The Disaster Riskscape across East and North-East Asia

KEY TAKEAWAYS FOR STAKEHOLDERS

Asia-Pacific Disaster Report 2019

PATHWAYS FOR RESILIENCE, INCLUSION AND EMPOWERMENT

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About the report

The Disaster Riskscape Across Asia-Pacific: Pathways for Resilience, Inclusion and Empowerment. Asia-Pacific Disaster Report 2019 (APDR 2019) captured a comprehensive picture of the complexity of disaster risk landscape ('riskscape') in the Asia-Pacific region. The full-length publication is available at https://www.unescap.org/publications/asia-pacific-disaster-report-2019.

Following the release of the APDR at the sixth session of the ESCAP inter-governmental Committee on Disaster Risk Reduction in August 2019, the report was customized for each of the five ESCAP sub-regions, namely East and North-East Asia, North and Central Asia, South-East Asia, South and South-West Asia and the Pacific. This sub-regional report presents the key findings for East and North-East Asia.

Acknowledgements

The *Asia-Pacific Disaster Report* (APDR) is a biennial flagship publication of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). Its 2019 issue was prepared under the leadership and guidance of Armida Salsiah Alisjahbana, Under-Secretary-General of the United Nations and Executive Secretary of ESCAP. Kaveh Zahedi, Deputy Executive Secretary and Tiziana Bonapace, Director, ICT and Disaster Risk Reduction Division (IDD) provided direction and advice. Sanjay Srivastava, Chief, Disaster Risk Reduction Section, IDD led the core drafting team.

The Disaster Riskscape across East and North-East Asia: Key Takeaways for Stakeholders is a joint publication of the United Nations ESCAP ICT and Disaster Risk Reduction Division and the ESCAP Sub-regional Office of East and North-East Asia. The report is compiled and synthesized by a team consisted of Maria Bernadet K. Dewi, Shreya Mukhopadhyay, Jiwon Seo, Karanveer Singh, Sung Eun Kim, Nobuko Kajiura, Kareff Rafisura, Madhurima Sarkar-Swaisgood, Laura Hendy, with the technical guidance of Sanjay Srivastava, Chief, Disaster Risk Reduction Section and overall guidance of Tiziana Bonapace, Director, ICT and Disaster Risk Reduction and Ganbold Baasanjav, Head of ESCAP Sub-regional Office for East and North-East Asia. Anoushka Ali served as the editor. Daniel Feary provided the design and graphic services. Armita Behboodi coordinated the editing, lay-out and printing. Chonlathon Piemwongjit and Narada Kalra provided administrative assistance during the production stage.

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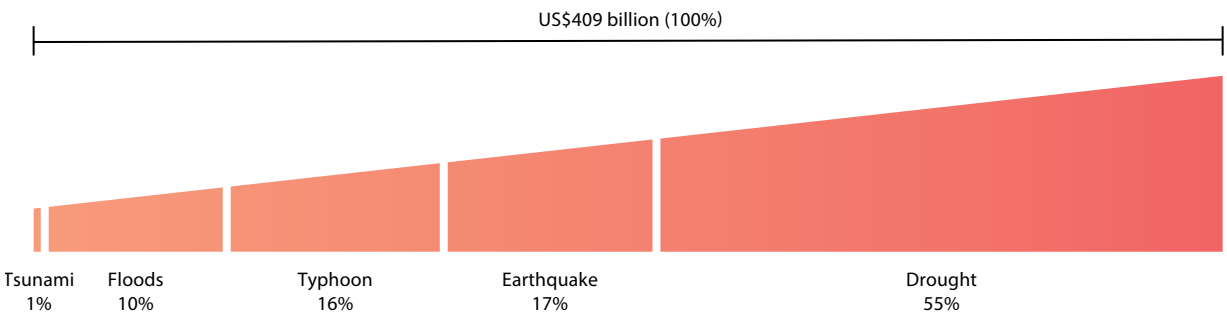
The riskscape for East and North-East Asia accounts for more than 60 per cent of the region's total of $675 billion in annualized economic losses.

