Azerbaijan, Kazakhstan, Turkmenistan, Australia, Fiji, the Solomon Islands, Cambodia, Indonesia, Myanmar, Timor-Leste, Afghanistan, Bangladesh, Bhutan, India, the Islamic Republic of Iran, and Sri Lanka are particularly vulnerable. Under a 2°C warming scenario, East and North-East Asia, including China, as well as Uzbekistan, are added to the list. Among the 18 countries at the highest risk, 11 are classified as least developed countries (LDCs) or landlocked developing countries (LLDCs).

FIGURE 2.16 **Countries at risk from increasing water and energy insecurity under current warming scenarios**



Source: ESCAP.
Note: ENEA = East and North-East Asia, NCA = North and Central Asia, SEA = South-East Asia, SSWA = South and South-West Asia.

FIGURE 2.17 **Countries at risk from increasing water and energy insecurity under 2°C warming scenario**



Source: ESCAP.
Note: ENEA = East and North-East Asia, NCA = North and Central Asia, SEA = South-East Asia, SSWA = South and South-West Asia.

2.2.3 Climate-related hazards degrade the environment and destroy biodiversity

Climate hazards have a cyclical relationship with environmental degradation. Extreme weather conditions, like drought, heatwaves and floods, drive land degradation. In turn, land degradation intensifies the impacts of extreme weather on populations and economies, affecting food production, livelihoods, and the production and provision of other ecosystem goods and services. Following are a few examples of increasing hazards driving environmental degradation and biodiversity loss.

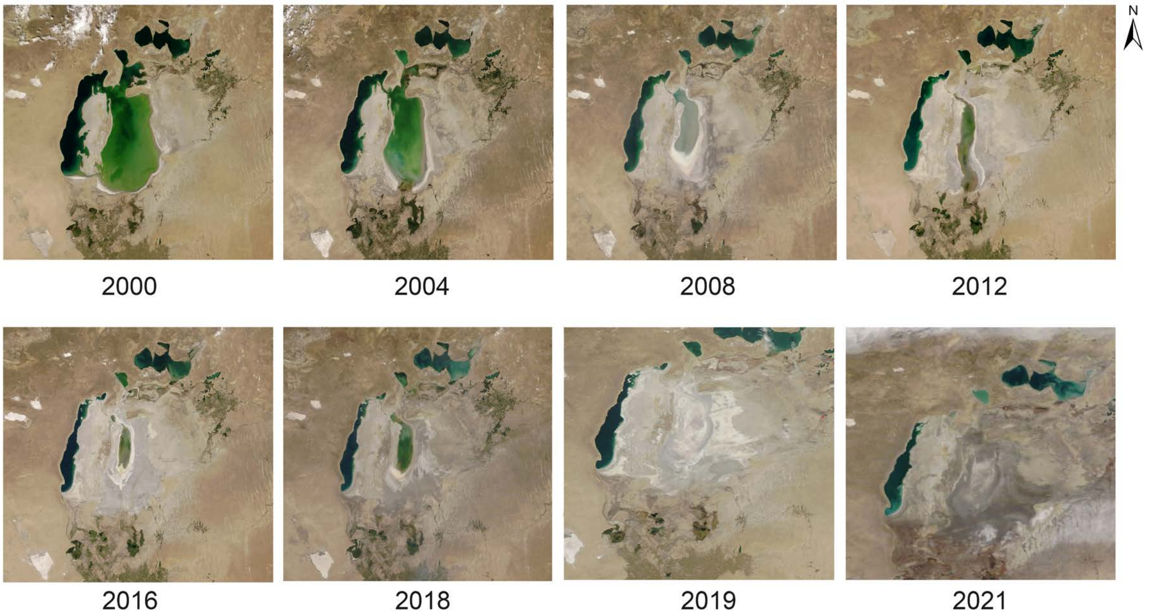
DROUGHT AND DESERTIFICATION DRIVE THE ARAL SEA CATASTROPHE

Desertification is a form of land degradation by which fertile land becomes a desert (WHO, 2020). Both natural variability in climate and global warming can affect rainfall patterns around the world, which can contribute to desertification. Rainfall has a cooling effect on the land surface, so a decline in rainfall can lead soils to dry out in the heat and become prone to erosion. Heavy rainfall can erode soil and cause waterlogging, subsidence and landslides. The key effect of climate change is through aridification, and this directly affects water supply to vegetation and soils.

The Aral Sea basin catastrophe in Central Asia is an example of this cascading disaster. The basin covers 60 per cent of the areas which stretches across Tajikistan, Turkmenistan, Uzbekistan, Kyrgyzstan and Kazakhstan, and the volume of water has significantly declined. Figure 2.18 shows the desiccation of the Aral Sea between 2000 to 2021. The total population in basins surrounding the Aral Sea is approximately 51 million, which includes people from Uzbekistan (55 per cent), Tajikistan (16 per cent), Kyrgyzstan (10 per cent), Turkmenistan (10 per cent) and Kazakhstan (9 per cent), and these populations are becoming more vulnerable, particularly with respect to the impacts of climate change on the basin.

FIGURE 2.18 The shrinking of the Aral Sea

WIND EROSION CAUSES DESICCATION OF LAKE URMIA WITH SIGNIFICANT IMPACTS ON HUMAN HEALTH



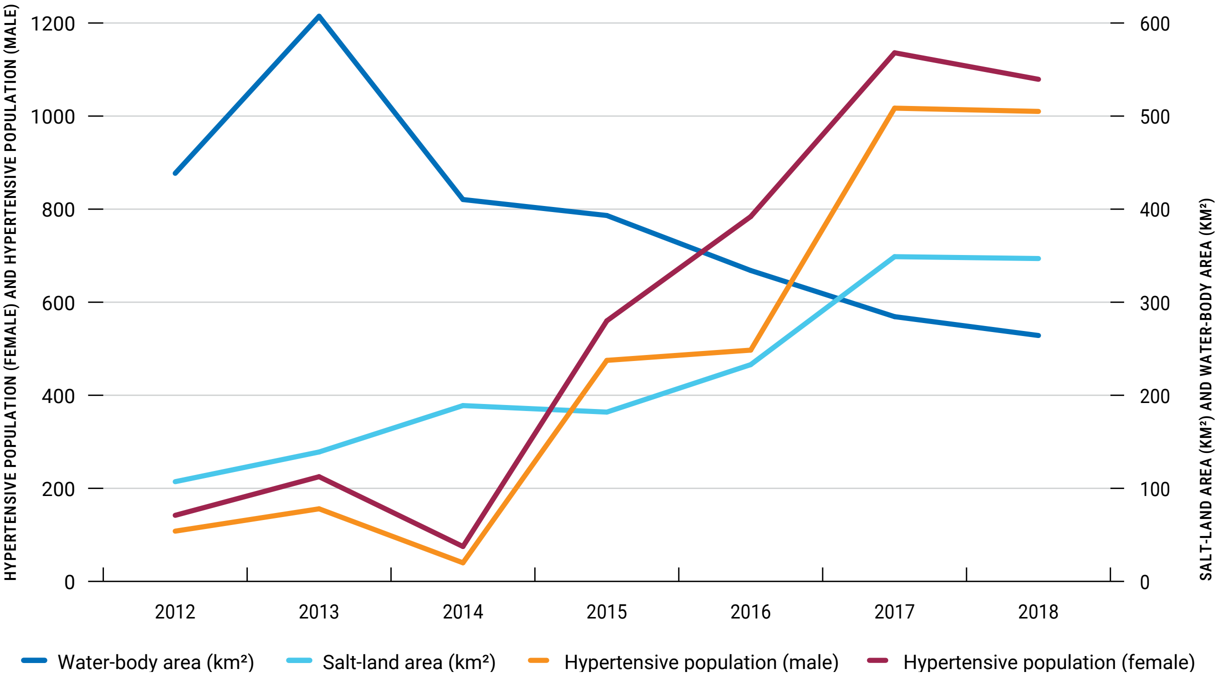
Source : MODIS on NASA's Terra satellite, 2019 and 2021. Available at: https://modis.gsfc.nasa.gov/gallery/individual.php?db_date=2019-10-11, https://earthobservatory.nasa.gov/world-of-change/AralSea and https://earthdata.nasa.gov/worldview/worldview-image-archive/aral-sea-kazakhstan-and-uzbekistan.

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 emergence of desiccated lakebed sediments and their exposure to wind erosion coupled with drought and desertification, as a consequence of climate change, poses a growing hazard. Airborne dust originating from such soils can create health and environmental issues due to their high salt content and the presence of toxic elements (Hamzehpour and others, 2022).

The desiccation of Lake Urmia in the Islamic Republic of Iran is a primary example of this compounding hazard. Drought has led to drying of water in the lake leading to hyper-salinity. This has led to salt release from the lake in the form of salt dust, which has increased the prevalence of diseases like hypertension and damaged the health of the local populations surrounding the lake. A time series study undertaken in the Shabestar County situated in the northern part of the lake shows a signification correlation between the time frame of the desiccation of the lake, increasing salinity and increased hypertension among people aged 35 to 60, which is the critical working age for any population (Feizizadeh and others, 2023). Figure 2.19 summarizes the results of the study, specifically demonstrating that as the water body decreased and salt area increased, so did hypertension, particularly among women and girls.

FIGURE 2.19 Relationship between desiccation of Lake Urmia and diminishing health of populations



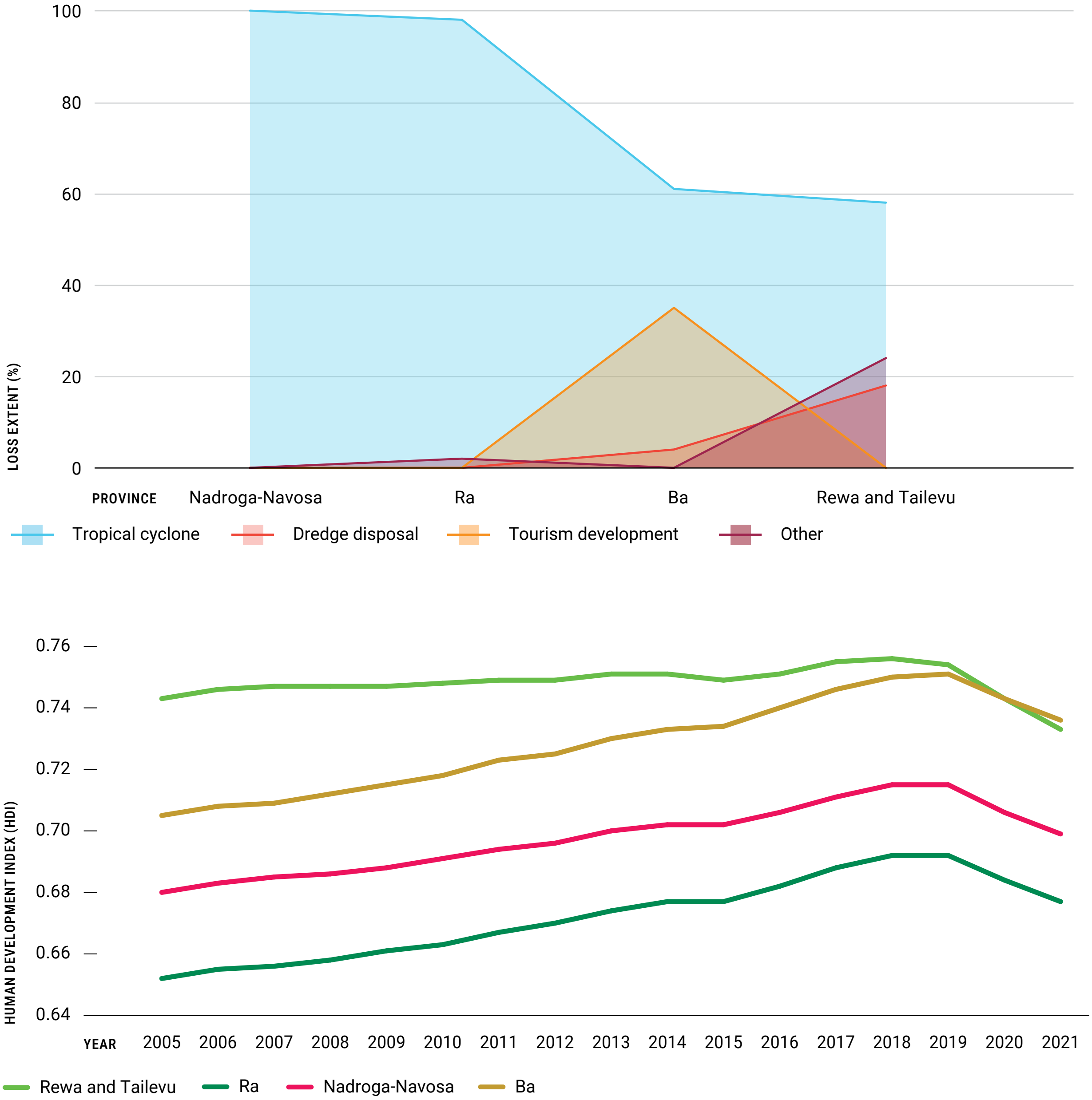
Source: ESCAP based on Bakhtiar Feizizadeh, and others, "Health effects of shrinking hyper-saline lakes: spatiotemporal modeling of the Lake Urmia drought on the local population, case study of the Shabestar County", *Scientific Reports,* vol. 13, No. 1622. (January 2023). Available at https://www.nature.com/articles/s41598-023-28332-6

CYCLONES ARE THE GREATEST CAUSE OF MANGROVE LOSS IN FIJI

Mangrove coverage in Fiji is among the highest of all Pacific countries. Mangrove ecosystems store carbon, provide important resources and are the first line of defence against tropical cyclones for many communities. While the primary drivers of mangrove loss in Fiji are manmade, tropical cyclones are themselves a key driver. Fiji lost 1135 hectares of mangroves between 2001 and 2018 and tropical cyclones accounted for 77 per cent of this loss (Cameron and others, 2021).

Figure 2.20 shows the riskscape of mangrove loss in four provinces of Fiji. In all provinces, tropical cyclones are the main cause. This is alarming because tropical cyclones are increasing in intensity in the Pacific SIDS and can cause development indicators to regress. Fiji's Subnational Human Development index shows a precipitous drop in the human development index, in 2018, for all concerned provinces (Global Data Lab, 2023). If the impact of the tropical cyclones on mangroves is not mitigated, this regression could continue.

FIGURE 2.20 The riskscape of mangrove loss in Fiji provinces, primary risk drivers and index of human development



Source: ESCAP, based on Clint Cameron, and others, "Landcover change in mangroves of Fiji: Implications for climate change mitigation and adaptation in the Pacific", *Environmental Challenges*, vol. 2 (January 2021). Available at https://www.sciencedirect.com/science/article/pii/S2667010020300184, and the Global Data Lab, 2023. Available at https://globaldatalab.org/.

CLIMATE PRESSURES OF TEMPERATURE AND PRECIPITATION INCREASE BIODIVERSITY LOSS IN THE ASIA-PACIFIC REGION

Thirty six per cent of global biodiversity hotspots that collectively comprise 2.5 per cent of the Earth's landscape are situated in the Asia-Pacific region (Habel and others, 2019). The increase in hydrometeorological hazards caused by climate change have already caused the loss of local species, increased diseases, and driven mass mortality of plants and animals, which has resulted in climate-driven extinctions. Higher temperatures have forced both plants and animals to move to higher elevations, with devastating consequences for many ecosystems. This is particularly significant as the biodiversity hotspots can act as natural carbon sinks and provide a nature-based solution to mitigate the impact of climate change (United Nations, 2022). A study of the world's biodiversity hotspots found that by 2030 many of these areas will be lost due to climate and agroeconomic pressures (Habel and others, 2019). Table 2.3 shows the biodiversity hotspots in the Asia-Pacific region with the accompanying loss of biodiversity areas projected for 2030. The biodiversity hotspots in South and South-West Asia and the

Pacific are under particular threat. Conservative projections of losses are estimated at 50 per cent for the biodiversity hotspots of the Western Ghats (mountain range in India) and Sri Lanka. In the Pacific, biodiversity losses in Australia and New Zealand are conservatively estimated at more than 20 per cent.

TABLE 2.3 Biodiversity hotspots in the Asia-Pacific subregions

Subregion	Hotspot of biodiversity loss	Percent loss area for biodiversity conservation from climate pressure (temperature, precipitation)	Endemic plant loss from climate and agroeconomic pressures
South and Southwest Asia			
	Western Ghats and Sri Lanka	51-74%	100%
	Himalaya	24-28%	18-67%
	Indian Ocean Islands	19-33%	100%
	Irano-Anatolian	15-24%	100%
South-East Asia			
	Philippines	20-45%	100%
	Indo-Myanmar	7-10%	12-49%
Pacific			
	Southwest Australia	39-49%	10-44%
	Forests of Eastern Australia	29-46%	N/A
	New Zealand	23-29%	3-17%
North and Central Asia			
	Mountains of Central Asia	14-27%	4-22%
East and Northeast Asia			
	Mountains of South-West China	32-52%	7-33%
	Japan	27-35%	4-20%

Source: ESCAP, based on Jan C. Habel, and others, "Final countdown for biodiversity hotspots", *Conservation Letters* (July 2019). Available at https://conbio.onlinelibrary.wiley.com/doi/epdf/10.1111/conl.12668

The high price of inaction described in this chapter will continue under a 'business as usual framework' as the world inches closer to 1.5°C and 2°C climate warming. Only a shift to a transformative adaptation model can halt, and perhaps reverse some of the losses in social, economic and environmental sectors. The next chapter will demonstrate the key pillars of this transformative adaptation and where investments with the largest benefits are most needed.

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CHAPTER 3

Protecting people and development gains

As disaster risk intensifies and multi-hazard risk hotspots expand in the Asia-Pacific region, millions of people are increasingly becoming vulnerable. The share of people exposed to multi-hazard risk is forecast to increase to 85 per cent of the region's population under 1.5°C warming and 87 per cent under 2°C warming. Food and energy systems are exposed to increasingly intense and frequent shocks. To protect people at risk and hard-earned development gains, this chapter focuses on transformative adaptation actions to strengthen multi-hazard warning systems and tackle the social, economic and environmental dimensions of disaster risk.

Multi-hazard early warning systems are one of the most effective ways to reduce mortality from natural disasters. Anchored in comprehensive risk management policies to build resilience, stronger sector-specific early warning systems could protect key agriculture and energy sectors, and reduce the economic cost of disasters by up to 60 per cent. Many countries in the region require urgent investment in this area. The 10 countries facing the most serious intensification of risks are those most in need of increased forecasting and preparedness and response capabilities. In response to environmental degradation, nature-based solutions are needed to protect ecosystems which are the first line of defence against disaster risk. Such solutions could deliver up to 40 per cent of required climate actions.

3.1 Introduction

Protecting development gains is a significant challenge as the impact of climate change is felt across Asia and the Pacific and disaster risk is increasing. In addition to ambitious and immediate measures to reduce greenhouse gas emissions, adapting to the consequences of climate change is imperative to protect people, economies, and the natural environment. The body of evidence detailing the benefits of transformative adaptation measures is growing.

The *Adaptation Gap Report 2022* chronicles slow progress in climate change adaptation and showcases nature-based solutions which could accelerate the pace of change (UNEP, 2022). The *Hydromet Gap Report 2021* argues that improved weather forecasting, early warning systems and climate information could save 23,000 lives globally and deliver US$ 162 billion worth of benefits every year (Alliance for Hydromet Development, 2021). The report, *Adapt Now: A Global Call for Leadership on Climate Resilience*, details the benefits of adaptation to urge action by governments, businesses, investors, and community leaders (Global Commission on Adaptation, 2019). *The Economic Case for Nature* report shows how protecting ecosystems can avoid trillions in losses to national economies (Johnson and others, 2021).

Building on these global and regional findings, a framework of four transformative actions is proposed that includes: (i) human necessities to protect people in multi-hazard risk areas and hotspots; (ii) economic necessities or the investment cost of multi-hazard early warning systems to protect people; (iii) economic necessities or the investment cost of protecting food and energy systems; and (iv) environmental necessities, especially conserving biodiversity through nature-based solutions (Figure 3.1).

3.2 Saving lives in riskier times

Asia and the Pacific accounts for almost half of the global disaster-related mortality, despite a significant reduction in the number of fatalities in recent years. The share of people exposed to multi-hazard risks in the region is forecast to increase from 82 per cent under the status quo to 85 per cent under a 1.5°C warming, and to 87 per cent under the 2°C warning scenario. By analysing the latest climate projections where populations are concentrated, the emerging and intensifying risk hotspots, and underlying vulnerabilities, it is possible to forecast where future mortality from disasters is likely to occur. In light of these forecasts, transformative adaptation measures are essential to build resilience to increasing and compounding disasters.

FIGURE 3.1 **A framework of four transformative actions for protecting the people at risk**

Human necessities: Protect People

- At risk communities in multi-hazard risk areas/risk hotspots
- People-centered early warning systems
- Focus on most vulnerable, multi-hazard risk hotspots

Environmental necessities: Nature-based solutions

- Eco-disaster risk reduction in coastal, arid/semi-arid and dryland, mountainous regions
- Grey and green infrastructure for reducing loss and damage
- Resilience-building

Economic necessities 1: Economic cost of fit-for-purpose multi-hazard early warning systems

- Investment cost of early warning to early action
- Pathways of early warning for all in Asia and the Pacific

Economic necessities 2: Economic cost of early warning systems for food and energy systems

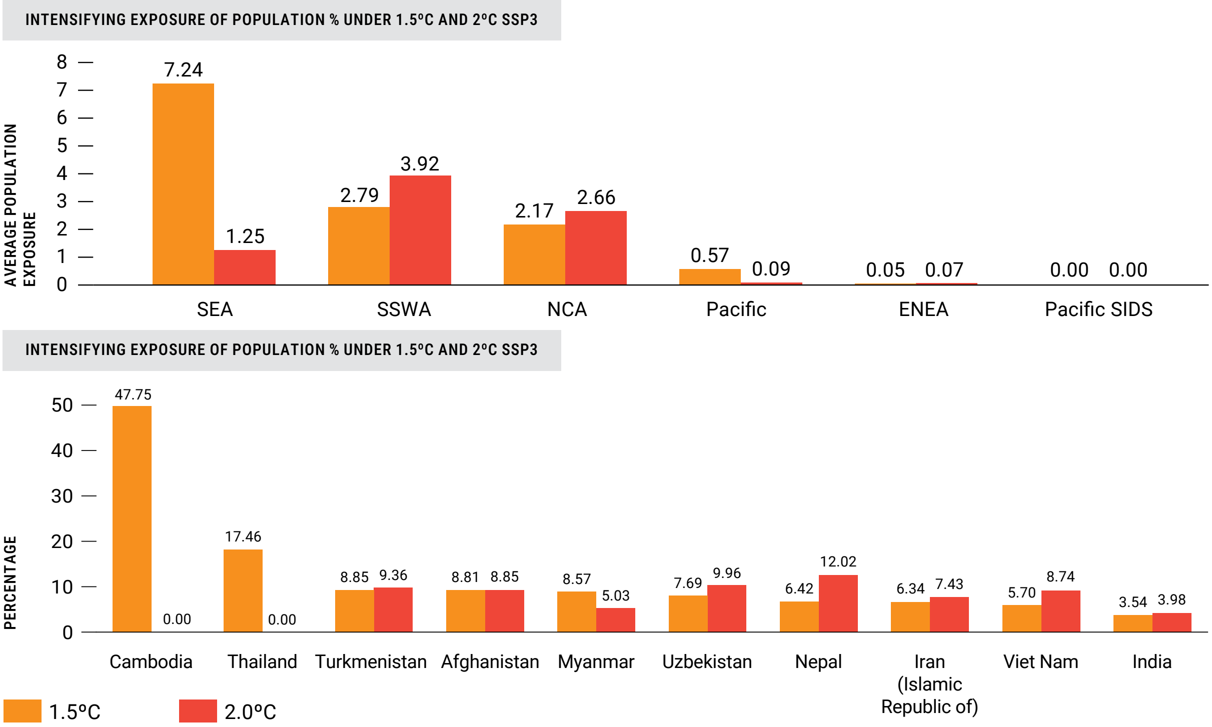
- Early warning and early actions for managing risk in food and energy systems

Source: ESCAP.

INTENSIFYING RISK HOTSPOTS

In Asia and the Pacific, there are 100 million people forecast to be exposed to intensifying hazards from climate change under both the 1.5°C and 2°C warming scenarios. This means 2.2 per cent of the population would be exposed to intensifying multi-hazard risks under 1.5°C warming. This exposure would be slightly reduced under 2°C warming. In the subregions, the populations most at risk live in South-East Asia, South and South-West Asia and North and Central Asia. The countries with the highest share of the population exposed to intensifying multi-hazard risks under the 1.5°C warning scenario include Cambodia, Thailand and Turkmenistan. Cambodia is forecast to experience the greatest increase in the percentage of its population exposed to intensifying multi-hazard risks reaching close to 50 per cent. Thailand follows with over 17 per cent of its population exposed, and Turkmenistan with close to 9 per cent of its population exposed to intensifying multi-hazard risks. Under the 2°C warming scenario, Nepal would experience the greatest increase with over 12 per cent of the population exposed, followed by Uzbekistan and Turkmenistan, each with over 9 per cent of exposure to intensifying risks.

FIGURE 3.2 **Intensifying exposure of population by ESCAP subregions and by countries**

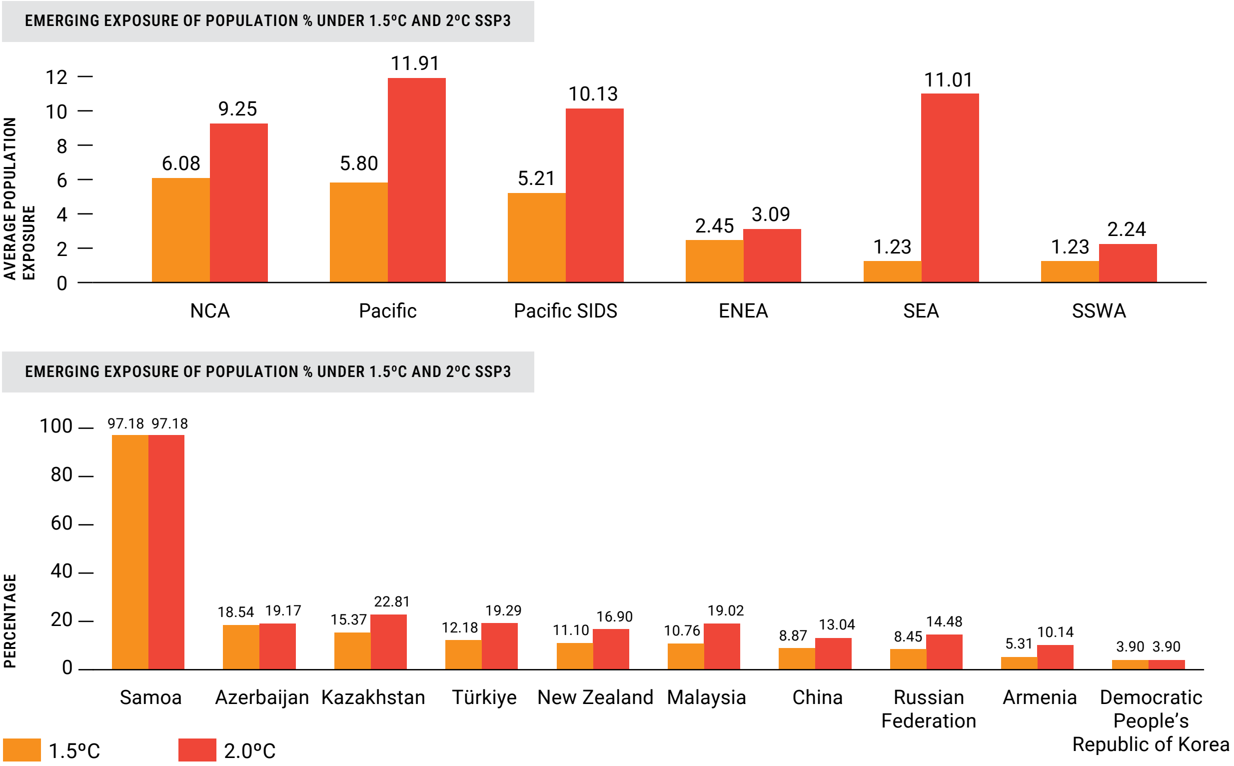


Note: NCA = North and Central Asia, ENEA = East and North-East Asia, SEA = South-East Asia, SSWA = South and South-West Asia.
Source: ESCAP.

EMERGING RISK HOTSPOTS

In Asia and the Pacific, 3.59 per cent of population is at risk of emerging multi-hazard risks under 1.5°C warning scenario and this increases to 8.01 per cent under a 2°C warming scenario. The populations most at risk are in the North and Central Asia, Pacific and the South-East Asia subregions. In the Pacific, Samoa is expected to experience the greatest increase in population exposure to newly emerging multi-hazard risks, with over 97 per cent of its population becoming exposed to emerging hotspots. Azerbaijan and Kazakhstan follow, with over 15 per cent of their population expected to become exposed to emerging hotspots under both climate scenarios.

FIGURE 3.3 Emerging exposure of population by ESCAP subregions and by countries



Note: NCA = North and Central Asia, ENEA = East and North-East Asia, SEA = South-East Asia, SSWA = South and South-West Asia.
Source: ESCAP.

3.2.1 Early warning to save lives

WHY IS EARLY WARNING SO IMPORTANT?

Early warning is one of the most effective ways to reduce mortality from natural hazards. Upgrading all hydro-meteorological information production and the early warning capacity of developing countries to that of developed-country standards could save an average of 23,000 lives every year, according to the World Bank (Hallegatte, 2013). A 24-hour prior warning of an incoming storm or a heatwave can reduce the ensuing damage by 30 per cent. An investment of $800 million on such systems in developing countries would avoid losses of $3-16 billion per year (Global Commission on Adaptation, 2019).

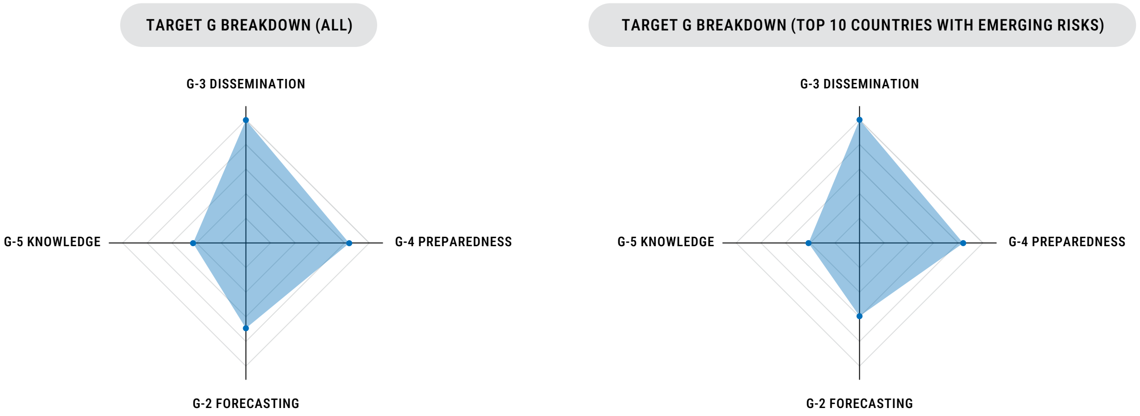
Enhancing early warning systems is a critical tool with which to address the climate risks highlighted by the Sendai Framework for Disaster Risk Reduction and the Paris Agreement. The United Nations Office for Disaster Risk Reduction (UNDRR) estimates that countries with limited to moderate multi-hazard early warning system (MHEWS) coverage have nearly eight times the mortality rate of countries with substantial to comprehensive coverage. Advancing the coverage of effective MHEWS, especially in risk hotspots, is thus critical to reduce the number of disaster risk-related fatalities (UNDRR and WMO, 2022).

EXISTING EARLY WARNING SYSTEMS: INSUFFICIENT COVERAGE

Target G of the Sendai Framework for Disaster Risk Reduction monitors the availability of and accessibility to multi-hazard early warning systems and disaster risk reduction information. It is a good indicator of the status of the disaster risk and where action is needed. This information and calculations of exposure to disaster risk are critical for the design, implementation, and reinforcement of early warnings. By March 2022, 120 countries had provided information on their Target G status of which 95 reported the existence of MHEWS. While this represents a twofold increase from the achievement reported in 2015, fewer than half of countries in the world have MHEWS (UNDRR and WMO, 2022).

In Asia and the Pacific, out of the top 10 countries with populations most exposed to emerging climate risk hotspots, three countries (Azerbaijan, China, and the Democratic People's Republic of Korea) did not report the status of their MHEWS. Out of the remaining seven countries, three countries (Malaysia, the Russian Federation and Samoa) did not report on all components of Target G. Kazakhstan reported very limited forecasting and monitoring systems and very limited disaster risk information and assessment. It nonetheless reported having good dissemination and preparedness.

FIGURE 3.4 Target G breakdown of all Asia and the Pacific countries (left), and of the top 10 countries with emerging risks (right)



Source: United Nations Office for Disaster Risk Reduction (UNDRR) and World Meteorological Organization (WMO), *Global Status of Multi-Hazard Early Warning Systems: Target G*, Geneva, 2022. Available at https://www.undrr.org/publication/global-status-multi-hazard-early-warning-systems-target-g

The top 10 countries with intensifying risks are those most in need of enhanced disaster risk knowledge and forecasting capabilities.[6] Out of these countries, only Thailand reported a high score for forecasting (0.81). Nepal reported a low score (0.13) despite having over 6 and 12 per cent of the population exposed to intensifying risk under the 1.5°C and 2°C scenarios, respectively. Cambodia, the Islamic Republic of Iran, Turkmenistan and Viet Nam did not complete Target G reporting, and Afghanistan, India, Thailand, Uzbekistan did not report on all aspects of Target G.

To fully understand the state of preparedness, in the face of increasing and cascading risk from climate change, it is imperative to understand the risks, the vulnerabilities and where countries need to increase their focus. Increasing the reporting of Target G of the Sendai Framework is one important step towards building this understanding.

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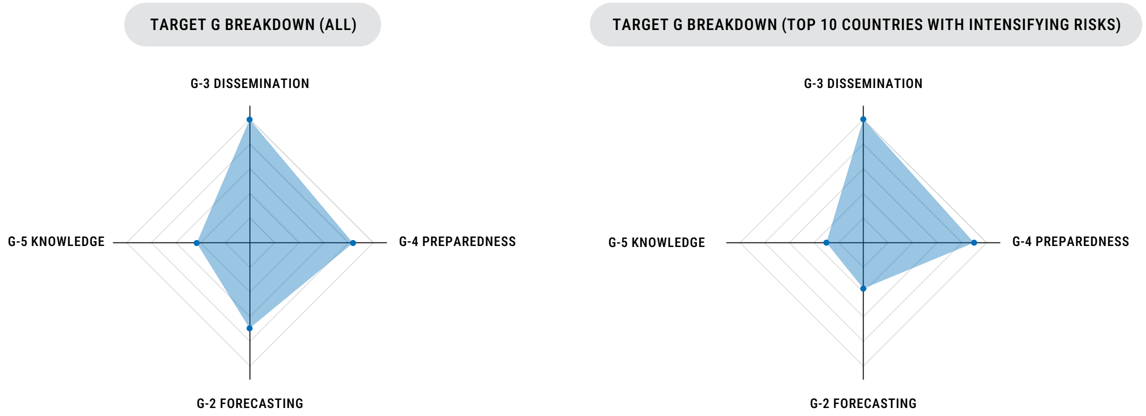
[6] Top 10 countries with intensifying risks under 1.5°C (in descending order): Cambodia, Thailand, Turkmenistan, Afghanistan, Myanmar, Uzbekistan, Nepal, Iran, Viet Nam, India.

FIGURE 3.5 Target G breakdown of all Asia and the Pacific countries (left), and of the top 10 countries with intensifying risks (right)



Source: United Nations Office for Disaster Risk Reduction (UNDRR) and World Meteorological Organization (WMO), *Global Status of Multi-Hazard Early Warning Systems: Target G*, Geneva, 2022. Available at https://www.undrr.org/publication/global-status-multi-hazard-early-warning-systems-target-g

EARLY WARNING SYSTEMS: THE EXECUTIVE ACTION PLAN TO SAVE LIVES

On World Meteorological Day in March 2022, the UN Secretary General, António Guterres, announced the Early Warnings for All Initiative. Its goal is to ensure every person on Earth is protected by early warning systems within the next five years. This was followed by the launch of an Executive Action Plan for the Early Warnings for All initiative, based on four pillars adopted at COP27 through the Sharm El-Sheik Implementation Plan (Figure 3.6). Delivering on the UN Secretary-General's goal requires global collaboration and significant investments. It calls for the mobilization of at least $3.1 billion to implement the plan on a global scale.

FIGURE 3.6 Four components of an early warning system

DISASTER RISK KNOWLEDGE

SYSTEMATICALLY COLLECT DATA AND UNDERTAKE RISK ASSESSMENTS

- Are the hazards and the vulnerablllties well known by the communities?
- What are the patterns and trends in these factors?
- Are risk maps and data widely available?

DETECTION, OBSERVATIONS, MONITORING, ANALYSIS AND FORECASTING OF HAZARDS

DEVELOP HAZARD MONITORING AND EARLY WARNING SERVICES

- Are the right parameters being monitored?
- Is there a sound scientific basis for making forecasts?
- Can accurate and timely warnings be generated?

PREPAREDNESS AND RESPONSE CAPABILITIES

BUILD NATIONAL AND COMMUNITY RESPONSE CAPABILITIES

- Are response plans up to date and tested? Are local capacities and knowledge made use of?
- Are people preapred and ready to react to warnings?

WARNING DISSEMINATION AND COMMUNICATION

COMMUNICATE RISK INFORMATION AND EARLY WARNINGS

- Do warnings reach all of those at risk? Are the risks and warnings understood? Is the warning information clear and usable?

Source: World Meteorological Organization, "Early Warnings For All Initiative scaled up into action on the ground", 21 March 2023. Available at https://public.wmo.int/en/media/press-release/early-warnings-all-initiative-scaled-action-ground.

FOUR PILLARS OF EARLY WARNING SYSTEMS

The Executive Action Plan, developed with key partner organizations, summarizes the initial actions required to achieve the goal of protecting every person on Earth by early warning systems within the next five years, and sets out the pathways for implementation, building on the four components of multi-hazard early warning systems.

The plan identifies key areas for advancing universal disaster risk knowledge-building on the aforementioned Target G of the Sendai Framework. It prioritizes the main technical actions required to enhance the capacity to detect hazards, close the observation gap, and advance global forecast data processing systems and data exchange, thereby enhancing people-centred early warning dissemination, communication, preparedness and response capabilities.

FIGURE 3.7 Four pillars of an early warning system

Source: World Meteorological Organization, "Early Warnings for All: the UN global early warning initiative for the implementation of climate adaptation: Executive Action Plan 2023-2027", 2022. Available at https://library.wmo.int/index.php?lvl=notice_display&id=22154

TABLE 3.1 Budgetary breakdown of the top 5 priorities of the Early Warnings for All initiative

Item	Pillar	Amount (% of total)
Increase local capacities to respond effectively and timely based on early warning alerts	Pillar 4: Preparedness and response	$625 million (20%)
Global observations: Satellite data use in at least 100 countries	Pillar 2: Observations and forecasting	$500 million (16%)
Infrastructure networks and services	Pillar 4: Dissemination and communication	$420 million (14%)
Systematic Observations Financing Facility (SOFF) implementation in at least 100 countries	Pillar 2: Observations and forecasting	$400 million (13%)
Financial: Increasing financing for preparedness and anticipatory action	Pillar 4: Preparedness and response	$369 million (12%)

Source: World Meteorological Organization (WMO), "Early Warnings for All: the UN global early warning initiative for the implementation of climate adaptation: Executive Action Plan 2023-2027", 2022. Available at https://library.wmo.int/index.php?lvl=notice_display&id=22154

Successful implementation of the initiative would ensure that further investment in MHEWS should be undertaken across the value cycle and in close collaboration with those who need to receive the warnings. According to a study examining the 12 deadliest and costliest disasters this century, the lack of early warning system protection stemmed not from inadequate forecast capability, but rather from inadequate communication and response capability (Coughlan de Perez and others, 2022). For instance, Tropical Cyclone Nargis, killed over 138,000 people in Myanmar in 2008. Despite accurate international forecasts and advisories, limited warnings reached the public and limited evacuation infrastructure was available (Coughlan de Perez and others, 2022). The 2022 floods in Pakistan demonstrated the limited ability of the authorities to undertake preparedness measures despite the capacity of technical agencies in observations, analysis and forecasting of the specific hazards (Government of Pakistan, 2022).

Moreover, strengthening multi-hazard early warning systems must address gaps to meet the needs of women, people with disabilities, the elderly and any other groups identified as vulnerable (Government of Pakistan, 2022). This can also be applied in the case of earthquakes, where increased research is ongoing, especially in the forecasting capability of seismology. To ensure success, balanced investment in all four pillars of early warning systems is needed (Coughlan de Perez and others, 2022).

