The Disaster Riskscape Across Asia-Pacific

PATHWAYS FOR RESILIENCE, INCLUSION AND EMPOWERMENT

Asia-Pacific Disaster Report 2019

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Foreword

The Asia-Pacific region continues to be hit by a relentless sequence of disasters: cyclones, earthquakes, tsunamis, floods, droughts, dust storms and heatwaves. These disasters can strike anyone, anywhere, but they do their greatest damage in the poorest communities — often those of minority groups, or of people living in remote areas, or in the fragile marginal zones of the region's rapidly expanding cities.

Countries across the region have committed themselves to the Sustainable Development Goals (SDGs) by 2030 — to ensure that 'no one is left behind'. But they cannot achieve many of the SDG targets if their people are not protected from disasters that threaten to reverse hard-won development gains. This means not just building resilience in the priority zones but doing so across the entire 'riskscape'— reaching the most marginal and vulnerable communities.

This *Asia-Pacific Disaster Report* shows that more of today's events are linked to environmental degradation and climate change. This is generating disasters of increasing complexity and uncertainty. Taking slow onset disasters into account, economic losses due to disasters quadruple as compared to estimates in previous editions. The report shows key hotspots emerging where fragile environments converge with critical socioeconomic vulnerabilities — thus making it much more likely that disasters will transmit poverty, marginalization and disempowerment across generations. In these hotspots, disasters are closely linked to poverty and inequality of income and opportunity.

The report gives empirical evidence of how disasters impact health, employment, and education of the most vulnerable populations leading to a vicious downward cycle. However, this is not inevitable. Governments can break this vicious cycle by investing to outpace disaster risk and the report shows that investments will inevitably be large, though far smaller than the damage and losses from unmitigated disasters. Moreover, these same investments will deliver co-benefits — in the form of better education, health, social and infrastructure services, and higher agricultural production and incomes.

Disaster resilience can also benefit from rapid advances in technology. Even the poorest countries can be empowered by smart digital technologies. Artificial intelligence and big data techniques, for example, can build a live picture of rapidly developing events by merging satellite imagery with data from mobile phones. At the same time, digital identity systems can offer more ways to deliver essential social protection services, before, during and after disasters.

This report also points out that many of the region's disaster hotspots extend across national boundaries. Dust storms can easily sweep on to neighbouring countries, and floods in one country can soon rush on to others downstream. This underlines the importance of regional cooperation both to monitor the evolution of disasters and to work together across the riskscape to mitigate the impacts and build cross-border resilience. For example, partnership between ESCAP and ASEAN is mobilizing Member States towards the development of an ASEAN strategy on drought resilience to reduce the impacts of drought, protect the poorest communities and foster harmonious societies.

We hope that this *Asia-Pacific Disaster Report* will illuminate and inform this critical effort — demonstrating the scale of this important task, but also identifying the wide range of potential solutions.

Armida Salsiah Alisjahbana
Under-Secretary-General of the United Nations and Executive Secretary of ESCAP

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Members of the core drafting team led by Sanjay Srivastava, Chief, Disaster Risk Reduction Section, IDD, consisted of Kareff Rafisura, Madhurima Sarkar-Swaisgood and Sanjay Srivastava (lead authors), Maria Bernadet K. Dewi, Laura Hendy, Hyun-mi Kang, Yuki Mitsuka and Jiwon Seo (co-authors).

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Executive Summary

Understanding risk is at the heart of building resilience to disasters. The *Asia-Pacific Disaster Report 2019* presents a new analysis of the regional "riskscape" and pathways for managing the risk for "Empowering people and ensuring inclusiveness and equality" – the theme of the 2019 High Level Political Forum on sustainable development.

Slow-onset disasters account for nearly two thirds of disaster losses in the region. The *Report* captures a comprehensive picture of the complexity of disaster risk in the Asia-Pacific region for the first time. It is revealed that annualized economic losses more than quadruple to USD $675 billion when slow-onset disasters are added to the region's riskscape.

The intensification and changing geography of disaster risks signal a new climate reality. Hazards are deviating from their usual tracks and becoming more intense, creating greater complexity and deep uncertainty that are harder to predict. The region is not sufficiently prepared for this climate reality. It has experienced unprecedented flooding in Iran, in March 2019, and in the state of Kerala in India, in August 2018. There was unusual cyclone activity as cyclone Ockhi developed near the equator in December 2017, and the lasting impacts of cyclone Gita affected eight Pacific Island countries. Furthermore, quick succession of flooding and heatwaves were experienced in Japan in July 2018, and collisions of sand and dust storms, with thunderstorms raged across the Persian Gulf, the Arabian Sea and the Bay of Bengal in May 2017. The Sulawesi and Sunda Strait tsunamis in Indonesia, in 2018, presented the complexity of near field tsunami risks.

The Asia-Pacific region is facing complex disaster risks clustered around hotspots. Report identifies four distinct hotspots where fragile environments are converging with critical socioeconomic vulnerabilities. The first is located within the transboundary river basins of South and South-East Asia, where poverty, hunger and under-nourishment are coupled with exposure to intensifying floods that alternate with prolonged droughts. The second surrounds the Pacific Ring of Fire, where transport and ICT infrastructure and poor populations are exposed to typhoons and tectonic hazards. The third is the Pacific Small Islands Developing States (SIDS), where vulnerable populations and critical infrastructures are exposed to climate-related hazards of increasing intensities. A person in Pacific SIDS is found to be three to five times more at risk than those in other parts of the region.

Disasters widen inequalities in outcomes and opportunities and slow down poverty reduction. The *Report* demonstrates that losses due to disasters will undermine the ability of economic growth to reduce poverty and inequality by 2030, by widening inequalities in outcomes and opportunities and disempowering at-risk communities. The Report shows that a 1 percentage point increase in exposure to climate events increases the Gini coefficient by 0.24, increases under-five mortality rates by 0.3, and decreases education rates by 0.26 percentage points, respectively.

The *Report* also highlights groups with intersecting vulnerabilities. By geo-locating the most disadvantaged people, it shows that in many countries, poor households depending on agriculture employment are more likely to also be situated in high multi-hazard risk areas and are therefore not only the hardest hit but also excluded and disempowered. Almost 40 per cent of disaster impacts are on the social sectors of health, education, and livelihoods, resulting in deeper inequalities of opportunity that are transmitted over generations. This creates a vicious cycle of poverty, inequality and disasters, which must be broken to prevent disasters from reversing hard-won development gains.

Inclusive investments can outpace disaster risk. The links between poverty, inequalities and disasters can be broken. This will require transformative change, with social policies and disaster resilience no longer treated as separate policy domains. The Report highlights how a comprehensive portfolio of risk-informed investments in social sectors may reduce the numbers of people living in extreme poverty across 26 countries that contain 90 per cent of the region's population. With disaster risk, 119 million people are projected to be living in extreme poverty in these countries in 2030. However, investing in line with global averages in education, health and social protection will bring this number down, to 80 million, 69 million and 53 million, respectively.

Investments in resilience deliver important social co-benefits. While financing additional investments presents a significant challenge, the additional amounts are small compared to the costs incurred from disasters. Furthermore, policymakers can enhance the quality of investments through policy reforms for more inclusive and empowered societies, to ensure that poor and vulnerable groups are not excluded from the benefits of investments due to barriers in accessing land, reliable early warning systems, finance, and decision-making structures. The *Report* showcases examples of innovative risk-informed social policy and pro-poor disaster risk reduction measures that can be replicated throughout the region. The approaches advocated in this *Report* may also deliver co-benefits through better education, health, social and infrastructure services, higher agricultural production and incomes.

Big data innovations help mitigate the challenges of climate reality. Big data innovations, using the large data sets from mobile phone tracking to satellite platforms, reveal patterns, trends, and associations of the complex disaster risks. The use of risk analytics: descriptive, predictive, prescriptive and discursive, helps understand, monitor and predict the risk of both extreme as well as slow onset events, and thus addresses the key challenges of the new climate reality. The substantial reductions in mortalities and economic losses due to typhoons in North and East Asia can be attributed to big data applications that enabled impact-based forecasting and risk-informed early warning. For example, the devastating potential of super typhoon Mangkhut (2018) was minimized by Big Data applications. Further opportunities are available in flood forecasting, a recent innovation in ensemble prediction systems. Machine learning can also be used to accurately predict the location and severity of floods.

Emerging technologies hold unprecedented promise for inclusion and empowerment. Official data collection systems often exclude the most vulnerable who are hardest to reach and empower. The report presents how Big Data, digital identity systems, risk analytics and geospatial data reduce the barriers in information flows to include and empower at risk communities. For example, direct benefit transfer was targeted and delivered to millions of drought-affected small and marginal farmers through digital identity system and risk analytics, which demonstrates its transformative capacity for inclusion and empowerment. Similarly, these systems use satellite data and computer-based flood models and deliver index-based flood insurance pay-outs to small and marginal farmers. Nevertheless, new technologies bring new risks, including algorithmic bias and issues of privacy and cybersecurity. It is vital that vulnerable, marginalized groups are protected from these risks, so that everybody can benefit from this rich, new source of information and knowledge.

We must seize the opportunities for action. Countries have committed themselves to achieving the Sustainable Development Goals (SDGs) by 2030, to ensure that 'no one is left behind'. This cannot be achieved unless Governments utilize new opportunities for breaking the vicious cycle between poverty, inequalities and disasters. Governments must implement risk-informed policies and investments supported by emerging technologies to empower the most vulnerable populations across the riskscape.

Ultimately regional cooperation is required to reinforce national efforts. ESCAP can support this through the Asia-Pacific Disaster Resilience Network (APDRN), which will pool the strengths of the region to address transboundary disasters as all countries of the region adjust to the new climate reality.

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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; Turkey; 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 Turkey

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; Tuvalu and Vanuatu. Samoa was part of the least developed countries prior to its graduation in 2014

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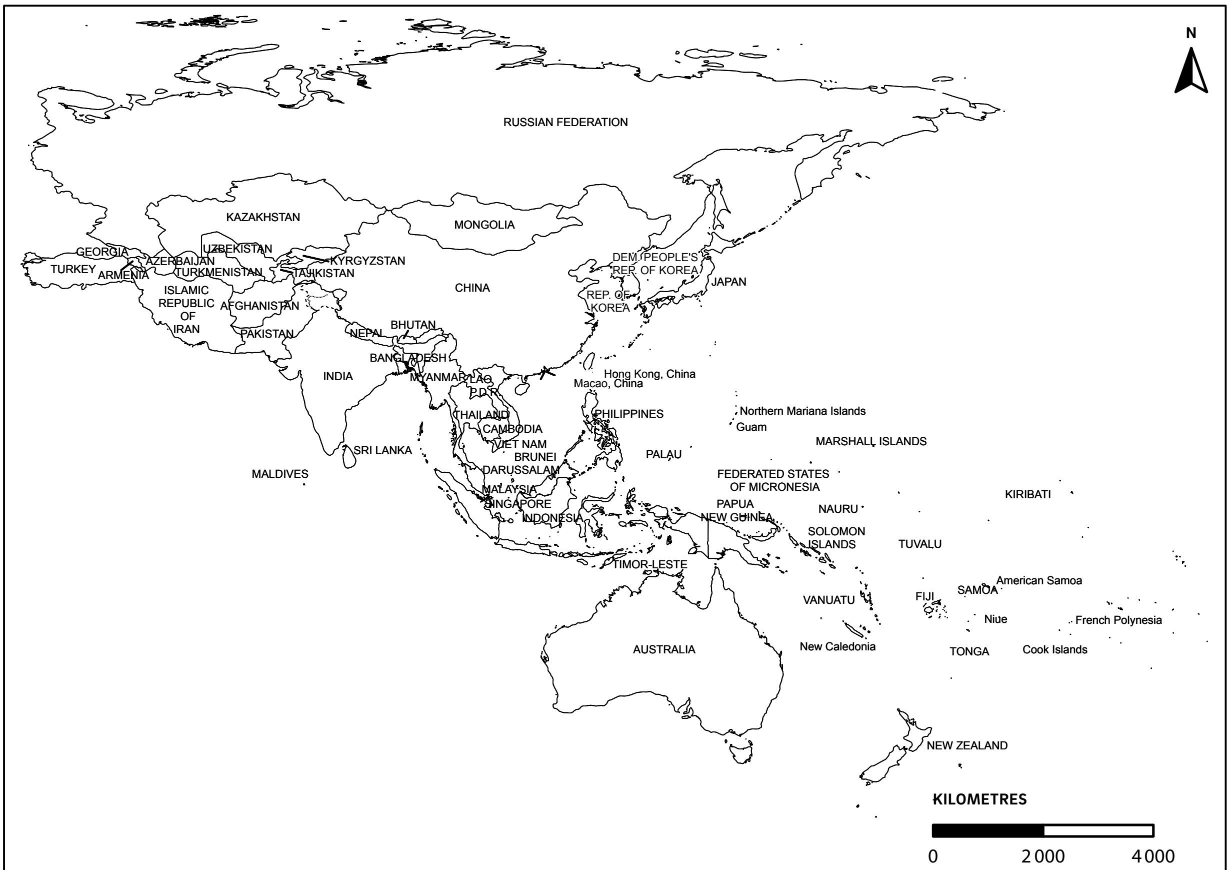
References to dollars ($) are to United States dollars, unless otherwise stated. The term "billion" signifies a thousand million. The term "trillion" signifies a million million.

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



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Acronyms and Abbreviations

AAL	Average Annual Loss
ACCCRN	Asian Cities Climate Change Resilience Network
ADB	Asian Development Bank
AHA Centre	ASEAN Coordinating Centre for Humanitarian Assistance on disaster management
AI	Artificial intelligence
APDIM	Asian and Pacific Centre for Development of Disaster Information Management
APDRN	Asia-Pacific Disaster Resilience Network
APFSD	Asia-Pacific Forum for Sustainable Development
ASEAN	Association of Southeast Asian Nations
CCA	Climate Change Adaptation
CCI	Climate Change Initiative (European Space Agency)
CGE	Computable General Equilibrium model
CMA	China Meteorological Administration
DART	Deep-ocean Assessment and Reporting of Tsunamis
DHS	Demographic and Health Survey
DLR	German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt)
DRFS	Disaster-related Statistics Framework
DRR	Disaster Risk Reduction
EM-DAT	Emergency Events Database
ENEA	East and North-East Asia (ESCAP Sub-region)
ESCAP	Economic and Social Commission for Asia and the Pacific
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GADRRRES	Global Alliance for Disaster Risk Reduction and Resilience in the Education Sector
GBM	Ganges-Brahmaputra-Meghna
GDACS	Global Disaster Alerting Coordination System
GDP	Gross domestic product
GFDRR	Global Facility for Disaster Reduction and Recovery (World Bank)
GIS	Geographic information system
GPS	Global Positioning System
HDI	Human Development Index
HLPF	High-level Political Forum on Sustainable Development
ICHARM	International Centre for Water Hazards and Risk Management
ICT	Information and communications technology
IoT	Internet of things
IPCC	Intergovernmental Panel on Climate Change
JMA	Japan Meteorological Agency

LAPAN	Indonesia National Institute of Aeronautics and Space
LDC	Least Developed Countries
LIDAR	Light Detection and Ranging
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration (United States)
NCA	North and Central Asia (ESCAP Sub-region)
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration (United States)
OFDA	Office of United States Foreign Disaster Assistance
PDNAs	Post-Disaster Needs Assessments
RIMES	Regional Integrated Multi-hazard Early Warning System for Asia and Africa
SDGs	Sustainable Development Goals
SEA	South-East Asia (ESCAP Sub-region)
SIDS	Small Island Developing States
SME	Small and Medium Enterprise
SSWA	South and South-West Asia (ESCAP Sub-region)
UAVs	Unmanned aerial vehicles
UHC	Universal Health Care
UNCCD	United Nations Convention to Combat Desertification
UNCDF	United Nations Capital Development Fund
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO-IOC	Intergovernmental Oceanographic Commission of UNESCO
UN-GGIM	United Nations Global Geospatial Information Management
UN-GGIM-AP	United Nations Global Geospatial Information Management for Asia and the Pacific
UNICEF	The United Nations Children's Fund
UNDRR	United Nations Office for Disaster Reduction
UNITAR-UNOSAT	United Nations Institute for Training and Research- UNITAR Operational Satellite Applications Programme
UNOPS	United Nations Office for Project Services
USAID	United States Agency for International Development
WFP	World Food Programme
WHO	World Health Organization
WMO	World Meteorological Organization
WRI	World Resources Institute


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CHAPTER 1

The Asia-Pacific disaster riskscape

The Asia-Pacific region faces a daunting spectrum of natural hazards. The extent of disaster risk can be represented in the regional 'riskscape'. This comprehensive analysis takes into account all types of disaster — intensive or extensive, rapid or slow-onset. It shows that many of the region's disasters are linked to environmental degradation and to climate change, leading to a more complex future of unpredictable multi-hazard risks.

The Asia-Pacific regional riskscape presented in this chapter uses a probabilistic risk model that builds on a global model originally produced for the United Nations Office for Disaster Risk Reduction (UNDRR), and subsequently developed by Economic and Social Commission for Asia and the Pacific (ESCAP) with partners.[1] It estimates the risk of earthquakes, tsunamis, floods, tropical cyclones and storm surges, as well as for the first time that of slow-onset hazards such as drought. In the case of drought, there is not a full probabilistic drought risk model for the region, so the analysis identifies those countries at the greatest risk and estimates the region's agricultural drought.

Intensive risk

Intensive disaster risk refers to high-severity, mid- to low-frequency disasters, such as earthquakes, tropical cyclones, riverine floods and tsunamis. The extent of the total risk is represented by the absolute average annual loss (AAL) in US dollars. For the region as a whole, the multi-hazard AAL is $148,866 million, which represents 54 per cent of global multi-hazard risk. Of this, 34 per cent is contributed by earthquakes, 33 per cent by riverine floods, 32 per cent by tropical cyclones, and 2 per cent by tsunamis. The highest AAL is concentrated in higher-income countries, notably Japan with 40 per cent, and China with 18 per cent.

Earthquakes — The costliest events are generally earthquakes, particularly in developed areas. Of the region's total earthquake AAL, 64 per cent is in Japan and 14 per cent in China. Other countries with a significant proportion of the region's earthquake AAL include the Islamic Republic of Iran, Turkey, Indonesia and the Philippines. However, the countries with the highest earthquake risk are Kyrgyzstan, Tajikistan, Georgia, Afghanistan and the Islamic Republic of Iran.

Floods — Of the total flood AAL, China represents 28 per cent and India 13 per cent, followed by the Russian Federation at 9 per cent and Australia at 7 per cent. Other countries with a significant proportion of the region's flood AAL include Japan, Bangladesh, Thailand, Viet Nam, Indonesia and the Republic of Korea. The countries with the highest flood risk are Myanmar, Lao People's Democratic Republic, Cambodia and Bangladesh.

Tropical cyclones — Japan represents 47 per cent of the total tropical cyclone AAL, followed by the Republic of Korea at 16 per cent, Philippines 14 per cent and China 13 per cent. The countries with the highest tropical cyclone risk are Tonga, Vanuatu, Palau, Philippines and Fiji.

Tsunamis — Japan represents 91 per cent or the total tsunami AAL, whilst Australia and Indonesia both represent 2 per cent each. The highest tsunami risk is in Tonga, Palau and the Philippines.

Extensive risk

Extensive risk refers to low-severity but high-frequency hazardous events. These risks which are generally highly localized cannot be modelled analytically at the global or regional scale. But evidence from countries where extensive risk has been modelled suggest that such risk could increase the total multi-hazard AAL by between 10 and 50 per cent. Assuming an average of 30 per cent, then the total multi-hazard risk for the Asia-Pacific region would rise to $193,525 million.

These estimates refer only to direct losses. A methodology developed by the UN Economic Commission for Latin America and the Caribbean indicates that direct losses normally represent only 30 to 40 per cent of total losses. Applying this assumption to the Asia-Pacific region the total average annual loss, including indirect losses, would rise to $270,936 million — representing 1 per cent of the region's gross domestic product (GDP). However, in individual countries it can be much higher. In Small Island Developing States (SIDS), such as Vanuatu, the total loss represents 15 per cent of GDP, and in Tonga 14 per cent. In larger countries, like Myanmar, it represents 6 per cent and in the Philippines 5 per cent. In these and other countries disaster risk is a very severe drag on economic development.

Slow-onset risk

Risk can also be widespread, slow-onset and creeping — notably as it occurs during drought. As yet there are no probabilistic hazard estimates for Asia and the Pacific. However, other measures can be used as proxies — such as those related to agriculture, the sector in which drought has the greatest impact (Box 1-1). The countries most exposed are those that depend on agriculture for a high proportion of their GDP — notably India at 17 per cent, Pakistan at 26 per cent and Viet Nam at 17 per cent. In China, agriculture is only 9 per cent of total GDP — though this still amounts to $890,000 million.

Another proxy for exposure to drought is the proportion of the population living in rural areas, which is generally associated with labour-intensive, low-productive agriculture and a high degree of rural poverty. On this basis, Nepal, Tajikistan, Lao People's Democratic Republic and Afghanistan are likely to be more vulnerable.

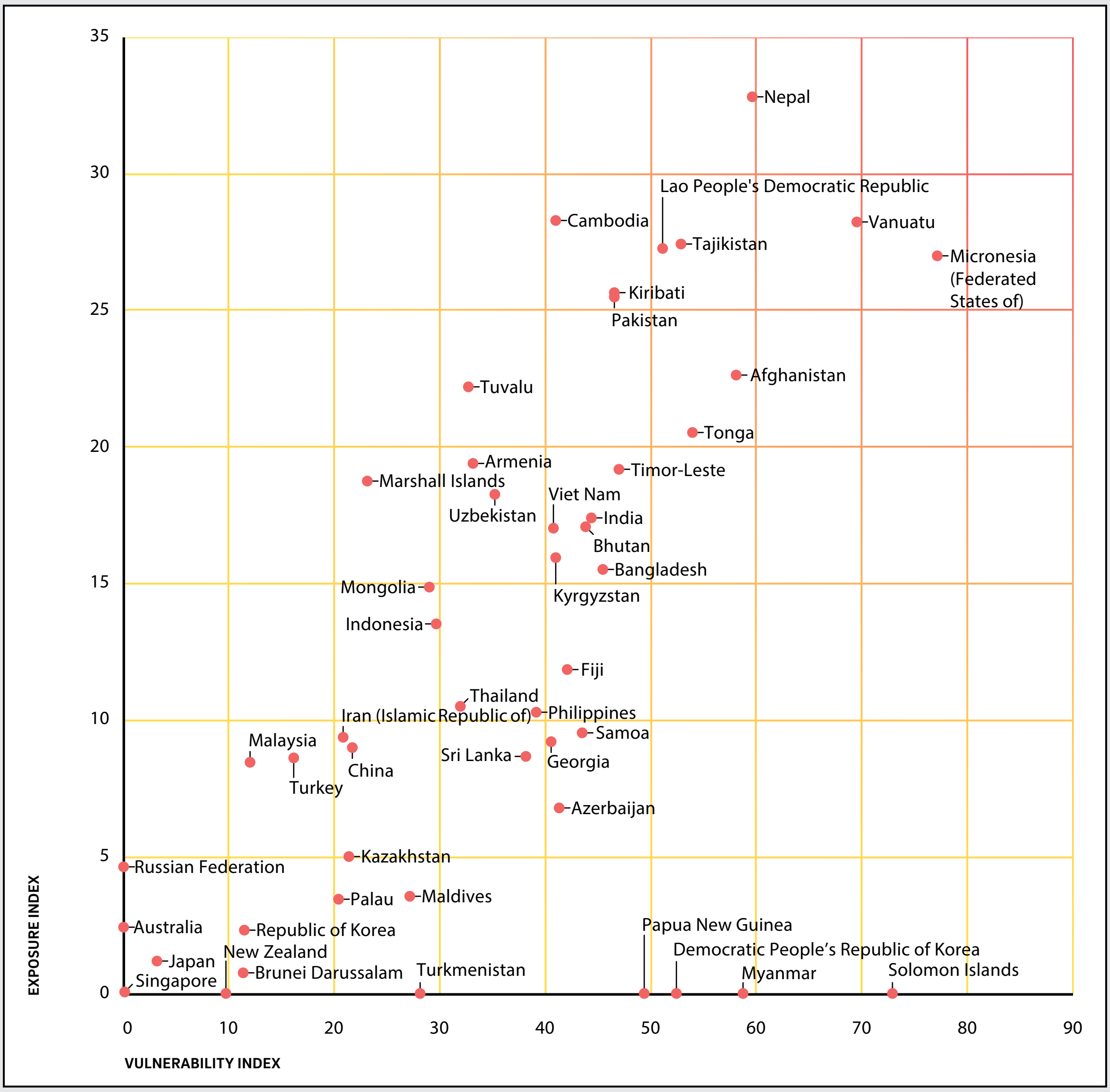
The risks from drought in agriculture are often high in SIDS. But the risk also extends to larger countries, such as Afghanistan, Bangladesh, Cambodia, India, Lao People's Democratic Republic, Nepal, Pakistan, Tajikistan and Timor-Leste — countries with large agricultural sectors and large rural populations with high levels of poverty.

BOX 1-1 Average annual loss from agricultural drought

Droughts differ from most other natural hazards in that their effects often accumulate slowly over an extended period, in some cases several years, and they can spread over large geographical areas with impacts that are difficult to measure. Assessing drought risk to the agricultural sector requires detailed knowledge of the types of agricultural products and their distribution, as well as of climate dynamics. It is important to note that agricultural drought AAL is not directly comparable with the multi-hazard AAL in the built environment as it represents a proportion of economic flow (GDP) rather than capital stock.

The values for agricultural drought AAL are obtained from a rough proxy estimate which indicates that in many countries it is of equal or greater importance than the AAL from rapid-onset hazards. One proxy of the exposure of the agricultural sector to drought is the ratio of agricultural GDP to total GDP. To account for vulnerability, a 'vulnerability index' is proposed, comprising the proportion of the population in rural areas, the extent of rural poverty and proportion of employment in the agricultural sector. The Box 1-1 shows a scatter plot of the exposure index to the vulnerability index, indicating propensity of countries to the impacts of droughts.

BOX 1-1 Vulnerability index and exposure index of countries in Asia and the Pacific



Source: ESCAP, based on probabilistic risk assessment.

Other global regions have carried out probabilistic drought risk assessments and estimated the drought AAL at a maximum of 20 per cent of the agricultural GDP. Using this as a proxy value for Asia and the Pacific, the agricultural drought AAL of the region would be $404,479 million, around 1.4 per cent of the region's GDP. If the agricultural drought AAL is added to the total risk (direct + indirect) then the total regional AAL rises to $675,415 million or 2.4 per cent of regional GDP (Table 1-1). The regional riskscape for agriculture drought constitutes 60 per cent of the annualized average (Figure 1-1). The methodological details for AAL are in Annex 1.

Countries can be ranked in terms of total multi-hazard AAL. On this basis, the five countries at greatest risk are Japan, China, Republic of Korea, India, and the Philippines. But the geography of risk changes when slow-onset disasters are added. The new order is led by China, followed by Japan, India, Indonesia, and Republic of Korea (Figure 1-2).

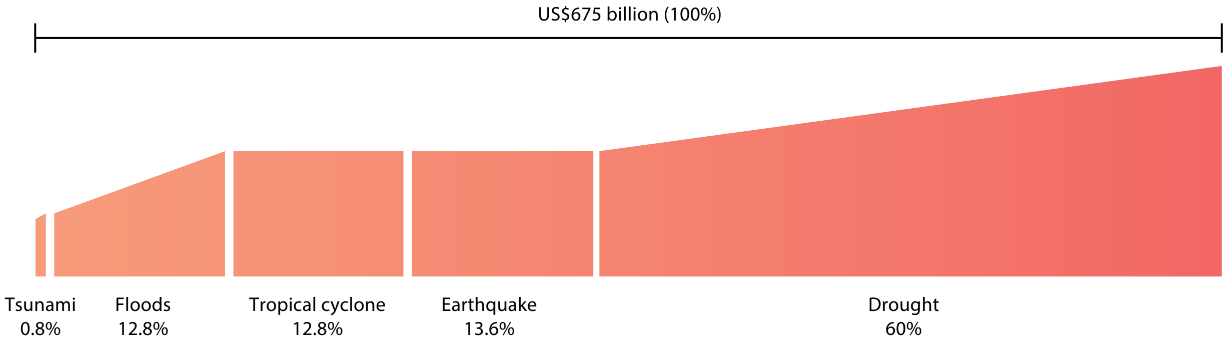
TABLE 1-1 Disaster risk in Asia and the Pacific (AAL, millions of US dollars)

SOURCE OF RISK	AAL	PROPORTION OF REGIONAL GDP
Intensive risk — multi-hazard AAL	148,866	0.5%
Extensive risk — multi-hazard AAL	193,525	0.6%
Extensive risk — multi-hazard AAL including indirect losses	270,936	0.9%
Agricultural drought AAL	404,479	1.4%
Total — including intensive, extensive, direct and indirect loses, and agricultural drought	675,415	2.4%

Source: ESCAP, based on probabilistic risk assessment and ESCAP, 2019.

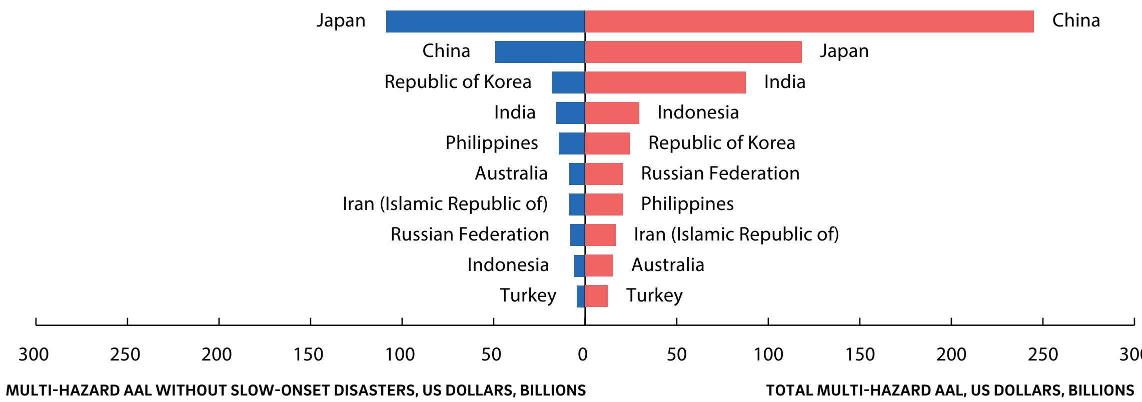
There are also many countries, including China, India, Indonesia, Pakistan and Turkey where the agriculture AAL represents more than 80 per cent of the total AAL. Thus, to obtain a complete picture of the risk to economic and social development it is important to estimate the drought risk in agriculture. This is particularly critical where agriculture also represents

FIGURE 1-1 Asia-Pacific regional riskscape (average annual losses) — volumetric analysis



Source: ESCAP based on probabilistic risk assessment.
Note: Volumetric analysis is a measurement by volume (impacted population, geographical area and economic losses).

FIGURE 1-2 Riskscape in numbers (AAL, billions of US dollars)



Source: ESCAP, based on probabilistic risk assessment.

a large part of the total GDP and employment, as in Cambodia, Lao People's Democratic Republic, Nepal, Pakistan and Tajikistan.

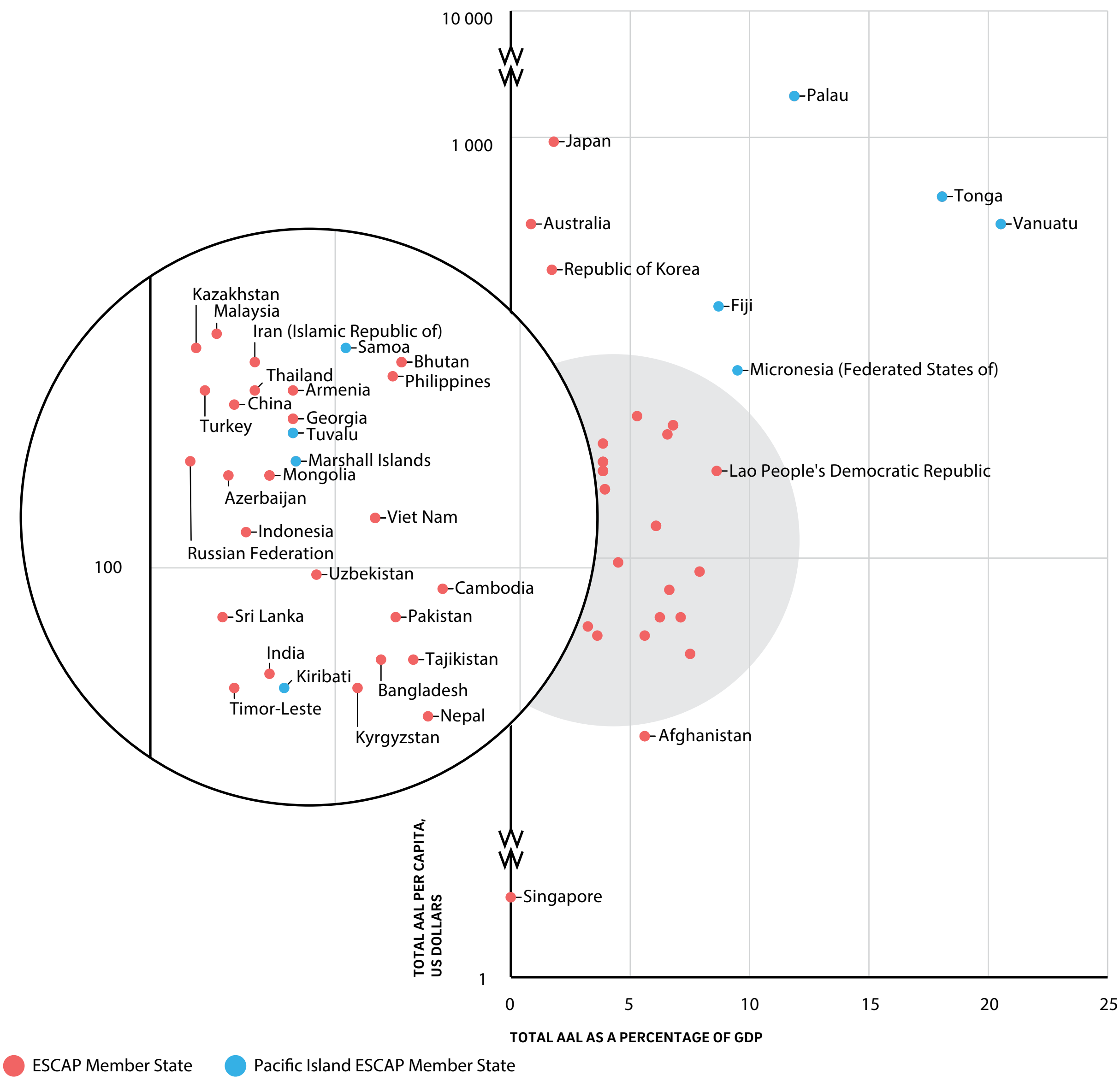
The ratio of total multi-hazard AAL with a country's population and national GDP presents at risk population and economy scenarios. The analysis indicates that Pacific SIDS, such as Vanuatu, Tonga, and Palau are in the extreme range of population and economies at risk. A person in Pacific SIDS is three to five times more at risk than a person in South-East and South Asia. Most of the least developed countries, such as Bangladesh, Bhutan, Cambodia, Nepal and others, have relatively large numbers of both; at risk population and economies (Figure 1-3).

A year of surprises in historical context

In 2018, almost half of the 281 natural disaster events worldwide occurred in Asia and the Pacific and the region witnessed eight of the ten deadliest natural disasters.[2] The most devastating were earthquakes and tsunamis. Even though there were no mega-disasters there were still major events.[3]

Climate change and its associated extreme weather events have added a complexity to disasters that is creating deep uncertainty. To be sure, enhanced technology and greater data availability have made

FIGURE 1-3 Distribution of AAL per capita and as a percentage of GDP



Source: ESCAP, based on probabilistic risk assessment, GDP and population data of ESCAP from 2017.
Note: Logarithmic scale is used for the Y axis.

many disasters more predictable. However, recent disasters, especially those triggered by climate change have deviated from the usual tracks, making it difficult to apply historical records for their analysis and to respond with adequate disaster management. It is now more difficult to determine which areas should prepare for what kind of disaster. As a result, non-prepared areas can suddenly be hit — as with floods even in Japan (Box 1-6).

Fatalities

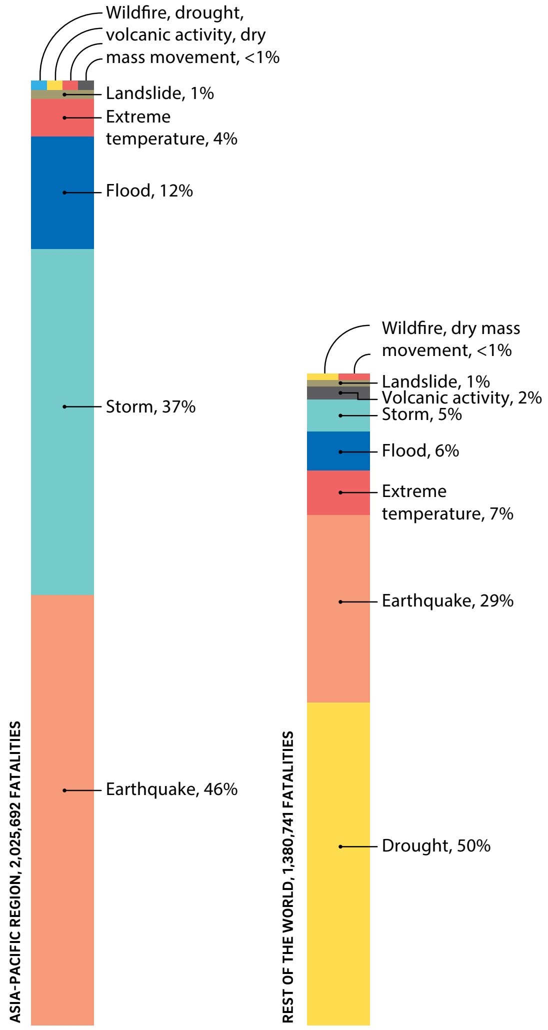
Since 1970, natural disasters in Asia and the Pacific have killed two million people — 59 per cent of the global death toll. In the rest of the world, the average number of fatalities per year was 28,730 but in Asia and the Pacific it was much higher at 42,000. As indicated in Figure 1-4, the principal causes of natural disaster deaths were earthquakes and storms, followed by floods. Floods have also taken a greater share of fatalities over this period, with multiple incidences occurring in Afghanistan, China, the Democratic Republic of Korea, India, Japan, Lao People's Democratic Republic and other countries, in 2018.

In the rest of the world the pattern was different: the death toll was lower, and the principal killer was drought, followed by earthquakes. There was a major earthquake in Mexico, while in Europe and the Americas an increasing share of fatalities was from extreme temperature. The rest of the world also saw more epidemics — of cholera, malaria, and meningococcal meningitis, as well as the Ebola outbreak in Africa, in 2014. Globally, the number of fatalities decreased in 2018 due to, among other things, better disaster management, prevention and increased early warning capacity.

People affected

Although fewer people have been dying from natural disasters in Asia and the Pacific, there has been an increase in the number of people affected. Affected refers to "people requiring immediate assistance during a period of emergency i.e. requiring basic survival needs such as food, water, shelter, sanitation and immediate medical assistance."[4] Between 1970 and 2018, the Asia-Pacific region, with 60 per cent of the global population, nevertheless had 87 per cent of the people affected by natural disasters. Over this period, the average number of people affected annually in Asia and the Pacific was 142 million compared with 38 million in the rest of the world (Figure 1-5).

FIGURE 1-4 **Fatalities from natural disasters, 1970–2018**

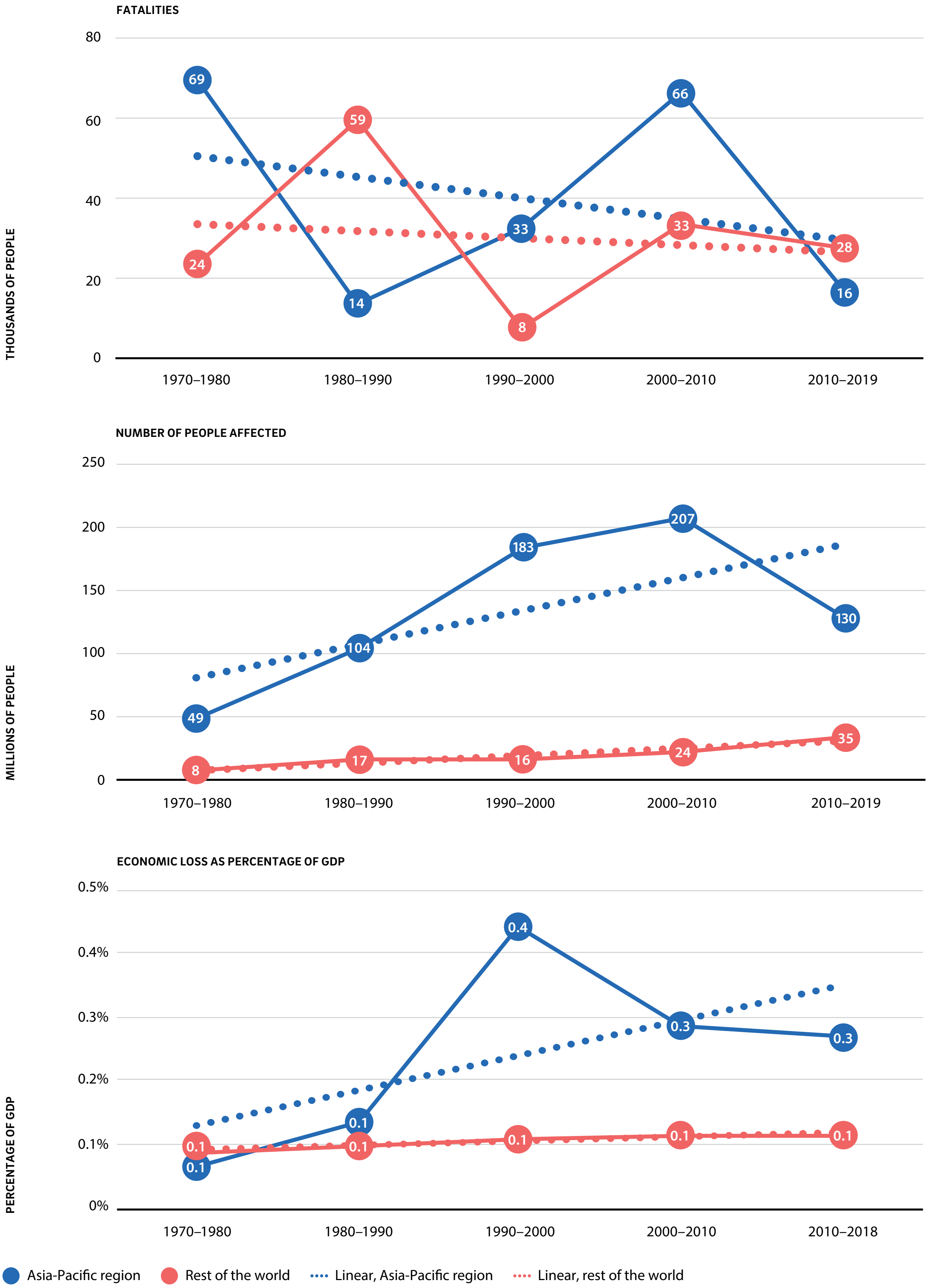


Source: Based on data from EM-DAT (Accessed on 30 May 2019).
Note: From 1990, including data from countries of the former Soviet Union.

Economic losses

Disasters also caused large-scale economic damage — measured in current US dollars as the "value of all damages and economic losses directly or indirectly related to the disaster."[5] Between 1970 and 2018, the region lost $1.5 trillion, mostly as a result of floods, storms and droughts, and earthquakes including tsunamis.[6] The cost of damage has been rising. This is partly because, as GDP increases, there are more new physical assets at risk. Moreover, disaster impacts have been outpacing the region's economic growth, rising as a proportion of GDP, from around 0.1 per cent in the 1970s to about 0.3 per cent in recent decades, while in the rest of the world economic losses remained almost stable at 0.1 per cent of GDP (Figure 1-5). The trend is clear: disasters as a percentage of GDP cause more damage in Asia and the Pacific than in the rest of the world, and this gap has been widening.

FIGURE 1-5 Average deaths, people affected and economic losses from natural disasters



Source: ESCAP, based on EM-DAT (Accessed on 30 May 2019).

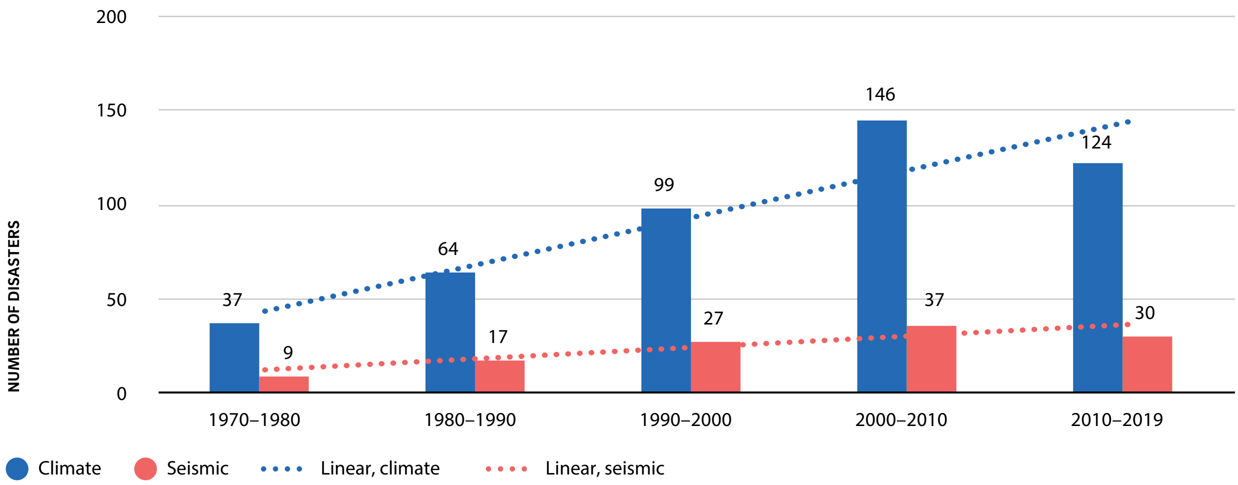
Emerging trends of disaster risk

Recent developments and diagnostic analysis suggest a series of major trends in disaster risk in Asia and the Pacific. As indicated in Figure 1-6, the overall number of disasters is on an upward trend, largely toward an increase in the number of climate-related events and the related environmental degradation. Despite the increasing number of disasters, the fatalities have been reduced, largely on disaster caused by climate-related events (Figure 1-7).

Increasing proportion of climate-related disasters

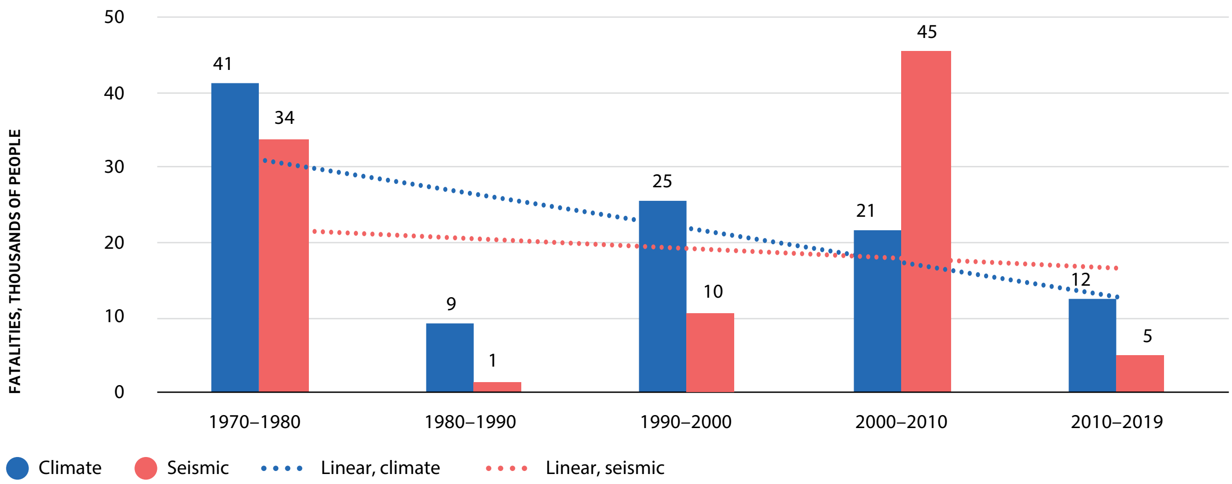
Climate-related hazards in this report comprise droughts, extreme temperatures, floods and storms.[7] Climate change is a main driver for changes in the disaster riskscape.[8] Recent climate-related extremes have been threatening people's well-being and their livelihoods.[9, 10] The Intergovernmental Panel on Climate Change (IPCC) reported, in October 2018, on the impacts and related pathways of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways.[11, 12] The IPCC concluded that if global warming continues to

FIGURE 1-6 Disaster events in Asia-Pacific region — average per decade



Source: ESCAP, based on EM-DAT (Accessed on 30 May 2019).
Note: seismic hazards are composed of earthquake, landslide triggered by tsunami, and tsunami.

FIGURE 1-7 Disaster fatalities in Asia-Pacific region — average per decade



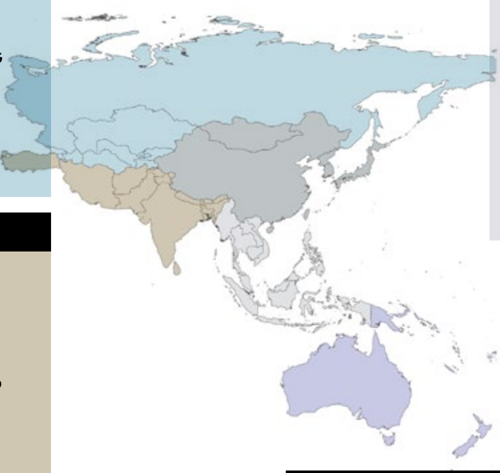
Source: ESCAP, based on EM-DAT (Accessed on 30 May 2019).

increase at the current rate, it is likely to reach 1.5°C between 2030 and 2052.[13] The potential impact in terms of disaster risk in each subregion is presented in Figure 1-8.[14]

The impacts of climate change differ by subregion. Thus, temperature increase is likely to cause a rise in the number and duration of heat waves and droughts — which will affect semi-arid and arid areas, such as North and Central Asia. Climate change is also expected to increase cyclone intensity with serious threats along the coastal areas of countries in South-East Asia. In particular, an increase in extreme rainfall is a danger for countries with major river basins in South and South-West Asia. A complex sequence of climate and weather disasters such as drought, sand and dust storms, desertification and floods are on the rise in arid and semi-arid sub-regions of South West and Central Asia, as indicated clearly in the recent IPCC Global Warming of 1.5°C degree report, which refers to such phenomena as a 'new normal'. The decrease in soil moisture will increase the frequency and intensity of sand and dust storms in South, South-West and Central Asia.[15] Climate change will also have many socioeconomic impacts. The countries at higher risk will be those with dryland regions, the SIDS, and the least developed countries.[16]

As is evident from the experience of 2018, extreme weather is not extreme anymore, rather becoming the 'new normal'. The good news is that the number of deaths from climate-related events is decreasing (Figure 1-7). This is probably due to advances in technology, as well as increasing experience with climate related disasters, with better early warning systems and effective measures to mitigate the impact.