For the first time, annualized economic losses are presented, which include both losses due to intensive risk and those due to extensive risk, indirect losses and slow-onset disasters. Incorporating these additional sources of risk means that the Average Annual Losses (AAL) are exponentially higher than previous estimates, reaching $409 billion and accounting for 60 per cent of the region's total AAL (Figure 1).

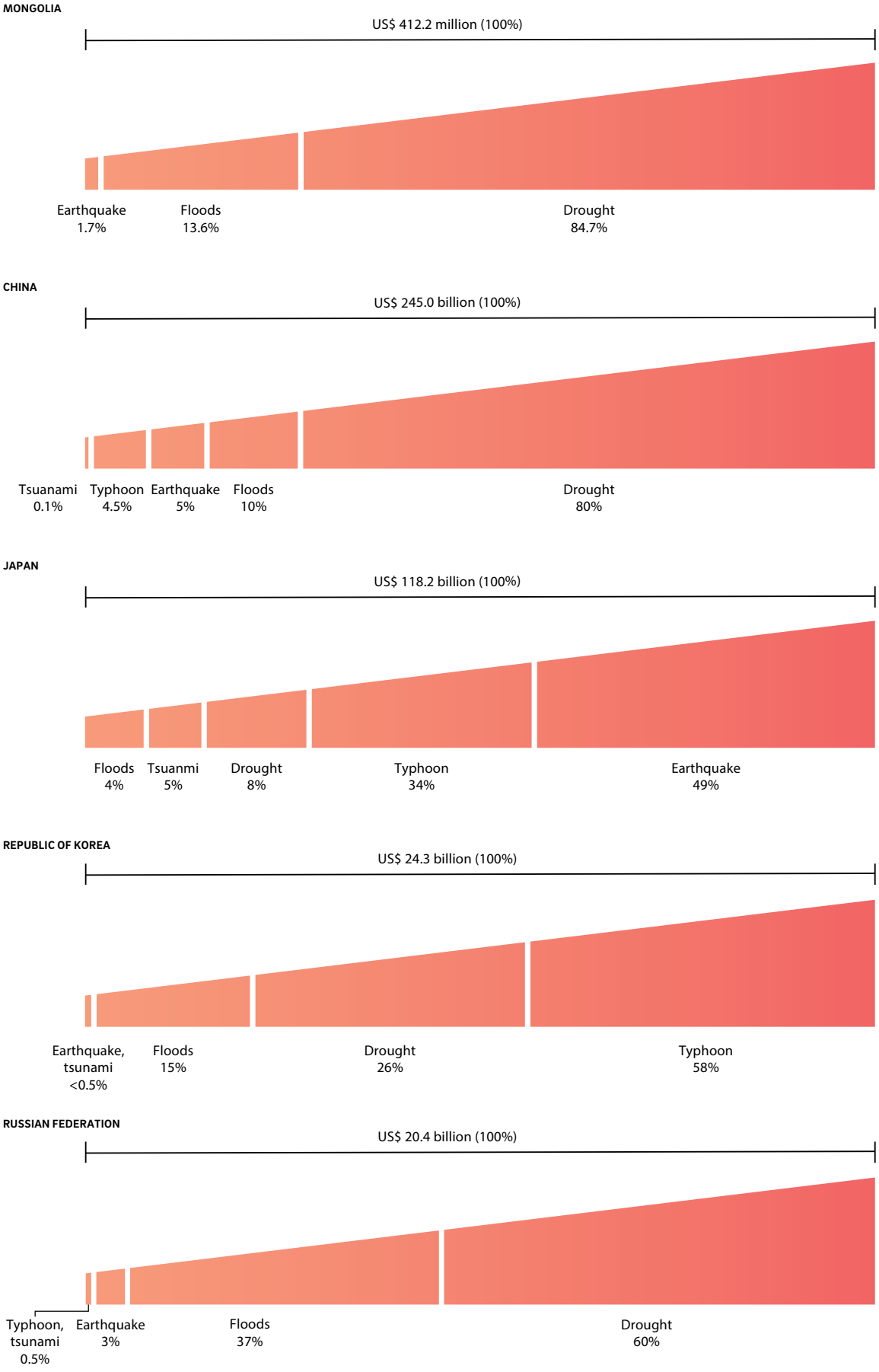
Mongolia remains the most affected by slow-onset drought followed by China and the Russian Federation, while typhoons and floods are the highest cause of AAL in Japan and in the Republic of Korea. Japan also has the highest AAL for earthquakes and tsunamis due to its geographical location in the Ring of Fire (Figure 2).