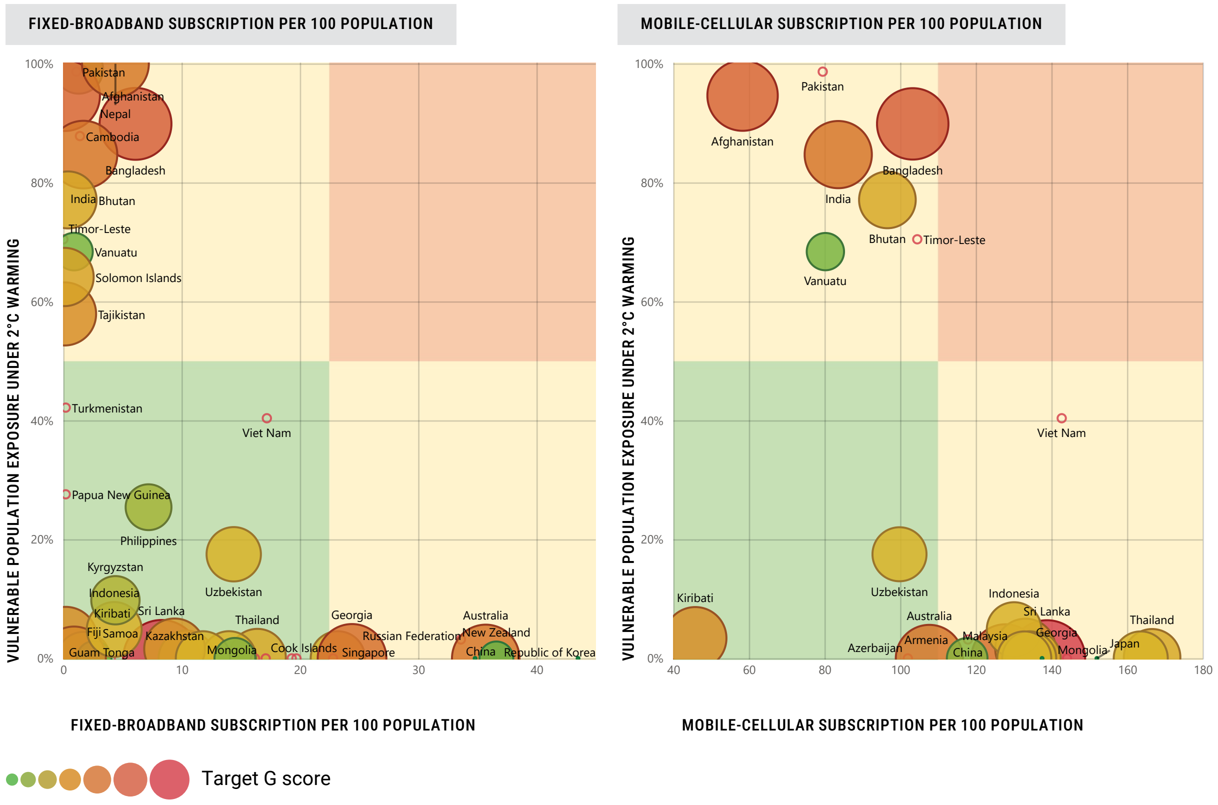
PEOPLE-CENTRED EARLY WARNING SYSTEMS

To reach the most exposed, vulnerable and often hard-to-reach populations, an integrated people-centred approach is needed to deliver early warning services. Multi-level cooperation and stakeholder engagement can shape systems, which reflect the needs, priorities, capacities, and cultures of the people at risk. Analysis of the 12 deadliest and costliest disasters this century, shows the damage and impact from disasters cannot be mitigated without the early warnings reaching those at risk. These warnings must be informative, clear, and relevant to the context and existing capabilities of the area at risk.

Climate projections make it possible to identify countries that are exposed to higher risk. They can help identify the existing status and capability of an early warning system, and assess its ability to reach vulnerable populations. The left panel in Figure 3.8 displays the reach of fixed broadband, and the right panel shows the mobile phone connectivity of the population of countries in the Asia-Pacific region. It demonstrates that in the Asia-Pacific region, many more people are connected through mobile phones rather than through fixed broadband. This is especially the case in developing countries.

Afghanistan stands out as a country that has a very high vulnerability under 2°C warming scenario, with over 94 per cent of its population exposed to disaster risk. It has a low reach of both mobile and fixed-broadband subscriptions, and is lacking in MHEWS. Bangladesh and India have a significant percentage of the vulnerable population exposed to disaster risk under the 2°C warming scenario, with over 84 per cent of their populations exposed. Although this vulnerability is somewhat mitigated through the better reach of mobile phones, as indicated by the mobile-cellular subscription (both countries over 83 per cent), other pillars of early warning systems could be improved to reduce the high vulnerability.

FIGURE 3.8 Percentage of vulnerable population exposure under the 2°C warming scenario, Target G score and population reach



Source: ESCAP.

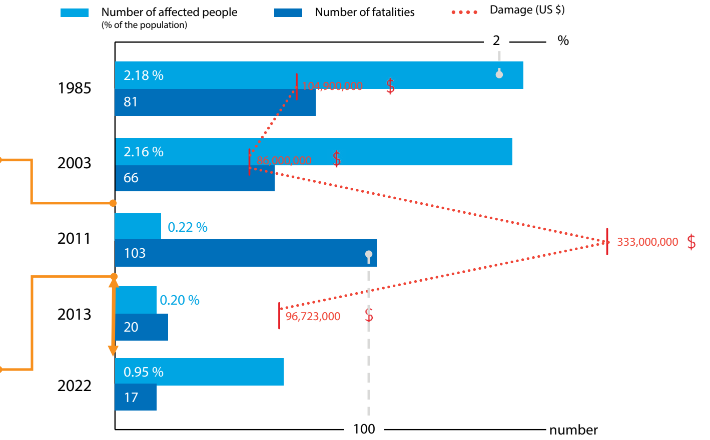
Note: Countries that have no data on the reach indicator such as fixed-broadband subscription or mobile-cellular subscription do not feature on the visuals. Countries that did not submit Target G are represented as an empty circle. The size and the colour of the bubble indicate the Target G score (the bigger the redder the lower the Target G score).

BOX 3.1 Saving lives through improving the early warning system (Philippines)

Typhoon in the Philippines

TTF-01	06-10	Support to the establishment of capacities in the region to observe and evaluate anomalous sea level conditions for early warning of tsunamis in the Indian Ocean and Southeast Asia
TTF-07	09-10	End-to-end early warning of tsunamis and other natural hazards for disaster preparedness and mitigation in the Indian Ocean and So utheast Asia: Phase 2
TTF-12	09-11	ABU Early Warning Broadcast Media Initiative

TTF-18	12-14	Technical assistance for enhancing the capacity of end-to-end mul ti-hazard Early Warning Systems (EWS) for coastal hazards in Myanmar, Sri Lanka, and the Philippines
TTF-19	12-15	ABU Disaster Risk Reduction Broadcast Initiative
TTF-22	12-15	Synergized Standard Operating Procedures (SSOPs) for Coastal Multi-Hazard Early Warning Systems
TTF-25	14-16	CAP on a MAP – Improving Institutional Responsiveness to Coas tal Hazards through Multi-Agency Situational Awareness



Year	Name	Death	Affected	Damage (US $)	Population
1985	Dot	81	1,183,626	104,900,000	54,280,000
2003	Imbudo	66	1,795,601	86,000,000	83,050,000
2011	Nesat	103	205,885	333,000,000	95,570,000
2013	Nari	20	200,000	96,723,000	98,870,000
2022	Noru	17	1,072,282	Under assessment	112,918,986

Source: EM-DAT, "The International Disaster Database". Available at https://www.emdat.be

The ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness ("Trust Fund") is a multi-doner trust fund that was created in 2005 after the 2004 Indian Ocean Tsunami resulted in a widespread tragic loss of life and livelihoods. The Trust Fund has provided global-to-regional-to-local financial support for the establishment of key initiatives that deliver cost-effective warning products and services in 19 countries, which have directly benefitted from support in building regional and national end-to-end warning systems for coastal hazards, including the Philippines.

Comparing impacts of Tropical Cyclone Noru (2022) to that of Tropical Cyclone Nari (2013) and Tropical Cyclone Nesat (2011), it is possible to see a significant reduction in the number of deaths from over 100 to 20 deaths in 2013, and to 17 in 2022. Between the three most recent big cyclones, four initiatives were supported by the Trust Fund, which included improving early warning systems by strengthening their operational capacity and modelling methods on early-stage detection of natural hazards, developing guidelines for communicating with persons with disabilities in emergencies, and improving capacity to issue warnings in the common alerting protocol (CAP) format.

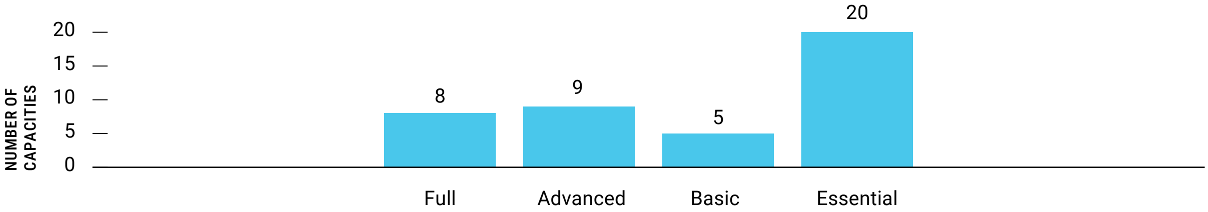
SECTOR-SPECIFIC EARLY WARNING SYSTEMS

Many countries lack the capacity to incorporate an impact-based approach to forecasting. Accessing, analysing and translating prediction model outputs into actionable warning messages is an ongoing challenge. Recognizing this, many National Meteorological and Hydrological Services (NMHSs) are moving towards a Multi-hazard Impact-based Forecast and Warning Services approach that translates meteorological and hydrological hazards into sector and location-specific impacts, and supports the development of responses to mitigate those impacts.

Early warning systems need to be well incorporated into a comprehensive risk management policy to build resilience in key sectors, especially in the food and energy sectors. Looking at sectoral impacts of disasters, including those in 2022, agriculture continues to bear the brunt of their impact. This is especially the case in countries where the sector holds an important share of the economy. For example, the agriculture sector employs over 30 per cent of the labour force in developing countries, such as Cambodia, India, Indonesia, the Philippines, Sri Lanka, and Viet Nam. The energy sector is also strategic as it serves as the backbone of the economy accounting for almost 35 per cent on average in Asia and the Pacific. As the abrupt spike in energy prices in 2022 has shown, the disruption in energy supply can be far-reaching and pervasive.

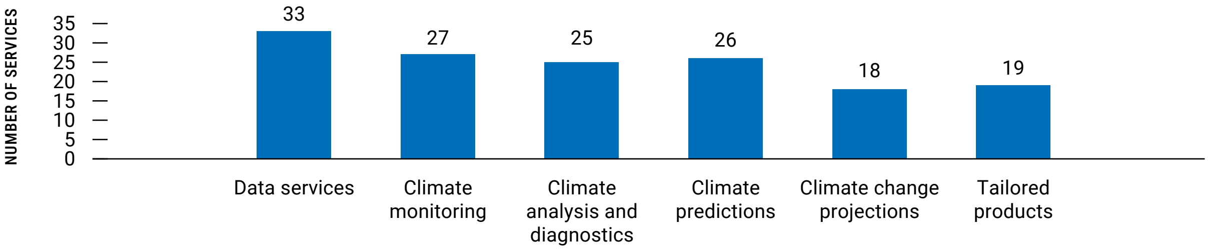
According to data from the National Meteorological and Hydrological Services (NMHSs), collected by the WMO, 21 per cent of countries in the Asia-Pacific region indicated providing climate services at an advanced level, while the majority (48 per cent) provide climate services only at an essential level (WMO, 2017).[7] Specifically on sector information, 79 per cent of the countries in Asia and the Pacific reported providing climate data services for the energy sector. The same trend is confirmed for the agriculture sector where 83 per cent of countries in the region reported providing climate data services, but only 57 and 42 per cent of the countries reported providing climate change projections products for the agriculture and energy sectors, respectively.

FIGURE 3.9 Overview of ESCAP climate service capacities



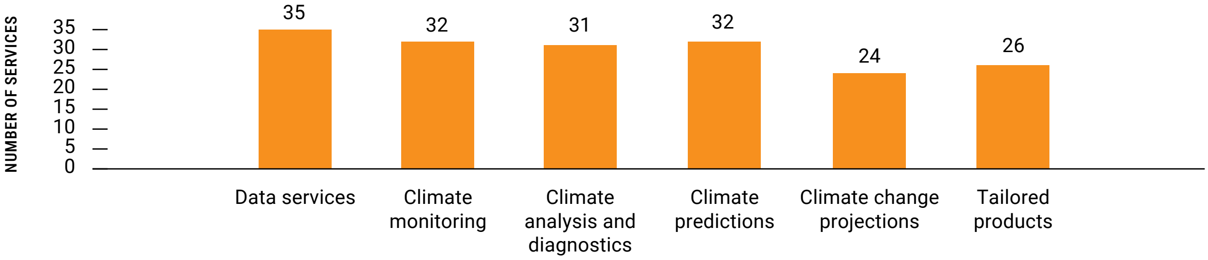
Source: WMO Climate Services Checklist Data.

FIGURE 3.10 Number of meteorological services providing climate services to the energy sector by type of product



Source: WMO Climate Services Checklist Data.

FIGURE 3.11 Number of Meteorological services providing climate services to the agriculture and food security sector by type of product



Source: WMO Climate Services Checklist Data.

It is possible to identify countries that are exposed to higher risk in food resilience due to climate change and where improving the early warning system is especially needed. As can be seen in Figure 3.12, in Nepal, Afghanistan, Bangladesh, and India, the high exposure of agriculture to disaster risk (exceeding 90 per cent in all countries) and of vulnerable populations (exceeding 84 per cent in all countries) is made more dangerous by the low capacity of early warning systems. Although scoring relatively highly in the reported early warning system capacity, Myanmar has a high percentage of the value of its agricultural sector exposed (over 98 per cent of exposure under both 1.5°C and 2°C warming scenarios), and has

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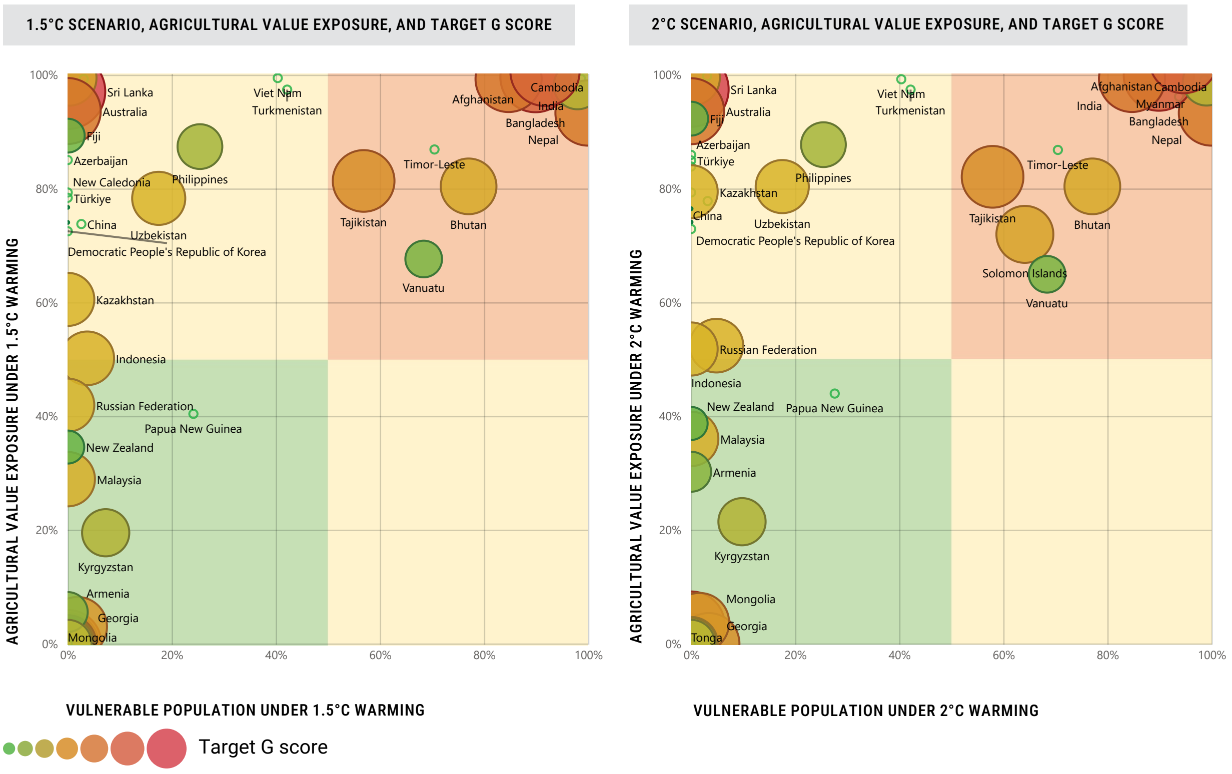
[7] Data from WMO derived only for ESCAP member States. 42 of ESCAP member States response were received in Asia and the Pacific.

a high percentage of its vulnerable population exposed to the multi-hazard risk from climate change (above 97 per cent of exposure under both scenarios). Other countries, such as Sri Lanka, Australia, and Thailand have a high percentage of the value of their agricultural sector exposed under both climate scenarios. However, the resilience of their food system resilience is helped by having a lower percentage of the vulnerable population exposed to climate change. This may help reduce the compounding effect of disasters, the negative impact on agricultural production, and the existing vulnerability of people.

FIGURE 3.12 **Percentage of vulnerable population exposure under the 1.5 and 2 °C warming scenario, Target G score and percentage of agricultural value exposure**



1.5°C SCENARIO, AGRICULTURAL VALUE EXPOSURE, AND TARGET G SCORE

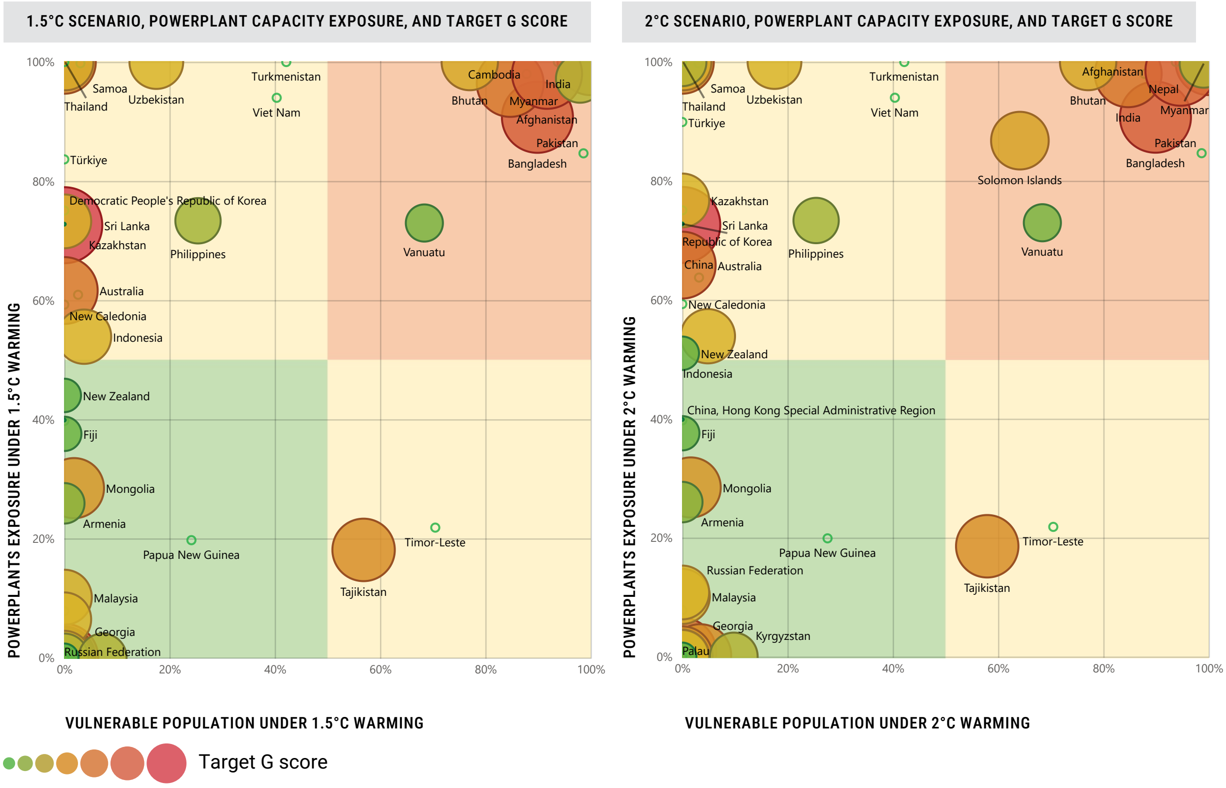
2°C SCENARIO, AGRICULTURAL VALUE EXPOSURE, AND TARGET G SCORE

Source: ESCAP.

Note: Countries that did not submit Target G are represented as an empty circle. The size and the colour of the bubble indicate the Target G score (the larger and redder the circle, the lower the Target G score).

It is possible to identify countries with energy sectors exposed to higher energy risk due to climate change, which are ill-equipped due to insufficient MHEWS, and have a high number of vulnerable people. In both the 1.5°C and 2°C warming scenarios, Afghanistan, Nepal, Bangladesh, and India stand out as countries with a high percentage of the powerplants and vulnerable people exposed to the risk of climate change, and that also have low early warning capacity. Although scoring relatively highly in the early warning system capacity, Myanmar and Bhutan have a high percentage of their energy security at risk under both climate projections. Over 97 per cent of energy production capacity would be at risk in Myanmar in both scenarios and 100 per cent would be at risk in Bhutan. Both Myanmar and Bhutan also have a high percentage of vulnerable populations exposed to the multi-hazard risk from climate change. The Solomon Islands stand out as a country where energy insecurity and vulnerable populations will increase substantially under a 2°C warming scenario. Over 86 per cent of power plants would be exposed, and over 64 per cent of vulnerable population would be exposed to disaster hazards.

FIGURE 3.13 Percentage of vulnerable population exposure under the 1.5 and 2 °C warming scenario, Target G score and powerplant capacity exposure


1.5°C SCENARIO, POWERPLANT CAPACITY EXPOSURE, AND TARGET G SCORE

2°C SCENARIO, POWERPLANT CAPACITY EXPOSURE, AND TARGET G SCORE

Source: ESCAP.
Note: Countries that did not submit Target G are represented as an empty circle. The size and the colour of the bubble indicate the Target G score (the larger and redder the circle, the lower the Target G score).

3.3 Protecting people: An economic necessity

Strengthening early warning systems is the low-hanging fruit of transformative climate change adaptation because it is a relatively cost-effective way of protecting people and assets, providing a tenfold return on investment (Global Commission on Adaptation, 2019).

This section outlines the economic necessity of strengthening early warning systems to neutralize the risk of economic losses from disaster events and protect critical assets.

3.3.1 Economic benefits of strengthening early warning systems

HOW DOES EARLY WARNING REDUCE ECONOMIC LOSSES?

While it is relatively straightforward to survey and estimate post-disaster damage and losses, it is often harder to demonstrate the "preventable or avoidable damages" that an effective early warning system could bring about. Studies have outlined how only a 24-hour warning of an oncoming storm or heatwave could reduce damages by 30 per cent, and how flood warnings could alone avoid 32.85 per cent of damages (Global Commission on Adaptation, 2019; Pappenberger and others, 2015).

The WMO and the World Bank estimate that the economic benefits of weather prediction services could result in a 20 to 60 per cent reduction of losses due to disaster events (World Bank, 2019).

In addition to reducing damage and losses, weather services are also attributed to making significant gains in productivity (Table 3.2). The benefits to a society of early warning systems and early actions should not be underestimated, both in terms of economic and intangible benefits. Table 3.4, at the end of this chapter, outlines the benefits and early action across social, environmental, and economic sectors.

TABLE 3.2 The minimum annual socioeconomic benefits of weather prediction

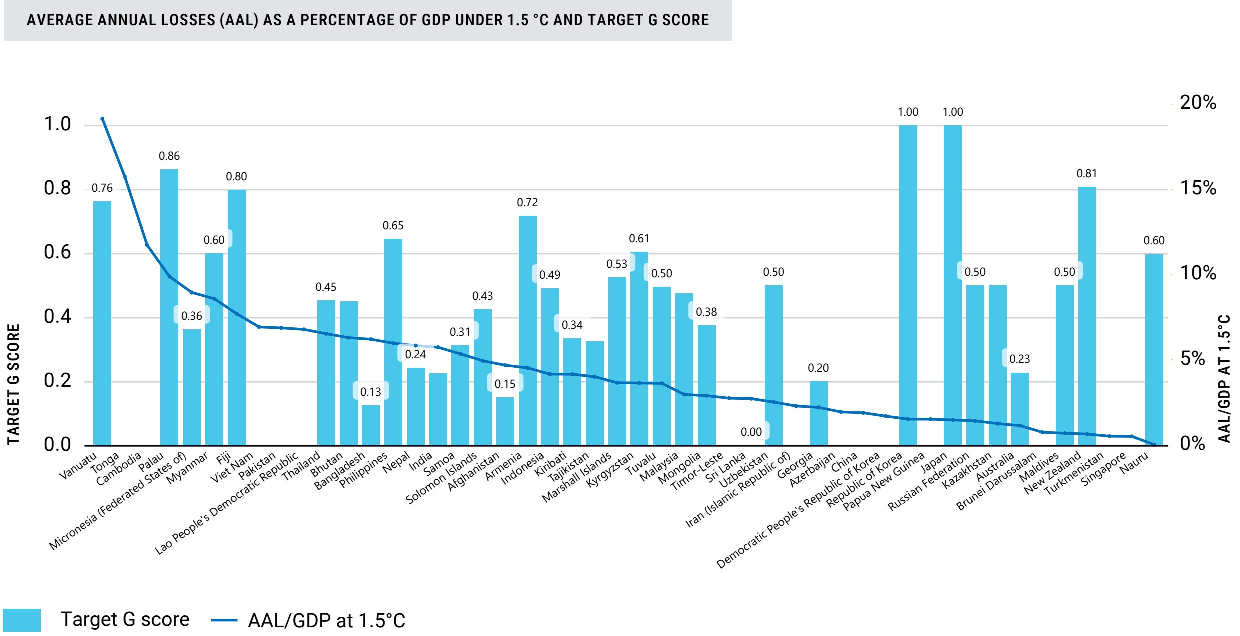
Avoided Losses	Disaster management	$66 billion
Increased Productivity	Agriculture	$33 billion
	Energy	$29 billion
	Transportation	$28 billion
	Water supply	$ 5 billion
	Construction	$1 billion
Total		**$162 billion**

Source: Alliance for Hydromet Development, "Hydromet Gap Report 2021", 2021. Available at https://alliancehydromet.org/gap-report/

WHERE DO THE ECONOMIC RISKS LIE?

Analysing average annual losses (AAL) as a percentage of GDP against self-reported multi-hazard early warning system coverage can identify which countries in Asia and the Pacific have economies that are at most risk of being impacted by disaster events. These countries have the most to gain from implementing adaptation measures, such as early warning systems to reduce economic losses and mitigate permanent losses due to disaster events. Communities at lower socioeconomic levels suffer disproportionately as economic losses have larger implications on lower income groups.

FIGURE 3.14 Average Annual Losses (AAL) as a percentage of GDP under 1.5°C and Target G score



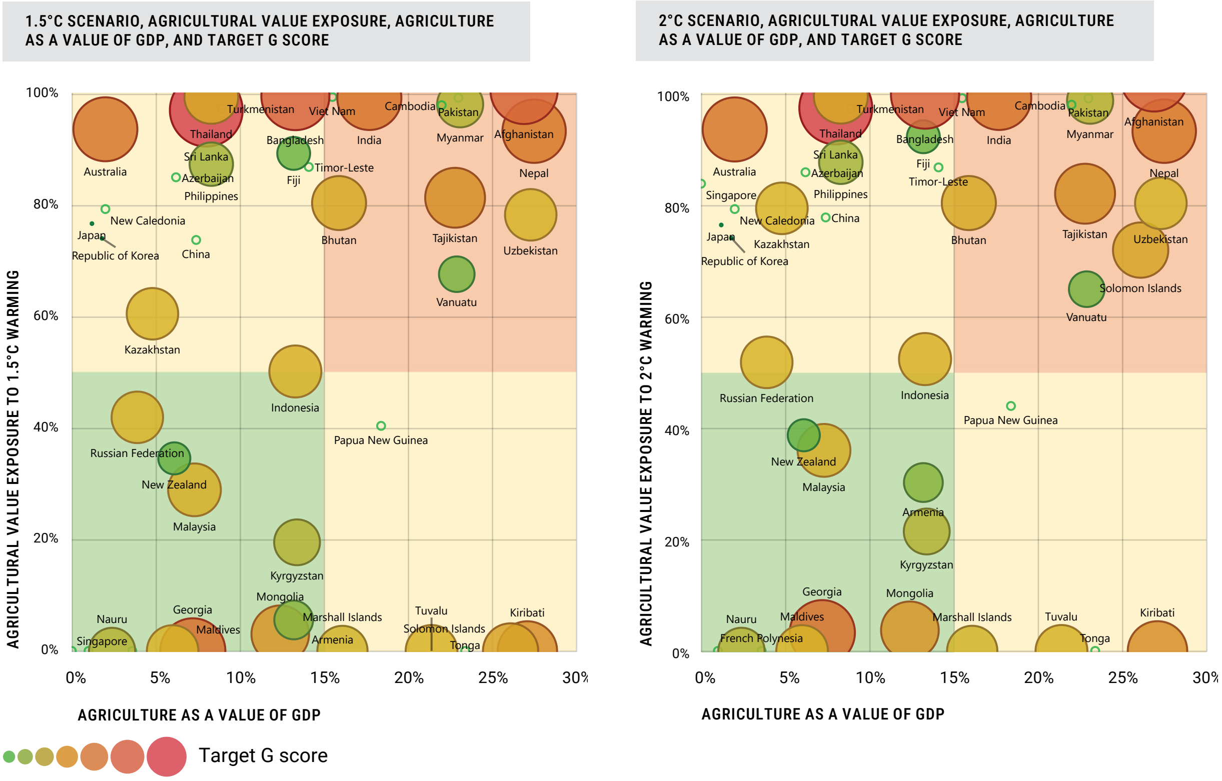
Source: ESCAP.
Note: Countries that have not reported on Target G are not included.

The countries most at risk exhibit varying levels of self-reported multi-hazard early warning system coverage (Target G scores), indicating that some countries can face significant potential losses due to the impacts of climate change, even with better warning system coverage. These countries include Vanuatu, Tonga, Cambodia, Palau, the Federated States of Micronesia, Myanmar, and Fiji. Many of the most impacted countries with the highest Average Annual Losses (AAL) as a percentage of GDP share a common economic vulnerability; they rely on climate-sensitive sectors and this makes them more susceptible to the consequences of extreme weather events and other climate change-related disruptions.

WHERE ARE THE RISKS TO CRITICAL SECTORS?

There are many sectoral benefits to early warning systems (see Table 3.2). For the countries with a lower level of economic diversity, ensuring that key industries are protected from disaster events is particularly important. Due to the criticality of energy and agriculture sectors across the region, the next section presents an analysis that combines agriculture and power plant exposure to multi-hazards under 1.5°C and 2°C warming scenarios, and the relative value added of agriculture and industry, against the self-reporting Sendai Framework Target G scores on a risk matrix. For those countries with low reported multi-hazard early warning systems, yet high exposed economic value due to at-risk agriculture or energy sectors, it will be critical to advance sector-specific early warning systems to protect these assets.

FIGURE 3.15 Percentage of agricultural value exposure under the 1.5 and 2 °C warming scenario, Target G score and agriculture as a value of GDP



1.5°C SCENARIO, AGRICULTURAL VALUE EXPOSURE, AGRICULTURE AS A VALUE OF GDP, AND TARGET G SCORE

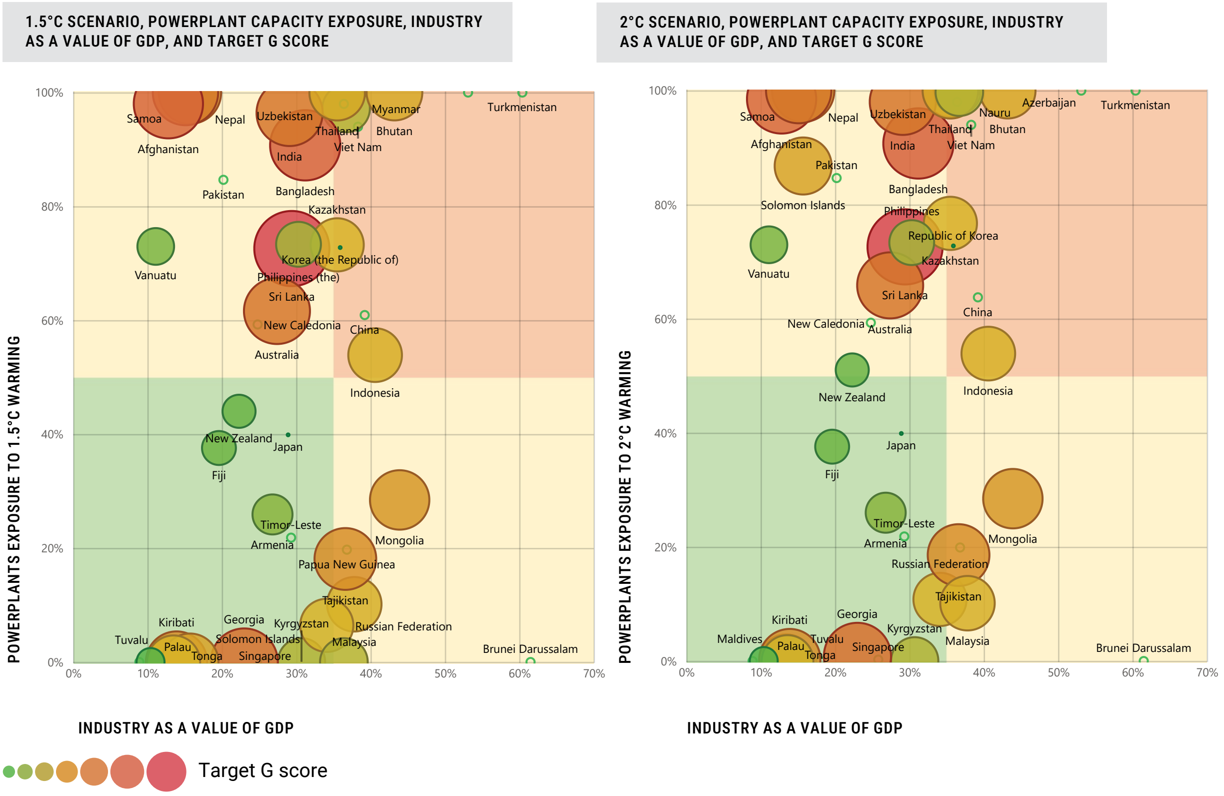
2°C SCENARIO, AGRICULTURAL VALUE EXPOSURE, AGRICULTURE AS A VALUE OF GDP, AND TARGET G SCORE

Source: ESCAP.
Note: The size and the colour of the bubble indicate the Target G score (the larger and redder the circle, the lower the Target G score).

Among the countries which report low multi-hazard early warning system coverage and high agricultural economic value exposure, Afghanistan, Nepal, India, Uzbekistan, the Solomon Islands, and Tajikistan stand out as a larger proportion of their economies rely on agriculture. This makes them especially vulnerable and highlights the urgent need for the establishment of sector-specific early warning systems to protect their agricultural assets. Countries like Myanmar, Vanuatu, and Fiji exhibit higher Target G scores, but nonetheless have substantial agricultural exposure. Sustained efforts are needed to maintain and improve early warning systems to safeguard their agricultural sectors.

Countries, such as Bhutan, Myanmar, and Thailand located in the top right area of the chart, have reported low levels of multi-hazard early warning systems and high economic value exposure due to at-risk power plants. Sector-specific early warning systems are needed to safeguard their power plants and reduce energy sector vulnerability. Countries, such as the Republic of Korea, the Philippines, Kazakhstan, Myanmar, and Uzbekistan exhibit higher Target G scores, but have relatively high energy exposure. These countries should continue to maintain and improve their early warning systems to ensure the protection of their power plants from the increasing risks posed by climate change and other hazards.

FIGURE 3.16 Percentage of powerplant exposure under the 1.5 and 2 °C warming scenario, Target G score and industry as a value of GDP



1.5°C SCENARIO, POWERPLANT CAPACITY EXPOSURE, INDUSTRY AS A VALUE OF GDP, AND TARGET G SCORE

2°C SCENARIO, POWERPLANT CAPACITY EXPOSURE, INDUSTRY AS A VALUE OF GDP, AND TARGET G SCORE

Source: ESCAP.

Note: The size and the colour of the bubble indicate the Target G score (the larger and redder the circle, the lower the Target G score).

3.3.2 Implementing early warning for all in Asia and the Pacific

PROTECTING CRITICAL ECONOMIC ASSETS: INCREASED LEAD TIMES AND REDUCED UNCERTAINTIES

Early warnings are only effective if they can be used to facilitate action that reduces the impact of disasters. Their benefits are enhanced by longer lead times and higher levels of accuracy. It is important to understand weather information and our perception of risks to ensure that early warning results in early actions that mitigate the impacts of disaster events. The progress made in scientific forecasts and risk assessments enable precise predictions about when and where extreme weather will occur. This is especially true for large-scale events, such as cyclones, droughts or river floods, where the likely impacts can be predicted to minimize their effect on people. This can be different for more localized extreme weather events affecting localities that lack monitoring and forecasting capabilities.

When providing forecasts for early warnings, trade-offs are required. Balancing accuracy, timelines, reliability, the cost of false alarms and damage avoided, all influence the lead-time of a warning (Rogers and Tsirkunov, 2010). It has been estimated that for flood forecasting, a lead time of 12 hours provides a potential 60 per cent reduction in damage, whereas one hour results in only a 20 per cent reduction (Rogers and Tsirkunov, 2010). Box 3.2 presents a similar study that evaluated lead-time with damage reduction for cyclone warnings in Samoa. A less accurate forecast received earlier can have greater value than a more accurate forecast received later (Malik and others, 2014). This is especially the case for at-risk communities and sectors that do not have access to motorized transport options (Alliance for Hydromet Development, 2021).

BOX 3.2 Benefits of economic assessment of cyclone early warning systems - A case study on Cyclone Evan in Samoa

Located in the South-West Pacific, Samoa is exposed to increasing and intensifying disaster risks, such as cyclones, droughts, floods, pest infestations, and storm surges. It experiences substantial economic losses from natural hazard events. One such event was category 4 Tropical Cyclone Evan in 2012, which resulted in damages amounting to 28 per cent of the country's GDP for 2011.

Focused on presenting a cost-benefit analysis for cyclone early warnings in the island nation, Fakhruddin and Schick (2019), in their study, aimed to quantify the benefit of early warning systems. Namely the losses incurred without early warning, minus the decreased loss after appropriate measures are taken and the investment made in the EWS. Through stakeholder consultations with national agencies and community representatives, the study estimated the direct and indirect tangible benefits, considering factors like economies of scale, improved meteorological services, institutional and community involvement, emerging technologies and forecast accuracy probabilities. The results show important benefits for Samoa in investing more in early warning services. It concluded that for every $1 invested in EWS, there is a return of $6.0 in benefits.

Approximately 81.45 per cent of losses and damages caused by Cyclone Evan could have been avoided with efficient implementation of early warning systems in Samoa.

The study demonstrated the significant correlation between lead time of warnings provided and damage reduction across various sectors, emphasizing the critical role of accurate and timely early warning systems in facilitating effective disaster preparedness and response (see Table 3.3). A 24-hour lead time permits basic protective actions, resulting in only minimal damage reduction. A 48-hour lead time allows for more thorough preparations, which contribute to a significant reduction in damages. Lead times of up to seven days offer the greatest damage mitigation, as they enable the deployment of extensive protective measures across all sectors.

TABLE 3.3 Damage reduction due to early warning of different lead times[a]

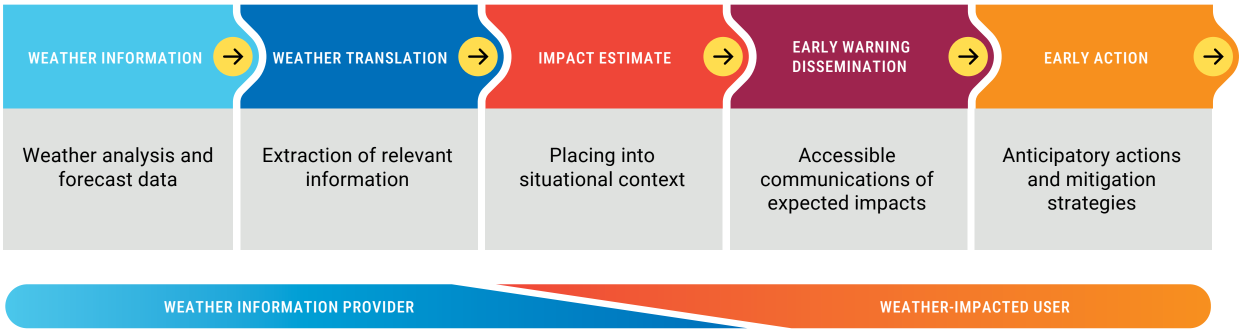
Item	Lead time	Damage reduction (%)	Actions taken to reduce damages
Household items	24 h	20	Removal of some household items
	48 h	80	Removal of additional possessions
	Up to 7 days	90	Removal of all possible possessions, including stored crops
Livestock	24 h	10	Poultry moved to safety
	48 h	40	Poultry and farm animals moved to safety
	Up to 7 days	45	Poultry, farm animals, forage and straw moved to safety
Agriculture	24 h	10	Agricultural implements and equipment removed
	48 h	30	Nurseries and seed beds saved, 50% of crop harvested, and agricultural implements and equipment removed
	Up to 7 days	70	Nurseries and seed beds saved, fruit trees harvested, 100% of crop harvested, and agricultural implements and equipment removed
Fisheries	24 h	30	Some fish, shrimps and prawns harvested
	48 h	40	Some fish, shrimps and prawns harvested, and nets erected
	Up to 7 days	70	All fish, shrimps and prawns harvested, nets erected, and equipment removed
Open sea fishing	24 h	10	Fishing net and boat damage avoided
	48 h	15	Fishing nets removed, and boat damage avoided
School or office	24 h	5	Money and some office equipment saved
	48 h	10	Money and most office equipment saved
	Up to 7 days	15	Money and all office equipment, including furniture, protected

[a] This estimate is based on field experiences.

