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.

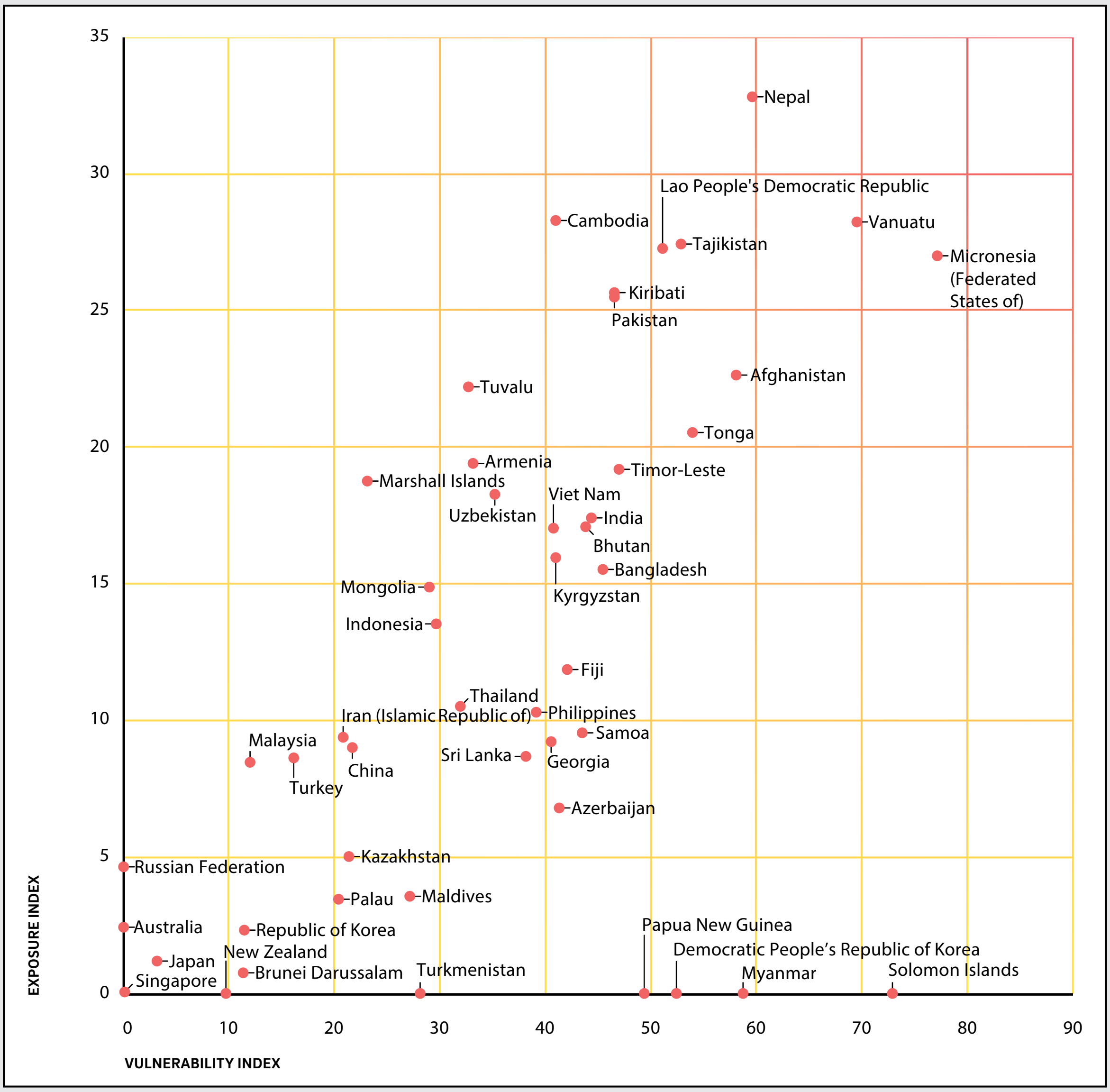
The risks from drought in agriculture are often high in SIDS. But the risk also extends to larger countries, such as Afghanistan, Bangladesh, Cambodia, India, Lao People's Democratic Republic, Nepal, Pakistan, Tajikistan and Timor-Leste — countries with large agricultural sectors and large rural populations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

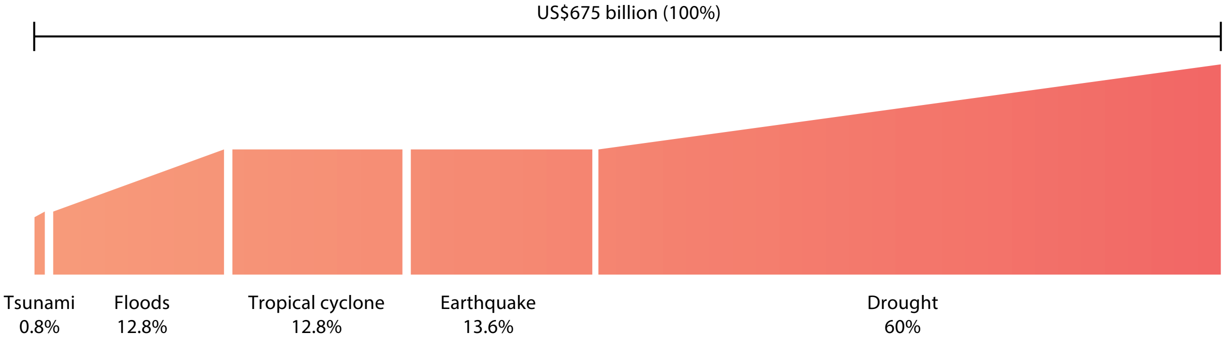
TABLE 1-1 Disaster risk in Asia and the Pacific (AAL, millions of US dollars)

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.

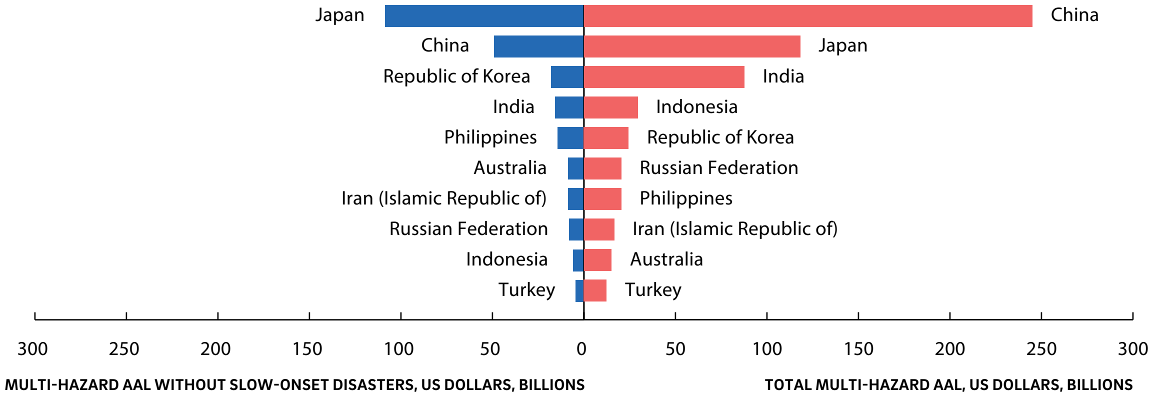
There are also many countries, including China, India, Indonesia, Pakistan and Turkey where the agriculture AAL represents more than 80 per cent of the total AAL. Thus, to obtain a complete picture of the risk to economic and social development it is important to estimate the drought risk in agriculture.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