FIGURE 1 **East and North-East Asia disaster riskscape (average annual losses)**



Source: ESCAP, based on probabilistic risk assessment.
Note 1: Volumetric analysis is a measurement by volume (impacted population, geographical area and economic losses).
Note 2: Drought average annual losses data of Democratic People's Republic of Korea is not available.

FIGURE 2 Riskscape of selected East and North-East Asian countries



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

East and North-East Asia has the highest AAL for both intensive and extensive disasters.

The disaster riskscape for East and North-East Asia can be better understood in terms of intensive and extensive risk.

Intensive risk

Intensive disaster risk refers to high-severity, mid- to low-frequency disasters, such as earthquakes, typhoons, riverine floods and tsunamis. For the East and North-East Asian subregion, the multi-hazard AAL for intensive disasters is $101 billion, which represents 68 per cent of the Asia-Pacific region's multi-hazard riskscape. The highest AAL in the Asia-Pacific region is concentrated in higher-income countries, notably Japan with a 40 per cent share in the region's AAL, and China with an 18 per cent share (Figure 3).

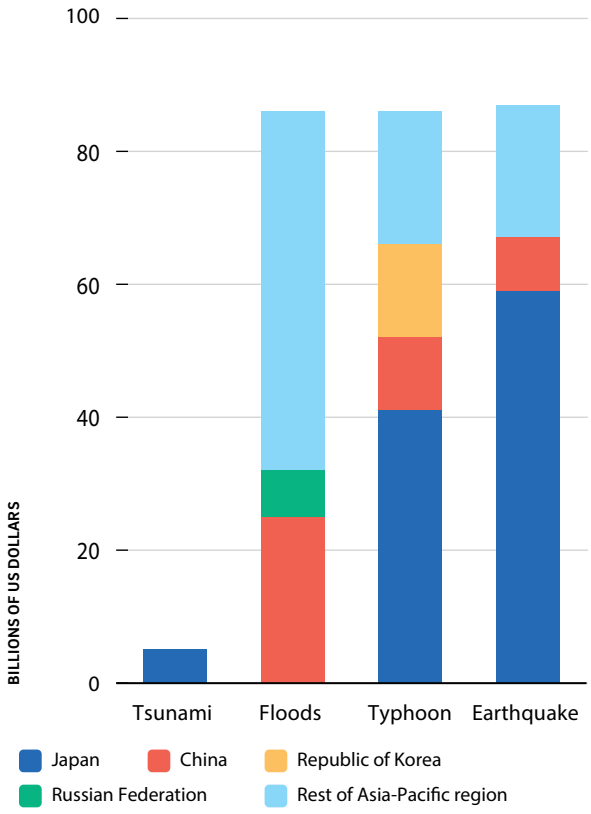
Earthquakes – The costliest events are generally earthquakes, that occur particularly in developed areas, with 64 per cent of the region's total earthquake AAL in Japan, and 14 per cent in China.

Floods – China represents 28 per cent of the total flood AAL in the Asia-Pacific region. Other countries with a significant proportion of the region's flood AAL include Japan and the Republic of Korea.

Typhoons – Japan represents 47 per cent of the total typhoon AAL in the region, followed by the Republic of Korea at 16 per cent.

Tsunamis – Japan represents 91 per cent of the total tsunami AAL in the region.

FIGURE 3 Multi-hazard AAL - extensive risk - including indirect losses in the Asia-Pacific region



Source: ESCAP based on probabilistic risk assessment.