Source: B.S.H.M. Fakhruddin, and Lauren Schick, "Benefits of economic assessment of cyclone early warning systems - A case study on Cyclone Evan in Samoa", *Progress in Disaster Science*, vol. 2 (July 2019).

Innovation and new science capable of advancing early warnings need to be championed. Tangible benefits come to fruition when multi-sectoral cooperation is fostered, which is sometimes difficult when forecasting uncertainties are misunderstood. Linking the scientific advancements with disaster management offices provides a more amenable partnership to deliver effective early warning systems. Recognizing the inherent uncertainties in science around many hazard hotspots, technological innovations that advance scientific knowledge should be encouraged.

FIGURE 3.17 **Early warning, early action as facilitated by weather information providers and weather-impacted users**



Source: Baode Chen, and Xu Tang, "Translating weather forecasts into impact-relevant information", 2014.

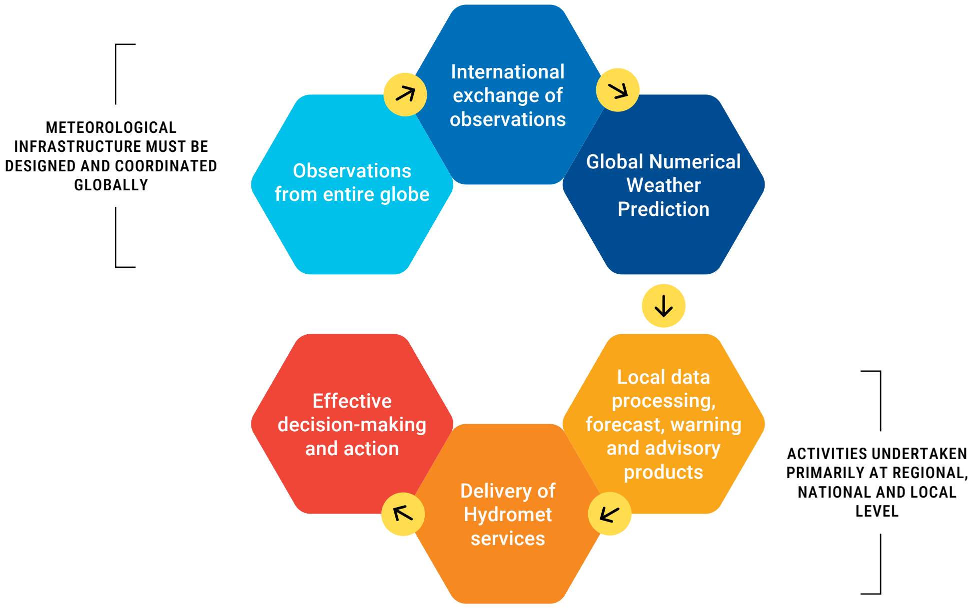
As demonstrated by Figure 3.13, the agriculture sector in many countries represents a large share of overall economic value added and is highly climate sensitive. Economic losses due to crop damage can be mitigated by effective agrometeorology services. Yet, forecasts can sometimes be generic and not provide readily actionable information for farmers. Agrometeorological advisories translate weather and climate information into specific information relevant to the agricultural sector, and communicate it to farming communities.

PROTECTING CRITICAL ECONOMIC ASSETS: SEAMLESS METEOROLOGICAL VALUE CHAIN

Weather and climate services are generated by the meteorological value chain. The effectiveness of early warning systems depends on all links working seamlessly (Alliance for Hydromet Development, 2021). The top three links in the value chain, shown in Figure 3.18 in blue, constitute the global meteorological infrastructure and rely on global collaboration. The bottom three links, shown in Figure 3.18 in orange, are typically implemented nationally. The importance of the implications relating to the top three global links cannot be overstated.

Beyond a horizon of 24 to 36 hours, global observational data are needed to underpin predictions in any location. Conversely, without local efforts to make and exchange observations, global models cannot effectively generate the data needed for forecasting at the national and local levels. All countries therefore share an interest in the top three links in the chain and must handle the bottom three individually. Low-capacity nations, such as least developed countries, and the Pacific small island developing States have the least maturity in climate services and early warning products, which also impedes the forecast quality on a global level. The global-to-local link in early warning systems is especially critical for addressing transboundary hazards and achieving economies of scale. This is where the interoperability of regional and subregional components within the global-to-local early warning information value chain assumes significance.

FIGURE 3.18 **The meteorological value chain. All links in the chain must operate effectively to yield success**



Source: Alliance for Hydromet Development, "Hydromet Gap Report 2021", 2021. Available at https://alliancehydromet.org/gap-report/

Improving the observation network globally would allow all countries to strengthen risk knowledge, develop more accurate weather predictions, and increase lifesaving and damage, thereby reducing lead-times for early warnings (WMO, 2015). Such an approach would ensure that all NMHSs have access to the latest technology and methodologies, even those of traditionally lower capacity. Financing models to address the high costs of maintaining and operating global and regional numerical modelling systems, without burdening NHMSs will be further discussed in Chapter 5.

3.4 Nature-based solutions

Around 28 per cent of land area in the Asia-Pacific region is affected by land degradation. The marine and the coastal ecosystems are also overexploited (ESCAP, 2022). The threat is multi-fold when large populations in a highly degraded environment are exposed to climate change and its impacts. Environmental degradation is driving disaster risk in Asia and the Pacific.

Environmental degradation is particularly pronounced in the eastern part of China, the Mekong River basin area in Thailand, Cambodia and Viet Nam, the Ganga-Brahmaputra-Meghna (GBM) basin area in India and Bangladesh, the Indus River basin in Pakistan, and the Aral Sea basin in Uzbekistan and Kazakhstan due to the convergence of different factors (Cherlet and others, 2018). These areas are highly populated and are already highly exposed to multi-hazards risks. In parts of the GBM basin, the Indus basin, the Aral Sea basin, and the Mekong River basin, the risk is intensifying under 1.5°C and 2°C warming scenario in future.

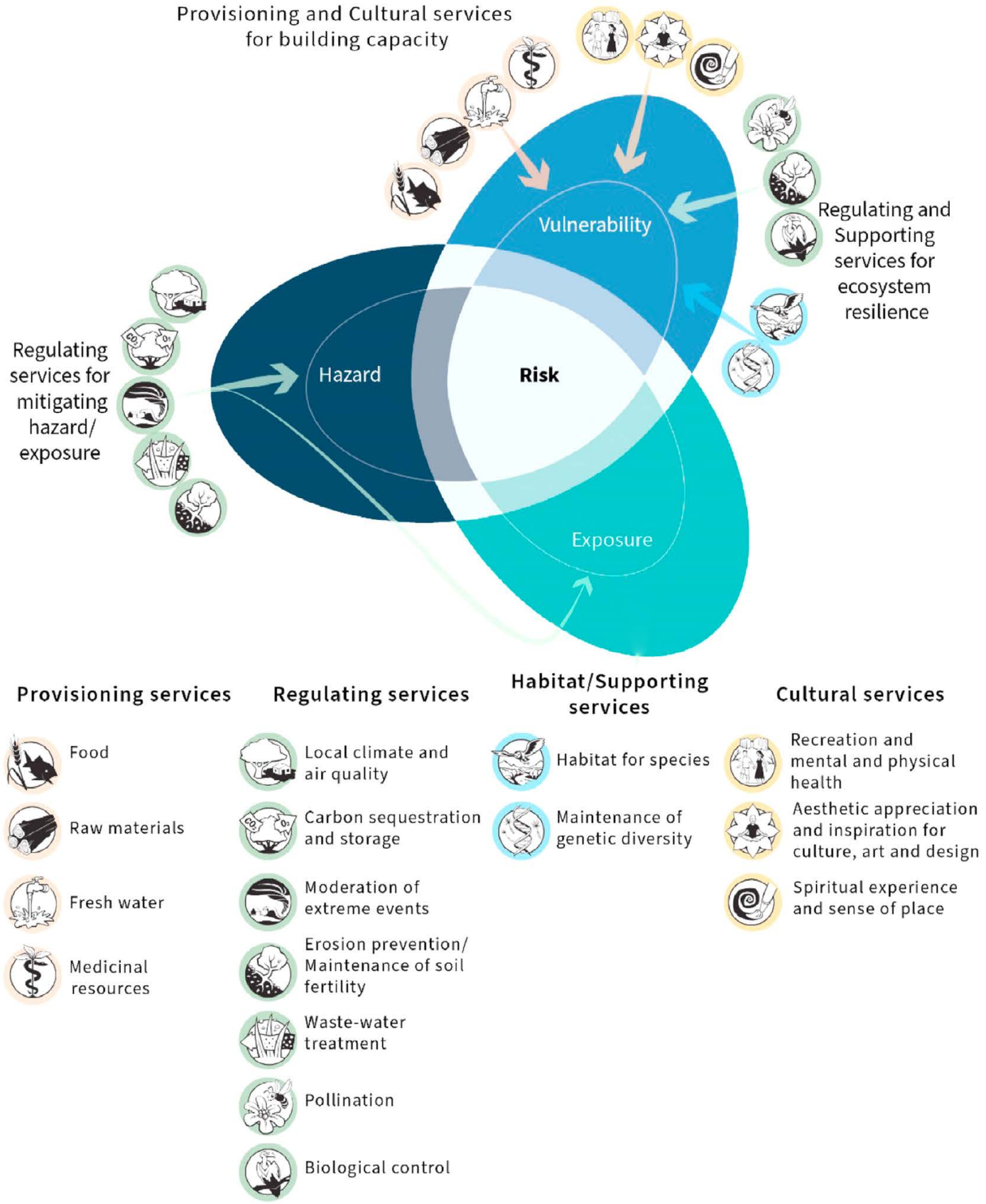
The adaptation strategies for disaster risk reduction need to be strengthened to protect people and property (ESCAP, 2021). Nature-based solutions (NbS) have great potential to sustainably manage, protect and restore the degraded environment and simultaneously reduce disaster risk. The "green infrastructures" developed through NbS are cost-efficient and sustainable in the long term, simultaneously avoiding impacts on the natural environment compared to the conventional "grey infrastructures". There is a spectrum on the infrastructure scale, from grey (cement/steel/carbon nexus) to green (grey infrastructure that has adaptive green elements to it) to natural infrastructure which is the true example of NbS, such as mangroves that mitigate against storm surges and coastal erosion.

3.4.1 Healthy ecosystems are the first line of defence against disaster risks

Healthy ecosystems are naturally able to reduce the impacts of disasters through their ecosystem services (ES), particularly to weather extremes. They prevent hazards from becoming disasters through their invaluable services. It is estimated that around 40 per cent of climate action can be achieved through nature-based solutions, specifically through forest restoration and carbon positive agriculture (Steiner, 2018).

Sixteen out of seventeen ecosystem services classified by The Economics of Ecosystems and Biodiversity (TEEB) support disaster risk reduction in different dimensions (Figure 3.19) (Walz and others, 2021).

FIGURE 3.19 Ecosystem services relate to the three dimensions of disaster risk



Source: Yvonne Walz, and others, "Disaster-related losses of ecosystems and their services. Why and how do losses matter for disaster risk reduction?" *International Journal of Disaster Risk Reduction*, vol. 63 (2021). Available at https://www.sciencedirect.com/science/article/pii/S2212420921003861?via%3Dihub

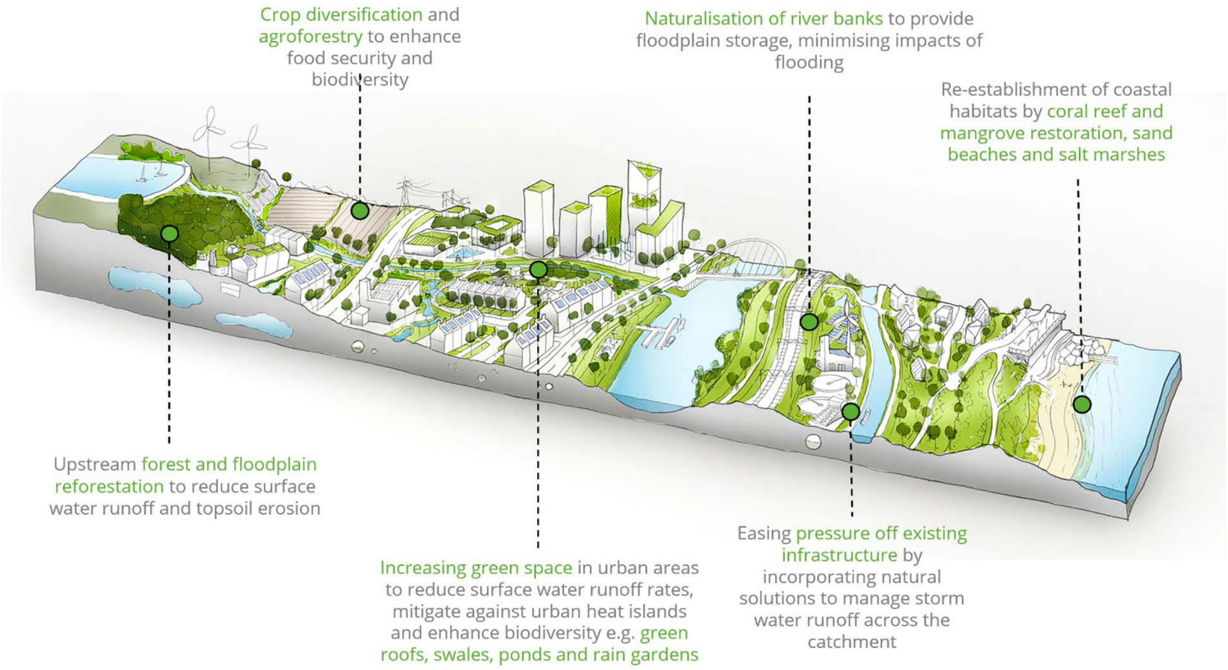
Disaster risk reduction actions can gain momentum if functional terrestrial, coastal and marine ecosystems are preserved in good ecological condition. Ecosystems are better managed for sustainable use by humans, and degraded ecosystems can be restored through NbS. However, the ecological status and resilience of the ecosystems must be maintained if they are to sustainably support disaster risk reduction. Ecosystems, when heavily affected by hazards, lose their services and need a long period to recover. For example, in 2016, Cyclone Winston affected 47 per cent of native forests, 67 per cent of mangroves and 79 per cent of coral reefs in Fiji, which were within a 50 km radius of the cyclone's path. It is expected to take at least 15 years for native and mangrove forests, and 10 years for the coral reefs to recover a pre-cyclone condition and deliver the same quality of ecosystem services (Government of Fiji, 2016). Similarly, Cyclone Pam significantly affected and damaged mangrove areas in Vanuatu (Government of Vanuatu, 2015).

3.4.2 Nature-based solutions for hydro-meteorological disasters

Nature and ecosystems can attenuate the water-related extreme climate events: they reduce downstream flooding and the flow velocity of flood waters through flood plains and wetlands; reduce crop vulnerability to drought through maximizing groundwater storage, agroforestry and blue-green infrastructure. Parks and urban green spaces moderate temperature and help to cope with heatwaves and drought in cities. On a larger scale, transboundary solutions to hydro-meteorological disasters are necessary to reduce multi-hazard risks in transboundary basins, such as the GBM basin, the Indus basin, the Aral Sea basin, and the Mekong River basin. Those can be achieved through NbS and sustainable and integrated water management.

Wetlands, coastal plains, forests, and many other permeable surfaces provide inexpensive or even free services which engineered infrastructures can only deliver at the cost of billions of dollars (Scientific American, 2023). However, the efficiency of the NbS system depends on the spatial and time scale of the implementation. Cooperation and coordination between upstream and urban communities will also be essential to address hydro-meteorological disasters (Civitelli and Gruère, 2017). Figure 3.20 demonstrates the application of NbS for water-related disasters in varying geography. The following section provides examples of the application of NbS for water-related disaster risk reduction.

FIGURE 3.20 Numerous applications of nature-based solutions for water-related disasters

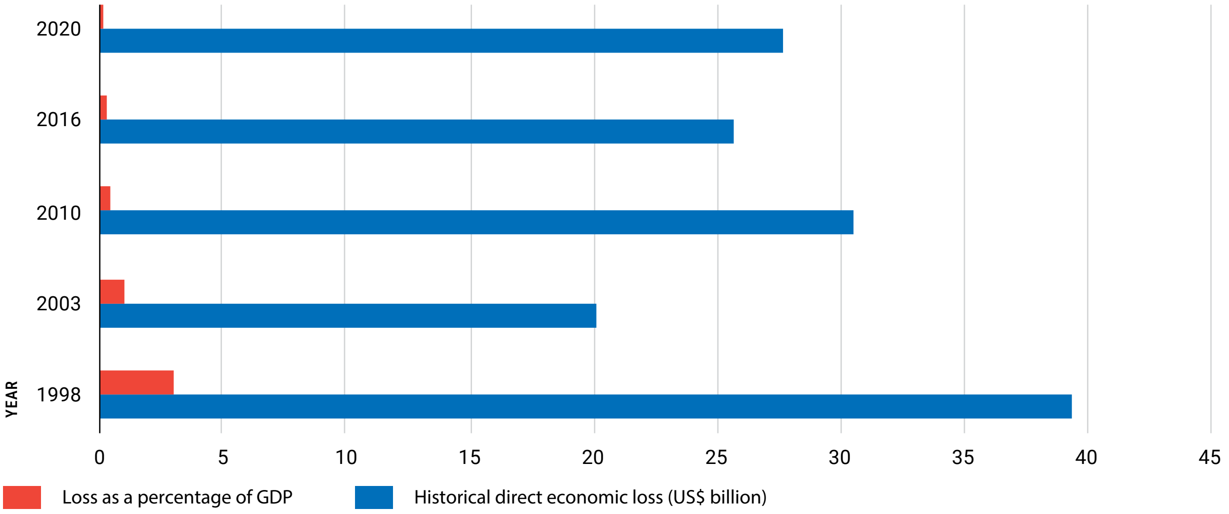


Source: Pacific Network for Environmental Assessment (PNEA), "PNEA InSights: Nature based solutions for resilient infrastructure development in the Pacific", 2023. Available at https://pnea.sprep.org/node/1115

3.4.3 Upstream forest and floodplain reforestation

Floodplains and forests can act as flood defence mechanisms. In the Yangtze river basin area, reclamation of the flood plains for agriculture and erosion and siltation in the watershed increased the exposure to flooding and its scale. After the 1998 flood, afforestation was undertaken in steep farmlands to reduce erosion and the flood plains were restored by removing embankments and returning agricultural polders to increase the floodwater retention capacity (IUCN French Committee, 2019). These measures helped to gradually reduce the population's exposure, fatality rates and economic losses to large flood events since 1998 (Figure 3.21).

FIGURE 3.21 Loss statistics of large flood events in different periods in China



Source: Huicong Jia, and others, "Flood risk management in the Yangtze River basin - Comparison of 1998 and 2020 events", *International Journal of Disaster Risk Reduction*, vol. 68 (January 2022). Available at https://doi.org/10.1016/j.ijdrr.2021.102724

Flood-retention basins, such as farmland, sports, parks, and wildlife habitat improve the water quality of nearby rivers. In Japan, flood-retention basins have been constructed widely, and have decreased the impact of floods and cyclones**.** The flood control basins in central parts of Japan, particularly along the Tone and Watarase rivers have protected the surrounding cities from the impact of Typhoon Hagibis. According to the Tone River Upstream Office, it restored approximately 250 million cubic metres of water (Ishiyama and others, 2022). Another example is the flood retention basin of Tsurumi, Japan. This basin is located along the coastal area of Yokohama city and its capacity was designed to withstand a flood once in 150 years. However, it could also protect surrounding cities from floods which return more frequently (World Bank, 2022). Commonly, a flood retention basin also functions as nature conservation area. Eighty-eight per cent of flood-control basins in Japan have biodiversity conservation areas, paddy fields, reed marshes, and water surfaces which are similar to wetlands (Suwa and Nishihiro, 2020).

3.4.4 Crop diversification and agroforestry

NbS measures, such as crop diversification and agroforestry can avoid the impacts of drought and water scarcity in agriculture and subsequently enhance food security. Crop diversification is already widely used in the drought prone areas of South-East Asia. In the central dry zone of Myanmar, intercropping of rice with groundnut, pigeon pea, green gram, sesame, sorghum enhances drought resilience and food security. Plantation of medicinal trees, such as the Thanakar tree, and fruit trees as alternative crops is common in Myanmar (Tun Oo, Boughton, and Aung, 2023). Agroforestry, integrated crop-livestock farming, and rice-shrimp farming is practiced in Viet Nam, Indonesia, the Philippines, Myanmar, the Lao People's Democratic Republic and Thailand for drought resilience and food security, and helps increase profitability of farms even during the dry periods (Wangpakapattanawong and others, 2017; ACIAR, 2017).

In the drought prone districts of Karnataka, India agroforestry was initiated in spite of water scarcity and land degradation problems that were being faced over several years. Farmers continued their effort through economically beneficial afforestation and reforestation, which supports an efficient climate-resilient farming system contributing to several SDG targets. Instead of resource-intensive farming, the crop lands were converted into forests and pastures, which helped achieve land degradation neutrality (SDG 15 of Life on the Land). Harvests from forests provides farmers with alternative livelihood opportunities (SDG 1: no poverty, SDG 3: good health and well-being and SDG 2: zero hunger), and helped farmers move from inequality to dignity (SDG 10: reduced inequalities and SDG 4: higher equality education). In this process, the increasing number of trees contribute to carbon sequestration (SDG 13: climate change). The interventions in the study area have contributed to overcoming severe social and environmental challenges, such as poverty, food security and climate change (Telwala, 2023).

3.4.5 Increasing green space in urban areas

The future of urban resilience will rely heavily on upscaling NbS for both urban and climate change planning (ESCAP and others, 2019). Floods are projected to expose populations in East and North-East Asia, South East Asia, South-West Asia, and the Pacific. In 2019, the Asia-Pacific region had over 50 per cent of its population living in urban areas (ESCAP, 2022), and 70 per cent of the region's population will live in cities by 2050 (ESCAP and others, 2019). The vulnerability of this urban population is greater than in non-urban areas due to population density and human activities which interact with the environment. Nature-based solutions and grey and green infrastructure can help mitigate urban flooding and must become integral to inclusive urban planning. Governments in the Asia-Pacific region should work towards better integrating environmental, disaster resilience, health sector and well-being goals into national and subnational urban development through NbS (see Sponge Cities Concept in China in Section 3.4.6 for details).

The NbS suitable to mitigate the impact of floods in cities vary in scale. The smallest ones can be implemented at the district or neighbourhood level, such as increasing green space in urban areas. This includes green roofs and permeable pavements which can reduce stormwater runoff. Green roofs retain 50 to 100 per cent of stormwater (Ozment and others, 2017). By conserving a natural environment, NbS reduce the temperature of the surrounding neighbourhood, and reduce the effects of the urban-heat island. In addition, NbS deliver the social benefit of recreational places.

BOX 3.3 Heatwaves adaptation strategies through NbS

Adaptation measures to address extreme heat, at a large scale, can be achieved through nature-based solutions, such as parks and wetlands. Water bodies have lower surface temperature compared to areas with vegetation, and the highest temperature is on streets and building surfaces. Urban parks can reduce mean daytime temperature by 1°C. Consequently, a larger park will have greater temperature decline. Individual trees can decrease the impact of urban-heat island depending on their type, shapes and size. Trees with large leaves and crowns have a greater cooling effect.[a]

In larger buildings, green roofs and green walls also reduce building and street temperatures by nearly 10°C. Several countries have provided financial incentive for the construction of green roofs and green walls, such as Australia, Japan and Singapore. Financial incentive policies were enacted, given to households or buildings that implemented green-building standards. Australia and Japan have provided incentives for green roofs and green building through funding, low-interest loans, and tax credits.[b] Incentives are also provided by local governments through technical support.

[a] United Nations Environment Programme (UNEP), "Nature-based solutions for urban challenges", 2021. Available at https://www.unep.org/resources/emerging-issues/nature-based-solutions-urban-challenges

[b] Siwei Chen, and Zhonghua Gou, "An Investigation of Green Roof Spatial Distribution and Incentive Policies Using Green Buildings as a Benchmark", *Land*, vol. 11, No. 11 (November 2022). Available at https://doi.org/10.3390/land11112067

3.4.6 Urban water management through natural, green and grey infrastructure

The concept of green-grey infrastructure for tackling urban floods entails reducing storm-water runoff, increasing storm-water retention and enabling wastewater treatment. Urban wetlands and streams can withhold floods up to100 and 200-year return period, as shown in the best practices in China and the Republic of Korea. Bioretention areas filter pollutants up to 90 per cent of heavy metals from stormwater (Zhang and others, 2012). This section will discuss the types of NbS for urban flood resilience, such as the integrated urban water management strategy and restoration of urban water bodies.

The urban water-management strategy includes managing stormwater flows across the city, water retention and drainage waste treatment. Singapore has developed a water management strategy through the Active, Clean, Beautiful (ABC) Waters program (UNEP, 2021). The ABC Waters program mainly provides guidelines on water drainage, flood control, stormwater management, and health risk. Within 11 years of implementation, flood prone areas have declined by 91.0 per cent (Soz, Kryspin-Watson, and Stanton-Geddes, 2016). As of 2021, 90 projects with involvement of private and public sectors have received the ABC Waters certification (Singapore's National Water Agency, 2021). One example is the Kalland River - Bishan–Ang Mo Kio Park. This constructed wetland protects the river and provides the social benefit of increasing the area's recreational value (Ozment and others, 2017).

The restoration of urban water bodies, such as streams, rivers and lakes, lead to enhanced urban flood protection. The Cheonggyecheon urban stream revitalization programme (Republic of Korea) recovered the stream which had been converted into highways by demolishing the highways and using the debris to construct the walls of the stream. This wall now protects the city from floods. In case of heavy precipitation, the Cheonggyecheon stream can withstand floods up to 200-year return period (World Bank, 2022). This stream has increased its biodiversity by sixfold (ADB, 2016). It also has become a recreational corridor of Seoul. During extreme hot days, the urban heat island effect is reduced by 3.3°C to 5.9°C along the stream. Air pollution which contributed to health risk has been reduced by 35 per cent. The programme also benefitted through multi-stakeholder participation as prior to and during the construction processes, the Government engaged in consultations with stakeholders.

Furthermore, flooding and erosion in urban areas can be prevented through the restoration of wetlands. Wetlands work by absorbing excess water from surface water, rain, snowmelt, ground water and flood waters. An acre (0.4 hectares) of wetland can retain 3.8 to 5.7 million litres of floodwater (Ozment and others, 2017). Most coastal and inland wetlands have a cooling effect and are suitable for protecting urban areas from extreme temperatures (Taillardat and others, 2020). In this regard, the Colombo (Sri Lanka) Beddagana Wetland Park provides a useful example. Due to urbanization, the wetlands of Colombo experienced a 30 per cent capacity reduction in recent decades (World Bank and others, 2018). This project incorporated green and grey infrastructure, such as wetland conservation, flood retention parks, and concrete protection walls. The economic analysis is clear: the more wetlands are restored, the greater the flood protection benefits (World Bank, 2015).

The sponge cities concept of China is a good example and a comprehensive nature-based solution to urban flood, which uses natural areas, such as parks, lakes, permeable pavements, green roofs and wetland restoration to absorb excess runoff water, and store, filter and purify rainwater. It is designed to withstand 100-year return period of floods and storms. Given that 641 out of 654 Chinese cities are exposed to frequent floods, this measure will immensely enhance the urban flood resilience (Jiang, Zevenbergen, and Fu, 2017). Beginning in 2015 with 30 pilot cities (Ozment and others, 2017), currently there are approximately 50 pilot cities chosen in the national sponge city construction program (Fu and others, 2022). The Government has provided funding and technical support, while public-private-partnerships have played an important role in the project design and construction phase (Wishart and others, 2021).

The implementation of NbS is most effective if a wide range of stakeholders are involved through public-private partnerships (PPP). By promoting the engagement of private sectors and communities, projects can be optimized through varied funding sources and technical expertise. A constructed community-based wetland in Tamavua-i-Wai community of Suva, Fiji is another good example. This wetland treated wastewater from 40 households in vulnerable communities. It enhances the quality of sanitation and reduces flood risk and the impacts of drought (PNEA, 2023). The neighbourhood was supported by local authorities and academia working in close collaboration with the local community, who played a significant role in the maintenance of the infrastructure (RISE, 2023).

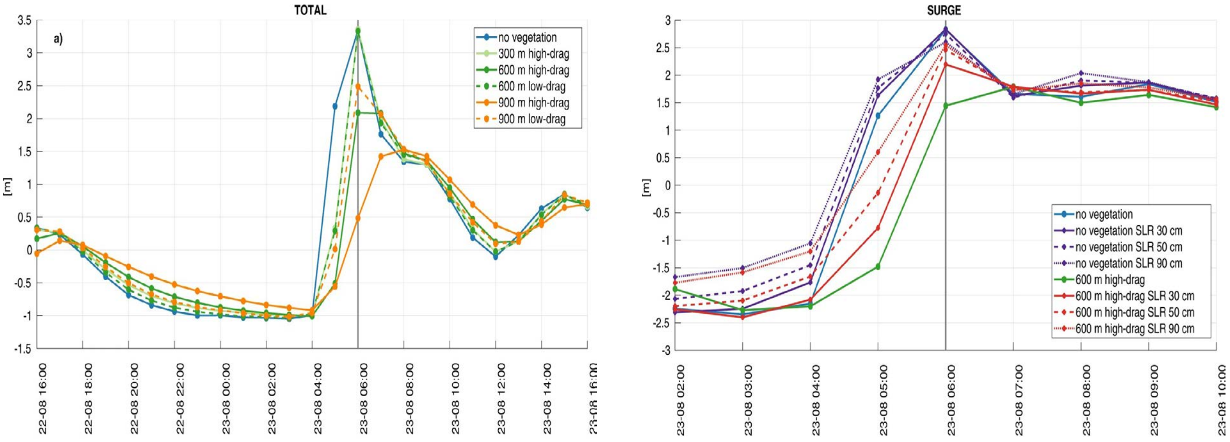
3.4.7 Mangrove and coral reef restoration

Nature-based coastal defences using mangroves are well recognized for adaptation, resilience, and sustainable development strategies against coastal flooding. This has been advocated by many coastal nations in their recently submitted NDCs (FCCC/PA/CMA/2022/4). Without the exiting mangroves, 15 million more people would be flooded annually across the world (Menéndez and others, 2019).

The extent of the coastal protection by mangroves depends on their density, height and width. Up to 66 per cent of wave height can be reduced by over 100 meters of mangroves, and up to 100 per cent by over 500 meters of mangroves.

Figure 3.22 demonstrates how mangroves with different vegetation drag can attenuate wave height and sea level rise in the Pearl River Delta, China (De Dominicis and others, 2023).

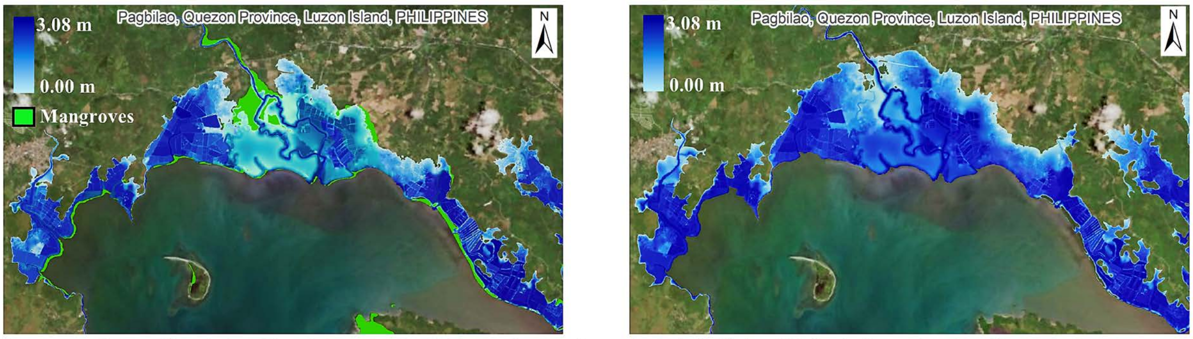
FIGURE 3.22 Water levels during Typhoon Hato (a) and Sea Level Rise (b) with and without mangroves in Shenzhen Bay, China



Source: Michela De Dominicis and others, "Mangrove forests can be an effective coastal defence in the Pearl River Delta, China" *Communications Earth and Environment*, vol. 4, No. 13 (January 2023). Available at https://doi.org/10.1038/s43247-022-00672-7

Mangroves reduce the extent of flooding in low-lying coastal areas where a small reduction in water levels makes a big difference to exposure and impact. An assessment of the coastal flood protection provided by the mangroves in Pagbilao, Philippines, reveals that without mangroves the extent of flooding is much wider and affects more people and property (Fig 3.23) (Menéndez and others, 2019).

FIGURE 3.23 **Coastal flooding produced by 1-in-50 years tropical cyclone in Pagbilao, Philippines – with and without mangroves**



Source : Pelayo Mene´ndez, Iñigo J. Losada, Sau´ l Torres-Ortega, Alexandra Toimil, Michael W. Beck. Assessing the effects of using high-quality data and high-resolution models in valuing flood protection services of mangroves, 2019

Note : Map not to scale

Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

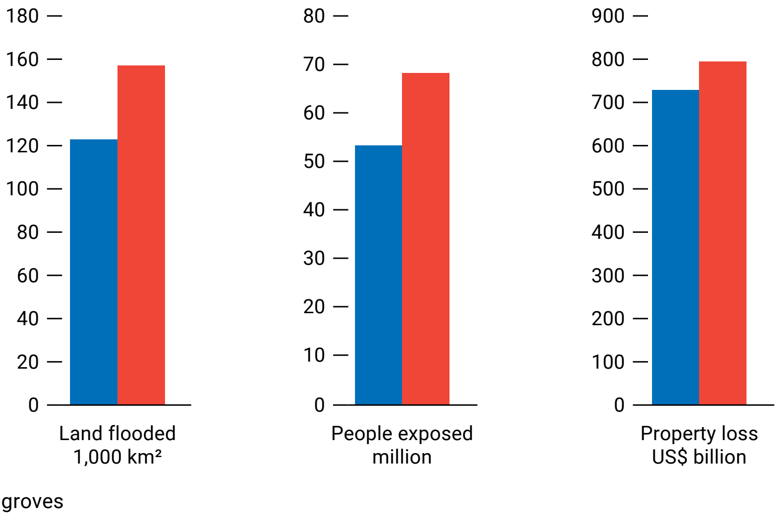
Source: Pelayo Menéndez, and others, "Assessing the effects of using high-quality data and high-resolution models in valuing flood protection services of mangroves", *PLoS ONE*, vol. 14, No. 8 (2019). Available at https://doi.org/10.1371/journal.pone.0220941

The economic benefit of mangroves under a cyclone and storm surge scenario is estimated by Menendez and others (2020). Their study shows that globally, population exposure, loss of properties and extent of flooding is significantly reduced in the "with mangrove" scenario compared to the "without mangrove" scenario (Figure 3.24).

FIGURE 3.24 **Global annual benefit expected from flood protection**

Annual expected benefits from mangroves for flood protection. Estimates of the effects of mangroves on avoided flooding to land (a), people (b) and property (c).

The differences between scenarios with and without mangroves are the present flood protection benefits of the habitat.



Source: Pelayo Menéndez, and others, "The global flood protection benefits of mangroves", *Scientific Reports*, vol. 10, No. 4404 (March 2020). Available at doi: 10.1038/s41598-020-61136-6.

Considering the benefits of mangroves, there have been extensive efforts to restore mangrove forests in many Asian countries, such as Indonesia, Bangladesh, Sri Lanka and Viet Nam (Menéndez and others, 2019; DasGupta and Shaw, 2017; and Wylie, Sutton-Grier, and Moo, 2016). In Sulawesi, Indonesia, 43 hectares of mangroves in Tanakeke island, 20 hectares in Tiwoho, and 21.5 hectares near the provincial capital of Makassar have been restored. This was later upscaled across over 2000 hectares. The National Forest Department of Bangladesh has undertaken mangrove plantation initiatives outside the protective coastal embankments to provide greater protection for inhabited coastal areas. The initial success of the initiatives led to the development of a large-scale mangrove afforestation program and more than 120,000 ha of mangroves have been planted so far. In Satkhira, Bangladesh, 200 hectares of coastal embankment have been planted with mangroves to naturally shield the coastal community against tidal surges through a collaborative effort undertaken by the Government of Bangladesh, the International Union for Conservation of Nature (IUCN), local NGOs and the local community (Siddique, 2022).

Part of the ambition of SDG 14, focused on conserving life below water, is to enhance the resilience of coastal ecosystems and populations. Coral reef and mangrove restoration and management plays an important role in reducing the impact of coastal disasters. Like mangroves, coral reefs reduce storm surges and tidal floods by wave breaking and buffering the ocean currents. Coral reefs can reduce wave energy by approximately 97 per cent and protect the population living in coastal areas that are 10 meters above sea level and are within 50 km of a reef (Ferrario and others, 2014). Yet despite their ability to protect coastlines, coral reefs are vulnerable to climate change and coral bleaching caused by tropical cyclones (Ferrario and others, 2014).

According to the *Status of Coral Reefs of the World 2020* report, coral reef ecosystems along the coastlines of South Asian countries, such as Bangladesh, India, Pakistan and Sri Lanka have been declining due to human activities, including coastal development, overfishing, pollution and sedimentation (GCRMN and others, 2022). There has been a decline of 31.3 per cent in coral reefs in the Pacific countries from 1998 to 2019. The decline increased by 2.7 per cent from 2015 to 2017 due to the El Niño effect (GCRMN and others, 2022). The sustainable management of coral reefs and mangroves is essential to protect marine biodiversity and increase the resilience of populations living in coastal areas. Coral restoration in Port Villa, Vanuatu (Figure 3.25) was initiated in 2014 and completed in 2017. By involving thousands of local communities, this project aimed to restore coral reefs, increase disaster resilience of coastal areas, and promote eco-tourism (INAD, 2023).

FIGURE 3.25 Coral reefs of Port Villa, Vanuatu

Source: Inspired by Nature-based Actions and Solutions (INAS), "Climate-resilient coral varieties - Port Villa, Vanuatu", 2023. Available at https://ap-plat.nies.go.jp/inas/goodpractices/development/4.html

Nature and ecosystems are critical assets and underpin livelihoods. They are "natural capital" and should be valued as wealth because of the marketable goods that are received from ecosystems. Related services are considered a bonus. A World Bank report estimated that the decline in selected ecosystem services may cause a reduction of existing global GDP of $90 billion and up to $225 billion in 2030 (Johnson and others, 2021). Understanding the economic benefits currently received from nature is critical. Its potential to protect people and infrastructure should not be neglected as temperatures rise.

Annex: Table of Early Warning and Early Actions

TABLE 3.4 Benefits and Early Actions of Early warning systems

Sector / Theme		Early actions	Examples
Social	Health / Life safety	- Early warning systems are used to make everyday decisions, including whether to go outside, how to travel safely, what to wear or whether to close schools when adverse weather conditions are predicted. - Early warning of major disasters can signal the need for households to stock up on essentials and charge all devices in case of power outages or road closures, or for potentially life-saving evacuations in cases of extreme events. - Seasonal forecasts can inform households about many decisions, ranging from whether to purchase insurance to what types of household fortification to undertake. - Early warning alerts can also lead to automatic shut-downs of infrastructure to avoid injury or loss of life, such the grounding of elevators in the event of earthquake detection. - Early warnings and early actions in hospitals will lead to stopping surgeries safely and disconnecting ventilator tubes to prevent fatal errors; closing blinds to minimize glass debris; securing radioactive sources and switching all equipment to safe mode.	Typhoon Molave in Viet Nam (2020):[a] - Early-warning systems in Viet Nam helped to evacuate over 1.2 million people before the storm hit, reducing casualties. - The Government used technology, such as mobile phone alerts, loudspeakers, and social media to notify residents of the approaching typhoon and encourage them to evacuate.
	Social consciousness	- Education and training, along with early warning systems, play an important role in fostering a sense of social responsibility towards disaster preparedness. - Collective confidence in the shared resilience of a community contributes to the day-to-day safety, comfort and enjoyment of citizens	Philippines' Disaster Preparedness Program for Children (2022):[b] - The Government of the Philippines has launched a nationwide program to teach children about disaster preparedness and response. - Disaster drills help children understand the importance of early-warning systems and support their families prepare for potential disasters.
Environmental	Protect natural environment	- Through the early warning system, if a disaster is expected, damage can be minimized by creating shelters for wild animals. - When typhoons and floods are expected, damage can be minimized by installing facilities to prevent landslides. - Early warning systems can help prevent environmental damage caused by human activities by facilitating preparedness and providing timely information.	Black Summer Bushfire in Australia (2019-2020):[c] - More than 60,000 koalas impacted by bushfire crises. - By using natural hazard early warning system, the lives of wild animals can be saved.
	Water management	- Early warning systems can minimize the damage. If a drought is expected, damage can be minimized by securing water in advance. - By providing advanced notice of impending natural hazards, early warning systems can help water management agencies reduce the risk of water contamination and pollution, which can have negative impacts on the environment and public health. - Improved early warning systems can lead to more efficient reservoir operations.	Floods in Kerala, India (2018):[d] - The state government established early warning system using AI technology. - Possible to predict areas with a high probability of flooding. - Take real-time flood forecasting and response measures by utilizing past flood data and meteorological data.