FIGURE 1-8 Impact of global warming of 1.5°C in Asia and the Pacific



NORTH AND CENTRAL ASIA

ANNUAL HIGHEST MAXIMUM TEMPERATURE
North Asia: +0.9°C
Central Asia: +0.8°C
AVERAGE RAINFALL
North Asia: +9%
Central Asia: +5%
POPULATION EXPOSED TO WATER SCARCITY
North Asia: +6 million
Central Asia: 13 million
POPULATION AFFECTED BY RIVER FLOODING
Kazakhstan: +163%
Kyrgyzstan: +71%
Russian Federation: +220%
Tajikistan: +29%
Uzbekistan: +163%
ECONOMIC DAMAGES FROM RIVER FLOODING
Kazakhstan: +190%
Kyrgyzstan: +101%
Russian Federation: +223%
Tajikistan: +42%
Uzbekistan: +80%

EAST AND NORTH-EAST ASIA

ANNUAL HIGHEST MAXIMUM TEMPERATURE
East Asia: +1°C
AVERAGE RAINFALL
East Asia: +4%
ASIAN MONSOON
East Asia, summer average: +8%
East Asia, annual maximum: +7%
East Asia, decadal maximum: +8%
POPULATION EXPOSED TO WATER SCARCITY
East Asia: +48 million

SOUTH-EAST ASIA

ANNUAL HIGHEST MAXIMUM TEMPERATURE
South-East Asia: +0.7°C
AVERAGE RAINFALL
South-East Asia: 0%
POPULATION EXPOSED TO WATER SCARCITY
South-East Asia: +79 million
POPULATION AFFECTED BY RIVER FLOODING
Cambodia: +71%
Lao People's Democratic Republic: +135%
Myanmar: +47%
Thailand: +129%
Viet Nam: +139%
FLOODING IN THE GANGES-BRAHMAPUTRA -MEGHNA DELTA IN BANGLADESH
Average area: 980–1470km^2
% of region: 5–8%
Depth of flooding: 0.16–0.19m
ECONOMIC DAMAGES FROM RIVER FLOODING
Cambodia: +70%
Lao People's Democratic Republic: +143%
Myanmar: +49%
Thailand: +119%
Viet Nam: +148%

SOUTH AND SOUTH-WEST ASIA

ANNUAL HIGHEST MAXIMUM TEMPERATURE
South Asia: +1.2°C
AVERAGE RAINFALL
South Asia: 0%
West Asia: +3%
Indian monsoon extreme rainfall: +20%
ASIAN MONSOON
South Asia – summer average: +3%
South Asia – annual maximum: +6%
South Asia – Decadal maximum: +8%
POPULATION EXPOSED TO WATER SCARCITY
East Asia: +20 million
POPULATION AFFECTED BY RIVER FLOODING
Bangladesh: +245%
Bhutan: +277%
India: +358%
ECONOMIC DAMAGES FROM RIVER FLOODING
Bangladesh: +227%
Bhutan: +261%
India: +326%

PACIFIC

ANNUAL HIGHEST MAXIMUM TEMPERATURE
Northern Australia: +0.6°C
Likelihood of another 2006 drought in SE Australia: 3%
Average drought length in Oceania (months): +2
POPULATION EXPOSED TO WATER SCARCITY
Northern Australia: +0 million
Southern Australia & New Zealand: +1 million
Frequency of extreme high river flows in the Murray-Darling: -30%

Source: ESCAP, based on IPCC, 2018.
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.

Increasing economic impact

With rapid economic development in high-disaster-risk areas, more infrastructure is now exposed to hazards.[17, 18] This includes social infrastructure (for education, health, housing and shelter) and physical infrastructure (for energy, transport, water/irrigation dams, water supply and sanitation), also information and communications technology (ICT) and telecommunications. As indicated in Figure 1-9, many economically developed coastal regions are exposed to cyclones and storm surges, notably, the coastal areas of China, Japan, the Republic of Korea, and areas with a high concentration of economic stock on limited land such as on the Pacific islands. Cyclones also cause damage in South-East Asia's coastal cities.

Floods cause economic losses in coastal cities in China and South-East Asia's continental area and along the Mekong River Basin. In South Asia, floods, cyclones and storm surges affect economic stock in the Ganges-Brahmaputra-Meghna Basin, southern India, and Sri Lanka in South and South-West Asia.

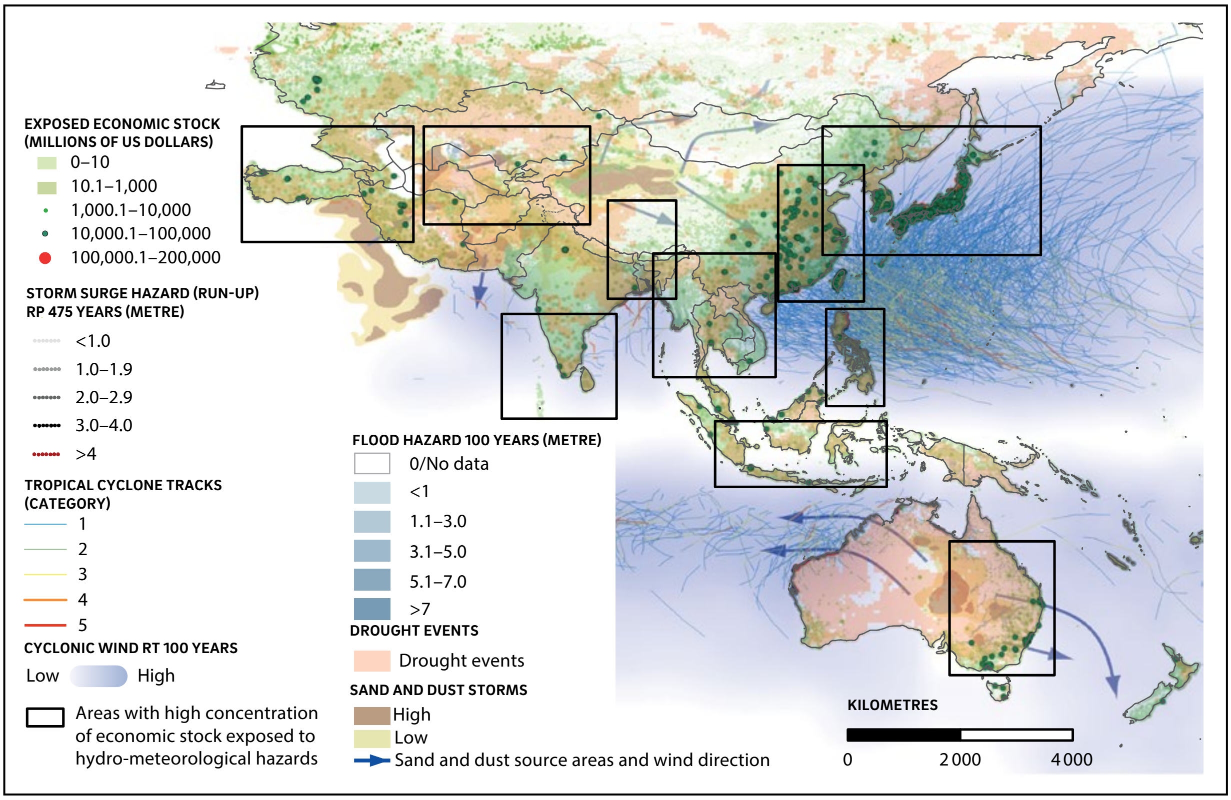
Exposure of economic stock to geological hazards such as earthquakes, landslides and tsunamis, is indicated in Figure 1-10. These include major economies along the Pacific Ring of Fire, as well as smaller economies along with coastal areas of Pacific which are at risk of tsunamis, such as the east coast of Australia, India, Maldives, and Sri Lanka. South-West Asia, such as the west of Islamic Republic of Iran and Turkey are exposed to earthquakes and landslides. Earthquakes and landslides threaten North and Central Asia's major cities in southern parts of Kazakhstan, Kyrgyzstan, and Tajikistan economies.

More people exposed

In a similar way, the following charts show the geographic distribution of the people who will be at risk in the future. Overlaying hazard hotspots with demographic data reveal cities and areas of high human density with many people at risk.

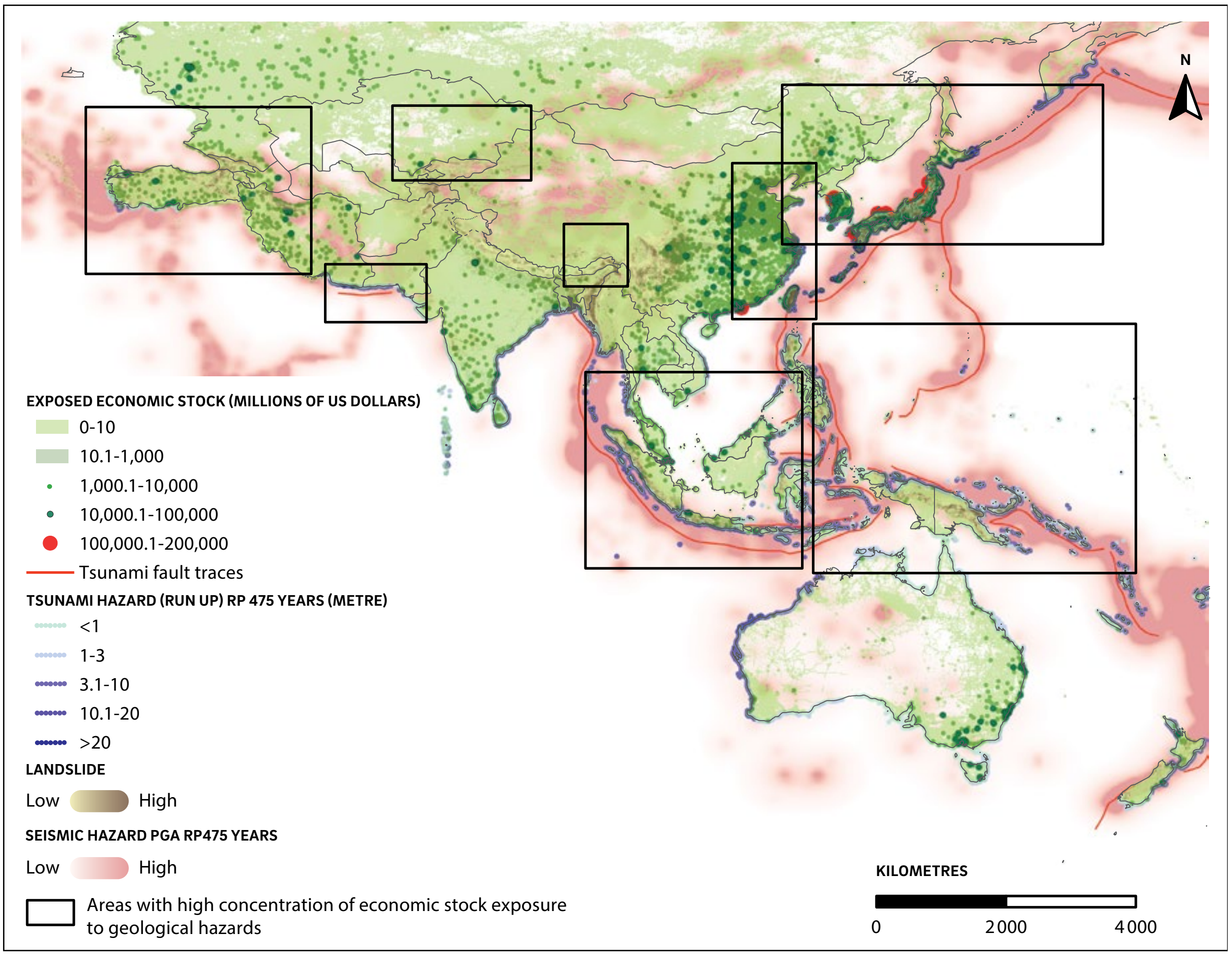
In the case of climate related hazards, residents along the coastal areas, are prone to cyclones and storm surges particularly in major cities in North-East Asia

FIGURE 1-9 Exposure of economic stock to hydro-meteorological hazards



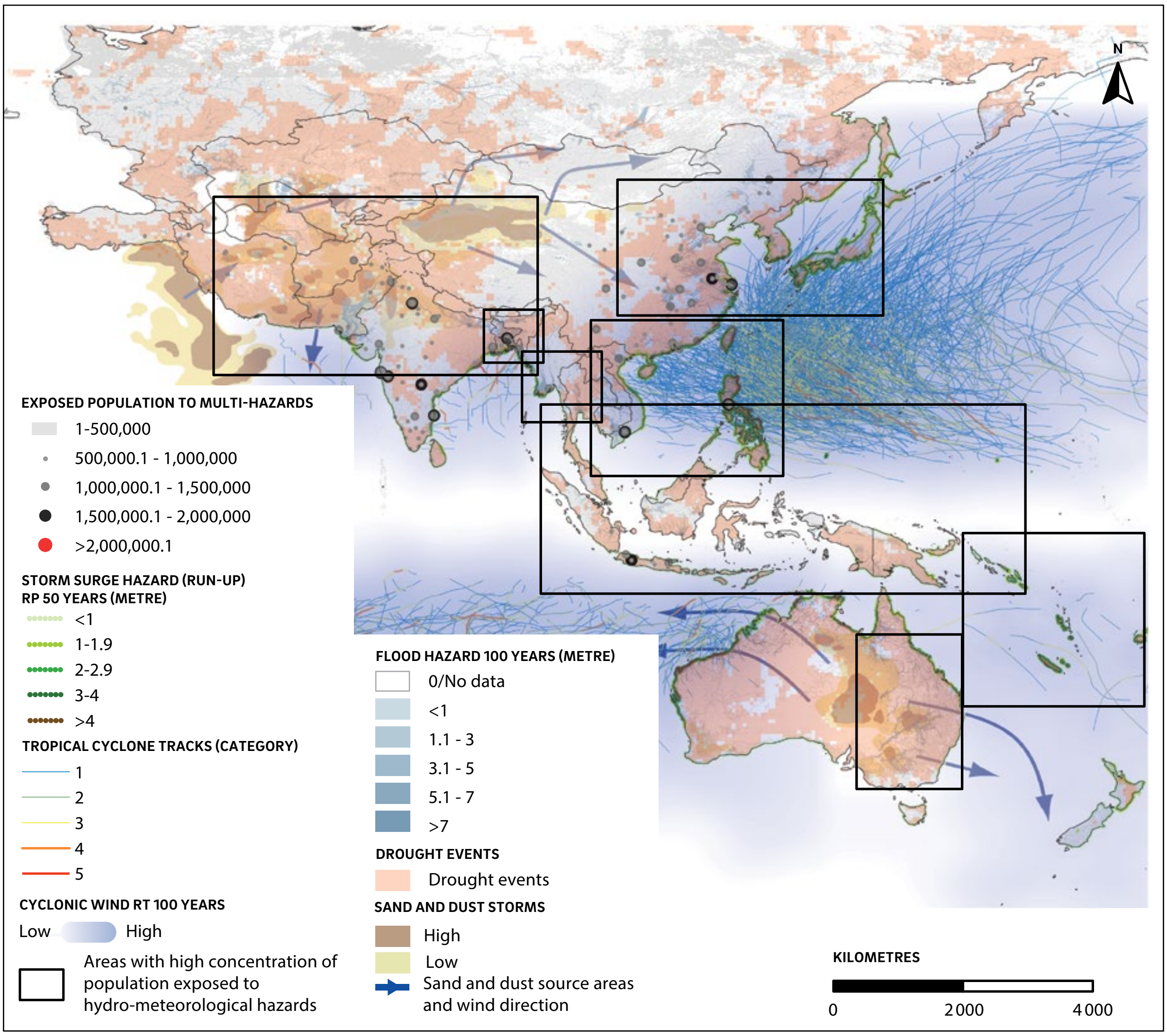
Sources: ESCAP, based on: Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015; Global Risk Data Platform, 2013; Muhs, and others, 2014.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United 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.

FIGURE 1-10 Concentration of exposed economic stock to geological hazards



Sources: ESCAP, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015; Global Landslide Hazard Distribution v1, 2000.
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.
Note: PGA RP 475 years is the seismic hazard with a return period of 475 years expressed in peak ground acceleration. This means that a level of ground shaking is expected to occur once in 475 years. Tsunami hazard RP 475 years is a tsunami hazard run-up height with a return period of 475 years.

FIGURE 1-11 Concentration of exposed population to climate-related hazards

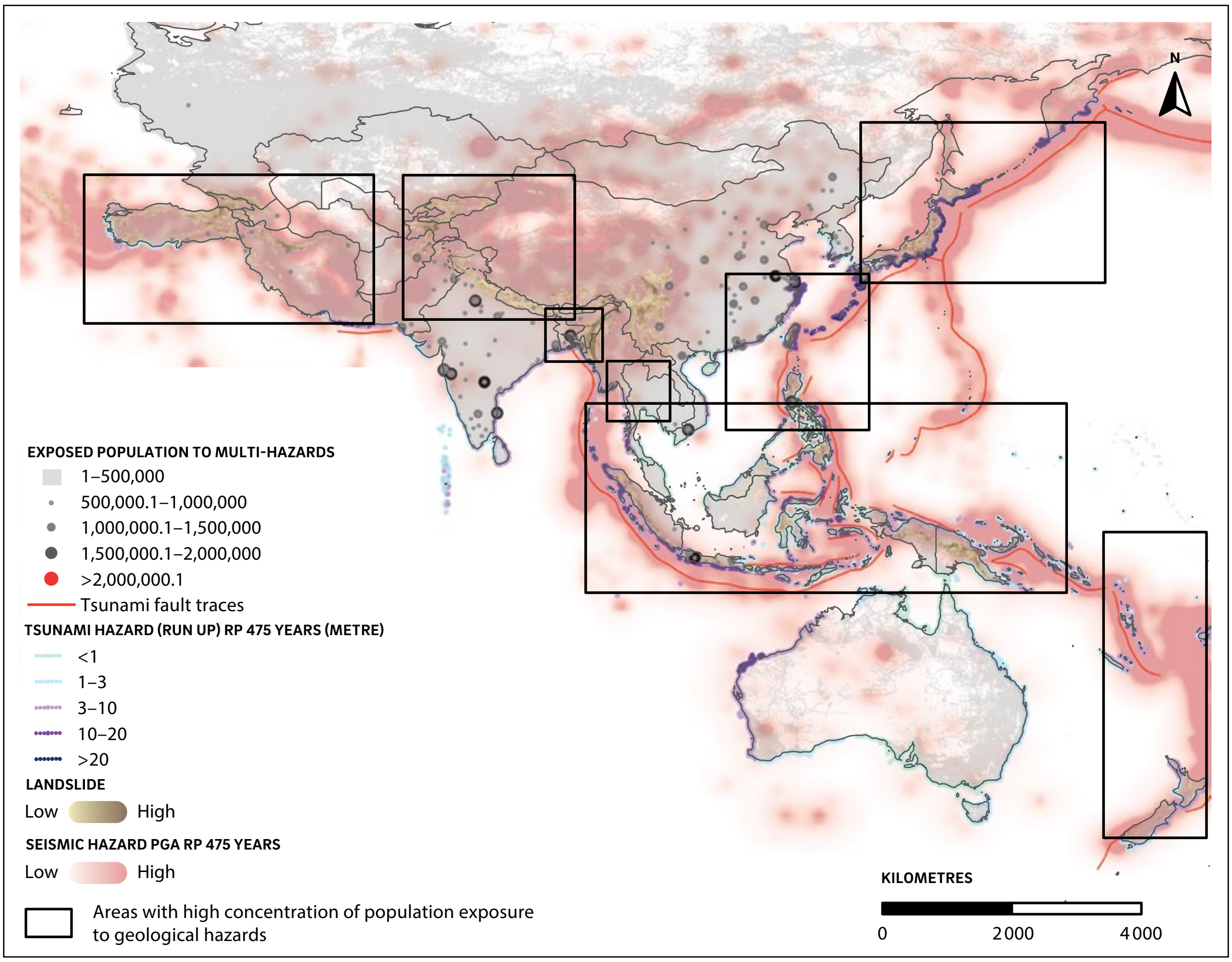


Sources: ESCAP, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015; Global Risk Data Platform, 2013; Muhs, and others, 2014.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United 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."

(the east coast of China, Japan, and Republic of Korea) and South Asia (Bangladesh, coastal areas of India, and Maldives), as indicated in Figure 1-11. Cyclones also threaten small Pacific populations and coastal residents in South-East Asia, such as Indonesia, the Philippines and Timor-Leste. Floods, cyclones and storm surges mostly affect populations in the Ganges-Brahmaputra-Meghna Basin and in South and South-West Asia. Drought and sand and dust storms chiefly affect North and Central Asia (southern parts of Kazakhstan, Kyrgyzstan and Tajikistan), and major cities on the east coast of Australia. Floods threaten people in South-East Asia in the Mekong River Basin.

Figure 1-12 indicates that for seismic risk, the people most exposed to earthquakes, landslides and tsunamis are along the Pacific Ring of Fire (Pacific Islands, Indonesia, Japan, New Zealand, Philippines, and Timor-Leste). Also, at risk of tsunamis but at a lower level are people on the east coast of Australia and in India, Maldives, and Sri Lanka. Earthquakes and landslides threaten populations in South and South-West Asia (Bhutan, northern India, Islamic Republic of Iran, Nepal, Pakistan, Sri Lanka, and Turkey), North and Central Asia (southern parts of Kazakhstan, Kyrgyzstan, Tajikistan), and East and North-East Asia (western China).

FIGURE 1-12 Concentration of population exposed to seismic risks



Sources: ESCAP, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015; Global Landslide Hazard Distribution v1, 2000.
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.

More risks complexity

Asia and the Pacific is also facing disasters of greater complexity as with cyclone Gita which battered the Pacific (Box 1-2) or with typhoon Mangkhut which affected people from China, South-East Asian and Pacific Island countries (Box 1-3).

Especially complex are multi-hazard disasters. This was evident, for example, in the experience of the 2018 Indonesian tsunamis. On the island of Sulawesi, the biggest and the most unexpected killer was soil liquefaction: intense tremors caused saturated sand and silt to take on the characteristics of a liquid. The liquefaction swallowed up some neighbourhoods of Palu (Box 1-4). Similarly, the tsunami in the Sunda Strait was triggered by a huge volcanic eruption, submarine explosions, and a rapidly sliding volume of soil — a phenomenon not captured by tsunami early warning systems that were configured for seismic origins.[19, 20]

Continuing environmental degradation

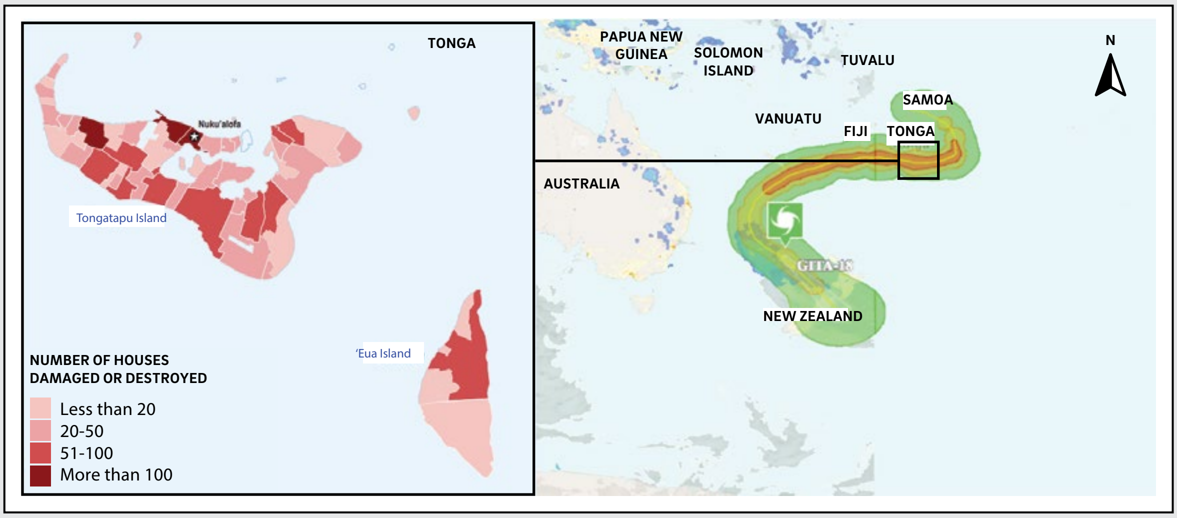
One of the strongest defences against natural disasters is a healthy ecosystem. Thus, risks are heightened by environmental degradation. This was demonstrated, in 2018, by the floods in the state of Kerala in India. Kerala is long and narrow with its highlands leading to steep slopes, midlands and coastal tracts. Almost the entire state is a drainage system for run-off from the Western Ghats, where a dense network of rivers links the hills to the Arabian Sea. But the stability of the hilly regions has been affected by construction projects, deforestation and excessive quarrying. This environmental degradation combined with a lack of disaster preparedness resulted in a deadly extreme weather event.[21, 22, 23]

There are also dangers of degradation in arid and semi-arid regions in East and North-East Asia, North and Central Asia and South and South-West Asia. Many of these countries are impacted by slow-

BOX 1-2 **Tropical cyclone Gita in Tonga**

In 2018, Cyclone Gita hit the Pacific Island nations of American Samoa, Fiji, Niue and Tonga, Samoa, Vanuatu, and the Territory of the Wallis and Futuna Islands with the most significant damage being reported in the Samoan Islands and Tonga. Tropical Cyclone Gita was the most intense tropical cyclone to impact Tonga since reliable records began. The cyclone passed through the country just 40 kilometres from the capital city of Nuku'alofa as a category five cyclone, with winds up to 200 kilometres per hour, affecting 80 per cent of Tonga's population. The storm did not cause any fatalities, but resulted in significant material damages. Also, 87,000 people were affected in Tongatapu and 'Eau islands.[a]

BOX 1-2 **Number of houses affected by tropical cyclone Gita**



Source: Based on Tonga Post-Disaster Needs Assessment – Cyclone Gita, 2018.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

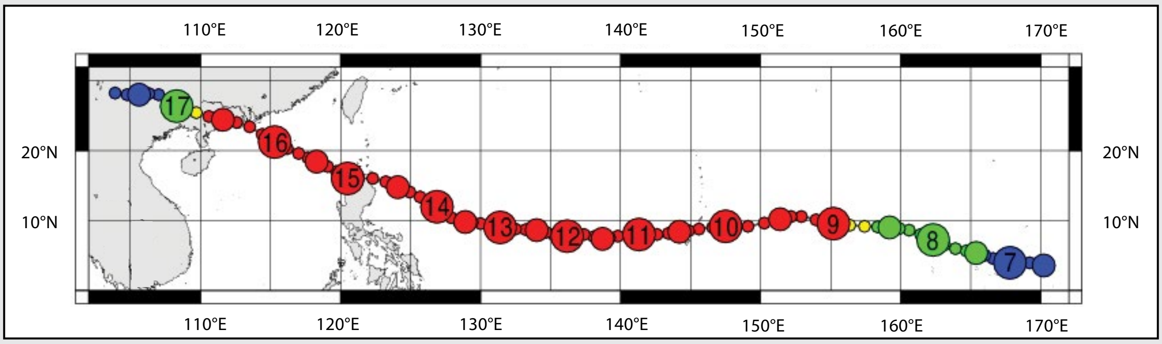
a USAID (2018).

BOX 1-3 **Typhoon Mangkhut**

Typhoon Mangkhut hit the Philippines between 7 and 16 September 2018 and reached wind intensity five. This was the strongest tropical cyclone in 2018 and the second strongest after typhoon Haiyan in 2013. Typhoon Mangkhut reached a maximum wind speed of 287 kilometres per hour and a maximum storm surge of 2.7 metres.[a] The storm's intensity was increased by higher sea temperature resulting from climate change.[b]

The transboundary impact of the typhoon was felt across a wide geographical area including the southern part of China; Hong Kong, China; Guam; Northern Mariana Islands; the Philippines; Thailand and Viet Nam.[c, d] Mangkhut formed in the North-West Pacific Ocean, north of Marshall Islands on 7 September and moved towards Guam Island bringing heavy rain and strong winds on 10 September.[e] It reached Cagayan, Philippines on 15 September, and triggered cascading impacts such as landslides and flooding.[f] The final landfall in southern China; Hong Kong, China, and Macau, China on 16 September caused hurricanes of category two.[g] Typhoon Mangkhut brought heavy rains, big waves and tidal surges that flooded the coastlines in Hong Kong, China.[h] The devastating effects of typhoon Mangkhut affected more than 2 million people, injured 134, and killed 52 in the Philippines.[i]

BOX 1-3 **Typhoon track forecast, by Japan Meteorological Agency (JMA)**



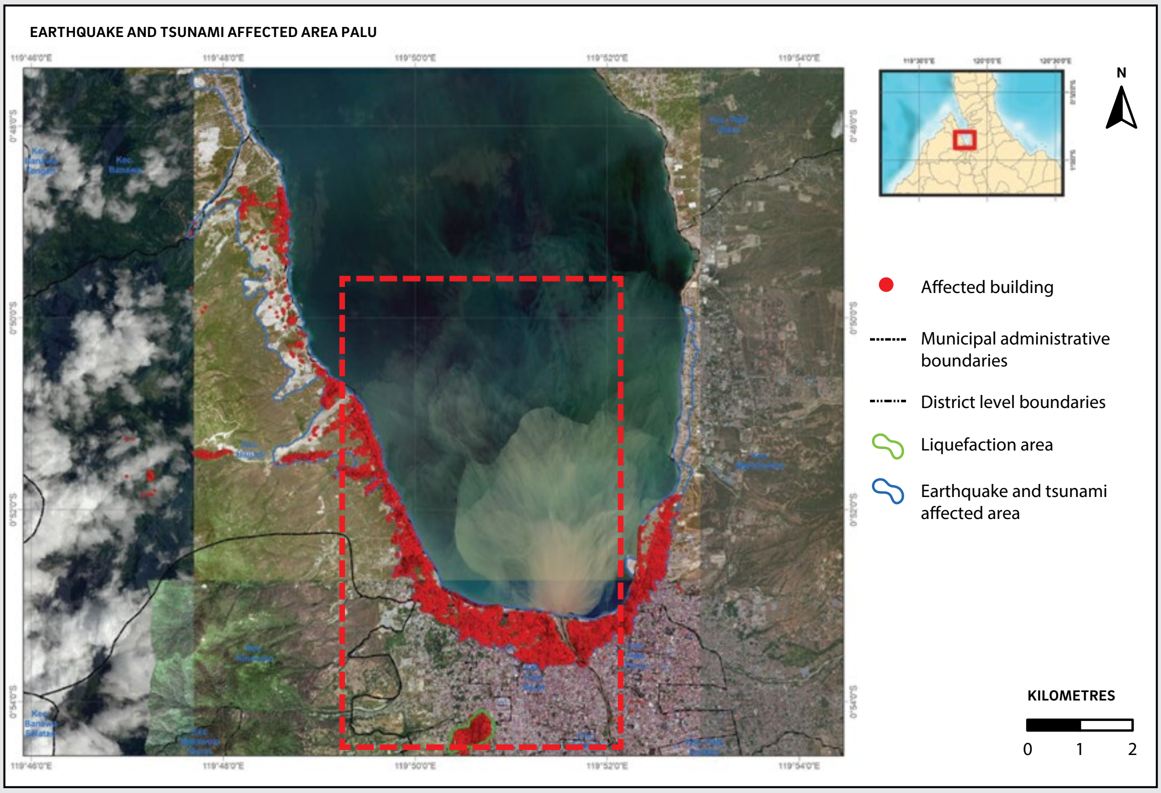
Source: Kitamoto, National Institute of Informatics, 2019.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

a GDACS (2018).
b WMO (2018).
c ReliefWeb (2018h).
d ReliefWeb (2018l).
e Weather Channel (2018b).
f AHA-Centre (2018).
g Weather Channel (2018b).
h Hong Kong Observatory (2018).
i AHA-Centre (2018).

BOX 1-4 Earthquake and tsunami in Indonesia, 2018

A 7.4 magnitude earthquake struck Palu and Donggala, Central Sulawesi Province of Indonesia on 18 September 2018, displacing 206,494 people, causing 4,438 major injuries and damaging 68,451 houses.[a] The earthquake set off a cascade of impacts comprising of tsunami, liquefaction and landslides. The figure Box 1-4 shows the post-event rapid assessment mapping of affected houses and buildings, based on topographic map, national digital elevation model, satellite images and ground survey.[b]

BOX 1-4 Post-event rapid assessment mapping



Source: Abidin, Geospatial Information Agency, 2018.
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 major factors in determining tsunami inundation are coastal geomorphology, bathymetry and seafloor topography.[c] The contour or slope topography can be used to predict the slope stability and submarine landslides. Palu Bay has very uneven topography lines with sharp curves on the southern part that indicate the risks of tsunamis. The uneven topography lines and sharp curves at the southern part of Palu Bay created a higher risk of tsunami run-up. Apart from the tsunami, the liquefaction and landslides occurred over a vast area of Palu and Donggala. This earthquake caused liquefaction and landslides in several sub-districts with 3,027 houses and buildings destroyed and 374 damaged.[d]

a AHA-Centre (2018).
b Geospatial Information Agency of Indonesia (2018).
c Efthymios Lekkas, and others (2011).
d ReliefWeb (2018m).

onset, transboundary disasters, including drought, desertification and sand and dust storms. Sand and dust storms are both extensive and intensive risks, with wide geographical coverage and cross-sector links, and have severe short- and long-term impacts. In 2018, sand and dust storms in the Islamic Republic of Iran and neighbouring countries made fragile semi-arid and arid areas environmentally vulnerable (Box 1-5).

Deep uncertainty

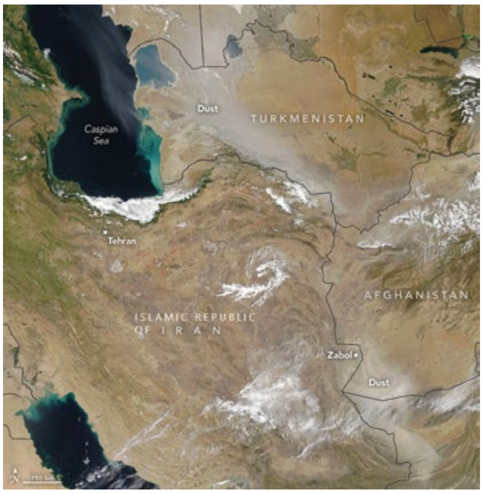
Climate change and the complexity of disasters is creating deep uncertainty. Thanks to enhanced technology and greater data availability, many disasters can be predicted. But disasters triggered by climate change deviate from the usual tracks, making it difficult to apply historical records for their analysis and to respond with adequate disaster management. In 2017, cyclone Ockhi, for example, developed near the Equator, affecting areas that had no recent experience of cyclones.[24]

The difficulties in forecasting were also evident for some extreme events in 2018. It is now more difficult to determine which areas should prepare for what kind of disaster. As a result, non-prepared areas can suddenly be hit — as with floods in Japan (Box 1-6) and in Lao People's Democratic Republic.[25] New patterns of disaster demand adjustment, and further investment in disaster risk reduction and management.

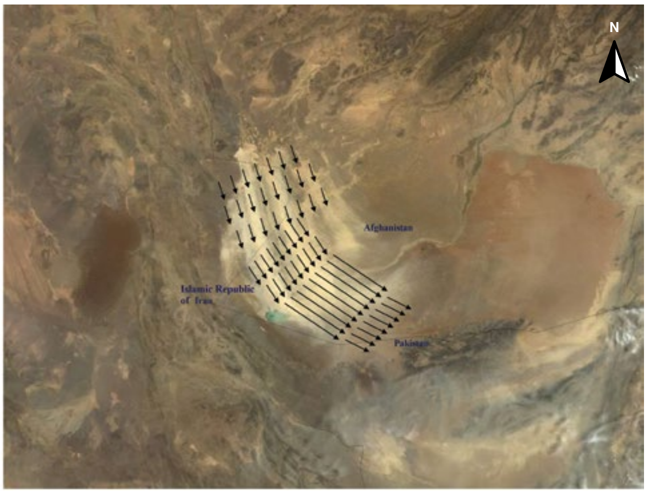
BOX 1-5 Transboundary risk of sand and dust storms in Asia and the Pacific

In May 2018, a powerful dust storm swept over eastern Islamic Republic of Iran, south-western Afghanistan and north-western Pakistan. At the same time, a toxic salt storm from the dry Aral Sea, known as the Aralkum Desert, hit the northern part of Turkmenistan and western parts of Uzbekistan. Subsequently, these dynamic corridors of sand and dust moved through the Islamic Republic of Iran, Afghanistan, Pakistan and north-west India and collided with the pre-monsoon weather events such as thunderstorms and rain, impacting a wide geographical area, with the loss of hundreds of lives. Sand and dust storms are transboundary and cross-sectoral and quite complex with widespread and cascading impacts.[a]

BOX 1-5A Regional dust storms, 28 May 2018



BOX 1-5B Dynamic sand and dust storms risk corridors covering Islamic Republic of Iran, Afghanistan, Pakistan and India



Source: Moderate Resolution Imaging Spectroradiometer (MODIS) image from Terra satellite (NASA), 2018 and Department of Environment of the Government of Islamic Republic of Iran, 2018.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

a ESCAP and APDIM (2018).

BOX 1-6 Heavy rainfall and floods in Japan, 2018

In July 2018, record-breaking rainfalls particularly from western Japan to the Tokai region created a complex and unpredictable multi-hazard situation. This was a consequence of two extreme climate events; massive moist air streams over west Japan and the persistence of upward air flow associated with activation of the stationary Baiu front.[a] The heavy rain in July 2018 was followed by heat waves. The heat wave was formed as a result of net positive suction head that was significantly stronger than normal in Japan. Northern Japan experienced average temperatures while eastern and western Japan faced above normal temperatures.[b]

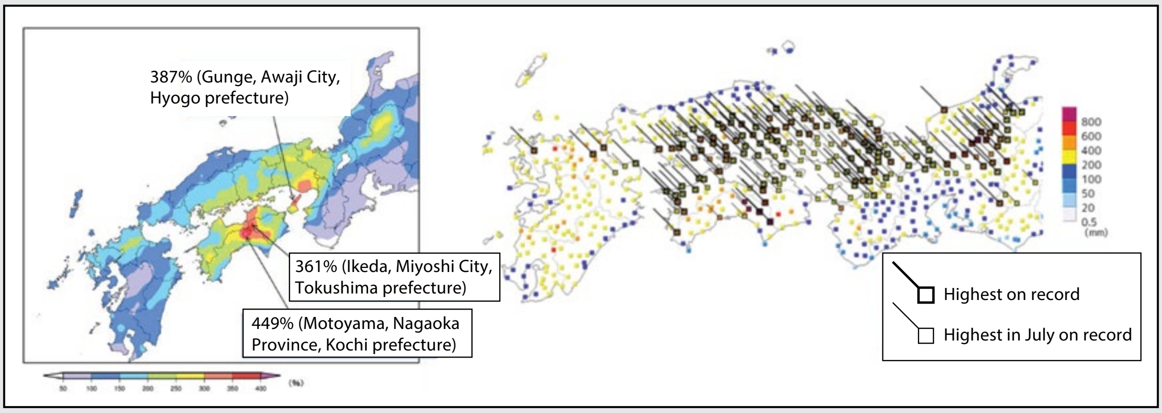
This anomaly mean temperature was +2.8°C. The heat wave during the flood response phase, hospitalized tens of thousands with heat-related illnesses. In Japan, the weather killed more than 300 in July 2018.[c]

Some areas in Japan experienced two to four times the normal precipitation for July.[d] Flooding caused rivers to breach their banks, carrying flows of debris and causing urban inundations.[e] Prefectures in western Japan suffered significant economic damage. Eight dams in the area exhausted their flood control capacities. This was a shock for Japan, one of the most disaster-prepared countries in the world. Around 232 people either died or went missing.

Japan and other countries are now seeing more complex disasters, occurring with greater frequency. These are typically induced by multiple causes with confluences in certain zones and huge simultaneous flows of water and sediment. These water-related disasters are also happening at a time when Japan has to respond to an ageing population.[f]

BOX 1-6A Total precipitation as a percentage of the normal, July

BOX 1-6B Maximum 72-hour precipitation during the event from Western Japan to the Tokai region



Source: JMA, 2018.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

a JMA (2018).
b Ibid.
c Weather Channel (2018a).
d JMA (2018).
e Ibid.
f ICHARM (2019).

Disaster risk hotspots: opportunities for building regional resilience

Drawing from these 'new normal' trends, the region's complex and diverse risks are clustered around four hotspots. Figure 1-13 illustrates the hotspots classification based on assessment of multi-hazards and exposure to population, economy, and critical infrastructure such as energy power plants, transport infrastructure — road, airports and ports, and ICT infrastructure. Here, fragile environments converge with critical socioeconomic vulnerabilities — thus making it much more likely that disasters will transmit poverty, marginalization and disempowerment across generations.

The first is transboundary river basins hotspots with critical vulnerabilities

In South and South-East Asia there are pockets where persistent poverty, hunger and undernourishment co-exist with the risks of floods and droughts (Figure 1-14). The Asia-Pacific region has ten of the top 15 countries in the world with the most people and economies exposed to annual river floods.[26] The region also has many transboundary river basins that are home to poor and vulnerable communities dependent on agriculture. Around 40 per cent of the world's poor live on or close to the major transboundary river basins such as Ganges-Brahmaputra-Meghna (GBM) basin in South Asia.[27]

Another widespread disaster hazard in South and South-East Asia is drought (Figure 1-15). In these subregions, climate change and variability often manifest themselves in monsoon variability, the appearance of El Niño and La Niña, and other extreme weather events. Under the 1.5°C scenario, many flood- and drought-prone countries will face greater risk. The IPCC has estimated that climate change could increase the risk of hunger and malnutrition by up to 20 per cent by 2050.[28] In the Asia-Pacific region, in areas affected by food insecurity, there is a high correlation between hunger and climate risk. In general, countries in South and South-East Asia are exposed because they have high population densities in vulnerable settings.[29]

FIGURE 1-13 The key characteristics of the disaster risks hotspots

HOTSPOT 1	TRANSBOUNDARY RIVER BASINS
Flood and drought prone areas, South and South-East Asia	
Population exposure	Very high (mostly poor)
Economic stock exposure	High
Infrastructure: energy	Low
Infrastructure: transport	Moderate
Infrastructure: ICT	Low

HOTSPOT 2	RING OF FIRE
Earthquake, landslide and tsunami, typhoon tracks, North and East Asia, South-East Asia	
Population exposure	High (disproportionate impact on poor)
Economic stock exposure	Very high
Infrastructure: energy	Very high
Infrastructure: transport	High
Infrastructure: ICT	Moderate

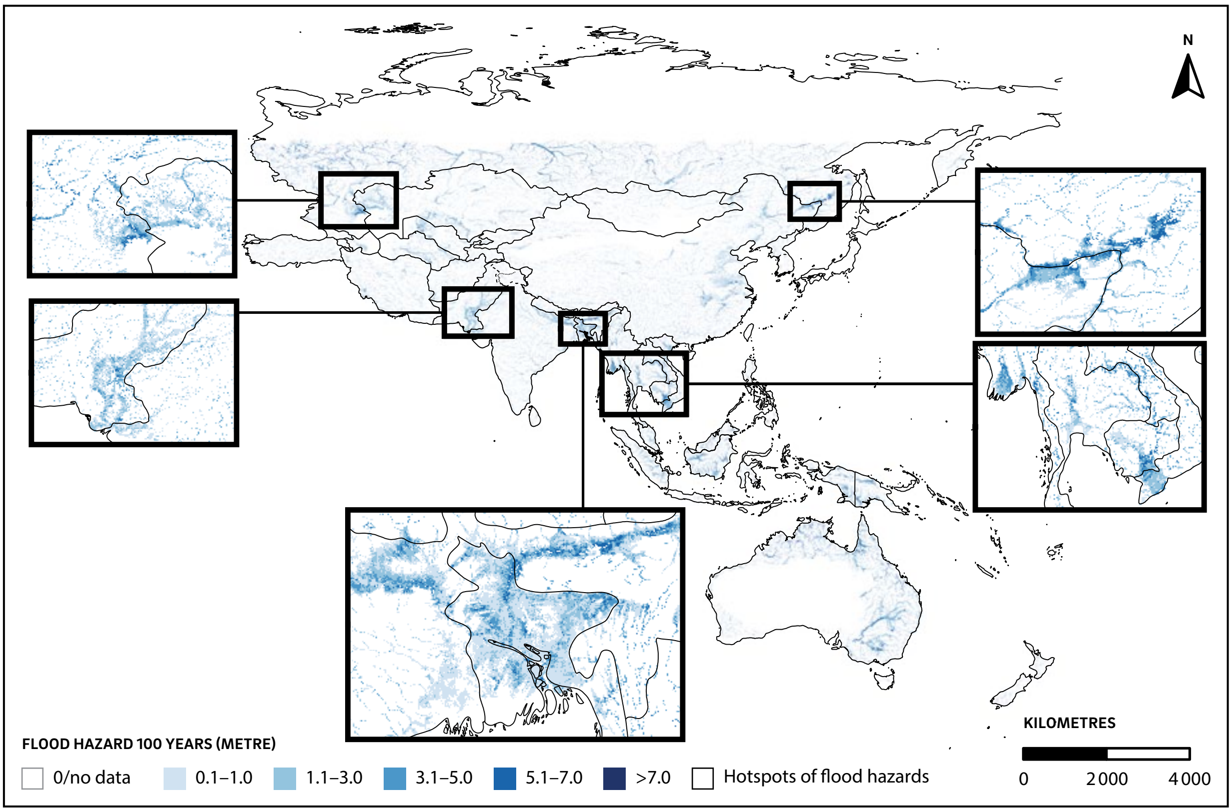
HOTSPOT 3	PACIFIC SMALL ISLAND DEVELOPING STATES
Tropical cyclone, El Niño, earthquake and landslide	
Population exposure	Very high (mostly poor)
Economic stock exposure	High
Infrastructure: energy	High
Infrastructure: transport	Moderate
Infrastructure: ICT	Low

HOTSPOT 4	SAND AND DUST STORM RISK CORRIDORS
Sand and dust storms, drought and floods, South Asia, South-West and Central Asia)	
Population exposure	High (mostly poor)
Economic stock exposure	High
Infrastructure: energy	Moderate
Infrastructure: transport	Moderate
Infrastructure: ICT	Low

Very high	Approximately over 75 per cent are exposed to hazards
High	Approximately 51–75 per cent are exposed to hazards
Moderate	Approximately 25–50 per cent are exposed to hazards
Low	Approximately less than 25 per cent are exposed to hazards

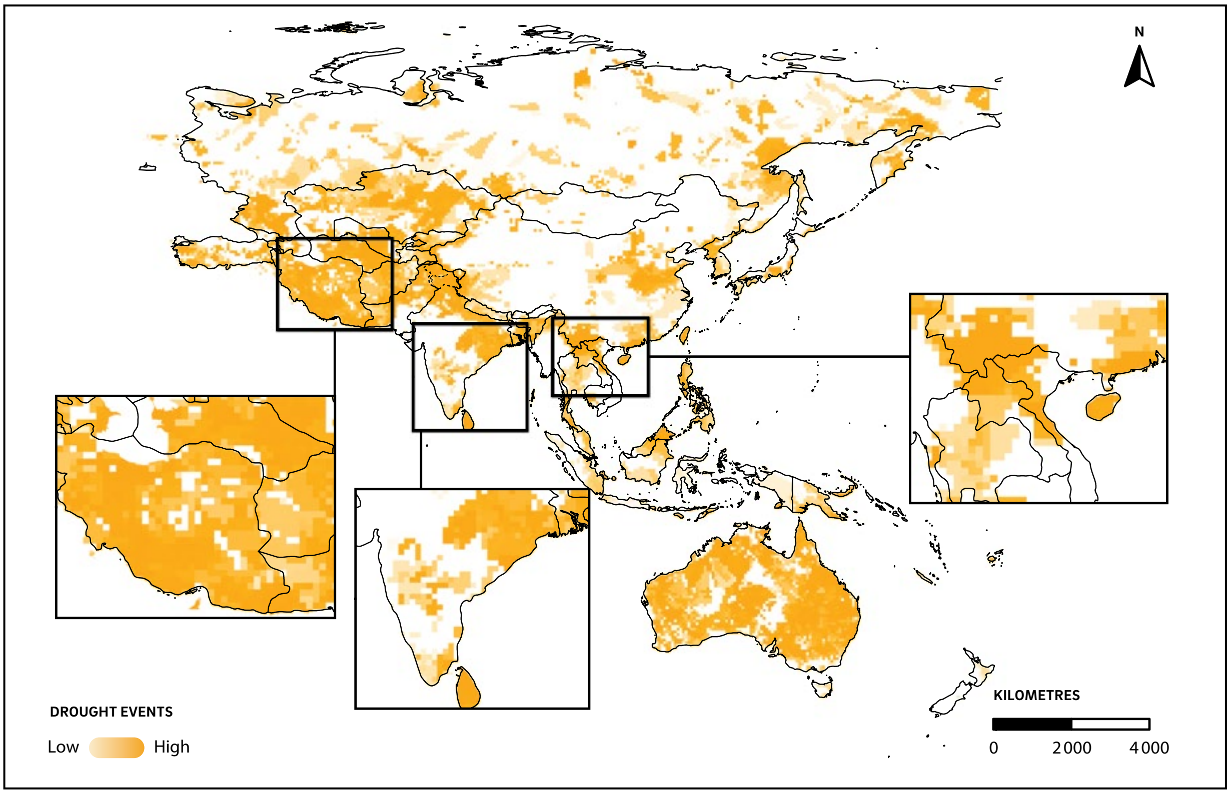
Source: ESCAP, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015; Global Risk Data Platform, 2013; ESCAP, Asia Information Superhighway, 2018(b); ESCAP Asia-Pacific Energy Portal 2018(a); ESCAP Transportation Data 2018(c); Muhs, and others, 2014.