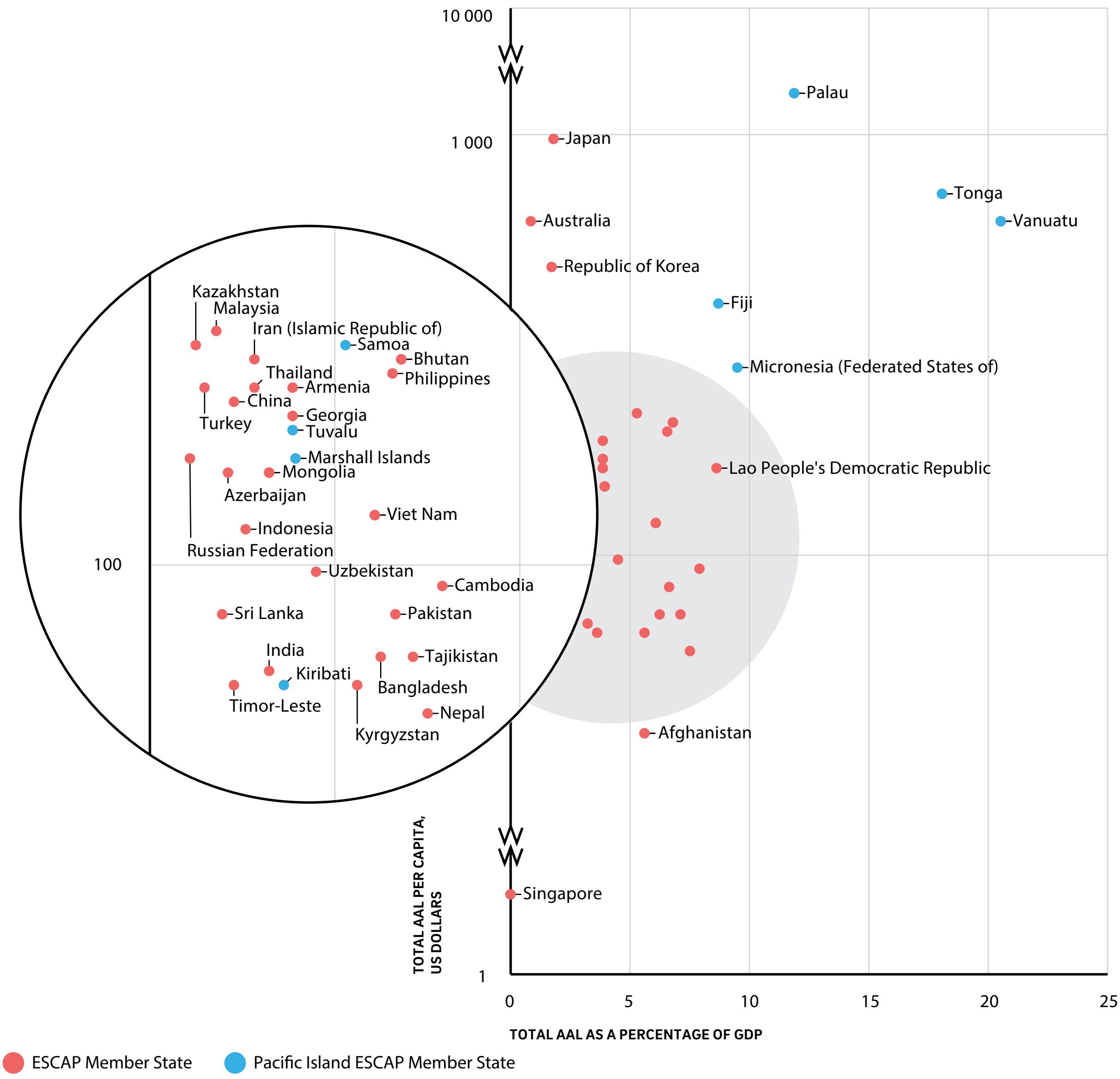
The ratio of total multi-hazard AAL with a country's population and national GDP presents at risk population and economy scenarios. The analysis indicates that Pacific SIDS, such as Vanuatu, Tonga, and Palau are in the extreme range of population and economies at risk. A person in Pacific SIDS is three 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

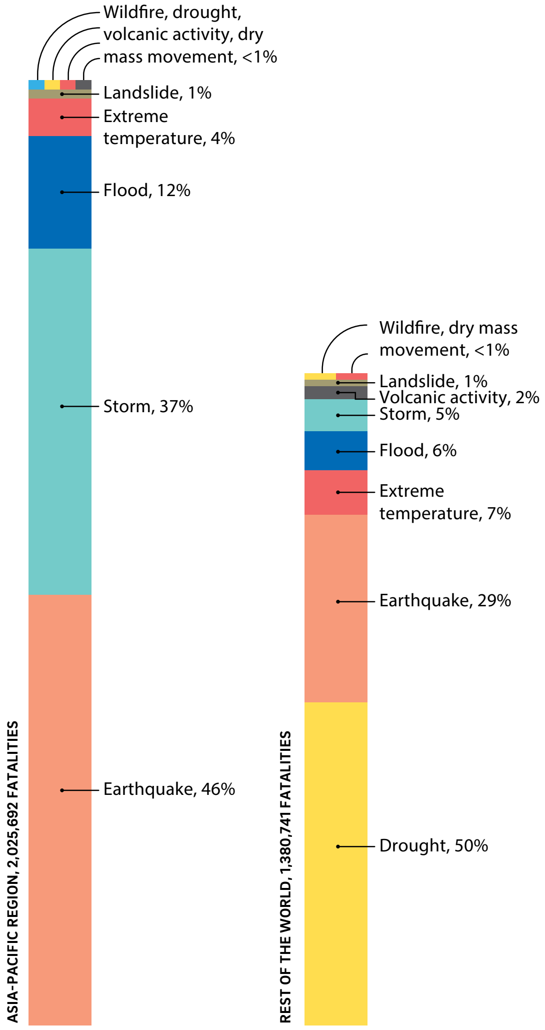
Since 1970, natural disasters in Asia and the Pacific have killed two million people — 59 per cent of the global death toll. In the rest of the world, the average number of fatalities per year was 28,730 but in Asia and the Pacific it was much higher at 42,000. As indicated in Figure 1-4, the principal 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

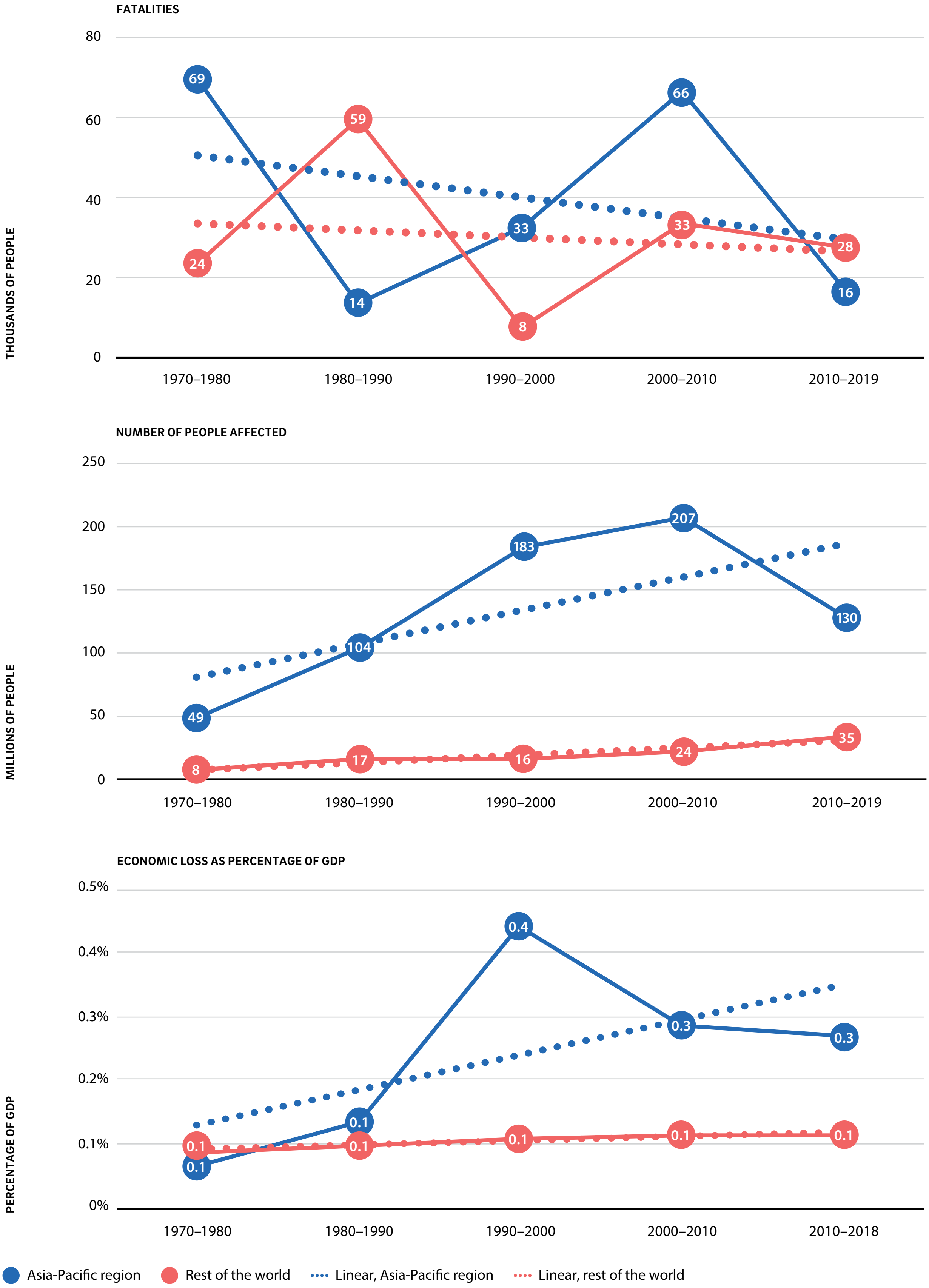


Source: Based on data from EM-DAT (Accessed on 30 May 2019).
Note: From 1990, including data from countries of the former Soviet Union.

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).