Source: ESCAP, adapted from:
Arun S. Malik, and others, "Framework for conducting benefit-cost analyses of investments in hydro-meteorological systems", Occasional Paper Series, Washington, D.C.: World Bank, 2014. Available at https://openknowledge.worldbank.org/entities/publication/e0daf3bf-4c54-58f7-a306-517f9f2c91aa
Jennifer Strauss, and Richard Allen, "Benefits and costs of earthquake early warning", *Seismological Research Letters*, vol. 87, No. 3 (May 2016). Available at https://www.researchgate.net/publication/301707251_Benefits_and_Costs_of_Earthquake_Early_Warning
World Meteorological Organization (WMO), "Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services" WMO-No. 1153, Geneva, 2015. Available at https://library.wmo.int/doc_num.php?explnum_id=3314

Economic	Agriculture	- Knowing, in advance, when a disaster is about to occur is extremely important for evacuating livestock. - With a seasonal early warning system, ideal planting times can be planned and the timing of pesticide spraying can be modified, since accounting for rainfall is very important for seeding and pesticide applications. - Timing of planting and harvesting as well as seed type decisions can be improved.	Typhoon Goni in Philippines (2020):[e] - The assistance of the agriculture department will be provided by the crop insurance corporation as an indemnification fund, with insured farmers and fisherfolk set to receive claims between $200 to $300 for their damaged crops, farm equipment, and fishing boats and gears.
	Insurance	- By using the early warning system, in seasons when natural hazards occur frequently, insurance companies can reduce damage by modifying the special contract of the product. - Travel insurance companies can evacuate policyholders from affected areas in case of extreme weather events, avoiding costly medical bills or liability claims. - Insurers can assess potential damage and prepare for large payouts, reducing the risk of insolvency.	Ping An group in China (2021):[f] - In 2021, Ping An announced that it had developed an early warning system that can predict the likelihood of floods and typhoons in China with a high degree of accuracy. -The system uses artificial intelligence and big data to analyse weather patterns, water levels, and other factors to predict the probability of natural hazards.
	Manufacturing	- In the event of a natural hazard, workers at manufacturing facilities are sent home quickly to prevent damage to personnel. - When a natural hazard is expected, damage to facilities is prevented by immediately stopping plant operations, and isolating hazardous chemical systems, shutting of gas valves, and reducing cascading failures. - Early warning systems can minimize transaction-related economic losses by extending delivery deadlines in the event of a disaster.	Earthquake in Japan (2022):[g] - Toyota Motor Corp., and Nissan Motor Co., halted operations at plants in northern Japan after a magnitude 7.4 earthquake struck off the coast of Fukushima prefecture.
	Energy	- Annual natural hazard patterns have an effect on peak energy use patterns, and a more accurate early warning system can inform power plants when to shut down production and to review dam safety conditions. - Hydro-electric generators benefit from improved streamflow forecasts, so those individuals who care concerned about the season of natural hazards can prepare.	Nuclear accident in Fukushima, Japan (2011): [h] - As a result of this accident, radiation leaked due to a nuclear explosion. Without early warnings, there would have been human casualties due to exposure to radiation, and the Japanese economy would also have suffered a major blow. - When the earthquake hit, some units automatically “scrammed”, that is, control rods were inserted into the reactor cores to suppress nuclear fission.
	Shipping / Transport	- When an earthquake warning is issued, trains are immediately stopped to prevent harm to passengers. Alerts on signage can bring awareness and prompt actions, such as preventing motorists from entering bridges and tunnels. - When a disaster is expected, roads are closed to prevent further damage. - Early warning systems can guide ships to change course when a disaster is expected. - Air traffic controllers will be able to manage air traffic safely considering the early warnings, planes can stop taxiing; baggage handlers can get away from hazardous situations; and planes on approach can go around adverse weather conditions.	Earthquake in Japan (2011):[i] - When an earthquake occurs, sensors detect the seismic waves and send out an alert before the shaking reaches populated area, giving people a few seconds to prepare and take cover. - The system is also used to automatically stop trains, shut down factories, and perform other safety functions when an earthquake is detected.

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b United Nations International Children’s Emergency Fund (UNICEF), “Philippines: Humanitarian Situation Report No. 10, 12 September – 16 October,”, 28 October 2022. Available at https://www.unicef.org/philippines/media/5621/file/UNIPH-2022-Odette-SitRep-28Oct2022-full.pdf

c World Wildlife Fund (WWF), “60,000 Koalas impacted by bushfire crisis”, 7 December 2020. Available at https://www.wwf.org.au/news/news/2020/wwf-60000-koalas-impacted-by-bushfire-crisis

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CHAPTER 4

Implementing transformative adaptation

Transformative adaptation provides a major opportunity to build a resilient future as global temperatures rise. This chapter examines what is needed to make transformative adaptation possible so as to better respond to intensifying disaster risks and multi-hazard risk hotspots in the vulnerable subregions of Asia and the Pacific. It considers the fundamental changes required of our societies, our economies, and the management of ecological systems, in anticipation of climate change and its impacts. Shaped by the principle of 'a just transition for climate change adaptation' and the 'think resilience' approach, the chapter introduces building blocks for implementing transformative adaptation. It presents comprehensive disaster and climate risk management solutions and far-reaching transitions across sectors and systems needed to ensure no one at risk is left behind.

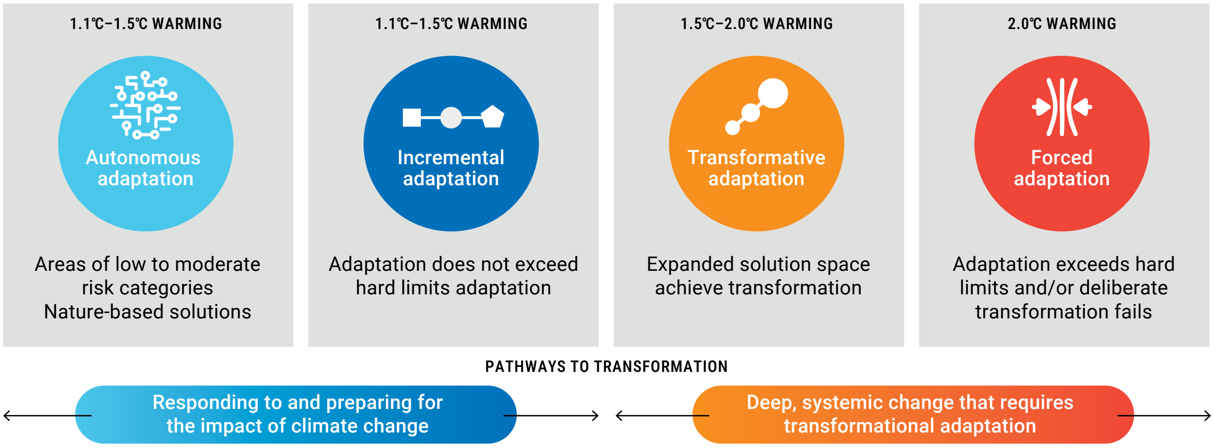
Moreover, this chapter considers how aligning social protection and climate change interventions can build the resilience of poor and climate vulnerable households by strengthening their capacity to adapt, absorb and transfer risks. It looks at how comprehensive Disaster and Climate Risk Management must be implemented to strengthen synergies between disaster risk reduction and climate change adaptation, and how building resilience in climate change hotspots should be prioritized to strengthen food systems. The approach which must be applied to strengthen energy systems resilience is explored, along with practical solutions, such as microgrid systems and proactive hydropower management. Emerging technologies with enormous potential to transform adaptation and strengthen early warnings systems are also presented.

4.1 Pathways to transformation

Transformative adaptation facilitates a type of adaptation to climate change which goes beyond adjusting existing practices (IPCC, 2022). It can be adopted on a large scale to underpin new strategies, in a region or resource system and has a potential to transform places. Transformative adaptation entails deep and long-term societal changes that advance sustainable development. While distinguishing itself from incremental adaptation, it catalyses broader changes in systems and structures. In the specific context of low- to medium-risk areas at 1.1°C to 1.2°C warming, adaptation may be autonomous, could stay within soft limits and hold risks at a tolerable level. Incremental adaptation may work until it reaches hard limits. Transformative adaptation expands the solution space and is critical in multi-hazard risk hotspots at 1.5°C warming when adaptation is no longer a choice but a necessity. Adaptation exceeds a hard limit when warming increases beyond 1.5°C to 2°C, as set out in Figure 4.1.

FIGURE 4.1 **Pathways to transformation in a warming world**

Adaptation in a warming world: Adapting to further warming requires action at national and sub-national levels can mean different things to different people



Source: ESCAP.

4.2 Building blocks of transformative adaptation

Transformative adaptation has shaped the goals of 'a just transition to climate adaptation' and 'think resilience' (Global Platform for Disaster Risk Reduction, 2022). As the impacts of climate change hit the most vulnerable the hardest, a just transition prioritizes protecting people (Adaptation Without Borders, 2021).[8] A 'think resilience' approach directs risk-informed investments, policy decisions and actions towards strengthening the resilience of communities, infrastructure, services, and systems. Beyond this, the building blocks of transformative adaptation include an imperative to leave no one behind who is at risk in multi-hazard risk hotspots, to conduct comprehensive disaster and climate risk assessments, and to transition from a sector to a system approach (ESCAP, 2017). Technology and innovations can greatly support the integration of sectoral interests.

FIGURE 4.2 Four pillars of transformative adaptation

Building blocks of transformational adaptation: Built on the promises of 'a just transition to adaptation' and 'think resilience'

Leave no one behind at risk: To address unmet needs of adaptation and resilience to vulnerable, poor and marginalized populations in multi-hazard risk areas

Comprehensive risk management: A comprehensive disaster and climate-risk-management strategy with transformative actions in the key sectors such as food and energy systems.

Sector to system approach: Breaking down 'silos' and opening out channels for inter-sectoral communication and coordination along with energy, food, and ecosystems

Technology and innovations: Technology and innovations in policy actions integrating all sectoral interests and capacity building of end users to complete the loop for an actionable agenda, including an effective multi-hazard early warning systems

Source: ESCAP.

4.2.1 Leave no one at risk behind

Transformative adaptation should include and prioritize the needs of vulnerable, poor and marginalized populations while operationalizing this at scale in a way that no one is left behind in multi-hazard risk hotspots. The previous chapters have identified and located those most at risk in multi-hazard risk hotspots and the challenges they face. Transformative adaptation should therefore be aligned with the principles of social, economic, and environmental justice and equity, while avoiding potential maladaptation (UNFCCC, 2023). This is where a 'just transition for climate adaptation', in support of the community at risk, assumes greater significance.

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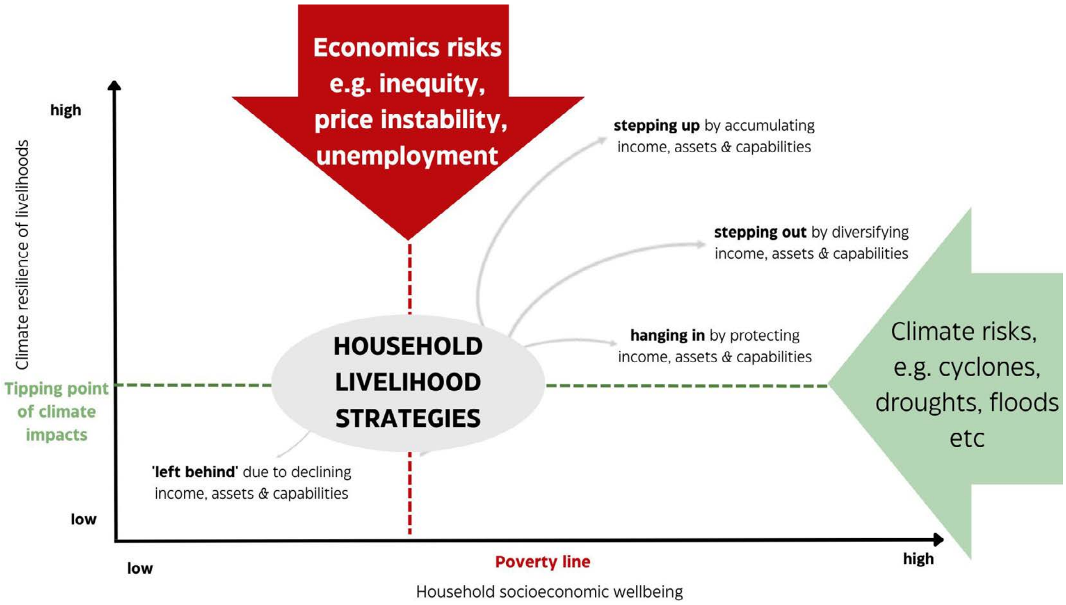
[8] The "Seven principles for a just transition for mitigation", developed by Atteridge and Strambo in 2020, serves as a useful starting point of defining a just adaptation: 1) Actively encourage adaptation; 2) Avoid the creation of adaptation "losers" or redistributing climate risk; 3) Provide international support for vulnerable regions and communities; 4) Support people and communities who are negatively affected by adaptation measures; 5) Reduce climate risk and distribute the burdens of adaptation fairly, ensuring that risk is not transferred from the private to the public sector; 6) Address existing global inequalities, including the distribution of climate risk; and 7) Ensure that a planning process is both inclusive and transparent. See, A. Atteridge and C. Strambo, "Seven principles to realize a just transition to a low-carbon economy", SEI policy report, Stockholm Environment Institute, Stockholm, 2020. Available at https://www.sei.org/publications/seven-principles-to-realize-a-just-transition-to-a-low-carbon-economy/

Among the pathways for a just transition for climate adaptation, aligning social protection and climate change instruments is one way forward. This can help build the resilience of poor and climate vulnerable households by strengthening their capacity to adapt, absorb, transform or transfer risks. Yet, social protection needs to evolve from the provision of safety nets to poor and vulnerable groups to climate change response measures that enable households to plan and manage the challenges and opportunities associated with climate change.[9] Such policies have the potential to build resilience in poor and vulnerable households by protecting assets and capabilities and providing sustainable, climate-resilient opportunities for graduation out of poverty.

Despite most countries having comprehensive strategies for both social protection and climate change, there has been little attempt to align the two (Steinbach and others, 2016). In practice, social protection and climate change responses remain institutionally separate, with separate intra-sectoral coordination groups and funding channels. This limits their potential to develop synergies for more sustained, durable efforts to reduce social, economic and environmental vulnerability. Developing policy coherence has the potential to help at risk communities and their households find sustainable and resilient pathways out of poverty and climate vulnerability.

FIGURE 4.3 A just transition for climate adaptation: The 'hanging in, stepping up and stepping out' framework



Source: ESCAP, adapted from A. Dorward and others, "Hanging in, stepping up and stepping out: Livelihood aspirations and strategies of the poor", *Development in Practice*, vol. 19, No. 2 (April 2009).

The policy coherence of social protection and climate change response measures can be based on the adaptation of the 'hanging in, stepping up and stepping out' framework (Figure 4.3) (Dorward and others, 2009). Recognizing the tipping points of climate impacts and those left behind, the framework introduces two key actions: hanging in and stepping up.

I Hanging-in refers to protecting the income and well-being of vulnerable groups and women according to multidimensional indicators and capabilities in the context of climate change and other shocks.

II Stepping-up and stepping-out refers to improving the income, multidimensional indicators of well-being and capabilities of these groups despite climate and other livelihood shocks.

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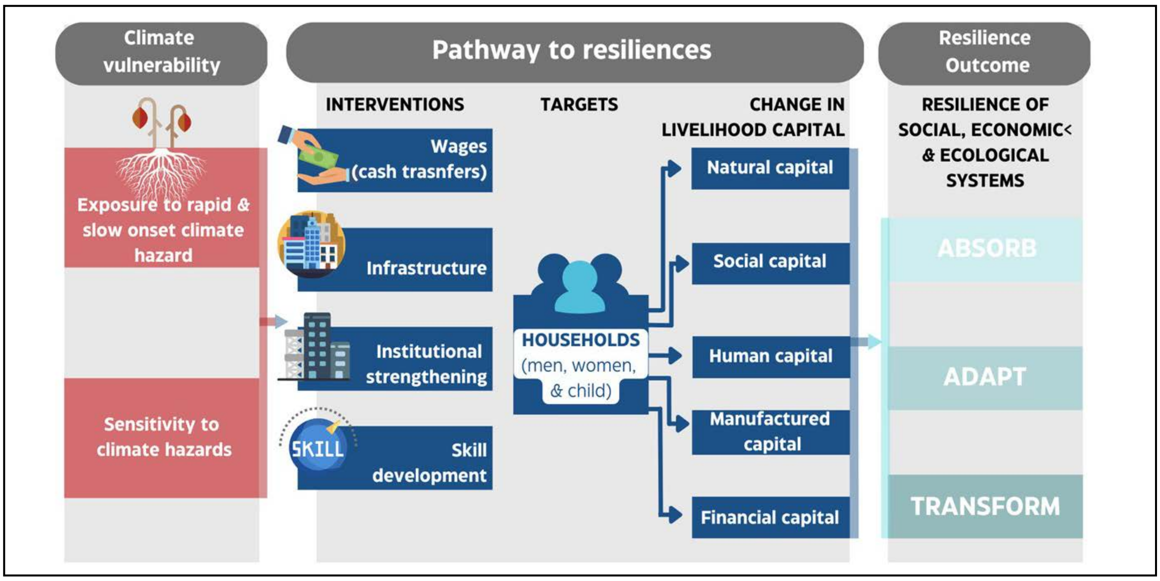
[9] "Climate change response measures" to refer to both climate change adaptation and climate change mitigation measures. Mitigation of climate change: "A human intervention to reduce emissions or enhance the sinks of greenhouse gases". Climate Change Adaptation: "In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects". See IPCC, 2018.

By understanding the context of the policy, institutional, socioeconomic and climate risk profiles, the framework can be used to align the social protection and climate change response measures. In this regard, the Mahatma Gandhi National Rural Employment Guarantee Act, 2005 (MGNREGA) sets an example. It is the world's largest state-implemented labour guarantee social protection programme. With an annual budget of $13 billion (in 2020), the MGNREGA addresses adaptation priorities in multi-hazard high risk areas of the country. Sixty-five per cent of the allocated MNREGA budget goes into natural resources management, water management, drought proofing, building grey and green infrastructure, including nature-based solutions (Kaur and others, 2019). It helps build community resilience through natural resource management, inclusion, and livelihood security of poor and marginalized (Box 4.1).

BOX 4.1 India's Mahatma Gandhi National Employment Guarantee Act: A just transition for climate adaptation

To understand how social protection and climate change response measures are being aligned in practice, the case studies show how MGNREGA's core social protection interventions: guaranteed wage labour; new rural infrastructure; stronger local institutions; and development of new skills, help households change their livelihood capitals to achieve absorptive, adaptive and transformative resilience to address complex risks (Figure 4.4). MGNREGA is not designed to contribute to a fundamental change in the structure of a household's income, consumption, assets and capabilities. Yet, for a small group of households it acted as a stepping stone to transformative adaptation and resilience when delivered in convergence with other risk management instruments. MGNREGA plays a significant role in building resilience to climate risks in the poorest households and within the local economy.a To support the climate-proofing of public assets created under MGNREGA, the MGNREGA Environmental Benefits programme (MGNREGA-EB) has been piloted by the German Agency for International Cooperation (GIZ) in selected high risk multi-hazard districts of India. It is an ecosystem-based adaptation intervention with a mainstreamed approach to aligning social protection and climate change response measures.

FIGURE 4.4 Integrating shock-responsive social protections and climate change response measures



Source: N. Kaur, and others, "Building resilience to climate change through social protection: Lessons from MGNREGA, India", International Institute for Environment and Development (IIED) Working Paper, London, 2019. Available at https://www.iied.org/10197iied

a N. Kaur, and others, "Building resilience to climate change through social protection: Lessons from MGNREGA, India", International Institute for Environment and Development (IIED) Working Paper, London, 2019. Available at https://www.iied.org/10197iied

Poor, women, children, and disabled communities would be less vulnerable to the impacts of disasters if they could rely on social protection that includes disaster preparedness. Over the years, countries have been offering more shock-responsive social protection. Yet, the scale of disaster impacts demonstrates that social protection would benefit from being shock-prepared, imbued with a culture of prevention that builds on inclusiveness and resilience. This requires a comprehensive portfolio of investments in the poor throughout their life cycles. Many countries already have the building blocks in their health and education investments. Now they need to offer universal and shock-prepared social protection. Some of the measures needed are listed in Table 4.1.

People-centred early warning systems are another pathway for a just transition for climate adaptation. Effective, people-centred early warning systems must include the most vulnerable and those living in multi-hazard risk hotspots (Chapter 3 provides further insights). The on-going work on people-centred early warning systems and anticipatory action, and the forecast-based financing (FbF) approaches adopted by the International Federation of Red Cross and Red Crescent Societies (IFRC) and National Red Cross and Red Crescent Societies in vulnerable countries are important reference points (IFRC, 2021).

TABLE 4.1 Key actions for shock-responsive social protection

<table>
<tr><th colspan="6">Using emerging technologies to support resilience, ensure that routine social protection programming is based on a solid understanding of the risks, shocks and stressors, including cascading hazards.</th></tr>
<tr><td colspan="3">Focus on vulnerability to shocks: expanding routine coverage in areas frequently affected by shocks; and incorporating vulnerability criteria into routine targeting.</td><td colspan="3">Safeguard continuity of service delivery when recipients need support the most. This is often referred to as 'resilience-building of systems' to future shocks, adopting the principles of contingency planning.</td></tr>
<tr><th colspan="6">Prepare to scale up existing programmes or activate new emergency programmes to accommodate new populations and needs.</th></tr>
<tr><td colspan="2">Vertical expansion of an existing programmes. Benefits or lengths of programmes can be temporarily increased. New components may also be added.</td><td colspan="2">Horizontal expansion of programmes to temporarily include new beneficiaries.</td><td colspan="2">Where possible, build emergency programmes on existing systems. These could be led by the social protection sectors or by humanitarian actors, or those engaged in disaster risk management.</td></tr>
<tr><th colspan="6">Where relevant, align existing social protection programmes with scalable measures for disaster preparedness.</th></tr>
<tr><td colspan="3">Incorporate multi-hazard parameters to strengthen social protection systems and disaster preparedness and align the objectives, and targeting and delivery.</td><td colspan="3">Extending services to fully cover complex and multi-dimensional risks, such as wrapping a child protection or nutrition-support programme around a standard cash transfer programme.</td></tr>
</table>

Source: Adapted from United Nations Children's Fund (UNICEF), "Programme Guidance: Strengthening Shock Responsive Social Protection Systems", New York, 2019. Available at https://www.unicef.org/media/63846/file Accessed on 21 March 2021.

4.2.2 Comprehensive disaster and Climate Risk Management (CRM)

Comprehensive disaster and Climate Risk Management (CRM) is aligned with the Sendai Framework Target E: Increase national and local disaster risk reduction strategies. CRM is a comprehensive approach which considers several factors to strengthen synergies between disaster risk reduction and climate change adaptation. It does so by identifying mutually beneficial opportunities across policies and programmes, while developing capacities of governments for cross-sectoral planning and ensuring vertical alignment (UNDRR, 2023a).

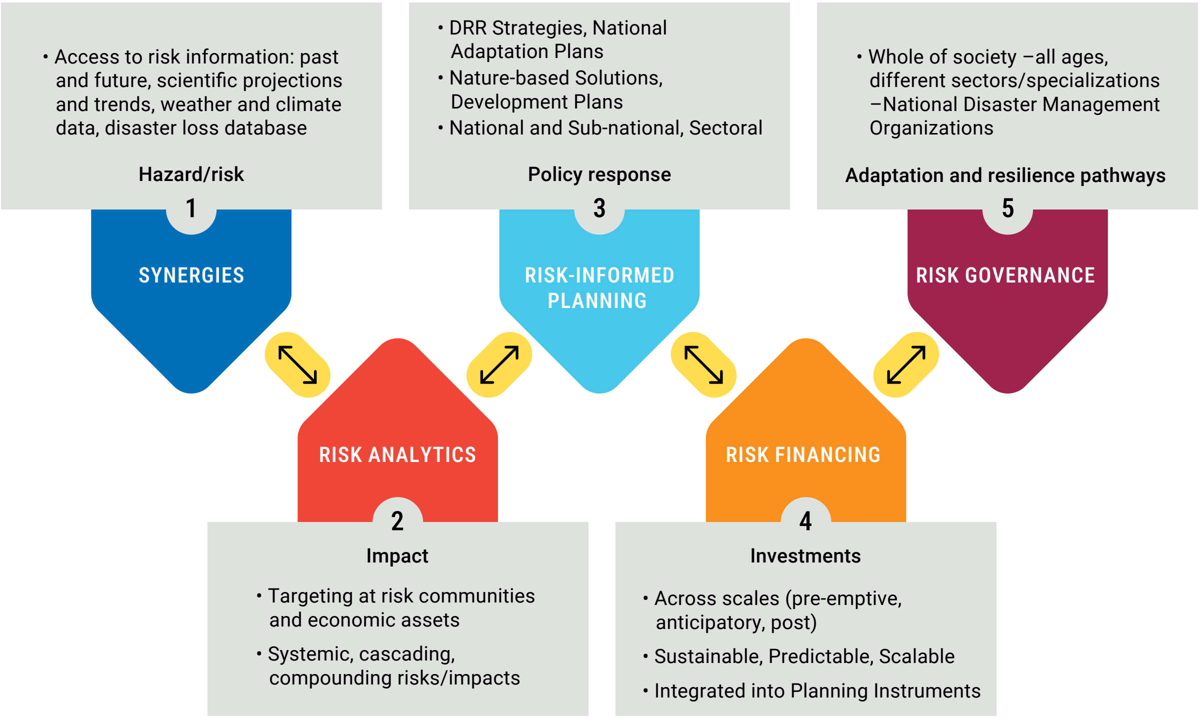
Building on this approach to risk, the CRM programme promotes application of a full-spectrum analysis of risk. This shapes risk-informed development policies, investments, and risk governance frameworks in a country (Figure 4.5). This approach is based on the analysis of the existing policy landscape between disaster risk reduction and climate change. The CRM programme seeks to integrate risk-centred approaches into National Adaptation Plans (NAPs), and climate/forecast information into national and subnational disaster risk reduction strategies, aligning them better with national adaptation goals.

The CRM programme focuses on risks across different timescales; short-, medium-, and long-term, and uses information from weather, seasonal and climate forecasts. It translates this information into meaningful information to enable more comprehensive planning and implementation.

National Adaptation Plans (NAPs), Nationally Determined Contributions (NDCs), national and local development plans, and spatial and sectoral planning processes need to apply CRM principles and consider how trade-offs and co-benefits will influence potential systemic risks, such as pandemics and displacement (UNFCCC Secretariat, 2017). Improved metrics on adaptation and risk management are urgently needed to measure the degree to which the climate emergency is corroding the resilience and achievement of the Sustainable Development Goals and the targets of the Sendai Framework. Better prevention and risk management minimizes adverse effects and creates opportunities to transform systems and societies. Disaster risk management and adaptation plans should be based on analysis of both historical disaster trends and future climate and disaster risk projections.

The number of countries with strategies to promote policy coherence and compliance, notably with the Sustainable Development Goals and the Paris Agreement, and to implement Target E: Increase national and local disaster risk reduction strategies, has reached 118, compared with only 44, in 2015. However, there has been limited progress at the local level. Numerous least developed countries, the Pacific small island developing States and landlocked developing countries identified a near complete absence of local government and community involvement in disaster risk reduction planning (UNDRR, 2023b). Siloed disaster risk reduction agencies and policies continue to limit integrated risk-informed decision-making before risk manifests as a shock or disaster.

FIGURE 4.5 Risk-informed policy response to development, investments, and governance



Source: ESCAP.

CRM of transboundary disaster riskhotspots: The *Asia-Pacific Disaster Reports* note a multitude of risk hotspots in the Asia-Pacific region (ESCAP, 2015; ESCAP, 2019). Chapter 1 of this *Asia-Pacific Disaster Report 2023* highlights how the riskscape of these hotspots are shifting under global warming of 1.5°C and 2°C. Adaptation measures must therefore include integration of the climate change scenarios into various medium- and long-term plans and programmes. In transboundary hazards, teleconnections exist between natural resources and natural ecosystem services. While economic and social linkages alter the nature of teleconnection, climate change has a substantial impact on this relationship. While adaptation pathways need to be risk-informed at all levels, subregional approaches that capture the transboundary multi-hazard risk hotspots align well with the CRM. Subregional approaches integrate the science of the IPCC reports with NAP and sectoral adaptation plans (Figure 4.6). A recent study on the transboundary Aral Sea catastrophe considers this relationship and quantifies risk and its impacts from 2020 to 2100 (Narbayep and Pavlova, 2022). It anchors subregional adaptation pathways that capture the teleconnection between natural resources and natural ecosystem services in the changing climate risk scenarios of the Aral Sea (Box 4.2).

FIGURE 4.6 CRM approaches to addressing transboundary multi-hazard risk

SUBREGIONAL SOLUTIONS	Joint climate change adaptation measures through regional cooperation
NATIONAL ADAPTATION PLAN THAT INCLUDES TRANSBOUNDARY RISKS	• National DRR strategies • Voluntary National Review • Nationally Determined Contributions
SECTORAL (FOOD, ENERGY, ETC.)	• to include transboundary risks

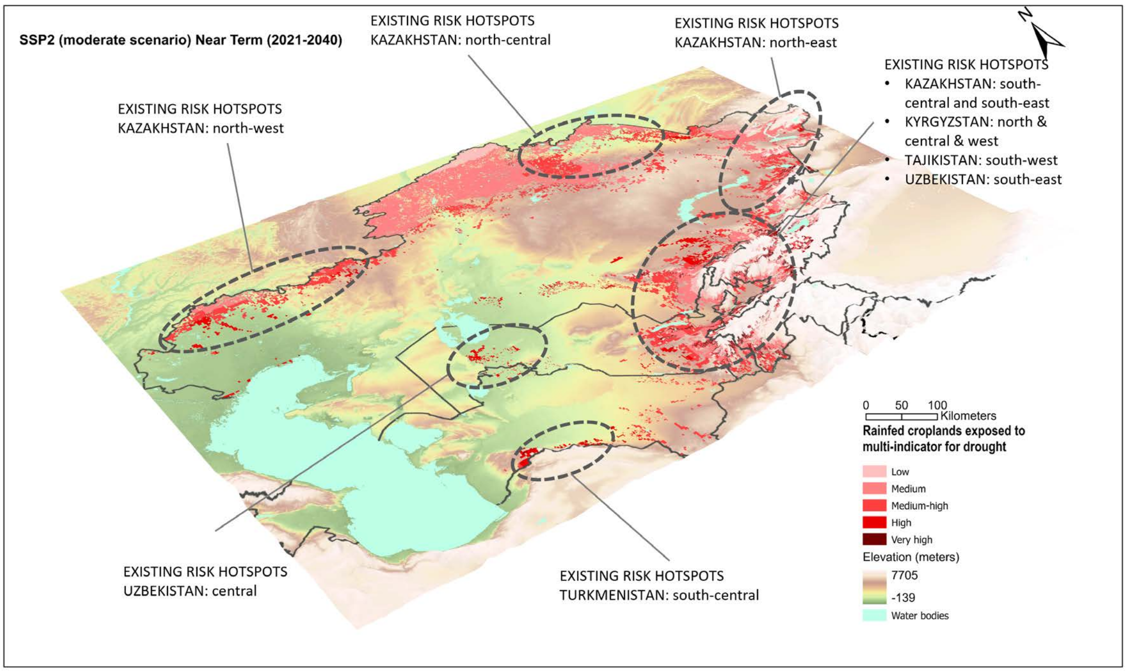
Source: ESCAP.

BOX 4.2 CRM approach and the Aral Sea catastrophe

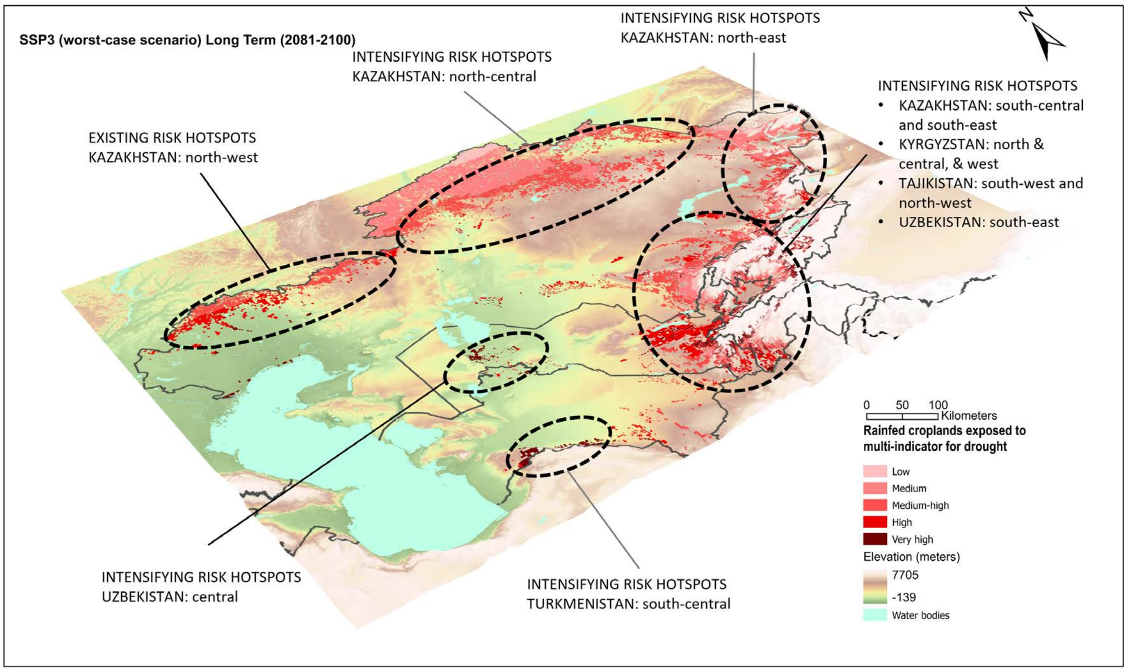
ESCAP analytical work zooms in on the Aral Sea as a transboundary hazard and visualizes the climate risk scenarios in the near (2021-2040) and long-term (2081-2100). The changing climate scenarios project a decrease in summer rainfall in the Aral Sea, increasing the number of dry days as well as temperature, resulting in higher aridity. On the contrary, winter rainfall is likely to increase along with the number of rainy days. The elevation of the Aral Sea contributes to the changing patterns of the climate scenarios. Changes in land use and water management practices are likely to result in many clusters of agricultural risk hotspots (Figure 4.7).

The study introduces a set of adaptation priorities: (i) strengthening multi-hazard risk assessment and early-warning systems; (ii) improving dryland agriculture crop production; (iii) making water resources management more resilient; (iv) nature-based solutions; and (v) making new infrastructure resilient. It is crucial that adaptation priorities tackling transboundary Aral Sea hazards be risk-informed and attuned to regional specificities. For example, multi-hazard risk assessment and early warning systems are useful to mitigate all types of cropland exposure to multi-hazard risks, particularly drought and flooding. Early warning monitoring is necessary to plan and reduce the impact of multi-hazard risks on agriculture, which is directly linked to food security and people's well-being. Analysis shows that adaptation measures, like strengthening multi-hazard risk assessment and early warning systems, as well as improving dryland agriculture crop production, have the highest priority score in all five Central Asian countries in the various climate change scenarios.

FIGURE 4.7 **3D visualization of hotspots of rainfed agriculture exposure to drought under SSP2 near-term and SSP3 long-term scenarios**



Sources : ESCAP calculations based on IPCC WGI Interactive Atlas - Coupled Model Intercomparison Project Phase 6 (CMIP6) 2021;the Global Aridity Index Version 2, 2019; Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model Version 3 (GDEM 003),2018; Global Food Security-support Analysis Data 30 meter (GFSAD30) Cropland Extent,2017; and World Water Bodies, 2021.
Notes : 1. The multi-indicator for climate consist of a) Increase in temperature (°C) b) Percent decrease in precipitation, and c) Increase in maximum number of annual consecutive dry days.
2. The Aridity Index for arid and semi-arid regions are all values less than 0.5. The classification is based on generalized climate classification scheme for Aridity Index values (UNEP 1997).
3. Dry day is defined as day with mean precipitation less than 1 mm.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.



Sources : ESCAP calculations based on IPCC WGI Interactive Atlas - Coupled Model Intercomparison Project Phase 6 (CMIP6) 2021;the Global Aridity Index Version 2, 2019; Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model Version 3 (GDEM 003),2018; Global Food Security-support Analysis Data 30 meter (GFSAD30) Cropland Extent,2017; and World Water Bodies, 2021.
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Source: Marat, Narbayep, and Vera Pavlova, "The Aral Sea, central Asian countries and climate change in the 21st century", United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) Working Paper Series Part 1: Aral Sea, 2022. Available at https://www.unescap.org/kp/2022/aral-sea-central-asian-countries-and-climate-change-21st-century

The CRM has emerged as a practical approach to build a shared understanding of risk as the common denominator for climate change adaptation and disaster risk management planning. Such an approach considers climate risks alongside other hazards and pre-existing vulnerabilities. Mainstreaming CRM requires the collaboration of humanitarian, development, and climate stakeholders. Only this collaboration can deliver greater coherence in the design, implementation, and monitoring and evaluation of actions taken. Integrated approaches need to include a spectrum of interventions, such as social protection, solidarity funds, and early warning systems as key building blocks of anticipatory action. Integrating disaster risk reduction and climate adaptation plans leads to a 'one-country one-plan' approach, where countries can develop integrated plans and identify aggregated funding (Resilience Hub, 2022).

4.2.3 Transitioning from sector to system approach

As disaster risk is turning systemic with compounding and cascading impacts, siloed disaster risk reduction policies continue to limit integrated risk-informed decision-making. Breaking down 'silos' and opening out channels for inter-sectoral communication and coordination is vital for ensuring a systematic, collective, and meaningful response to embark on transformative adaptation with a system-thinking approach. Science-based solutions require science-policy dialogues to underpin the necessary transformative adaptation processes. The pathways for transformative adaptation lie in transitioning from a sector to system approach. The triple crisis of food, energy and finance associated with the COVID-19 pandemic, global conflicts and climate change, highlighted the multifaceted vulnerability and underlined the importance of managing systemic risks (UNSDG, 2022). To manage such a crisis in the future, a comprehensive risk management approach can ensure resilient food and energy systems.

The synthesis of NDCs submitted to the COP 27 of the United Nations Framework Convention on Climate Change (UNFCCC) highlights the 42 countries which disaggregated their adaptation costs and needs by sector in their NDCs or NAPs. Developing countries have indicated the highest adaptation finance needs in the agriculture sector (23 per cent), followed by infrastructure and settlements (16 per cent), water (14 per cent), forests and ecosystems (12 per cent), climate-induced disasters (10 per cent), energy (6 per cent), human health (6 per cent), coastal and marine resources (4 per cent), tourism (1 per cent), and other sectors (8 per cent). The importance of food and energy system resilience is emphasized in the NDCs of parties from Asia and the Pacific (UNFCCC, 2022).

A. FOOD SYSTEM RESILIENCE

The analysis of the sectoral impacts of disasters, as discussed in Chapters 1 and 2, demonstrates that agriculture is the sector which suffers most acutely. The FAO 2021 assessment report, based on the data from 71 Post-Disaster Needs Assessments (PDNA) conducted between 2008–2018, highlights that agriculture absorbed 26 per cent of the overall impact caused by medium-to large-scale disasters in low- and lower-middle-income countries (FAO, 2021a).

Comprehensive risk management is critical to make food systems, including agri-food production, more resilient. Risk reduction can protect development investments in agriculture (including crops, livestock, fisheries, aquaculture, and forestry), as well as markets and transportation, ecosystems and child and maternal health. The sectors and systems that support and connect food systems and food security are highly integrated. If risks at producer-level are not effectively managed, this can have cascading effects across all components of the food value chain, potentially leading to food system failures. The 2022 Pakistan floods, which struck before the harvest, caused unprecedented damage to crops, livestock, and entire food systems. The floods threatened to create the conditions for a national food security crisis (ICIMOD, 2022). According to the Pakistan's Nationally Determined Contributions (NDCs), agriculture is a sector most impacted by climate variabilities which are compounded by extreme weather events (Government of Pakistan, 2021).