FIGURE 1-14 Hotspots of flood hazard



Source: ESCAP, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015.
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.

FIGURE 1-15 Hotspots of drought hazard



Source: ESCAP, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015.
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.

Second, the Ring of Fire hotspots with critical infrastructure exposure

Another important aspect is the vulnerability and exposure of critical infrastructure. Especially in the emergency phases of disaster, well-functioning road networks, airports and ports are essential for evacuations and distribution of supplies. Energy failure, in particular, can have cascading impact, for health services and ICT. The proportions of each type of infrastructure exposed to multi-hazards are: energy power plants (28 per cent); ICT fibre-optic cables (34 per cent); road infrastructure (42 per cent); airports (32 per cent), and ports (13 per cent) (Figure 1-16).

Asia and the Pacific have a number of countries along the Pacific Ring of Fire, where tectonic plates create around 90 per cent of the world's earthquakes, with the potential for associated tsunamis (Figure 1-17). These fault lines threaten ICT infrastructure particularly in technologically advanced countries, such as China, Japan, and the Republic of Korea. ICT infrastructure is also exposed to earthquake hazards in Armenia, Azerbaijan, Georgia, Islamic Republic of Iran, and Turkey. Further hotspots lie in Indonesia and the Philippines as well as along the west coast of Australia.

There are also seismic and climate risks to energy resources and transport. And highway nodes and roads across Asia and the Pacific are exposed to earthquakes.

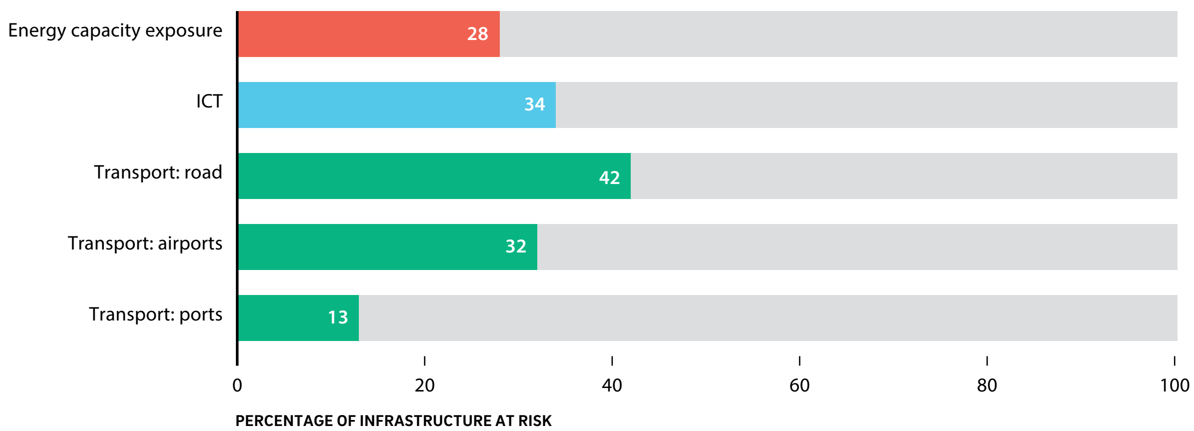
A third hotspot involves vulnerabilities of Pacific Small Island Developing States

Many Pacific small island developing countries (SIDS) lie in the tracks of cyclones. With small populations, these countries may present a low absolute number of people affected, but this still represents a substantial proportion of their population. The most vulnerable countries are those with special needs, including SIDS. As well as having people at risk, they also have exposed infrastructure. Transportation is exposed as these countries rely heavily on their ports and airports, which are vulnerable to climate-related hazards including tropical cyclones (Figure 1-18). Several areas also have high concentrations of solar and wind power plants that are highly exposed to cyclones.

A fourth hotspot is sand and dust storm risk corridors

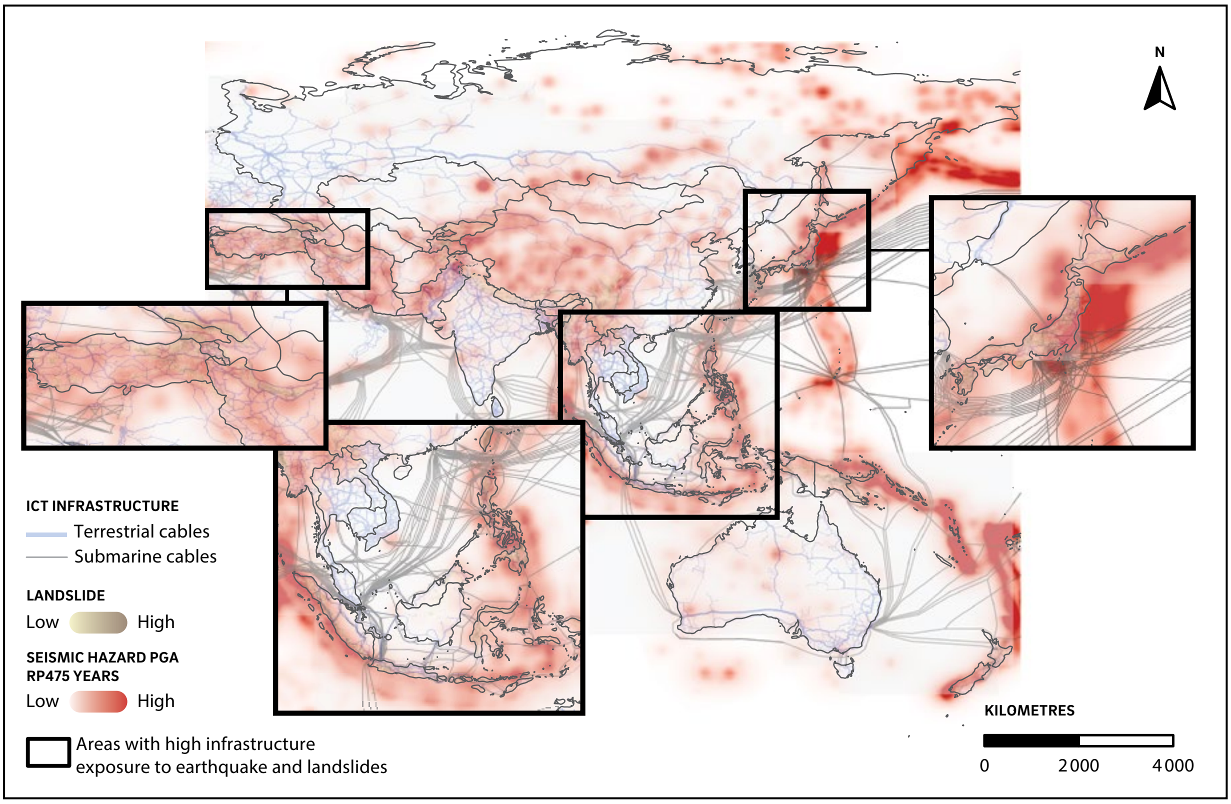
This hotspot is to be found along a corridor that traverses the environmentally fragile areas. In arid and semi-arid regions, there is growing alarm over the increasing frequency and intensity of sand and dust storms. These storms are a consequence of land degradation, desertification, climate change and unsustainable land and water use and they swirl through risk corridors in East and North-East Asia, South and South-West, and Central Asia (Figure 1-19). In South and South-West Asia and Central Asia, the highest dust storm frequencies occur in the Sistan

FIGURE 1-16 Percentage of infrastructure at risk to multiple hazards



Source: Global Risk Data Platform, 2013; Global Landslide Hazard Distribution v1, 2000; Muhs and others, 2014; ESCAP, Asia Information Superhighway, 2018(b); ESCAP Asia-Pacific Energy Portal, 2018(a); ESCAP Transportation Data, 2018(c).

FIGURE 1-17 Hotspots of ICT infrastructure exposed to earthquakes and landslides



Sources: ESCAP, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015; Global Risk Data Platform, 2013; Global Landslide Hazard; ESCAP, Asia Information Superhighway, 2018(b).
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.

Basin in south-eastern Islamic Republic of Iran and south-western Afghanistan, areas of south-eastern Islamic Republic of Iran, north-western Baluchistan in Pakistan, the Thar Desert of Rajasthan in western India, the plains of Afghan-Turkestan and the Registan area of Uzbekistan. Dust from these areas is transported north to Central Asia, south over the Arabian Sea, and east over South-East Asia.[30, 31] Large-scale sand and dust storms disrupt economic flows by damaging multi-modal transport infrastructure.

Disaster resilience, inclusion and empowerment

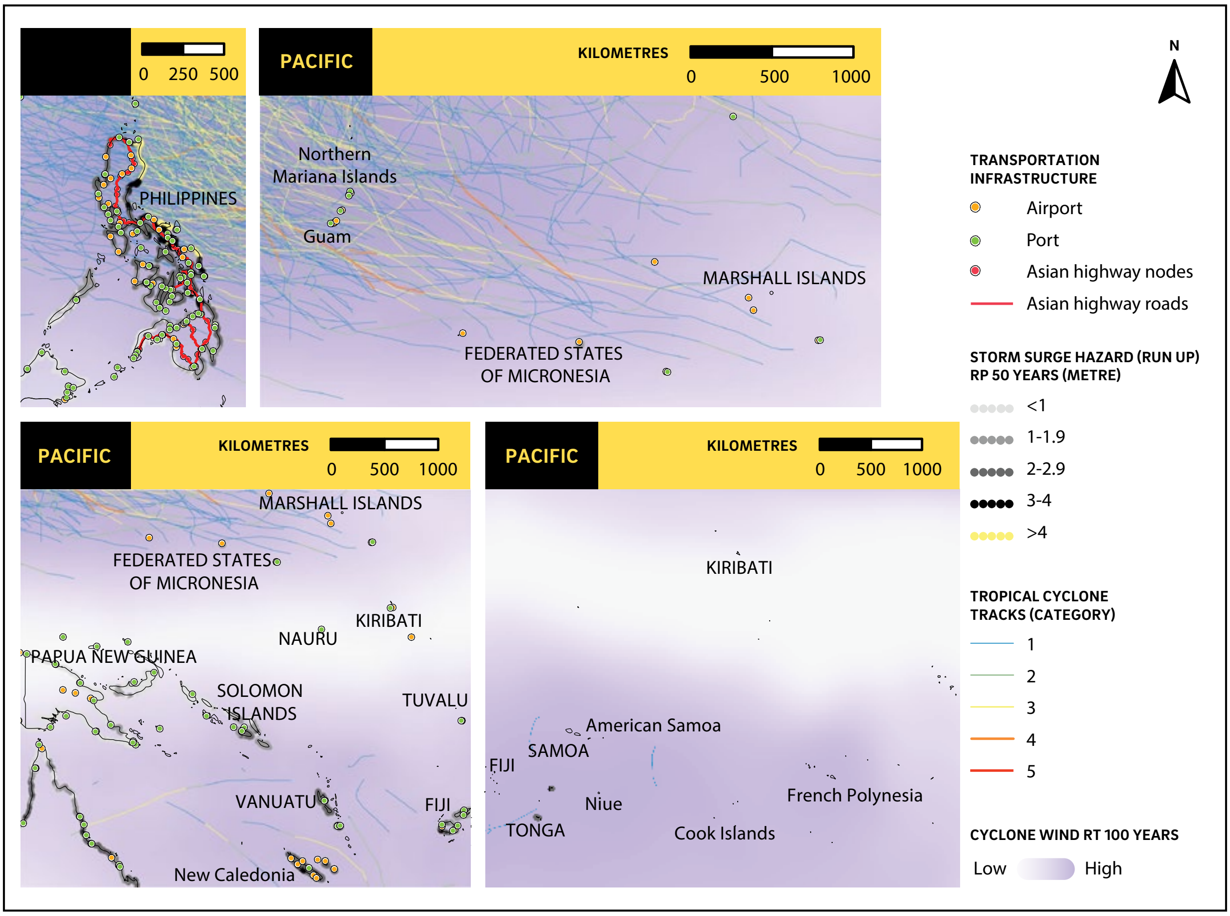
The Asia-Pacific regional riskscape outlined in this chapter has highlighted the risks to poor communities. A rapid sequence of disasters can outpace people's resilience, relentlessly eroding development gains by aggravating poverty, intensifying environmental degradation, disempowering vulnerable groups and widening inequalities. Indeed, three years into the implementation period of the 2030 Agenda, the region seems to be moving in the wrong direction on inequality and environmental degradation.

As a result, many countries in Asia and the Pacific could be reaching a tipping point beyond which disaster risk, fuelled by climate change, exceeds their capacity to respond. The region urgently needs, therefore, to build greater resilience, particularly among the most vulnerable people.

These efforts should be grounded in the Sendai Framework for Disaster Risk Reduction 2015–2030. The Regional Road Map for Implementing the 2030 Agenda for Sustainable Development in Asia and the Pacific is closely linked with the United Nations High-level Political Forum on Sustainable Development (HLPF), and the Asia-Pacific Forum for Sustainable Development (APFSD).

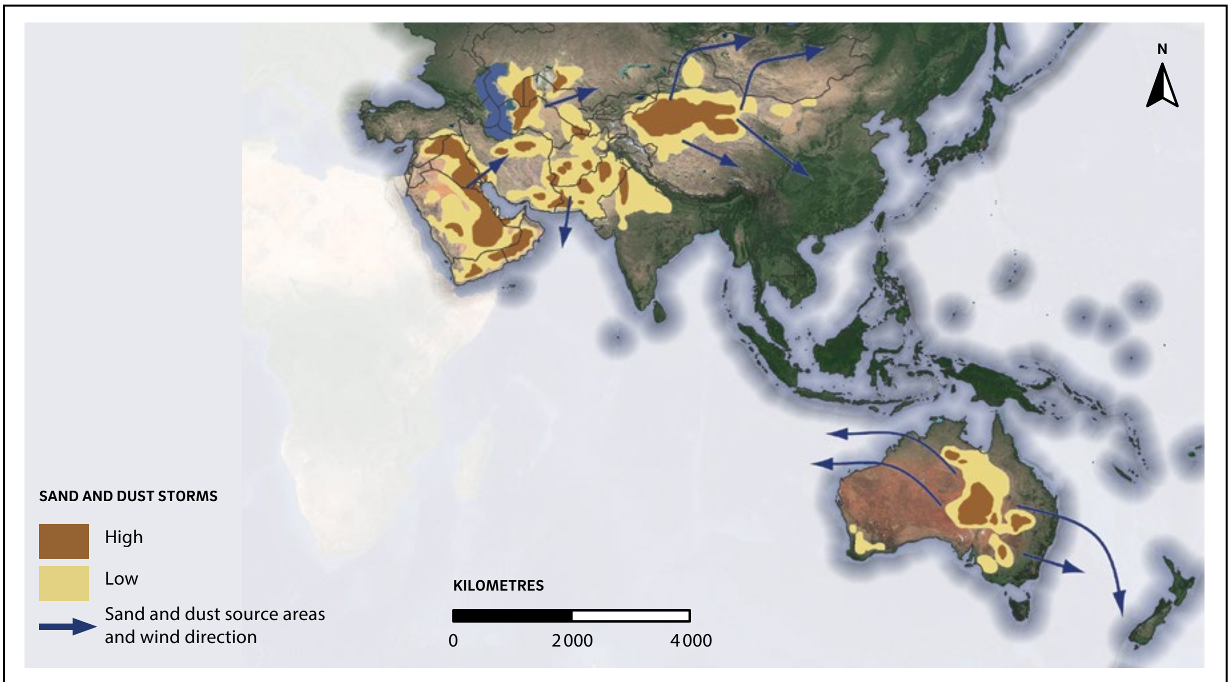
This *Asia-Pacific Disaster Report 2019*, with its central theme being 'Empowering people and ensuring inclusiveness and equality' is aligned to the HLPF 2019. Subsequent chapters of this report analyse the needs of and the opportunities available to countries within the region in terms of building disaster resilience and offer practical recommendations and proven solutions.

FIGURE 1-18 Airports and seaports exposed in tropical cyclone areas of the Pacific



Sources: ESCAP, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015 and ESCAP Transportation Data, 2018(c).
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

FIGURE 1-19 Sand and dust storm risk corridors in Asia and the Pacific



Source: ESCAP, based on Muhs, and others, 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.

Endnotes

1 UNISDR (2017).
2 D. Guha-Sapir (2019).
3 Ibid.
4 Ibid.
5 Ibid.
6 Ibid.
7 All other natural disaster refers to earthquakes, landslides, mass movements, volcanic activities and wildfire.
8 Climate change refers to changes not only in temperature but also in other properties of the climate system such as precipitation, sea level, extremes and wind speeds. The most recent IPCC assessment, the Fifth Assessment Report (2013/2014), states that warmer global temperatures are already impacting the climate and natural systems. See: WMO and UNEP (2018).
9 Climate is defined as the long-term average of weather (temperature, precipitation and others, often defined as at least a 30-year period. The climate system includes many domains besides the atmosphere, such as the ocean, the cryosphere (frozen world) and biosphere. Over many decades, human-caused emissions of greenhouse gases such as CO_2 and changes to natural carbon sinks through deforestation have been changing the climate by increasing the temperature, altering precipitation patterns, changing the water balance and others. See: WMO and UNEP (2018).
10 WMO and UNEP (2018).
11 Global warming describes the 20th and 21st century increase in global average temperature. Both observations and models are used to estimate temperature changes. See: IPCC (2018).
12 IPCC (2018).
13 Ibid.
14 Annual highest maximum temperature by 2081–2010, relative to 1996–2015; Average rainfall relative to 1861–1900; Population exposed to water scarcity: Change in freshwater availability in below normal conditions (Q20); water demand threshold: $1000m^3$ per person per year, population held constant at 2015 levels, relative to 2006–2015; Population affected by river flooding: Population held constant at 2015 levels, relative to 1976–2005, assumes no change in GDP, land use or flood protection; Economic damages from river flooding: Damage in euros at Purchasing Power Parity in 2010 values, relative to 1976–2005, assumes no change in population, GDP, land use or flood protection; Asian Monsoon relative to 2006–2015; Indian monsoon extreme rainfall: 3-day rainfall total in a 1-in-100 year event; relative to a baseline of 1969–2005; Flooding in the Ganges-Brahmaputra-Meghna delta in Bangladesh: Area inundated during an average flood, without flood defenses, excluding cyclones; Likelihood of another 2006 drought in SE Australia: Likelihood ’ 1 per cent without climate change; Average drought length in Oceania (months): Defined as a Standardized Precipitation Index for 12 months of <-0.5; relative to 1976–2005; Frequency of extreme high river flows in the Murray-Darling: Return period for a 1-in-100 year extreme high flows in 2006–15. See: Lorenzo Alfieri, and others (2016).
15 ESCAP and APDIM (2018).
16 IPCC (2018).
17 ESCAP and UNISDR (2012).
18 Kamal Kishore (2018).
19 Thomas Gianchetti and others (2012).
20 BNPB (2018).
21 ReliefWeb (2018n)
22 Government of Kerala (India), UN, ADB and European Union (2018).
23 Venkatesh and Kuttapan (2018).
24 Regional Specialized Meteorological Centre New Delhi (2018).
25 Assessment Capacities Project (26 July 2018).
26 WRI (2015).
27 World Bank (2015).
28 IPCC (2015).
29 IPCC (2012).
30 Nicholas J. Middleton (1986).
31 ESCAP and APDIM (2018).

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CHAPTER 2

Reaching those left behind

The 2030 Agenda for Sustainable Development promotes equality, empowerment and inclusivity by addressing the needs of people who have been discriminated against, marginalized or excluded. Fulfilling this agenda will, however, depend not just on promoting human development but also reducing the many disaster risks for vulnerable groups and building their resilience. It is especially important to identify and reach those who are furthest behind if the goal of eradicating poverty by 2030 is to be achieved.

Disasters cause huge economic losses. According to the World Bank, disasters threatened the GDPs of all the Least Developed Countries and more than 60 developing countries. In a small developing country, even a single medium-size disaster can reverse economic development. In a matter of minutes or hours, rapid-onset catastrophic disasters like earthquakes, tsunamis, flash floods and volcanoes can destroy the hard-earned development gains of decades or even centuries.

Disasters also undermine social development, affecting health, education, housing, culture and religion, water and sanitation, and social protection, as well as the livelihoods of vulnerable communities, particularly in agriculture and fisheries. Recurring disasters repeatedly erode livelihoods and coping capacities that insidiously disempower people and communities over generations.[32] This chapter argues that disasters and exposure to multiple hazards play a significant role in reversing social development that will continue to widen various gaps in inequality unless enhanced efforts and investments are undertaken for reducing the risks and impacts. This chapter will address the general impact on disasters, poverty, deprivations and inequalities. The chapter further identifies the most vulnerable groups within high multi-hazard risk areas and also provides a geographical analysis of people located in areas of overlapping exposure and vulnerability. The chapter will provide empirical evidence using both aggregate and household level data from the Demographic and Health Survey (DHS) and, using computable general equilibrium models (CGE), will show how disasters contribute to persistent poverty, rising inequalities and the further exclusion of vulnerable sections of society. By identifying the specific vulnerabilities of those left furthest behind, this data provides a deeper understanding on the key question of how policies for disaster resilience can help include and empower the poor. By empirically showing how the layered vulnerabilities stem from residing in multi-hazard risk hotspots, the chapter will contribute to a deeper understanding of disaster risk as it evolves dynamically over time for the poorest and most marginalized. Furthermore, by geographically locating the populations most at risk, the chapter shows priority areas where policy action is needed.

Evidence from the ground- disaster impacts on social sectors and vulnerable populations

To assess the overall impacts of disasters on these development sectors, ESCAP analysed 29 post-disaster needs assessments (PDNA) from 20 countries in Asia and the Pacific. The data shows that almost 40 per cent of disaster impacts were on social and productive sectors (Figure 2-1).

Within the social sectors, the hardest hit are housing, education and social protection (Figure 2-2). While in the productive sector the greatest impact is on subsistence livelihoods (Figure 2-3).

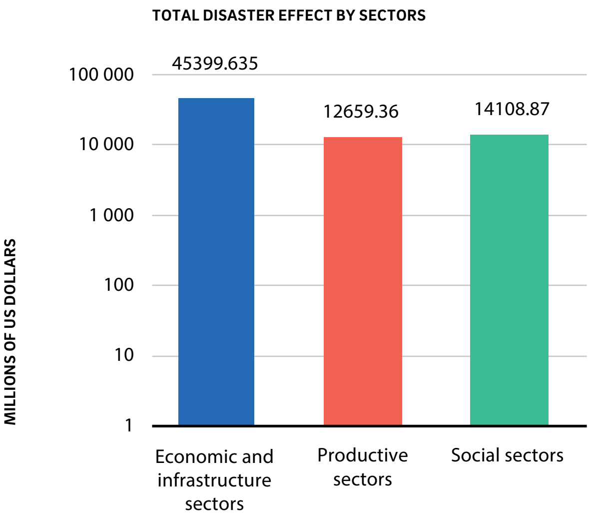
The impact on the social sectors is even greater in the LDCs.[33] Disasters are particularly harmful for vulnerable populations in these countries who rely heavily on strong social and productive sectors to work their way out of poverty. In this way disasters decrease their ability to absorb shocks, and as people try to cope by decreasing nutritional intake or removing children from school, disasters are a transmission belt for transmitting poverty intergenerationally.

Disasters impact all forms of inequalities within and across countries

The Asia-Pacific region has a greater intersection between risks from disasters, inequalities of income, opportunity, and poverty because the region's population is more highly exposed to disaster risk than all other regions of the world. The following sections will demonstrate empirical modelling analysis linking disasters to various forms of inequalities across the region and within countries.

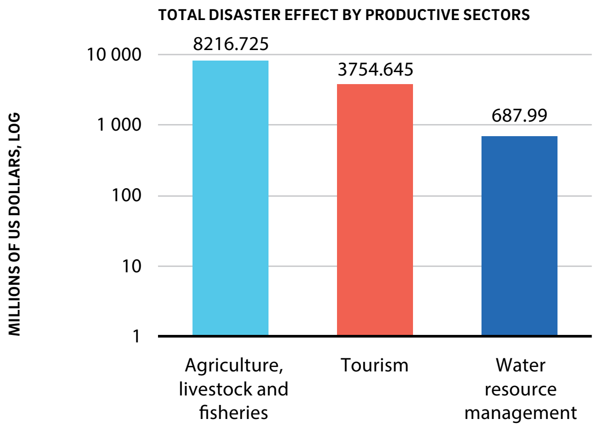
In the next section, where possible, these intersectional linkages have been demonstrated using the latest Demographic Health Survey (DHS) data along with multiple hazard exposure data from the 2015 Global Assessment Report. Hazard data was derived for provinces from the exposure data available in the Global Assessment Report and recoded into high- and low-hazard risk depending on the land area exposed to floods, earthquakes, landslides (earthquakes and floods), and cyclones. The sociodemographic data from DHS and the hazard exposure from GAR were combined to examine the

FIGURE 2-1 Disaster impacts by sector



Source: ESCAP, based on GFDRR, PDNA reports.

FIGURE 2-3 Disaster impacts on productive sectors



Source: ESCAP, based on GFDRR, PDNA reports.

FIGURE 2-2 Disaster impacts on social sectors

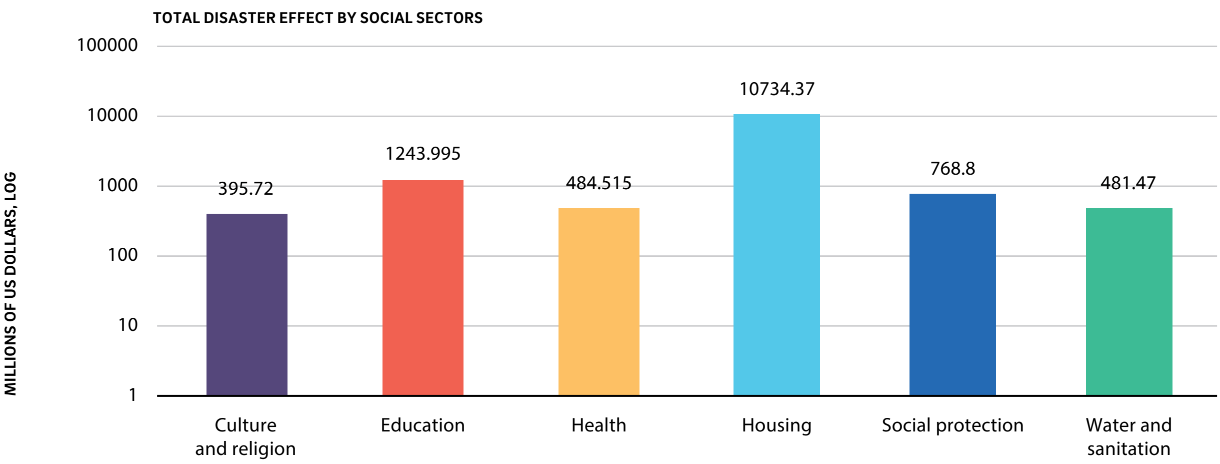
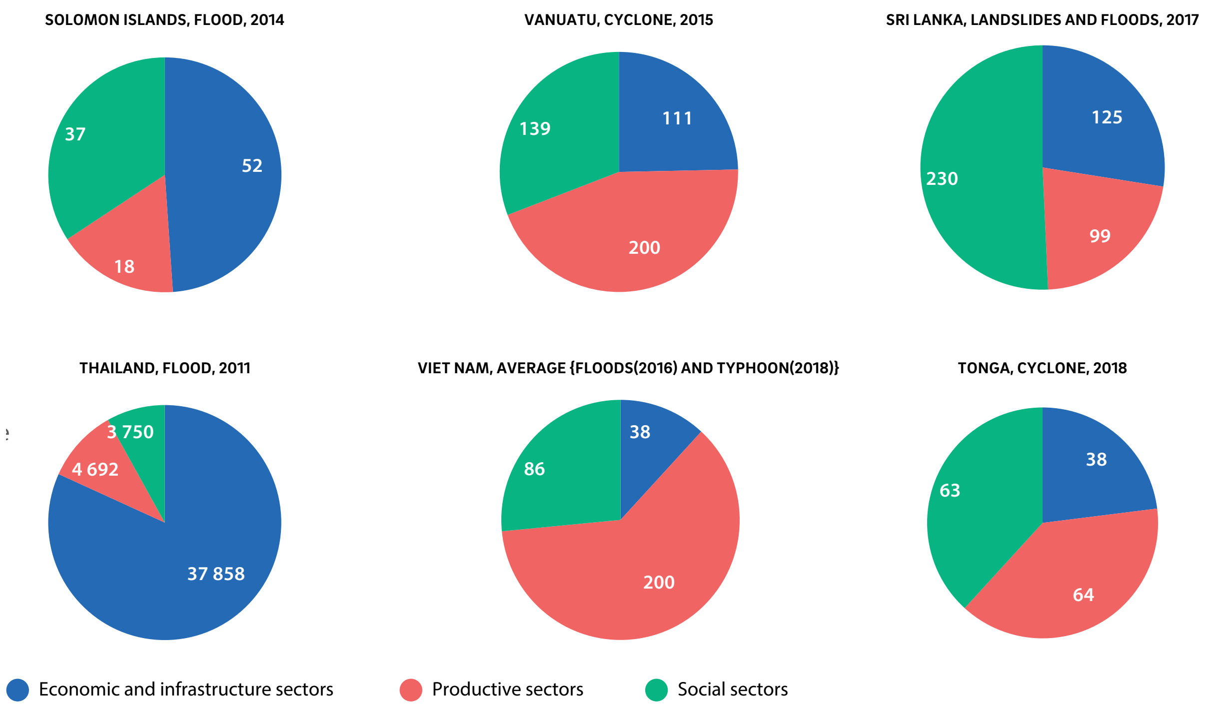


FIGURE 2-4 Sectoral impact of disasters on selected countries (US$ million)



Sources: Country PDNA, Global Facility for Disaster Reduction and Recovery.

FIGURE 2-5 Impact analysis of disasters on social sectors and vulnerable populations

PAKISTAN

FLOODS, 2011

Health and sanitation

- 2.5 million children and 1.2 million women affected ; people dislocated.
- 50% of health facilities were damaged, increasing the vulnerability of women and children, due in part to disruptions in the provision of pre-and post-natal care.
- 80% of illnesses were due towater-borne diseases in Sindh.
- Out of 326 water sources tested by WHO in Sindh, 86 per cent were found to be biologically and chemically contaminated due to inadequate water collected systems.

Education

- Almost 60% of school buildings were damaged-pushing 733,000 children out of school.
- 8% eight per cent of households with children that were hit by income shocks took their children out of school.
- 10% of households had to put their children to work.

Vulnerable populations

- Aid was less accessible to minorities women, children, the landless, non-ID-card holders, Afghan refugees, older persons and perscns with disabilities.

MARSHALL ISLANDS

DROUGHT, 2015–2016

Employment

- Men spent more time fishing, and women and children had to seek other sources of food and water.

Health

- Increased cases of diarrhoea due to contaminated water.
- Increase in influenza-like illnesses caused by changing air temperatures.
- More causes of conjunctivitus and scabies.
- Increased the the number of children with malnutrition.

Education

- School absenteeism rates rose by 10–20 per cent particularly at the elementary level.

Women and girls

- Thehealth and hygiene needs ofwomen and girls suffered from the lackof good-quality water for bathing.
- Daily water collection stations were often crowded requiring long waits and putting women and accompanying children at risk.
- The lack of access to water, and increased lime burden for both men and women exacerbated gender-based violence.

TONGA

CYCLONE GITA, 2018

Employment

- Workers in Tongatapu moved from paid employment to informal work after the cyclone.
- Cyclone Gita exacerbated the already high youth unemployment rates.

Poverty

- 26,000 Tongans living below the poverty line and particularly in rural areas needed assistance.

Vulnerable populations

- The assistance available was generally not accessible to people with disabilities.
- Evacuation shelters were unable to cater for the specific needs of the elderly and those with disabilities, lacking appropriate facilities such as ramps, adequate bathrooms, or disabled toilets.

Women and girls

- Damaged plants which women use to make their handicrafts for family income.
- Women felt vulnerable due to lack of power for lighting or charging phones, making it difficult to call for help and the police.
- Female students felt unsafe walking home from school after dark. leading to a decline in school attendance.
- Shelters lacked sufficient supplies and safe spaces for women, children, and lactating mothers.

Source: Country PDNA, Global Facility for Disaster Reduction and Recovery.

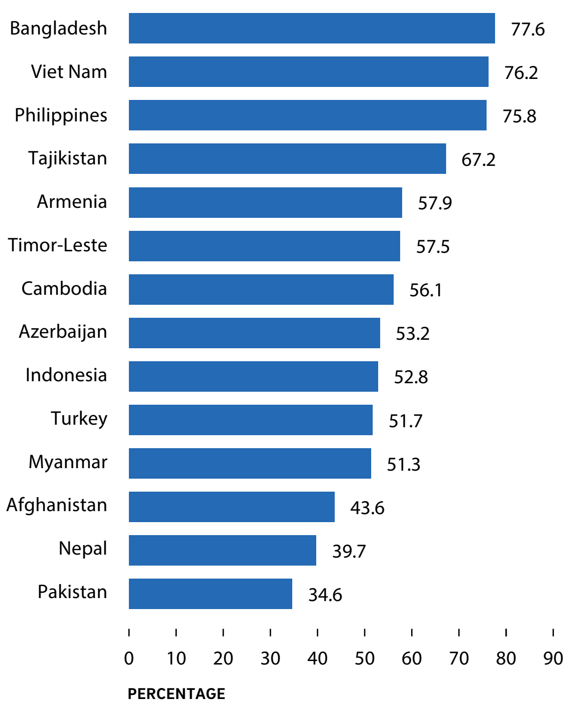
overall impacts of disaster on inequalities at the regional level (across countries) and at the household level (within countries).

At the regional-level (across countries) regression analyses were conducted, using aggregated DHS household data at the provincial level from 17 countries spanning 247 provinces[34] (see Annex 2.1 for list of countries), to examine region-wide relationships between disasters and inequalities. When examining the regression results, it is noted that while the coefficients are in the small to medium range, they are still significant and demonstrate that disasters are nevertheless a serious risk that needs to be accounted for when considering development.

In addition, for 14 of these countries, logistic regression analyses were conducted using household-level DHS data to examine how, within countries, disasters can exacerbate existing inequalities of income and opportunity leaving already marginalized people more vulnerable.

Figure 2-6 shows the overall extent of the population's exposure to multi-hazard risk among the 14 Asia-Pacific countries with DHS data.

FIGURE 2-6 **Proportion of population living in high-multi-hazard-risk areas**



Source: ESCAP, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015 and DHS Household Survey.

Overlaps of disasters with inequalities in incomes and opportunities can leave people more vulnerable

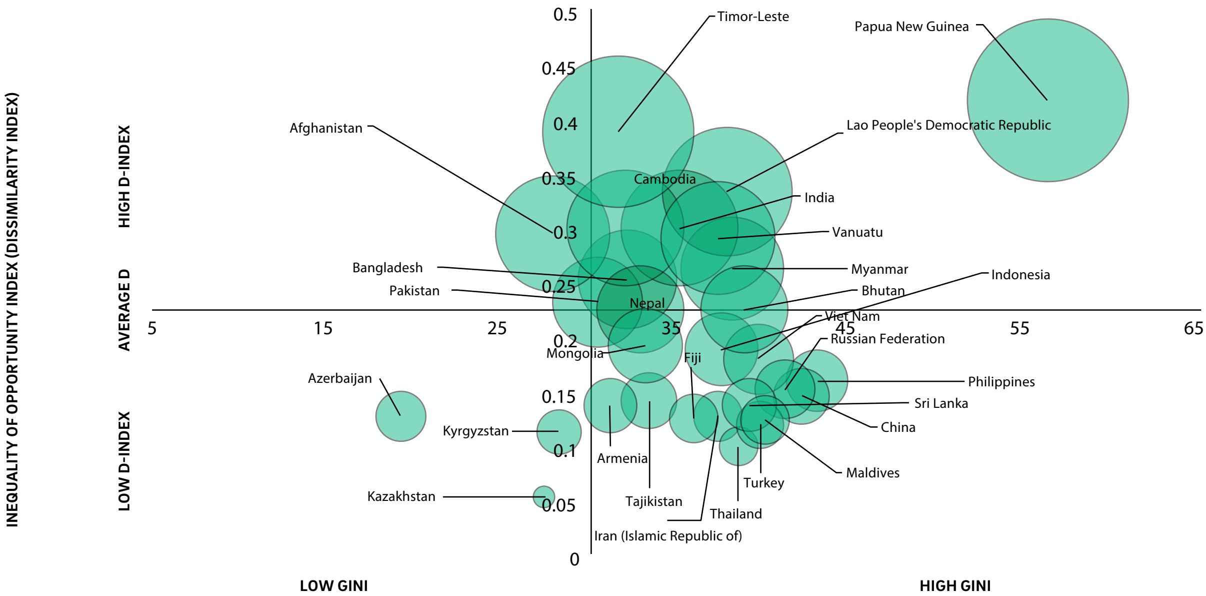
Inequality of income refers to how income generated in the production of goods and services is distributed across a population. The best-known measure is the Gini coefficient.[35] Inequality of opportunity refers to differences in "access to key dimensions necessary for meeting aspirations regarding quality of life."[36] This can be measured with the D-index,[37] which shows how all population groups fare in terms of access to opportunities such as attainment of education, childhood nutrition, and household access to basic services. These indices can be used along with the UNDP human development index to follow the linkages and pathways between disasters and inequalities.

Figure 2-7 illustrates the overlaps of inequalities of income and disaster risk. For example, the highest disaster risk (as represented by the size of the bubble) is for Papua New Guinea which also has the highest levels of inequality in income. Many of the selected countries fall within the quadrants of high-income inequalities. The exceptions are a few Central Asian countries such as Armenia, Azerbaijan, Kazakhstan, and Kyrgyzstan. The countries most likely to have significant overlaps between inequalities and disasters include Bangladesh, Cambodia, India, Lao People's Democratic Republic, Timor-Leste, Myanmar, Papua New Guinea, and Vanuatu.

Similarly, Figure 2-8 illustrates the interactions between inequalities of opportunity and disaster losses (average annual loss). The countries most likely to continue to suffer from the combined vulnerabilities include Bangladesh, Bhutan, Cambodia, Lao People's Democratic Republic, Papua New Guinea, and Vanuatu. As noted in Chapter 1, when the risk of slow-onset disasters, like drought, is added to the existing annual average loss, the emerging riskscape is very different from the previous riskscape. In this riskscape, Vanuatu emerges as the country with the highest disaster loss as a percentage of GDP (8.3 per cent).

Figure 2-7 and 2-8 both show that the most vulnerable and marginalized people in these countries face higher risks of being affected by disasters, thus widening the inequality gaps. This leads to a vicious cycle of poverty, inequality and disasters.

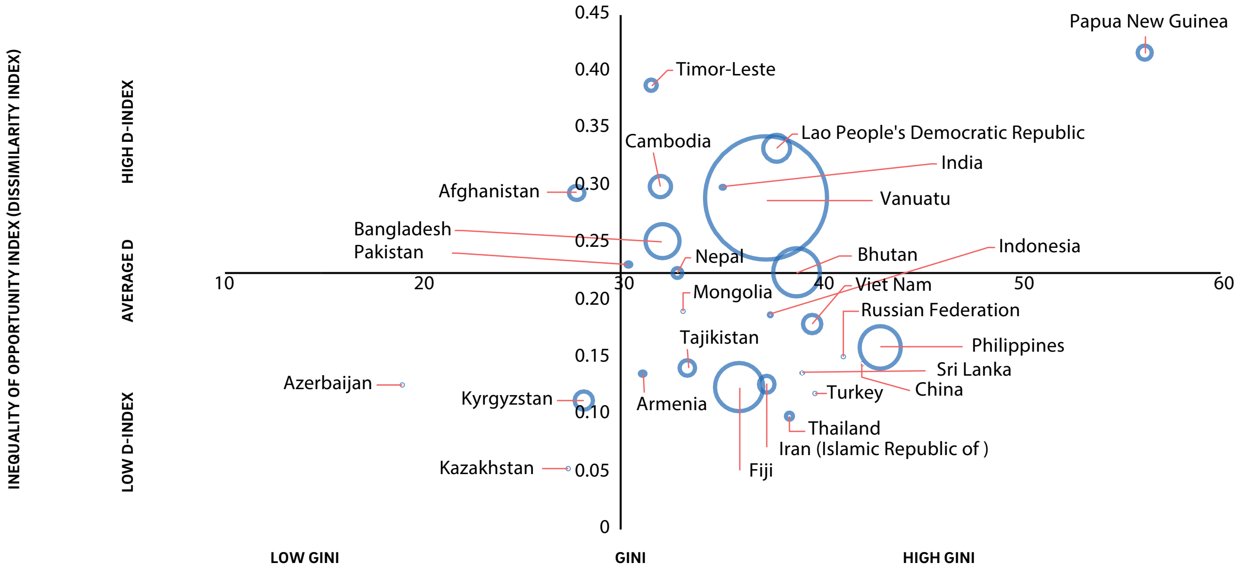
FIGURE 2-7 Overlaps of inequalities of income and disaster risk for select countries



Source: ESCAP calculations for GINI, ESCAP calculations for Average annual loss, ESCAP calculations for Dissimilarity Index (D-Index) from ESCAP theme study "Inequality in Asia and the Pacific in the era of the 2030 Agenda for Sustainable Development."
Note: The size of the bubble indicates the extent of risk from multiple hazards

FIGURE 2-8 Overlap of inequalities of opportunities and disaster losses for select countries

THE INTERSECTION OF INCOME INEQUALITY (GINI), INEQUALITY OF OPPORTUNITY (D-INDEX) AND AVERAGE ANNUAL LOSS AMONG SELECTED ASIA-PACIFIC COUNTRIES



Source: ESCAP data based on DHS surveys, ESCAP calculations for GINI, Inform Index, 2019, Average annual loss (ESCAP figures).
Note: The size of the bubble indicates annual average losses as a proportion of GDP.

Disasters contribute to income inequality and poverty

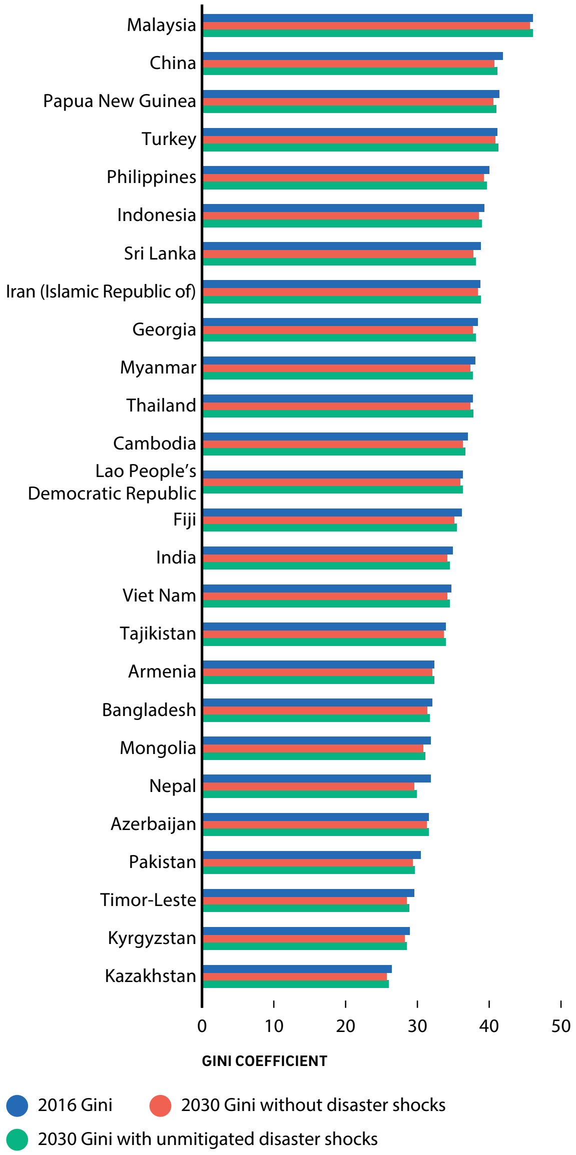
The *Asia-Pacific Disaster Report 2017* examined the impact of disasters on inequality and estimated that for Asia-Pacific countries, a 1 percentage point increase in the number of disasters corresponded to a 0.13 percentage point increase in the Gini coefficient. This report examines the relationship more closely. The across-country regression analyses using DHS data show that provinces that are more exposed to multiple hazards (floods, cyclones, landslides and earthquakes) have higher Gini coefficients. Annex 2.2 shows the regression results across the 17 countries with available data. While the coefficients are not large, meaning disasters do not impact the Gini coefficient as much as education, for example, they are still significant. Adjusting for wealth, education and population, exposure to hydrometeorological hazards (floods and landslides), on average, increases the Gini coefficient by 0.24 percentage points.

Another technique is used to project the impact of disaster shocks on income inequality. This is a comparative 'static computable general equilibrium model' (CGE) which indicates how disaster shocks affect inequality. (The model explanation, its uses and limitations are detailed in Annex 3.1). Figure 2-9 shows how income inequality varies across 26 Asia-Pacific countries, being the highest in Malaysia, and lowest in Kazakhstan. It also shows how the Gini is modelled to change by 2030, with and without disaster shocks. All countries can expect inequality to fall by 2030, but the decrease is lower in countries hit by disasters.

There is also a close connection between disasters and poverty. Previous research by ESCAP found that the poorest nations and the poorest people had the least capacity to mitigate the impacts of disasters and were often the worst affected.[38] Poor populations typically lose more because they are overexposed to disasters and have less ability to cope and recover, especially if they have little social protection or post-disaster support. Moreover, disasters often have permanent impacts on their education and health.[39]

Within-country analysis, using the DHS surveys, concludes that among the 14 countries where data is available, wealthier individuals are better able to protect their assets and well-being because they can avoid living in areas likely to be hit by disasters. Poorer people, on the other hand, are more exposed and are repeatedly hit by disasters and lose wealth and assets. This is illustrated in Figure 2-10 which shows how the lower risks for the wealthy vary between countries. Tajikistan, for example, has the highest discrepancy between the wealthy and poor living in high disaster risk areas. The World Bank notes that despite Tajikistan's sustained economic growth of the past few years and the country's notable achievements, poverty and low standards of living remain a pressing problem;[40] poorer populations, who have higher odds of residing in high disaster risk areas, can continuously lose wealth and assets which push them deeper into poverty. On average, across the 14 countries, the wealthiest individuals comprising the top 20 per cent of the wealth distribution are almost 70 per cent less likely to reside in high-multi-hazard risk areas.[41]

FIGURE 2-9 Projected Gini in 2030, with and without unmitigated disaster shocks



Source: ESCAP calculations based on CGE model.

BOX 2-1 **Resilience and the 2030 development agendas**

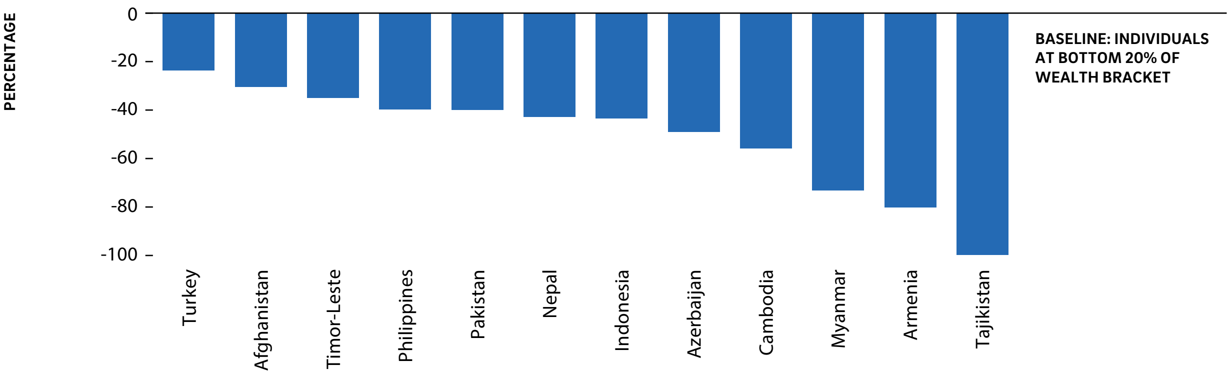
The Sendai Framework for Disaster Risk Reduction 2015–2030 acknowledges that disaster risk reduction requires empowerment and participation that is inclusive, accessible and non-discriminatory, paying special attention to people disproportionately affected by disasters, especially the poorest. The framework advocates that gender, age, disability and cultural perspectives should be integrated in all policies and practices of disaster risk management.

Article 6 (5) of the Paris Agreement states that adaptation actions should follow a 'country-driven, gender-responsive, participatory and fully transparent approach, taking into consideration vulnerable groups, communities and ecosystems with a view to integrating adaptation into relevant socioeconomic and environmental policies and actions.'

The New Urban Agenda adopted at Habitat-III of 2016 developed a vision of cities for all. It refers to 'the equal use and enjoyment of cities and human settlements, seeking to promote inclusivity and ensure that all inhabitants, of present and future generations, without discrimination of any kind, are able to inhabit and produce just, safe, healthy, accessible, affordable, resilient and sustainable cities and human settlements to foster prosperity and quality of life for all.'

The Agenda for Humanity advocates key 'strategic and normative transformations' in order to ensure that no one is left behind. These include addressing displacement and migration, ending statelessness, empowering and protecting women and girls, ensuring education for all and empowering young people.