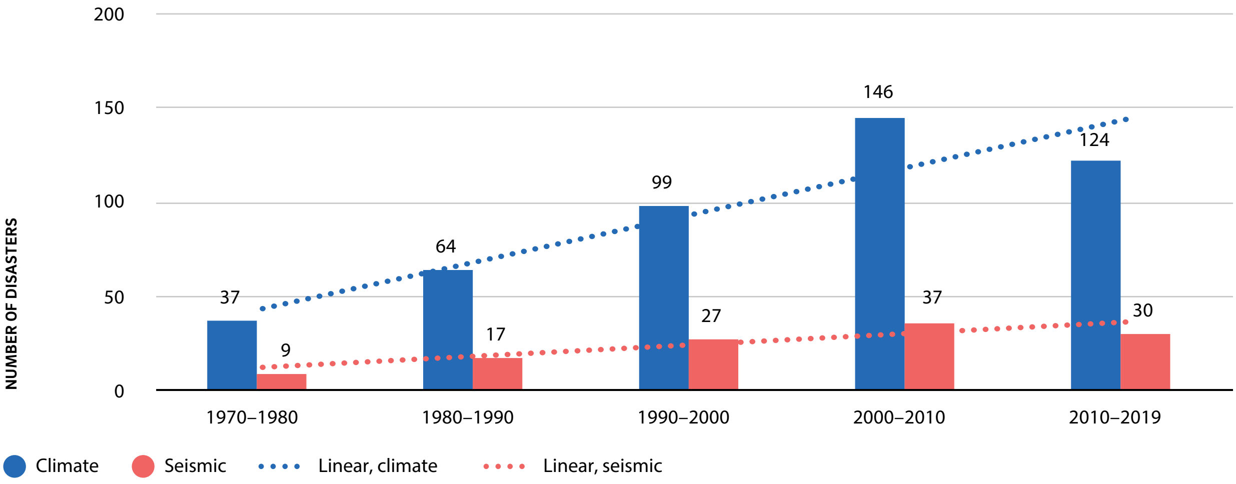
Emerging trends of disaster risk

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

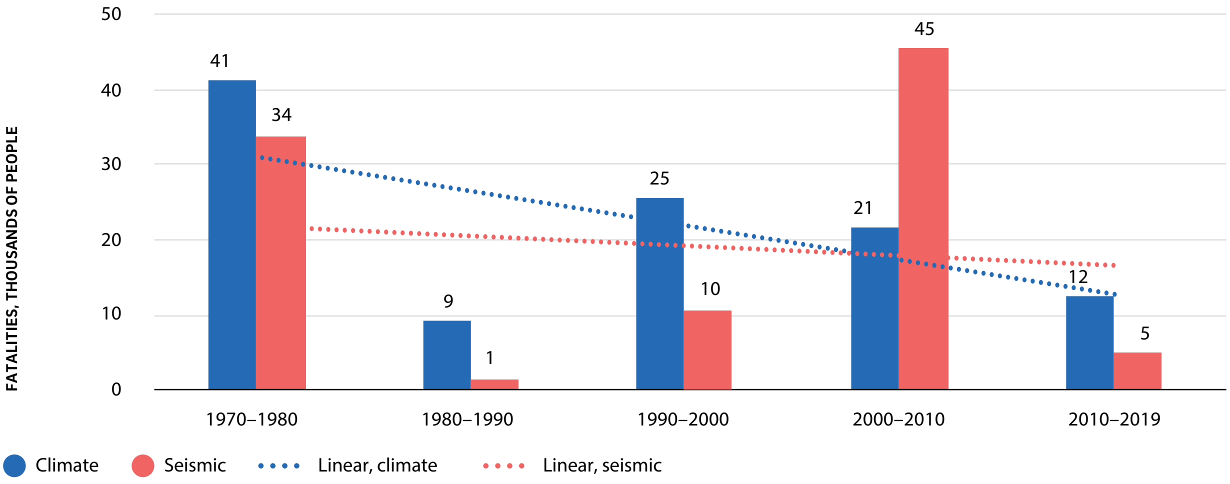
Climate-related hazards in this report comprise droughts, extreme temperatures, floods and storms.[7] Climate change is a main driver for changes in the disaster riskscape.[8] Recent climate-related extremes have been threatening people's well-being and their livelihoods.[9, 10] The Intergovernmental 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



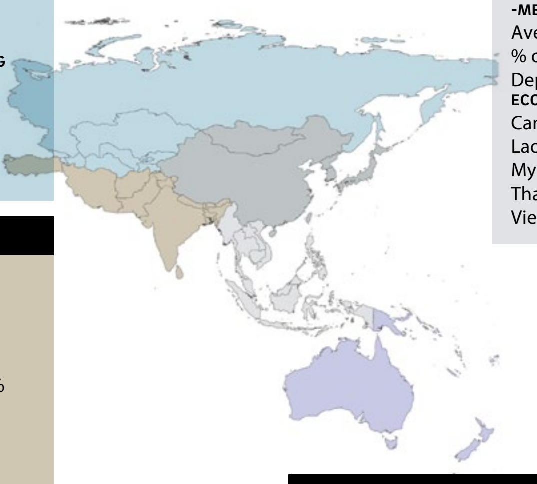
Source: ESCAP, based on EM-DAT (Accessed on 30 May 2019).

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.

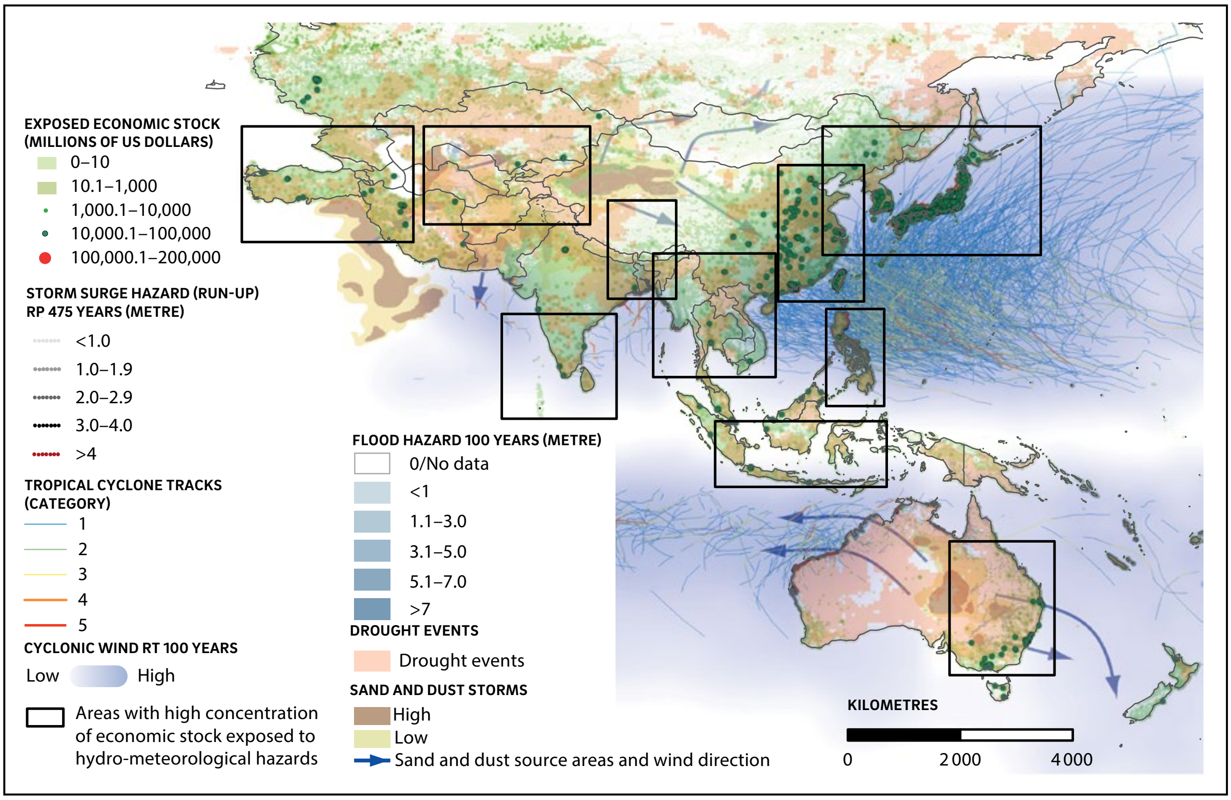
Exposure of economic stock to geological hazards such as earthquakes, landslides and tsunamis, is indicated in Figure 1-10. These include major economies along the Pacific Ring of Fire, as well as smaller economies along with coastal areas of Pacific which are at risk of tsunamis, such as the east coast 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.
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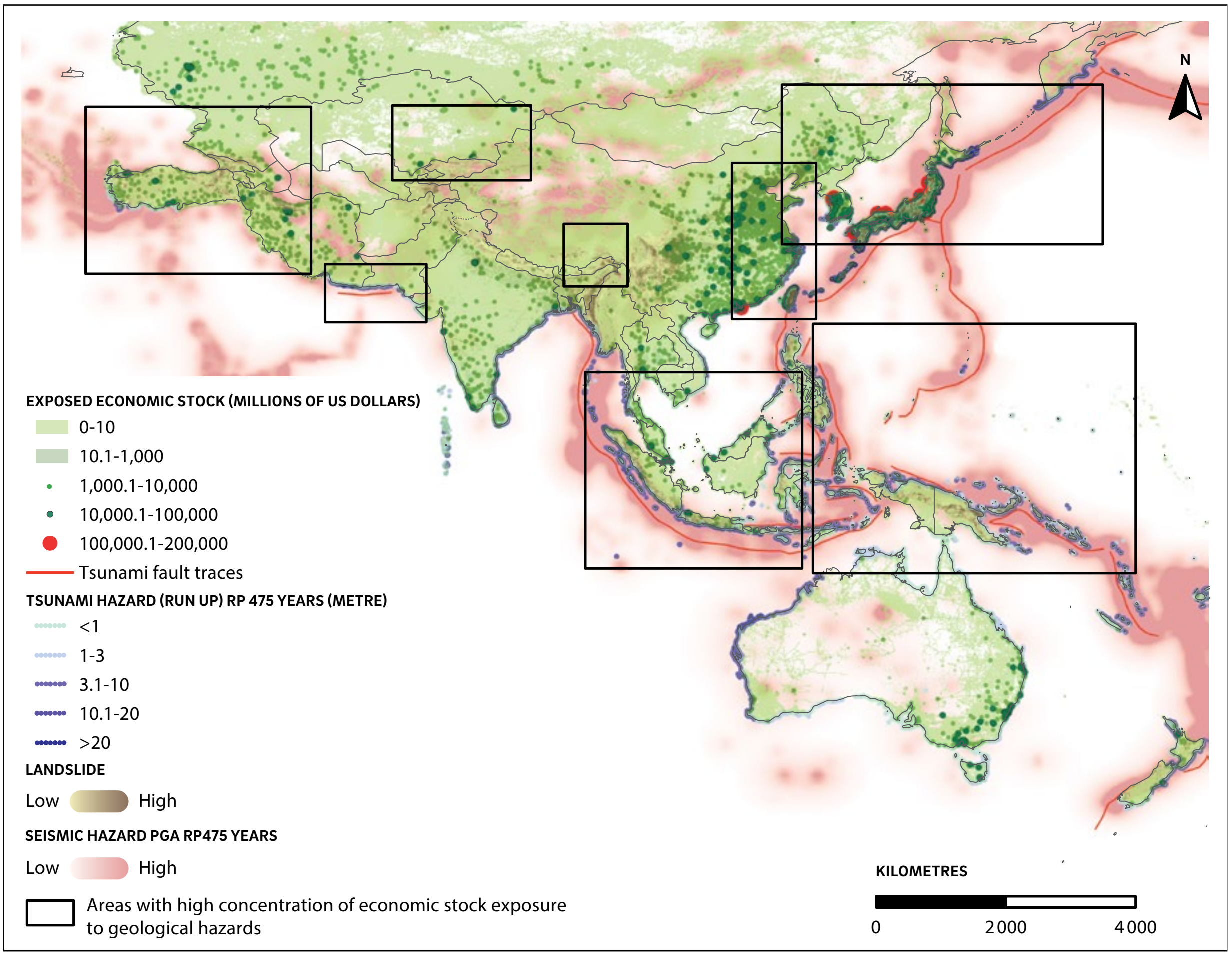
FIGURE 1-10 Concentration of exposed economic stock to geological hazards