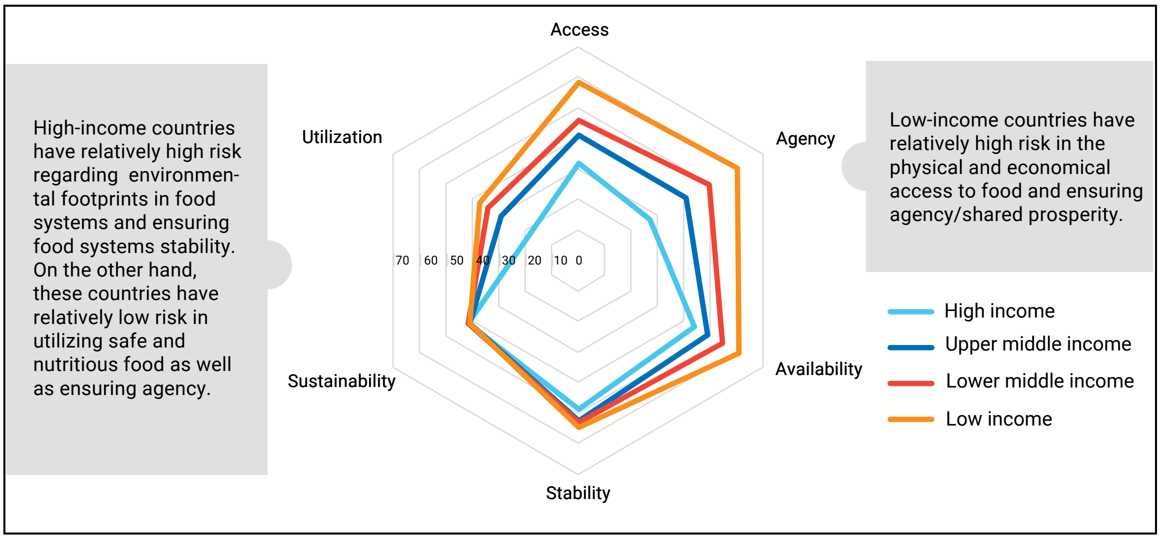
Food system resilience can be understood according to the difference between the status of food systems components at pre-shock (t1) and post-shock (t2) intervals. This provides an insight into how well the components of given food systems, and the food system as a whole are able to cope with shocks. Food systems resilience capacities are comprised of the structural conditions, policies and strategies that a country has in place as protections for the different components of a given food system. Food system capacities may be viewed as providing anticipatory, absorptive, adaptive, or transformative capacities against shocks (Constas and others, 2021). Contributions to food system risk differ by country income category. The framework presented in Figure 4.8 helps compare the contributions to risk across the six dimensions of food security to strengthen policy and decision-making. The risk framework helps countries compare their risk-trajectories with others, identifying those with high and increasing risk, as well as those that face high and persistent risk. While demonstrating the feasibility of this approach to measure food system resilience at the county level, countries in the Asia-Pacific region (Figure 4.9) and sub-Saharan African countries have exhibited the lowest levels of food systems resilience, followed by South and Central Asia and the Pacific.

BOX 4.3 A risk model for assessing multidimensional food systems risk

A new risk model for food system risk assessment responds to rising food insecurity in the Asia-Pacific region within a complex risk landscape by providing insights on multidimensional risk, including those related to climate change, macroeconomic crises, trade disruptions, conflicts, and health shocks.[a] It integrates a food security lens focused on the six dimensions of food security: access, agency, availability, stability, sustainability, and utilization.[b] The risk model has a risk assessment lens conceptualizing risk as a product of hazard and exposure, vulnerability and lack of coping capacity to assess risk to three food system outcomes: (i) human health and nutrition; (ii) ecosystem health; and (iii) shared prosperity.[c]

Managing risk is critical for the successful implementation of food systems transformation pathways established in the wake of the United Nations Food System Summit 2021. The risk assessment model can be applied across countries, including at national level, with modification for use of spatially referenced data. Risk mapping can reveal the disparities between localities in terms of their multidimensional risk profiles and trends, helping to prioritize interventions in high-risk areas. Evidence-based risk mitigation measures that are tailored to local circumstances can help secure a future for healthier, more resilient, sustainable, and equitable food systems.

FIGURE 4.8 Risk by food security dimension by income group, 2022

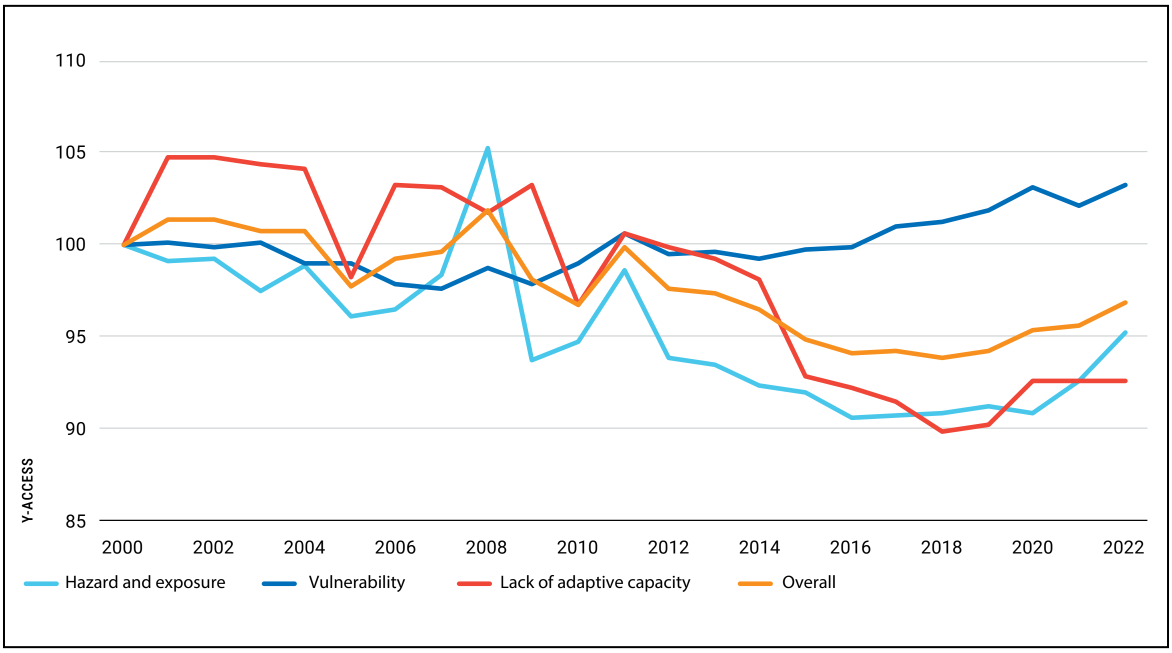


High-income countries have relatively high risk regarding environmental footprints in food systems and ensuring food systems stability. On the other hand, these countries have relatively low risk in utilizing safe and nutritious food as well as ensuring agency.

Low-income countries have relatively high risk in the physical and economical access to food and ensuring agency/shared prosperity.

Source: ESCAP. These are (unpublished) preliminary results from the INFER model.

FIGURE 4.9 Change in food system risks in Asia and the Pacific in 2000-2022



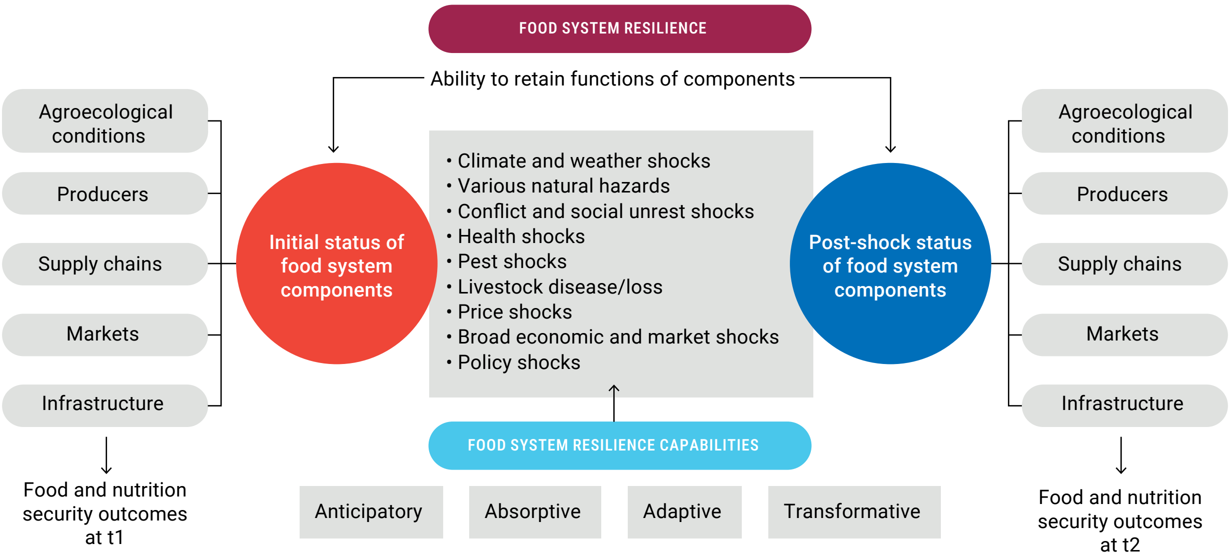
Source: ESCAP. These are (unpublished) preliminary results from the INFER model.

[a] The results shown are from the first prototype of the risk assessment framework, Version 1.0, developed by ESCAP and the World Food Programme, with contributions by the FAO and the United Nations Environment Programme, forthcoming, 2023. Next steps include further refinement of the framework and application at the national/subnational level.

[b] High Level Panel of Experts (HLPE), "Food security and nutrition: Building a global narrative towards 2030", A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome, 2020. Available at https://www.fao.org/3/ca9731en/ca9731en.pdf

[c] M. Marin-Ferrer, L. Vernaccini, and K. Poljansek, "Index for Risk Management (INFORM): Concept and Methodology Version 2017", Italy, 2017. Available at https://publications.jrc.ec.europa.eu/repository/handle/JRC106949

FIGURE 4.10 Components of food system resilience



Source: Mark A. Constas, and others, "Resilient food systems: A proposed analytical strategy for empirical applications", Background paper for The State of Food and Agriculture 2021. Food and Agricultural Organization of the United Nations (FAO). Rome, Italy, 2021. Available at https://www.fao.org/documents/card/en?details=cb7508en%2f

The potential agricultural losses that could be incurred under the current, 1.5°C and 2°C warming scenarios have been examined in Chapter 2. The food system producing zones of Asia and the Pacific are in multi-hazard risk hotspots in countries with high exposure to potential agricultural losses, and which suffer from high levels of food insecurity. Transformative adaptation is key to develop food system resilience in climate risk hotspots, such as semi-arid and desert regions, coastal rice paddy regions, and glacier and snow-fed agricultural areas of Asia and the Pacific. Transformative adaptation to build resilience of food systems in riskier times requires longer-term, systemic approaches to protect the lives and livelihoods of millions of small-scale farmers and herders. It necessitates investment in comprehensive, long-term adaptation programs that span several years and recognize how climate change will affect the interconnectedness of food systems with other systems and socioeconomic factors. Allowing for longer timelines affords the opportunity to distribute costs and risks while maintaining flexible adaptation pathways (Carter and others, 2021).

Transformative adaptation means prioritizing resilience-building in climate hotspots, such as semi-arid and arid regions and coasts, where systemic tipping points make fundamental changes urgent (Figure 4.11). Transformative approaches to agricultural adaptation require continually shifting the locations of specific types of crops and livestock to areas with more suitable climatic conditions. It will also require changing agricultural production systems to better fit changing landscapes and ecosystems. For instance, rice growers in Bangladesh need to shift to aquaculture in response to increased salinity due to rising sea levels and reduced seasonal river flows. In the Mekong Delta in Viet Nam, rising sea levels are increasing the salinization of aquifers, putting at risk cultivation that is critical to the region. Innovative production methods and technologies, such as low-cost greenhouses that help Indian vegetable farmers to conserve water and protect their produce from storm damage, will also be needed to promote long-term resilience. Incremental adaptation, while important, will be insufficient to avert dramatic increases in hunger, poverty, and displacement over the next 30 years (Carter and others, 2021). Instead, greater commitments to plan, fund, and implement transformative adaptation measures will be essential to ensure food security.

Key to transformative adaptation is the capacity of the five distinct resilient food systems to prevent, anticipate, absorb, adapt and transform. Building such capacity is critical to confront unforeseen shocks, and complements risk management of those shocks that can be anticipated. Risk management strategies for shocks, such as droughts, floods and pests, including multi-risk assessments, timely forecasts, early warning systems and early action plans, are necessary to build resilient food systems (FAO, 2021b). The UN Food Systems Summit (2021) underscored the importance of addressing the fragilities underpinning food systems and to regenerate and strengthen these systems to better respond to the needs of people and ecosystems (FAO, 2021b). The *Ready for the Dry Years* publication series, co-produced by the ASEAN and ESCAP secretariats that informed the ASEAN Regional Plan of Action for Adaptation to Drought (ARPA-AD), discusses how to integrate disaster risk management and climate change adaptation in the agricultural sector (ASEAN Secretariat, 2020; and ASEAN Secretariat and ESCAP, 2020). The ASEAN recently launched its Framework on Anticipatory Action in Disaster Management (ASEAN Secretariat, 2022). The Framework provides an opportunity for ASEAN member States to converge their efforts through a common definition for anticipatory action as "a set of interventions that are carried out when a hazard poses imminent danger based on a forecast, early warning, or pre-disaster risk analysis" (ASEAN Secretariat, 2022).

FIGURE 4.11 **Ecosystems most vulnerable to water stress and other slow-onset climate change impacts**

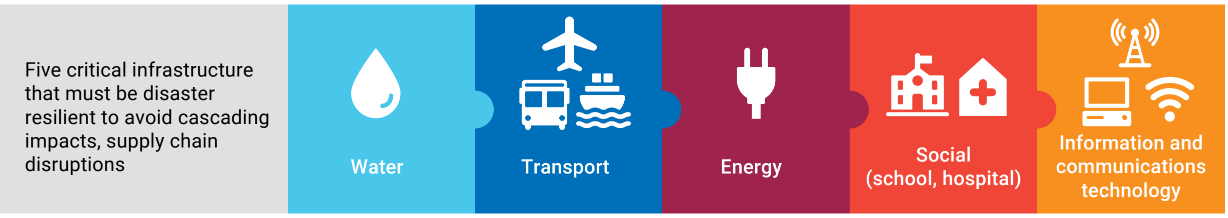
SEMI-ARID & ARID AGRICULTURE	GLACIER & SNOWPACK-FED AGRICULTURE	COASTAL AGRICULTURE	AGRICULTURE IN DEGRADED WATERSHEDS	AGRICULTURE IN WATER SYSTEMS WITH LONG-TERM MEGA INFRASTRUCTURE
Tipping Point: Decreased or unreliable water availability requires a transition from rainfed to irrigated agriculture or a transition to less water dependent agricultural product E.G.: Increasing aridity in northern Kenya severely impacts cattle herders, encouraging a switch to camel production	**Tipping Point:** Melting glaciers or snowpack decreases or eliminates water available for agriculture E.G.: Reduced glacial-melt water available for necessary irrigation Peruvian highlights-what happens next is yet to be determined	**Tipping Point:** Coastal agriculture is regularly or permanently inundated E.G.: Increasing frequency of coastal flooding (in conjunction with soil salinization) sparks transition from rice paddy to aquaculture in Bangladesh	**Tipping Point:** Landscapes already degraded by mismanagement and/or overpopulation are pushed beyong cultivation limits by climate impacts E.G.: Desertification of Mongolian rangelands due to overgrazing & increasing temperatures causes communities to introduce sylvopastoralism and new livelihoods	**Tipping Point:** Long-term mega infrastructure amplifies climate change impacts such that previous agricultural practices become nonviable E.G.: Mega-dams in East Africa permanently alter critical seasonal agricultural flooding dynamics in combination with increasindly unpredictable rainfall causing practices to be untenable, and causes communities to relocate

Source: Carter, Rebecca. "How to Transform Food Systems in the Face of Climate Change." *World Resources Institute,* 23 June 2021, https://www.wri.org/insights/how-transform-food-systems-face-climate-change

B. ENERGY SYSTEM RESILIENCE

Critical infrastructure sectors that comprise energy, water, information and communication technology (ICT) and transport, together with social infrastructure, such as schools, hospitals and community buildings are vital for the normal functioning of states and businesses. They underpin everyday life and are often referred to as 'lifelines' (Figure 4.12). These sectors are not single systems but networks, which means that a local emergency could quickly spread and lead to severe disruptions. These sectors are becoming increasingly interdependent, especially with the digitization of services. Energy is the backbone of these critical infrastructure systems and networks.

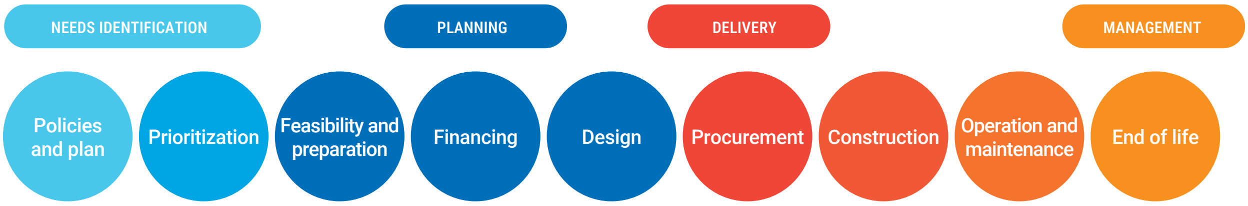
FIGURE 4.12 **Energy systems are the backbone of critical infrastructure**



Source: ESCAP.

Developing resilient critical infrastructure systems and network requires a 'think resilience' approach on risk-informed decisions and actions by practitioners across the whole infrastructure life cycle (Figure 4.13). At each stage, there are opportunities to enhance the resilience value of an infrastructure project and to ensure that existing resilience value is maintained. 'Think resilience' needs to factor in whole systems approaches: adaptive capacity; prioritizing infrastructure needs; infrastructure financing; regulation, codes and standards; capacity and resourcing and; data, information and technology (Kannan and others, 2021). To deliver resilient infrastructure, a framework for resilience is required. This can help anticipate future shocks and stresses better, improve actions to resist, absorb and recover from shocks and stresses by testing for vulnerabilities and addressing them, and value resilience and drive adaptation before it is too late (National Infrastructure Commission, 2021).

FIGURE 4.13 The ‘think resilience’ approach through the life cycle of infrastructure



Source: Akshaya Kannan, and others, “Governance of infrastructure for resilience. White Paper. Coalition of Disaster Resilience Infrastructure (CDRI) and The Resilience Shift”, November 2021. Available at https://www.cdri.world/upload/pages/1727000334484455_202203111051whitepaperongovernanceofinfrastructureforresilience_0_compressed.pdf

Chapter 2 provided a comprehensive overview of the climate impacts and hazards facing energy systems. Heatwaves and droughts are already putting existing energy generation under stress, and as the impact of extreme weather increases, protecting energy access will be at the forefront to save people’s lives and livelihoods. As projected with the current, 1.5°C and 2°C warming scenarios, climate change disruptions are likely to increase the magnitude of both the supply and demand of energy.

In the energy systems, periods of drought and high temperatures have led to increased demand for cooling. Reduced electricity production from hydroelectricity has resulted in an increased demand for nuclear power. Disruptions in the global energy commodity markets have resulted in increased prices of natural gas, coal, and oil, and led to increases in food commodity prices, putting additional strains on the balance sheets of countries with national budgets under pressure from the impacts of the COVID-19 pandemic and climate-related disasters.

There are seven key principles that help build energy system resilience (UNDRR, 2022). They include: (i) defining critical infrastructure – national/subnational context vis-à-vis criticality of energy systems; (ii) incorporating energy infrastructure resilience in national and local disaster risk reduction strategies; (iii) developing a better understanding of interdependencies, interaction, and connectedness of energy infrastructure systems; (iv) improving coordination at different levels and among all relevant parties; (v) actively engaging and creating incentives for private sector participation supported by risk-based performance; (vi) facilitating the collection of risk data and making the disclosure of information on climate disaster risks mandatory; and (vii) enhancing knowledge and building capacity.

In high disaster risk areas, microgrid energy systems hold promise for sustainable and resilient energy. Centralized power systems that rely on large power plants and transmission grids are susceptible to single points of failure, which makes them vulnerable to extreme weather events. The recent Cyclone Gabrielle, and the flooding in Auckland, New Zealand, which resulted in widespread power outages are prime examples of this (IEA, 2021). Microgrids are self-sufficient and can operate independently or in conjunction with the larger grid. They can run on different types of renewable energy sources, including solar, wind and hydro power. Hydro-electro power systems are more vulnerable to the adverse impacts of climate change. In South and South-East Asian hydropower systems, the following policy recommendations can contribute to enhancing the climate resilience (IEA, 2021):

- **Build robust climate databases and strengthen climate impact assessments**. Although various climate-related changes have critical implications for hydropower generation in the region, the climate data and projections for specific locations or events are still limited due to a lack of reliable data and the complexity of meteorological systems.
- **Integrate climate resilience as a key element in hydropower planning and construction**. As the region seeks to expand hydropower generation to meet its growing economy and energy needs, integrating climate resilience in new project planning and construction will be crucial.
- **Build climate resilience into hydropower operation and maintenance strategies**. As hydropower plants age, they tend to become more vulnerable to climate change. Governments can set guidelines or standards for project operators to integrate climate resilience monitoring and adaptation processes

into operation and maintenance plans. These could include the regular collection of climate and hydrological information, the implementation of which can prevent widespread devastation in the agricultural sector.

A comprehensive approach to assessing and managing the climate and disaster risk is critical to make energy systems more resilient. This requires building climate-resilient infrastructure to minimize the cascading impacts of disasters and supply chain disruptions. ESCAP's energy transition pathways for the 2030 Agenda, including SDG7 roadmaps, provides an opportunity to promote resilient energy systems. This includes effective grid planning and operations and cross-border power system integration. To accelerate the shift to a multi-hazard, multi-sectoral, and systemic risk perspective fit for cascading risks, the Asia Pacific Risk and Resilience Portal provides risk scenarios, including the economic cost, multi-hazard risk hotspots and adaptation priorities for the 56 countries in the region (ESCAP, n.d., b). The Asia Pacific Energy Portal serves as an informational foundation (ESCAP, n.d., a). Both these portals address critical gaps in understanding climate risk in order to build resilient energy systems.

4.2.4 Technology and innovations

Transformative adaptation activities and initiatives range from simple techniques and practices to highly sophisticated technologies. In the transformative adaptation context, technology and innovations can be grouped into three clusters: (i) science-intensive technologies (agriculture, health, and indirect adaptation); (ii) engineering-based technologies (coastal, water, and infrastructure), and (iii) data science and emerging technology-based early warning systems (impact-based forecasting, early warning and early action, anticipatory actions). Adaptation technologies show strong technological complementarities with mitigation given that more than 25 per cent of adaptation technologies carry mitigation benefits. Policymakers can harness these synergies to accelerate progress towards both goals (Hötte and Lee, 2022). The *Green Technology Book 2022* captures a range of technology and innovations which facilitate climate change adaptation (World Intellectual Property Organization, 2022). It touches on how to build national innovation ecosystems in which novel technologies can be developed for this purpose.

Engineering-based adaptation technologies must be risk-informed. All new infrastructure, such as coastal, water, food and energy systems as well as the retrofitting of existing structures, must consider changing climate scenarios. The best way to do this is by combining traditional grey infrastructure with green infrastructure. For example, for water resource management, grey infrastructure components would include building reservoirs, pipe networks and treatment plants, while complementary green infrastructure would include watersheds that improve water source quality and wetlands to filter wastewater effluents. This is not only the most cost-effective approach, but it also empowers communities by engaging local stakeholders and incorporates longer-term flexibility for responding to changing climate conditions (World Bank, 2019). Technology and innovations, built on data science and emerging technologies, offer promise of further transformative adaptation.

A. DATA SCIENCE AND EMERGING TECHNOLOGIES TO ADVANCE EARLY WARNING SYSTEMS

Emerging technologies have the potential to transform and enhance early warning systems for disasters. Technologies, like the Internet of Things (IoT) sensors and remote sensing combined with artificial intelligence (AI), can help extract information from the large volume of unstructured data and provide real-time predictions, and improve the accuracy of predictions. ChatGPT is a Natural Language Processing (NLP) branch of computer science that is based on a deep learning model that can learn and adapt to provide up-to-date information on the ever-changing disaster environment. It can analyse data from multiple sources, including past disasters, social media platforms, current environmental conditions, and satellite imagery, to warn communities of potential disasters quickly and accurately (Frąckiewicz, 2023). It can also provide information on evacuation routes, safe shelter locations, and other resources and early actions to help people prepare for disasters.

AI-powered chatbots can improve how early warning messages are shared with users. They can chat with users in natural language to address questions and provide real-time updates to reduce confusion and panic during emergencies. AI-powered chatbots, like ChatGPT, can understand specific characteristics and needs of different communities and users by analysing conversations. This allows them to provide personalized suggestions, such as connecting people with relevant organizations and providing psychological support, on a large scale without overloading resources.

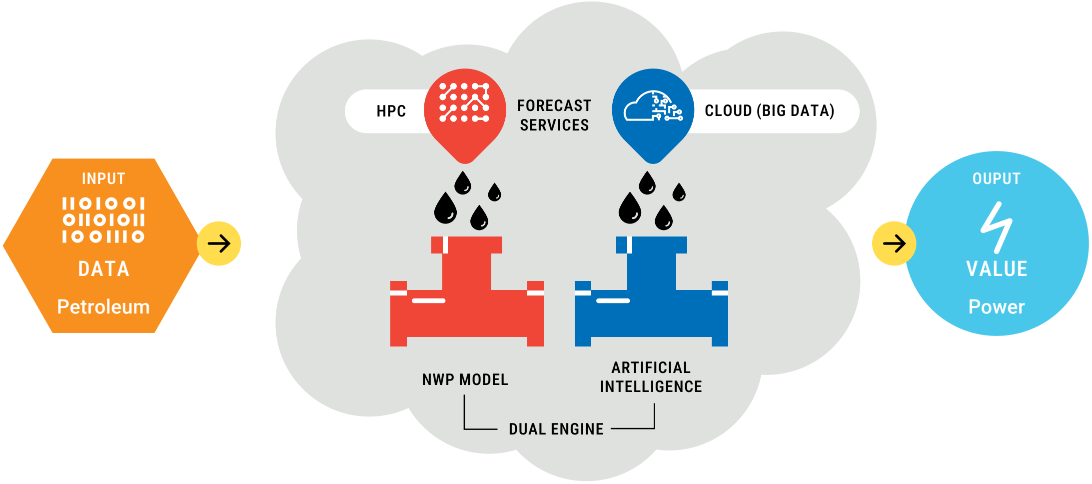
This evolution of how disaster early warning can be shared and understood with the support of technology can be attributed to what is known as impact-based forecasting. This form of forecasting is a second-generation early warning product that enables realization of the shift in paradigm from *what the weather will be* to *what the weather will do* (ESCAP and WMO, 2021).

Advances in frontier technologies are enabling countries in the Asia-Pacific region to move towards impact-based forecasts, allowing warnings to be communicated in a way that facilitates early action decisions. These warnings help mitigate the impact of extreme weather or climate events, while communicating any uncertainties surrounding the forecasts.

To empower countries to provide adequate early warnings for all, more support is needed to ensure greater data availability, to provide tools and packages to assist with AI development, to enhance model understanding, to offer new applications for AI-based methods, and to contribute to the development of standards. Opportunities to leverage AI to enhance disaster risk reduction approaches, and services also lies in sharing of open-source data, developing the tools and advancing AI-related research. Another opportunity to support the implementation of AI in disaster risk reduction is standardization; that is, the creation of internationally-recognized guidelines (Kuglitsch and others, 2022).

Innovative technology solutions offer transformative potential for the success of early warnings for all. The use of AI in combination with NWP (Numerical Weather Prediction) models can improve the weather forecast for early warning systems. NWP models use mathematical equations to simulate weather conditions. The data collected from them can be utilized by AI models to help generate accurate weather forecasts. In a recent study, a deep neural network (residual neural networks, and long short-term memory networks) was used to analyze typhoon satellite cloud images and accurately identify typhoon rapid intensification (RI) trends, even with missing or imbalanced data in the north-west Pacific and South China Sea (Zhou and others, 2022). The researchers also tested this method on operational typhoon satellite cloud images in 2019, and on four typhoon cases with RI processes from 2019 to 2021 and found that it could forecast and identify the trend of typhoon RI with higher accuracy. The new technology is still being tested, but the results are promising, and this method has the potential to be expanded to other sea areas worldwide.

FIGURE 4.14 Gridded, smart, impact-based, and risk-informed early warning



Source: China Meteorological Agency, "Dual Engines for Meteorological Services: Numerical Weather Prediction Model + AI", 29 June 2022.

B. EARLY WARNINGS SUPPORTED BY INNOVATIVE TECHNOLOGY AND AI

There are good practices and emerging trends on geospatial technology and information applications for the Sustainable Development Goals especially those related to disaster risk reduction and resilience (ESCAP, 2022b). There is evidence of operational AI applications delivering early warnings for floods, earthquakes, and landslides. Building on the work on flood forecasting in previous years, Google extended its AI-based next generation flood forecasting work in India and Bangladesh. In this regard, ESCAP/WMO Typhoon Committee has taken several initiatives to adopt AI technologies for forecasting the impacts of tropical cyclones on communities, economies and environment.

In 2022, the ESCAP developed a methodology and capacity-building modules for flood inundation mapping and hotspot analysis. The methodology involved using temporal active (Synthetic Aperture Radar) and passive (optical) satellite images in Google Earth Engine (GEE) cloud computing for flood inundation mapping, change detection and flood hotspot monitoring.

GOOGLE AI: FLOOD AND MULTI-HAZARD FORECASTING

Google AI for Social Good demonstrates the untapped potential of engaging the private and public sectors to scale up innovative technology to advance access to and availability of early warning systems around the world.

Google's flood early warning service started in Bangladesh in 2018. The new forecasting model allows to double the lead time of many of the alerts, providing more notice to governments and giving tens of millions of people an extra day to prepare. It also provides people with information about flood depth: when and how much 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 local languages. Following the success of its flood early warning system, Google expanded its services in India, a country prone to severe flooding during monsoon seasons. In the first three years, Google covered the entire country. By 2021, the company had expanded its coverage to include 360 million people in India and Bangladesh, resulting in over 115 million alerts. Over time, Google scaled up its flood forecasting services to cover more than 90 countries. This global expansion allows Google to provide critical early warning alerts to millions of people living in flood-prone regions (Nevo, 2020). It is an important technological breakthrough to enhance predictive capacity and overall outreach of flood forecasting.

Google has created a multi-hazard early warning system for natural hazards. The system covers various types of disasters, including wildfires and hurricanes. It provides real-time safety information and alerts to at-risk communities (Google Crises Response, n.d.). For wildfires, infrared and optical imagery is used to identify hot spots and at-risk communities receive real-time safety information. Google's earthquake early warning system utilizes Android phones as mini seismometers to detect earthquakes. The system aggregates accelerometer sensor data from Android phones, and phones that detect shaking send a signal to servers for analysis to determine if an earthquake is taking place. The system has detected hundreds of quakes without false positives. For hurricanes, Google Maps provides crisis notification cards and up-to-date road conditions for safe navigation (Modi, 2023).

C. ICT PLATFORMS AND NETWORK RESILIENCE

The ICT sector is vulnerable to disaster risk. This has cross-sectoral implications for critical infrastructure and essential public services, which means building ICT resilience is of critical importance (Horrocks and others, 2010). ICT resilience is the ability of a system or a sector to withstand, recover, adapt, and potentially transform in response to stressors, such as impacts of climate change (Ospina and others, 2017). The ICT Infrastructure Business Planning Toolkit (2019) offers countries a practical methodology for the accurate economic evaluation of infrastructure deployments (ITU, 2019). The *Last-Mile Internet Connectivity Solutions Guide* supports the improved design of the networks and the selection of appropriate last-mile connectivity solutions (ITU, 2020b).

The convergence of the COVID-19 pandemic with devastating natural hazards highlights the need for meaningful universal connectivity for inclusive, affordable ICT services through a resilient infrastructure. ITU's initiative, Connect2Recover, focuses on supporting the development of a resilient national digital infrastructure through a phased approach. The key stages include the development of a global methodology, country landscape assessments, national ICT strategies, pilot activities, and deep-dive studies (ITU, 2023).

To help countries better manage disaster response activities, countries have started to adapt ITU guidelines for the development and implementation of National Emergency Telecommunication Plans (NETPs) and other tailored contingency plans. These plans are essential to articulate a national strategy for using ICTs in the overall response framework to ensure communications throughout the disaster management cycle (ITU, 2020a). Recognizing the need and importance of NETPs, ITU responded to the request of the Government of Tonga for the development of its NETP by engaging all relevant stakeholders in the wake of the volcanic eruption in January 2022. Following the formal consultation process, Tonga's Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change, and Communications (MEIDECC) is expected to adopt the NETP before the cyclone season which usually starts in the Pacific in October.

The private sector offers an efficient and low-cost avenue to ensure access to emerging technologies for all by providing high-speed Internet connectivity to disconnected and previously unconnected remote island communities. The Starlink emergency communication support to recent Vanuatu cyclones is a good example (Box 4.4).

D. THE FUTURE OF EARLY WARNINGS

Emerging and innovative technologies, such as those offered by AI, improve early warning system availability, accuracy, and efficiency. The private sector and regional cooperation provide cost-effective avenues for low-capacity, or technologically poor countries to access advances in technology for disaster risk reduction.

To further strengthen early warning systems for all countries in Asia and the Pacific, emerging technology should enable hazard early warnings to be synergized. Shifting from separate single hazard early warning systems to multi-hazard early warnings will provide economies of scale. At a global level, the Common Alerting Protocol will be a crucial element of standardized and synergized early warning systems. At a local level, identifying early actions that are applicable for multiple hazards, such as evacuation routes and shelters for tropical cyclones, flooding, and tsunami events, will lower the learning and uptake curve needed for community-based and owned early warning systems.

The potential for technology to help adapt to climate change has yet to be fully tapped. It is important to develop, apply and transfer climate technologies to developing countries. Much of the innovation of climate adaptation technology is happening in the global North, but most people in the firing line of climate change impacts are in the global South. With this in mind, the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030) presents a regionally coordinated pathway to harness space and geospatial applications, as well as digital innovations towards enabling countries to harness the power of space-derived data and services (ESCAP, 2022a).

BOX 4.4 Starlink connecting island communities during times of disaster

Following the twin Tropical Cyclones Judy and Kevin, which were both of category 4 intensity and made landfall in Vanuatu, between 1 and 3 March 2023, mobile network coverage dropped by approximately 50 per cent nationwide. To support emergency response efforts, Starlink loaned 10 satellite terminals to the Government of Vanuatu, which were configured and activated through the Pacific Emergency Telecommunications Cluster (ETC) in priority Provincial Emergency Operations Centres. The ETC also prepared a Starlink installation guide for technicians and a user guide for the Vanuatu national clusters. The user guide is available in English, French and Bislama.[a]

Similarly, following the eruption of the Hunga Tonga-Hunga Ha'apai volcano, Tonga lost all communications. Twenty-five days later, Starlink broadband Internet connection was provided through an ad-hoc Starlink gateway station established in Fiji and 50 VSAT terminals provided free of charge by SpaceX.[b]

"It is rather paradoxical for a devastating volcanic eruption and tsunami to bring to our shores the latest in satellite and communications technology" – Siaosi Sovaleni, Prime Minister of Tonga

FIGURE 4.15 The ETC installing a Starlink satellite data terminal at Penama PEOC in Ambae

Source: Emergency Telecommunications Cluster (ETC), "Vanuatu – earthquake and cyclones emergency", ETC Situation Report #6, 13 – 19 April 2023. Available at https://www.etcluster.org/document/etc-vanuatu-sitrep-5-12-april-2023

[a] Emergency Telecommunications Cluster (ETC), "Vanuatu – earthquake and cyclones emergency", ETC Situation Report #6, 13 – 19 April 2023. Available at https://www.etcluster.org/document/etc-vanuatu-sitrep-5-12-april-2023

[b] K. Needham, "Musk's Starlink connects remote Tonga villages still cut off after tsunami", *Reuters.* 23 February 2022. Available at https://www.reuters.com/world/asia-pacific/musks-starlink-connects-remote-tonga-villages-still-cut-off-after-tsunami-2022-02-23/#:~:text=SYDNEY%2C%20Feb%2023%20(Reuters),eruption%20and%20tsunami%20in%20January

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CHAPTER 5

Racing to resilience: Raising financing ambitions

Climate risk-informed adaptation investments in Asia and the Pacific are inadequate, covering less than 10 per cent of the required amount. Closing this financing gap is crucial for effectively addressing the impacts of climate change and building resilience in the region.

Innovative financing mechanisms, such as thematic bonds and biodiversity credits, can help raise funds for adaptation projects with environmental benefits. Encouraging private sector involvement can further enhance the availability of finance for adaptation initiatives.

Strengthening risk financing facilities and promoting regional cooperation are essential for scaling up adaptation investments. By utilizing catastrophe-triggered financial instruments, improving insurance infrastructures, and fostering collaborative efforts among countries, the region can enhance its capacity to manage climate-related risks and build a sustainable future.

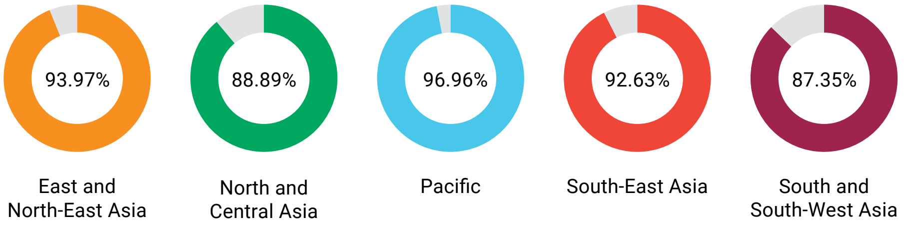
5.1 Introduction

The previous chapters highlighted the key hotspots of emerging and intensifying risks and how to protect people so that no one at risk is left behind, along with the co-benefits of building systemic resilience to disaster and climate risks. Transformative adaptation is the key to a resilient future in a warmer planet. The building blocks of transformative adaptation were set out in Chapter 4. This chapter addresses the cost of transformative adaptation. To date, while varying degrees of progress have been made, most countries still undershoot their capital outlays for system disaster risk reduction and transformative adaptation (Ishiwatari, 2022).

The Sendai Framework for Disaster Risk Reduction notes that disaster and climate risk-informed adaptation and risk-reduction investments are far more cost-effective than post-disaster response and recovery, and that these investments contribute to sustainable development. The Framework further emphasizes the need for public and private sector investments to complement public sector financing. Unlocking financing for hard- and soft-measures is a priority to protect critical facilities, infrastructures and the environment, and to strengthen risk transfer and social protection programmes (UNDRR, 2015; UNDRR, 2007). Studies have shown that the benefits from pre-emptive investment can be significant for the developing world. When measured through the 'benefit-cost' ratio, the benefits of investing in adaptation can range from 2:1 to 10:1 (GCA and WRI, 2019).

Figure 5.1 shows the unmet adaptation financing needs in the Asia-Pacific region, with the Pacific subregion once again showing the highest unmet needs. It is estimated that, overall, the actual adaptation financing flow, through bilateral and multilateral public finance and export credits, from the accounts of developed countries leave an estimated gap of 97 per cent for the Pacific region.

FIGURE 5.1 **Unmet financing adaptation needs**



Estimates show that the current level of adaptation finance flows **does not cover 91.96 per cent** of the current adaptation costs in the Asia-Pacific region.

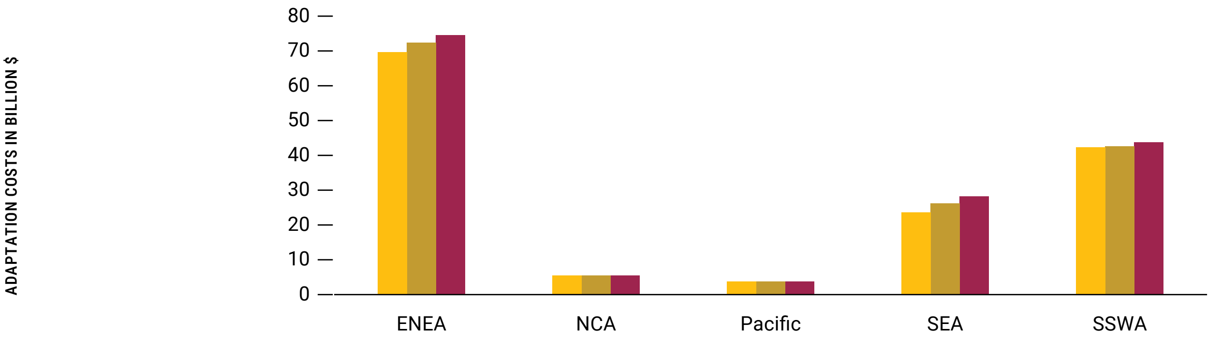
Source: Estimates from ESCAP; and United Nations Framework Convention on Climate Change (UNFCCC) (2022), "Fifth Biennial Assessment and Overview of Climate Finance Flows Technical Report", Bonn. Available at https://unfccc.int/documents/619173
Note: ENEA = East and North-East Asia, NCA = North and Central Asia, SEA = South-East Asia, SSWA = South and South=West Asia.