FIGURE 2-10 **Odds of the wealthiest 20 per cent living in high-multi-hazard risk area**



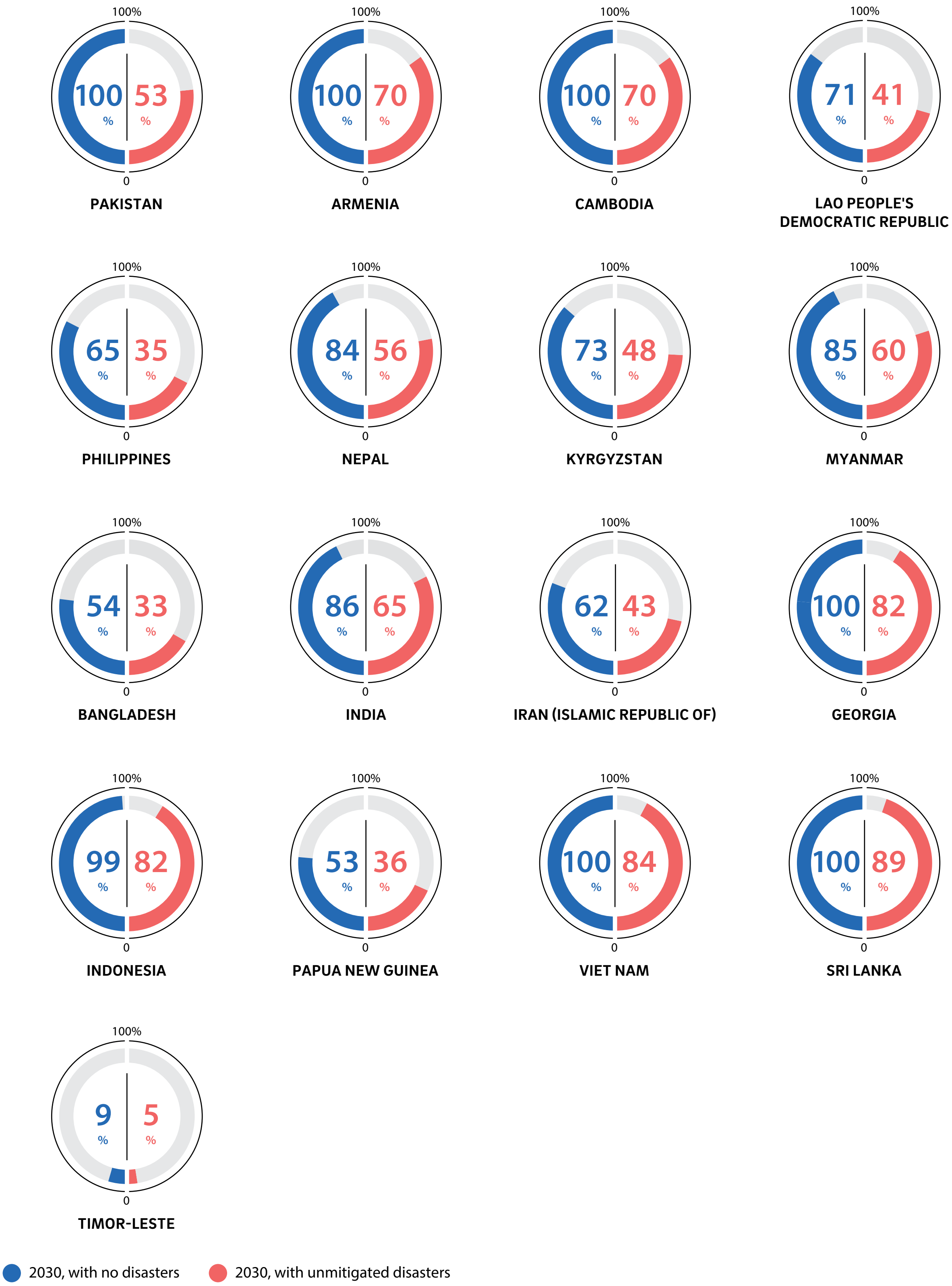
Source: ESCAP calculations based on DHS surveys, latest data and multi-hazard data from Global Assess Report, 2015.
Note: Results are based on country-specific logistic regressions. Only countries with statistically significant coefficients and odds-ratios are shown.

Another CGE model was used to project the impact of disaster shocks on poverty. The results are displayed in Figure 2-11, which estimates how disasters could affect poverty rates among 17 Asia-Pacific countries in 2030. For most countries with no disaster shocks, the projected poverty rates will fall. But if disaster shocks and their impacts go unmitigated poverty rates will fall less.

In Bangladesh, for example, the current poverty rate is 15 per cent. Without disaster shocks, the rate, in 2030, will decrease to around 7 per cent. However, with continued unmitigated disaster shocks the poverty rate will increase to around 10 per cent, lower than the current rate but higher than it would have been had the shocks been mitigated.

In Timor-Leste, on the other hand, unmitigated disaster shocks will cause poverty to rise even above the current level of 41 per cent. Without disaster shocks, poverty is projected to decrease by 2030 to 38 per cent. However, with unmitigated repeated disasters, the poverty rates are projected to be 43 per cent. This demonstrates the importance of immediate and long-term efforts at mitigation.

FIGURE 2-11 **Percent reduction in extreme poverty rates in 2030 with and without disasters in selected countries (Baseline poverty rate=2016)**



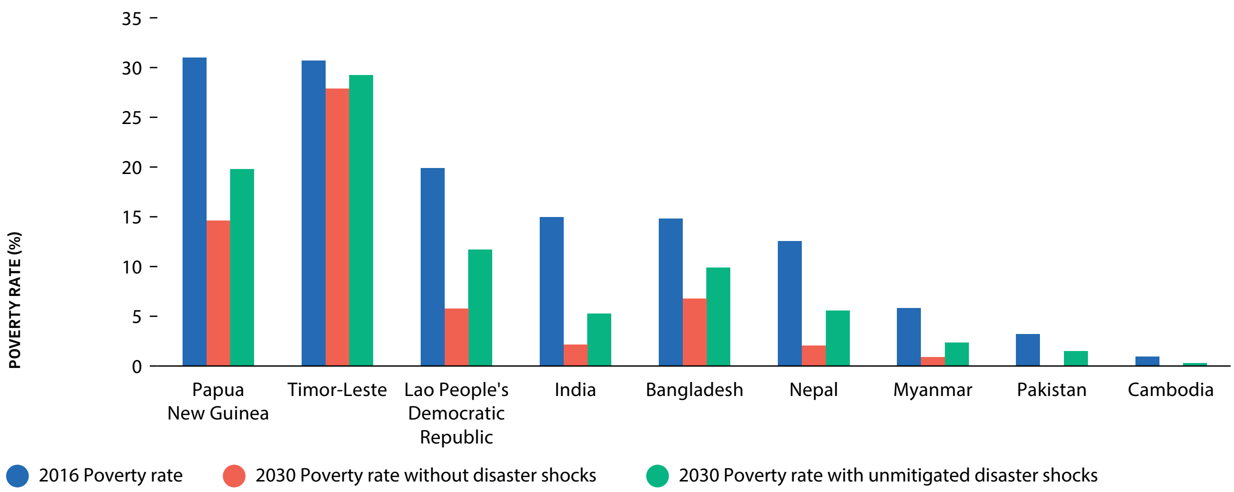
Source: ESCAP calculations based on CGE model.

The effects of disasters on poverty are greatest for countries in the top-right quadrants of Figure 2-7 and Figure 2-8. This is further indicated in Figure 2-12, which shows that the percentages of people living in poverty in these countries are projected to increase at much higher rates. These countries are also the same countries that belong to the key disaster risk hotspots as noted in Chapter 1, and are part of the emerging riskscape. Unmitigated and repeated disasters will continue to keep people in poverty or push them back into poverty.[42] Thus, efforts to reduce poverty and disaster risks should be complementary.

Disasters contribute to inequality of opportunities

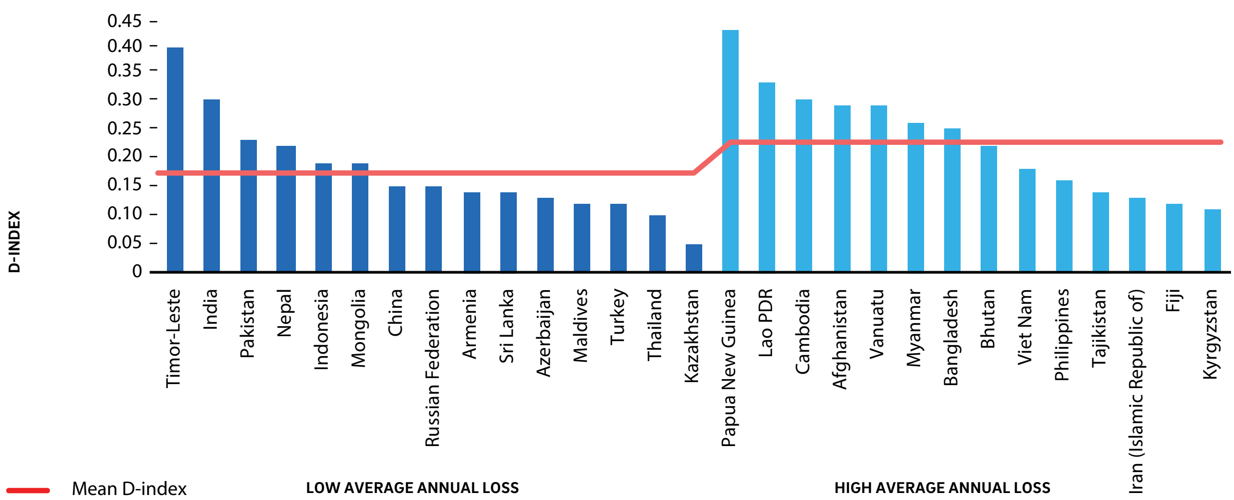
ESCAP analysis shows that countries with high annual average disaster losses currently have high inequality of opportunities. Continuing with business as usual, with no efforts at mitigation or prevention, will result in these inequalities widening further. This is illustrated in Figure 2-13. The group of countries on the right, with high future disaster losses, as measured by AAL, are generally those with greater inequality of opportunity, as measured by the D-index.

FIGURE 2-12 Countries with high Gini and high D-index, projected poverty rates in 2030



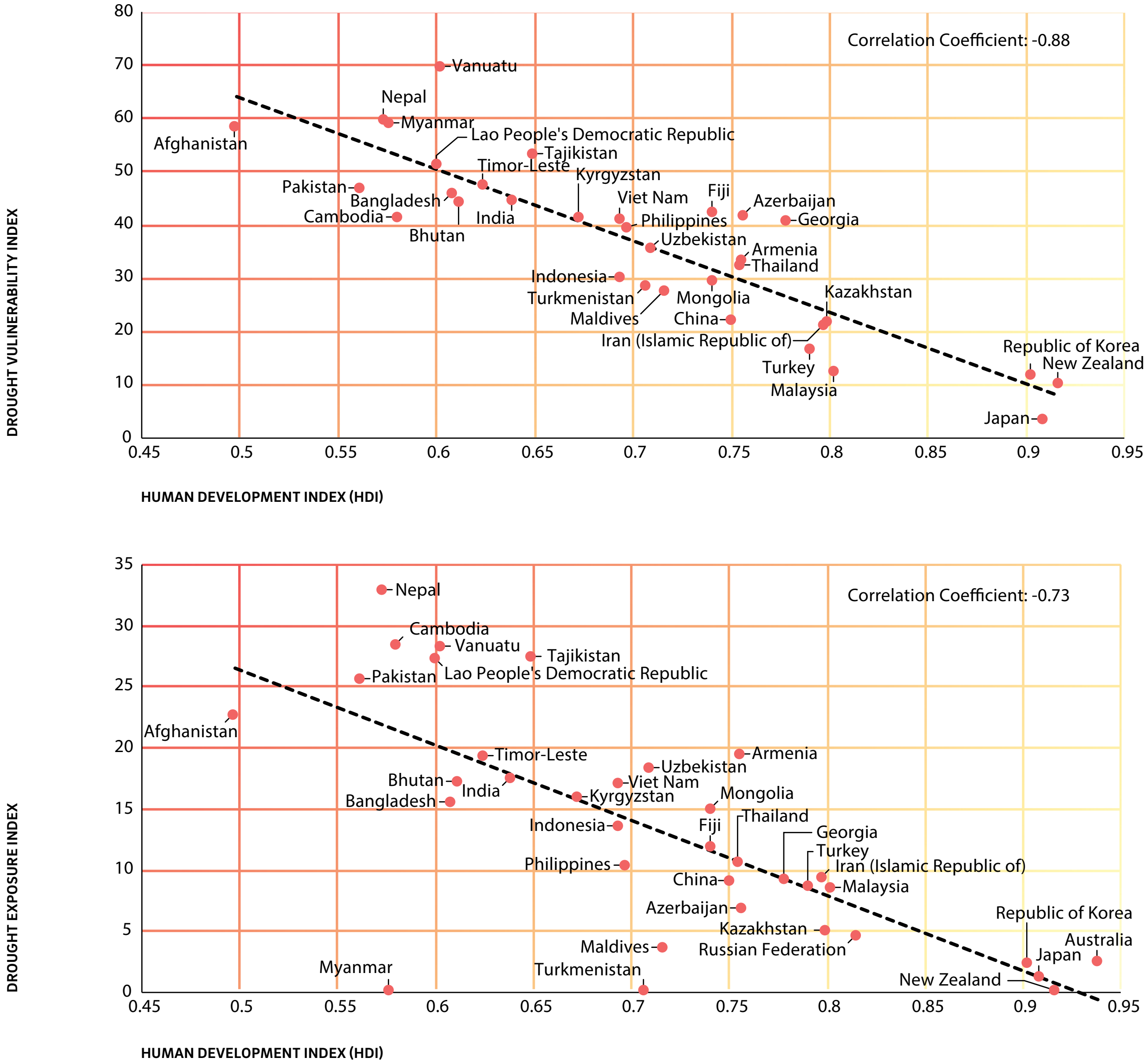
Source: ESCAP calculations based on CGE model.

FIGURE 2-13 Overlap of inequality in opportunities and future disaster losses



Note: The group of countries on the right, with high future disaster losses, as measured by AAL, are generally those with greater inequality, as measured by the D-index.

FIGURE 2-14 **Influence of drought exposure and vulnerability on human development index**



Sources: ESCAP, based on HDI data from UNDP and probabilistic risk assessment.

Among these countries, drought, in particular, takes a high toll on human development. The economies of many of these countries are based on agriculture. Slow-onset droughts have caused significant losses in agricultural production, depleted fresh water supplies, and increased both inflation and poverty.[43] As noted in Chapter 1, new ESCAP analysis finds that, in many countries, the risks associated with drought and the agricultural sector represent a very significant proportion of overall multi-hazard risk. In the region as a whole, this is a major opportunity cost to economic and social development.[44] This is reflected in a significant and high correlation between drought exposure and vulnerability and human development (Figure 2-14). Countries at the highest risk are those with high exposure and vulnerability to drought and low human development index such as Afghanistan, Cambodia, Nepal, Pakistan, and Vanuatu.

Fulfilling the 2030 Agenda will mean reducing inequality so as to leave no-one behind. Many countries, embracing the fundamental principles of equality between human beings, have encouraged affirmative action to address inequalities. They have helped remove many inequities and started to unleash the latent energies of communities and countries that have been subdued for centuries. Nevertheless, around the world there are still many forms of inequality — indeed in some cases there are new layers of injustice. These fall broadly into two categories, based either on deprivation or on discrimination.

Inequality through deprivation

Millions of people around the world continue to be deprived in many ways; principally lacking food, employment, health care and education.[45] As can be seen in Figure 2-13, countries with high inequality as measured by the D-index are the ones that will suffer the most from future disaster losses.

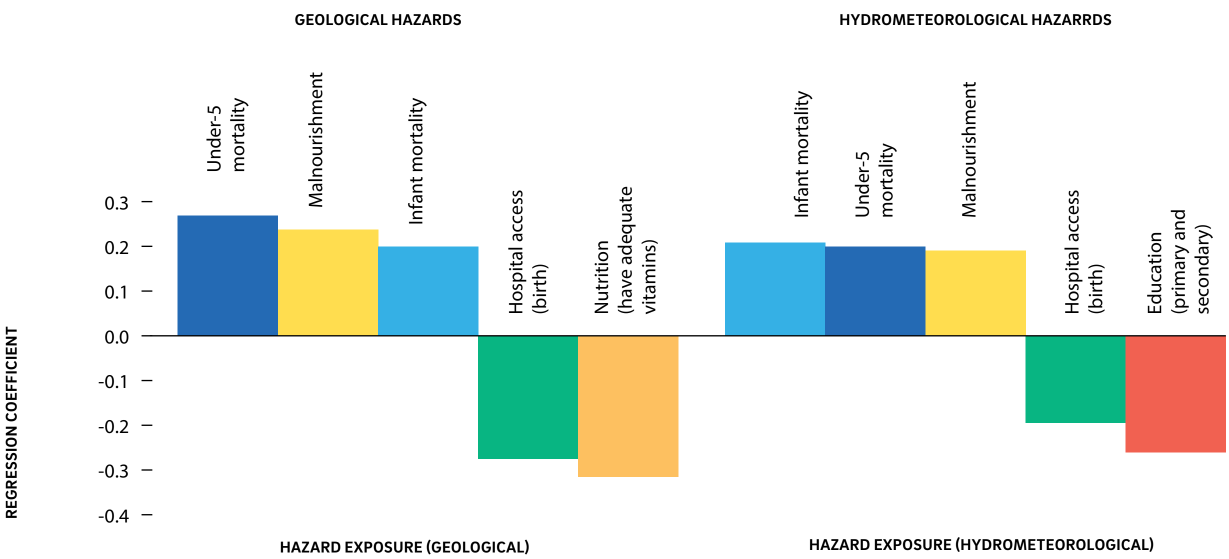
Across the Asia-Pacific region, having many people living in multi-hazard areas tends to increase deprivation. This is illustrated in Figure 2-15 which summarizes regression analyses (Annex 2.2) and shows the size of impact of hazards on four deprivations across the region with province-level data from 17 Asia-Pacific countries. These results are based on cross-sectional data so causality may be difficult to determine, but they do indicate pathways through which increased exposure to disasters can exacerbate inequalities in social development. Figure 2-15 will be referred to when examining each deprivation in depth.

Hunger and malnutrition

Climate-related disasters, notably floods and drought, have been increasing and they have significant implications for hunger and malnutrition. Floods can impact food security and nutrition through a reduction in food production which affects livelihoods of both agriculture and nonagriculture-based populations.[46] For droughts there are fewer data, but these indicate that droughts have an extremely severe impact on nutrition. In 2017, in Afghanistan, for example, a drought that caused scarcities of water and food exacerbated already high malnutrition rates among children, and pregnant and lactating women.[47] As noted in Chapter 1, drought and floods are endemic to the region and are key drivers of hunger and malnutrition and almost 70 per cent of total average annual losses from disasters are in agriculture.

Droughts have their greatest impacts on countries that depend heavily on agriculture. For example, among ASEAN countries, agriculture generates around 11 per cent of value-added to GDP, and more than 25 per cent in countries such as Cambodia and Myanmar.[48] ESCAP measured the impact of drought using regression analysis with data from the INFORM risk index, which takes into account the number of people affected, the frequency of drought, and the extent of exposed cropland. The analyses show that while drought by itself has no significant relationship on the GDP of the Asia-Pacific region as a whole, for

FIGURE 2-15 Hydrometeorological and geological exposure and impact on deprivation (summary of regression analyses)



Source: ESCAP calculations based on DHS survey reports, latest data and multi-hazard data from Global Assess Report, 2015.
Note: Only statistically significant coefficients in the model are shown.

ASEAN countries however, drought and GDP have a significant negative association where increase in the drought index has the potential to reduce the GDP of ASEAN countries. Thus, for the 10 ASEAN countries, a 1 per cent point increase in the drought index can lead to a 0.62 per cent point decrease in sub-regional GDP (Details of the analyses are available in Annex 2.4). A prolonged drought, can decrease agriculture production and availability of food, therefore increasing the rates of overall malnutrition.

Child nutrition is threatened by both climate-related and geological hazards. Across the assessed countries in the region, for climate-related hazards, a 1 percentage point increase in exposure leads to a 0.19 percentage point increase in malnutrition among children under five, while a similar increase in exposure to geological hazards increases the malnutrition rate by 0.24 percentage points (Figure 2-15). This is a serious risk for young children; malnutrition not only threatens their survival but also affects brain development, increases the risks of infection, and reduces educational attainment and productivity.[49]

The harm to children can also be reflected in low birthweights. Analysis among households in 14 Asia-Pacific countries shows that living in high-multi-hazard risk areas is a significant risk factor for low birthweight, which is also linked to mother and child malnutrition. This is illustrated in Figure 2-16, which shows that children born in high-risk multi-hazard areas have lower odds of being born an average size at birth.[50] In Myanmar, for example, they are 44 per cent less likely to be born an average size. This may be because their mothers are malnourished during pregnancy. Low birthweight increases the risk of infant mortality as well as of health and developmental problems in adulthood.[51, 52, 53]

This underlines the importance of key services for children in hazard-prone areas. Such services need to be tailored and strengthened to reach the most marginalized and sustain access for all.

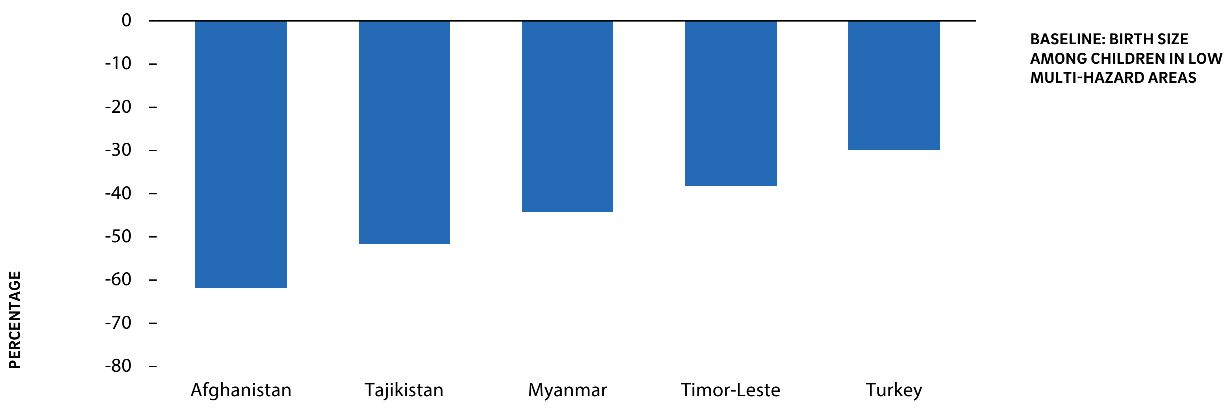
Health

Large sections of humanity are still deprived of the basic human right to health. One key indicator of the standard of health in any country is the under-five mortality rate. Between 1990 and 2016 the overall worldwide child mortality rate fell from 91 to 41 per 1,000 live births. Nevertheless, this still meant that around six million children under the age of five were dying each year.

Overall health, as indicated in child mortality rates, depends on many factors, such as wealth, education, and employment. But disasters also play a part. Across-region regression analysis from Figure 2-15 indicates that a 1 percentage point increase in exposure to disasters increases infant and under-five mortality rates by 0.2 and 0.3 percentage points respectively.

Other measures of health show more direct impact of disasters. Floods, for example, have been shown to increase water-related infectious diseases, such as diarrhoea, due to water contamination and damage to water systems. Floods and cyclones also increase

FIGURE 2-16 **Lower odds of average birth size among children born in high-multi-hazard risk areas**



Note: Only countries for which there are statistically significant results are included.
Source: ESCAP calculations based on DHS surveys from 14 countries for the latest years. Multi-hazard data are from the Global Assessment Report, 2015.

the number of breeding sites for mosquito vectors and facilitate transmission of diseases such as leptospirosis.[54] Earthquakes can also cause outbreaks of endemic infectious disease due to displacement of populations and overcrowding in temporary shelters.[55] In Viet Nam, for example, a study of 4,645 reports of typhoons, earthquakes and floods found significant increases in communicable diseases both pre- and post disasters.

Disasters also affect health by reducing the quality and reach of services. Across the 247 provinces for 17 Asia-Pacific countries, ESCAP's analysis indicates that living in high-multi-hazard areas tends to reduce access to healthcare for women giving birth. Among the 247 provinces across the 17 countries in the region, a 1 percentage point increase in exposure to hydrometeorological and geological hazards leads to decreases of 0.2 and 0.3 percentage points, respectively, in access rates to hospitals for women giving birth (Figure 2-15). This demonstrates the need for resilient, critical infrastructure in high-risk multi-hazard areas, which are more susceptible to earthquakes and related landslides.

Within-country analysis at the household level also shows that, in several countries in Asia and the Pacific, women living in high multi-hazard-risk areas have less access to professional medical help (doctors, nurses or midwives) pre- and post childbirth. In Timor-Leste for example, they are 43 per cent less likely to have such help than women in low-risk areas (Figure 2-17).

Employment

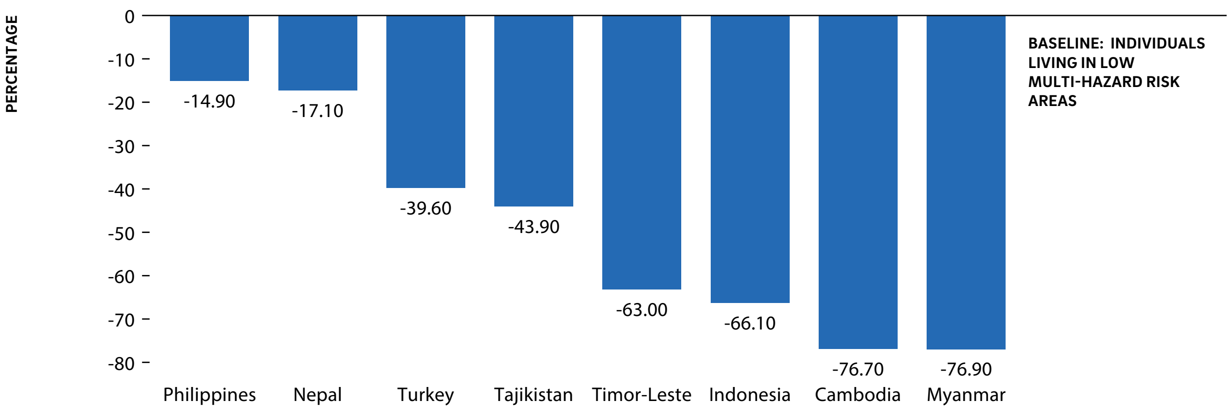
In Asia and the Pacific, the overall unemployment rate is low at 4.2 per cent. This is due largely to fast economic growth in larger economies like China, India and Indonesia. However, this only refers to formal employment and does not capture high levels of unemployment and underemployment in the informal sector, which largely goes unreported and is at the highest risk from disasters, particularly in agriculture.

There is some evidence that women's employment decreases post disasters.[56] However, due to lack of data there has not been much analytical work. Through the analysis of DHS household surveys, the following evidence-based insights on how disasters can impact employment can be provided.

The first insight is that in high-risk, multi-hazard areas, women are significantly more likely to be employed. Across the 17 countries, regression analysis shows that for each percentage point increase in area exposure to hydrometeorological hazards, women's employment rate increases by 0.2 percentage points. And in the case of geological hazards, the increase is around 0.4 percentage points Figure 2-15. This also probably reflects higher levels of poverty that require more women to work.

Within-country logistic regressions show that in Nepal, in high-multi-hazard risk areas, women's rate of employment was 2.3 times, or almost twice of that of men (Annex 2.3). In the Philippines it was 1.2 times

FIGURE 2-17 Lower odds of access to prenatal and medical care for women in high-multi-hazard risk areas

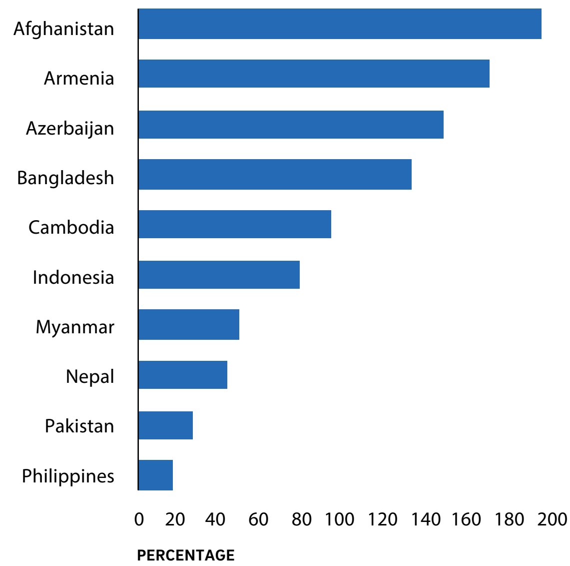


Source: ESCAP calculations based on DHS surveys from 14 countries, latest year and multi-hazard data from Global Assess Report, 2015.
Note: Shows the odds of people in high-risk areas accessing health care compared with those in low-risk areas. Adjusted for wealth and education. Only statistically significant coefficients in the model are shown.

that of men. Because in high-multi-hazard risk areas a higher proportion of women are employed, their livelihoods are more heavily tied to, and impacted by recurrent disasters and may provide additional insights into why women's employment decreases post disasters more than that of males. Only in Pakistan, men are significantly more likely to be employed than women in high-risk areas.

Second, within-country logistic regressions show that in many countries, households depending on agriculture employment and especially those who are poor, are significantly more likely to also be situated in high multi-hazard risk areas (Figure 2-18). For example, in the Philippines, poor households with agricultural employment are 2.4 times more likely to live in high- multi-hazard risk areas. In landlocked developing countries such as Armenia and Azerbaijan, agriculture is a large part of the economy. In Armenia, for example, nearly 35 per cent of the workforce is in agriculture and weather events push thousands into poverty.[57] The livelihoods of subsistence agricultural populations therefore are extremely susceptible to disaster shocks, since they exist within the perfect storm of multiple risks and deprivations.

FIGURE 2-18 Higher odds of agricultural poor living in high-multi-hazard risk areas



Source: ESCAP calculations based on DHS survey reports, latest data and multi-hazard data from Global Assess Report, 2015.
Notes: (1) Only statistically significant results from the model are shown (2) Adjusted for wealth, education, and urban/rural divide.

Education

Education shapes inequality in access to all opportunities, including nutrition, employment, and household-level services.[58] In education, the Asia-Pacific region has experienced significant advances and is on track to meet the 2030 SDG education goals.[59] But this achievement has not been happening in a balanced way, so the playing field has yet to be levelled. Disasters threaten education as they are liable to destroy schools and increase rates of dropout and non-attendance.[60] Education accounts for 8 per cent of the damage and loss in the social sector.

In countries such as Nepal, where earthquakes have caused large-scale disruption, many children have lost months of education. The Philippines, Indonesia and Myanmar often experience repeated disasters every year, so children regularly lose school days, thus reducing the quantity and quality of schooling.[61]

ESCAP regression analysis, across 17 countries at the provincial level, indicates that a 1 percentage point increase in exposure to hydrometeorological decreases education rates for primary and secondary education on average by around 0.26 percentage points respectively (Figure 2-15).

Discrimination—who will be left the furthest behind when disaster hits?

Evidence from prior sections show that in many Asia-Pacific countries, populations are more likely than not to be highly exposed to multi-hazard risks. It has also been demonstrated that people living in high multi-hazard areas are thus likely to have lower nutrition rates, lower education rates and lower access to healthcare. But they can also face discrimination based on gender, age, ethnicity, religion and other divisions. Potential gender-based discriminations can be exacerbated by disasters, as noted previously.

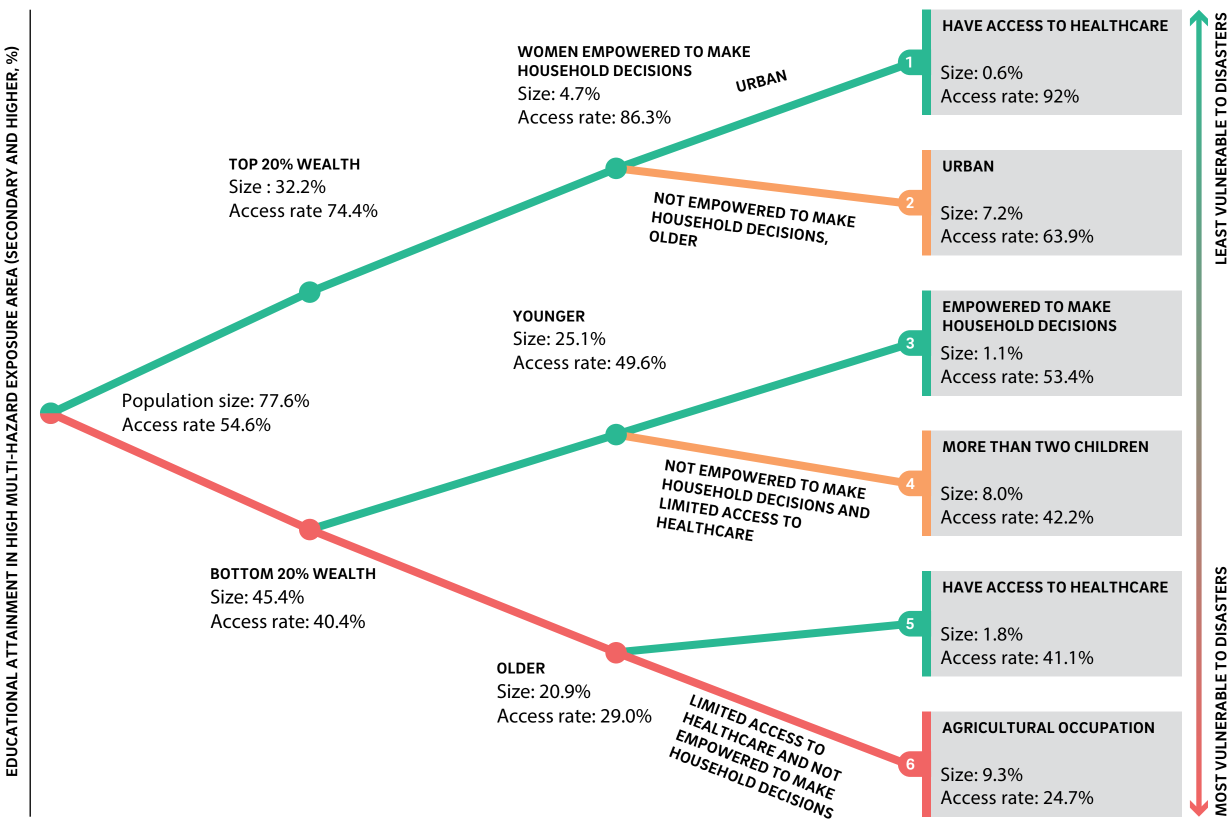
A study of these discriminations from a disaster risk perspective opens the door to a deeper exploration on the intersections of deprivations and discriminations within areas that are already exposed to high-hazard risk. Examining these intersections will help identify groups that are the furthest left behind and where strengthening disaster risk reduction can support social development, including building individual resilience.

This section uses the classification tree methodology to identify those households and individuals that lack access to specific opportunities in high multihazard areas. The trees reveal the circumstances shared by the most disadvantaged and advantaged groups in the high multi-hazard risk areas. Using an algorithm, the analysis produced country- and opportunity-specific classification trees for the 14 countries for which sufficient DHS data and hazard data were available for education and health care opportunities.[62] The classification tree methodology is similar to the one used in a prior ESCAP (2018) publication entitled, "Inequality in Asia and the Pacific", and a detailed description of the methodology can be found there. The approach is commonly used in data mining and machine learning where an algorithm splits the value for each access rate to an opportunity into significantly different population groups based on shared pre-determined circumstances.[63]

This approach can be illustrated for Bangladesh to show who is most at risk from the overlaps of deprivation, discriminations and hazard risk. The classification tree, in Figure 2-19, shows which populations will be the most disadvantaged when disasters hit, specifically for education. The tree starts with the average rate of secondary or higher educational attainment in high-multi-hazard risk areas (55 per cent). The algorithm determines that this population should first be split into the bottom 20 and top 20 per cent of population in terms of wealth. Individuals who belong to the top 20 per cent wealth bracket have educational attainment of rates of 74 per cent as opposed to those at the bottom 20 per cent who have a 40 per cent attainment rate.

The tree indicates that within the bottom 20 per cent wealth group, older individuals (50–64) are worse off than younger individuals. In high multi-hazard risk areas, younger populations have secondary or higher education rates of almost 20 per cent higher. The tree can then be branched further down to show that the worst-off group in terms of education are the poorer, older

FIGURE 2-19 Education levels and vulnerability in high-multi-hazard risk areas in Bangladesh



Sources: ESCAP, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015, and DHS Household Survey.

populations, who have limited access to healthcare, are not empowered to make household decisions, and work in agriculture.

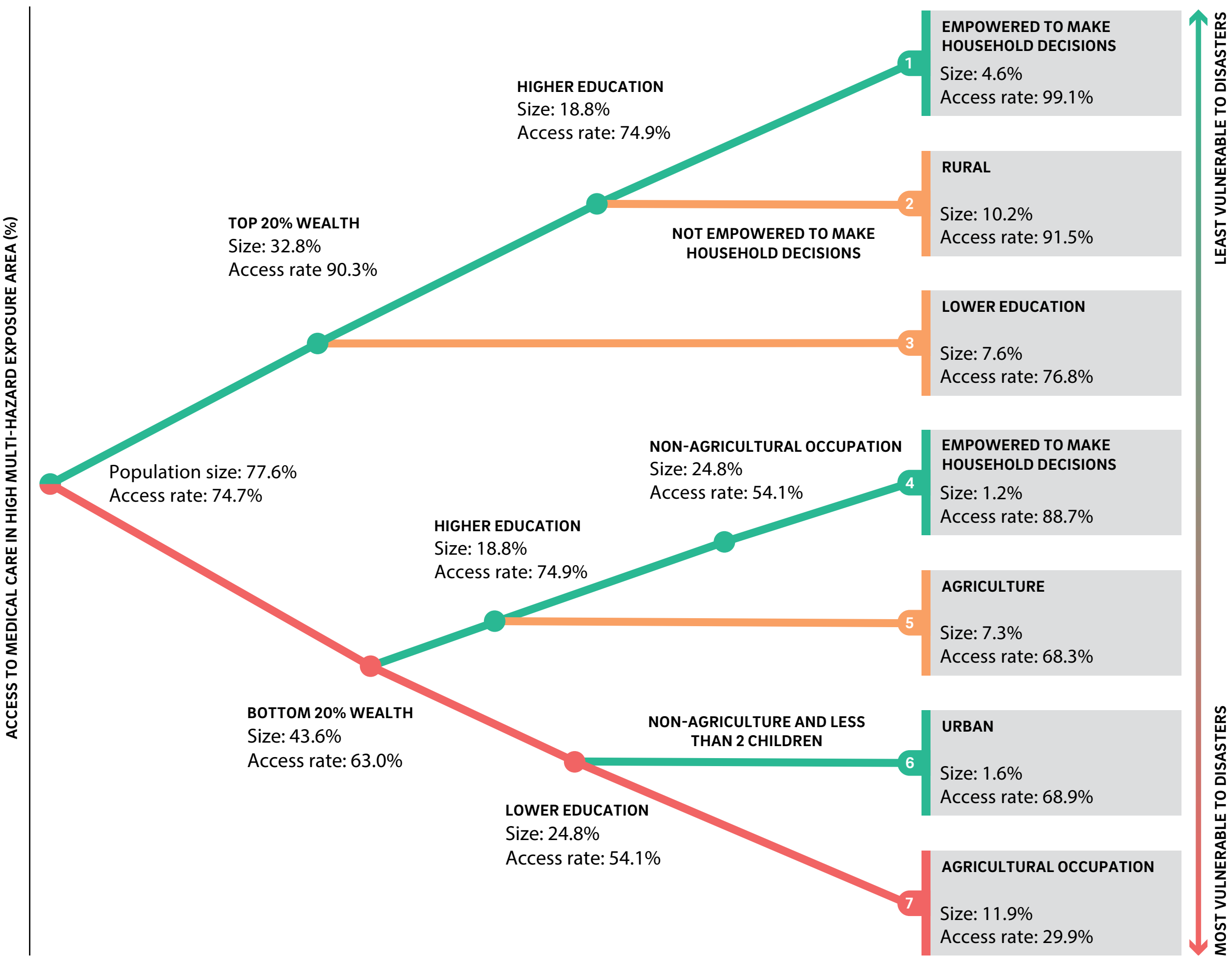
The total gap between the groups with the highest and lowest access is a staggering 68 percentage points for the set of population that lives in high multi-hazard risk areas.

The tree for healthcare follows a similar pattern (Figure 2-20). Access is highest for those in the highest wealth bracket, who are highly educated and whose women are empowered to make household decisions. For these women, healthcare access is almost 100 per cent. This is in sharp contrast to those in the worst-off group: for women in the bottom 20 per cent of wealth, with low education, and in agricultural occupations, the access rate is around 30 per cent. The total gap between the groups with the highest and lowest access is 70 percentage points. Thus, the characteristics of these groups need to inform the development of community-based resilience policies as well as policy development at the national level across all sectors.

It is clear from the classification tree that when disasters hit, the cumulative effects of these negative circumstances will hit these vulnerable groups the hardest. If education is already difficult to attain, when disaster hits the scant number of children who are going to school could drop out. The large inequalities between the best-off and the worst-off groups also suggest that the worst off are more susceptible to disaster impacts where school or hospital infrastructure is not robust.

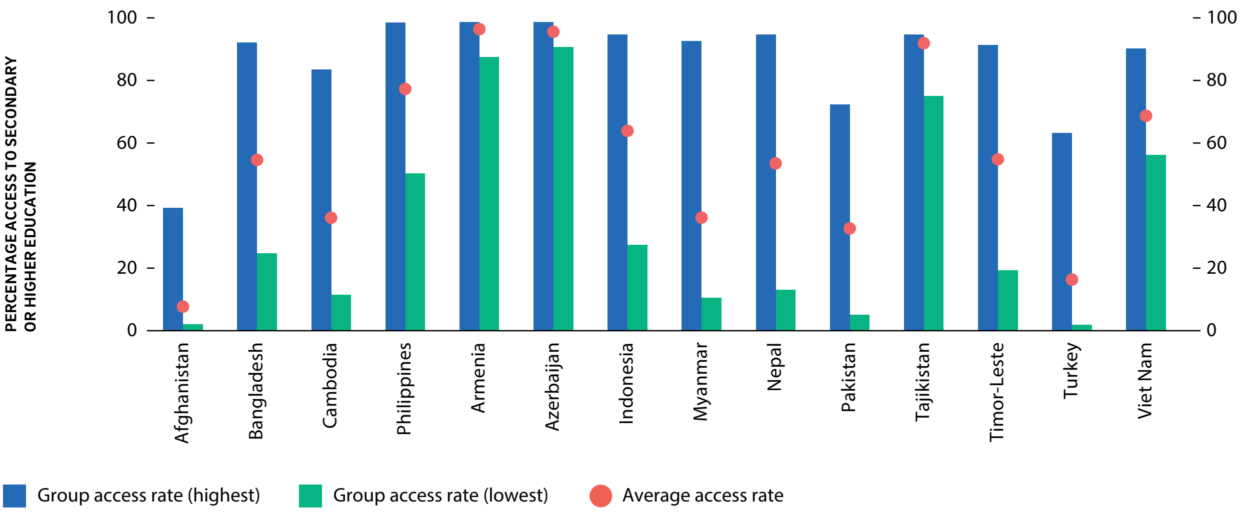
The classification trees therefore indicate the group characteristics for policies that focused on reaching those furthest behind.[64] The trees for education and healthcare for all 14 countries in high-multi-hazard areas are summarized in Figure 2-21 and Figure 2-22 respectively. The blue lines represent the access of

FIGURE 2-20 **Access to health care and vulnerability in high-multi-hazard risk areas in Bangladesh**



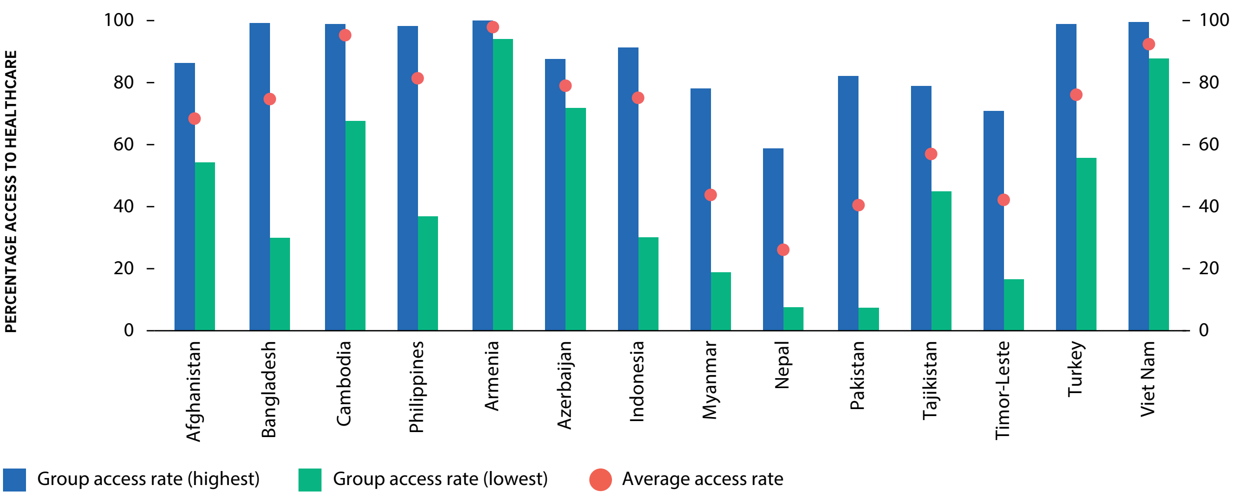
Sources: ESCAP, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015, and DHS Household Survey.

FIGURE 2-21 Inequality of access to education in high-multi-hazard risk areas



Source: ESCAP calculations using data from the latest DHS surveys and GAR hazard risk data.

FIGURE 2-22 Inequality of access to healthcare in high multi-hazard risk areas



Source: ESCAP calculations using data from the latest DHS surveys and GAR hazard risk data for countries in Asia and the Pacific.

the most advantaged groups; the grey bars represent the access of the most disadvantaged groups; and the circles indicate the average access.

Table 2-1 summarizes the findings from the classification trees for the two opportunities and shows the circumstances of populations who are left the furthest behind in high-multi-hazard risk areas. Besides being in the bottom 20 per cent of the wealth bracket, the most common shared circumstance of the most disadvantaged is employment in agriculture. Others, in declining order, are older age, living in rural areas, having more than two children, and for women a lack of empowerment reflected through property ownership. The poor, it seems, have a multitude of circumstances that work hand in hand to keep them 'furthest behind' — generation after generation.

Disaster displaced populations— an emerging discrimination

Different climate hazards present different dilemmas in terms of mobility responses; how and where people move when disaster strikes. Much will depend on people's economic circumstance, and there are many other scenarios and possibilities. If people are hit by slow and repeated hazards, such as sea-level rise and coastal erosion, they may choose to migrate on a long-term basis.

TABLE 2-1 The groups hardest hit by disasters

SHARED CIRCUMSTANCES OF THE WORST-OFF AND BEST-OFF GROUPS IN HIGH-MULTI-HAZARD RISK AREAS IN ACCESS TO SELECTED OPPORTUNITIES			
INDIVIDUALS LEFT BEHIND IN SECONDARY OR HIGHER EDUCATION ATTAINMENT IN HIGH-MULTI-HAZARD RISK AREAS			
FURTHEST BEHIND		FURTHEST AHEAD	
CIRCUMSTANCES	IMPORTANCE OF CIRCUMSTANCE IN DETERMINING ACCESS TO OPPORTUNITY (IN %)	CIRCUMSTANCES	IMPORTANCE OF CIRCUMSTANCE IN DETERMINING ACCESS TO OPPORTUNITY (%)
Bottom 20% of wealth	13%	Top 20% of wealth	16%
Agricultural occupation	8%	Non-agricultural occupation	7%
Age 50–64	7%	Age 15–49	3%
Age 15–49	1%	Age 50–64	1%
No or limited access to healthcare	8%	Have access to healthcare	1%
Lack of empowerment: Women in household not empowered to make decision or hold ownership of property	6%	Women in household empowered to make decision or hold ownership of property	2%
More than 2 children	7%	Less than 2 children	3%
Rural	3%	Urban	7%
INDIVIDUALS LEFT BEHIND IN ACCESS TO MEDICAL CARE IN HIGH-MULTI-HAZARD RISK AREAS			
Bottom 20% wealth	12%	Top 20% wealth	15%
Agricultural occupation	10%	Non-agricultural occupation	5%
Lower or primary education	13%	Secondary or higher education	11%
Women in household do not hold ownership of property	5%	Women in household hold ownership of property	1%
Rural	6%	Urban	6%
More than 2 children	6%	Less than 2 children	1%
Less than average child birthweight	1%	Less than average child birthweight	1%
Age 50–64	2%		

Sources: ESCAP, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015, and DHS Household Survey.

Most of these hazards and their responses would fall under the threat of extensive risk. For intensive risks, such as sudden-onset disasters in the form of floods, storms and cyclones, people are likely to be forced out on a temporary basis until critical infrastructure is restored. Such risks are projected to increase much further with climate change.[65]

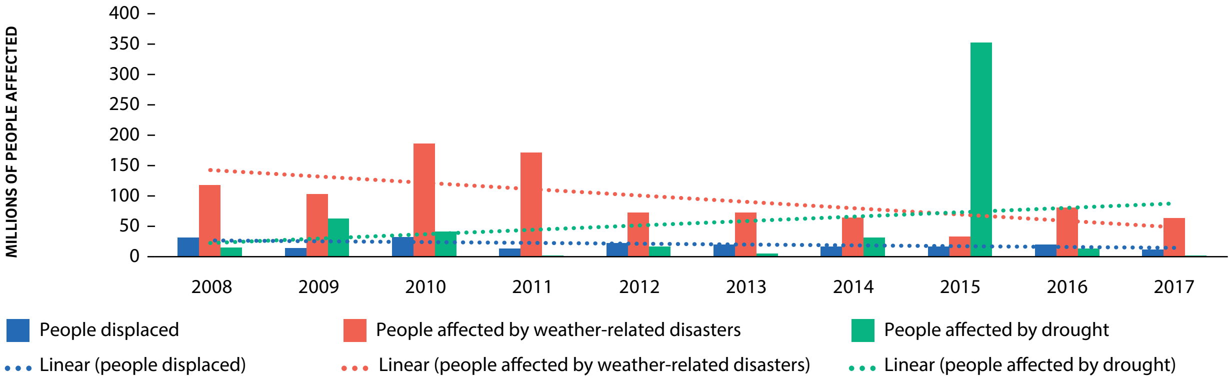
While the number of people being displaced by weather-related hazards overall is decreasing, the number of people being displaced by drought, is significantly increasing, on average by 10 million more people per year.[66] Indeed, Figure 2-23 shows that slow-onset disasters are contributing to a greater share of internal displacement and will play a larger role in the future.

Finding the furthest behind

The following sections identify the geographical location, where poverty, population density, along with low human development and disaster risk areas converge. They provide empirical spatial evidence that support the identification of the 5 risk hotspots that were discussed in Chapter 1. This analysis uses the human development index (HDI), a composite measure of average achievements in three key dimensions of human development: a long and healthy life, education, and decent standard of living. This is combined with the GAR 2015 hazard exposure models, and data on land degradation. A novel interpolation and small area estimation method is used to locate those who live in poverty.