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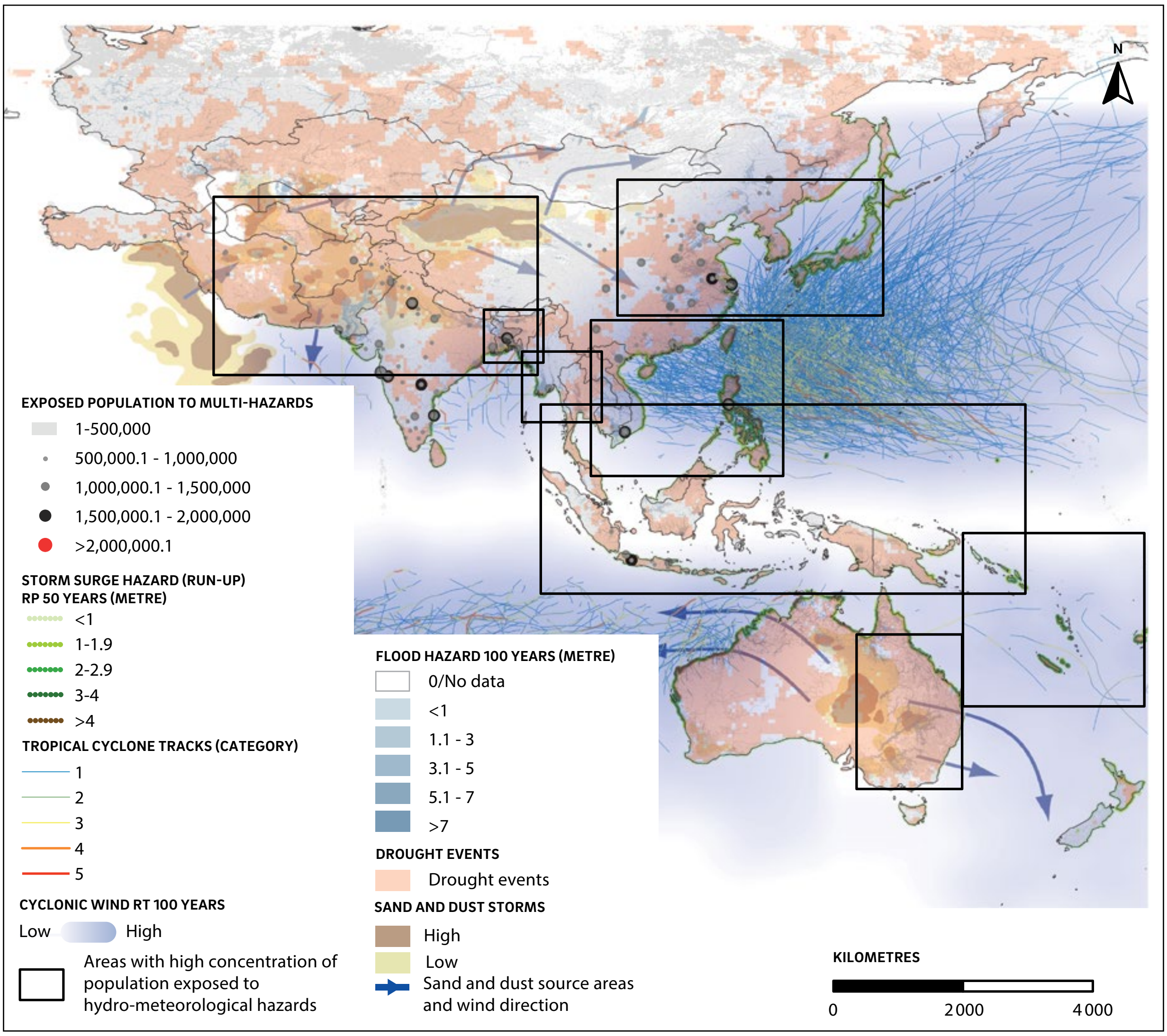
Note: PGA RP 475 years is the seismic hazard with a return period of 475 years expressed in peak ground acceleration. This means that a level of ground shaking is expected to occur once in 475 years. Tsunami hazard RP 475 years is a tsunami hazard run-up height with a return period of 475 years.