5.2 Scale of investments needed

At the 15th meeting of the Conference of the Parties (COP15), held in 2009, in Copenhagen, countries committed to mobilizing US$100 billion a year by 2020. This amount was to be split equally between adaptation and mitigation to address the needs of developing countries (FCCC/CP/2009/11/Add.1). The goal remains unmet and recent estimates suggest available financing falls well short of actual financing needs. Adaptation financing has been particularly neglected (United Nations Climate Change, 2021). The UNEP *Adaptation Gap Report* (UNEP, 2020) estimates that annual adaptation costs in developing countries will be $70 billion and could reach $140-300 billion by 2030, and $280-500 billion by 2050.

Calculating Average Annual Losses (AAL) under the three climate scenarios, using the new IPCC AR6 models, ESCAP analysis shows that the investments needed for transformative adaptation stand at $144.74 billion for the region. The East and North-East Asia subregion accounts for 48 per cent of the total absolute adaptation costs, followed by South and South-West Asia (28 per cent), and South-East Asia (24 per cent). These numbers increase to $150.50 billion and $155 billion under the 1.5°C and 2°C climate scenarios, respectively (Figure 5.2). As a per cent of the subregional GDP, the Pacific region will need to invest the highest amount in adaptation (almost 1.4 per cent of its GDP) (Figure 5.3).

FIGURE 5.2 Adaptation costs for different climate scenarios, in billions of US dollars



	ENEA	NCA	Pacific	SEA	SSWA
🟨 Current	69.59	5.50	3.71	23.63	42.31
🟫 1.5°C Climate Scenario	72.36	5.52	3.73	26.24	42.65
🟥 2°C Climate Scenario	74.57	5.54	3.77	28.24	43.79

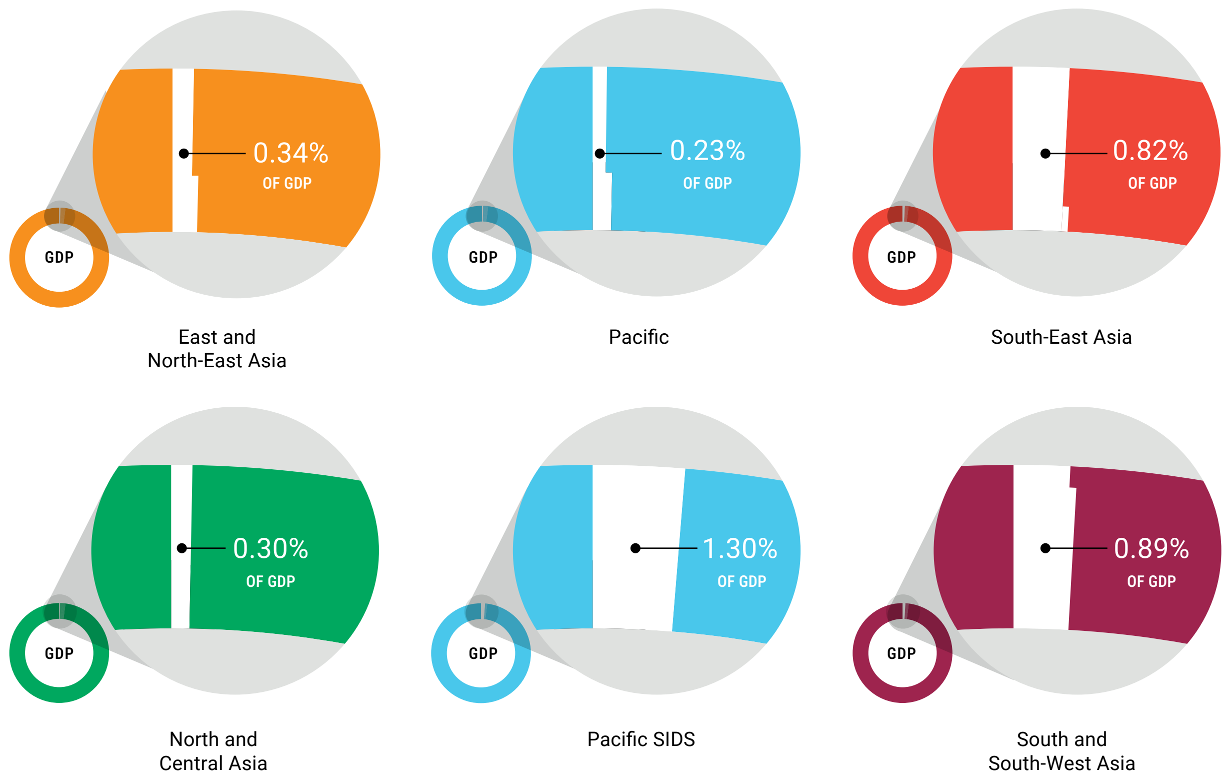
Source: ESCAP.
Note: ENEA = East and North-East Asia, NCA = North and Central Asia, SEA = South-East Asia, SSWA = South and South=West Asia.

TABLE 5.1 Subregional adaptation costs as a percentage of GDP, in billions of US dollars

	Adaptation Cost (Current)* (US$ Billion)	Adaptation Cost* 1.5°C (US$ Billion)	Adaptation Cost* 2.0°C (US$ Billion)	Adaptation Cost Current/GDP (Percentage)	Adaptation Cost 1.5°C Scenario/GDP (Percentage)	Adaptation Cost 2.0°C Scenario/GDP (Percentage)
ENEA	69.59	72.36	74.57	0.34%	0.35%	0.36%
NCA	5.50	5.52	5.54	0.30%	0.30%	0.30%
Pacific	3.71	3.73	3.77	0.23%	0.23%	0.24%
Pacific SIDS	0.43	0.44	0.46	1.30%	1.34%	1.41%
SEA	23.63	26.24	28.24	0.82%	0.91%	0.98%
SSWA	42.31	42.65	43.79	0.89%	0.90%	0.92%
Regional Total	**144.74**	**150.50**	**155.90**	**0.46%**	**0.47%**	**0.49%**

Source: ESCAP.
Note: ENEA = East and North-East Asia, NCA = North and Central Asia, SEA = South-East Asia, SSWA = South and South=West Asia, Pacific SIDS = Pacific small island developing States.

FIGURE 5.3 Adaptation costs as a percentage of GDP



Source: ESCAP estimates.
Note: ENEA = East and North-East Asia, NCA = North and Central Asia, SEA = South-East Asia, SSWA = South and South=West Asia, Pacific SIDS = Pacific small island developing States.

In the Asia-Pacific region, 19 countries are currently rated at high risk of debt distress (ESCAP, 2023a). The Vulnerable Twenty (V20) group has a total external public debt of $686.3 billion, comprising 27 per cent of the group's GDP. This is owed to private creditors and multilateral development banks, such as the World Bank which is the group's biggest lender (Ramos and others, 2022). ESCAP analysis shows that countries in the region that are highly vulnerable to climate and disaster-induced impacts also have high external debt. Consequently, a significant portion of their earnings go into external debt repayments leaving limited room for investing in transformative adaptation (Figure 5.4).[10]

Tajikistan, Samoa, Tonga, Vanuatu, Cambodia, the Lao People's Democratic Republic, and Bhutan are countries that have a high concentration of climate and disaster-induced losses measured from AAL as a percentage of their GDP, as well as high external debts (Figure 5.4). Mongolia, Armenia, Georgia, Kyrgyzstan, the Marshall Islands and Maldives are on the brink of both debt and climate distress. These countries carry the enormous burden of providing for climate action from domestic public sources of funds while their external debt burden reduces their revenue receipts. This leaves very little room for investments in building resilience and mitigating disaster risk.

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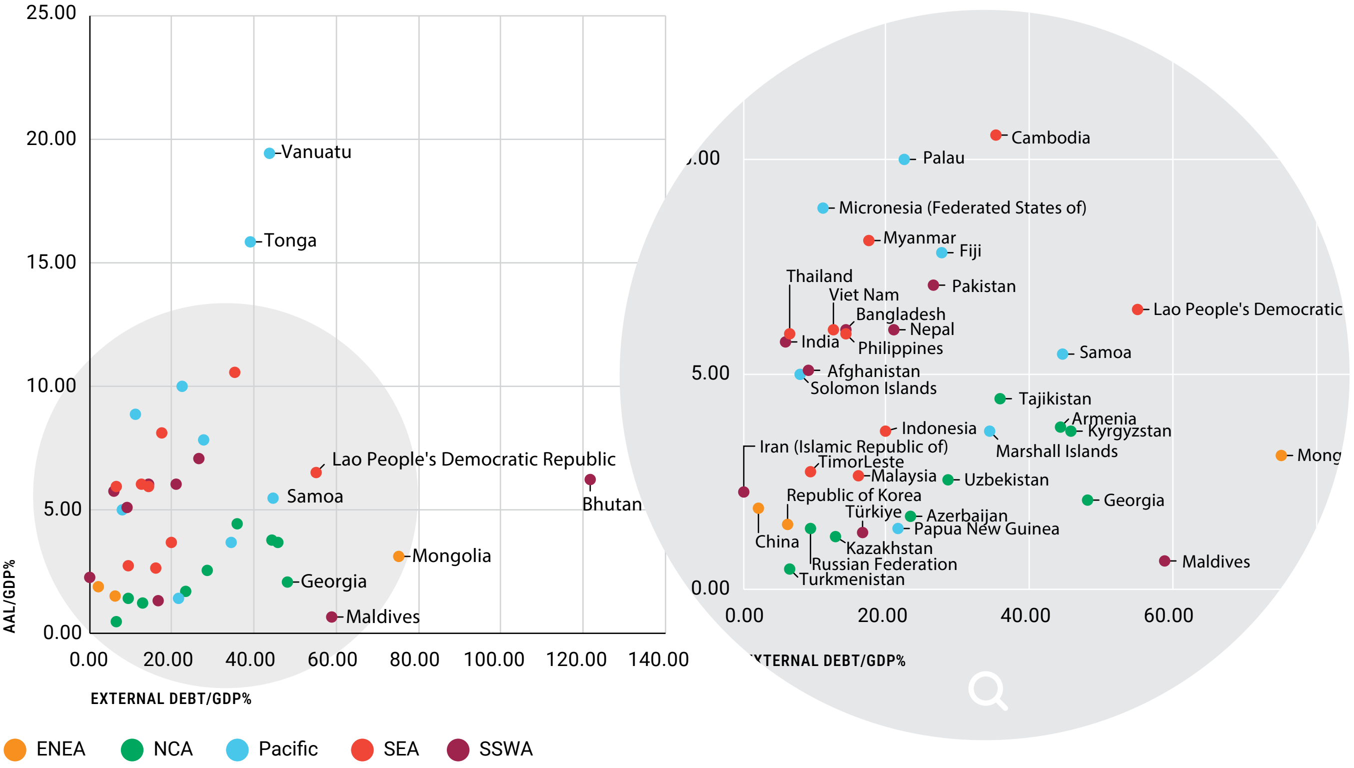
[10] Understanding of public debt in the context of financing sustainable development and transformative adaptation needs a much more nuanced approach. Debt can be a very important mechanism for financing investments that yield returns. The financing gap for adaptation should be seen in the light of domestic capacities and macroeconomic fundamentals. For instance, raising finance needs fairly developed domestic capital markets and ICT systems, strong capacities of government officials, enabling policy frameworks, independent and capacitated central banks and financial supervisory authorities. These can vary across countries. Therefore, an external debt percentage of 35 per cent of GDP may be fine for a developed economy, but it can be a strong limiting factor for investing in adaptation in small island developing nations of least developed countries. Even though much debt from multilateral banks can be concessional for small island developing states and least developed countries, its volume in proportion to the GDP can be a big hurdle in the development trajectory of a country. Poor institutional capacities can quite often result in investments that are not economically productive and not yielding returns. The assessment here uses fundamental statistics to highlight the root issue of the concentration of climate and disaster risk hotspots in economies that also are vulnerable economically and cannot make significant budgetary investments into building resilience. The analyses, therefore, should be seen in the light of this scope.

FIGURE 5.4 Multi-hazard Losses (AAL/GDP%) vs. External Debt Status (External Debt/GDP%) among Asia-Pacific countries



Highly vulnerable countries (External Debt/GDP>=35% and AAL/GDP>=4%): Tajikistan; Samoa; Tonga; Vanuatu; Cambodia; Lao People's Democratic Republic; Bhutan.
Vulnerable countries (External Debt/GDP>=35% and AAL/GDP>=0.5%): Mongolia; Armenia; Georgia; Kyrgyzstan; the Marshall Islands, Maldives.
Source: ESCAP estimates.

5.3 Financing measures to close the adaptation gap

Climate finance flows to adaptation in the region points to three challenges. First, collectively there is a big gap between adaptation costs and the available finance. This gap will continue to increase in both 1.5°C and 2°C climate scenarios. Second, the most vulnerable regions and hotspots in the Asia-Pacific region are under external debt distress. Third, the available finance is structured in a way that is unsuited to the macroeconomic fundamentals, low technical capacities of the institutes, inadequate infrastructure, and unfavourable policy environments of the most vulnerable countries. There is an urgent need to use financing measures that have demonstrated their suitability to the macroeconomic conditions, riskscape and specific capacities and vulnerabilities of the region. COP27 highlighted the need for innovative adaptation financing to build broad partnerships to achieve adequate development finance.

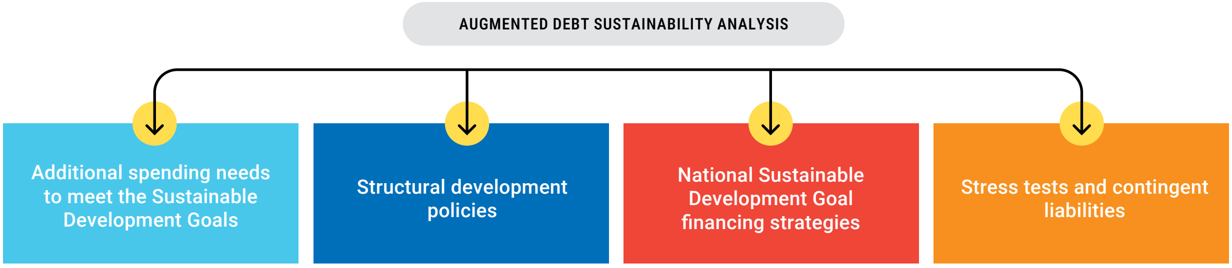
This section will examine some of the relevant initiatives in the region which can be replicated and scaled up to meet urgent adaptation needs. It presents innovations in financing tools that can be used for adaptation and nature-based solutions. It explores the "augmented public debt sustainability" assessment, which analyses long-term public debt trajectories, taking into account Sustainable Development Goals (SDGs) spending needs, the blended finance approach for improving private sector financing, and regional risk financing facilities. The solutions presented have been piloted and have yielded promising results. They would need to be customized to suit a country's context and to overcome implementation challenges.

5.3.4 Augmented debt sustainability analytical approach

Figure 5.4 notes the highly vulnerable countries where high external debt coincides with high multi-hazard risks. However, there are opportunities in these countries to use the debt to build resilience. The 2023 ESCAP report, *Economic and Social Survey of Asia and the Pacific 2023: Rethinking Public Debt for the Sustainable Development Goals*, notes that public debt provides opportunities to increase spending for the SDGs and national climate ambitions (ESCAP, 2023a). The approaches that are most used by institutions like the International Monetary Fund (IMF) and the World Bank and credit rating agencies have focussed on short to medium-term debt sustainability. While the most common approaches used by the World Bank and the IMF have undergone several adjustments to make the debt sustainability assessments more contextually relevant, they are still short-term in nature. This limits the potential of public debt for investment in the long-term transformative climate adaptation.

ESCAP has proposed an "augmented approach" for assessing long-term public debt sustainability by considering a country's SDG spending needs, structural development policies, and national SDG financing strategies (Figure 5.5) (ESCAP, 2023a). The approach shows different trajectories of public debt, under different scenarios of policy interventions and shocks, and supports governments in making risk-informed choices for meeting their ambitions on the Sustainable Development Goals.

FIGURE 5.5 Augmented approach for integrating climate sustainability into debt

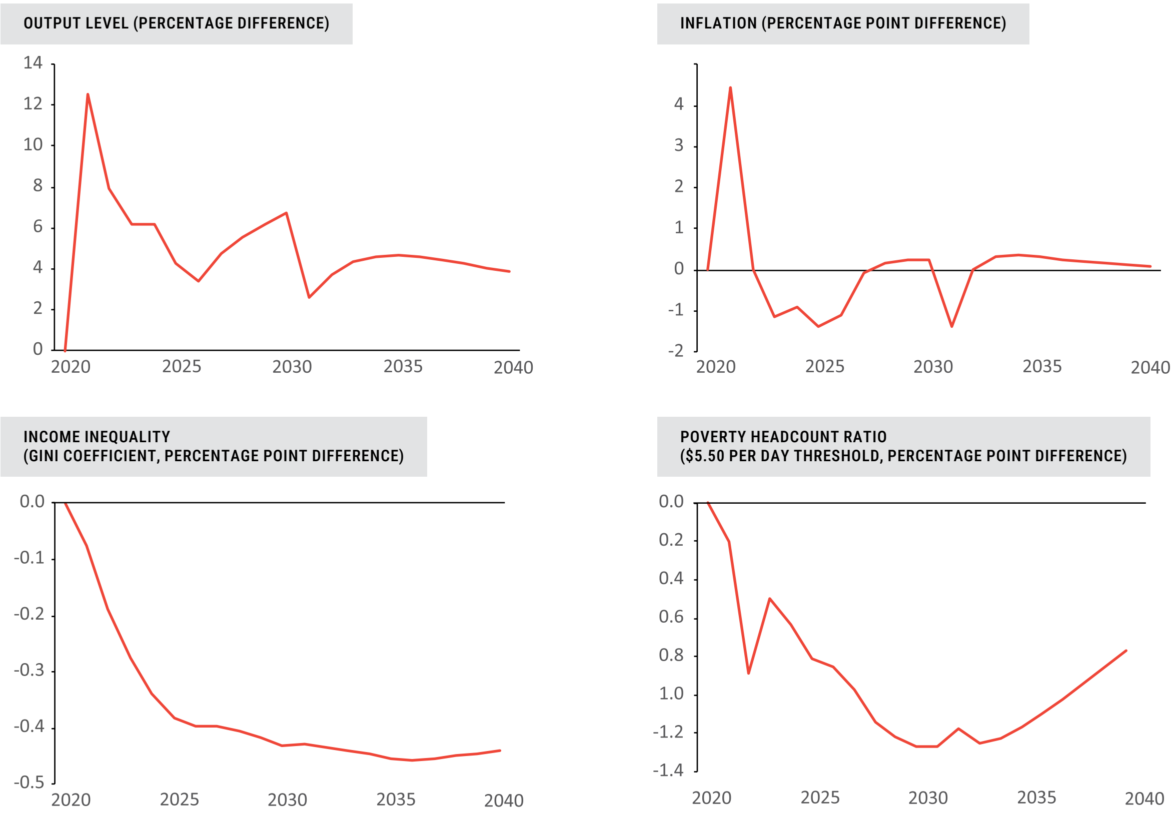


Source: *Economic and Social Survey of Asia and the Pacific 2023: Rethinking Public Debt for the Sustainable Development Goals* (United Nations publication, 2023a). Available at https://www.unescap.org/kp/2023/economic-and-social-survey-asia-and-pacific-2023-rethinking-public-debt-sustainable

The augmented debt sustainability analytical approach can be a powerful tool for sustainable development, if used judiciously and with a long-term horizon. The approach can be used to finance evidence-based risk investments in disaster and climate resilient infrastructure, health care, and other areas that can not only promote economic growth and social development but increase the future resiliency of economies. For example, a debt approach using augmented debt sustainability analysis can use debt to build levees to protect against flooding or to build early warning systems to alert people to impending disasters. Thus, this new approach to public debt management that considers the long-term social, economic and environmental benefits of public investment, can be a valuable tool for sustainable development and for helping countries cope with disasters (ESCAP, 2023b).

This approach is particularly relevant for transformative adaptation because it seeks structural changes in mainstreaming adaptation considerations, and mainstreams climate risks into policies and investments. The approach explores the trajectories of macroeconomic fundamentals of an economy in a systematic manner and provides policymakers with a menu of options for potential trajectories to achieve the Sustainable Development Goals. ESCAP tested this approach for Mongolia and concluded that even with an increase in public debt, increasing investments in SDGs bring sizeable socioeconomic benefits in the long run (Figure 5.6).

FIGURE 5.6 Impact of SDG spending on selected socioeconomic variables in Mongolia



Source: *Economic and Social Survey of Asia and the Pacific 2023: Rethinking Public Debt for the Sustainable Development Goals* (United Nations publication, 2023a). Available at https://www.unescap.org/kp/2023/economic-and-social-survey-asia-and-pacific-2023-rethinking-public-debt-sustainable

5.3.1 Innovations in bonds and debt for adaptation

(I) THEMATIC BONDS

Thematic bonds are debt securities issued by governments and private sector entities on the condition that the funds obtained are used to finance projects with a clear social and environmental impact (ESCAP, 2021a). Their benefits can relate to energy efficiency, renewables, resilience-building or green transportation. Thematic bonds include, but are not limited to, green bonds, social bonds, sustainability bonds, sustainability-linked bonds, and SDG bonds.[11] In the case of green bonds, the use of proceeds can be allocated to climate adaptation, which could help scale up adaptation finance. Similarly, social bonds could be used to finance adaptive social protection to support people who are vulnerable to disaster risk.

Bonds are particularly suited for large-scale capital-intensive projects that yield revenues and can help discounted finance access through blended finance mechanisms (UNDRR, 2022). According to ESCAP (2023c), the Asia-Pacific increased its issuance of thematic bonds from $75 billion in 2020 to $187 billion in 2021 and $206 billion in 2022. In 2022 green bonds represented 55 per cent of the total, followed by social bonds (26 per cent), sustainability bonds (13 per cent), sustainability-linked bonds (4 per cent), and transition bonds (2 per cent). The bond market represents a significant potential for growth, both at national and subnational levels.

The issuance of sovereign bonds to support sustainable development is on the rise in the region. For example, Singapore launched its "Green Plan 2030" in 2021 to align its development agenda with its NDC and the SDGs. In 2022, the finance ministry announced the issuance of green bonds worth $35 billion

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[11] Among these types of bonds, sustainability-linked bonds are the only one that is not based on use of proceeds. They can finance the general business activities of the issuer, but they must demonstrate a commitment to sustainability and propose to achieve some Sustainability Performance Targets (SPTs) to be measured through selected Key Performance Indicators (KPIs).

(≈ $ 26.3 billion) (Government of Singapore, 2022a). These bonds were issued in accordance with Singapore's Green Bond Framework (Government of Singapore, 2022b). The proceeds are intended to be directed to projects under eight thematic areas, which include biodiversity conservation and sustainable management of natural resources and land use, climate change adaptation, sustainable water and wastewater management, and renewable energy. In 2021, Indonesia raised €500 million (approximately $545 million) under the SDG Bond Framework verified by CICERO[12] and International Institute for Sustainable Development (IISD) to raise finance social and environmental projects aligned to its SDG agenda (Republic of Indonesia, 2021).

At the subnational level, practitioners have long argued there is scope to develop adaptation-specific bonds to bridge the adaptation finance gap. India issues municipal bonds, many of which are directed towards building social infrastructure on health, water and sanitation, and smart city development. According to the Reserve Bank of India, cities in India have issued $738 million worth of municipal bonds since its first issue in 1997 (RBI, 2022). These bonds have helped municipalities move away from reliance on traditional sources of revenue which are inadequate, and plan for targeted local-level adaptation initiatives for the vulnerable zones in the defined urban boundaries.

(II) DEBT FOR ADAPTATION

Debt distress is on the rise in several developing countries and for such countries which need to build resilience to climate change immediately, Debt for Adaptation Swaps can help reconcile this trade-off. Countries that have borrowed from private bondholders and bilateral creditors have occasionally arranged debt for nature swaps that allowed them to allocate savings on debt servicing costs to nature conservation projects (Isgut and Taloiburi, 2022). A similar idea has been proposed to finance investments in climate resilient projects in highly indebted countries (Hebbale and Urpelainen, 2023). As a precedent, Conservation International (CI) supported a debt swap for conservation-related adaptation activities in Indonesia in 2009. The debt relief was channelled through an Indonesian environmental foundation, namely KEHATI. The United States Agency for International Aid (USAID), the creditor, cancelled debt claims with a nominal value of $30 million owed by the Government of Indonesia. The US Treasury contributed $20 million to USAID, along with CI and KEHATI, which contributed by paying a swap of $1 million each. The Government of Indonesia serviced its debt in instalments to a debt service account. This account transferred money to a grants management account of KEHATI for environmental projects that KEHATI jointly identified in consultation with an expert committee (Yue and Wang, 2021).

Debt swaps offer a way out to finance adaptation investments in debt-stricken countries. While in the past these swaps have been characterized by high transaction costs and time-consuming negotiations, recent debt for nature swaps in countries such as Belize and Barbados have been concluded in significantly shorter times. ESCAP (2021b) discusses the conditions for debt swaps to be effective, including through the design of a term-sheet to reduce transaction costs and negotiation times. Other recommendations include conducting negotiations with all relevant stakeholders to ensure a strong political support for the deal, adopting an effective monitoring, reporting, and verification (MRV) framework, and ensuring national ownership and additionality.

5.3.3 Financing ecosystem adaptation for environmental co-benefits

(I) PAYMENT FOR ECOSYSTEM SERVICES

Payment for ecosystems is a relatively new concept. As a public good, it is hard to exclude beneficiaries/ users from the services that ecosystems provide. This makes implementation of user charges or other market-based instruments difficult because users cannot have exclusive benefits. However, these payments for conservation and protection of watersheds have been used successfully in Viet Nam (Government of Viet Nam, 2009). In 2008, a pilot scheme on 'payment for forest ecosystem services' was

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[12] Shades of Green, formerly part of Center for International Climate Research (CICERO), Norway's foremost institute for interdisciplinary climate research, is now a part of S&P Global. It provides independent, research-based evaluations of green bond and sustainability financing frameworks to determine their environmental robustness.

launched in Lam Dong and Son La provinces. Those who directly benefited from watershed services, such as the hydropower plants and water distributors, were required to pay for conservation and management of forest ecosystems and watersheds (Nam and Endo, 2021). Following this pilot, Viet Nam worked to develop legal frameworks and institutional arrangements to scale it up at the country level. These led to the establishment of the Provincial Forest Protection and Development Funds in 42 provinces (Nam and Endo, 2021). A 2016 evaluation showed that the Viet Nam Forest Protection and Development Fund mobilized $257 million for the conservation and restoration of 5.6 million hectares of forest to be pursued by more than half a million households comprising indigenous peoples, ethnic minorities and forest communities (ADB, 2021). This payment removed the financial burden of conservation from the government and transferred it to the parties that were key beneficiaries and could afford to pay for it.

(II) BIODIVERSITY CREDITS

Biodiversity credits or biocredit projects are being implemented in different parts of Asia and the Pacific. The credits rest on the principle of incentivizing actions that will help reverse the loss of ecosystems. These credits are tradeable and have the primary objective of improving biodiversity, in quantity, quality and composition (Porras and Steele, 2020; UNDRR, 2022). Biocredits have many purposes, making them useful in the field of conservation, adaptation to climate change, poverty alleviation and sustainable livelihoods for forest communities.

The biocredit issuance mechanism works by actively engaging with local communities to prepare projects around conservation of ecosystems. The projects are then registered with a certifier which validates the project, and reports and issues biocredits. These credits are then opened for sale to buyers, such as corporations, the tourism industry, and governments. The buyers pay for these biocredits, and the money is transferred through bio-banks or trust funds to local communities and other agencies involved in conservation (UNDRR, 2022). Periodic third-party verifications are carried out to ensure the validity of biocredits. Being a charitable organization, Plan Vivo is committed to sharing benefits fairly between participants or local communities and project coordinators.

The engagement of local communities in the design of projects and ensuring that they are the primary recipients of benefits is important for project sustainability. At present the market for these credits is very small. The success, replication, scaling up and success of biocredits will depend on the robustness of methods, transparency, guidelines and regulations for monitoring and reporting biodiversity. It requires strong regulatory mechanisms that guide the trading and registration and promote the use and trade of these credits. Other than Plan Vivo, the United Nations, and certifiers like Gold Standard and Verra are engaged in developing and facilitating standard methodology and frameworks for biocredits (Humphreys and others, 2023).

(III) RESTORATION INSURANCE SERVICE COMPANY (RISCO)

RISCO is a social enterprise that is responsible for mangrove conservation and the restoration of coastal zones which comprise high-value assets, such as those belonging to high-net-worth individuals or to the tourism industry (Climate Finance Lab, 2019; Bechauf, 2020). RISCO is responsible for directly working with insurance companies or their associations to secure annual payments for verified conservation and restoration of mangroves. This annual payment is site dependent, and is determined by the conservation effort required, exposure to hazards, and estimates of benefits provided by mangroves. Aside from this revenue stream accrued to RISCO for reducing risk exposure, the company can become financially viable through biodiversity and carbon credits.

The first such initiative is underway in the Philippines where there is government buy-in to support the initiative and where there is local knowledge for conservation. The growing risk insurance market is an opportunity for the stakeholders to try different risk pooling instruments. An estimated 95 per cent of all industrial property policies in the Philippines include coverage for natural catastrophes. The challenge, however, is that government-mandated minimum insurance premiums can be priced as low as 0.05 per cent of asset value for flood and typhoon coverage. This makes the market very competitive as the premium prices are set at the bare minimum. For ecosystem approaches to risk management, as for mangrove conservation, the estimates of benefits are not precisely known. They are therefore not incorporated into market prices of premiums. The premium prices therefore tend to be high (Beck, Quast, and Pfliegne, 2022).

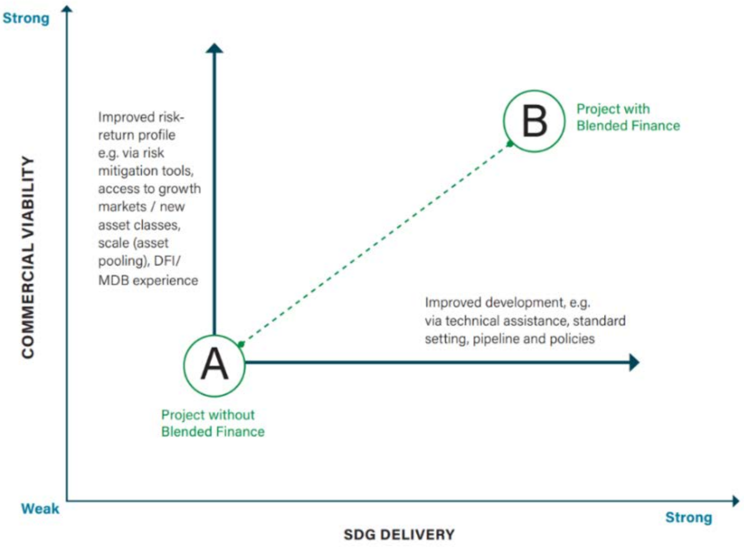
Once a successful model is functional in the Philippines, RISCO has opportunities for replication in countries, such as Indonesia and Malaysia. The replication, scaling up and success of these methods will depend upon their robustness, transparency and guidelines and regulations for monitoring and reporting biodiversity. A strong regulatory mechanism that guides registration and the use and trade of credits is also needed.

5.3.5 Public-private synergies through blended finance

At the COP 27 roundtable on "Innovative Finance for Climate and Development", the need for generating finance from innovating financial mechanisms to finance projects supporting NDCs, such as green bonds, environmental impact bonds, debt-for-climate swaps, blended finance, was emphasized (COP 27 Presidency, 2022). Blended finance is a structuring approach that makes use of catalytic capital from public or philanthropic sources to increase private sector investment in sustainable development (United Nations, 2015; Blended Finance Taskforce, 2018). It allows organizations with different objectives to come together under the blending financing structure and invest to achieve their respective objectives (Figure 5.7). Currently, less than 1.6 per cent of all adaptation financing comes from the private sector. For the Asia-Pacific region, it was estimated to be $294 million in 2020. There is considerable room to scale up private sector investments in adaptation (ESCAP estimates).

The global financing community is actively innovating in blended finance to bring the cost of private investments down by reducing risks for private financers, thereby removing a key barrier in unlocking the potential of commercial financing for climate action. If private sector investment into transformational adaptation has to happen only through competitive commercial finance, this may happen only on a very small scale. If synergies with public sources of funding are used to mitigate the risk for the private sector by dealing with systemic challenges, and missing capacities and creating an enabling environment for investments, then it incentivizes the private sector to invest in sustainable development priorities.

FIGURE 5.7 **Blended finance: Improving the commercial viability of SDG-related investments**

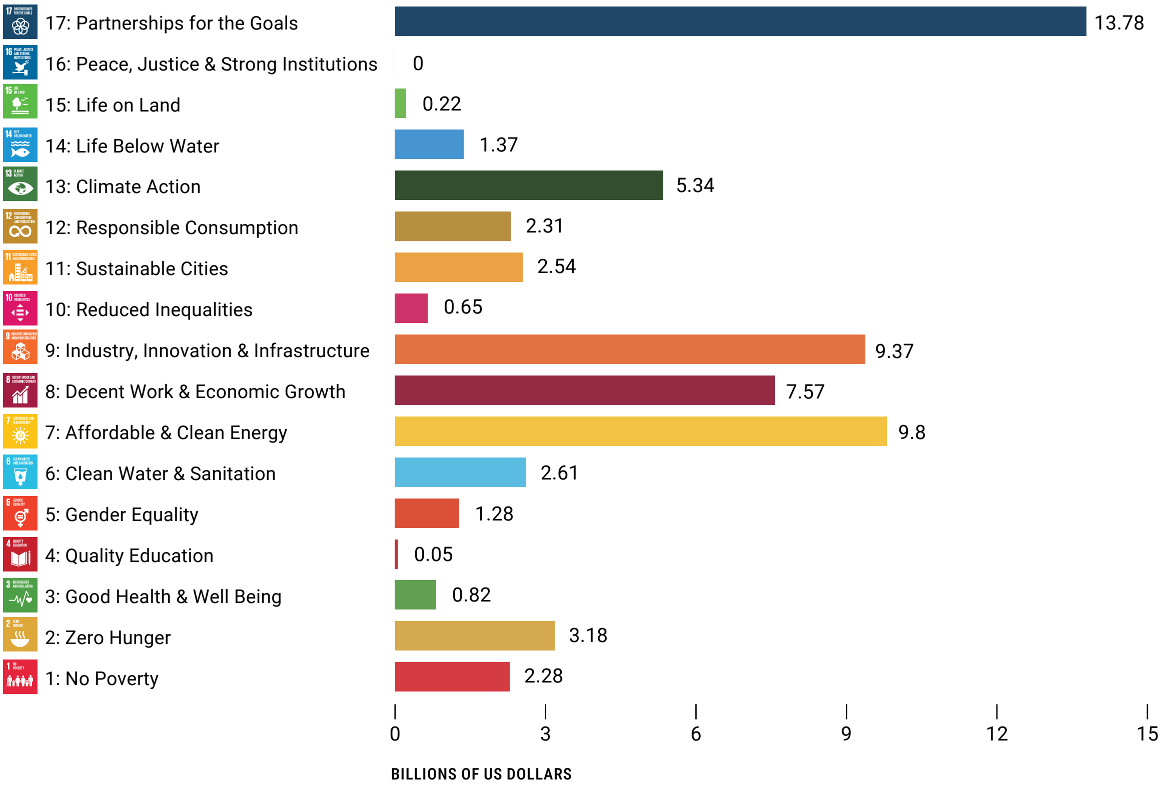


Source: Blended Finance Taskforce, "Better Finance, Better World", London, 2018. Available at https://www.blendedfinance.earth/better-finance-better-world
Note: DFI denotes Development Financial Institution and MDB denotes Multilateral Development Bank.

According to Convergence, the global network for blended finance, there were about 4900 financial commitments to blended financing transactions between 2011 and 2021. The total volume of blended finance has shown an average annual growth rate of over 15 per cent (Convergence, n.d.). At a regional level, for the period 2019-21, Sub-Saharan Africa received over 40 per cent of the climate blended finance deals followed by Asia and the Pacific (except Central Asia) at 30 per cent. Adaptation blended finance continues to lag behind energy-centric investments and has totalled $6.8 billion historically, making it less than 10 per cent of the total climate-centric blended finance in the last decade (Convergence, 2022).

Looking at all the SDGs, blended finance has contributed to supporting practically all of them[13] in the past three years. In particular, resources have gone to SDG 7 (Affordable and Clean Energy) with 67 per cent; SDG 8 (Decent Work and Economic Growth) with 49 per cent, and SDG 9 (Industry, Innovation and Infrastructure) at 41 per cent. Thirty-three per cent of the transactions were directed to SDG 13 on Climate Action (Figure 5.8).[14]

FIGURE 5.8 Total financing mobilized towards the SDGs by blended finance transactions (2019-2021), in billions of US dollars



Source: Convergence, "State of Blended Finance 2022", Toronto, 2022. Available at https://www.convergence.finance/resource/state-of-blended-finance-2022/view

Trends show that most of the blending finance deals occur in the middle-income countries, while the LDCs accounted for an average of 15 per cent of private capital mobilized between 2018 and 2020 (Inter-agency Task Force on Financing for Development, 2023). The biggest infrastructure needs are in social infrastructure which supports water, sanitation and health care public services. There is great potential to unlock blended finance opportunities to support investment in these areas and strengthen community resilience and locally led-adaptation to leave no-one behind.

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[13] This is with the exception of SDG 17. All investments made under blending financing contribute to SDG target "17.3. – Mobilize additional financial resources for developing countries from multiple sources".

[14] In principle, all the private sector finance mobilized contributes to SDG 17 Target 3 i.e., mobilizing additional financial resources for developing countries from multiple sources. Therefore 100 per cent of private finance (as part of blending arrangement) going into SDGs contributes to Goal 17: Partnerships for the Goals.

The Addis Ababa Action Agenda reinforces the need for the rapid scaling of blended finance (United Nations, 2015; Inter-agency Task Force on Financing for Development, 2023). UNDRR has called for innovation financing through approaches like blended finance for financing prevention and de-risking investments (UNDRR, 2021). The Inter-agency Task Force on Financing for Development emphasizes five key design elements for blended finance. The first is a strong focus on development impact rather than on the leverage. The second is to calibrate public sector support and not overcompensate the private partner. The third focuses on systemic and structural changes by building capacities among partners. The fourth is a multistakeholder approach with community involvement. The fifth ensures transparent monitoring and reporting.

Engaging the private sector is critical to meet NDCs targets in the Asia-Pacific region. At the macro level, climate goals cannot be met without engaging all partners, particularly the private sector. At a micro level, private sector enterprises will have to incorporate climate risks into their continuity planning and ensure its operations are climate resilient to be financially sustainable. The engagement of the private sector therefore needs to be enforced through regulation and policy within the country, in line with the overall strategy to achieve NDC targets. The private sector needs to prioritize investment in resilience planning using its own resources or blended finance opportunities supported by government initiatives. There is a need for this to be done urgently, to ensure a meaningful private sector participation in achieving NDC targets. By making a business case for investments, which the private sector would not have done on its own, blended financing offers an opportunity for both the public and the private capitalize on each other’s strengths.

5.3.6 Scaling existing catastrophe-triggered financial instruments for long-term investments in adaptation

These financing facilities can be scaled up for post-disaster losses and long-term adaptation financing. These risk financing facilities have been instrumental in bringing down the cost of capital (reserves and cost of risk transfer), information and operations. As real-time information becomes more available, they offer a transparent and accountable mechanism for risk financing. This is helping policymakers align their development plans and to more systematically manage their efforts in the event of a disaster, supported by the analytical assessments done by these facilities. One area of work, currently being explored, is in the intersection of adaptive social protection and disaster risk financing which will significantly improve disaster preparedness and consequently the delivery of post-disaster relief, rehabilitation, and rebuilding.

One of the under-tapped potentials of risk financing facilities is that they can strengthen regional cooperation by facilitating policy dialogue and improved collaboration among member countries (ESCAP, 2018). Regional cooperation can be strengthened in designing a comprehensive disaster risk financing strategy, contingency planning, collaboration on the climate risk management agenda and developing a pre-agreed disaster response plan. Information-sharing, early warnings, knowledge and technology transfer can happen in a much more organized manner under these facilities.

The demonstration and communication of results from existing facilities is important for this approach to be scaled up. After the COVID-19 pandemic, many countries in the region now have their risk finance strategies in place. These strategies differ in their priorities, mechanisms and solutions. Identifying commonalities and opportunities for implementing pooled risk management solutions is one of the entry points for replication and expansion of regional risk financing facilities. A number of these facilities have been established in the Asia-Pacific region, notably the Southeast Asia Disaster Risk Insurance Facility (SEADRIF) and the Pacific Catastrophe Risk Insurance Company (PCRIC) as discussed below, and can be further replicated and scaled.

(I) SOUTHEAST ASIA DISASTER RISK INSURANCE FACILITY (SEADRIF)

SEADRIF was set up after the Thailand flood of 2011 in collaboration with the World Bank. The facility has an insurance company floating catastrophe insurance and it is owned by member countries. The objective of this facility is to improve access to pre-arranged financing through market-based mechanisms to respond to disasters in South-East Asian countries. The World Bank has presented a model in which a regional risk financing facility, supported by a technical assistance facility, serves as a transformation vehicle between countries and the global risk markets where the ultimate risk takers reside (ESCAP, 2018).