Figure 2-24 shows socioeconomic-hazard risk areas among some selected subregions. The figures amalgamate the index of high population, low HDI and high-hazard risk or high land degradation.[67] The

FIGURE 2-23 Disaster displacement and people affected by weather-related disasters, Asia and the Pacific, 2008–2017



Source: IDMC, 2017. Internal displacement figures by country, EM DAT (Accessed on 16 January 2018).
Notes: People affected by weather-related disasters include extreme temperature, flood, storm and wildfire.

BOX 2-2 The 2015 Nepal earthquake a setback to development

The destruction was widespread covering residential and government buildings, heritage sites, schools and health posts, rural roads, bridges, water supply systems, agricultural land, trekking routes, hydropower plants and sports facilities. The geodetic network centres including horizontal and vertical control points have been damaged in a manner that affects reconstruction planning. Rural areas in the central and western regions were particularly devastated and further isolated due to road damage and obstructions. In the worst-hit areas, entire settlements, including popular tourist destinations like Langtang, were swept away by landslides and avalanches triggered by the earthquakes. Due to the weakened, ruptured, and destabilized slopes and surfaces, the vulnerable areas have now become even more susceptible to flooding and landslides that can occur during the monsoon.

Hundreds of historical and cultural monuments, at least a century old, were either destroyed or extensively damaged. Over half a million houses were destroyed. The damage exposed the weaknesses of houses that lacked seismic-resistant features or were not in accordance with the building codes.

The disaster also highlighted inequities in Nepali society spanning geography, income and gender. Poorer rural areas have been more adversely affected than towns and cities due to their inferior quality of houses. More women and girls died than men and boys, partly because of gendered roles that disproportionately assign indoor chores to women. The earthquakes pushed an additional 2.5 to 3.5 per cent of Nepalis into poverty in fiscal year 2015–2016, which translated into at least 700,000 additional poor. Moreover, the deterioration of water and sanitation services, disruption of schools and health services, and the possible increase in food insecurity led to a bigger impact on multidimensional poverty.

The effects of the disaster illustrate that the estimated value of total damages and losses (changes in flows) was equivalent to about one-third of the GDP in fiscal year 2013–2014. In addition, for that year the estimated value of damage was equivalent to more than 100 per cent of gross fixed capital formation. To put it differently, if all other capital formation activities were stopped, it would take Nepal more than one year to rebuild the fixed capital that was destroyed by the earthquakes. Furthermore, the estimated production losses represented about 10 per cent of the added value of all goods and services produced in one year, which resulted in a slowdown of the economy in the short term, even though the losses for cultural heritage and environment, among others, would unfold over several years.

Annual economic growth, in 2014–2015, was expected to be the lowest in eight years, at 3 per cent. The losses continued to accumulate during the fiscal year 2015–2016 and beyond until major sectors recovered fully.

Source: Nepal Earthquake 2015. National Planning Commission.

analysis shows that, for example, within South Asia, the most vulnerable populations live in the Ganges-Brahmaputra-Meghna (GBM) basin and parts of Pakistan and Afghanistan. The same analysis in the Pacific shows that Vanuatu is the most vulnerable country in the subregion with a high overlap of low HDI with disaster risk throughout the country.

A similar analysis was performed to identify hotspots comprising the overlaps of socioeconomic deprivation and land degradation in two subregions. Figure 2-25 shows that the highest concentration of people combined with low HDI, and high-hazard risk in Central Asia are in Turkmenistan and Tajikistan. Figure 2-26 further indicates that the highest risks in South-East Asia, are in Myanmar, Indonesia and Viet Nam.

These risk hotspots tend to cut across national boundaries. One of the most extensive is the Ganges–Brahmaputra–Meghna (GBM)river basin, which is the world's largest river basin and is shared by four South Asian countries Bangladesh, Nepal, India and Bhutan.[68] The GBM basin shapes social and cultural lives of around 630 million people, almost 70 per cent of whom are rural, and account for the largest concentration of poverty in the world.[69] Furthermore, they are also people who are at high risk from multiple hazards. Geo-locating these people and understanding their spatial distribution can provide guidance on the priority areas that should receive risk-sensitive investments.

Figure 2-27 uses a small area estimation methodology to estimate a probable location of the poor in the GBM basin.[70] These use a range of data; urban built up area, nightlight data, as well as the DHS wealth index data. This empirically shows that poorer populations, who will be least able to cope are the ones most exposed to flooding. The box in the figure notes the locations where additional investments and policy attention can bolster the resilience of those who are the furthest behind. The map also shows that the worst-off populations are not confined to a single country so these measures should involve cooperation among the riparian countries.

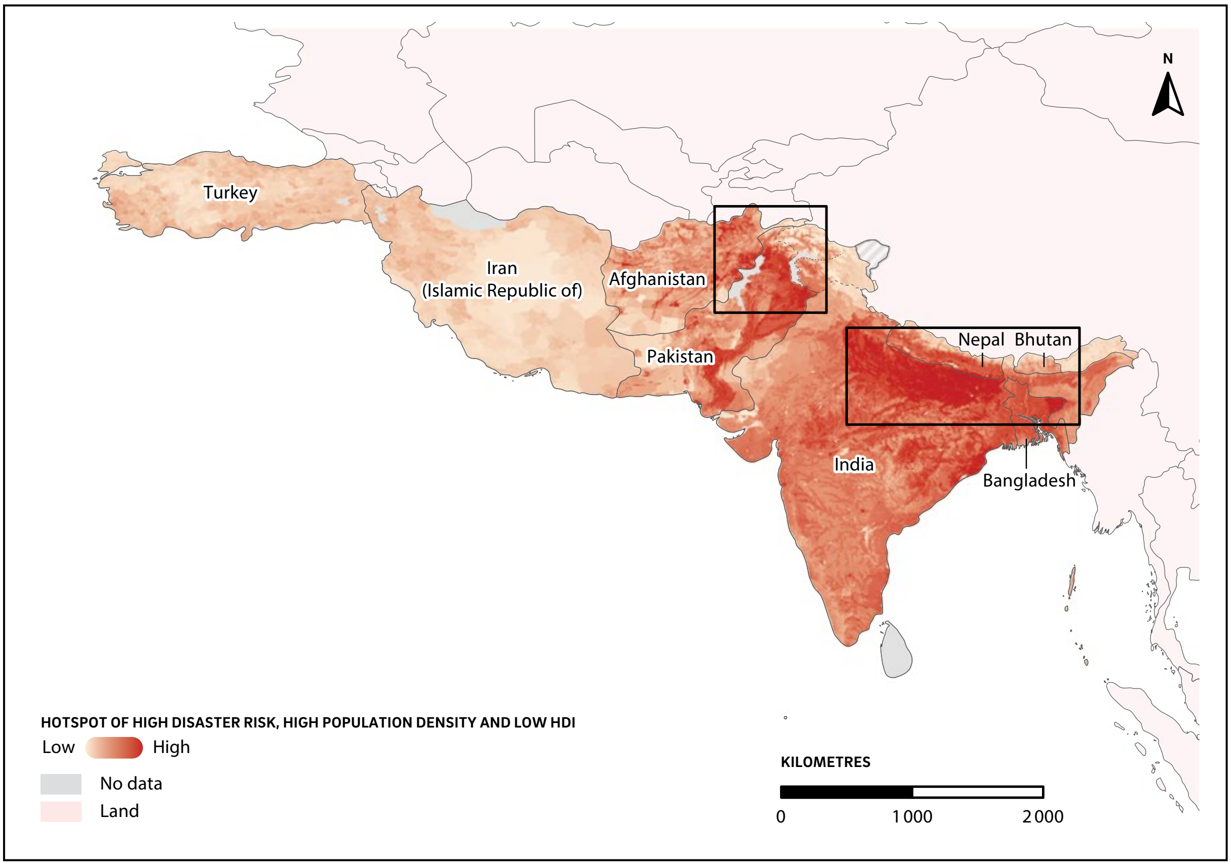
While disasters are often transboundary, many strategies to reduce risk will be local, and community based.[71] For this purpose, it is useful to identify the most vulnerable communities using the DHS geographic information system (GIS). Figure 2-28 illustrates this for Nepal showing that the concentration of risk overlap is greatest in the eastern parts of the country, particularly in Province 3, and the borders between provinces 1 and 3. The second map overlays the country's primary care hospitals. This can be useful in identifying the critical infrastructure needed to support the most vulnerable populations. The handful of hospitals within the most at-risk areas, if built or upgraded in a resilient and risk-sensitive manner, can support the most vulnerable populations during disaster shocks.

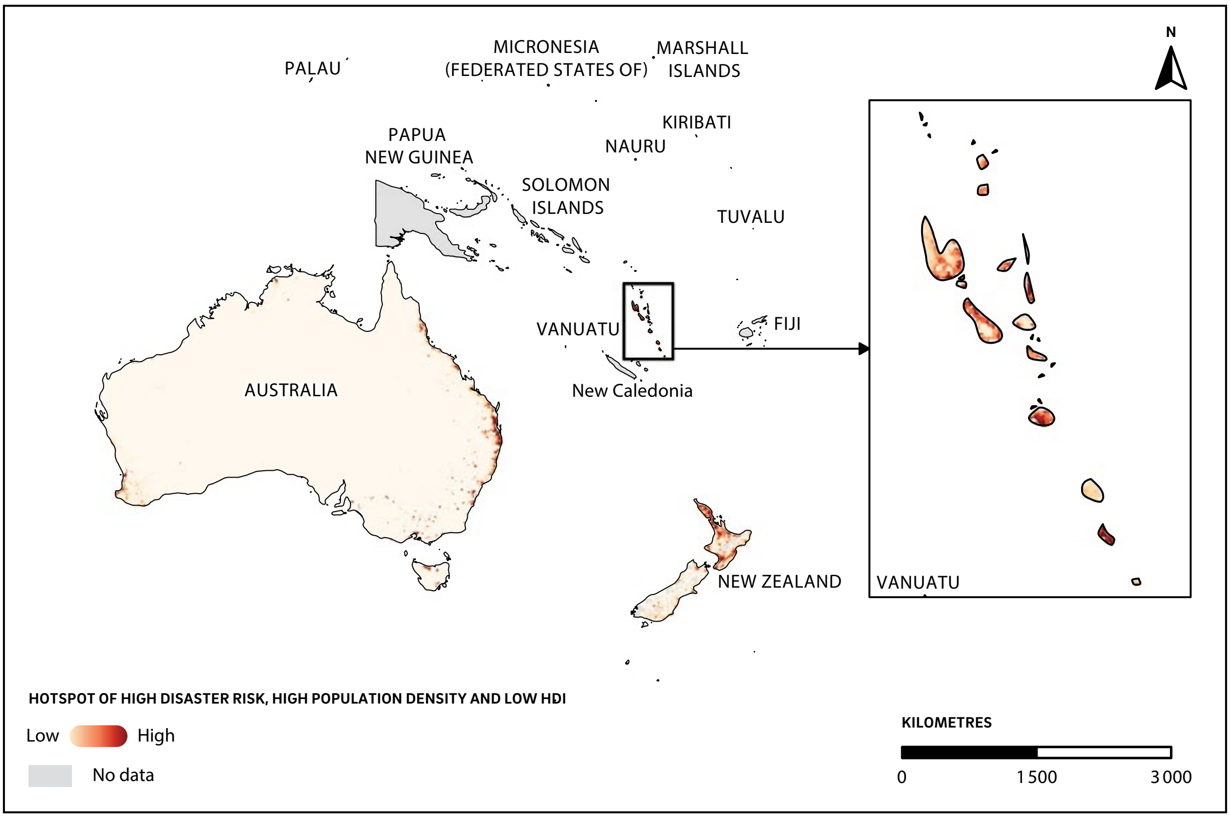
Figure 2-29 shows the corresponding maps for Bangladesh. This shows that the highest concentrations of socioeconomic-hazard risks are along the floodplains. The populations living there are subject to recurrent annual flooding. In addition, it also shows where critical infrastructure, like hospitals, need to be upgraded to withstand disasters and where the most resilient infrastructure needs to be built to support the most vulnerable populations.

What next?

2030 Agenda for Sustainable Development pledged to ensure that "no one is left behind" and to "endeavour to reach the further behind first."[72] This chapter has shown that in the Asia-Pacific region there are multiple overlaps between socioeconomic risks and disaster risks that challenge the capacity to fulfil this pledge. The next chapter will demonstrate ways to build comprehensive risk-informed and disaster-resilient policies that will help uplift those left furthest behind.

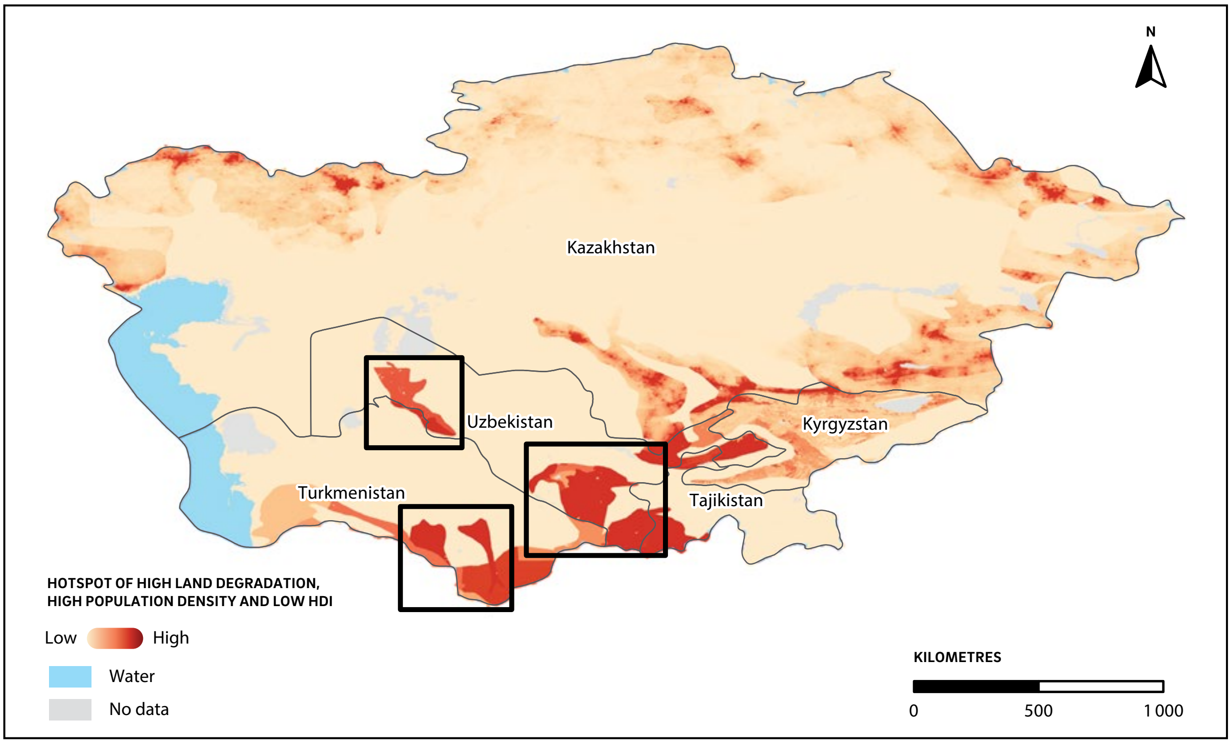
FIGURE 2-24 Hotspots of low HDI, high population density, and hazard risks





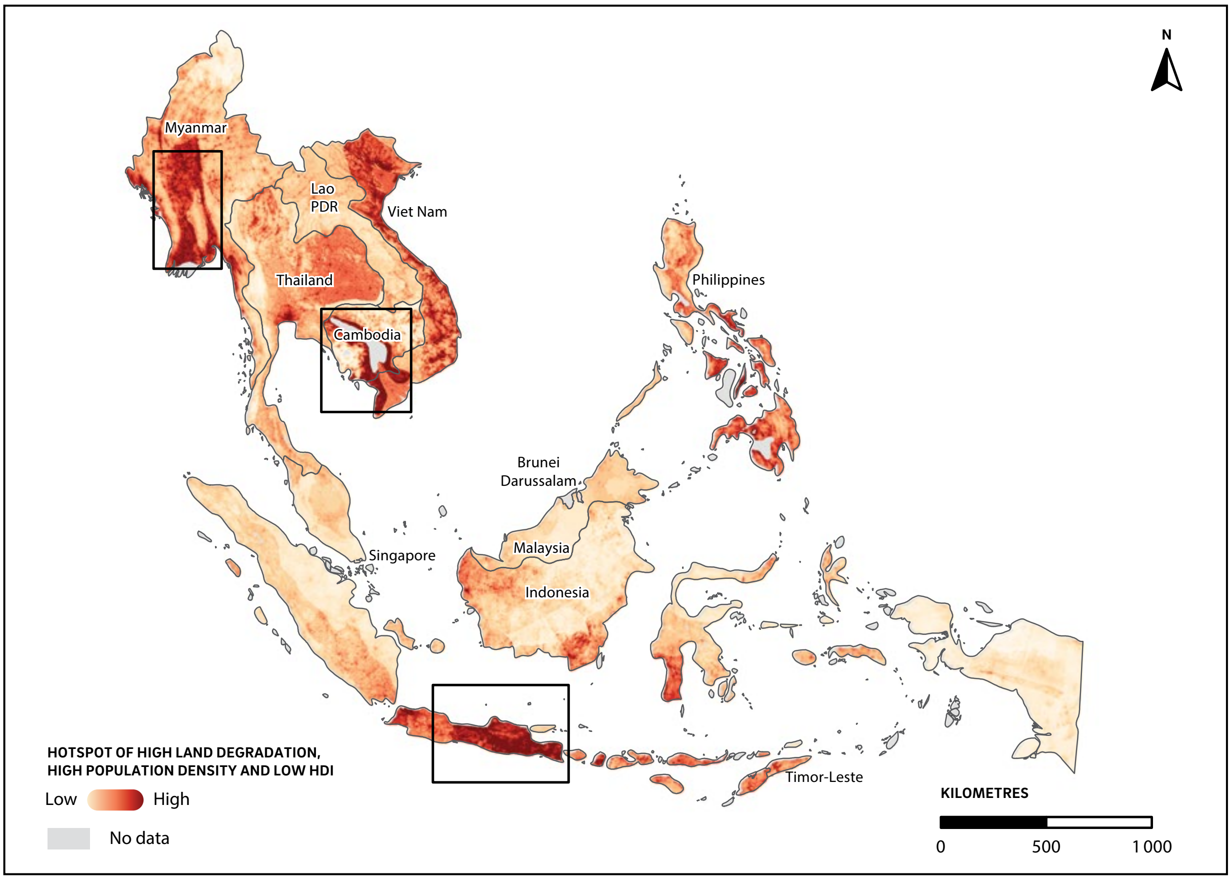
Sources: Calculations by ESCAP based on (1) sub-national HDI data from UNDP, (2) Population statistics from WorldPop, (3) and hazard data from GAR, 2015.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations. 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.

FIGURE 2-25 Hotspots of low HDI and land degradation in Central Asia



Sources: Calculations by ESCAP based on (1) sub-national HDI data from UNDP, (2) Population statistics from WorldPop, (3) and land degradation data from the Global Assessment of human-induced soil degradation (UNEP).
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

FIGURE 2-26 Hotspots of low HDI and land degradation in South-East Asia



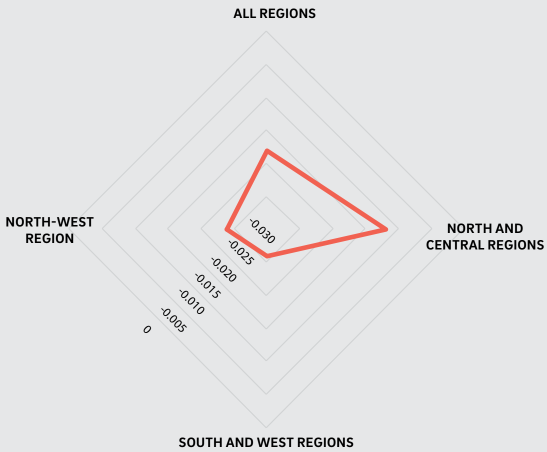
Sources: Calculations by ESCAP based on (1) sub-national HDI data from UNDP, (2) Population statistics from WorldPop, (3) and land degradation data from the Global Assessment of human-induced soil degradation (UNEP).
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

BOX 2-3 Drought impacts on human development in India

Floods and droughts are a recurrent phenomenon in India. In many states, below-average monsoon rains can cause severe droughts. Hardest hit are the rural areas and livelihoods dependent on agriculture. This is especially true where rainfall is the only source of water for agricultural production, as in rain fed and minor tank irrigation areas. In India, at least 30 per cent of the population has agriculture-dependent livelihoods.

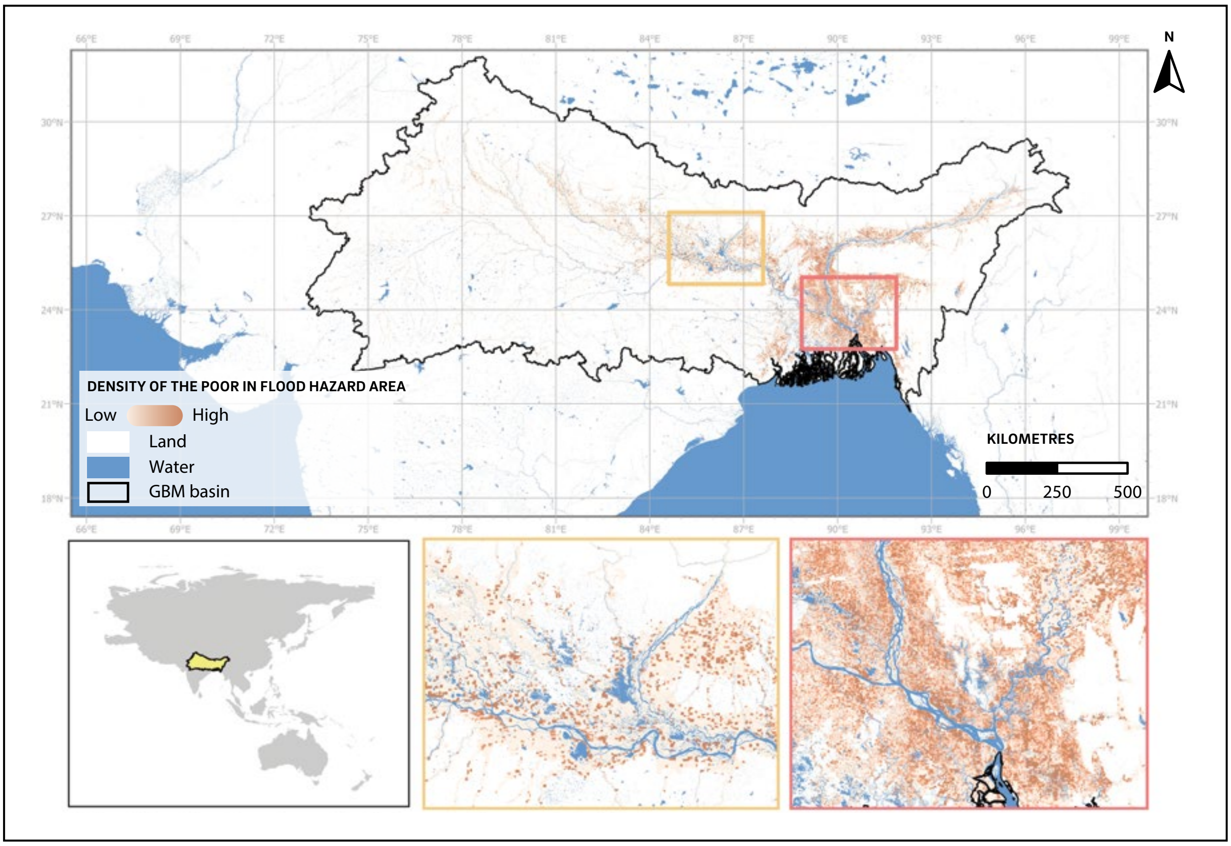
A new forthcoming study shows that in all regions but one, drought decreases the state-wide human development index (HDI), particularly in India's north and central regions. The HDI is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. The index is the geometric mean of normalized indices for each of the three dimensions.

BOX 2-3 Decrease in HDI as a result of drought



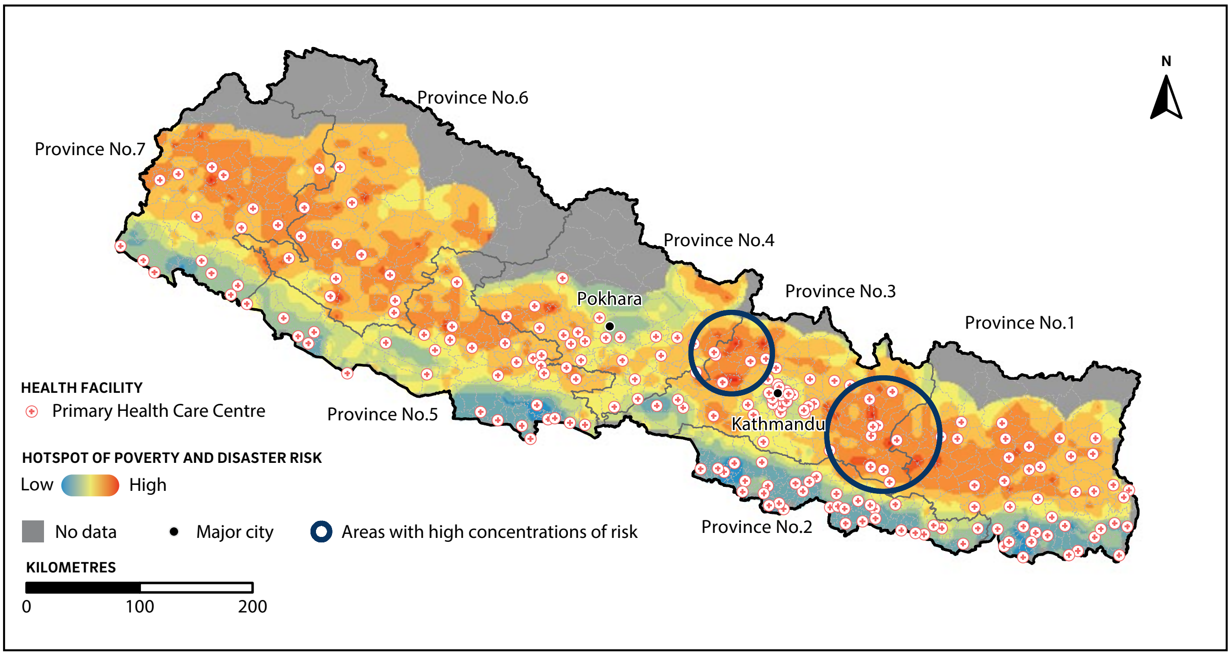
Source: ESCAP based on G. Amarnath, "Impacts of natural disaster on economic growth and human development in India- State wise analysis", (forthcoming 2019).
Note: The summary chart of regression coefficients show that droughts affected the North and Central region of India the highest.

FIGURE 2-27 The most vulnerable populations in the GBM basin



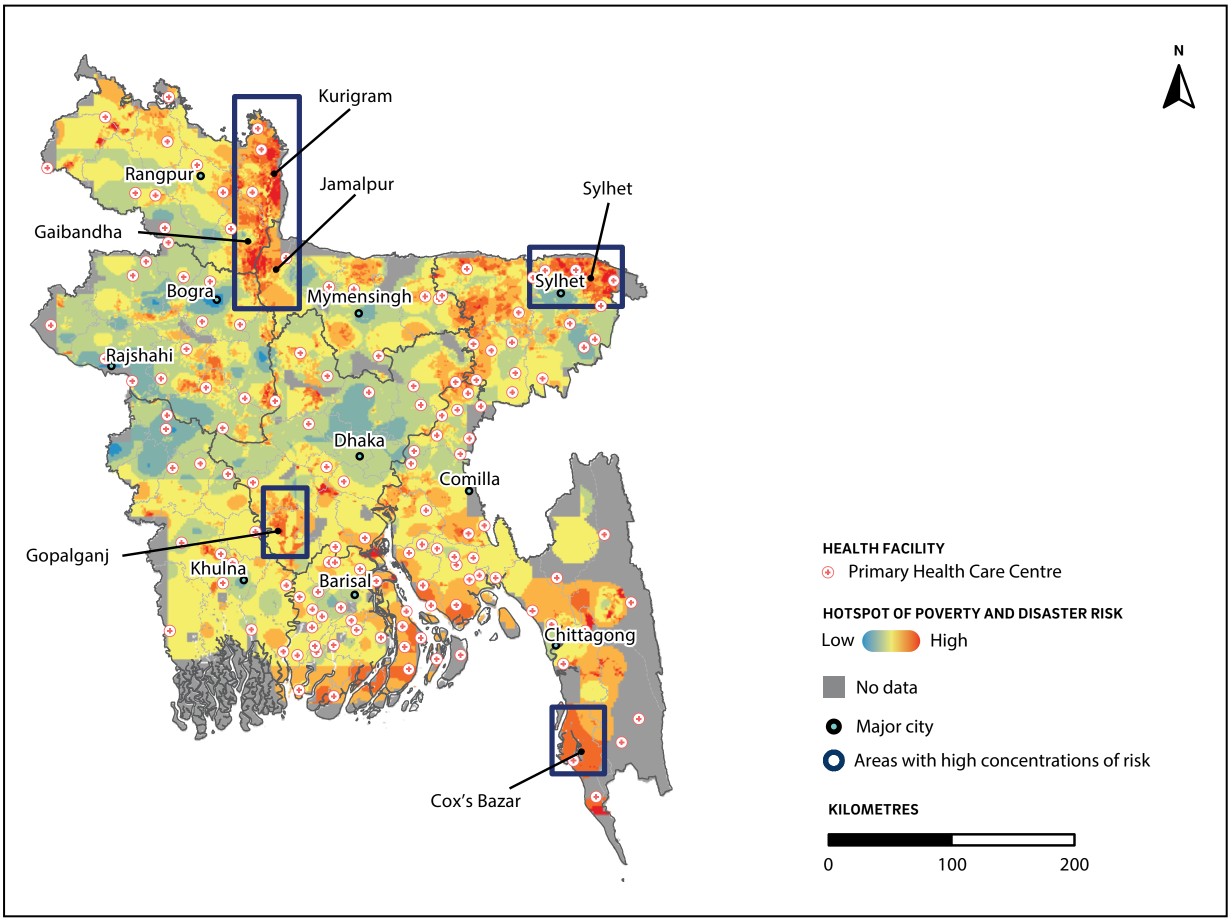
Source: Calculations by ESCAP based on Official population statistics from national statistics office of each of the 5 countries, (2) DHS Programme Household Survey results from Bangladesh, India and Nepal, (3) German Aerospace Centre (DLR) Global Urban Footprint, (4) Earth Observations Group at NOAA Nightlights data, (5) European Space Agency Global Climate Change Initiative (CCI) Land Cover, and (6)UNISDR GAR, 2015 Probabilistic Hazard Maps.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

FIGURE 2-28 Mapping vulnerable communities and health facilities in Nepal



Sources: ESCAP, based on DHS Programme Household Survey for Nepal, and multi-hazard data from Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

FIGURE 2-29 Mapping vulnerable communities and health facilities in Bangladesh



Sources: ESCAP, based on DHS Programme Household Survey and Service Provision Assessment Survey for Bangladesh, and multi-hazard data from Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Endnotes

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36 Ibid.
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63 ESCAP (2018b).
64 Ibid.
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CHAPTER 3

Investing to outpace disaster risk

The previous chapter showed that disasters slow down any progress that is made in reducing poverty and inequality. This is not inevitable. Governments can break this link by implementing a comprehensive portfolio of sectoral investments and policies. This will require additional finance, but it will also deliver co-benefits, through better education, health, social and infrastructure services, higher agricultural production and incomes. It will also lead to better results for the many disaster risk reduction interventions already underway in the region which will help to break the cycle between disasters, poverty, inequality and disempowerment.

The previous chapter revealed that those left behind in multi-hazard areas belong to the bottom 20 per cent of the wealth distribution, and are likely to be farmers who lack access to education and medical care, and women who do not have the power to make decisions or own property. Chapter 2 also highlighted the vulnerability of key critical infrastructure, within the education, housing and health sectors. Thus, for the groups likely to be left behind, these are the sectors that matter the most. This chapter demonstrates how sectoral investments can be adapted to deliver disaster risk reduction (DRR) for those left behind. If these strategies are to work, Governments will need to eliminate the barriers faced by those left behind in accessing land, early warning systems, finance, and decision-making structures.

The actions proposed in this chapter are transformative; they require a shift in the focus of disaster risk reduction from addressing only disaster impacts to addressing the fundamental drivers of vulnerability that make people susceptible to the impacts of disasters and climate change.

Investing more

Investment scenarios

This chapter presents the results of computable general equilibrium modelling (CGE) quantifying the relationship between poverty, inequality and disasters. For an explanation of how the model works, see Annex 3.1. Eleven scenarios were used to explore how the percentages of national populations living in poverty (at the $1.90, $3.20 and $5.50 a day thresholds), and the Gini coefficient, would potentially change over 2016–2030, depending on the levels of economic growth, disaster risk and sectoral investments. Modelling was conducted for 26 countries for which sufficient information is available. Collectively, these account for 90 per cent of the region's population.

A. Growth
B. Growth + investment in social protection
C. Growth + investment in education
D. Growth + investment in health
E. Growth + investment in infrastructure
F. Growth + disaster risk
G. Growth + disaster risk + investment in social protection
H. Growth + disaster risk + investment in education
I. Growth + disaster risk + investment in health
J. Growth + disaster risk + investment in infrastructure
K. Growth + disaster risk + investment in all four key sectors

Growth in each country is assumed, in the model, to be the average Gross Domestic Product (GDP) growth rate of the last five years. Between 2016 to 2030, in scenario A, this is projected to reduce the average percentage of the national populations living in extreme poverty ($1.90 a day) from 6.3 per cent to 2.4 per cent, and the average Gini index score from 35.45 to 34.72. In scenarios B to E, further improvements are achieved by investing in social sectors and infrastructure in line with international norms. Scenarios B, C and D include investments in social sectors at the level of current global averages for public expenditure as a percentage of GDP. These are 11 per cent for social protection; 5 per cent for education; and 4 per cent for health. Scenario E includes investments in infrastructure at 2 per cent of GDP. Under each scenario, almost all countries eradicate extreme poverty at the $1.90 threshold, and at the $3.20 threshold reduce poverty to less than 30 per cent.

Impacts of disaster risk

These results do not hold when the model incorporates the potential impact of disasters, which will undermine any progress in human development. In scenario A, the average percentage of the national populations living in extreme poverty falls to 2.4 per cent, but in scenario F, it only falls to 3.6 per cent. There are comparable differences for the higher poverty thresholds. Additionally, while in scenario A the Gini coefficient falls, in Scenario F it rises to 37.15.

The analysis also highlights the 'high-impact' countries, namely Bangladesh, India, Lao People's Democratic Republic, Nepal, and Papua New Guinea, which have the largest differences between scenarios A and F; more than three percentage points in the number of people living under $1.90 a day in 2030. The 'moderate-impact' countries where the increase is between one and three percentage points are Indonesia, Myanmar, Pakistan, Philippines and Timor-Leste. 'Low-impact' countries, where the increase is less than one percentage point, are Armenia, Azerbaijan, Cambodia, China, Fiji, Georgia, the Islamic Republic of Iran, Kyrgyzstan, Mongolia, Sri Lanka, Tajikistan, Turkey, and Viet Nam. Even for most low-impact countries, the poverty level in 2030 is higher under scenario F than scenario A. Thus, disaster risk is expected to undermine the ability of economic growth to reduce poverty for most of the 26 countries. To protect development gains and eradicate poverty countries across the region must address disaster risk.

Countries for which Scenario F results in a Gini coefficient score in 2030 at least 2.5 points higher than for scenario A are Cambodia, China, Georgia, Indonesia, the Islamic Republic of Iran, Lao People's Democratic Republic, Malaysia, Myanmar, Papua New Guinea, Philippines, Sri Lanka, Thailand and Turkey. Countries for which the increase is between 1.0 and 2.5 points are Armenia, Azerbaijan, Bangladesh, Fiji, India, Kazakhstan, Kyrgyzstan, Mongolia, Nepal, Pakistan, Tajikistan, Timor-Leste and Viet Nam. No countries see an increase of below one point.

These results show that disasters erode development in all subregions, as well as in low-, middle- and high-income countries. To meet the Sustainable Development Goals (SDGs), all countries will therefore need to engage in disaster risk reduction.

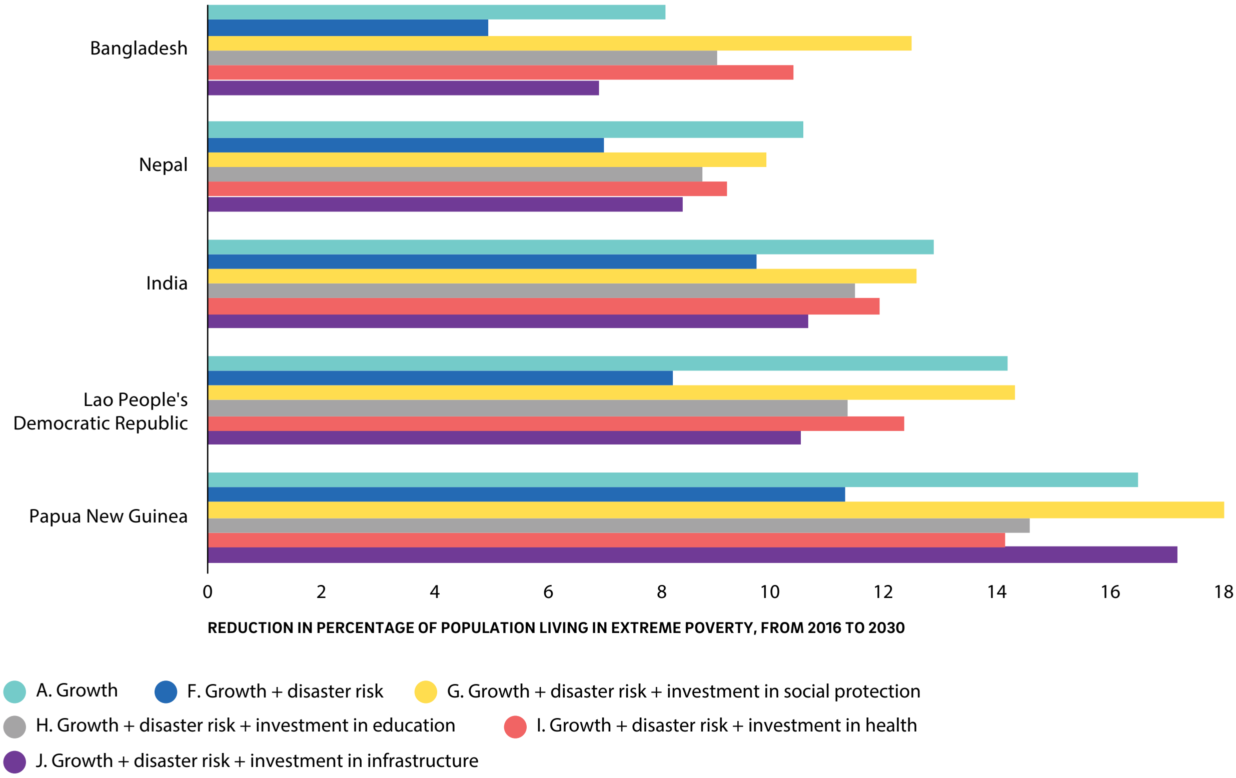
Reducing poverty and inequality through investments in key sectors

Scenarios G to J incorporate projected economic growth, disaster risk and investments in each sector. Figures 3-1 and 3-2 show the resulting changes in levels of extreme poverty from 2016 to 2030, for each of these scenarios, compared to scenarios A and F (growth, and growth with disaster risk). The results are displayed separately for high and medium impact countries so that different scales can be displayed. They show that for each country, growth will reduce poverty compared to 2016, this will be undermined by disasters, but poverty can be reduced again by investing in key sectors. The greatest benefits result from investment in social protection. This echoes earlier ESCAP reports which call for increased investment in social protection to ensure that nobody is left behind.[73]

Figures 3-1 and 3-2 demonstrate that the projected economic growth (scenario A) is expected to reduce poverty, but that these reductions are lower when disaster risk is taken into account (scenario F). Nevertheless, investments in each sector can mitigate this impact of disasters, and deliver higher reductions in poverty than scenario F.

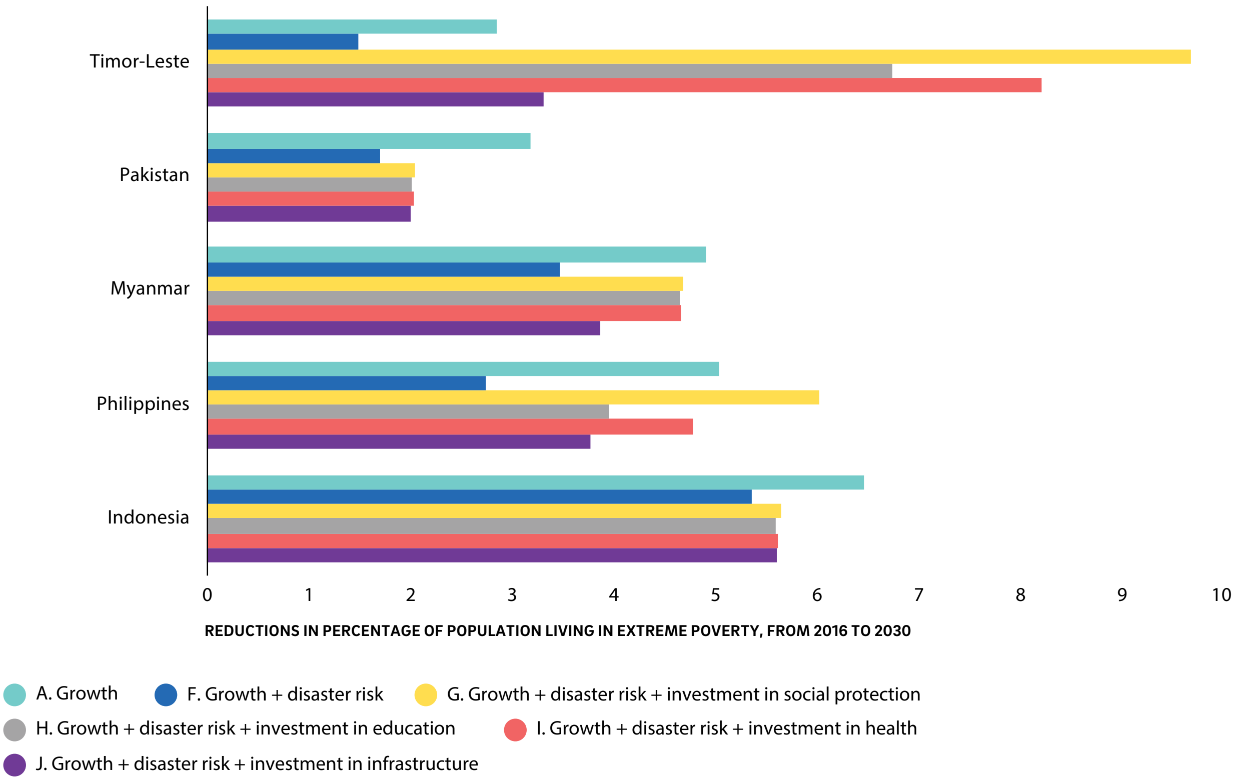
Translating these percentages into population numbers reveals how many people will be lifted out of poverty, and how many will be left behind. Across the 26 countries, approximately 272 million people were living in extreme poverty in 2016. Economic growth between 2016 and 2030 is expected to lift 220 million people out of extreme poverty by 2030. This will still leave 52 million people in extreme poverty, but incorporating disaster risk raises the figure substantially to 119 million (Figure 3-3). However, increasing investments in the social sectors so as to reach global averages would bring this number down: through social protection to 53 million; through health to 69 million; and through

FIGURE 3-1 Impact of investments on poverty levels, 2016–2030, high disaster impact countries



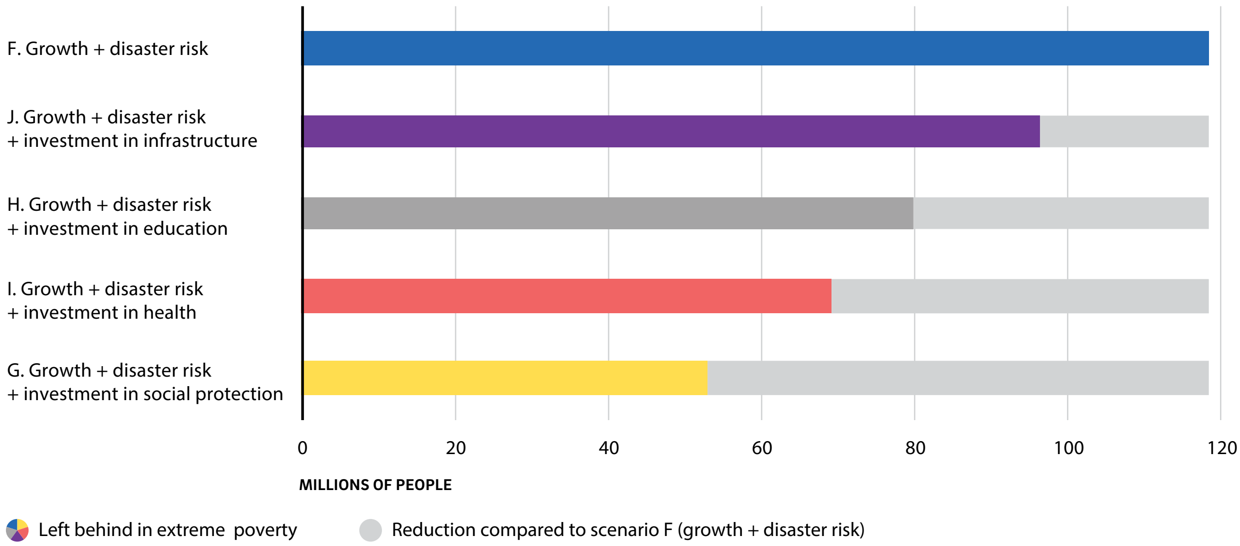
Source: ESCAP calculations based on CGE model simulation.

FIGURE 3-2 Impact of investments on poverty levels, 2016–2030, moderate disaster impact countries



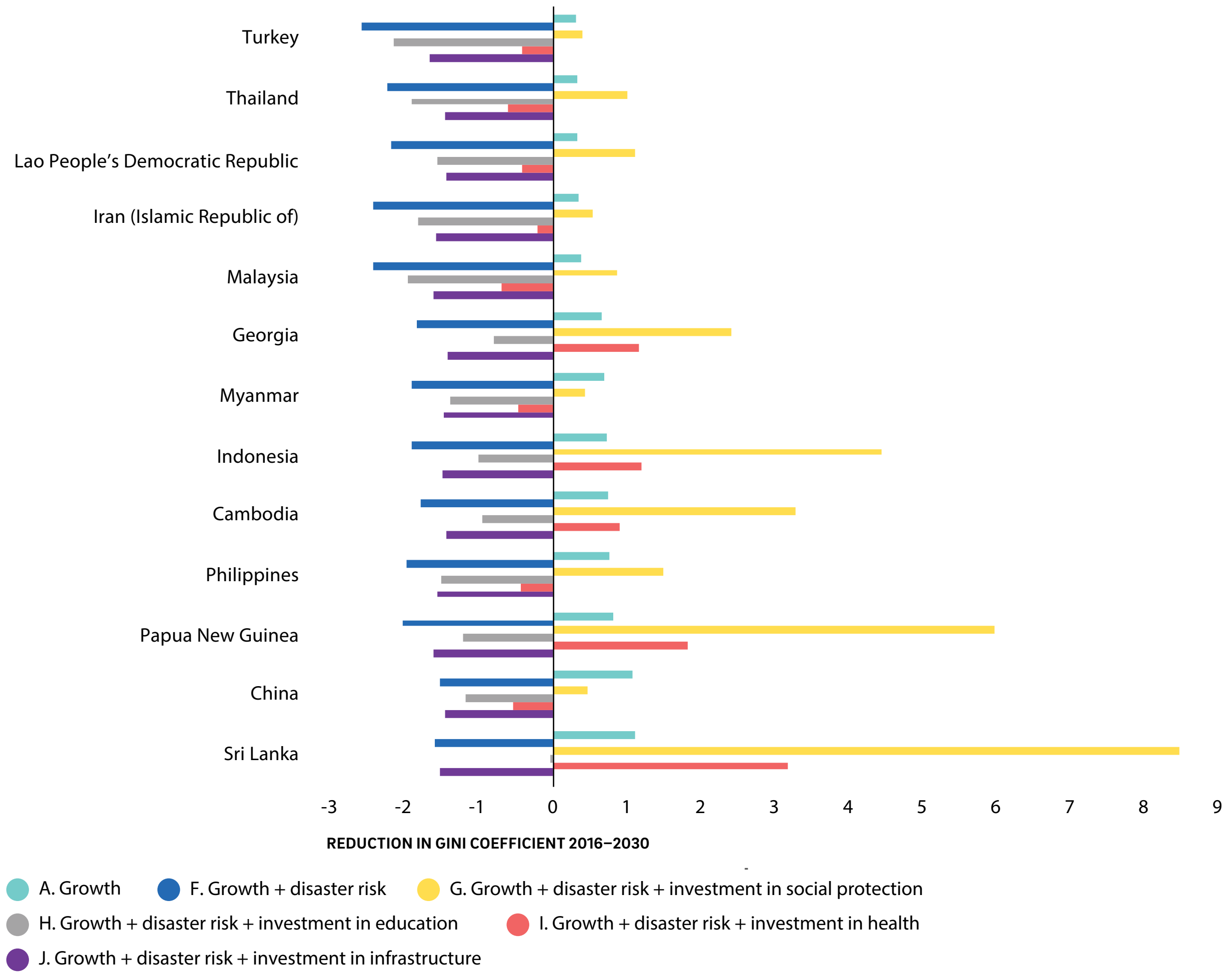
Source: ESCAP calculations based on CGE model simulation.
Note: Growth refers to a business as usual scenario, calculated based on the average GDP growth rate of the latest 5 years, in each country.

FIGURE 3-3 Projected number of people living in extreme poverty in 2030, with disaster risk



Source: ESCAP calculations based on CGE model simulation.

FIGURE 3-4 Impact of investments on inequality, 2016–2030, for high disaster impact countries



Source: ESCAP calculations based on CGE model simulation.
Note: A positive value corresponds to a reduction in the Gini coefficient and therefore a reduction in inequality, whereas the inverse is true for negative values.

education to 80 million. Furthermore, increasing expenditure on infrastructure to reach at least 2 per cent of GDP would bring this number down to 96 million.