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.
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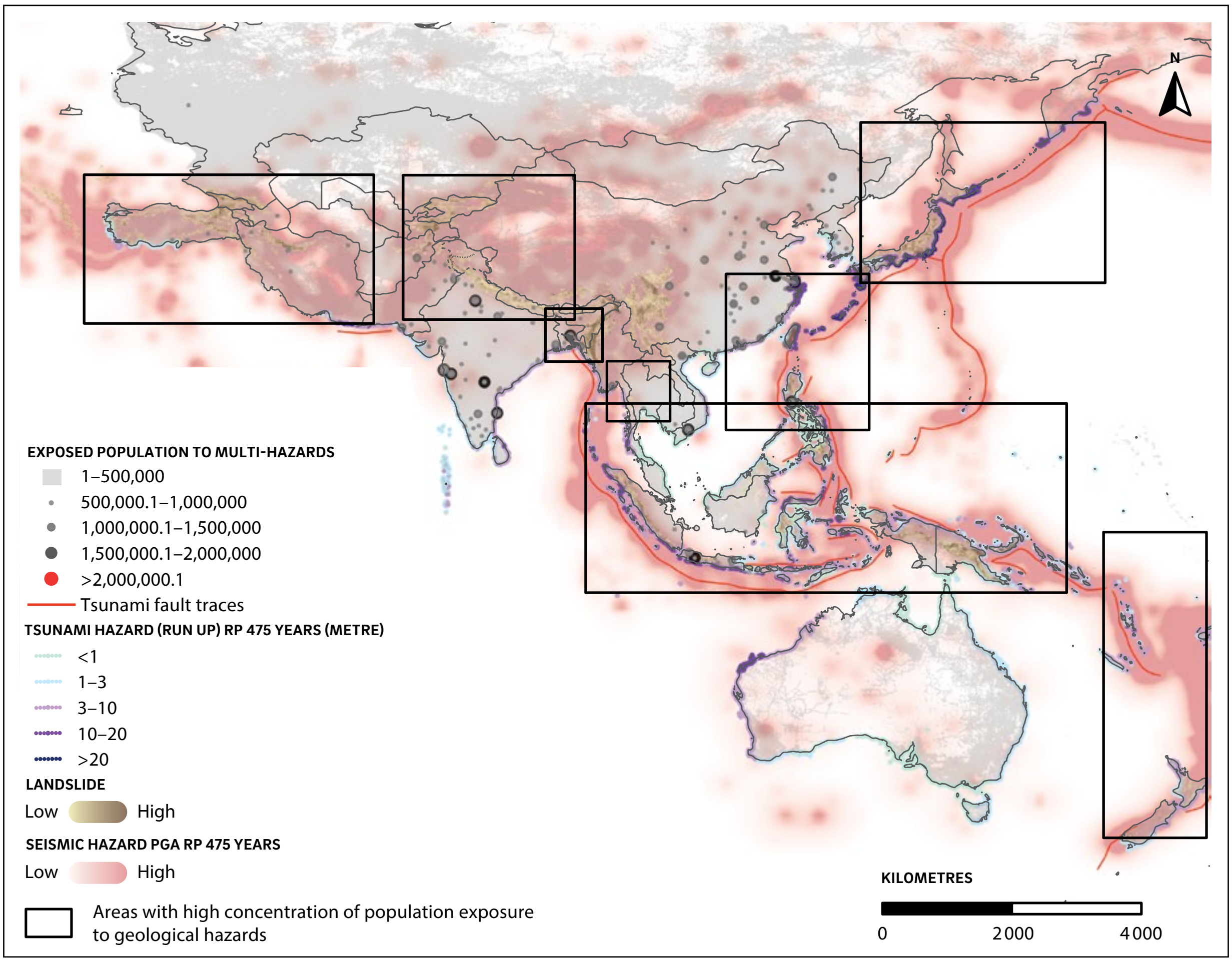
(the east coast of China, Japan, and Republic of Korea) and South Asia (Bangladesh, coastal areas of India, and Maldives), as indicated in Figure 1-11. Cyclones also threaten small Pacific populations and coastal residents in South-East Asia, such as Indonesia, the Philippines and Timor-Leste. Floods, 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



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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

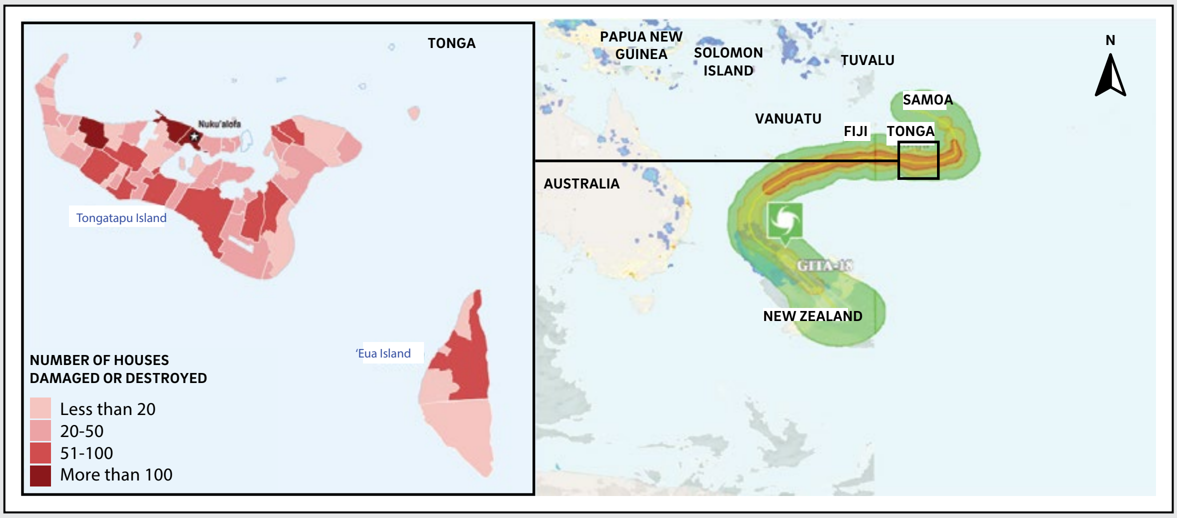
One of the strongest defences against natural disasters is a healthy ecosystem. Thus, risks are heightened by environmental degradation. This was demonstrated, in 2018, by the floods in the state of Kerala in India. Kerala is long and narrow with its highlands leading to steep slopes, midlands and coastal 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.

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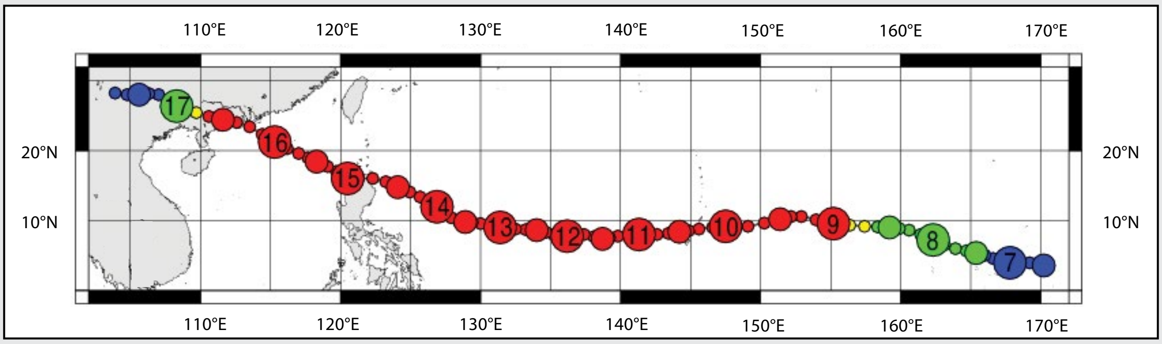
[a] USAID (2018).

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)



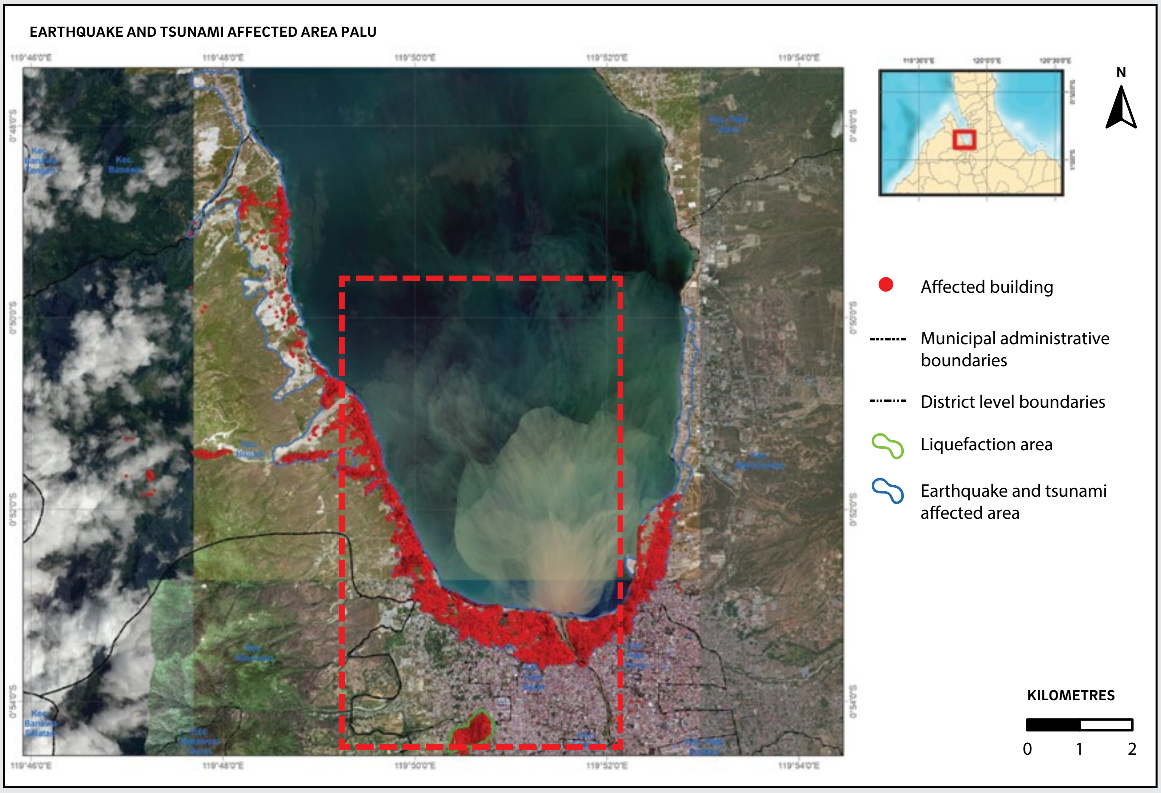
Source: Kitamoto, National Institute of Informatics, 2019.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