(II) PACIFIC CATASTROPHE RISK INSURANCE COMPANY (PCRIC)

The PCRIC is a regional risk pool that is now well-capitalized and offers parametric (modelled loss) coverage for tropical cyclones and earthquakes (including tsunami impacts) with an established, low-cost route to the international risk markets. Announcements made at COP23 in Bonn suggest that the Pacific small island developing States were seeking to expand their use of insurance. The PCRIC is a vehicle designed to facilitate such an expansion if it takes place on an inter-country basis.

The mechanisms noted above can be used to support nature-based and adaptation solutions and well as disaster risk reduction for long term resilience. While the tools discussed are being used in developed countries, it is important to note that especially for less developed countries, there are challenges in accessing these tools including having less developed domestic capital markets and ICT systems, and needing stronger technical capacity of government officials, central bankers, and financial regulators.

5.3.7 International cooperation and official development assistance (ODA) can play a significant role in uptake of financing mechanisms

International cooperation including official development assistance (ODA) particularly plays a crucial role in assisting less developed countries in accessing innovative financing mechanisms, which can help address their unique development challenges.

Financial Resources and Technical Assistance: ODA can provide financial resources and technical assistance to help less developed countries explore and access innovative financing mechanisms. This can involve grants, concessional loans, and capacity-building programs to enhance countries' understanding of these mechanisms and facilitate their participation. Additionally, international organizations and development partners can offer expertise and guidance in structuring financial instruments and developing innovative financing models tailored to the specific needs of less developed countries.

Knowledge Sharing and Capacity Building: International cooperation fosters knowledge sharing among countries, institutions, and stakeholders, enabling less developed countries to learn from the experiences of others who have successfully utilized innovative financing mechanisms. This knowledge exchange can help build capacity and expertise within local institutions, enabling them to navigate and effectively engage with these mechanisms. International cooperation initiatives, workshops, and training programs can equip policymakers and stakeholders with the necessary skills and knowledge to access and utilize innovative financing options.

Facilitating Partnerships and Platforms: International cooperation can facilitate partnerships between less developed countries, international financial institutions, private sector actors, and philanthropic organizations. These partnerships can create platforms for collaboration and knowledge exchange, enabling countries to access innovative financing mechanisms through joint initiatives and pooled resources. Platforms such as impact investing networks, climate finance platforms, and public-private partnerships can connect less developed countries with potential financiers and investors interested in supporting sustainable development projects.

Policy and Regulatory Support: International cooperation can assist less developed countries in developing supportive policy frameworks and regulations that encourage the use of innovative financing mechanisms. This can involve technical assistance in aligning national policies with international standards, creating an enabling environment for private sector investment, and implementing regulatory reforms that attract innovative financing sources. By providing guidance and support in policy formulation and implementation, international cooperation can help unlock the potential of these mechanisms and foster an environment conducive to their adoption.

Risk Mitigation and Blended Finance: Lastly, international cooperation can play a crucial role in mitigating risks associated with innovative financing mechanisms. This can involve the provision of guarantees, insurance products, and risk-sharing instruments that attract private sector investment in less developed countries. As noted previously, blended finance approaches, which combine public and private sector resources, can also be facilitated through international cooperation to mobilize additional financing for development projects in less developed countries.

By leveraging the various pathways of international cooperation, developing countries can tap into innovative financing mechanisms that offer new and sustainable sources of funding for their development priorities. These mechanisms can provide avenues for attracting private sector investment, addressing gaps in traditional financing, and supporting transformative projects that contribute to inclusive and sustainable development.

5.4 Technological advances to amplify financing adaptation

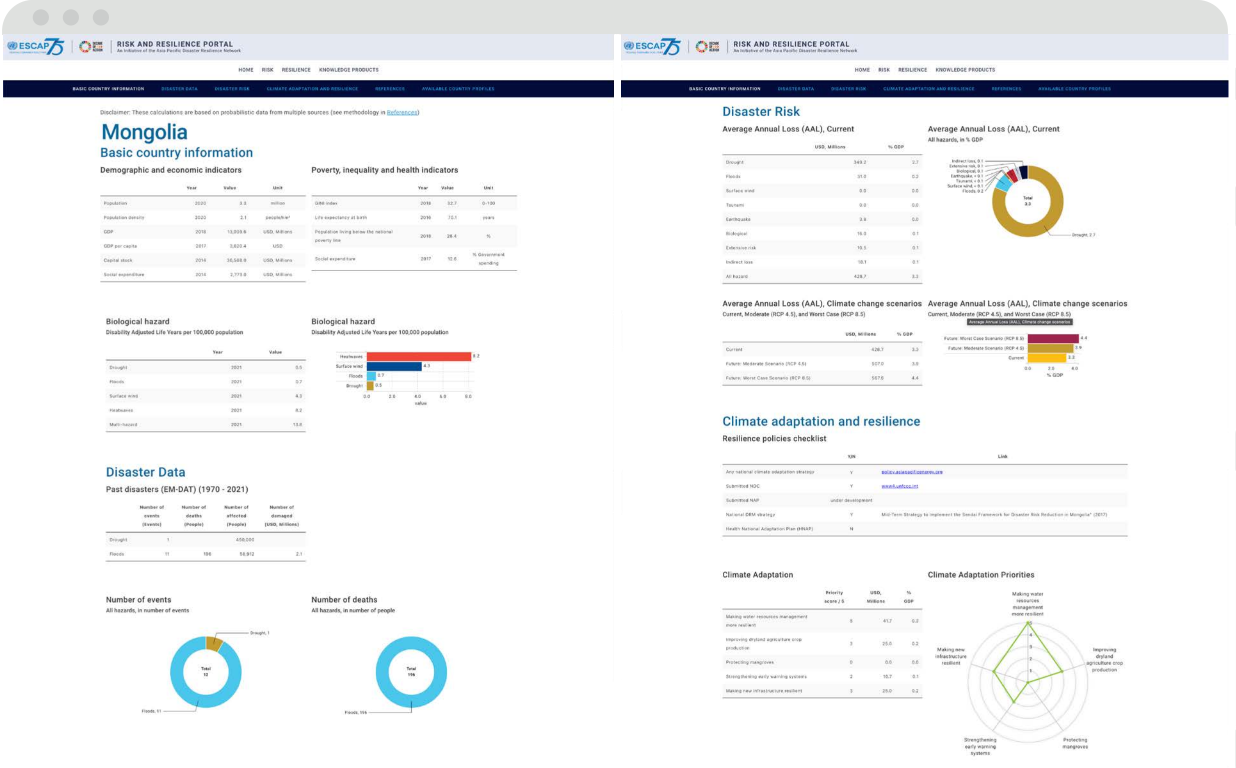
Digital technologies can greatly support financing for adaptation by improving efficiency, transparency, and accessibility in various aspects of the process. They enable efficient collection and analysis of data, informing evidence-based decision-making and prioritizing adaptation needs. Digital platforms allow for crowdfunding and peer-to-peer financing, connecting project proponents with potential funders and democratizing access to adaptation funding. Mobile and digital payment technologies facilitate faster and secure financial transactions, while blockchain ensures transparency and accountability in fund tracking. Digital tools also aid risk assessment, insurance solutions, impact monitoring, and reporting, enabling real-time data collection and evaluation. Additionally, they foster knowledge sharing and capacity building, facilitating collaboration and learning among stakeholders.

5.4.1 Innovations in digital platforms that promote investment decisions in climate change adaptation

(I) ESCAP ASIA PACIFIC RISK AND RESILIENCE PORTAL TO SUPPORT EVIDENCE-BASED PLANNING:

Planning and policy mechanisms need risk assessments and scientific evidence in the current, and future climate change scenarios to ensure interventions are effective and efficient. Contextual assessments of hazards, vulnerabilities, socioeconomic variables, and historical disaster losses can help policymakers prioritize their interventions and resources, and shape risk-informed policy decisions. ESCAP has put in place the Risk and Resilience Portal to deepen policymakers' understanding of climate risks and impacts not just in the current scenario but in future climate change scenarios using the latest CIMP6 data from IPCC. The portal provides risk scenarios including the economic cost, multi-hazard risk hotspots as well as adaptation priorities for 56 countries. Under the country profiles tab in the Portal, policymakers are able to find and download a pdf of their country report (Figure 5.9) that provides an estimate of: (i) the combined average annual losses from climate related hazards of the country under a current and two climate change scenario; (ii) the highest climate adaptation priorities for the country; and (iii) the cost of climate adaptation for the country under the worst-case climate change scenario.

FIGURE 5.9 Country-specific risk and resilience profiles for all countries in the Asia and the Pacific



Disclaimer: These calculations are based on probabilistic data from multiple sources (see methodology in References)

Mongolia

Basic country information

Demographic and economic indicators

	Year	Value	Unit
Population	2020	3.3	million
Population density	2020	2.1	people/km²
GDP	2018	13,009.6	USD, Millions
GDP per capita	2017	3,620.4	USD
Capital stock	2014	36,588.0	USD, Millions
Social expenditure	2014	2,773.0	USD, Millions

Poverty, inequality and health indicators

	Year	Value	Unit
GINI index	2018	32.7	0-100
Life expectancy at birth	2016	70.1	years
Population living below the national poverty line	2018	28.4	%
Social expenditure	2017	12.6	% Government spending

Biological hazard

Disability Adjusted Life Years per 100,000 population

	Year	Value
Drought	2021	0.5
Floods	2021	0.7
Surface wind	2021	4.3
Heatwaves	2021	8.2
Multi-hazard	2021	13.8

Biological hazard

Disability Adjusted Life Years per 100,000 population

Disaster Data

Past disasters (EM-DAT) (1970 - 2021)

	Number of events (Events)	Number of deaths (People)	Number of affected (People)	Number of damaged (USD, Millions)
Drought	1		450,000	
Floods	11	196	58,912	2.1

Number of events

All hazards, in number of events

Number of deaths

All hazards, in number of people

Disaster Risk

Average Annual Loss (AAL), Current

	USD, Millions	% GDP
Drought	349.2	2.7
Floods	31.0	0.2
Surface wind	0.0	0.0
Tsunami	0.0	0.0
Earthquake	3.8	0.0
Biological	16.0	0.1
Extensive risk	10.5	0.1
Indirect loss	18.1	0.1
All hazard	428.7	3.3

Average Annual Loss (AAL), Current

All hazards, in % GDP

Average Annual Loss (AAL), Climate change scenarios

Current, Moderate (RCP 4.5), and Worst Case (RCP 8.5)

	USD, Millions	% GDP
Current	428.7	3.3
Future: Moderate Scenario (RCP 4.5)	507.0	3.9
Future: Worst Case Scenario (RCP 8.5)	567.6	4.4

Average Annual Loss (AAL), Climate change scenarios

Current, Moderate (RCP 4.5), and Worst Case (RCP 8.5)

Climate adaptation and resilience

Resilience policies checklist

	Y/N	Link
Any national climate adaptation strategy	Y	policy.asiapacificenergy.org
Submitted NDC	Y	www4.unfccc.int
Submitted NAP	under development	
National DRM strategy	Y	Mid-Term Strategy to Implement the Sendai Framework for Disaster Risk Reduction in Mongolia" (2017)
Health National Adaptation Plan (HNAP)	N	

Climate Adaptation

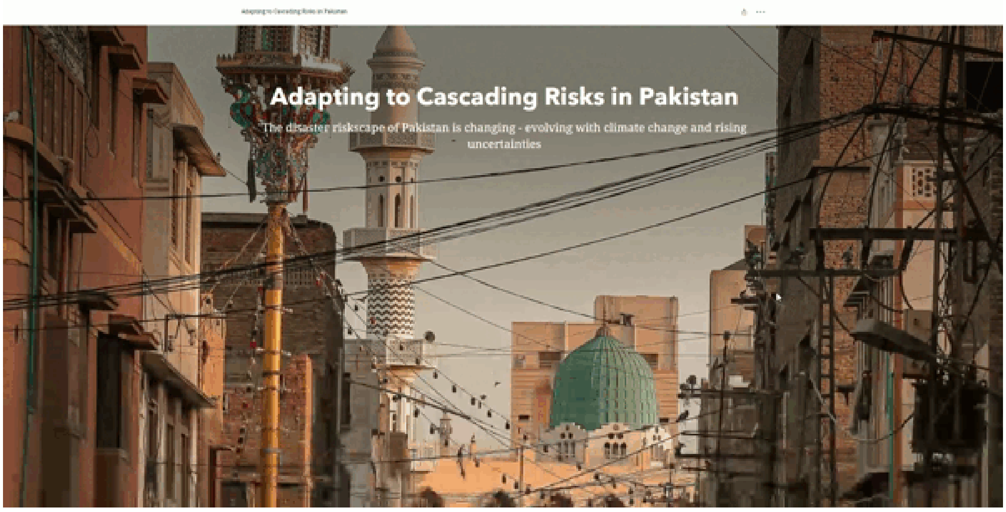
	Priority score / 5	USD, Millions	% GDP
Making water resources management more resilient	5	41.7	0.3
Improving dryland agriculture crop production	3	25.0	0.2
Protecting mangroves	0	0.0	0.0
Strengthening early warning systems	2	16.7	0.1
Making new infrastructure resilient	3	25.0	0.2

Climate Adaptation Priorities

Source: United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP), Asia Pacific Risk and Resilience Portal. Available at https://rrp.unescap.org

More recently, the Portal has developed a new type of interactive knowledge product known as story boards (Figure 5.10). These knowledge products are an interactive way for policymakers to explore and understand the vast array of scientific data and literature available on building resilience. Specifically, the country storyboard for the five target countries provides policy-oriented messages to support policymakers examine and explore the country data and interact with it to develop narratives around building resilience, especially in various socioeconomic sectors.

FIGURE 5.10 Interactive country-specific knowledge product for target country



Adapting to Cascading Risks in Pakistan

The disaster riskscape of Pakistan is changing - evolving with climate change and rising uncertainties

Source: United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP), Asia Pacific Risk and Resilience Portal. Available at https://rrp.unescap.org

(II) REDUCING THE COST OF INSURANCE THROUGH OPEN-SOURCE SOFTWARE

Modelling risks, which are complicated by climate uncertainties, is a very technical and expensive exercise. Both these factors make insurance expensive for the most vulnerable keeping a key resilience measure of reach (Kellett, 2022). Not surprisingly, therefore, the penetration of insurance continues to be low in Asia and the Pacific where around 77.54 per cent of losses are estimated to be uninsured (Banerjee, and others, 2023). Climate uncertainty and increased frequency of hazards adds to the costs of insurance.

Oasis hub is an open-source software that allows users to calculate potential damage (Oasis Hub, 2020). Oasis hub, worked closely with universities, research institutes and modelling companies to build loss modelling framework LMFs. An e-market connects the provision of this data and assessments. This e-market is a for-profit company and charges its users an annual subscription fee (Climate Finance Lab, 2016a). Capacity-building interventions support the developers and users so that they can develop these risks models for various planning purposes or to design insurance plans.

FIGURE 5.11 Estimated benefits from Oasis Platform Pilot

- 25–50% saving in modelling costs for re/insurers
- Catalysed US$1–9 million in new model development investments
- Additional US$ 1.4–6 billion of property insurance coverage

Source: Climate Finance Lab, "Oasis Platform for Catastrophe and Climate Change Risk Assessment and Adaptation: Lab Instrument Analysis", 27 June 2016b. Available at https://cpilabs.wpenginepowered.com/wp-content/uploads/2016/01/Oasis-Report.pdf

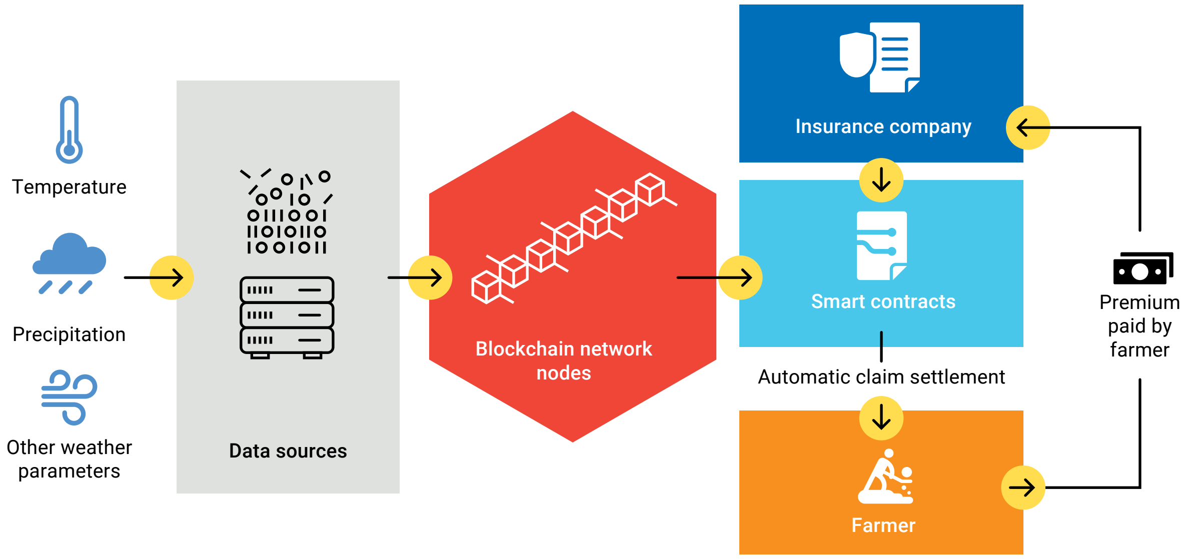
This system reduced the overall cost of assessment for service providers. Initial estimates of the pilots in the Philippines, Indonesia, and Bangladesh show a potential saving of 25-50 per cent in modelling costs (Climate Finance Lab, 2016b). With an estimated investment of $1-9 million for new model development, an estimated $1.4 – 6.0 billion of property insurance coverage can be achieved (Climate Finance Lab, 2016b) (Figure 5.11). While scaling up has its challenges, with some policy level support and capacity-building, such open-source risk modelling frameworks can be used to integrate climate factors into existing insurance designs.

(III) PARAMETRIC INSURANCE USING BLOCKCHAIN TO IMPROVE DELIVERY AND OUTREACH FUNDS TO CLIMATE-SENSITIVE SECTORS

Traditional indemnity insurance products largely rely on an insurer's subjective assessment of loss and damages and often struggle to offer accessible insurance coverage to combat disaster-related economic losses. In this context, parametric insurance is relevant. Under parametric insurance, the insured person automatically becomes eligible for the payout when parameter-based indices, such as temperature or precipitation, exceed a pre-determined threshold. It rules out the need for post-disaster loss assessment and makes the claims settlement faster and more efficient.

However, claims settlement is still a time-consuming process that requires manual supervision. Customers are often forced to trust their insurance providers to pay out fair claims. Besides, with the increasing demand for insurance, it has become extremely difficult for insurers to manage fraud. Insurance companies must engage in cautious supervision to mitigate the rising risk of information asymmetry.

FIGURE 5.12 **Parametric insurance using blockchains**



Source: Adapted from A. Shetty, and others, "Block Chain Application in Insurance Services: A Systematic Review of the Evidence", *SAGE Open*, vol. 12, No. 1 (2022). Available at https://doi.org/10.1177/21582440221079877

Innovative insurance infrastructure is needed to reinforce trust between both parties and accurately settle claims quickly. Blockchain technology helps to circumvent these challenges. It enables smart contract technology which has transformed manual, subjective claim settlements to a more automated and impartial system. This builds trust ensuring that neither the insurer nor the insured can tamper with the outcome of the contract. The weather data is fed into the blockchain network, which analyses and proves if the drought or flood has happened and automatically triggers the payout through smart contracts (Figure 5.12). Processing of documents, verification of parameters, and claim settlement can happen on the chain in a completely transparent manner. Efficiency increases and risk decreases, as supervision is automated. As transaction costs decrease, premia become more affordable.

Implementing these technologies need significant capacity-building, technically among the stakeholders and in digital infrastructure. It is equally important for the prospective policy holders to be capacitated on the limitations of the instrument, for example where considerable damage from an event or from consecutive events, do not trigger a payment.

(IV) USING TECHNOLOGIES FOR ASSESSING LOSS AND DAMAGE FASTER

Post disaster, faster assessment of losses and release of insurance pay-outs is critical for countries to manage relief and begin rebuilding work. SEADRIF's Flood Risk Monitoring Tool is a tool that calculates payouts as soon as a disaster is triggered (SEADRIF, 2023). It runs simulations to assess the probability of a flood event to determine the pricing. It uses satellite data and meteorological data to conduct near real-time flood ground impact assessments and determine the severity. This near real-time information has supported faster loss assessments and decision-making.

(V) BUILDING ECONOMIES OF SCALE FOR CLIMATE FINANCING TECHNOLOGIES

Ironically, as forecasts and technology advances make forecasts more accurate with higher resolution, these same forecasts become more difficult for low-capacity countries to access and use (Webster, 2013). For the benefits to be fully realized, partnership frameworks are needed for the sharing of advanced forecasts, appropriate technology and accessible services such as the ones provided by the Pacific Disaster Centre and the Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES). Cooperation reduces costs through data-sharing across countries, which decreases the required extent of hydromet equipment installation, or through sharing of weather service delivery networks (Malik and others, 2014). ESCAP's multi-donor Trust Fund, Tsunami, Disaster and Climate Preparedness, which set up RIMES provides an example of economies of scale delivered through such partnerships (Box 5.1) (UNDRR, 2023).

BOX 5.1 Trust Fund for Tsunami, Disaster and Climate Preparedness: Meeting unmet early warning needs in Asia and the Pacific

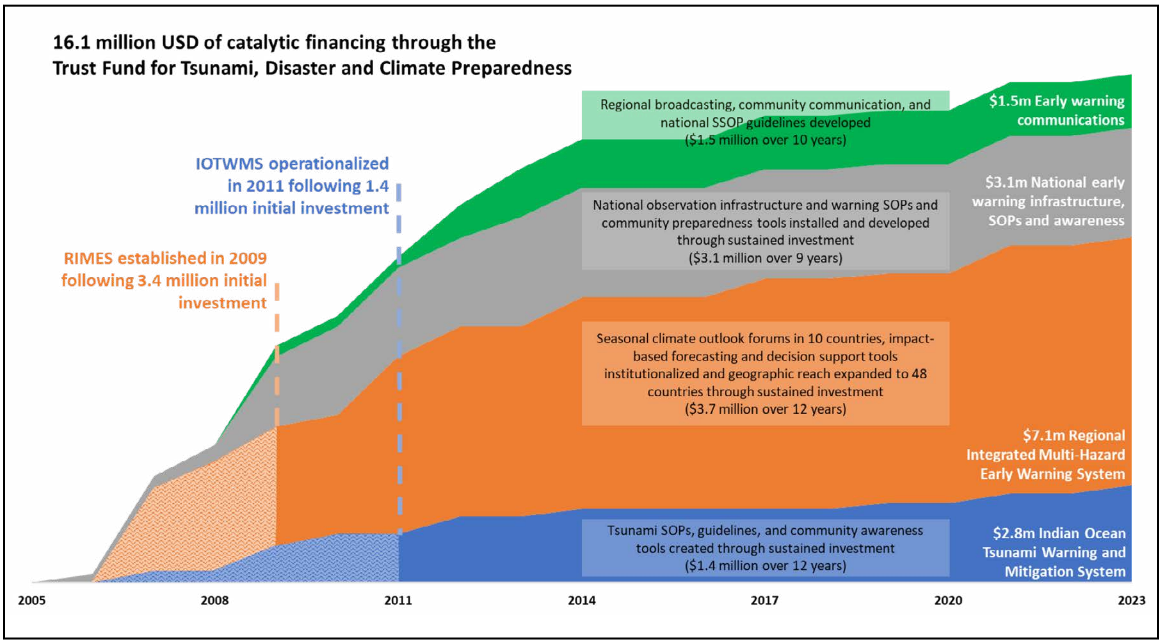
As the only regional funding mechanism to strengthen multi-hazard early warning, ESCAP's Trust Fund for Tsunami, Disaster and Climate Preparedness has mobilized US$ 16.1 million to address unmet needs in Asia and the Pacific through catalytic and sustained support since 2005 (Figure 5.13).

Upon inception, the Trust Fund focused on advancing and operationalizing tsunami warning systems following the 2004 Indian Ocean Tsunami. With less than $3 million (2006-present), the Indian Ocean Tsunami Warning and Mitigation System (IOTWMS) was operationalized in 2011; ensuring tsunami services from Australia, India, and Indonesia could be provided to 36 Indian Ocean basin countries, and advancing shared scientific risk awareness across the ocean basin.

To further illustrate, a catalytic investment of $3.4 million through the Trust Fund, from 2006 to 2009, successfully established the regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES). Further supported with sustained financing of $3.7 million, RIMES is now a fit-for-purpose institution, owned and supported collectively by 48 member States to serve them in building capacity for end-to-end multi-hazard early warning, many of which are LDCs and SIDS.

The Trust Fund has demonstrated that with catalytic initial investment to support regional cooperation coupled with sustained investment to deepen shared risk knowledge and operationalization of early warning systems, gaps in early warning systems across a range of hazards, geographies and capacities can be addressed.

FIGURE 5.13 Trust Fund investments, 2005-2023



16.1 million USD of catalytic financing through the Trust Fund for Tsunami, Disaster and Climate Preparedness

Regional broadcasting, community communication, and national SSOP guidelines developed ($1.5 million over 10 years)

National observation infrastructure and warning SOPs and community preparedness tools installed and developed through sustained investment ($3.1 million over 9 years)

Seasonal climate outlook forums in 10 countries, impact-based forecasting and decision support tools institutionalized and geographic reach expanded to 48 countries through sustained investment ($3.7 million over 12 years)

Tsunami SOPs, guidelines, and community awareness tools created through sustained investment ($1.4 million over 12 years)

IOTWMS operationalized in 2011 following 1.4 million initial investment

RIMES established in 2009 following 3.4 million initial investment

Source: ESCAP.
Note: IOTWMS denotes Indian Ocean Tsunami Warning and Mitigation System.

A multi-hazard early warning system with the ability to warn of one or more hazards increases the efficiency and consistency of warnings through coordinated and compatible mechanisms and capacities. Integrated multi-hazard comprehensive risk analysis places the system on a stronger foundation. Harmonized approaches for risk communication, warning dissemination, and preparedness minimize inefficiencies and maintenance costs. They maximize investments in awareness, education, and preparedness.

Scaling up climate action is urgent and financing is an important means of implementation. Demands on international development cooperation are at an all-time high. For the climate vulnerable and debt distressed countries of Asia and the Pacific, access to affordable and adequate finance for transformational adaptation is critical for addressing climate and disaster-induced vulnerabilities and building a resilient future.

The quantum of finance available for adaptation is insufficient and out of kilter with the ever-increasing costs and potential risks. It must be scaled up exponentially to meet the goals of the 2030 Agenda for Sustainable Development. Many countries in the Asia-Pacific region have COVID-19 recovery strategies which have entry points for sustainable climate adaptation interventions which must be tapped. Governments can play a critical role in ensuring economy-wide, climate-compatible investments and in increasing the domestic finance available for climate adaptation action.

The private sector is an indispensable partner. Its engagement in adaptation action and financing must be unlocked. This can be done with policies and regulatory frameworks that encourage transformative adaptation investment. Building capacities, investing in technologies and data, encouraging engagement in policies and planning are some of the ways in which private sector engagement in adaptation financing can be strengthened. Innovation in financial mechanisms instruments and de-risking methods are needed to widen the investor base and to support investment in transformative adaptation avenues.

Building capacities, promoting regional cooperation and knowledge exchange, engagement of different stakeholders, and a conducive policy environment are the key to enhancing the effectiveness and efficiency of finance flow to adaptation.

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CHAPTER 6

Understanding loss and damage

Responding to loss and damage caused by climate change has become an international priority, necessitating improved assessment methods to understand the impact of disasters and extreme weather events on both humans and ecosystems.

A deeper examination of innovative models and methodologies, that have been developed to evaluate loss and damage, is needed to address the challenge of attributing the extent of catastrophe impact to climate change and to assess its long-term consequences on economies, livelihoods, and resilience.

By leveraging digital technologies, such as data connectivity and smart Earth technology, there is potential to enhance risk management, response plans, and ecosystem monitoring, contributing to a further insight into evaluating climate change-related loss and damage across the diverse subregions of Asia and the Pacific.

6.1 Loss and Damage in Global Agendas

Loss and damage brought on by climate change are now a top priority on the international agenda. They also exhibit significant impacts to the Sustainable Development Agenda, to SDG Target 11.5 on reducing the number of deaths, the number of people affected, and decreasing the direct economic losses, and form the critical parts of Target A, B, C and D of the Sendai Framework for Disaster Risk Reduction. Loss and Damage may further include increased human mortality and morbidity due to increased heat and infectious diseases, inequality and poverty rates, risk to water and energy security due to drought and heat, and reduced economic output and growth. The historic Loss and Damage fund, established at the 27th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP27), made new funds available to support vulnerable countries suffering from the impacts of climate change (Wyns, 2023). Loss and Damage may include increased human mortality and morbidity due to increased heat and infectious diseases, inequality and poverty rates, risk to water and energy security due to drought and heat, and reduced economic output and growth (United Nations Climate Change, 2015).

The United Nations Framework Convention on Climate Change (UNFCCC) has been an essential mechanism for addressing loss and damage. In 2013, the Warsaw International Mechanism for Loss and Damage (WIM), was established under the UNFCCC. This has been critical in increasing awareness about the necessity of averting, minimizing, and addressing loss and damage, as well as providing a venue for nations to exchange their experiences and best practices in this area. Article 8 of the Paris Agreement recognizes the importance of averting, minimizing and addressing loss and damage associated with the adverse effects of climate change, including extreme weather events and slow-onset events. It emphasizes the role of sustainable development in reducing the risk of loss and damage, and stipulates that the Warsaw International Mechanism for Loss and Damage associated with climate change impacts will be subject to the authority and guidance of the COP (United Nations Climate Change, 2015).

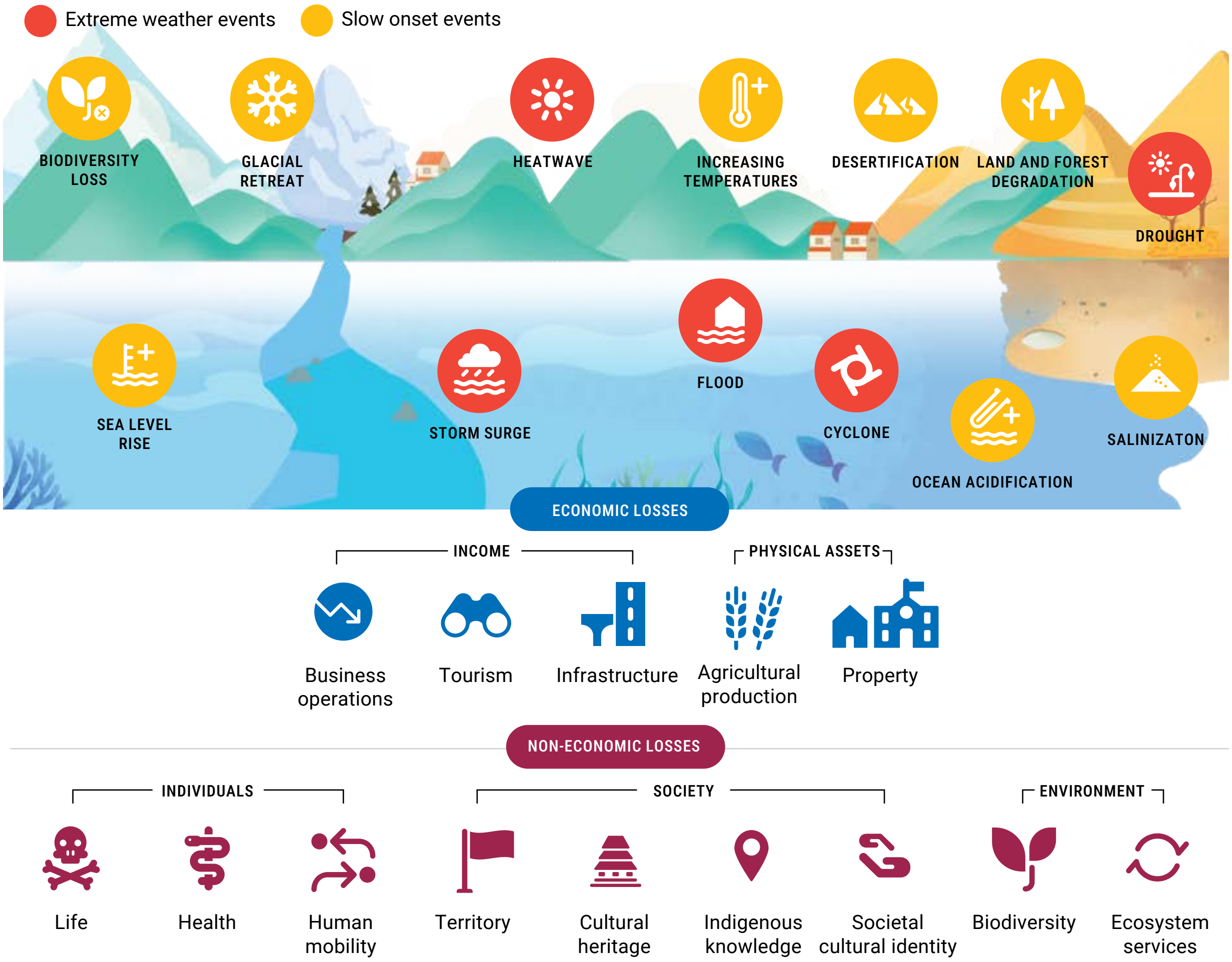
The inclusion of Loss and Damage in the Paris Agreement reflects the growing urgency of global action. At the regional level, the most climate-affected countries in the Asia-Pacific region have been actively promoting action on loss and damage, noting the escalating costs of damages associated with tropical cyclones (Basconcillo and Moon, 2022). The Pacific Islands Forum (PIF) for example, has been advocating for action. In 2019, it created the Pacific Climate Change and Migration Project, which aims to address the impacts of climate change on migration and displacement in the area.

6.2 Concept of Loss and Damage

Loss and Damage occurs when adaptation efforts fall short, become increasingly costly, or have unfavourable consequences.

Loss and Damage can result from a variety of factors, including increased heat and infectious diseases leading to higher human mortality and morbidity rates, increased inequality and poverty rates, and risk to water and energy security due to drought and heat. Potential consequences include reduced economic output and growth, loss of biodiversity, social and cultural identity, as illustrated in Figure 6.1.

FIGURE 6.1 Loss and damage from disaster and climate hazards

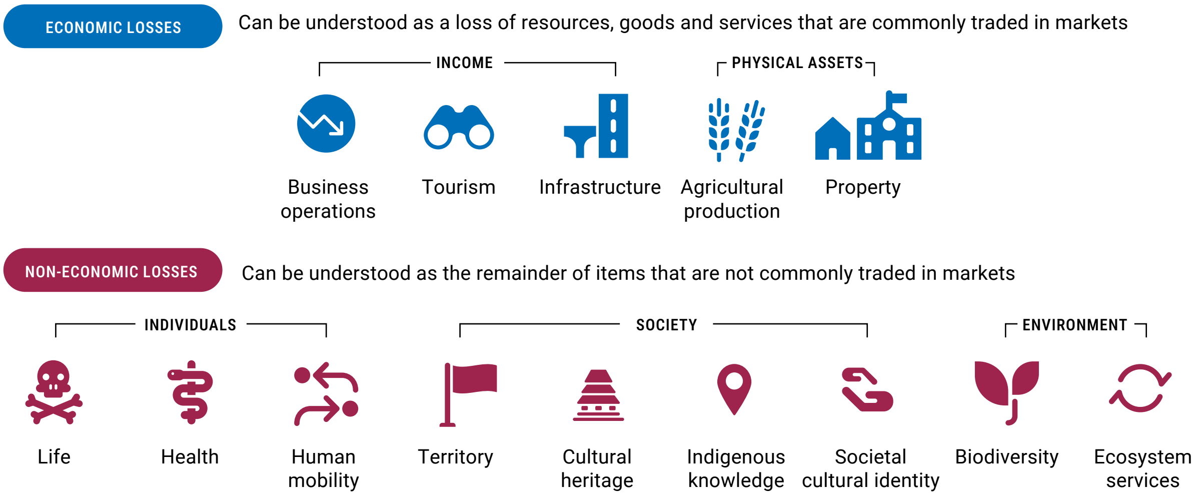


Source: ESCAP, adapted from United Nations Climate Change, "Loss And Damage: Online Guide", 2017. Available at https://unfccc.int/sites/default/files/resource/online_guide_on_loss_and_damage-dec_2017.pdf

Loss and Damage can be classified as either economic or non-economic (Figure 6.2), with the former being quantifiable in monetary terms, such as rebuilding infrastructure or loss of revenue from agricultural crops (United Nations Climate Action, n.d., b).

Non-economic Loss and Damage are more challenging to quantify in terms of monetary value and may include psychological pain brought on by a natural disaster, loss of community as a result of displacement, or loss of biodiversity (United Nations Climate Action, n.d., a). Loss and Damage can result from both rapid-onset events, such as cyclones and heat waves, as well as slow-onset disasters like sea level rise and ocean acidification (United Nations Climate Action, n.d., c). Loss and Damage can still happen, even before the limits of adaptation, which, as discussed in previous chapters, are the points at which adaptive investments stop shielding against the effects of climate change.

FIGURE 6.2 A brief overview of loss and damage



ECONOMIC LOSSES: Can be understood as a loss of resources, goods and services that are commonly traded in markets

NON-ECONOMIC LOSSES: Can be understood as the remainder of items that are not commonly traded in markets

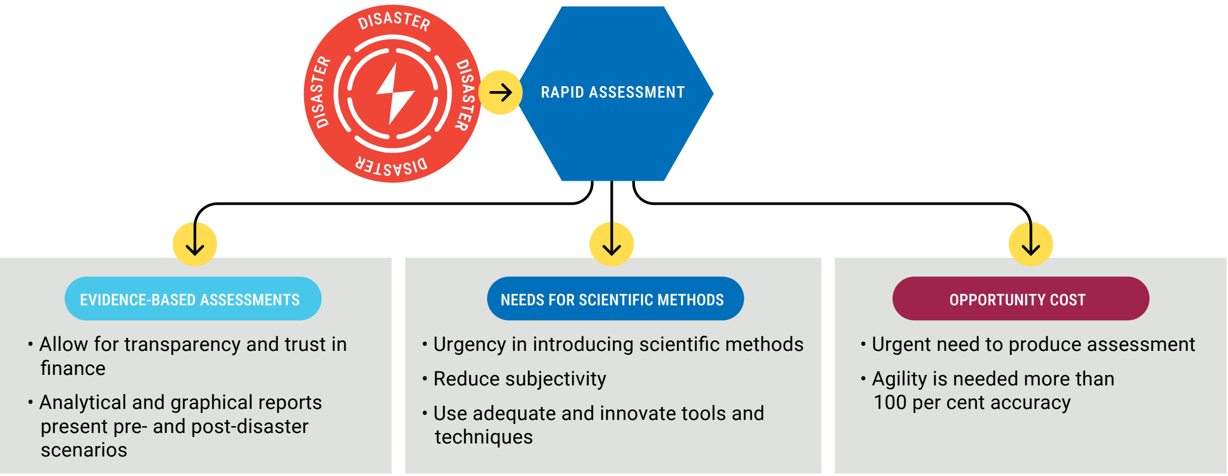
Source: ESCAP, adapted from United Nations Framework Convention on Climate Change (UNFCCC), "Loss and Damage: Online Guide", 2017. Available at https://unfccc.int/sites/default/files/resource/online_guide_on_loss_and_damage-dec_2017.pdf

In the aftermath of disasters, both governmental and non-governmental entities gauge the extent of the damage incurred. Historically, such assessments have been characterized by several shortcomings. Among these are the absence of baseline data prior to the disaster, as well as the narrow focus of economic and financial evaluations, which typically concentrate solely on the loss of assets and disregard the impact of flow disruptions, such as business interruption, labour shortages, and other associated costs.

6.3 New models of Loss and Damage and a review of existing assessment methodologies

In 2013, the United Nations, the World Bank and the European Union published guidelines for post-disaster needs assessments (PDNA) to support a thorough analysis of such needs. Making decisions quickly and accurately depends on rapid evaluations based on scientific assessments (Figure 6.3). The evaluation of post-disaster damage must therefore be conducted objectively, using quantitative data to provide an evidence-based, trustworthy assessment. The time-sensitive nature of conducting assessments during disasters minimizes the opportunity costs involved and serves the purpose of informing recovery planning, mobilizing resources, and reducing risks for a more resilient recovery.