Figure 3-3 demonstrates that, even with disaster risk, the number of people left behind in extreme poverty can be reduced by investing in any of the key sectors. The final scenario, K, incorporates investments in all four sectors. Here, extreme poverty is eradicated by 2030 in all countries except Timor-Leste and Papua New Guinea, which will require further investment. For further details, see Annex 3-2. This shows individual results for the 26 countries in the CGE model, for scenarios A, F and K, under the three poverty thresholds ($1.90, $3,20 and $5.50 a day).

These investments would also reduce income inequality as reflected by the Gini coefficient. Whilst inequality still increases within many countries from 2016 to 2030 under scenarios G-J, the increases are less than in scenario F. Furthermore, the scenarios result in reductions in inequality in particular countries. Figure 3-4 compares scenarios A, F and G-J for the 13 countries in which incorporating disaster risk has the highest impact on inequality. Scenario F results in a Gini Coefficient score at least 2.5 points higher than scenario A for each of these countries.

Figure 3-4 demonstrates that growth is expected to deliver small reductions in inequality, but disaster risk will increase inequality. For all 13 countries, inequality in 2030 is highest under F. However, the impact of disasters on inequality can be mitigated by investing in any of the 4 sectors. Results are most impressive for investments in social protection.

The need to invest more

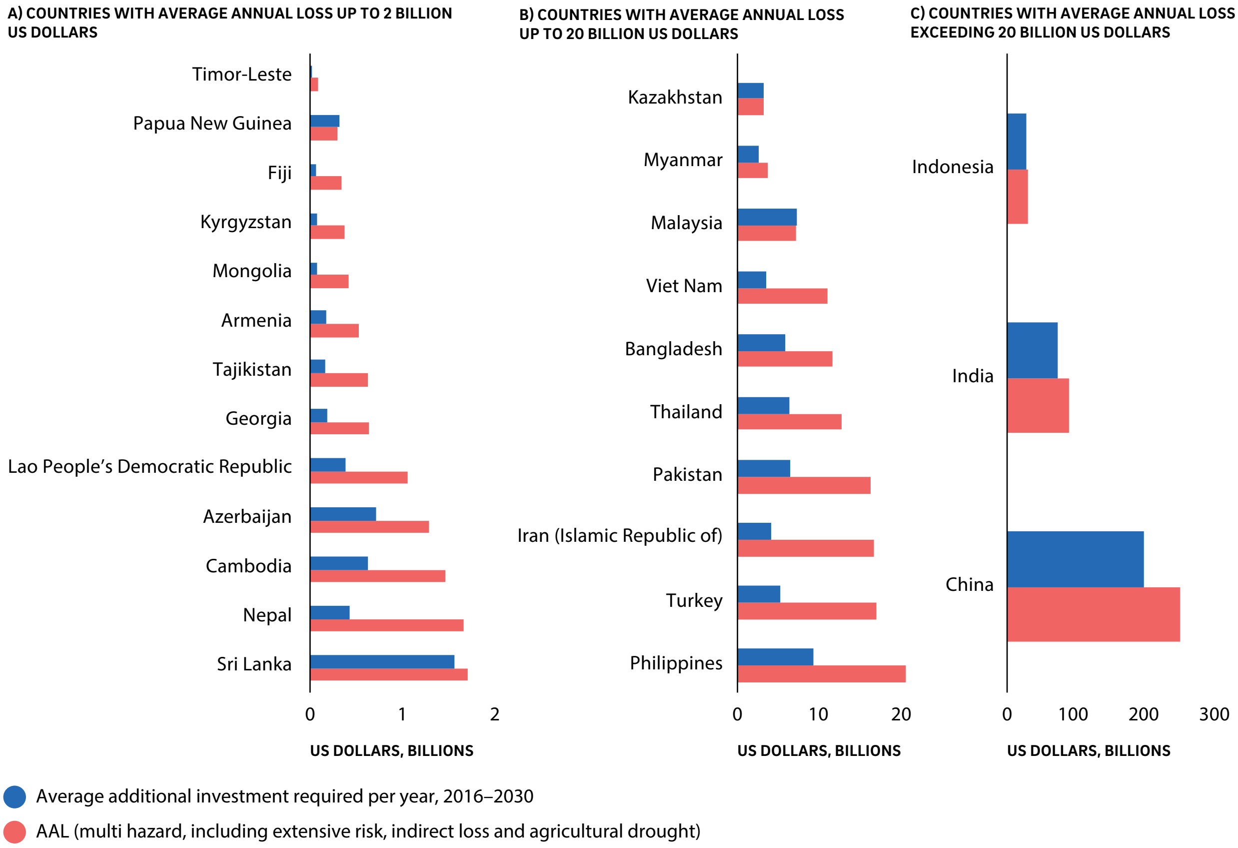
The overall message from the CGE modelling is that countries must invest more in key sectors in order to prevent disasters from reducing development gains. Projected rates of economic growth will not be sufficient to eradicate poverty or reduce inequality, given the levels of disaster risk. However, Governments can break the link between disasters, poverty and inequality by increasing investments in key sectors. This message reinforces the conclusion of the 2018 Social Outlook for Asia and the Pacific, which used similar CGE modelling to demonstrate that increasing investments in social policy provides an opportunity to lift people out of poverty.[74] To date, the region is investing less than global averages, and needs to catch up. The call to invest more in key policy areas is also in line with the 2019 Economic and Social Survey, which demonstrates that the region needs to pursue ambitions beyond economic growth.[75] A clear message is therefore emerging across the region; countries must invest more in people. This is particularly urgent for countries that have invested at rates lower than global averages from 2016 to 2019, and which therefore need to catch up in the next three to four years and continue at the level of global averages for the projected benefits to accrue.

Increasing investments will require significant additional finance. Whilst this is a daunting challenge, the additional amounts are still small compared to the damage and losses already sustained by countries in the region due to disasters. Increasing investments in social policy and infrastructure therefore offers a proactive and cost-effective approach to breaking the link between disasters and poverty. Figure 3-5 demonstrates how the figures measure up if countries meet global average investments in the social sectors, and 2 per cent of GDP in infrastructure. The average additional investment required per year to meet these levels, over the period 2016–2030, is compared to the Average Annual Loss (AAL), for each of the 26 countries.

Figure 3-5 demonstrates that the additional investments required per year are lower than AAL in 24 out of 26 countries. For 16 out of 26 countries, the additional investment required is even less than 50 per cent of the AAL. Moreover, the additional investments are less than the damage and losses sustained in major disasters. In Nepal, for example, the average additional investment required per year is $430 million, which is just 6 per cent of losses incurred due to the 2015 earthquake alone ($7 billion).[76] In Thailand, the average additional investment required throughout 2016 to 2030 is $6 billion, which is just 13 per cent of losses incurred due to the 2011 floods ($47 billion).[77]

The additional investments will also deliver benefits that cannot be captured only by comparing to disaster damage and losses. Improvements in social protection, health and education services, as well as in infrastructure, will improve the lives of everybody in society. Additional financing will also likely result in further gains than shown for individual spending scenarios, due to synergies between the sectors. Governments can maximize these synergies by investing more across multiple sectors simultaneously. Whilst additional financing presents a significant challenge, in many countries it will still

FIGURE 3-5 **Average annual loss compared to annual additional investment to meet international norms**



Source: ESCAP calculations based on CGE model and AAL probabilistic risk assessment.
Note: Additional investment figures refer to the difference between projected average annual investment if investment in each sector, from 2016–2030, continues at the same percentage of GDP as in 2016, and average annual investment required over 2016–2030, if investments in each sector meet international norms.

be cost effective to at least meet global averages, given that this will cost less than the impacts of disasters and will yield additional benefits.

Investing better

Governments can also do more to address disaster risk, poverty and inequality by investing better. The CGE modelling assumes that investments are 100 per cent efficient, with no leakages. Improving the quality of sectoral investments is therefore critical to ensuring that investing more will deliver the projected reductions in poverty and inequality.

Investing better must be achieved through a coherent approach. Governments should address all vulnerabilities through a comprehensive portfolio of sectoral investments combined with climate change action and disaster risk reduction. Policies that work for the general population may not work for the poor, near-poor and most vulnerable groups. Interventions must therefore be tailored to reach these groups. For example, in the case of small shocks, most households will be resilient if they are supported by basic social protection and are able to diversify their livelihoods. Larger shocks, however, will demand solutions that differ depending on the household. Wealthier households can access saving, credit and market insurance, while poorer households, who do not have these options, will need social insurance and scaled-up safety nets — financed by government reserve funds and insurance, and international aid.[78]

This section will present many ways in which investments in the key policy areas of education, social protection, health and infrastructure can be tailored to ensure that they strengthen disaster resilience for the poorest and most vulnerable groups. Similarly, it will show how to reach the same groups through investments in traditional entry points for DRR such as agriculture, livelihoods and land use planning.

Education

The CGE modelling shows that under a disaster risk scenario, investing 5 per cent of GDP in education will reduce the number of people left behind in poverty in 2030 from 119 million to 80 million. This reinforces evidence from across the region which indicates that investing in education offers an opportunity to strengthen disaster resilience throughout society. Investing in education is therefore a key entry point for breaking the link between disasters and poverty. This is particularly true for the most vulnerable groups, but it has to be inclusive.

Disasters disrupt educational continuity where school infrastructure is damaged, or when schools are used as emergency shelters, or students are injured or removed from school by parents who feel they cannot afford to keep them there.[79] Furthermore, many children have died from the collapse of school buildings following earthquakes, as in Sichuan in 2008, Gujarat in 2001 and Kashmir in 2005.[80]

Conversely, investments in school resilience can protect education and save children's lives. The benefits of preparedness were demonstrated by the 'Kamaishi miracle' in the Great East Japan Earthquake of 2011. The 2,900 schoolchildren in the city of Kamaishi, were protected by earthquake-resistant buildings and then evacuated to higher ground. Of the 1,000 casualties, only five were school children, who were not at school that day. This success follows the introduction in 2005 of disaster risk management education programmes which built on a local tradition of 'tendenko', meaning to evacuate without first searching for relatives or friends.[81]

Successful interventions have also been implemented on much larger scales. For example, many Governments have mobilized the political will after a disaster to invest in stronger school buildings. In 2001, the collapse of 11,600 schools during the Gujarat earthquake highlighted the vulnerability of Indian schools. In 2005, the Government of Uttar Pradesh passed the Disaster Management Act, mandating that all existing school buildings be made seismically safe. As a result, 6,844 new school buildings were redesigned within four months to incorporate earthquake resistance. In this case, strong governmental will at local and state levels, further strengthened by the impacts of a previous disaster, facilitated an extensive and rapid overhaul of school safety.[82] However, Governments across the region cannot wait for a disaster before they invest in school safety. There is a tendency for investments in school safety to be donor driven and only in response to disaster. Governments must look beyond reconstruction to ensure that funding is also available for ongoing maintenance, and to enforce compliance with resilient construction standards.

In some countries, education has been used to promote DRR, through comprehensive reform of national school curriculums to incorporate disaster preparedness. This has been demonstrated in the Russian Federation. The national curriculum stipulates the minimum amount of time that pupils should spend on risk education as well as compulsory topics that are relevant across the country. Turkey has also used education reform to promote disaster education at a large scale. A new curriculum features DRR as one of eight cross-cutting issues in all primary school subjects. This focus on risk was facilitated by two years of teacher training and the introduction of 15,000 school-based disaster awareness instructors. 5.9 million students have been reached as a result. These investments in training were possible due to sustained funding and political commitment at all levels.[83]

Large-scale interventions for DRR through education can be supported by integrating DRR into the education ministry. The Philippines, for example, has established a dedicated disaster risk reduction and management office within the education department. Its staff work in the central, regional and divisional offices of the department, ensuring that DRR is part of its annual planning and budgeting. Similar coherence between DRR and other ministries would allow countries to ensure that investments in the social sectors deliver disaster resilience.

BENEFITS TO THE WHOLE OF SOCIETY

Strengthening school safety, and delivering disaster preparedness through schools, reduces the vulnerability of school children. There is also growing evidence that children transmit disaster preparedness learnt in school to family members. This is particularly valuable in poorer households, providing a pathway to reach many vulnerable people.[84]

Governments can also extend school-based DRR in order to reach the wider community, including adults who have missed out on education. In the Islamic Republic of Iran, the Safe Schools — Resilient Communities programme implemented by the Ministry of Education and the International Institute of Earthquake Engineering and Seismology since 2015,

BOX 3-1 Identifying new possibilities for investments in DRR

In many countries, the DRR budget is part of disaster risk management, alongside preparedness, response and recovery. Some Governments have also created dedicated or special funds, and some funds might also come from international assistance. But, by and large, donors give much more for emergency response, reconstruction and rehabilitation, seeing DRR as a low priority.[a]

Increasing government expenditure on social policies and public services is very often financed by higher taxation which may decrease households' disposable income and impact inequalities. This has to be designed very carefully to prevent counter-productive consequences on inequalities.[b] Progressive tax policies are indeed central to realizing the benefits of the investments as described in this chapter.[c]

The solutions presented in this chapter requires a substantial broadening in the way Governments traditionally think about potential sources of financing for DRR. ESCAP (2018) calculations show that in many countries in the Asia-Pacific region, there is room for pursuing an expansionary fiscal stance without undermining fiscal sustainability so long as the deficit spending is used for sustainable development, such as enhancing human capacities. It may also be possible to redirect funds: Indonesia, Mongolia and Thailand have all reprioritized finance away from military expenditures and energy subsidies towards critical areas like education, health and social protection.[d]

Second, Governments can tap more funds from the private sector, by collaborating with Small and Medium Enterprises (SMEs), national companies, Multi-National Corporations (MNCs) and the investor community. At present, most work is with multi-national corporations and other large players who have sufficient capacity and can take on sizeable concessional financing arrangements. Furthermore, most of this support goes for the built environment or manufacturing industries but less so for agriculture.[e] There is scope for dealing with other parts of the private sector and for investing in sectors and locations that the private sector does not normally consider viable.

Third, countries can consider new and emerging sources of funding, such as the Green Climate Fund. Another option is blended finance, which combines financing from various public and private, domestic and international sources.[f] Least Developed Countries (LDCs), which the private sector considers riskier, find it more difficult to attract investment. Research is currently ongoing on overcoming barriers to implementing blended finance in these countries.[g]

Private sector funds must be deployed carefully. Decision makers must not allow private sector interests to overshadow the interests of those at risk of being left behind.

a Jan Kellet, A. Caravani and F. Pichon (2014).
b Sandra Baquie, Columbia University, Peer review comments (April 2019).
c In general, progressive tax policies are central to fostering a fairer distribution of income and wealth. In OECD countries, for instance, tax and transfers together bring down overall income inequality by more than a third, on average. This is a broad topic and is beyond the scope of this chapter. Readers are referred to Oxfam International and ESCAP (2017).
d ESCAP (2018c).
e PwC (2013).
f United Nations Capital Development Fund (UNCDF) (2019).
g Blended finance has been proposed as a solution for leveraging private capital for SDG related investments. The upcoming UNCDF report entitled 'Blended Finance in the Least Developed Countries', provides more information about the latest research into opportunities and challenges of utilizing blended finance for development in LDCs. See report at https://www.uncdf.org/bfldcs/home

has trained local facilitators to provide risk education and preparedness sessions to communities. These sessions build on the knowledge already gained by school children which, encompasses risk maps of local areas, shelter and evacuation procedures, and risk mitigation measures in the home.

Further empirical evidence suggests that investing in education continues to strengthen disaster resilience after a child has left school. Cross-country analyses have found that higher levels of education correlate with lower disaster death rates for many hazard types, even when controlling for income levels, health and degree of democracy.[85, 86] This suggests an inherent relationship between education and vulnerability to disasters, aside from links to opportunities for income generation and health.

Higher education levels also reduce the impact of disasters on livelihoods. Following the 2015 earthquake in Nepal, a higher number of education years was linked with lower death rates for both humans and livestock.[87] Education can also support disaster recovery. Five years on from the 2004 Indian Ocean tsunami in Aceh and North Sumatra, higher numbers of school years were associated with improved psycho-social and economic well-being and access to permanent housing over the long term.[88] Investing in education can thus reduce the vulnerability not only of schoolchildren, but of the society as a whole.

Furthermore, investing in education can facilitate the success of other DRR interventions. For example, literacy and financial literacy empower people to mitigate their disaster risk, by encouraging them to save and take out insurance. Higher literacy rates and numbers of school years are also associated with more diverse livelihoods and higher incomes, that increase people's ability to cope with economic shocks.[89]

Education can also empower people to engage with their Governments, both for mitigating risk and for recovering from disaster. Many studies demonstrate that more educated people will be more aware of disaster risk and can obtain the information and resources to reduce risk and also recover from the impacts of disasters.[90] During the 2010 drought and floods in Thailand, for example, villages whose inhabitants had more years of schooling were better able to apply for government financial assistance than villages whose inhabitants had fewer school years.[91] Education and literacy also support people to engage with their Governments to secure land rights, and advocate for themselves in grievance procedures related to social protection and post-disaster compensation.

EDUCATION MUST BE INCLUSIVE TO DELIVER DRR FOR THE MOST VULNERABLE

To reduce disaster risk of the most vulnerable, education-based interventions must be inclusive. At present, too many people continue to be left behind. This may not be evident from government statistics which typically do not disaggregate data on forms of exclusion according to gender, disability, socioeconomic status, ethnicity, caste or migration status. However, several empirical studies in disaster-prone areas show such forms of exclusion do restrict access to education, and that this can worsen following disasters.[92]

Particularly vulnerable are children with disabilities. They may be less able to take advantage of early warning systems, evacuations, shelter facilities and relief distributions because of medical conditions, and physical and social structures.[93] Their needs are widely ignored in many DRR policies.[94] Ensuring that they are at school will enable them to protect themselves, while also encouraging schools to better understand their specific vulnerabilities and capacities, which can then be addressed by more informed interventions. This must start in schools, with preparedness activities such as classroom evacuation drills addressing their specific needs and capacities.

School-based disaster preparedness also misses children that have a low attendance rate or are excluded from schools altogether due to economic circumstances. This includes children in informal urban settlements who live and/or work on the streets as well as those working informally as house help, which is particularly prevalent in South Asia. These children often have a double vulnerability as their lack of legal identity and exclusion from censuses renders them 'invisible' to the state.[95] Expanding access to education for these children provides an opportunity for Governments to address their vulnerabilities and to ensure that school-based DRR can deliver for them.

Expanding educational access is also vital post disaster, as children may be removed from school to provide domestic labour or generate income.[96] This reinforces marginalization, particularly of girls. Again, this may not be tracked in official statistics, so school attendance rates must be disaggregated by age, sex and many socio-cultural-economic factors, and by seasonality. Research from India and Kenya demonstrates that educational access can be improved by interventions that extend beyond schools.[97] For example, Governments can provide cash transfers to parents who might otherwise remove children from school to support income generation after a shock, and invest specifically in migrant support programmes to reach children in migrant families who are excluded from censuses. In the Philippines, off-school learning approaches are used to promote educational continuity during times of disaster, when children are required to support household farming activities. Such interventions can also incorporate DRR to empower youth to strengthen the resilience of their communities.[98]

Social protection

The CGE modelling shows that, under a disaster risk scenario, investing 11 per cent of GDP in social protection will reduce the number of people left behind in poverty in 2030 from 119 million to 53 million. Increasingly, many forms of social protection have been used to strengthen disaster resilience, with demonstrated success over different time scales and at all stages of disaster management. As indicated in Table 3-1, social protection can be protective, preventative, promotive and transformative. As the risks from climate change rise, social protection can be expected to be adaptive, integrating climate, disaster risk and socioeconomic information. By promoting alternative strategies that yield higher and more reliable incomes, that do not increase exposure to climate risk and exacerbate climate vulnerabilities, social protection can help promote integrated solutions.

The region also offers many examples of such social protection systems, that are shock responsive.[99] These have in-built flexibility that allows them to be adapted in the event of a disaster. Table 3-2 illustrates five forms they can take. Each has benefits and challenges, so should be chosen based on individual context. Factors to consider include the numbers of people affected by the disaster, how much is known about them, how an inflow of cash may affect the local economy, the level of trust in the implementing agencies, and the ability of stakeholders to collaborate.[100]

Several countries in the Asia-Pacific region have already implemented shock-responsive social protection systems, that offer important lessons for other countries. ASEAN countries are in the process of developing regional guidelines, with support from the Asian Development Bank and the Food and Agriculture Organization of the United Nations. Meanwhile, the examples in Box 3-2 demonstrate how shock responsive social protection systems can facilitate quick responses, the pooling of resources and more rapid decision-making.

Ensuring that these systems respond to new patterns of vulnerability involves some form of identification of beneficiaries. Post-disaster programmes that apply conditions and targeting based on poverty can be counterproductive, as people may not be able to comply with requirements to provide identification documents or attend workshops. Governments are also likely to know little about new vulnerabilities created by the disaster, including increases in poverty. To avoid exclusion errors, and ensure that the most vulnerable people are reached, social protection systems should instead employ universal measures, where benefits are extended to everyone within an area or category such as age group, regardless of income or wealth and without any conditions.[101]

Identification for shock-responsive social protection systems should therefore be informed by exposure to hazards. Furthermore, with climate change vulnerabilities on the increase there is a need to design social protection programs that promote climate adaptation. This requires overlaying climate and disaster risk information on maps of hazard-prone areas to pre-identify how the social protection system should be expanded to reach more people after a disaster.[102]

TABLE 3-1 Social protection pathways for disaster resilience

	PROTECTIVE	PREVENTATIVE	PROMOTIVE	TRANSFORMATIVE
Social protection measures	Social services Basic social transfers Pension schemes Public works programmes	Social transfers Livelihood diversification Weather-indexed crop insurance	Social transfers Access to credit Public works programmes Access to common property resources	Promoting minority rights Anti-discrimination campaigns Social funds
Pathways for reducing disaster risk	Protects vulnerable groups from impacts of climate risks such as asset losses, disruption to livelihoods	Prevents erosive coping strategies, such as selling off livestock or withdrawing children from school	Promotes resilience through livelihood diversification Promotes opportunities arising from climate change	Transforms social relations to combat the discrimination that produces vulnerability
Examples of successful interventions	Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), India. Guarantees rural households employment for 100 days a year, so they can maintain their incomes even during drought. Public works programmes, such as irrigation and afforestation, reduce disaster risk. Helps participants smooth their incomes and diversify their livelihoods.	Index-based livestock insurance, Mongolia. Herders are provided with insurance for livestock deaths due to *dzud*. Led to reductions in distress asset selling.	Bihar Rural Livelihoods Project, India, provides rural households in disaster-prone areas with improved livelihood opportunities. Mobilizes women into self-help groups to support access to financial services including savings, credit and insurance. Interventions led to substantially higher incomes, diversified livelihoods, new microenterprises, reduced debts and increased household food security.	Chars Livelihood Programme, Bangladesh. Wide range of activities including public works, asset transfers, training, stipends and micro-enterprise development. Combined with transformative measures to empower the poorest groups, including the provision of leasehold farming to landless households, crop diversification and land transfers.

Source: Adapted from Davies, Mark and others, 2009.

TABLE 3-2 Five forms of shock-responsive social protection

DESIGN	EXAMPLE	BENEFITS	CHALLENGES
Piggybacking — using part of an established system or programme such as the beneficiary list, staff, registration or payment mechanisms.	During typhoon Haiyan in Philippines (2013), the World Food Programme (WFP) and the United Nations Children's Fund (UNICEF) piggybacked onto the existing 4Ps cash transfer programme –enabling them to reach beneficiaries much quicker.	Use of established systems and relationships allows quicker delivery, and prevents the multiple, parallel instruments that can undermine the integrity of national systems, increase the administrative burden on the government, and confuse beneficiaries Most useful where a large or well-established and well-trusted system is already in place.	The need to carefully analyse an existing system delivered by another agency, and coordinate multiple agencies. Piggybacking on government systems may raise concerns about whether they will respect key principles of humanity, neutrality, impartiality and independence.
Vertical expansion — temporarily increasing the value or duration of an intervention to meet existing beneficiaries' additional needs.	Following tropical cyclone Winston in Fiji, the Government, with support from the World Bank, topped up the cash transfers for beneficiaries of all the national social protection programmes.	Increased protection for the most vulnerable. Established systems and relationships mean quicker delivery. Most useful where there is no risk of worsening local conditions, for example, by increased cash in local markets, and for mature systems that can both withstand the shock and stretch beyond their regular capacity.	The most vulnerable may not be reached, particularly where there are new vulnerabilities or the existing system fails to reach some groups. Calculating the size of top up. Adherence to pre-set procedures that could result in a slow response. Coordination, communication with communities.
Horizontal expansion — temporary inclusion of a new caseload into a social protection programme, by either extending geographical coverage, enrolling more eligible households in existing areas, or altering the enrolment criteria.	One of the main scale-up responses to the triple F crisis in Bangladesh. The Vulnerable Group Feeding programme was expanded by 25 per cent to reach 7.5 million households.	Could reach more disaster-affected people than through vertical expansion alone, and the extra beneficiaries could eventually be incorporated into the programme's regular caseload. Most useful where a disaster increases the number of vulnerable people, and an existing system has capacity to expand to include them.	Conceiving what the benefit is intended to cover; selecting new recipients; resourcing, adherence to pre-set procedures, communicating the changes to usual and new beneficiaries without diluting or obscuring the core objectives of the programme, or undermining its brand.
Parallel operation — designing an intervention with elements resembling others that already exist or are planned, but without integrating the two, e.g. align identification method, transfer value or delivery mechanism.	During the 2014 drought in Guatemala there was no robust, cash-based social assistance programme in the affected areas. WFP designed a cash-based emergency response that ran parallel to the social protection system, with the Government eventually taking over.	The new delivery system can be maintained for future disasters, strengthening the capacity of the Government for future disaster response. Most useful where a system is designed but not yet operational, and in areas with very weak capacity or high fragility.	Requires an understanding of the relative strengths of the options, which may be difficult in volatile contexts that are subject to frequent changes of government, personnel or policy.
Refocusing — adjusting the existing social protection programme to refocus assistance on groups within the caseload that are most vulnerable to the shock.	During cuts in public expenditure in Mongolia during the 2008 financial crisis, the universal Child Money Programme was initially maintained and made more progressive by providing more money to successive children, given the higher poverty rate among larger families.	Prioritises protection for those most in need. Most useful where a financial crisis occurs or budget cuts are made.	Trade-offs between coverage and amounts that can be transferred.

Source: Adapted from O'Brien, 2018.

BOX 3-2 Helping the poorest people bounce back quickly after a disaster

PHILIPPINES — TYPHOON HAIYAN 2013

The Government of the Philippines demonstrated the value of a comprehensive shock-responsive social protection system for addressing large-scale increases in vulnerability following a disaster.[a] The Government expanded the existing national conditional cash transfer programme Pantawid Pamilyang Pilipino Programme (4Ps). This prevented people from falling into poverty as a result of asset losses. The success was facilitated by prior preparation, including provisions for design change. Earlier, in 2013, the Department for Social Welfare and Development had declared that the conditions for cash transfer programmes could be waived for three months if a state of calamity was declared. This meant that once the typhoon hit, the cash transfers became unconditional even for households that had lost their identity cards. Furthermore, WFP and UNICEF piggybacked onto the programme's infrastructure. WFP was able to provide extra cash and rice to 105,000 households and UNICEF provided a top-up to 5,800 households with children for six months during recovery. In this way, the organizations were able to start within a month and benefit from lower transaction costs.

The expansion of the 4Ps programme demonstrates how social protection systems can be adapted over the long-term. In 2014, the cash transfer programme was expanded horizontally to include an extra 20,000 households. At the same time, the Social Security Scheme underwent vertical expansion. Members in disaster affected areas were granted a moratorium on repaying outstanding loans as well as pension advances, and salary loans and house repair loans on concessional terms. Four months after the disaster, more than 80,000 members had received relief assistance through salary loans and pension advances. Developing adaptive social protection systems therefore, allows Governments to capitalize on the opportunity to 'build back better' following a disaster.

This example demonstrates the value of social protection at all stages of the disaster management cycle. Even before the disaster, 4Ps monthly family development sessions that accompanied the cash transfers covered early warning systems and evacuation procedure. In the aftermath of typhoon Haiyan, these sessions were adapted to cover methods to recognize and cope with post-traumatic stress.

FIJI — CYCLONE WINSTON 2016

Cyclone Winston marked the first instance of a Pacific Island country delivering recovery assistance using an existing social safety net programme.[b] The Government used vertical expansion to increase payments to beneficiaries of three existing schemes. 90,000 recipients of the Poverty Benefits Scheme, the poorest 10 per cent of households, received a lump sum of F$600 (US$280). 3,257 households with children and single mothers benefiting from the Care and Protection Allowance Scheme received F$300 (US$140) and 17,232 elderly people benefiting from the Social Pension Scheme received a lump sum of F$300. Each of these cash transfers was paid in addition to the usual benefits as well as housing vouchers provided through a reconstruction scheme.

This approach facilitated rapid delivery and the payments were well utilized by recipients with repaired dwellings and agricultural land and restored food stocks and repaired neighbourhood infrastructure. According to the World Bank, the impact of the cyclone on the poorest Fijians was reduced by more than 20 per cent and the cost-benefit ratio was greater than 4.[c] However it failed to address the increased vulnerability of the near-poor who were just above the income threshold for government assistance programmes. Disaster assistance may thus affect the balance of vulnerabilities between socioeconomic groups. To address this the Poverty Benefit Scheme could be extended to include details of near-poor households so as to permit a horizontal expansion at times of disaster.

a Gabrielle Smith, and others (2017).
b A. Mansur, J. Doyle, and O. Ivaschenko (2018).
c Adapted and expanded from Government of the Republic of Fiji and World Bank (2017).

The examples in the Philippines and Fiji (Box 3-2) demonstrate that Governments can take ex-ante steps to adapt social protection schemes to ensure that they will be able to reach the most vulnerable people. To do so, Governments can prepare through:[103]

· *Guidelines* — Develop guidelines for disaster-responsive social protection in collaboration with Non-Governmental Organizations (NGOs) and the private sector, including plans for expanding and piggybacking on existing schemes.

· *Contingency plans* — Develop contingency plans for specific disaster scenarios which take expected future climate changes into account.

· *Databases* — Expand databases on poor and vulnerable households to include near-poor households who will likely need extra support.

· *Delivery systems* — Ensure delivery systems for cash transfers are accessible for poor and marginalized groups, particularly those in remote rural settlements or with limited access to the required technologies.

· *Communications plans* — Develop communication plans for informing recipients on how to access extra post-disaster support. It is also important to explain the basis for expanding existing schemes to prevent tension between recipients and non-recipients.

· *Financial resources* — Secure financial resources for measures that reduce disaster risk and strengthen adaptive capacity. Also align short-term contingency funds with the wider emergency-related contingency budget with access to contingent credit facilities when needed.

Health

The CGE modelling shows that under a disaster risk scenario, investing 4 per cent of GDP in health will reduce the number of people left behind in poverty in 2030 from 119 million to 69 million. Investing in health offers a pathway for breaking the many links between disasters, health and poverty. For example, disasters directly impact health through fatalities, casualties and consequences for mental health. Indirectly, they cause infectious disease outbreaks by disrupting water and sanitation infrastructure, and decrease food security and nutrition by disrupting agriculture and livelihoods. Particularly impacted are vulnerable groups such as pregnant women, children, elderly people and minorities.[104, 105] There are also greater risks of gender-based violence and malnutrition among women and children.[106]

Simultaneously, disasters reduce health care access by damaging infrastructure such as hospitals, clinics, medical equipment, and transport systems, and by affecting skilled personnel. Many disasters in the region have resulted in catastrophic disruptions to health systems, as cascading impacts render many services inaccessible or inoperable. Following the 2015 earthquake in Nepal, for example, 446 public health facilities and 16 private facilities were destroyed, whilst damages were sustained to a further 765 health facilities.[107] This underlines the importance of resilient health infrastructure, including smaller health clinics which may not sustain the greatest economic costs but offer vital support for the poorest and most vulnerable people in rural areas. This was demonstrated by the 2015 floods and landslides in Myanmar, in which almost all of the 21 health care facilities destroyed were station hospitals, rural health centres and sub-centres.[108]

Disaster impacts on health intersect with poverty and vulnerability. The poorest groups are most affected, as they often struggle to pay for health care following a disaster due to disruptions to livelihoods, asset losses and competing expenditures for response, such as food and shelter. This may lead to catastrophic health expenditure, which SDG 3 defines as 10 per cent of household consumption expenditure. Additional expenditures and drops in income are particularly burdensome for the poor who have limited savings to absorb such shocks. They also devastate the near-poor. The World Health Organization (WHO) states that such health expenditures are the leading cause of pushing the near-poor back into poverty, affecting 100 million people globally each year.[109]

The linkages between disasters, health and poverty are also compounded by vulnerabilities such as age and gender. This was demonstrated by the 2018 floods in Kerala, which severely affected maternal and child health. Despite gender-targeted evacuations and hospitalizations, the additional medical needs of many women and children were not met, due to lost patient records and damage to maternal health facilities and their equipment, medical, hygiene and nutritional supplies. This highlights the need to prepare for specific health vulnerabilities within hazard-prone areas, to prevent disasters from exacerbating health inequalities.[110]

THE VALUE OF UNIVERSAL HEALTH CARE

A universal health care system (UHC) provides everyone access to good quality essential health care services, medicines and vaccines and reduces disaster impacts, particularly for the poor and vulnerable groups.[111] As a large scale, government-funded public good, any UHC system is an inherently political project. It will therefore require strong political commitment as well as context-specific pathways for financing, governance and delivery. One common requirement is that for the health-care system to be sustainable and equitable, it must be risk informed. This requires the capacity to assess the unique vulnerabilities within each context, robust information systems that can direct investments, adaptive funding mechanisms, and a retainable workforce and supply chains that can be augmented during disasters. Each of these capacities must also be resilient to shocks. This is best achieved through a whole-of-government and whole-of-society approach that engages a range of national sectors, plus academics, civil society organizations, and health professionals.[112]

The UHC in Thailand demonstrates the potential for rapidly introducing a full-scale system.[113] Launched in 2001, when the country was still recovering from the 1997 Asian financial crises, the Universal Coverage Scheme reached 47 million people within one year, including 18 million who were previously uninsured. People were no longer at risk of catastrophic health expenditures. Between 2004 and 2009, this prevented an estimated 292,000 households from falling into poverty. The UHC system was realized when gross national income was only $1,900 per capita, but was possible due to political commitment, a strong civil service, active civil society organizations, support from the population, and collaboration amongst stakeholders at multiple levels of government and different industries.[114] All of these carry lessons for other countries.

Ensuring affordable healthcare requires an integrated approach that considers the multiple dimensions of vulnerability and marginalization that restrict access for the poorest groups. This is highlighted by the aftermath of typhoon Haiyan in the Philippines, during which the most significant economic barriers to healthcare for poor groups included not only the cost of health services, but other associated expenses which made healthcare unaffordable. In the first week following the disaster, respondents who declined to travel to health facilities cited a range of reasons, including a lack of money for consultation and transportation, as well as poor road conditions, long distances to the health facilities, and some closure of facilities. Over the longer-term recovery, the majority of respondents continued to cite the costs of consultation (58 per cent and 46 per cent) and transportation (25 per cent and 46 per cent) as the main barriers.[115] Interventions to ensure access to healthcare during disaster recovery must therefore address the intersecting barriers that exacerbate marginalization of the poor.

This integrated approach should be applied to social policy more broadly, so that Governments can capitalize on synergistic benefits from multiple interventions. For example, investments in household livelihood resilience can facilitate access to education as families can afford to send children to school even after disasters, whilst investments in education can encourage the expansion of cash transfer schemes, as more literate potential recipients will be more able to access information about changes to their entitlements.

Critical infrastructure

The CGE modelling shows that the link between disasters and poverty can be broken by investments in infrastructure. Under a disaster risk scenario, investing 2 per cent of GDP is expected to reduce the number of people left behind in poverty in 2030 from 119 million to 96 million. The total investment needed in all countries of the region is not known, however many reports are calling for countries to invest more in physical and social infrastructure, and to ensure that the infrastructure is disaster-resilient. They should pay particular attention to critical infrastructure — the physical structures, facilities, networks and other assets that are essential to the social and economic functioning of a community or society.

Investment should also focus on the infrastructure that serves the poorest groups. The poorest and most vulnerable often live in informal settlements and remote rural areas where hazard exposure is high and the infrastructure is vulnerable, reducing people's capacity to cope when hazards occur. This was demonstrated by the 2015 earthquake in Nepal, which caused losses and damages to the local road network totalling $42.7 million and $125 million respectively, or nearly 1 per cent of its GDP. As a result, people could not access health care or pursue their livelihoods. The impacts were particularly severe for women who depended on the road network to access urban markets for agricultural livelihoods, and for ethnic minority groups who lived in the most remote of settlements.

Housing infrastructure is also a particularly important entry point for strengthening the resilience of the poorest groups. The poorest people typically live in poorly constructed houses in areas of multiple hazard exposure. Such houses are likely to collapse during a disaster, resulting in death, casualties and economic damage. Before a disaster, the impacts could be reduced by improved housing design and retrofitting.

Post-disaster reconstruction also offers an entry point for strengthening resilience of housing. For example, following the Bam earthquake in the Islamic Republic of Iran in 2003, the Government financed low-income housing programmes by providing a financial and technical support package to each household, regardless of tenancy, socioeconomic conditions, or household make-up. The fixed amounts led to the replacement of big houses with smaller ones designed for single families which were built quite quickly. However, this approach meant that the reconstruction process was longer for households with more complex social arrangements. Moreover, larger extended families living in the same neighbourhood were disrupted by policies that allocated units in a residential complex in the city outskirts. This underlines the importance of designing infrastructure investment that is tailored to the needs of poor groups, by taking into account not only income and wealth, but also social dynamics such as household structure.[116]

It is also essential for investments in infrastructure to be informed by long-term climate change projections, as they may change the return periods of various hazards, meaning that past disaster risk probabilities will no longer provide robust guidance for infrastructural resilience standards.

Land use planning

Land use planning provides another tool for ensuring that new housing is not exposed to disaster risk, by identifying the safest zones for new developments, and restricting development or adjusting building standards for hazard-prone zones. Planning can also be used to control city layouts, for example, to reduce flooding and to facilitate rescue operations and evacuation procedures.[117] The aim should be to enable quick self-evacuation during a disaster. The significance of this was demonstrated by the 2018 tsunami in Sulawesi, Indonesia, in which crowded buildings, limited road access and blockages prevented many people, who had received early warning signals, from making a timely evacuation. Most people were able to successfully evacuate in the regency of Donggala and only 40 died. In the city of Palu, on the other hand, evacuation was severely restricted and the death toll, around 1,000 people, was much higher.[118]

Land use planning must also account for climate change, particularly in coastal regions and small island states that rely on flood risk management to address rising sea levels and risks of storm surges.[119] In these locations, Governments should limit development in exposed areas and ensure continuity in energy and water supplies along with effective waste management.[120] Adaptive pathways must be followed, prioritizing interventions to address most likely climate scenarios but also identifying alternative pathways and providing for other eventualities.[121]

In order to deliver strengthened disaster resilience for the poorest and most vulnerable, land use planning must also address competing local interests. For example, structural measures that reduce flood risk for expensive land may also increase flood risk in cheaper lands occupied by marginalized groups. Further, measures to protect and improve certain areas may increase property values so that the original residents can no longer afford rents and are displaced to land that may have even higher hazard exposure. Such outcomes are more likely when risk reduction is framed as a private responsibility rather than a public good, and where the affected vulnerable communities are not incorporated into the decision-making process. Land use planning must therefore negotiate multiple perspectives and needs. This can be achieved by incorporating participatory and inclusive consultations, so that interventions are chosen by consensus and have legitimacy among a variety of social groups.[122]

Risk-informed land use planning can also be enshrined in legislation. This has been recognized in the Philippines, where the National Land Use and Management Act (2018) requires the local authorities to identify disaster-prone areas and take the necessary measures for risk reduction. The Act also specifically addresses the danger that infrastructure may heighten disaster risk, forbidding, for example, dams that would interrupt the connectivity of river systems, disrupt coral ecosystems or alter seasonal flood regimes unless there were measures for mitigation.

Agriculture

In the Asia-Pacific region, the agricultural sector is severely affected by disasters. Its losses due to drought alone constitute 68 per cent of all disaster losses sustained in the entire region. This has huge consequences for those whose livelihoods depend upon agriculture, who are often poor or near-poor, and living in rural areas. However, Governments can intervene to strengthen agricultural resilience, through implementing a comprehensive package of interventions including market support, technology acquisition, and nature-based solutions. In order to be sustainable and to reach the poorest and most vulnerable, these interventions must be informed by climate and disaster risk.

Interventions for strengthened agricultural resilience can be achieved on a large scale, through comprehensive policy reform. This was demonstrated in Thailand, where almost 40 per cent (about 12.6 million farmers) of the total labour force is engaged in agriculture. In 2013, the Ministry of Agriculture and Cooperatives introduced the Smart Farmer Development Project. The aim was to improve rural livelihoods through training in agricultural production, to support livelihood diversification. By registering farmers that participate, the implementing agency is able to track performance and offer appropriate assistance, including during disasters.[123]

Nature-based solutions have emerged as a key entry point for building community resilience. In Bangladesh, for example, the Government is protecting rural communities along coastal belts from storms, typhoons, and tsunamis, by encouraging mangrove afforestation. The mangroves provide a double benefit; as a natural barrier against these hazards and an alternative income source.[124] Similarly, in southern Viet Nam, the Government has reversed the decline in mangrove coverage by establishing a protective mangrove forest between the sea dike and coastline. In northern Viet Nam, NGOs are helping reforest 18,000 hectares along a 100-kilometre stretch of sea dike.[125]

Nature-based solutions have also proven successful in empowering communities in Northern Samar in the Philippines, which is exposed to storm surges and other coastal hazards. To counter these risks, 250 households have worked together on an integrated strategy that involved disaster-resilient aquaculture, ecological mangrove restoration and value-chain development in mud crab fattening and marketing, an initiative which won an Equator Prize for boosting biodiversity while increasing incomes. This pilot was so successful that the provincial government introduced a mud crab ordinance to scale up the strategy for the entire province.[126]

Strengthening agricultural livelihood resilience also offers a pathway for reducing disaster impacts on women specifically. Disasters can heighten disadvantages for women and the burden increases when men migrate from disaster-prone areas in search of employment. Despite being temporary heads of household, women can be denied access to male-led local decision-making structures.[127] In Nepal, the Department of Agriculture is building on a successful pilot to combine climate-smart agriculture with financial inclusion. This includes seed banks through which women are provided with seeds that are well suited to the local climate and resistant to climate shocks. In Cambodia, farmers have been supported with simple rainwater harvesting technologies to ensure constant water supply during the dry season. A combination of drip irrigation and technical support to horticulture provides significant labour savings, especially where women spend up to three hours a day collecting water, saving time for further income-generation. Plastic mulch has also reduced the need for weeding, thereby reducing women's workload.[128]

Empowering and including

As Governments increase the amount invested and the range of policy interventions used for reducing disaster risk, it is important to consider which groups are currently being excluded from policy interventions, and how this exclusion manifests itself. Empowerment and inclusion approaches are needed to address the barriers that exclude certain vulnerable groups from the benefits of DRR interventions and other government investments in social policy, infrastructure and agriculture. This section identifies critical action areas, guided by the empowerment and inclusion framework presented in the ESCAP-ADB-UNDP SDG partnership report (2019) on: rights and justice, norms and institutions; resources and capabilities; participation and voice.

Rights and justice	**RIGHTS AND JUSTICE** · Protection against forced evictions to incentivize investments in resilient housing · Providing land tenure guarantees to incentivize household investments in livelihood adaptation to climate change
Resources and capabilities	**RESOURCES AND CAPABILITIES** · Access to land and finance · Nurturing enabling conditions and capabilities to act on early warning information
Participation and voice	**PARTICIPATION AND VOICE** · Participation in decision making, especially those involving trade-offs
Norms and institutions	**NORMS AND INSTITUTIONS** · Policy coherence across sectors · Translating climate risk information into action through local institutions

Access to land

In both rural and urban areas, the most vulnerable people are often those who do not have secure land tenure and are therefore unlikely to invest in disaster resilience. In the Philippines, for example, tenant farmers who are vulnerable to evictions have little incentive to re-invest in their livelihoods or to move beyond subsistence agriculture.[129] Empirical evidence shows that in Khulna, Bangladesh's third-largest city, unauthorized informal owners live with the constant fear of eviction and have little incentive to improve their environment. They are unable to elevate their land to the surrounding levels with less hazard exposure, and many have constructed dwellings in risky locations, using inferior materials.[130]

Lack of secure land and property rights is thus a persistent problem that must receive more attention. In urban areas alone, more than a quarter of the region's total urban population live in slums or informal settlements which lack security of tenure.[131] There are many reasons for this, including sociological, legal, political and economic factors as well as weak land registration and systemic biases against women, or indigenous groups. Furthermore, the very groups that need to secure these rights often lack the education or literacy requirements to claim them.[132]

Conversely, people who have security of tenure or ownership are more likely to invest in disaster risk reduction and adaptation, follow evacuation orders, and take advantage of services and post-disaster recovery support.[133] Empirical evidence from drought-prone areas in Mongolia, for example, shows that security of land tenure has encouraged landholders to invest in adaptation measures such as sustainable pasture use, construction of irrigation systems and development of drought-resistant crops.

Measures to provide land tenure security for poor and vulnerable people are therefore critical. The strongest instrument for guaranteeing land tenure is legislation. This could guarantee the rights of agricultural lessees to exclusive possession and enjoyment of home lots. Nevertheless, to be effective, legislation needs to be accompanied by soft measures such as capacity strengthening for government staff to recognize the rights of marginalized groups, informing remote communities of their rights, and incentives such as tax breaks for applying for land registration.

BOX 3-3 **Innovative finance for adaptive social protection systems**

The financing mechanism of the Chars Livelihoods Programme in Bangladesh allows the programme to be shock responsive. It is first and foremost a disaster risk reduction initiative which aims to reduce the vulnerability to flooding of poor households living chars (fluvial islands). But it also has the capacity to expand and support disaster response. Built into the project design is an annual contingency budget that can either be used for disaster response to support the beneficiaries of the main programme, or if unspent, can be redistributed to increase funding for the regular program activities. Since the programme aims to reduce flood risk, the need for the contingency fund reduces over time.[a]

a ADB (2018).

Legislative change and capacity strengthening at the government level can also be supported by innovative forms of tenure security, such as community land banks, long-term leases and usufruct agreements, that can provide secure, affordable and socially acceptable housing arrangements.[134] These can be used to ensure that land tenure can accommodate traditional collective ownership and have the flexibility to recognize traditional patterns of mobility. In Mongolia, for example, pastoralists have traditional customary rights to land approved by municipal and district councils to allow migration and rangeland rights in case of emergencies.[135] In drought-prone areas, land tenure must accommodate collective ownership and have the flexibility to recognize traditional patterns of mobility. In Viet Nam, some rural landholders need mobility to access less flood-prone land for agriculture during the wetter months.[136]

Access to finance

Another problem that hinders disaster resilience is exclusion from financial services. Poor groups may be excluded from banking for many reasons; a lack of assets to borrow against, poor credit history, financial illiteracy, as well as weak regulatory frameworks. As a result, they may be less able to achieve diversified and resilient livelihoods, invest in disaster risk reduction, or accumulate sufficient savings to smooth consumption after disasters. They may also be unable to access social protection schemes such as insurance and cash transfers, which are delivered to bank accounts. Women are at a particular disadvantage.[137] After disasters strike, poor women often experience a double burden as they take on increased economic responsibility for the household but are denied access to financial services.[138] Without financial support, households may resort to erosive coping strategies such as distressed asset sales, removing children from education or delaying health expenditures.

Financial inclusion refers to the use of a range of instruments to expand access to traditional financial services, including microfinance, insurance, small loans, and mobile banking. These strengthen disaster resilience by providing the opportunity to accumulate savings, which can be invested in risk mitigating measures such as crop diversification or retrofitting homes. Small loans can also prevent households from falling into poverty following disasters, by covering specific expenditures such as medical or funeral costs.[139] Risk reduction can also be implemented at the community scale through workshops and 'credit-plus' initiatives that accompany microfinance institutions and Village Savings and Loan Associations (VSLAs). Such workshops can include sessions on how to pursue riskier, higher yield livelihoods, or how to protect agricultural assets from local hazards.

These financial instruments work best in a supportive macro-economic environment.[140] This will require:

A regulatory framework — A transparent regulatory system will promote growth and competition in non-traditional financial services and offer users greater choice and flexibility to match their needs and capacities.

Support to service providers — Governments can strengthen the capacity and motivation of service providers through education and training so that banks and their employees have greater trust in poorer clients. Governments can also strengthen the financial literacy and technologies of service providers so that they have the capacity to reach the most vulnerable.

TABLE 3-3 Financial instruments for disaster resilience

INSTRUMENT	DESCRIPTION
Microfinance institutions	Provides loans and savings for income-generation activities and risk reduction as well as insurance, educational and health loans. Through 'credit plus' operations, microfinance institutions may also provide complementary services such as skills education and training, and workshops to promote best practices for agriculture, health and nutrition.
Innovative insurance	Provides businesses, farmers and households with rapid access to post-disaster liquidity, so that they need not get into debt.
Village savings and loans associations (VSLAs)	Provide simple savings and loan facilities in remote rural communities, to finance recovery. These associations also strengthen social networks that can be used to develop collective coping strategies and support mechanisms.
Mobile banking	Provides alternative forms of banking such as internet banking, card payment systems, mobile banking and point of sales This avoids the time and expense of travelling to banks and increases access to insurance and loans.

Source: Haworth and others, 2016.

Sound infrastructure — Investing in technological and infrastructure — enhancing internet connectivity and extending the coverage and sophistication of datasets. Investing in roads and public transport to make it easier to reach services.

Improving traditional financial services — Engaging with the domestic service providers to enable them to expand and scale up new and affordable financial services.

Working with vulnerable groups — Working directly with poor communities to strengthen their capacity, financial literacy and trust in the financial system and encourage them to take advantage of available services.

IMPROVING INSURANCE

One of the most common financial risk transfer tools is insurance, though this is not widely used in the Asia-Pacific region, especially for disasters. In the ASEAN countries, for example, less than 10 per cent of property damage insurance covers catastrophic disasters.[141] This is partly because many people cannot afford insurance and may not trust the providers, while insurers are often unwilling to cover disasters due to natural hazards because of limited risk information and high operational costs.[142] Insurance penetration is also restricted in the region by issues of fiscal policy such as capital controls, absence of liquidity flows, and accessing re-insurance markets. However, insurance can have many benefits (Table 3-4). Apart from acting as a safety net, it can increase credit ratings and investment in risk reduction.[143]

Governments can make special efforts to increase the take-up of insurance. In India, the Modified National Agricultural Insurance Scheme has reached a high number of participants by distributing information about the scheme through local actors trusted by targeted groups, such as farmers groups and societies, crop growers' associations, self-help groups and NGOs working with agriculture. In Cambodia, the take-up of insurance among low-income groups has been increased by providing vouchers to cover the costs of transport to enrolment locations. The requirement to travel could also be addressed through the provision of digital technologies, thereby increasing access for groups who are not only impoverished but also marginalized by their remote location.