[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

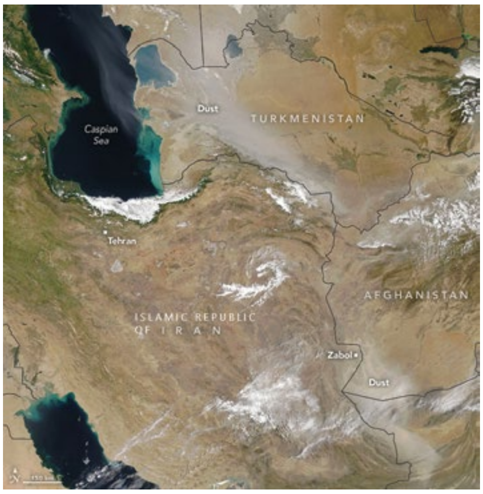
Climate change and the complexity of disasters is creating deep uncertainty. Thanks to enhanced technology and greater data availability, many disasters can be predicted. But disasters triggered by climate change deviate from the usual tracks, making it difficult to apply historical records for their 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.

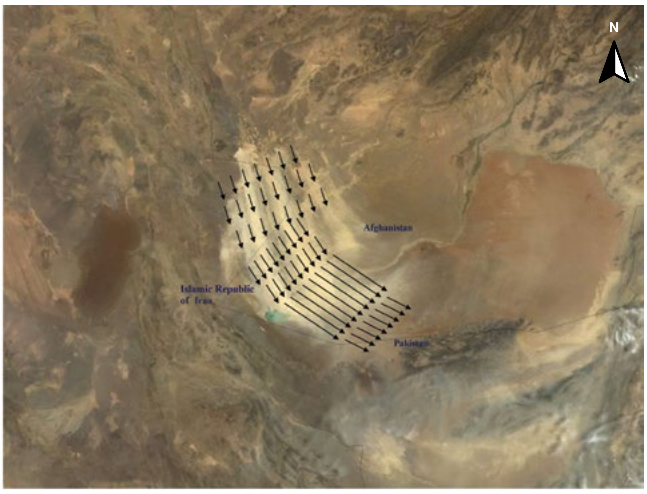
BOX 1-5 Transboundary risk of sand and dust storms in Asia and the Pacific

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]

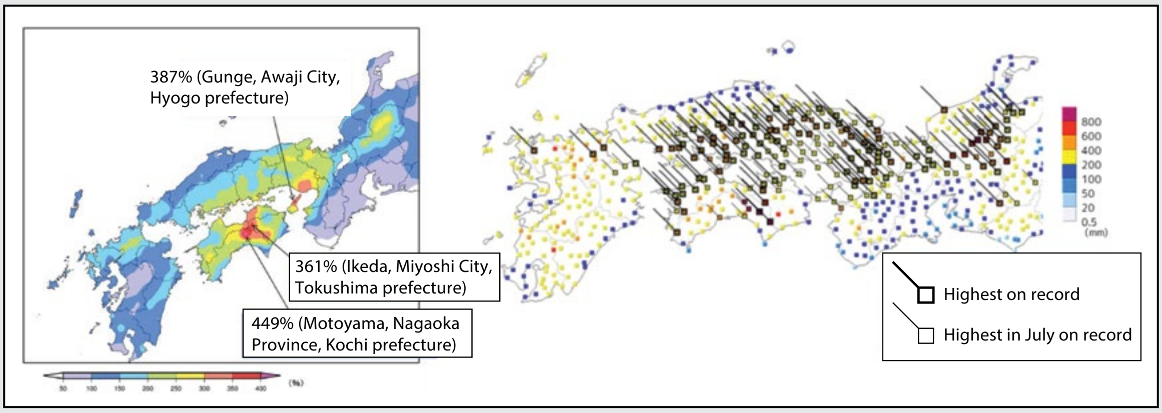
This anomaly mean temperature was +2.8°C. The heat wave during the flood response phase, hospitalized tens of thousands with heat-related illnesses. In Japan, the weather killed more than 300 in July 2018.[c]

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.

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[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

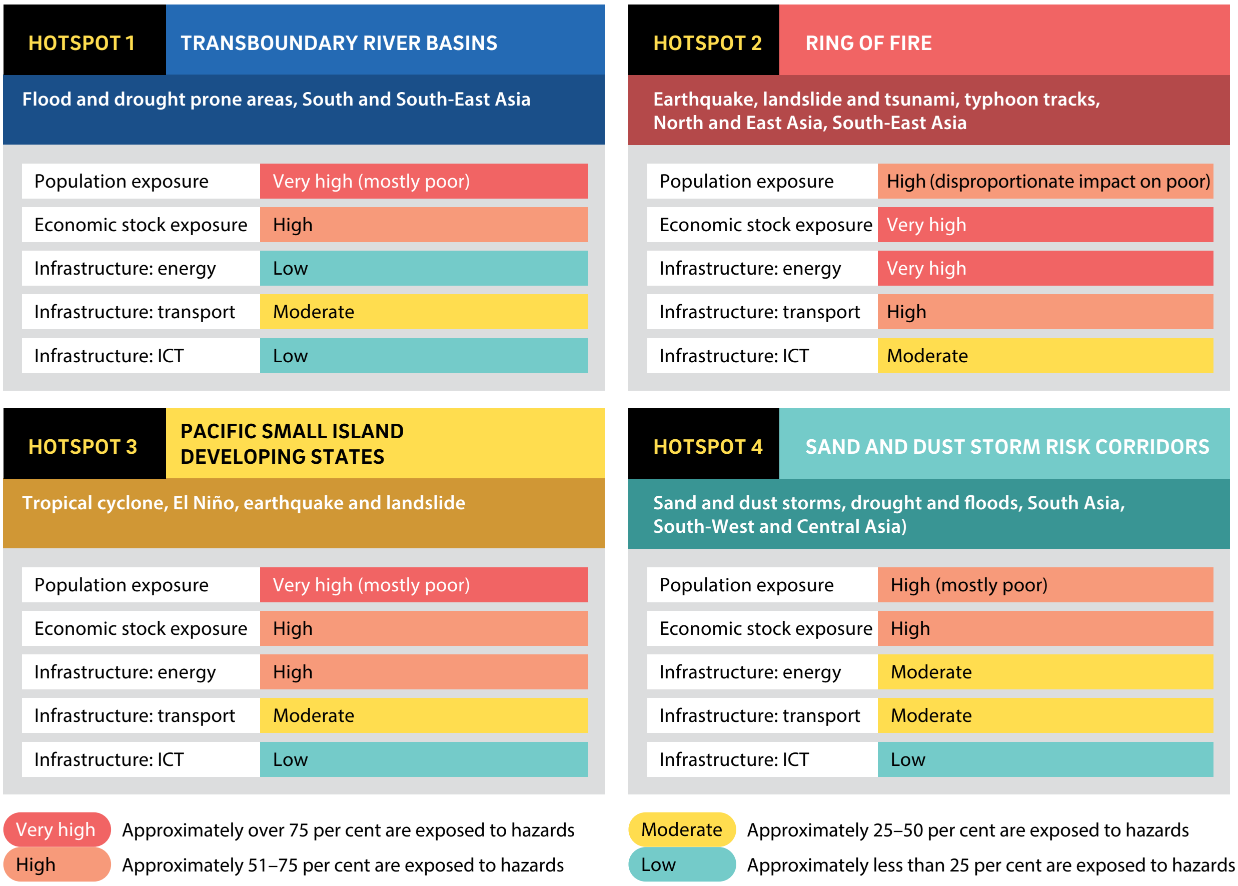
Drawing from these 'new normal' trends, the region's complex and diverse risks are clustered around four hotspots. Figure 1-13 illustrates the hotspots classification based on assessment of multi-hazards and exposure to population, economy, and critical infrastructure such as energy power plants, transport 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**