FIGURE 6.3 Rapid assessment of post-disaster loss and damage



EVIDENCE-BASED ASSESSMENTS

- Allow for transparency and trust in finance
- Analytical and graphical reports present pre- and post-disaster scenarios

NEEDS FOR SCIENTIFIC METHODS

- Urgency in introducing scientific methods
- Reduce subjectivity
- Use adequate and innovate tools and techniques

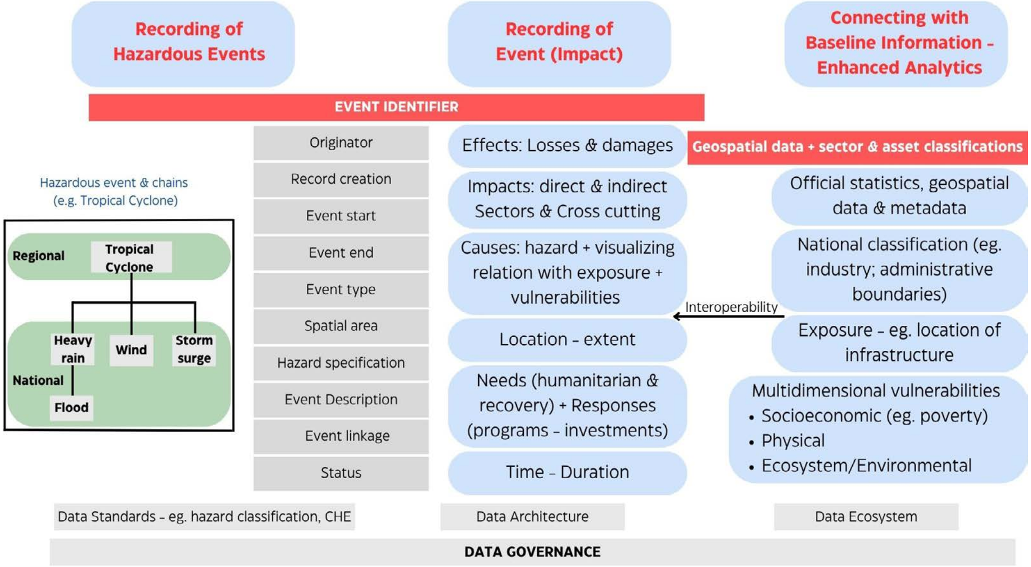
OPPORTUNITY COST

- Urgent need to produce assessment
- Agility is needed more than 100 per cent accuracy

Source: ESCAP, adapted from *Asia-Pacific Disaster Report 2015: Disasters without borders: Regional resilience for sustainable development* (United Nations publication, 2015). Available at https://www.unescap.org/publications/asia-pacific-disaster-report-2015-disasters-without-borders

In recent years, there have been advances in tracking disaster impacts and advancing the data architecture system for loss and damage. The UN Office for Disaster Risk Reduction (UNDRR), in collaboration with the United Nations Development Programme (UNDP) and the World Meteorological Organization (WMO), are innovating the DesInventar system towards a completely new, comprehensive, and systematic approach to track hazardous events and disaster loss and damage. (Figure 6.4).

FIGURE 6.4 **A systematic model of tracking hazardous events and disaster losses and damages**



Source: ESCAP, adapted from UNDRR, UNDP, and WMO, "Progress and advances in monitoring of Sendai Framework for Disaster Risk Reduction", Presentation, 13 March.

Researchers and practitioners have developed various models to quantify loss and damage costs. These models differ in their methodology, timing of application (i.e., ex-ante or ex-post), estimated nature of costs (i.e. economic and non-economic), and by the types of disasters they cover. While needs assessment models and economic models are generally able to provide Loss and Damage cost estimates after the occurrence of a disaster, risk assessment models can be used ex-ante to estimate future Loss and Damage costs.

1. LOSS AND DAMAGE METHODOLOGY (DALA) AND POST-DISASTER NEEDS ASSESSMENT (PDNA)

The loss and damage (DaLA) technique developed by the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) is a ground-breaking methodology that permits a thorough evaluation of the effects of catastrophe on a nation's economy and population. It provides a holistic view of the socioeconomic effects of catastrophes by analysing damages, losses, the macroeconomic impacts and the effects on livelihoods. The DaLA technique consists of four key processes: (i) the identification of risks; (ii) the evaluation of exposure and susceptibility, (iii) the measurement of material and financial losses, and (iv) the computation of recovery and rebuilding costs.

This is further discussed in Box 6.1.

There are also gaps that have emerged over time:

1. PDNAs assessments have yet to fully account for the loss and damage occurring from climate change.
2. PDNAs have tended to underestimate long-term consequences inherent to catastrophes, such as alterations in land use and population.
3. More attention on the impact of disasters on economies and livelihoods in countries is needed, in addition to evaluating the intensity of the hazard itself.

BOX 6.1 A meta-analysis of Post-Disaster Needs Assessment, sector loss and damage in Asia and the Pacific

ESCAP analysed 48 PDNAs (1 drought event, 10 earthquakes, 16 floods, 16 tropical cyclones, 1 tsunami, and 1 volcanic eruption) to examine the trends in impacts on mortality and morbidity and the social, infrastructure, productive and cross cutting sector losses.[a] The overall results indicate stagnating action on measures to mitigate loss and damage across multiple sectors. The results also show a decreasing trend of mortality and people affected from all disasters, however mortality from earthquakes which are not climate-related disasters is on the rise.

A disaggregated analysis by three ESCAP subregions, notes that the Pacific region shows increasing trends for loss and damage and deaths and people affected, while South and South-West Asia experiences a stark increase in economic losses and damages.[b]

Sectoral losses vary across the subregions. In the Pacific, the social and productive sector incurs about 30 per cent losses, while losses in infrastructure and cross cutting sectors stand at around 16 per cent. In South-East Asia, almost 80 per cent of disaster losses occur in the productive sectors, while in South and South-West Asia productive sector losses are high, at around 60 per cent, followed by social (25 per cent) and infrastructure (13 per cent) sector losses. Losses in the cross-cutting sectors are highest in the Pacific. Therefore, adaptive actions to build future resilience must be based on understanding risks at the sectoral level.

As climate change continues to increase the intensity and number of floods and cyclones, these negative trends are expected to continue. Only a complete transformation in how the region evaluates adaptation and implements measures to reduce the impacts can reverse these trends.

[a] Global Facility for Disaster Risk Reduction and Recovery (GFDRR) (2022). Post Disaster Needs Assessments. Available at https://www.gfdrr.org/en/post-disaster-needs-assessments

[b] S.I. Seneviratne, and others, "Weather and Climate Extreme Events in a Changing Climate", in *Climate Change 2021: The Physical Science Basis*, Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Masson-Delmotte, V., and others, eds. (Cambridge, UK, and New York: Cambridge University Press, 2021. Available at https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-11/

2. CATASTROPHE RISK MODELS

Catastrophe modelling has evolved from the intersection of property insurance and natural hazards science. These models combine scientific measures of environmental hazards and past events with geographic information systems (GIS) and advances in information technology. Employing a probabilistic methodology to determine current and future losses, these models assist the financial sector in planning for a wide range of uncommon occurrences, including pandemics, financial crises and political turmoil (UNDRR, 2012).

To determine the probabilistic estimates of future losses, catastrophe models have used historical observation data. However, climate change is increasing the uncertainties in historically observed data, and the IPCC notes that historical data may not reflect the true nature or hotspots of disasters. Furthermore, climate-related slow-onset hazards, such as desertification or sea-level rise have not yet been incorporated in many catastrophe models (Seneviratne and others, 2021).

3. PARTICIPATORY CAPACITY AND VULNERABILITY ANALYSIS

Understanding and assessing the vulnerability of communities and their subgroups to the risk of catastrophes is done by using participatory capacity and vulnerability analysis (PCVA). This approach aims to offer insightful information on the local context and structures, including informal networks that may be used to deal with loss and damage (AusAID and OXFAM Australia, 2012). Conventional development initiatives frequently ignore hidden capabilities, such as local connections, citizen engagement, and familiar knowledge that are vital to long-term resilience planning (Turvill and Turnbull, 2012). The drawbacks of these methodologies include a lack of uniformity and precision in PCVA implementation, which leads to variations in the interpretation of data (AusAID and OXFAM Australia, 2012). These methodologies also tend to focus on previous and present capacities and vulnerabilities of communities, while ignoring future scenarios and the possible impacts of climate change, particularly with respect to slow-onset disasters (Béné and others, 2014).

4. RISK ASSESSMENT MODELS

Risk assessment models are an important element of ex-ante disaster risk reduction, giving significant insights into the likelihood and possible repercussions of catastrophes. These models can provide a more thorough knowledge of not just 'what the weather will be' but 'what the weather will do' (ESCAP and WMO, 2021). Such impact-based forecasting for early action combines a weather forecast and assessment of possible impacts, including the timing, location and likelihood of the impacts. By providing the information needed to act before disasters, organizations and individuals can make critical decisions to ensure that resources and supplies are in place to mitigate disaster risk and respond quickly.

The German Agency for International Cooperation's (GIZ) "Global Programme on Risk Assessment and Management for Adaptation to Climate Change (Loss and Damage)" offers a comprehensive methodology that can be integrated in the climate risk management (CRM) framework and emphasizes the interdependencies between short-term extreme weather events and long-term slow-onset processes (GIZ, 2021).

5. PANEL-BASED ECONOMETRIC MODELS

Panel-based econometric models enable the analysis of hazard effects on economic production and individual behaviours, such as risk aversion. They can assess subjective well-being by considering demographic characteristics and endogenous variables. Incorporating future climate parameters is crucial for estimating potential economic and non-economic losses. Overall, panel-based econometric models offer a powerful analytical framework for understanding and quantifying the multifaceted nature of Loss and Damage caused by climate-related hazards (Basnayake and others, 2021).

6.4 Refining risk assessment models to reflect the spectrum of climate change impacts

Assessing and disaggregating the impacts of climate change is an evolving science. In this regard, two further aspects are worth highlighting. The first is that accounting for Loss and Damage must differentiate between rapid- and slow-onset disasters to gauge times involved in impact and recovery. The second is that Loss and Damage assessment must incorporate the new science of climate attribution to correctly account for climate change-related impacts.

1. LOSS AND DAMAGE IN RAPID VS. SLOW-ONSET DISASTERS UNDER THREAT FROM CLIMATE WARMING

Hazards must be unpacked based on their nature and respective phases of action. This includes the actions required to anticipate before, respond during, and recover after the impact. Yet, they must also be repacked into phases based on the nature of the hazards and the actions required to anticipate, respond and recover. For rapid-onset disasters (Figure 6.5), the phases which can be more directly quantifiable include:

- Pre-emptive actions (planned adaptation)
- Contingency planning (with fund accruing after impact)
- Anticipatory action (a few days after a major hazard is forecast)
- Short-term response
- Medium-term recovery (Addresses vulnerability and exposure dimensions of the disaster)
- Long-term reactive adaptation (reconstruction, climate proofing, building forward better)

FIGURE 6.5 Spectrum of actions in responding to climate impacts for rapid-onset disasters

Source: ESCAP, adapted from Santiago Network 2023, "Regional Scoping Workshop on Loss and Damage Under the Santiago Network: Latin America and Caribbean Region", Analysis of Workshop Discussions, 30 April 2023. Available at https://unfccc.int/sites/default/files/resource/lac_workshop_sn_april_mimansha.pdf

For slow-onset disasters, Loss and Damage is more difficult to quantify. Figure 6.6 demonstrates the latest discussions on accounting for slow-onset disasters. In particular, the long-term cascading and intersecting impacts of these hazards on multiple sectors, are consequential. Impacts of drought, for example, can span years affecting agriculture, food security, water resources and ecosystems. Drought can trigger emerging or expanding desertification. Therefore, Loss and Damage assessment for slow-onset disasters must not only consider the beginning of the disaster, but must determine the likely duration of the event to adequately compensate and build further resilience. This requires a potentially lengthier, more involved, and more iterative process spanning longer timelines than for rapid-onset disasters.

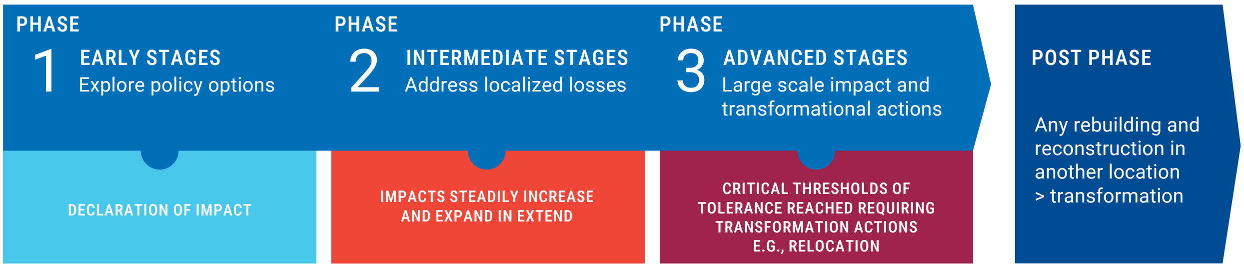
FIGURE 6.6 Spectrum of actions in responding to climate impacts for slow-onset disasters

Source: ESCAP, adapted from Santiago Network 2023, "Regional Scoping Workshop on Loss and Damage Under the Santiago Network: Latin America and Caribbean Region", Analysis of Workshop Discussions, 30 April 2023. Available at https://unfccc.int/sites/default/files/resource/lac_workshop_sn_april_mimansha.pdf

2. PERMANENT LOSS AND DAMAGE FROM CLIMATE DISASTERS

Some slow-onset phenomenon such as sea level rise and salinity intrusion, will have permanent and irreversible changes. This requires an estimation of not just loss and damage but ex-ante quantification of the costs of adaptation and risk-informed strategies, that guide investments and policies (Figure 6.7). Current estimations thus need to incorporate medium- and long-term scenarios to determine the priority of resources for infrastructure upgrades, repair, and relocation for the lifetime of these infrastructures.

FIGURE 6.7 Spectrum of actions in responding to anticipated permanent losses from climate warning



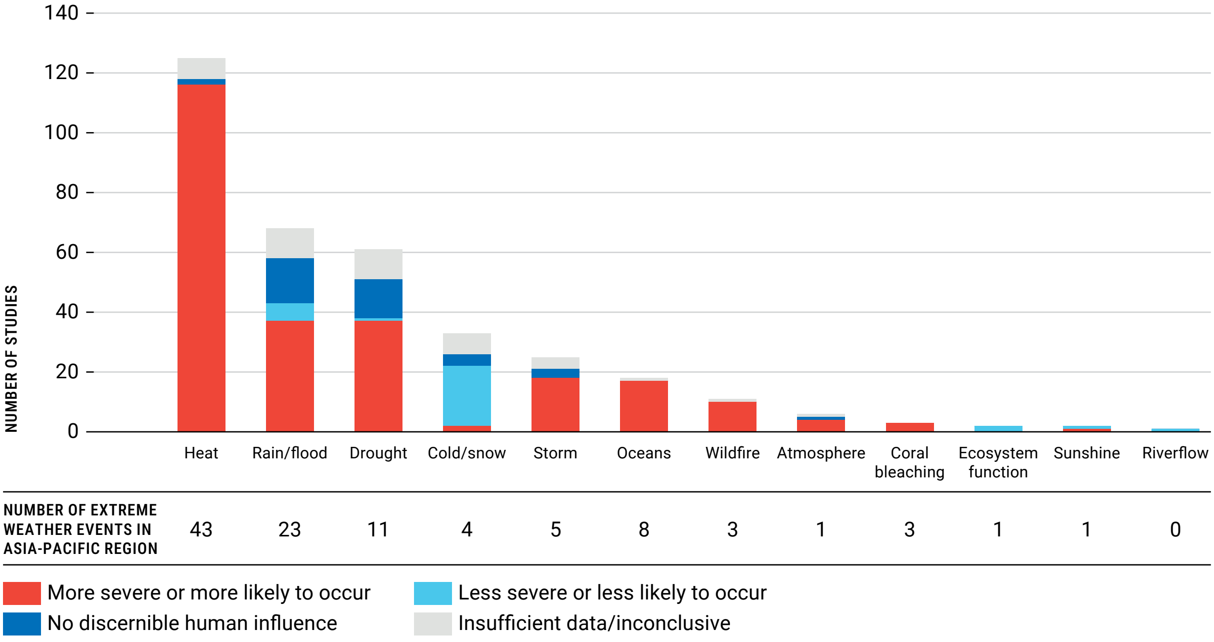
Source: ESCAP, adapted from Santiago Network 2023, "Regional Scoping Workshop on Loss and Damage Under the Santiago Network: Latin America and Caribbean Region", Analysis of Workshop Discussions, 30 April 2023. Available at https://unfccc.int/sites/default/files/resource/lac_workshop_sn_april_mimansha.pdf

INTEGRATING CLIMATE ATTRIBUTION METHODS TO BETTER QUANTIFY LOSS AND DAMAGE ASSESSMENTS

The IPCC Working Group II Report on *Climate Change 2022: Impacts, Adaptation, and Vulnerability* reveals that existing global warming has already caused dangerous and widespread loss and damage. As global warming increases, Loss and Damage becomes more severe and difficult to avoid without adequate adaptation measures. Current financial, governance, and institutional arrangements are insufficient in addressing the comprehensive challenges. The Pacific small island developing States (SIDS) are particularly vulnerable, with a critical threshold at 1.5°C where adaptation becomes increasingly challenging.

ESCAP estimates that there have been more than 300 peer-reviewed studies on the impact of climate change on weather extremes around the world since 2000 (United Nations Climate Change, 2013; UNFCCC, 2010; Béné and others, 2014). Many of these studies conclude that climate change would make around 70 per cent of extreme weather events either more likely or more severe. Figure 6.8 summarizes the extent of climate attribution pertaining to multiple extreme weather conditions. It notes that slow-onset disasters will be most impacted by climate change.

FIGURE 6.8 Relative confidence in attribution of different extreme events



	Heat	Rain/flood	Drought	Cold/snow	Storm	Oceans	Wildfire	Atmosphere	Coral bleaching	Ecosystem function	Sunshine	Riverflow
NUMBER OF EXTREME WEATHER EVENTS IN ASIA-PACIFIC REGION	43	23	11	4	5	8	3	1	3	1	1	0

Extreme event attribution tells us how much of the credit or risk for an event (or type of events) should go to global warming and how much should go to natural weather patterns or random climate variability (Box 6.2) (Lindsey, 2016). Knowing whether global warming influenced the probability or intensity of an extreme weather event can help communities and countries develop recovery and resilience plans that match their future risk. Extreme event attribution can support Loss and Damage methodologies by providing a local-scale perspective that governments, communities, and businesses can use to better anticipate future changes in extremes at their specific location (Imperial College Business School, 2022; IPCC, 2022b).

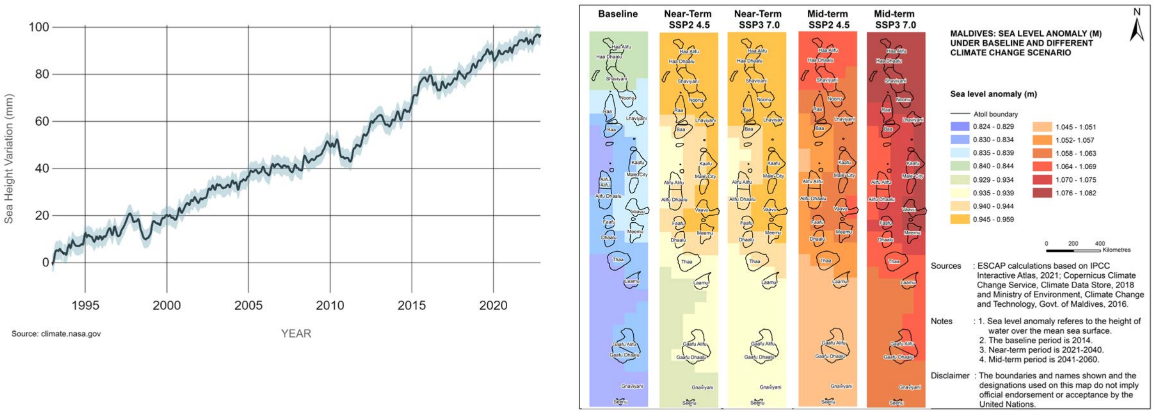
However, the accuracy of climate models can be affected by many factors including the quality and quantity of observational data used to develop them (Herring and others, 2022).

BOX 6.2 Sea level rise attribution in the Pacific small island developing States: A case study of the Maldives

Satellite measurements show that global sea level has risen by 96.7 mm since 1993 (Figure 12) and it is projected to rise in the future.[a] For the small islands, any climate-driven impatcts are amplified largely due to their geopolitical and political, environmental, socioeconomic and cultural factors. The IPCC 6th Assessment Report mentioned that the small reef islands and narrow coastal systems in the Indian ocean can expect 5-10 cm of additional sea-level rise with a doubling of flooding frequency.[b]

The Maldives has the lowest terrain in the world. More than 80 per cent of its islands are less than 1 m above the mean sea level. Given that global sea level is rising at a rate of 3 to 4 mm per year, 31-50 per cent of the population in the Maldives is likely to be exposed to seal level rise and related events, such as coastal storm surges and coastal inundation more frequently by 2100 under a business-as-usual scenario (SSP2).[c] ESCAP's analysis with IPCC (CMIP6) sea level projection data reveals that the sea level height is expected to increase more around the eastern part of the central atolls, including the highly populated capital city of Male and the northern atolls across all the climate change scenarios. The risk intensifies in higher emission scenarios creating even greater challenges for adaptation and mitigation (Figure 6.9)

FIGURE 6.9 **Change in global sea level since 1993, as observed by satellites (left) and sea level anomaly under baseline and climate change scenario for Maldives (right)**



Source: climate.nasa.gov

Sources : ESCAP calculations based on IPCC Interactive Atlas, 2021; Copernicus Climate Change Service, Climate Data Store, 2018 and Ministry of Environment, Climate Change and Technology, Govt. of Maldives, 2016.

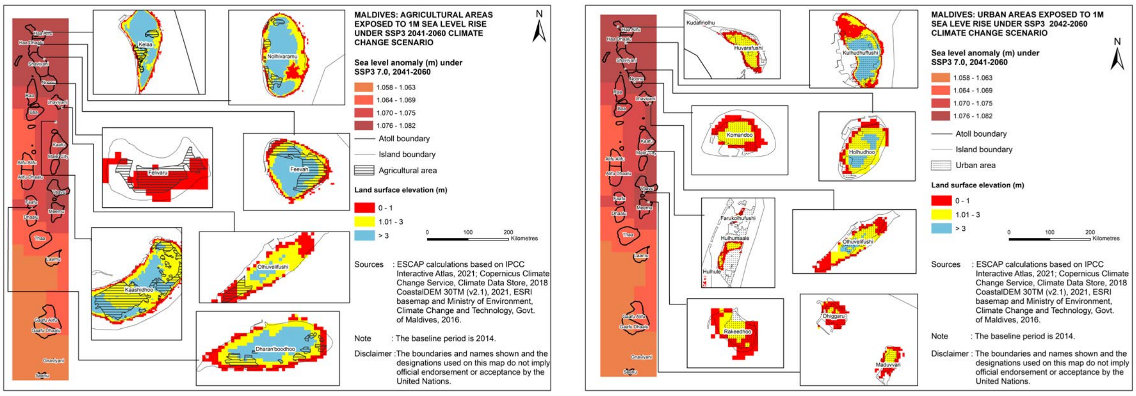
Notes : 1. Sea level anomaly referes to the height of water over the mean sea surface.
2. The baseline period is 2014.
3. Near-term period is 2021-2040.
4. Mid-term period is 2041-2060.

Disclaimer : The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

In many islands, the settlements and infrastructure are located in areas with 0-3 m elevation. Hence, in the absence of adaptation, risk is on the rise. Around 14 per cent of urban areas and 33 per cent of its population is now located below 1 m above mean sea level. They are exposed to sea level rise up to 1 m (Figure 6.10).

Similarly, although the Maldives is not an agrarian country, the agriculture policy of the country focuses on the ecological sustainability of the sector and its contribution to food security and nutrition by fostering home-grown produce.[d] With 13 per cent of agricultural lands located below 1 m of the mean sea level, it is likely that sea level rise and related flooding can have significant impacts on existing farmlands through saltwater intrusion.

FIGURE 6.10 **Agricultural areas (left) and urban areas (right) in Maldives exposed to 1 m sea level rise under climate change scenario**



Sources : ESCAP calculations based on IPCC Interactive Atlas, 2021; Copernicus Climate Change Service, Climate Data Store, 2018 CoastalDEM 30TM (v2.1), 2021, ESRI basemap and Ministry of Environment, Climate Change and Technology, Govt. of Maldives, 2016.

Note : The baseline period is 2014.

Disclaimer : The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

To address this problem, hard protection pathways have been adopted in the Maldives, for example by building seawalls and raising the heights of reclaimed lands. Yet, in the long-term these measures may become increasingly ineffective. Nature-based solutions through restoration and conservation of coastal and marine ecosystems, such as coral reefs and mangroves, can provide sustainable and economically beneficial solutions to sea level rise, coastal floods and storm surges. Hard measures, such as developing reclaimed lands higher off the ground, in combination with nature-based solutions, can be implemented provided the development is risk-informed.

[a] Global Climate Change, "Sea level", 2023. Available at https://climate.nasa.gov

[b] M. Mycoo, and others, "Small Islands", in Climate Change 2022: Impacts, Adaptation And Vulnerability, Contribution Of Working Group II To The Sixth Assessment Report Of The Intergovernmental Panel On Climate Chang, Pörtner H.-O., and others, eds. (Cambridge, UK and New York: Cambridge University Press, 2022). Available at https://www.ipcc.ch/report/ar6/wg2/chapter/chapter-15/

[c] Nasa Earth Observatory, "Preparing For Rising Seas In The Maldives", 2021. Available at Https://Earthobservatory.Nasa.Gov/Images/148158/Preparing-For-Rising-Seas-In-The-Maldives

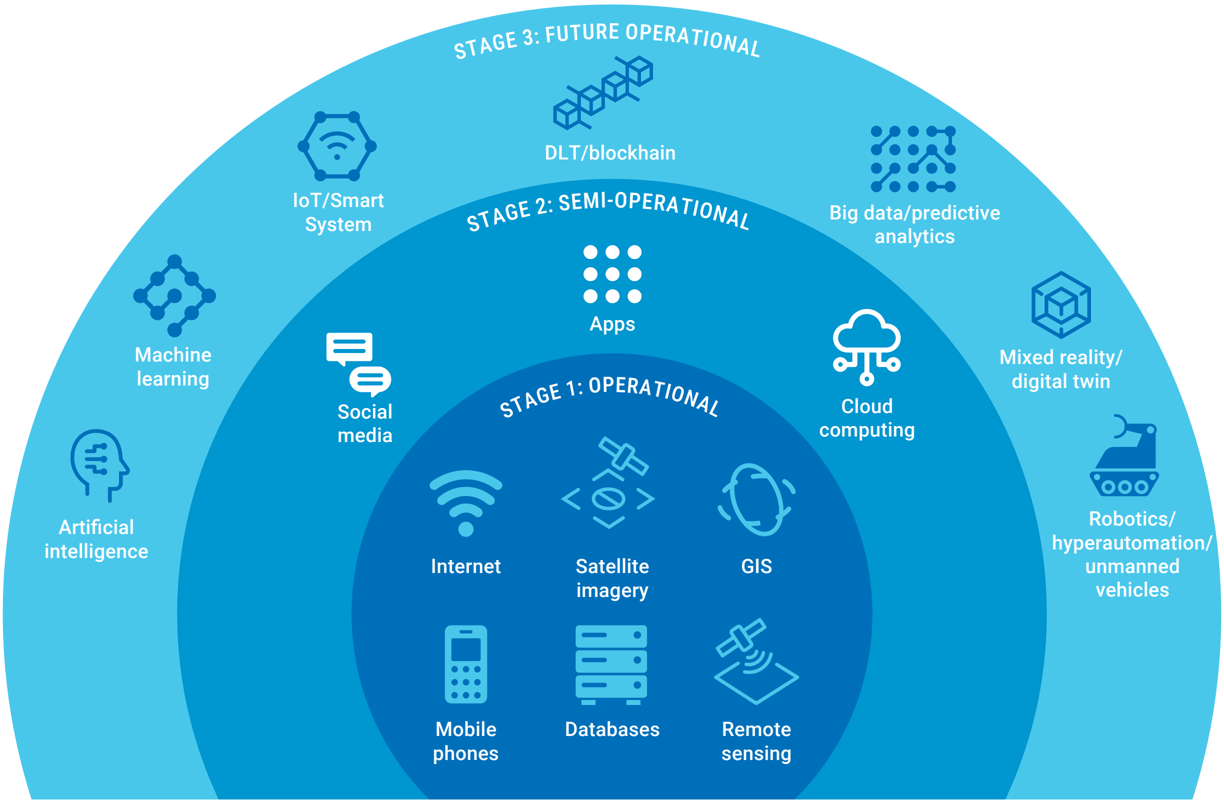
[d] Ministry of Fisheries, Marine Resources And Agriculture Of The Republic Of Maldives, and the Food and Agriculture Organization of the Unite Nations (FAO), "National Fisheries And Agricultural Policy 2019-2029", July 2019. Available at https://faolex.fao.org/docs/pdf/mdv205058.pdf

6.5 Enabling technologies for Loss and Damage estimation

The significance of digital technologies (DTs) and the expanding array of geospatial applications it makes possible, is increasing (ADB, 2021). Figure 6.11 depicts the role of DTs in three operational stages. Stage I encompasses readily accessible technologies, like the Internet and geographic information systems. Stage II includes accessible but underutilized technologies, such as social media, mobile applications, and cloud computing. Stage III refers to emerging commercial technologies like the Internet of Things (IoT), blockchain, and artificial intelligence (AI). Soon, it is expected that refined approaches for Loss and Damage assessment will be made possible through actionable Earth observation products with Stage II and III digital technology applications. Actionable earth observations products and Stage II and III digital technologies can support operationalization of Loss and Damage assessment approaches.

Some of these technologies are already being used effectively in countries in the Asia and Pacific region. These include DTs working as enablers to establish relevant connections between data sets, initiate communication among environmental sensors and databases, monitor and track ecosystem changes, analyse relevant data sets for disaster risk management, optimize sustainable supply chains, and develop highly accurate forecasting of traffic and weather phenomena. Similar to carbon trading systems, the opportunities of DT applications include decreased transaction costs and data and information protection.

FIGURE 6.11 Ecosystem of digital technologies



Source: ESCAP, adapted from Asian Development Bank (ADB), "Digital technologies for climate action, disaster resilience, and environment sustainability", October 2021. Available at https://www.adb.org/publications/digital-technologies-climate-change

By protecting people, property and ecosystems from climate-related stressors, Loss and Damage compensation measures today can help decrease present and future losses and damages. Technology is crucial, and a brief description of these technologies is given in Figure 6.12.

FIGURE 6.12 Innovations in technologies to support Loss and Damage methodologies

EWS	Early warning systems can lessen the effects of disasters by sending communities and governments early notifications.	AI	Artificial Intelligence assists and cooperate with existing technology to aid decision makers during rescue operations using real-time data.
BIM	Building information modeling is a technique that may be used to create structures that are more disaster-resistant.	UAVS	Unmanned aerial vehicles or drones are used to aid search and rescue operations as well as take high resolution pictures of disaster zones
GIS	Geographic information systems helps with mapping and analyzing hazard-prone regions to create tailored disaster risk reduction plans.	CI	During catastrophes, real-time information may be distributed and response activities can be coordinated via social media sites and crowd sourcing stems

Source: ESCAP.

1. INFORMATION TECHNOLOGY INFRASTRUCTURE

A robust information technology infrastructure and information governance approach must be established and kept up at all governmental levels to maximize data gathering, storing and analysis. This is the essential, albeit not sufficient, condition. Data collection and reporting are made easier by well-designed information technology systems, especially at the municipal level. Improved technology infrastructures can also help promote and synchronize international definitions and standardization of losses and damages data, which in turns help improve data quality on a global scale. To enhance data collection, recording and reporting at all levels, consistency and resource mobilization must be considered. The delivery of humanitarian aid and environmental governance techniques have undergone a paradigm change as a result (FCCC/CP/2013/10/Add.1; Bettini, Gioli, and Felli, 2020).

2. GEOSPATIAL DATA AND SMART EARTH TECHNOLOGY

A rising number of projects use “Smart Earth” technology to create more dynamic, responsible, and responsive risk management and response plans, although they do not necessarily specifically address Loss and Damage. The exponential expansion of sensing capabilities, data availability and big data analysis tools is opening new possibilities for anticipating, understanding, and visualizing disasters. It provides new means of repairing and recovering in the aftermath of a disaster.

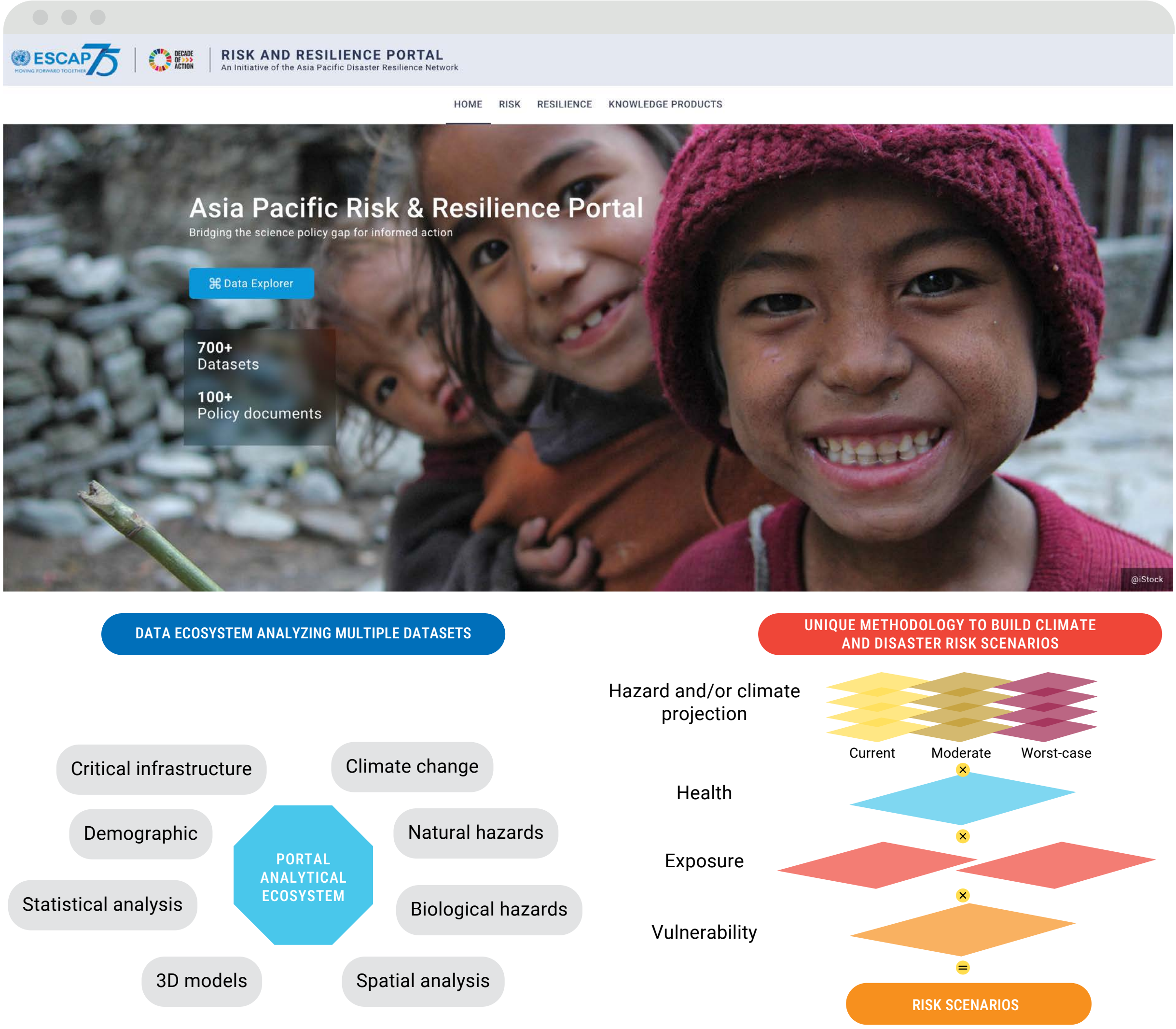
Geospatial data, remote sensing and satellite imaging are the main data sources used to assist disaster response activities (Qadir and others, 2016). Online databases are being created by several South-East Asian nations to compile data on the effects of major, minor, and recurrent catastrophes. For example, the Cambodia Disaster Loss and Damage Information System (CamDi), based on the DesInventar system, was created by Cambodia’s National Committee for Disaster Management. The system systematically gathers, stores, and evaluates data on Loss and Damage arising from catastrophe occurrences, including small and/or localized events, in over 110 countries.(ADB, 2018).

Insurers may use remote sensing technologies, such as satellites, drones, and IoT sensors to locate impacted properties, assess damage, and notify policyholders about the status of their claims before returning to the disaster-stricken region (Winkler and Rajamani, 2013). Unfortunately, putting this technology into practice on a large scale is challenging. The industry’s failure to enhance cost efficiency is a result of outdated procedures that impede the processing of claims. Yet, recent developments in remote sensing and analytics are already improving the capacity of insurers to assess damages following a catastrophe. Professionals can swiftly assess wind and flood damage by using high-resolution images from resources such as the Geospatial Insurance Consortium (Olney, 2022).

Drones, smartphone applications and communications through social media have been used to monitor and aid vulnerable populations during Cyclone Amphan (May 2020) in Bangladesh and India (De and Bandyopadhyay, 2020). AI and machine learning has been deployed in the Philippines to forecast course and strength of typhoon for impact assessment during Typhoon Goni (November 2020) (IFRC, 2023). IoT sensors and satellite images for the impact assessments of flash floods were used in Indonesia (January 2021). Drones captured high resolution images, replacing the longer process of receiving satellite images, during the 2019-2020 Australian forest fires. These are just some examples of how innovations in technologies are supporting post-disaster needs assessment efforts (Mechler and others, 2019).

A number of digital platforms have also been established. For example, for Loss and Damage, ESCAP’s Asia Pacific Risk and Resilience Portal discussed above, offers comprehensive information on the probable economic and social effects of natural catastrophes as one of its primary characteristics (Figure 6.13) (ESCAP, n.d.). The portal can calculate the number of individuals most likely to be impacted by a certain danger, the degree of infrastructure and property damage, and the financial resources required for recovery and restoration.

FIGURE 6.13 ESCAP Risk and Resilience Portal to support sectoral Loss and Damage assessment for climate hazards



Source: United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), Asia Pacific Risk and Resilience Portal, n.d. Available at https://rrp.unescap.org/

In the successful implementation of digital technologies in countries, it is crucial to establish an enabling environment and robust information governance. This involves governance structures with visible leadership support, the establishment of standards, and adherence to compliance measures. Additionally, ensuring that individuals possess the necessary capacities, skills, and responsibilities is vital. Adequate training and capacity-building initiatives should be in place to equip people with the skills required to effectively utilize digital technologies. Furthermore, a crucial part in maximizing the effectiveness of these technologies is played by well-defined processes with quality control mechanisms, documented procedures, and continuing assistance. By addressing these key components of an enabling environment and information governance, countries can create the necessary foundation for successful implementation and utilization of digital technologies.

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Way forward

Seizing the moment: protecting our future

The world faces a disaster emergency, yet nowhere is the threat more immediate than in Asia and the Pacific. The grim tally of disaster related deaths would inevitably rise, as would the annual cost of disaster related losses. To avoid this exponential growth of disaster risk, there is a narrow window of opportunity to increase resilience and protect hard won development gains. To seize the moment, four strategic actions are needed. They can no longer be postponed.

1. Greater investment in multi-hazard early warning systems must be a priority. Expanding coverage in the least developed countries is the most effective way to reduce the number of people killed. Multi-hazard early warning systems can shield people living in disaster risk hotspots and reduce disaster losses everywhere by up to sixty per cent. They provide a tenfold return on investment. To protect food systems and reduce the vulnerability of energy infrastructure - the backbone of our economies - sector specific coverage is needed.
2. Nature-based solutions should be at the heart of mitigation and adaptation strategies. They support the sustainable management, protection, and restoration of degraded environments, while reducing disaster risk.
3. Only transformative adaption can deliver the systemic change needed to leave no one behind in multi-hazard risk hotspots as well as avert, minimize, and address the disaster related loss and damage. Such change will cut across policy areas such as aligning social protection and climate change interventions, comprehensive disaster and climate risk management approaches, and capitalizing on innovations in technologies and climate science.
4. Disaster risk financing needs to be dramatically increased and innovative financing mechanisms scaled up. In a constrained fiscal context, we must remember that investments made upstream are far more cost-effective than spending after a disaster has occurred. We must tap innovative financing mechanisms to close the gap.

Now is the time to work together, to build on innovation and scientific breakthroughs to accelerate transformative adaptation across the region. A regional strategy which supports early warnings for all is needed to strengthen cooperation through the well-established United Nations mechanisms, and in partnership with subregional intergovernmental organizations. The United Nations 2030 Agenda for Sustainable Development can only be achieved if we ensure disaster resilience is never outpaced by disaster risk. Let us seize the moment and protect our future in Asia and the Pacific.

Extreme weather events and natural hazards have become more frequent and intense. Asia and the Pacific remains the most disaster-prone region in the world where 2 million people have lost their lives to disasters since 1970.

The *Asia-Pacific Disaster Report 2023* demonstrates that the existing disaster risk hotspots are forecasted to face more frequent and intense disasters and new risk hotspots are expected to emerge.

To protect people and the development gains, the Report urges for transformative adaptation measures, including increased investments in multi-hazard early warning systems, innovation and scientific breakthroughs capable of advancing early warnings and nature-based solutions.

In the absence of immediate action, temperature rises of 1.5°C and 2°C will cause disaster risk to outpace resilience beyond the limits of feasible adaptation and imperil sustainable development. The Report makes the case for scaling up regional cooperation to ensure disaster resilience is never outpaced by disaster risk in Asia and the Pacific

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