Premium costs can also be kept low through public-private partnerships. For example, in Mongolia the Index Based Livestock Insurance Project takes a risk-layering approach via public-private partnerships. Progressive scales of livestock losses are covered first by self-insurance, then market-based insurance and finally a social safety net. Herders themselves absorb the cost of small losses that do not affect the viability of their business (less than 7 per cent of livestock), whilst larger losses (between 7 per cent and 30 per cent) are covered by the private insurance industry, and catastrophic losses (over 30 per cent) are covered by the Government.[144] This minimizes premium costs for the herders, whilst reducing the burden on the Government which only has to pay out for infrequent, larger shocks.

TABLE 3-4 Benefits of insurance for poor and vulnerable groups

BENEFIT	EXAMPLE
ACTING AS A BUFFER AND SAFETY NET	
Prevention of negative coping strategies such as distress asset sales	Pastoralist households in Mongolia that purchased Index-Based Livestock Insurance recovered faster from the *dzud* of 2009/10, as they were less likely to resort to selling livestock early. Two years after the disaster, insured households owned between 22 and 27 per cent more livestock.[145]
UNLOCKING OPPORTUNITIES THAT INCREASE PRODUCTIVITY	
Increase savings	Evidence from Ethiopia, Senegal and Haiti demonstrates that insurance payouts support farmers to increase their savings.
Improve creditworthiness	Banks have more confidence in herders covered by the index livestock insurance, and have offered herders loans at decreased interest rates.[146]
Increasing investment in higher-return activities	Farmers in China with insurance are more likely to raise sows and tobacco, both risky production activities with potentially large returns.[147] In flood-prone areas of the Sirajganj district in Bangladesh, villagers with Index Based Flood Insurance (IBFI) invest more in seeds or fertilizers to grow more crops and enhance yields.[148]
SPURRING TRANSFORMATION IN RISK MANAGEMENT	
Incentivizing risk reduction behaviour	Modified National Agricultural Insurance Scheme in India features a discount provision if all farmers in a unit area adopt better water conservation and sustainable farming practices for better risk mitigation.[149]

Source: Adapted from Schaefer and Waters, 2016.

Insurance cover can extend beyond losses in assets and income to cover injury and death. In Sri Lanka, the SANASA Insurance Company has offered coverage not only for losses of livestock, but also for accidental death and hospitalization, all within one premium. This approach of bundling insurance packages increased the number of participating farmers.

Governments can also promote innovations such as parametric insurance, in which payouts are determined by defined parameters of the causal event such as rainfall or temperature, rather than the actual losses as with traditional, indemnity insurance. This facilitates quicker payouts with reduced costs, as providers simply need to verify the hazard occurrence based on transparent and readily available data instead of undertaking on-site assessment.

Parametric insurance is therefore well suited for supporting immediate response and short- to medium-term recovery needs following low frequency, high magnitude shocks, and where the use of transparent data overcomes low trust in the insurance industry. The subsequent chapter will explore how parametric insurance can utilize new technologies in order to extend coverage to poor and vulnerable groups whose livelihoods are highly exposed to climate risks.[150] Nevertheless, an important issue with parametric insurance is that it has a higher basis risk, that event-triggered payouts may not relate accurately to actual loss, than for indemnity insurance. For longer term recovery needs, indemnity insurance may be more effective.

In fact, no form of insurance is a panacea. Whilst it can help to protect poor people from low-frequency, high-intensity shocks, it is less suitable for slow-onset hazards associated with climate change such as sea-level rise and salinization. And insurance for the high-intensity shocks that are certain to become more frequent with climate and environmental change would require prohibitively high premiums.[151] Nor can insurance mitigate the non-economic costs of disasters, such as psychological impacts and disruptions to social networks. Further, the provision of insurance for poorer households should not be used to transfer the responsibility of addressing climate risk to those who are most vulnerable to the consequences of climate change. Rather, insurance must be seen as one part of a comprehensive risk management strategy, in which households have different support available for different shocks. Governments should support this using a layered approach to disaster risk financing. This provides flexibility to use different mechanisms to respond to different severities of events on different timescales, and will likely include various forms of insurance, as well as sovereign reserves, contingent credit, budget reallocation and sovereign debt.

Capability to act on early warning

With a few days warning, people can evacuate their livestock and other moveable livelihood assets to higher grounds, ensuring their own safety and protecting their assets.[152] Early warnings with longer lead time, such as seasonal climate forecasts can enable farmers to adjust their weather and climate-sensitive activities to avoid losses of inputs (seeds, fertilizer) and production.

Just as important as access to information is the capacity to act on it. Experience from West Java, Indonesia, has shown that to respond to climate information, farmers require a broad range of support from agricultural ministries, local agricultural services, and cooperatives.[153] If farmers are to act upon climate information, however, they will also need resources, in the form of seeds, fertilizers, water and credit.

The content and delivery of information must be tailored to people's circumstances and capacity to respond.[154] This is particularly important for people with physical, psycho-social and cognitive disabilities or those who have limited mobility due to advanced age. Their access to evacuation routes, public shelters, and relief distribution points must be addressed.[155] For this purpose, when designing policy, planning and interventions the relevant agencies can collaborate with organizations of people with disabilities. Following cyclone Pam in Vanuatu, in 2015, the Government found that people with disabilities not only had limited to access to evacuation shelters, but also faced barriers to access almost all services and activities.[156]

Response to early warnings is also influenced by security of land tenure and livelihood. People living in informal settlements are less likely to evacuate before a disaster. For example, people affected by typhoon Haiyan explained they did not want to leave before the storm because they feared that landowners would take the opportunity to bar them from returning. As a result, men typically choose to stay during disasters to protect their possessions and to make sure their family members could return.[157] Similarly, for cyclone Phailin which struck

the coastal state of Odisha, India in 2013, around 95 per cent of people evacuated. Those who did not, some of whom perished, were families concerned about their livestock. This shows the importance of putting in place arrangements for securing the safety of assets during evacuation.[158]

Participation in decision-making

Those who are left behind also tend to be the ones excluded from decision-making at various levels, from the household to national levels. Multidimensional inequality therefore tends to generate the means for its own perpetuation. Decades of development work have produced compelling evidence that it is fairer and far more efficient to involve people in making the decisions that affect their lives. For this, the starting point is widely available information. For example, a Right to Information Act has been introduced in India and information systems are being made more available to the general population in Bangladesh. Both innovations have reported positive results for development.[159] Sri Lanka offers an interesting insight into the benefits of empowering farmers to decisions through the existing local norms and practices (Box 3-4).

To ensure access to decision-making, Governments need to provide spaces for stakeholder participation and to encourage pressure from the bottom up to strengthen the bargaining power of marginalized citizens. This is particularly important for effecting the changes in public investment priorities advocated earlier in this chapter, which have to be articulated and championed. In India, for example, the National Rural Employment Guarantee Act, along with a series of other transformative social legislations, were enacted in response to population movements and demands.[160]

Governments also need to negotiate trade-offs. Land use changes, in particular, tend to produce winners and losers, with poorer people often having to relocate and lose access to their natural resource base. Governments therefore need to respond to the voices of the poorest. Ignoring their voices can in any case be very costly, as happened, for example, with the delays and opposition encountered by the Greater Dhaka Integrated Flood Protection Project (1991) and the Jakarta Coastal Defense Strategy (2012). Both cases demonstrate the need to include lower-income residents in the design process from the outset and to identify solutions that deliver strengthened disaster resilience for all residents.[161]

BOX 3-4 Empowering farmers to make decisions through climate and market information

Access to climate and other information can foster inclusiveness in decision-making. Insights from Sri Lanka suggest that forecasts are most effective in influencing risk management decisions when integrated into social processes. Seasonal forecasts from the Department of Meteorology are shared and discussed at pre-season meetings among farmer leaders, irrigation operators, agricultural extension officers and local officials. Through these meetings, the forecast is blended with local and contextual knowledge and market information to assess the risks during the season. The resulting insight empowers the farmers to make informed choices and decide on the level of trade-offs that are acceptable to them; whether to plant paddy or switch to less-intensive crops or forego planting altogether.

Sri Lanka offers an interesting insight into how social institutions, in tandem with climate information, can empower farmers to make risk-sensitive decisions. When a below-average rainfall is forecast, which means reduced irrigation coverage, farmers enact a collective drought management strategy called 'bethma'. This practice involves dividing the fields that can be serviced with irrigation water during the season equally among all participating families, regardless of ownership. Everyone thus receives equal access to land and water. Empirical studies suggest that farmers who participated in bethma have been better able to cope with Sri Lanka's recent succession of droughts.[a]

a Field work notes by ESCAP staff, September 2018; Burchfield, and others (2018).

Governments need to screen policies and decisions to ensure that they take into account the particular needs and circumstances of the poorest and marginalized.[162] DRR-related laws and plans need to ensure the active participation of marginalized groups. Recently, Mongolia, Philippines, Samoa, Vanuatu and Viet Nam have all taken significant steps in this regard.[163]

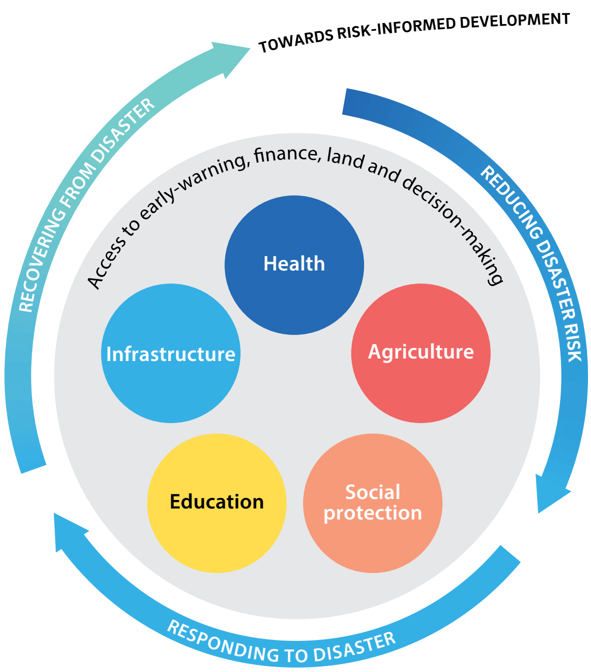
Breaking the cycle

This chapter has demonstrated that disasters threaten to reverse development gains, but that it is possible to break this link by investing more and investing better to reach those who are left behind. This will be difficult. Countries need to mobilize additional finance. They will also need to move beyond the traditional focus of DRR efforts on preventing only disaster impacts to preventing the fundamental causes that make people vulnerable to the impacts of disasters and climate change.

Figure 3-6 demonstrates how the investments and policies discussed in this chapter interact over the time phases of disaster management, to strengthen disaster resilience of those usually left behind. These interventions can break the cycle of disasters, poverty and inequality and facilitate risk-informed development.

The next chapter explores how such interventions can also be supported by emerging technologies to provide new ways of strengthening disaster resilience for the poorest and most vulnerable people in the region.

FIGURE 3-6 Breaking the link between disasters, poverty and inequality



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CHAPTER 4

Technological innovations for smart resilience

Even the poorest countries and most excluded communities can be empowered by smart digital technologies that are interconnected and autonomous, and can communicate, analyse and use data to drive intelligent action for disaster resilience. Innovation for smart resilience is therefore a key pathway to empowering and including.

Across developed and developing countries, Governments are increasingly using technology innovations that can promote inclusion and empowerment. These are the technologies that have emerged in the fourth industrial revolution, commonly known as industry 4.0. Industry 4.0 includes innovations in robotics, analytics, artificial intelligence (AI) and cognitive technologies, nanotechnology, quantum computing, wearables, the internet of things (IoT), big data, additive manufacturing, and advanced materials.

Opportunities from big data

Big data refers to the computer analysis of very large data sets to reveal patterns, trends, and associations. Big data has three elements: data crumbs; the capacity to analyse and use these data; and the community of people who produce, analyse and use the data.[164]

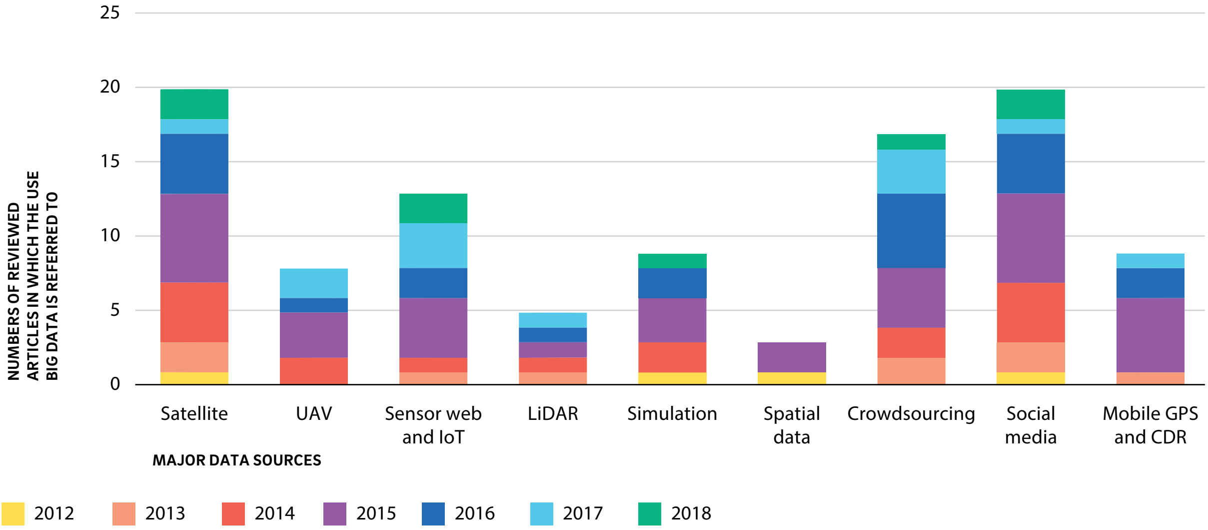
For disaster resilience the data crumbs can come from a wide variety of sources. These include satellite imagery, aerial imagery, videos from unmanned aerial vehicles (UAVs), the internet of things and sensor webs, airborne and terrestrial light detection and ranging, simulations, crowdsourcing, social media, mobile global positioning system (GPS) and call data records (CDR).[165]

The increasing use of these sources is illustrated in Figure 4-1, which shows the number of reviewed articles on these subjects over recent years. On this basis, the fastest-growing sources are satellite imagery, crowdsourcing, and social media.

Big data has opened up promising approaches for smart resilience that empowers the poor. Mobile phone data, for example, can provide an incredibly detailed view of population behaviour and movement in areas previously observed only infrequently and indirectly. Social networks like Twitter, Facebook and others, are already improving the ability of humanitarian and other organizations to monitor and respond to disasters. Further, these opportunities are clearly increasing as mobile phone penetration and internet access move, albeit slowly in the poorest countries, towards universality. Nevertheless, using big data is not easy. Typically, big data is high-volume, high-velocity, and/or high-variety, integrating many diverse data sources and requiring dense infrastructure networks. It is also unstructured and imprecise with a lot of 'big noise' that needs to be filtered out, requiring new forms of computer processing and analytics to enhance decision-making, the discovery of insights and process optimization.

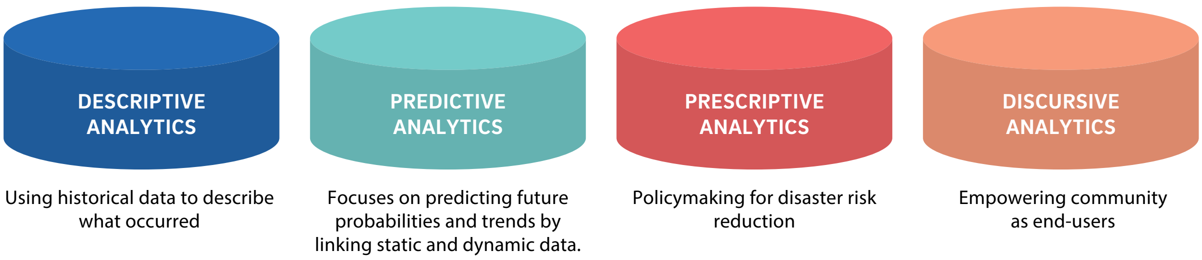
Big data can help in all phases of disaster management; filling in gaps in information flows in pre-response and post-disaster situations, using four types of analytics: descriptive, predictive, prescriptive and discursive (Figure 4-2).

FIGURE 4-1 Use of big data sources for disaster management, 2012–2018



Source: Manzhu Yu and others, 2018.
Note: Based on distribution of reviewed article by major data sources and year of publications.

FIGURE 4-2 Big data: four types of analytics for smart resilience



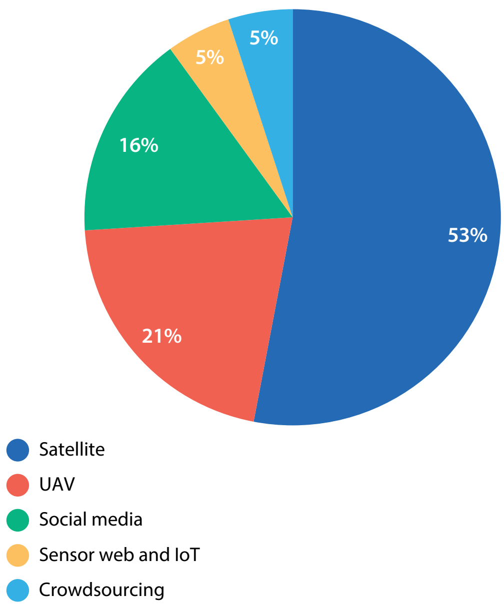
Source: ESCAP based on Data Pop Alliance Synthesis Report, 2015.

Descriptive analytics

Descriptive analytics can be used to highlight risk and to produce situation analyses particularly for damage assessment and people affected. As indicated in Figure 4-3, the most important data sources for this purpose are images from satellites and UAVs/drones. Remote sensing provides a quick initial assessment when in-situ observation is not yet available and can guide responders to the priority areas to be inspected (Box 4-1 and Box 4-2).[166]

All recent major disasters have been covered by multiple satellites and drones. These smaller devices are more flexible than manned aircrafts and can cover disaster-impacted areas close-up to produce higher resolution images. Drones can also provide 3 dimensional (3D) data that provides more meaningful information on the situation facing survivors of a disaster such as the extent of damage to buildings, indicating collapsed roofs, rubble piles, and inclined facades.

FIGURE 4-3 Data sources used for damage assessment, in percentage



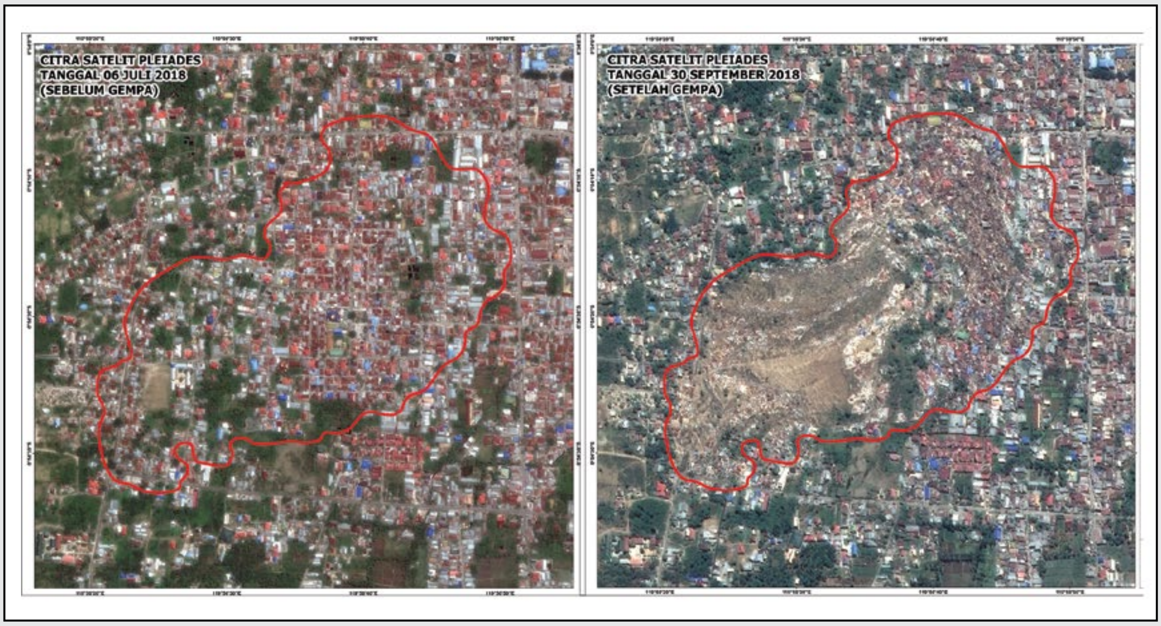
Source: Manzhu Yu and others, 2018.

BOX 4-1 Use of big data for damage assessment in the 2018 Sulawesi earthquake

The World Bank response to the Sulawesi earthquake and tsunami, started with a rapid assessment of the damage-affected areas using the Global Rapid Post-disaster Damage Estimation methodology. This was the first disaster response report to produce sector-based preliminary economic loss estimates, based on scientific, economic and engineering data and analysis.

Based on an open loss modelling approach, it included satellite and remote sensing imagery from a variety of sources. Other inputs were information from early assessments, as well as social media data for results calibration. Spatial characteristics developed for tsunami events included inundation extent and ground deformation analysis.

BOX 4-1 Pre- and post-tsunami satellite images



Source: International Disaster Charter, 2018.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

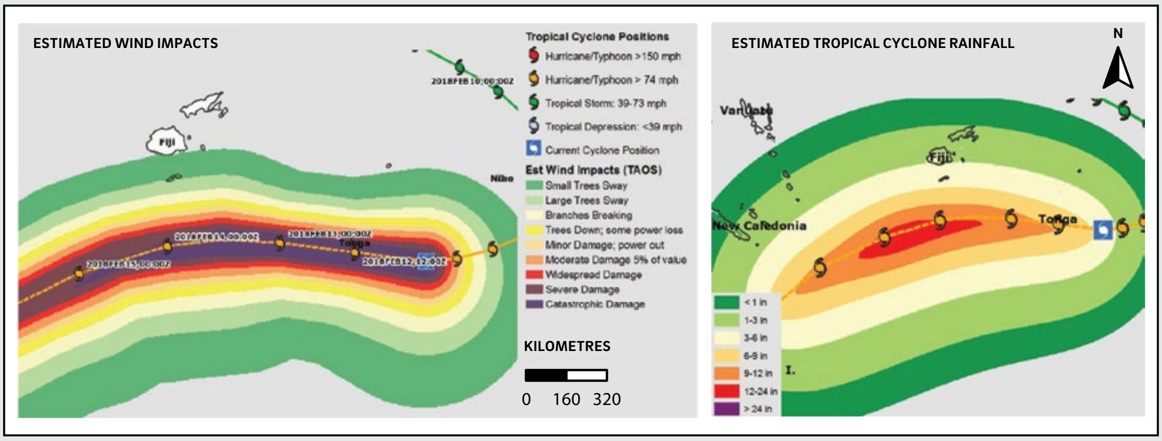
The main benefit was speed. Within 10–14 days of an event, stakeholders could access loss estimates and the spatial distribution of damage. Total economic damages were estimated at $500 million; $180 million for the housing sector; $185 million for commercial/industrial buildings; and $165 million for infrastructure.[a] The World Bank used this to programme its support for recovery and reconstruction with funding of up to $1 billion for the disaster-affected areas of Lombok and Sulawesi.

a Deepti Samant Raja (2016).

BOX 4-2 Impact-based forecasting and damage assessment for cyclone Gita

Between 10 to 13 February 2018, tropical cyclone Gita hit several countries in the Pacific, first Samoa, followed by Niue, Tonga, and Fiji.[a] The cyclone was predicted well in advance, so Governments could prepare for the impacts and plan countermeasures.[b] This involved the use of big data to estimate cyclone tracks and wind and rain impacts.

Tonga's post disaster needs assessment was carried out using drones. These had the advantage over satellites of producing higher-resolution imagery which was important for small-area damage estimation.[c] Drone images also captured damaged buildings and infrastructure and land cover and enabled rapid mapping which accelerated the process of reconstruction and recovery.



Source: Pacific Disaster Center, 2018.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

a ReliefWeb (2018).
b Marit Virma (2018).
c Ibid.

Disaster risk reduction can now take advantage of descriptive analytics and big data. Intensive use of descriptive analytics was a key feature of the rescue of the Thai junior football team trapped in a flooded cave underneath a mountain (Box 4-3).

Google Earth Engine, a cloud platform is also available to support location-specific damage and risk assessment-related analysis and decision-making. This uses datasets gathered from satellites, and GIS vectors datasets, as well as social, demographic, weather, digital elevation models and climate data.[167] Another example is the Open Data Cube, an open-source solution for accessing, managing and analysing large quantities of GIS data, with an analytical framework of data structures and tools to analyse gridded data sets including post-disaster impact assessments.[168] The Australian Geoscience Data Cube is the Government's open source analysis platform which uses the Open Data Cube initiative to support the descriptive analytics application.

Predictive analytics

Predictive analytics uses big data ecosystems as a basis for predicting both sudden and slow-onset disasters.

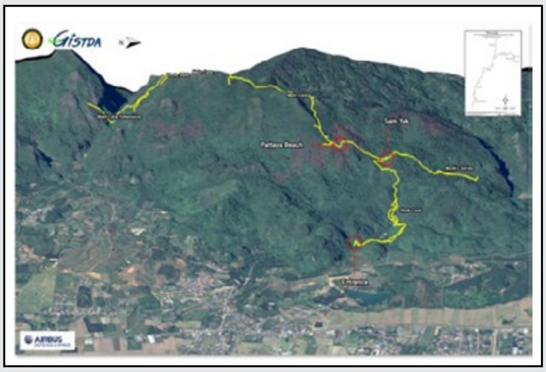
Earthquakes

A sensor web is a wireless sensor network architecture that uses the World Wide Web, enabling access to sensor networks and archived sensor data that can be discovered and accessed using standard protocols and application programming interfaces.[169] These sensors can be embedded in a wide variety of objects from buildings to mobile phones along with the many other smart objects that form part of the rapidly expanding internet of things (IoT). Data from these sensor webs can be combined with satellite data and other sources including user-generated data that reach various

BOX 4-3 The use of technology in Thailand cave rescue: Life-saving operation in a challenging terrain

In June/July 2018, 12 boys went on a field trip, in Thailand's Chiang Rai province, with their football coach and became trapped deep inside a cave underneath a mountain. The prevailing stormy weather conditions meant that flooding was imminent. The rescue was supported by 3D high-resolution satellite images, which provided better visualization and understanding of the risk scenarios, evaluation differences, and topographic features of the area. For instance, in the search for alternative access, the availability of real-time images helped to find openings to drop off survival boxes and seek any sinkholes for managing the water flowing into the cave system in order to maintain the water level. The rescue was supported by a variety of image data products in conjunction with contextual collateral information from multiple platforms.

BOX 4-3 3D-Satellite Image Map of Tham Luang, Khun Nam Nang Non-Forest Park, Chiang Rai, Thailand



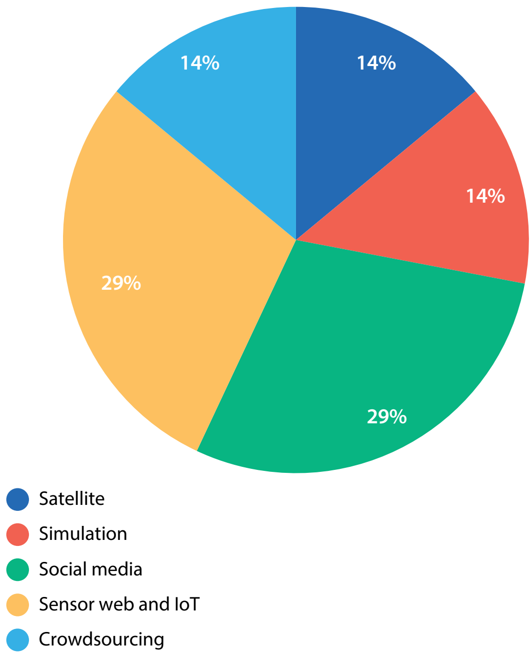
Source: Geo-Informatics and Technology Development Agency (GISTDA), 2019.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

platforms in real time through social media such as Twitter. These data can help predict extreme events such as earthquakes and tsunamis (Figure 4-4).[170]

Sensor costs have significantly decreased over the last decade making dense seismological networks and earthquake early-warning systems more affordable. In high-seismic-risk areas, these networks can give a better understanding of the location, timing, causes, and impacts of earthquakes and tsunamis. Even so, the warning time is short. Seismic waves travel at around two miles per second; therefore, someone who lives 30 miles from the epicentre could only receive 15 seconds of warning.

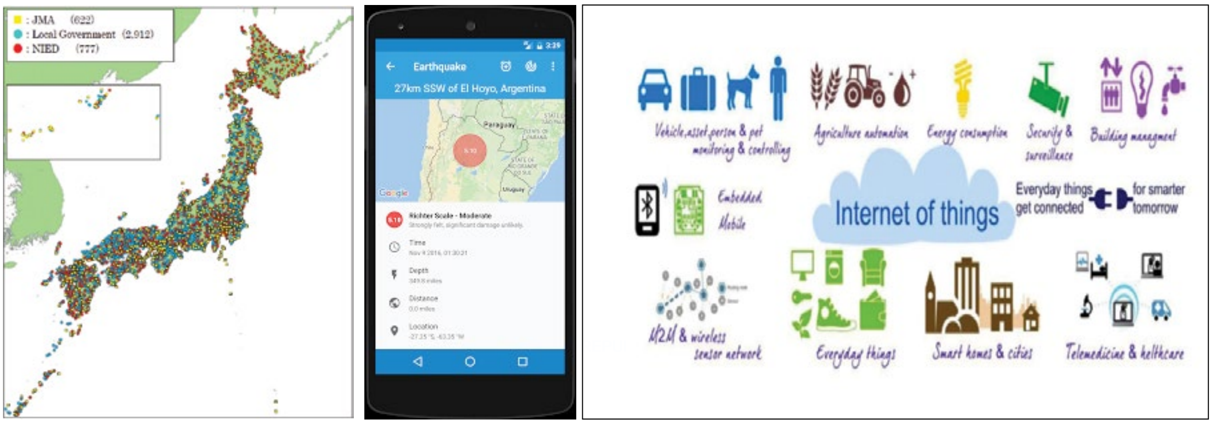
Sensor webs and the IoT have enabled efficient earthquake early warning systems in Japan (Figure 4-5). Zizmos, for example, uses smartphone apps to detect motion and serve as seismic sensors in high-risk areas.[171, 172] This network can provide up to 90 seconds of warning.

FIGURE 4-4 Data sources used for predictive analytics, in percentage



Source: Manzhu Yu and others, 2018.

FIGURE 4-5 IoT provides affordable earthquake early warning to communities in Japan



Sources: Japan Meteorological Agency, 2012; Android weather apps, 2016; Slideshare.net, 2015.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Tsunamis

Tsunamis in the ocean can be detected by the deep-ocean assessment and reporting of tsunamis (DART) system which comprises a series of surface buoys linked with recording devices on the sea floor that detect pressure changes caused by tsunamis. The surface buoy receives information from the recorder via an acoustic link, and then transmits data to a satellite, for onward dissemination (Figure 4-6). The system detects earthquakes and abnormal changes in sea level and helps scientists decide whether an earthquake has triggered a tsunami.

A tsunami wave in the open ocean can travel at more than 800 kilometres an hour, crossing the Pacific Ocean in less than one day. But if it is locally generated, a 'near field' tsunami, it can hit the coast within minutes, and up to a few hours at most. Buoys can be installed in the deep ocean, but this requires using a large number, which is quite difficult. A second option is to install the buoys along the shoreline, but they would provide very little warning. Recent innovations suggest a third option that use the faster acoustic waves radiating from the earthquake that triggered a tsunami.[173, 174]

Other options are also possible. For example, taking advantage of the installation of many new trans-oceanic and regional telecommunication cable systems, a Joint ITU/UNESCO/WMO Task Force has been working on establishing a global network of smart cables equipped with sensors that provides real-time data for ocean climate monitoring and disaster mitigation, particularly for tsunamis. Such system can mitigate the very costly problem of intentional vandalism or unintentional damage that sea-surface buoys are prone to.

FIGURE 4-6 Tsunami warning system in Indonesia

NETWORK OF BUOYS

MECHANISM

To record an earthquake, determine its location and strength.
↓
Depending on earthquake severity, a potential tsunami warning will be issued by national meteorology, climatology and geophysics agency.
↓
Issuance of tsunami warning: text messages and sirens.

NETWORK OF BUOYS

MECHANISM

To record changes in the sea level in deep water, by using buoy network.
↓
The buoys send a signal to a data center.
This alerts the national meteorological agency.
↓
This agency informs local authorities.

TIDAL GAUGES

MECHANISM

To measure changes in sea level every 15 minutes
↓
These send the data to the national meteorological agency.

Source: Singhvi and others, 2018.

Additionally, container ships and other commercial vessels can act as passive markers for vertical sea-surface motions, and precise Global Navigation Satellite Systems (GNSS) positions from these ships can be used to detect tsunamis. High accuracy GPS and satellite communications can serve to create a dense, low-cost tsunami sensing network that, when connected to big data ecosystems and the IoT, would improve detection and predictions of tsunamis, especially for near-field tsunamis, where communities are at a heightened risk due to the shorter evacuation lead time available.

Tropical cyclones

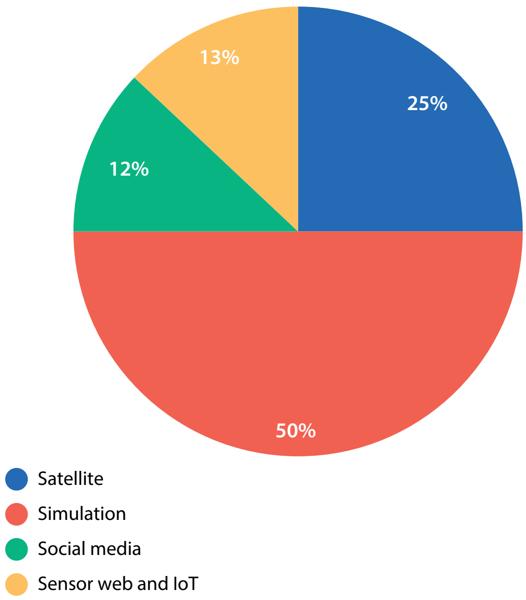
Flood and cyclone forecasting uses computer simulations. Increasingly this involves nested modelling that couples hydrologic and climate/weather models, which offer improved lead times and better locational accuracy (Figure 4-7). Tropical cyclone simulation can be based on sea surface temperature, ocean state, atmospheric parameters and retrospective seasonal prediction. These data can be combined with Earth observation satellite data on hydrologic, land cover, atmospheric and other ocean related data. Social media can then send early warning messages to communities at risk.

The China Meteorological Administration (CMA), for example, uses big data for gridded, smart and impact-based typhoon forecasting.[175] Impact-based typhoon forecasts and warnings help to pinpoint, with far more location and timing accuracy, the community at risk. This has improved evacuation exercises — number of people and timing of evacuation. Evacuations that occur just before a typhoon makes landfall helps increase compliance, as it minimizes livelihood disruption. Exposed economic assets can be protected through impact-based forecasting that enables risk-informed, spatial land use planning. As a result, there has been a significant decrease in casualties, even for super-typhoons (Box 4-4), and a reduction in disaster losses, as a proportion of GDP, as shown in the case of China in (Figure 4-8).[176]

Floods

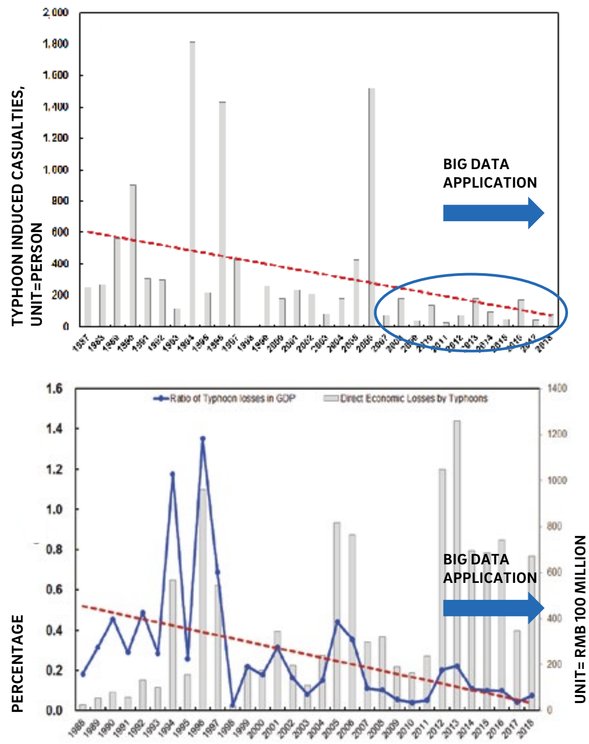
There has not been comparable advances in flood forecasting. Floods, especially recurring ones, therefore continue to be a driver of immiseration and disempowerment. Floods are complex because of their multiple cascading impacts, particularly in the case of flash floods. Forecasting can, however,

FIGURE 4-7 **Data sources used for predictive analysis that is effective in cyclone and flood forecasting, in percentage**



Source: Manzhu Yu and others, 2018.

FIGURE 4-8 **Typhoon casualties and losses in China, 1987–2018**

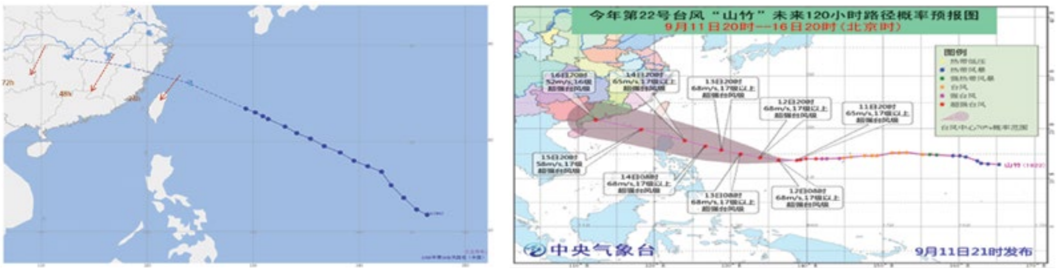


Source: CMA, 2018.

BOX 4-4 Big data makes a difference: a tale of two typhoons

In August 2006, super typhoon Saomeo hit Zhejiang province killing 483 people, displacing 1.8 million and causing losses of $2.5 billion. In contrast, in September 2018 super typhoon Mangkhut hit Guangdong Province killing just 16 people, displacing 1.5 million and causing direct losses of $2.1 billion.[a, b] The substantial reductions in mortalities and economic losses were attributed to big data applications that, by 2018, had enabled impact-based forecasting and risk-informed early warning.

Between 2006 and 2018 there had been substantial improvements in observational capacities of orbiting earth observation satellites, which resulted in more accurate and higher resolution data.[c] Typhoon Mangkhut was tracked and monitored more frequently by eight dedicated satellites as opposed to the three for Saomeo in 2006. Further, Mangkhut's track was forecast using cone areas indicating possible dynamic risk zones, providing a more precise location of possible impacted areas.[d]



Source: China Meteorological Administration, 2019.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

a China Meteorological Administration (2019).
b Organisation for Economic Co-operation and Development (OECD) (2019).
c Ibid.
d Ibid.

also benefit from big data, by overlapping real-time data onto maps of flood hazards, exposure and vulnerability. In this case, data from multiple platforms can be used as the basis for a precipitation estimate for a couple of hours in conjunction with a forecast for the few days (Box 4-5). A web-geographic information system (GIS) platform, for example, can aggregate data in space and time and build scenarios of risk and damage.[177]

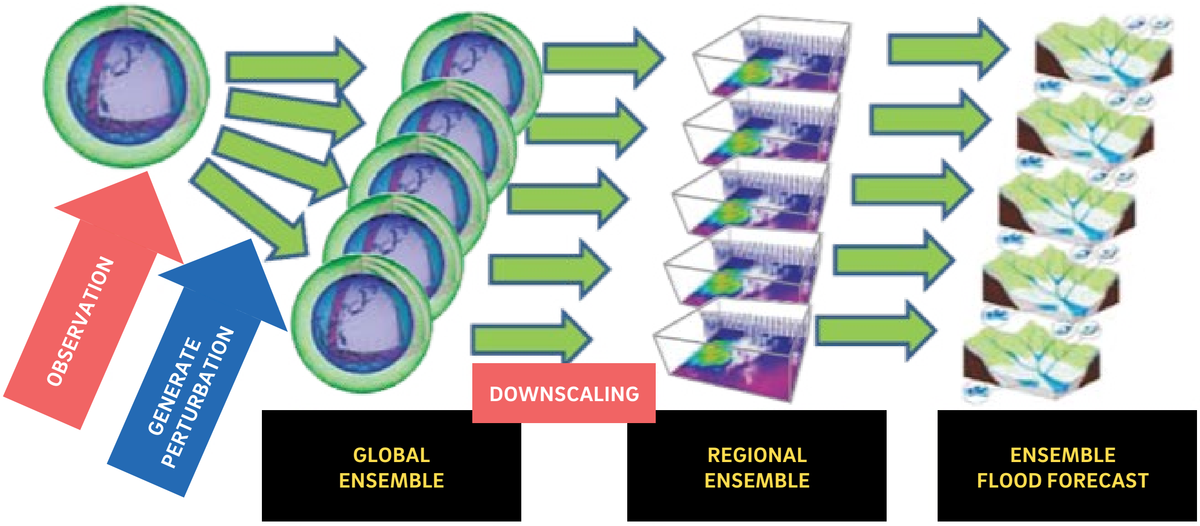
A recent innovation in climate modelling is the use of an ensemble prediction system (EPS). Instead of offering a single forecast, an EPS offers a group or ensemble of forecasts indicating a range of possible outcomes (Figure 4-9). EPS is particularly useful in transboundary river-basins where it is difficult to get hydrologic data. It is also possible to incorporate rainfall predictions from multiple weather centres, as well as rainfall and river observations from many platforms and institutions. Some stations offer forecasts for up to 16 days in advance.[178]

The experience of EPS for 2018 flood forecasting for Sri Lanka was a mixed bag of success. While it captured the intensity of torrential rain two days in advance,the forecast was not precise in its exact location (Figure 4-10).[179] The location accuracy can be improved not only with quality of downscaling ensembles but with densification of data network and putting in place an appropriate big data ecosystem.

Prescriptive analytics

Prescriptive analytics goes beyond description and inferences to incorporate pro-poor policy action. For example, policymakers can create a series of policy scenarios and run predictive analyses on the likely outcomes. In doing this, they must take into account complex interactions between climate, social and ecological systems to develop scenarios and trajectories that combine actions for pro-poor adaptation and mitigation. They can indicate pathways at four levels; risky (taking no action), passive (not backed by vulnerability responsive policy actions and budget), active (backed by vulnerability responsive policy actions and budget), and full (institutionalized responses supported by both short- and long-term policy actions).

FIGURE 4-9 **Ensemble prediction system: nested modelling for flood forecasting with longer lead-time**

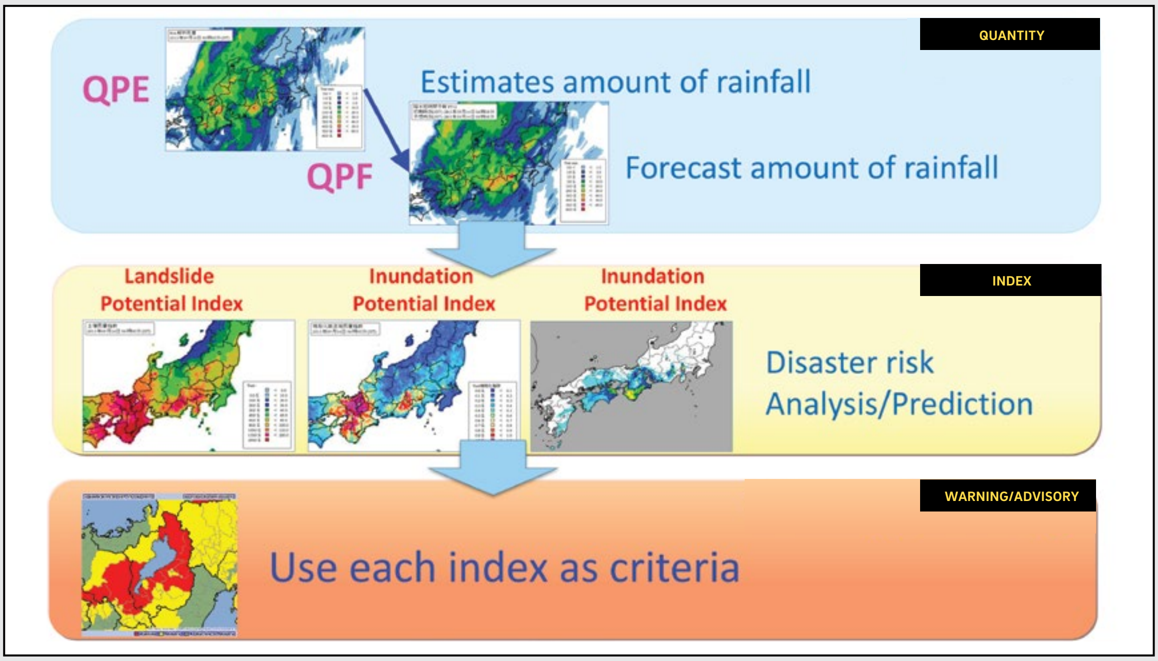


Source: Tomoki Ushiyama, ICHARM, 2019.

BOX 4-5 **Big data used for flood forecasting in Japan**

The Japan Meteorological Agency (JMA) uses a quantitative precipitation estimation (QPE) and a quantitative precipitation forecast (QPF) as warning criteria to identify risk levels of flood inundations and landslides in certain locations.[a]

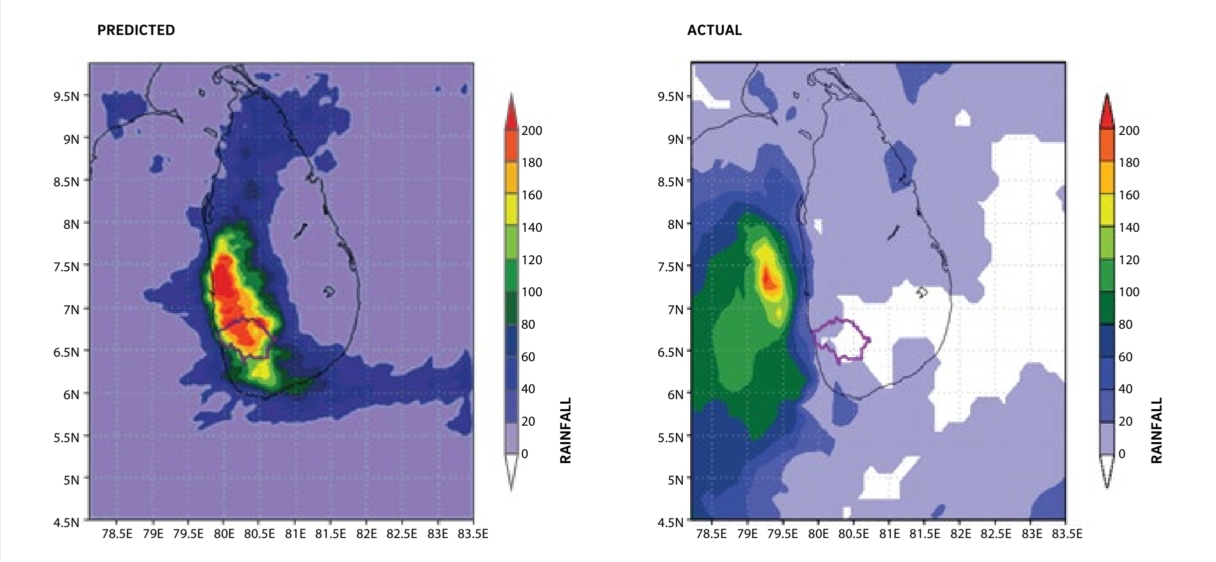
Based on QPE and QPF, potential risk indices have been developed for landslides and flood inundations. These indices serve as warning criteria for heavy rain, inundation and landslides. The model helps the Public Weather Service issue severe weather warnings. The JMA has built a solid disaster database to determine proper warning criteria.



Source: Japan Meteorological Agency, 2019.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

a Japan Meteorological Agency (2019).

FIGURE 4-10 Predicted and actual rainfall in Sri Lanka, 24 May 2019



Source: Tomoki Ushiyama, ICHARM, 2019.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

These scenarios can be seen as iterative, continually evolving processes for managing change within complex climate-sensitive systems. In Kazakhstan, for example, climate, geo-spatial and socioeconomic data have been used to create a flood vulnerability index that indicates the outcomes of different levels of policy action.[180]

Running policy scenarios can be considered a top-down approach. Another prescriptive application which is more bottom-up and empowering is behaviour 'nudging'. This might involve, for example, collecting from individuals their data on energy consumption, or their exposure to health risks, as a basis for providing them with personalized reports that might nudge them in a positive direction.