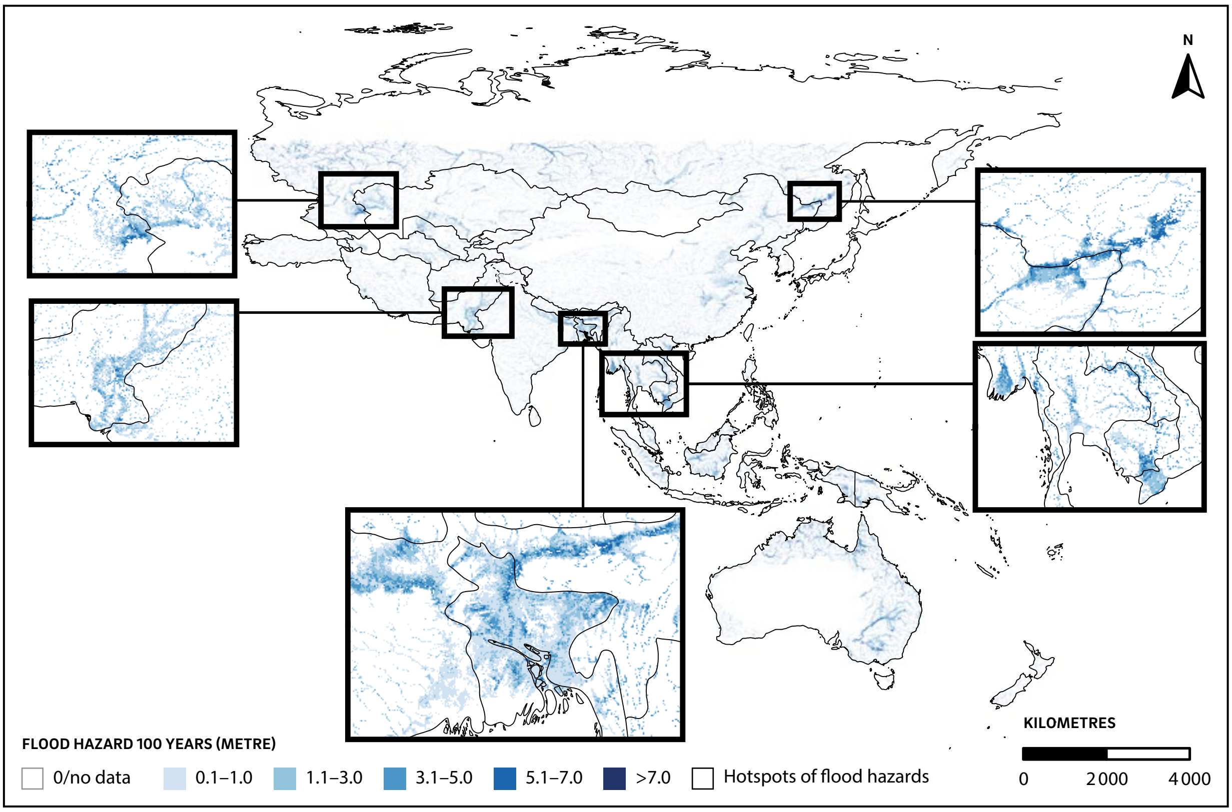
Sand and dust storms, drought and floods, South Asia, South-West and Central Asia)

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

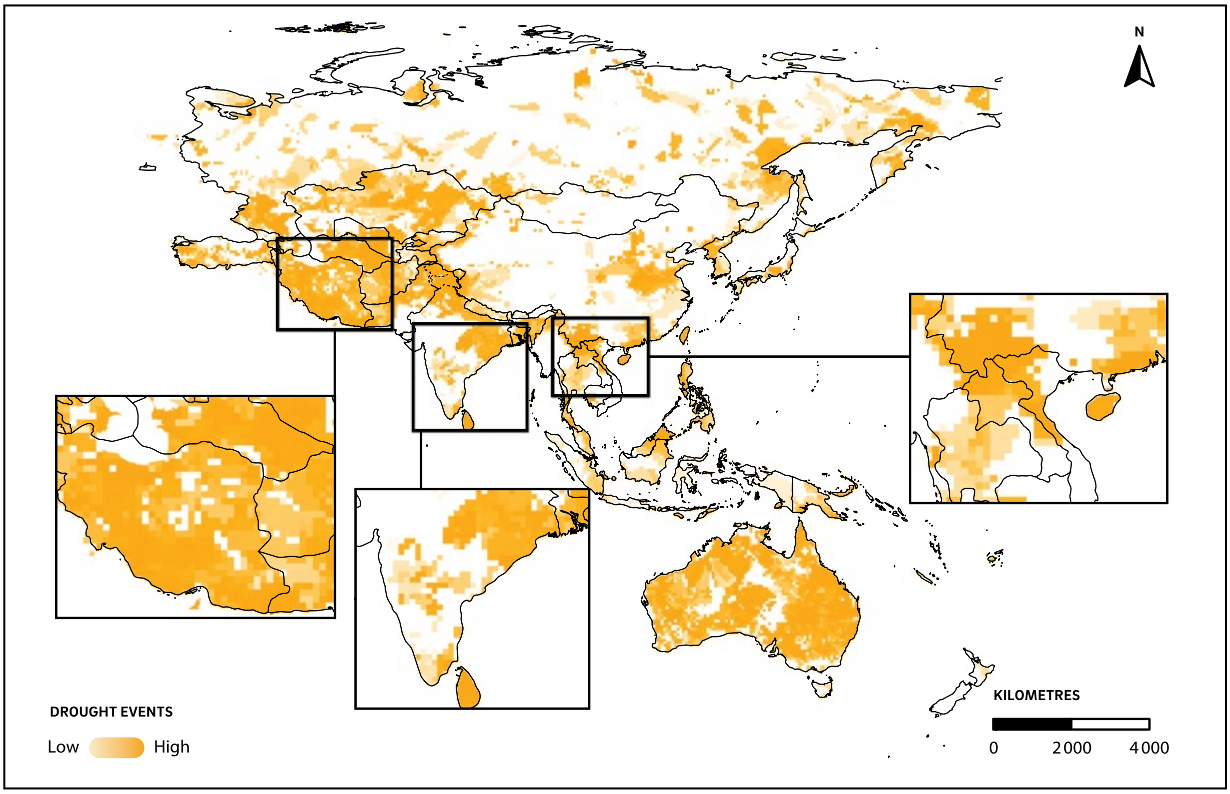
Source: ESCAP, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015; Global Risk Data Platform, 2013; ESCAP, Asia Information Superhighway, 2018(b); ESCAP Asia-Pacific Energy Portal 2018(a); ESCAP Transportation Data 2018(c); Muhs, and others, 2014.

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.

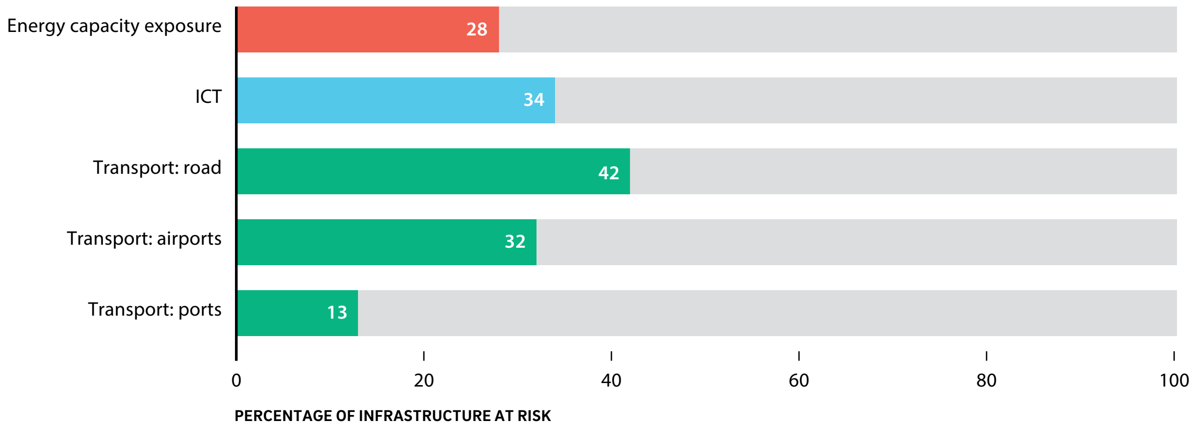
A third hotspot involves vulnerabilities of Pacific Small Island Developing States

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

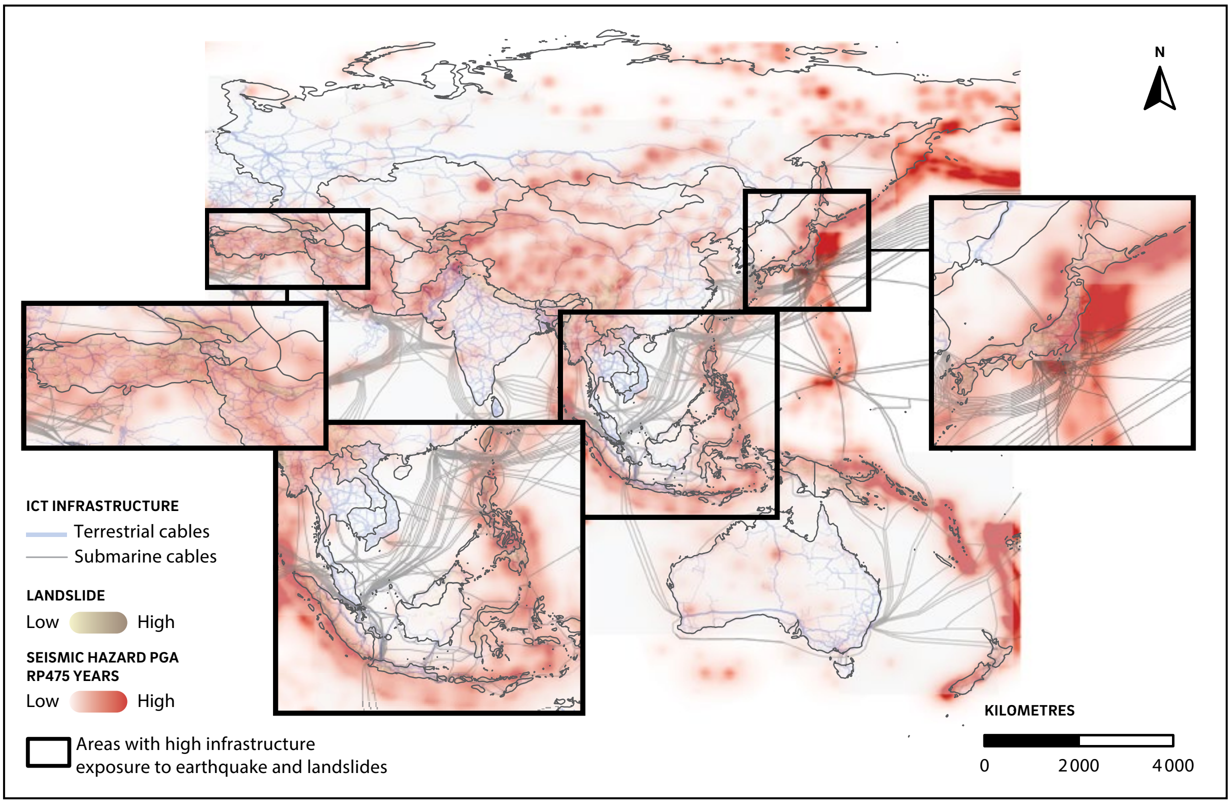
This hotspot is to be found along a corridor that traverses the environmentally fragile areas. In arid and semi-arid regions, there is growing alarm over the increasing frequency and intensity of sand and dust storms. These storms are a consequence of land degradation, desertification, climate change 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).
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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

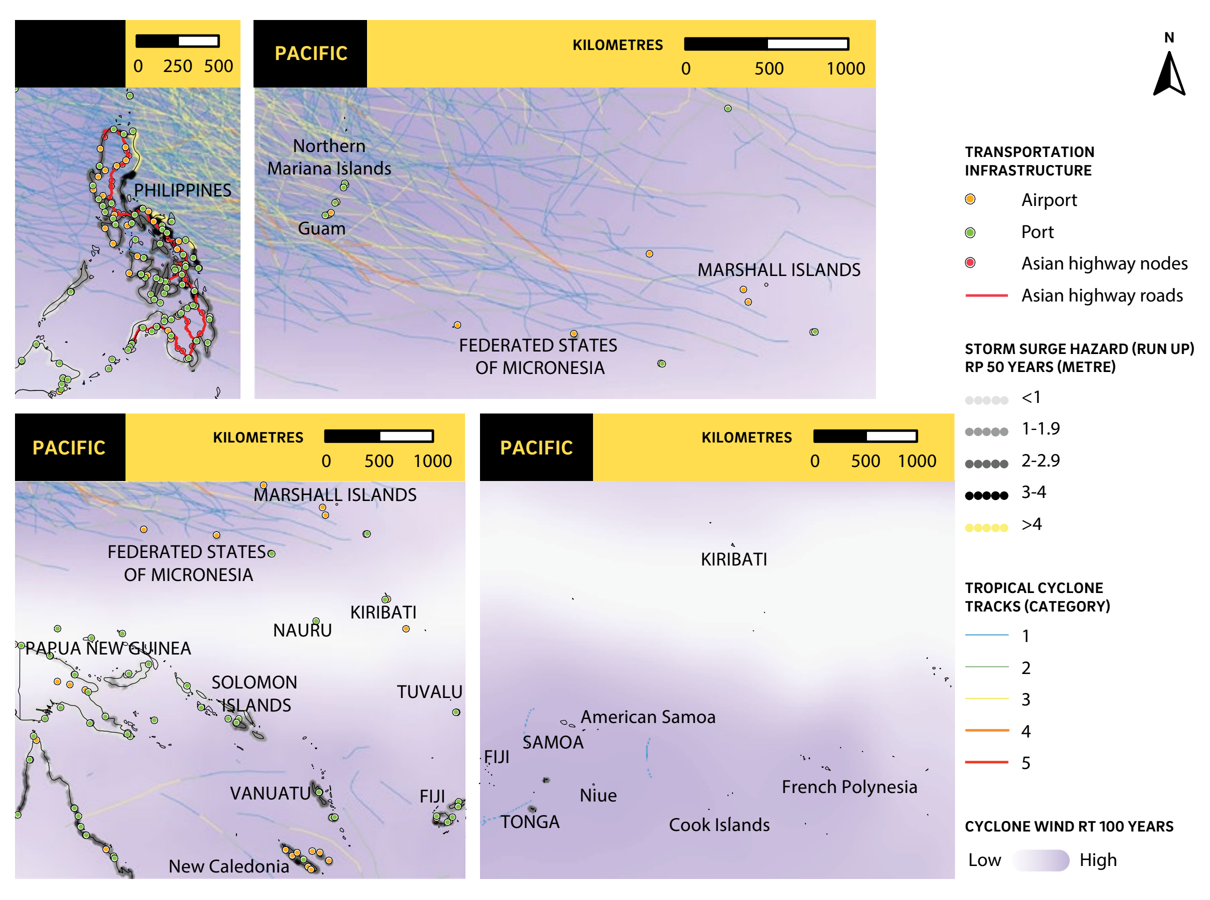
The Asia-Pacific regional riskscape outlined in this chapter has highlighted the risks to poor communities. A rapid sequence of disasters can outpace people's resilience, relentlessly eroding development gains by aggravating poverty, intensifying environmental degradation, disempowering vulnerable groups 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).

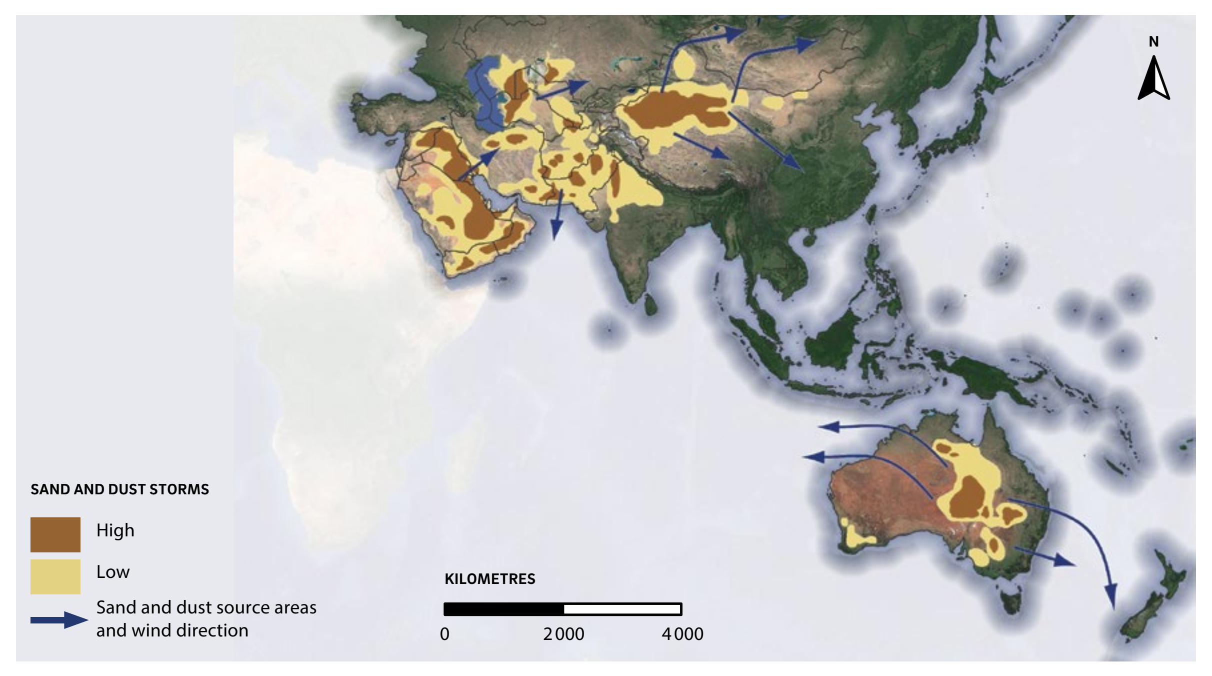
This *Asia-Pacific Disaster Report 2019*, with its central theme being 'Empowering people and ensuring inclusiveness and equality' is aligned to the HLPF 2019. Subsequent chapters of this report analyse the needs of and the opportunities available to countries within the region in terms of building disaster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