Another prescriptive use of big data is for index-based flood insurance (IBFI). In South Asia, IBFI systems use satellite data and computer-based flood models to assess the location, depth and duration of flooding and indicate when and where flooding reaches the threshold at which damage is severe enough to warrant compensation.[181] This simplifies decision-making and speeds up the delivery of insurance payouts which has helped alleviate the asymmetric impacts on poor farmers (Figure 4-11). IBFI has successfully been piloted in 2017/18 in Bihar, India.[182]

Discursive analytics

Discursive analytics involves using data to empower communities at risk. Data sources include satellite and aerial imagery combined with user-generated data. During major disasters, a useful way of following people is to use the call records of mobile phones which are regularly collected by phone companies for monthly billing. The United Nations Global Pulse initiative has shown several cases where mobile phone location data have been used to understand people's response during major disasters.[183]

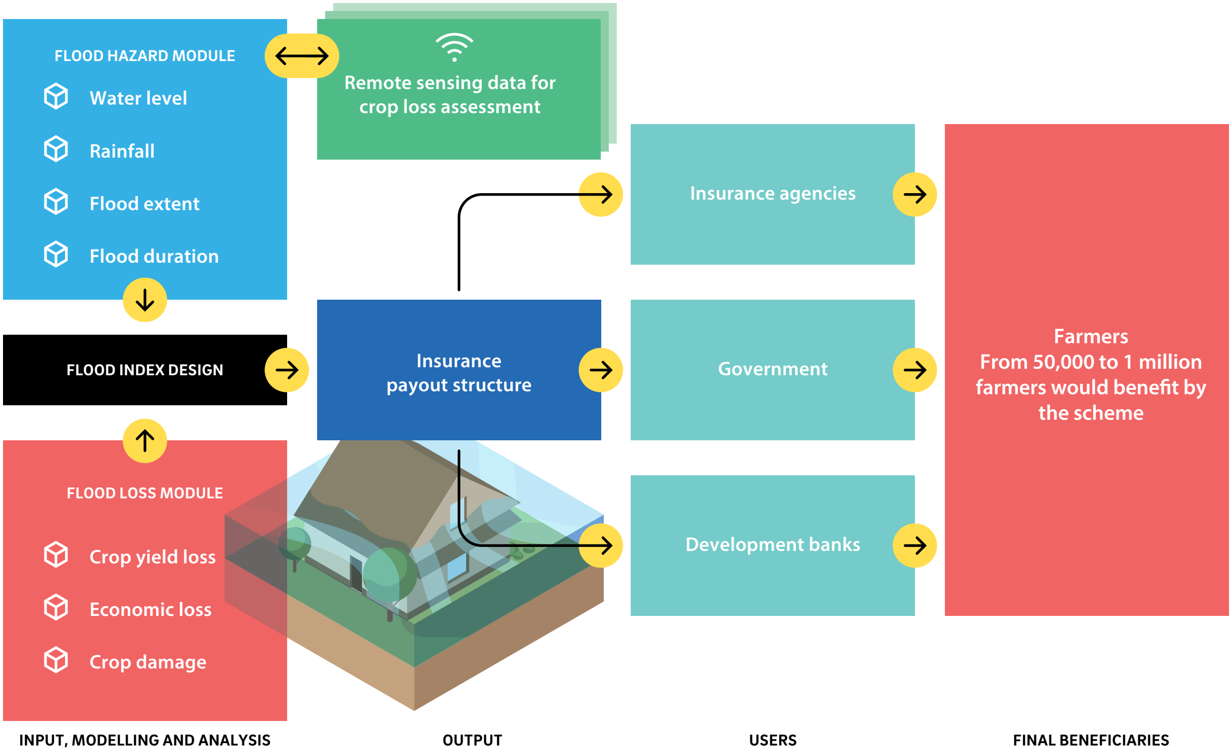
Discursive analytics can also make use of mobile phones to receive messages and alerts (Box 4-6). These activities are more efficient however when embedded alongside productive and prescriptive analytics into an overall systems approach.

Counting the excluded

Building disaster resilience for the most vulnerable communities requires good baseline data disaggregated by gender, age, and disabilities. Such data are often scarce or completely missing, since official data collection systems often exclude the most vulnerable people who are hardest to reach.

International household surveys can omit these people either by accident or by design. The Demographic and Health Surveys (DHS) and the Multiple Indicator Cluster Surveys, for example, do

FIGURE 4-11 Index-based flood insurance



Source: Amarnath, 2017.

not cover people who are homeless, or who sleep in shops or workplaces not enumerated as dwellings. Nor do they cover mobile, nomadic or pastoralist populations or people in refugee camps. Moreover, household surveys will typically under-represent those in fragile, disjointed or multiple occupancy households, those in slums who are difficult to identify and interview, those living illegally or stigmatized within households (due to mental health problems or other disabilities), or those living in their place of work such as domestic workers or security guards.[184] As a result, any mapping of the population for purposes of protecting the poorest is likely to omit important groups.

Figure 4-12 shows the standard sampling methodology based on census records with corresponding enumerated areas (EAs) and primary sampling units (PSUs). The second row of boxes shows the risks of exclusion at different stages, and the third row indicates some potential solutions.

Census enumeration areas are often arbitrary and delineated for administrative convenience rather than corresponding to population distribution. An alternative is to start again with satellite images which indicate populated areas. These geographical areas can then be divided into a grid of one kilometre squares. These 'primary grid cells' are then analysed to identify those with the highest residential populations, using characteristics such as building patterns, community size, and proximity to other land uses. These higher-population cells are then sub-divided into secondary grid cells of perhaps 15 square metres. From this set, some are chosen at random and screened for residences, either manually or by computer. In the chosen secondary cell, enumerators then carry out a micro-census contacting every household. This is termed one-stage sampling, as opposed to two-stage sampling which involves selecting households randomly. These new approaches have been used in urban slums of Hanoi, Kathmandu and Dhaka and indicate that gridded population sampling and one-stage sampling do address the problem of undercounting.[185]

Gridded population data can also be combined with other data to estimate the size and locations of populations at risk. This is illustrated in Figure 4-13 for populations in areas at risk of land degradation in Central Asia.

With the advances in geo-statistical interpolation techniques, it is also possible to integrate the disaggregated geospatial data into traditional sampling frames.[186] For Nepal, for example, statistical

BOX 4-6 The Tamil Nadu system for multi-hazard potential impact assessment and emergency response tracking (TNSMART) engages communities

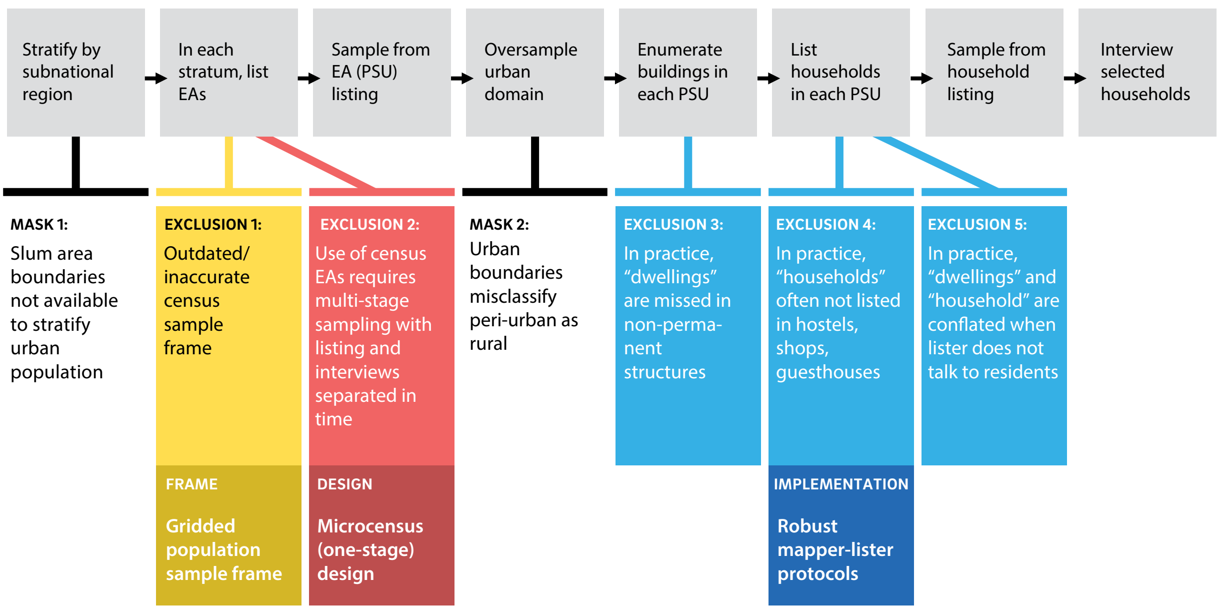
In India, the Tamil Nadu State Disaster Management Authority uses TNSMART, a web-GIS-based decision support system for operations and for communicating to communities.[a] The data sources include geospatial systems, remote sensing, satellite imageries, UAV, Light Detection and Ranging (LIDAR), and telemetry.[b]

The TNSMART web application classifies areas in terms of risk: very high, high, medium and low. The system prepares customized advisories for at-risk communities along with do's and don'ts. The TNSMART mobile application can then send alerts and information about mitigation measures while also receiving messages from users. TNSMART also provides forecast-based impact information especially for agriculture sector.

TNSMART was used, for example, during 2018 Northeast monsoon, particularly for cyclone Gaja. During the preparedness phase, TNSMART helped its 13,000 registered users understand the risk and also communicated this to field-level functionaries.[c, d] Distress messages were received from the general public in the State Control Center through the TNSMART app and forwarded to concerned officers/departments for action. TNSMART helped disaster managers provide location-based services while responding to communities at risk. This saved numerous lives due to timely evacuation.

a Tamil Nadu State Disaster Management Authority and RIMES (2019).
b Ibid.
c Ibid.
d Ibid.

FIGURE 4-12 Unintended exclusion of the poorest in a typical household survey



Source: Based on Dana Thomson and R. Bhattarai, 2018.
Note: EA = enumeration area PSU = primary sampling units (s).

geo-spatial data have been combined with DHS data to map a wealth index.[187] This wealth map is then combined with multi-hazard spatial data on floods, landslides and earthquakes to estimate the population exposed to disaster risks.

Identifying the excluded and digital empowerment

Around 2.4 billion people around the world, typically the poorest and most vulnerable lack formal identification records such as identity document (ID) cards or birth certificates.[188] They may then find it more difficult to access vital services and entitlements which can transmit exclusion over generations. To address these issues, Governments can take advantage of digital identity systems which offer greater choice and convenience. Digital identity systems strengthen the capacities of public and private sectors to deliver services and create a foundation on which to build new systems, services and markets (Figure 4-14).[189, 190]

In Bangladesh, for example, the Government is partnering with the World Bank on the Identification System for Enhancing Access to Services project. This system includes a unique identifying number and biometrics-based smart national ID cards for citizens, including those in high-risk areas, and the socially vulnerable and marginalized. Compared with laminated paper ID cards, the smart cards are more secure.[191]

Direct benefit transfer

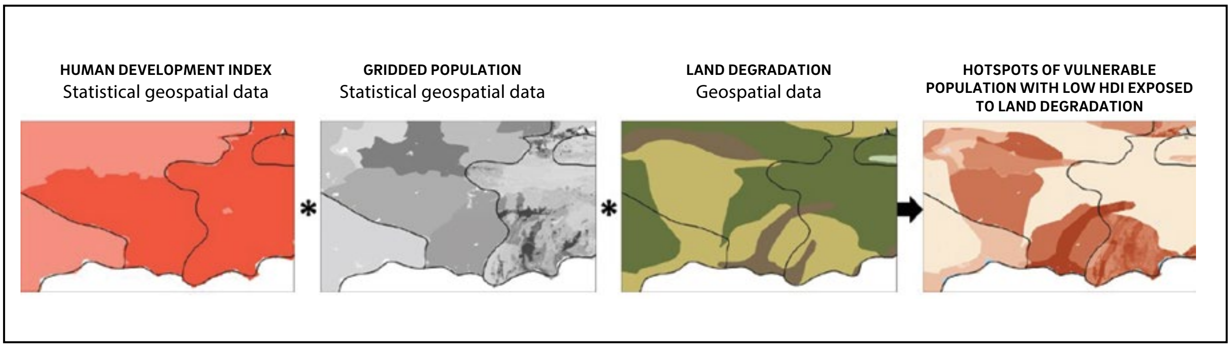
National ID cards can be used for delivering a variety of services to people at risk, including social welfare programmes. India, for example, has one of the world's largest public workfare programmes; the Mahatma Gandhi National Rural Employee Guarantee Act (MNREGA).[192] Since 2005, MNREGA has provided millions of jobs and has been a vital source of income for the rural poor who are at high risk of drought and floods. However, in the past, the programme suffered from many leakages and delays in wage payment. During droughts, some distressed poor people even found it uneconomical to work for the workfare programme so there was a fall in the number of beneficiaries.

This issue has been addressed through direct payments. In 2015–2016, the Government of India introduced a biometric-enabled national identity numbers, named Aadhar, for identifying MNREGA beneficiaries, with numbers which were linked to their bank accounts.[193] Aadhar-linked payments, reduced leakages, ensured speedy payment and helped to make the programme truly counter-cyclical (Figure 4-15). Moreover, beneficiaries now have more faith in the system, while the Government has timely and reliable data, and can transfer benefits directly to beneficiary bank accounts, which has also improved monitoring and implementation. In India, as a whole, the use of Aadhar-linked digital identity bank accounts for variety of subsidy and social protection schemes saves an estimated $11 billion per year.[194]

Risk-informed social protection

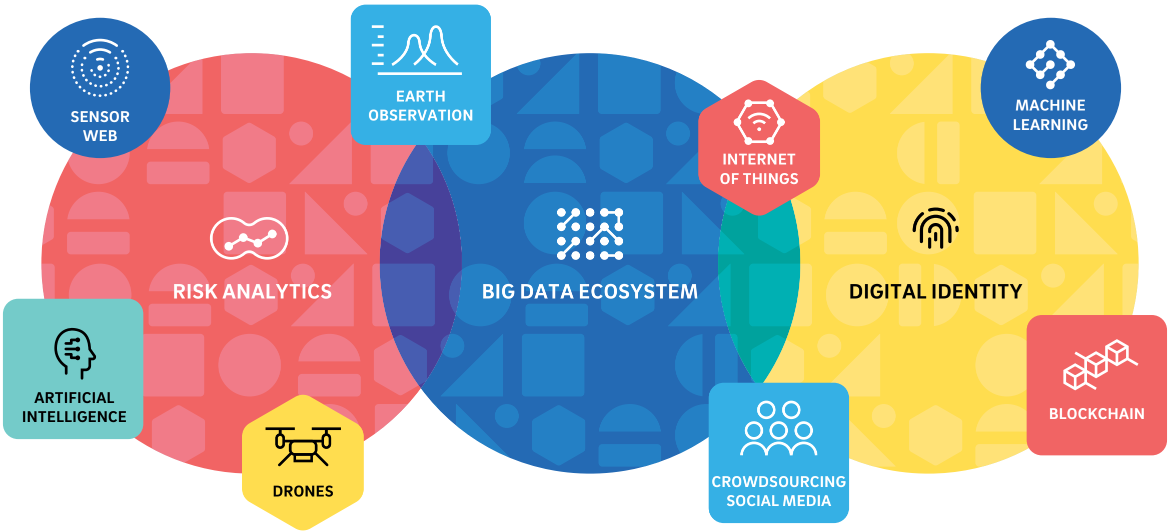
Social protection systems, as shown in Chapter 3, have the most impact on reducing extreme poverty and inequality. They help the poor and vulnerable cope with disaster risk, find jobs, and invest in the health and education of their children, while also protecting older people. Properly designed and implemented,

FIGURE 4-13 Overlaying four data sources to determine poor populations exposed to land degradation in Central Asia



Source: ESCAP, based on Global Data Lab, World Pop, FAO.
Disclaimer: The boundaries and names shown and the designations used on this map to not imply official endorsement or acceptance by the United Nations.

FIGURE 4-14 New technologies for resilience, inclusion and empowerment



social protection systems can efficiently protect the most vulnerable, both in normal times and in the event of a disaster.

Such programmes are, however, difficult to implement well. Governments often lack disaggregated data, or the mechanisms to identify and target people at risk, either for short-term emergency responses or long-term policy interventions. Another issue is fragmentation since many systems offer a range of benefits and services that are delivered in a piecemeal way. There are also challenges of horizontal and vertical coordination, including among multiple layers of government.

Improved social protection should be risk informed and sufficiently flexible and adaptable to reach specific groups that are most at risk of being excluded, and to be scaled up at times of disaster. During disasters, Governments have responded in various ways:[195]

- *Vertical expansion* — Increasing the benefit value or duration for existing beneficiaries
- *Horizontal expansion* — Adding new beneficiaries to an existing programme
- *Piggybacking* — Using social protection administrative mechanisms to deliver assistance for a separate shock-response programme
- *Parallel operation* — An additional aligned humanitarian programme
- *Refocusing* — Adjusting a social protection programme on the groups that are most vulnerable and excluded

These approaches require the main social protection programme to be sufficiently flexible and have a comprehensive mechanism for delivering benefits and services.[196] Governments also need the capacity and information to identify the vulnerable populations, determine the right responses, and prepare to scale-up.

Ideally the population at risk should already be registered, with digital IDs linked to bank accounts in which they can receive cash transfers. In Ethiopia, for example, the Productive Safety Net Programme expands at times of shock by increasing the period of time over which beneficiaries receive cash payments.[197]

Similarly, in Pakistan, following the floods of 2010 and 2011, the Government used its National Database and Registration Authority to implement a digital cash transfer scheme for 1.5 million people affected.[198] In Nepal, following the 2015 earthquake, DanChurchAid used technology from the Hello Paisa international money transfer service to make cash transfers to more than 10,000 people.[199] Governments and development agencies often prefer these systems as being more flexible and secure. Citizens too may prefer cash transfers, seeing them as a right associated with their citizen registration rather than as aid to them as 'victims'.[200]

Blockchains for empowering smallholder farmers

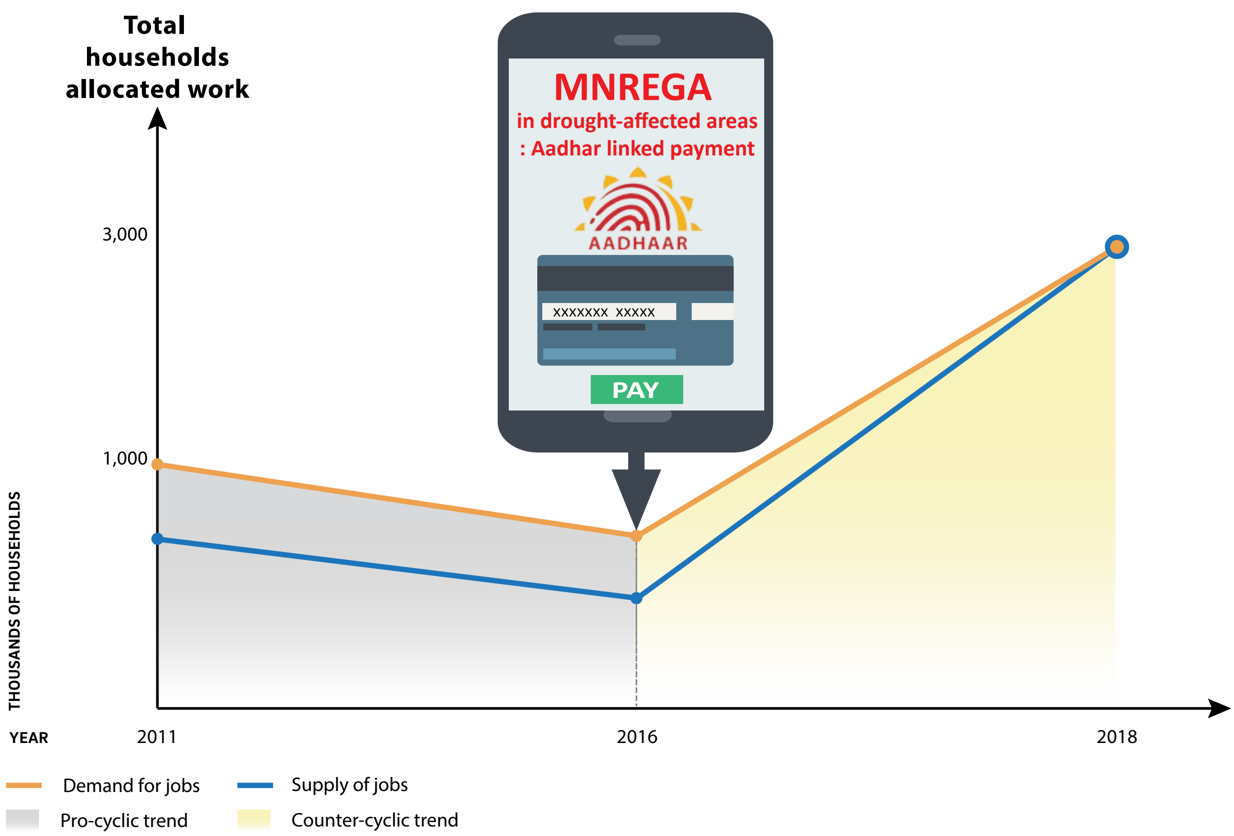
In principle, farmers affected by floods or droughts should benefit from low-cost agricultural insurance schemes. As yet, relatively few do so partly because of time-consuming mechanisms for validating claims and making payouts.[201] A better alternative is index insurance based on smart contracts which can automate and simplify the process so as to give instant payouts. Such contracts rely on automatic data feeds that provide hyperlocal weather data that eliminate the need for on-site claim assessment.[202] The contracts can use 'blockchain' technology, in which the data are held in a decentralized public digital ledger distributed across many computers. Allianz Risk Transfer and Nephila have successfully piloted such systems demonstrating that transactional processing and settlement between insurers and investors can be significantly accelerated and simplified by blockchain-based contracts.[203]

Machine learning for smart resilience

Disasters present very complex environments with very diverse types of data. Even experts can struggle to develop models that show the impacts on the built environment and society. Their work can, however, now be supplemented by machine learning in which an algorithm learns from previous data to add new information and insights. This will often require 'data mining' which involves discovering patterns in large data sets as well as 'image mining' for extracting patterns from large collections of images. Though the two terms are often used interchangeably, machine learning is a subset of artificial intelligence (AI) (Figure 4-16). The seamless linkage of machine learning with big data ecosystems — from the image, sound, and voice recognition features of smartphones, for example, enables disaster managers to identify where people are at risk.

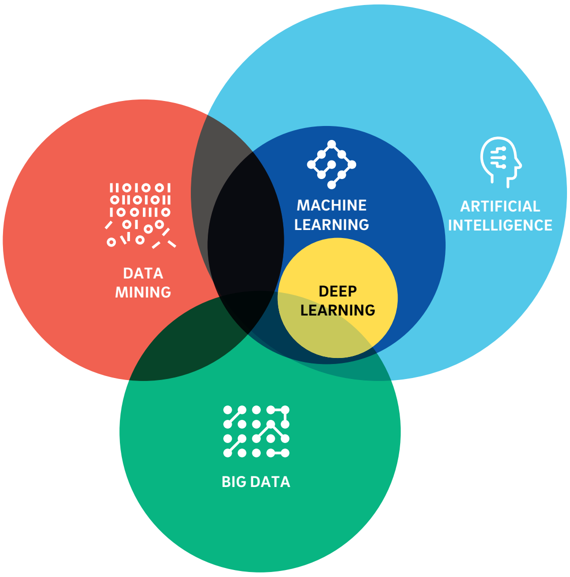
Machine learning is becoming one of the most effective methods of processing and analysing data on major heterogeneous disasters and speeding up

FIGURE 4-15 Job demand and supply in selected drought-affected areas in India, 2011–2017



Sources: ESCAP based on data from Prasad, Parijat Shradhey, and others, 2018.

FIGURE 4-16 Machine learning a subset of artificial intelligence



all the necessary analytics to identify the optimal responses. In the near future, we can expect more complex socioeconomic risk profiles, disaggregated by income, age, gender and a host of other vulnerabilities to become available, thus opening up vast possibilities for building smart resilience that is inclusive and empowering.

Earthquake prediction

Because large and devastating earthquakes, such as the magnitude 9.0 Tohoku earthquake that hit Japan in 2011, are currently considered unpredictable, they can be considered as the most disempowering of disasters. Scientists do not have sufficient seismic data to generate statistical insights and develop predictions. An alternative is to apply machine learning to data that are continuously generated in subduction zones; the boundaries where tectonic plates collide. These data reflect the slow deformation accumulating in the plates. This approach has been tested using computer models and could, in the future, predict the timing and size of natural subduction earthquakes.[204] However, this methodology needs much more research before it can become operational.

Flood prediction

As discussed earlier, advances in flood forecasting have lagged. Machine learning can be used to create better forecasting models for floods. This was pilot tested in the city of Patna, in the Bihar state in India, during the September 2018 floods using Google Public Alerts (Box 4-7). The models incorporated a variety of elements, from historical events, to river-level readings, to the terrain and elevation of a specific area, to accurately predict the location and severity of floods.[205]

Exposure and vulnerability

The Keio University in Japan has developed the 5D-World Map System that provides a multi-dimensional global knowledge platform to collect and analyse 'real time' data on SDG-related indicators.[206] The system integrates the analytical visualization of sensor data into a knowledge sharing platform with multimedia. This can be used for community-based data sharing, awareness building and evidence-based decision making.[207] The system uses machine learning to indicate the exposure of critical infrastructure and vulnerable populations in multi-hazard risk environments (Figure 4-17 and 4-18).[208]

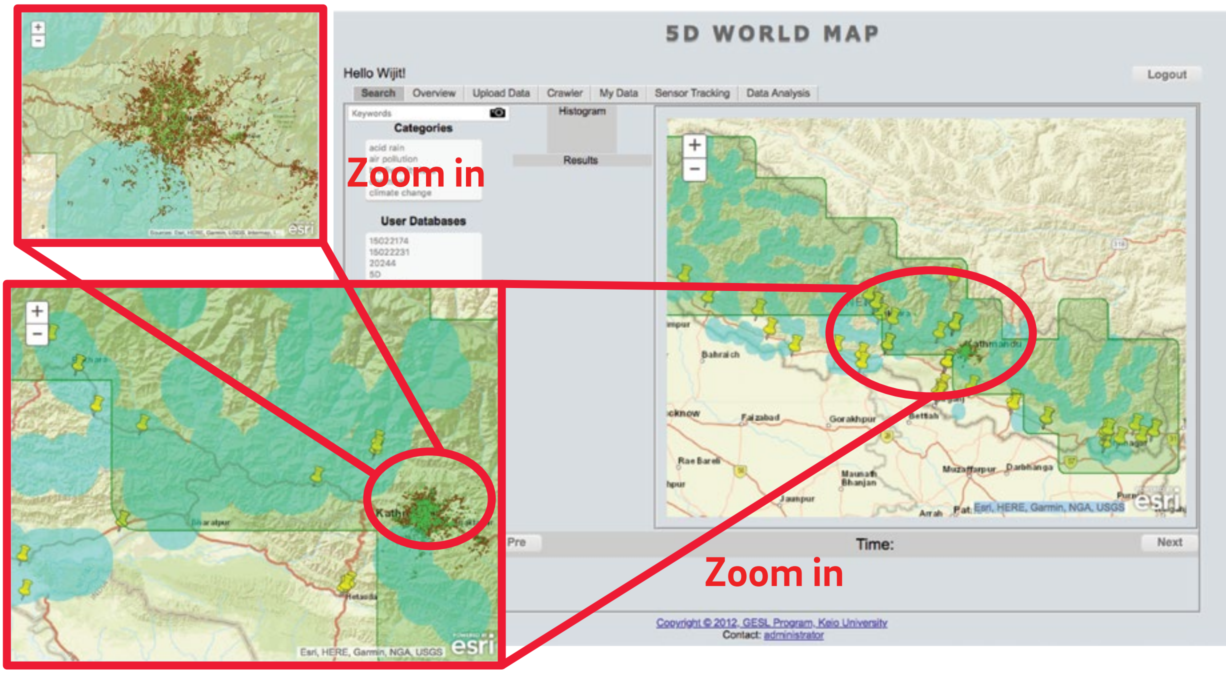
The big data ecosystem

This chapter has shown how such technological advances can be integrated into a big data ecosystem. Under this approach, asset-level data are gathered from various public and proprietary sources, such as satellites and censuses in a scalable process, along with impact data from previous disasters. These are then inserted in data-driven machine learning models that require no user inputs and can produce impact outputs at high spatial resolutions within minutes.

Real-time disaster data can generate accurate localized impacts that are updated continually as more information becomes available. These include data on ground shaking, water levels, temperature, and wind patterns from satellites and weather data. This interdisciplinary approach takes into account multiple-hazard models and dynamic data. It trains models on true observations of damage and, by seeking solutions that allow for unprecedented situational awareness, informs better decisions. Big data and machine learning thus create new grounds for risk-informed early warning, and dramatically shrink the innovation cycle by taking advantage of changing technology.

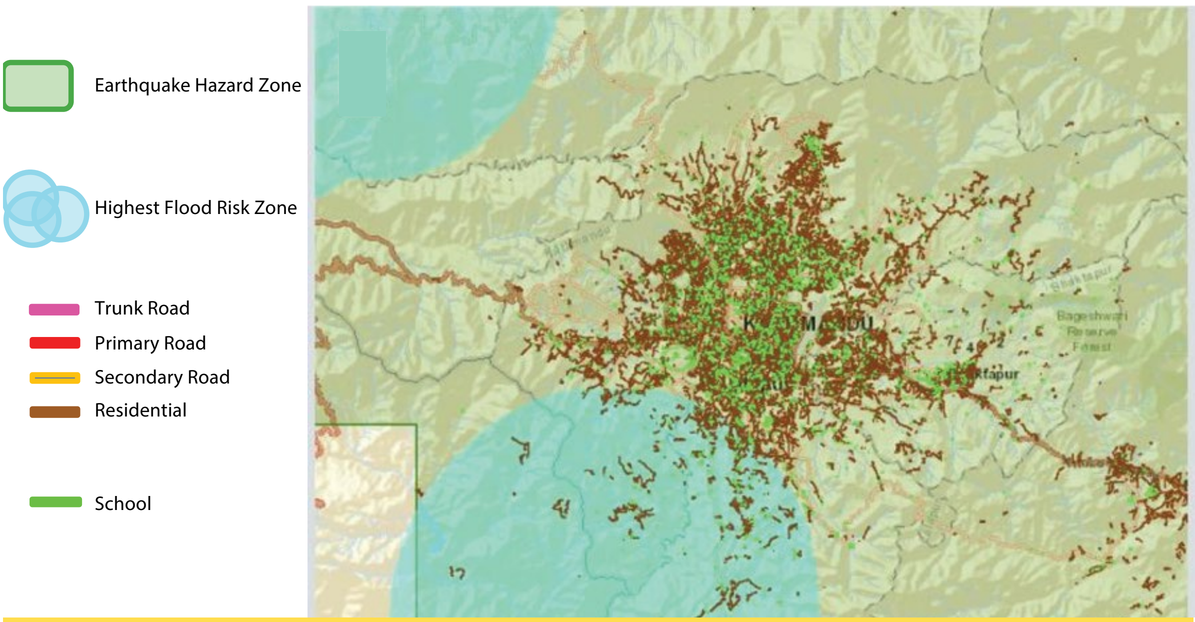
These technologies have spread rapidly in much of the world, boosting growth, opportunities, and service delivery. Yet, their aggregate impact has fallen short of what is possible and is also unevenly

FIGURE 4-17 **Residential roads and educational facilities in earthquake and flood high-risk areas in Nepal**



Source: Sasaki and Kiyoki, 2018.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

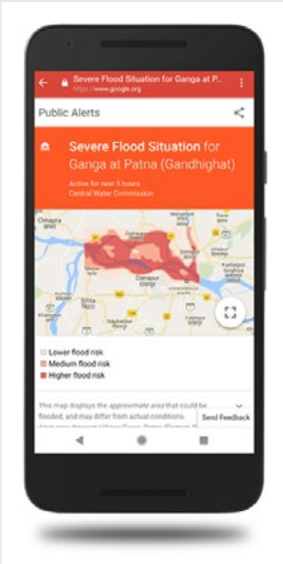
FIGURE 4-18 **Image mining and machine learning enabled multi-hazard exposure mapping of Kathmandu, Nepal**



THE ENTIRE REGION OF KATHMANDU IS COVERED BY EARTHQUAKE HAZARD ZONE, AND THE SOUTHERN PART OF KATHMANDU IS INCLUDED IN BOTH EARTHQUAKE AND HIGHEST FLOOD RISK ZONE.

Source: Sasaki and Kiyoki, 2018.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

BOX 4-7 Google Public Alerts



Source: TechEngage, 2018.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

When there is an important emergency alert Android phones will show a public alerts card. Google Public Alerts is a private sector platform for disseminating emergency messages such as evacuation notices for hurricanes and earthquakes and everyday alerts, such as storm warnings. Currently, it publishes content from Australia, Brazil, Canada, Taiwan Province of China, Colombia, India, Indonesia, Japan, Mexico, New Zealand, the Philippines and the United States. Google has sent out tens of thousands of public alerts which have been viewed more than 1.5 billion times. It has also activated SOS Alerts, which indicate a higher threat level of more than 200 times. Google Public Alerts has issues flood warnings which are delivered through Google Search, Google Maps, and Google Now.

distributed. There are also inherent risks, including algorithmic bias. The widespread sharing of data also raises issues of privacy and cybersecurity and potentially erodes individuals' trust in Governments and institutions.[209]

To be tools for smart resilience that empowers and includes those most at risk of being left behind, big data systems now need to address these issues. This is not easy. It means gathering sufficient data that can be translated into usable information along with coordination among multiple layers of government with integrated information systems. It is also important to build public awareness and consent, ensuring security and privacy and if necessary engaging communities in data collection, building their capacity to identify risks and vulnerabilities. Companies and Governments holding data should be open and accountable.

Above all, industry 4.0 technologies need to build disaster resilience of the poorest and most excluded. For this purpose, it is vital to close the remaining digital divide by ensuring universal and affordable high-velocity internet access and adapting people's skills to new demands. Advances in computational capabilities and communications seem likely to increase our ability to model and assess risk. But this does not automatically assure smart resilience for all. Results need to be communicated in ways that promote effective action and allow people to benefit from this rich new source of information and knowledge.

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CHAPTER 5

Resilience across the riskscape

Millions of people across Asia and the Pacific remain vulnerable to disasters. Those most exposed are often in remote areas, or who belong to minority groups or live on the fragile margins of big cities, with little defence against disasters and in danger of being left behind. But with sufficient effort and investment, and support at both national and regional levels, it is possible to extend protection to everyone in order to achieve resilience across the riskscape.

In adopting the 2030 Agenda for Sustainable Development, United Nations Member States pledged to ensure "no one will be left behind" and to "endeavour to reach the furthest behind first". Usually these are people who have been discriminated against, marginalized or excluded in the process of development, notably the poor, women, children, the disabled, the aged, migrants and other ethnic, religious, or linguistic minorities.

The Asia-Pacific region is now in the fourth year of implementing the 2030 Agenda for Sustainable Development. Progress has been mixed. The region is an economic powerhouse but economic growth in the region has come at a cost of social inclusiveness.[210] For the cluster of goals related to inequality and environmental degradation the region is moving backwards. This is based on evidence from the ESCAP SDG Progress Report 2019,[211] and evidence from voluntary national reviews.[212]

The evidence shows that for the bottom 10 per cent income group in the region, their income has doubled since the 1980s. However, the pace of their income growth is slower than that of the middle 40 per cent and of the top 10 per cent, and much slower than the top 1 per cent income group.[213] An important contribution to these disparities is the impact of recurring disasters. Track six of the United Nations Secretary-General Climate Action is 'the Resilience and Adaptation Pact' which aims for a fundamental shift in investments and behaviour. In the region's riskscape where nearly 85 per cent is occupied by climate-related disasters, such as floods and cyclone, concerted actions under 'the Resilience and Adaptation Pact' will go a long way towards achieving the 2030 Agenda for Sustainable Development (Box 5-1).

This report offers the first comprehensive riskscape for the region, as well as showing the impacts of disaster risk on poverty and inequality. Chapter 2 identified those likely to be left furthest behind. These include women in households in the bottom 20 per cent of the wealth bracket, who are employed in agriculture, and have more than two children and have little voice in their households. When hit by disasters, such groups are likely to become even poorer, with a rise in inequality.

Acceleration towards many of the SDGs will mean further empowering people and ensuring their inclusion.[214] The sixth Asia-Pacific Forum on Sustainable Development highlights the need to mobilize actions around four areas: rights and justice; norms and institutions; resources and capabilities; participation and voice. A further source of guidance should be the United Nations Secretary-General's Conference on Climate Action (Box 5-1).[215]

A way forward: opportunities for action

Increasing disaster resilience for all excluded groups will require action across three broad areas. First, to ensure that all policies and investments are risk-informed, notably in education, health, social protection, agriculture and infrastructure. Second, to capitalize on industry 4.0 technologies. Third, to unlock the potential of regional cooperation.

BOX 5-1 United Nations Secretary-General's Climate Action 2019

On 23 September 2019, the Secretary-General of the United Nations will host the Climate Action Summit in New York to accelerate action to implement the Paris Agreement.[a] Track 6 of the Secretary General Climate Action is 'the Resilience and Adaptation Pact' which aims for a fundamental shift in investments and behaviour. The pact aims to seek cross-sector commitment at the highest level to bring adaptation action to global scale. It will aim for:

- Resilient people: allow investment (both private and public) to adapt and to build resilience where it is most needed; including financial and technical support to build capacity of the most vulnerable.
- Resilient economies: integrate adaptation into norms, policies and long-term low-emission development strategies and embed climate risk and opportunities through all public and private planning, investment and financing.
- Resilient food and land-use: reduce land degradation and provide food security.
- Preparing for, and responding, to disasters/shocks: including preparatory financing, early warning systems, and insurance.

a United Nations Climate Action Summit (2019).

1 Implement risk-informed policies and investments

Policies and investments must be risk-informed but also tailored to local circumstances. In some hotspots, high-disaster risk is compounded by high levels of poverty and inequality. Here it will be important to ensure risk-informed services of social protection, education and health along with resilient agriculture and infrastructure. In other hotspots, disaster risk is closely linked with environmental fragility, so policies and investments need to be coupled with environmental protection and ecosystem restoration.

Many Governments across the region have already taken major steps in this direction; investing in the social sectors as part of pro-poor growth strategies. But if growth is to be inclusive, Governments need to go further and encompass disaster resilience. At the national scale this means developing a comprehensive portfolio of sectoral investments and policies that collectively address the differentiated risk profiles. The traditional approach has been to consider these as separate policy domains. Instead, to promote disaster resilience, multiple ministries should collaborate to align their plans, as well as their financing, monitoring and reporting systems. Different interventions may be necessary for different groups, according to their unique vulnerabilities and capacities.

2 Capitalize on new technologies

Disaster reduction can now make greater use of big data techniques for analysing very large data sets to reveal patterns, trends, and associations. In the case of early warning systems, big data can fill critical gaps and allow impact-based, risk-informed, people-centred and end-to-end early warning services down to community level. It also helps the transition from early warning to early action when used for forecast-based financing, forecast-based social protection and risk prevention.

Resilience building relies upon many different data types and information sources. Industry 4.0 technologies can also assist here through machine learning, which enables actions to be analysed and used rapidly, sometimes in near real time as well as for generating multiple risk scenarios. New technologies can also identify and count the excluded, the poorest and the most vulnerable, through the use of satellite imagery and geospatial disaggregation. Disaster risk reduction should now be grounded on a seamlessly integrated system that comprises big data, risk analytics and digital identity. But there are always risks that the technology might be used in damaging ways, so it will be important to tailor the framework to address disaster response and resilience-building measures in an inclusive and participatory manner (Figure 5-1).

Disaster resilience is increasingly reliant on space and geospatial information. In 2018, the third Ministerial Conference on Space Applications for Sustainable Development in Asia and the Pacific pledged to continue to work collectively towards using space and geospatial information applications in disaster risk reduction. Three core implementation modalities were identified: (a) research and knowledge-sharing; (b) capacity-building and technical support; and (c) intergovernmental discussions and regional practices. Among them, capacity building and technical support has been identified by countries as the priority.

ESCAP's partnership with Japan's Keio University on development of the 5D-World Map System is a good example of harnessing the potential of machine learning and artificial intelligence for disaster resilience. ESCAP Member countries from North-East and South-East Asia have been able to minimize losses of life using second-generation earth observation satellites, advanced modelling systems, artificial intelligence and big-data analytics.

The ESCAP/WMO Typhoon Committee adopted its action strategy for 2017–2021, focusing on applications of emerging technologies, multi-hazard approaches, impact-based forecasting, and risk-informed early warning systems.

The backbone for industry 4.0 is communications links, which can support disaster risk prevention, risk reduction and preparedness, as well emergency communication for disaster response and recovery. So it is vital after disasters to quickly restore ICT infrastructure and services. ESCAP's Asia-Pacific Information Superhighway initiative promotes regional cooperation on improving the access to affordable and resilient broadband connectivity by promoting regional cooperation under four pillars of: development of cross-border infrastructure connectivity; efficient internet traffic and network management; strengthened e-resilience from natural disasters; and access to affordable broadband connectivity for all citizens.

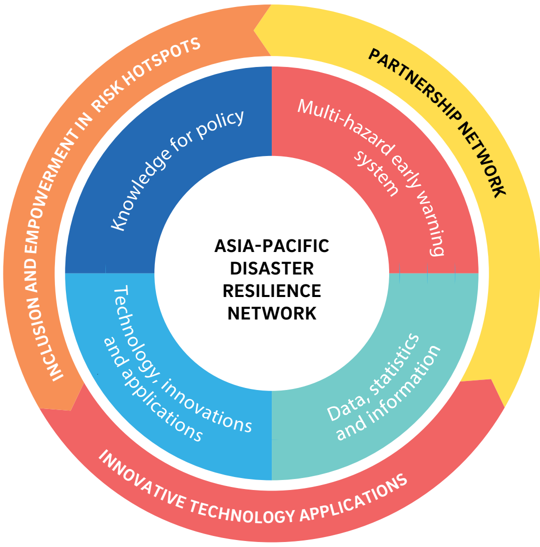
3 Unlock the potential of regional cooperation

Asia and the Pacific has some of the world's most extensive transboundary disaster hotspots. With climate change these are likely to expand still further, creating deep uncertainties. Addressing these will require strategies at the regional and subregional levels.

In 2017, to unlock the potential of regional cooperation, the ESCAP inter-governmental committee on disaster risk reduction established the Asia-Pacific Disaster Resilience Network (APDRN). APDRN, with an emphasis on partnerships and innovation, comprises four inter-related streams: (i) multi-hazard early warning system platform; (ii) data, statistics and information management, which also includes big data from emerging technological platforms and sources; and (iii) knowledge for policy (Figure 5-2).

FIGURE 5-1 An integrated system for resilience, inclusion and empowerment

FIGURE 5-2 **Structure of Asia-Pacific Disaster Resilience Network**



Regional multi-hazard early warning systems

The advances in industry 4.0 technologies enable more-effective, risk-informed and end-to-end multihazard early warning systems. The benefits can be scaled up through regional cooperation. The longer forecasting and warning lead times enabled through smart technologies go beyond saving lives to ensuring livelihood support. For small farmers in Bangladesh, for example, a flood-warning lead time of one day results in reductions in losses of up to 33 per cent for fish aquaculture. A lead time of seven days reduces household damage by up to 90 per cent. For the moderate 2007 floods of Bangladesh, a forecasting and early warning system could have reduced damages by an estimated $208 million. Estimated benefits over a decade of typical flooding would be about $1,700 million—more than 500 times the cost of a hypothetical forecasting and warning system.[216]

Tropical Cyclones — ESCAP and WMO are partners in the Typhoon Committee and the Panel on Tropical Cyclones which cover the Pacific and the Indian Ocean respectively. In 2018, the Panel on Tropical Cyclones in its 45th session recognized the intensification of tropical cyclones and laid out plans to address their complex risk patterns in South and South-West Asia. With inclusion of new Members, including the Islamic Republic of Iran, the Panel membership increased from 9 to 13.

Tsunamis — The ESCAP and UNESCO-IOC partnership supports effective end-to-end tsunami early warning systems in the Indian Ocean basins. With the lessons learned from the 2018 tsunamis in Sulawesi and the Sunda Strait in Indonesia, the ESCAP Multi-donor Trust on Tsunami, Disaster and Climate Preparedness has prioritized its funding support to multi-hazard risk assessment and early warning. The aim is to enhance the preparedness for near-field tsunamis and help IOC-UNESCO strengthen tsunami early warning in the North-West Indian Ocean.

Flooding — Forecasting transboundary floods and slow-onset disasters remains difficult. Efforts to strengthen regional cooperation for early warning for river basin floods are underway.

For the Pacific Island countries, early warning systems have had support from the Government of Japan and other key partners such as the Indonesian Agency for Meteorology, Climatology and Geophysics. This has helped these countries in the use of statistical and geospatial data for early warning systems via technical training, regional workshops and pilot projects.

Data, statistics and information

In support of strengthening big data ecosystems, APDRN has three initiatives.

The Asia-Pacific Disaster Risk Atlas — The atlas is the online data and information platform of ESCAP's regional institute, the Asian and Pacific Centre for the Development of Disaster Information Management (APDIM).[217] It serves as a decision support tool for risk-informed infrastructure investment and development policy decisions. With a set of geospatial vector and raster data, it covers natural hazards, exposure of critical infrastructure in the built environment, natural resources assets and the vulnerability of city populations. The atlas synthesizes data on cross-border risks and disasters including earthquakes, floods, droughts, tsunamis, cyclones and storm surges, showing where critical infrastructure is severely exposed. The atlas also uses the IPCC reports and synthesizes the state of the science to inform policy decisions on climate-resilient infrastructure.

The Disaster-related Statistics Framework — The Disaster-related Statistics Framework (DRSF) covers the core concepts and indicators defined in the Sendai Framework and the SDGs, aiming to translate these into specific instructions and technical recommendations for the production and dissemination of statistics.[218] For risk assessment and post-disaster impact assessments, the DRSF also analyses data on population, society, and economy from censuses and surveys. The DRSF capitalizes on UN Global Geospatial Information Management (UN-GGIM), particularly its Geospatial Information and Services for Disasters which promotes open data, communities and sources, as well as spatial data infrastructure. Since November 2018, ESCAP has been the secretariat of the Regional Committee of Global Geospatial Information Management for Asia and the Pacific (UN-GGIM-AP). ESCAP promotes new data acquisition and integration approaches, including Earth observations and geospatial information.

Data-and information-driven regional cooperation—Earth observation satellite and surface-based observations are used to capture transboundary impacts and origins of disasters. Sand and dust storms, for example, are frequently transboundary in nature; storm sources in China can be a thousand kilometres from the impacted regions. Risk-informed policy interventions therefore require dialogue and cooperation among the related countries.[219] The ecological restoration programme has reduced sand and dust storms by between 5 and 15 per cent in the North China Plain.[220] APDIM is currently establishing a regional slow onset hazards network and sand and dust storms alert system. ESCAP has also joined a United Nations Coalition on Combating Sand and Dust Storms to deepen regional cooperation in South and South-West Asia, Central Asia and North and North-East Asia.

Similarly, the Regional Drought Mechanism is a cooperative initiative where various countries or institutions support drought-prone developing countries and expand their capacity to use these and other tools to manage drought while building the capacity of Governments to more effectively utilize space applications. The Regional Drought Mechanism is supported by the Governments of Australia, China, India, the Russian Federation and Thailand.

As a part of the Regional Drought Mechanism, Australia has developed a comprehensive water accounting system pilot for Cambodia, along with DataCube which enables space- and ground-derived information to be better stored, combined and examined.

Knowledge for policy

ESCAP has put in place a knowledge and innovation platform and develops its analytical research products to promote risk-informed policies. This *Asia-Pacific Disaster Report*, for example, has been produced on a biennial basis and the report findings are discussed at the respective sessions of the Committee on Disaster Risk Reduction. The report also contributes to the High-Level Political Forum for Sustainable Development and its regional preparatory process, the Asia-Pacific Forum on Sustainable Development.

ESCAP has been working with the ASEAN Secretariat under its Joint Strategic Plan of Action on Disaster Management to enhance the capacity of national hydrometeorological services and risk-sensitive sectors in South-East Asia.[221] Partnership between ESCAP and ASEAN is mobilizing Member States towards the development of an ASEAN strategy on drought resilience.

As shown in chapter 3, interventions to build resilience cut across a range of issues including health, education, social protection, insurance, infrastructure, urban planning, housing, land tenure, agriculture and livelihoods, which no single ministry can address. Individually, each offers an entry point for breaking the link between disasters and poverty. However, the overall approach will be most effective when Governments consider the potential interactions between each intervention. Coherent strategies and plans, budget and financing, monitoring and reporting systems and inter-sectoral coordination will be a critical norm towards ensuring that all parts of a government pull in the same direction to build the resilience of those left behind.[222]

To provide the knowledge base for improving coherence across ministries, the ESCAP Secretariat and partner United Nations agencies are supporting countries with special needs through the Regional Learning Platform on Policy Coherence for Disaster Risk Reduction and Resilience. Organized for the first time in 2016, the Platform has now been institutionalized as an annual capacity building activity on policy coherence, an important guiding principle of Sendai Framework for Disaster Risk Reduction and its Asia Regional Plan. Attended mainly countries with special needs, participants of the 2018 Platform focused on policies and shared experiences around innovations and evidence-based approaches to policy coherence using the

"Policy Coherence for Disaster Risk Reduction and Resilience: From Evidence to Implementation" toolkit as the main input.[223]

To provide an analysis of the potential risks and impacts of an impending 2018/2019 El Niño event, ESCAP in partnership with the Regional Integrated Multi-hazard Early Warning System released an advisory for the Regional El Niño Group, made up of the United Nations, and major development and humanitarian agencies in Asia and the Pacific.

An analytical report, Ocean Accounting for Disaster Resilience in Pacific SIDS, contributed substantially to the Ocean Accounts Partnership for Asia and the Pacific. The report presented an ecosystem accounting framework to strengthen the linkages of SDG 14 with other SDG targets.

Resilience across the riskscape

The Asia-Pacific region has had considerable experience with reducing disaster risk. But with climate change and expanding disaster hotspots, the region is entering an increasingly uncertain future. All countries will need to consider how every aspect of development can face up to disaster risk. All ministries and departments should consider how they can work together in a more integrated way, so that they are able to identify the people in danger of being left behind, and empower them to protect themselves and build sustainable and resilient livelihoods.

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The Asia-Pacific region faces a daunting spectrum of natural hazards. Indeed, many countries could be reaching a tipping point beyond which disaster risk, fuelled by climate change, exceeds their capacity to respond.

This *Asia-Pacific Disaster Report 2019* shows how these disasters are closely linked to inequality and poverty, each feeding on the other and leading to a vicious downward cycle. It assesses the scale of losses across the disaster 'riskscape' and estimates the amounts that countries would need to invest to outpace the growth of disaster risk. It shows the negative effects of disasters on economies in the region and where investments are more likely to make the biggest difference.

While this will require significant additional finance, the report shows the amounts are small compared to the amounts that countries in the region are currently losing due to disasters. The report demonstrates how countries can maximize the impacts of their investments by implementing a comprehensive portfolio of sectoral investments and policies that jointly address poverty, inequality and disaster risk. It showcases examples from the region of innovative pro-poor disaster risk reduction measures and risk-informed social policies that are breaking the links between poverty, inequality and disasters. Similarly, it explores how emerging technologies such as big data and digital identities can be used to ensure the poorest and most vulnerable groups are included in these policy interventions.

Ultimately, the report argues that countries will have to invest more in the measures appropriate to their own circumstances, but that they should also work more closely together to unlock the potential of regional cooperation.

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