Extensive risk

Extensive risk refers to low-severity but high-frequency hazardous events. These risks are generally highly localized and cannot be modelled analytically at the global or regional scale. However, evidence from countries where extensive risk has been modelled empirically suggests that such risk could increase the total multi-hazard AAL between 10 per cent and 50 per cent. A methodology developed by the United Nations Economic Commission for Latin America and the Caribbean indicates that direct losses normally represent only 30 per cent to 40 per cent of total losses. Applying this assumption to the East and North-East Asian subregion, the total average annual loss, including indirect losses, would rise to $184 billion, which represents 0.95 per cent of the subregion's gross domestic product (GDP). For the East and North-East Asian subregion, the agricultural drought AAL is $225 billion, which is about 1.16 per cent of the subregion's GDP. Incorporating this into the subregion's total multi-hazard AAL increases this figure to $409 billion, which represents 2.11 per cent of its GDP (Table 1).

TABLE 1 Disaster risk in East and North-East Asia

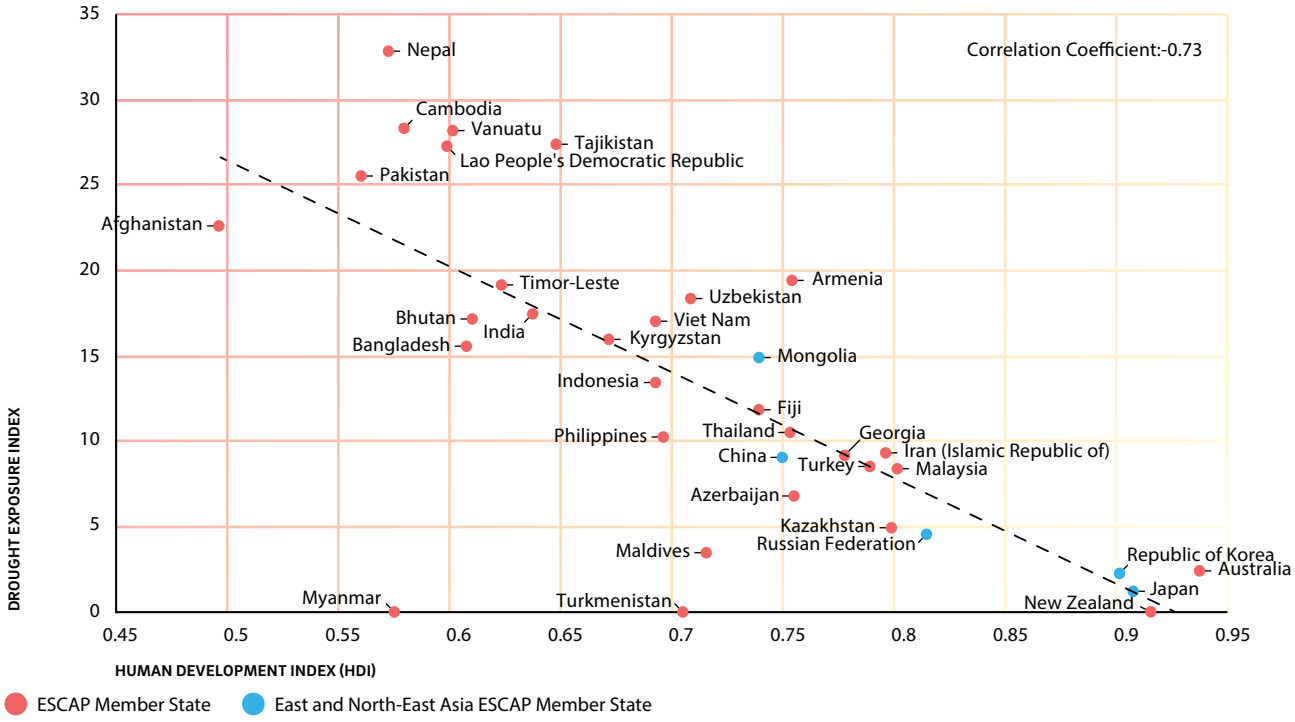
SOURCES OF RISK	AAL (US$ BILLION)	PROPORTION OF SUBREGIONAL GDP (PERCENTAGE)
Intensive risk - multi-hazard AAL	101	0.52
Extensive risk - multi-hazard AAL	131	0.68
Extensive risk - multi-hazard AAL including indirect losses	184	0.95
Agricultural drought AAL	225	1.16
Total - including intensive, extensive, direct and indirect losses, and agricultural drought	409	2.11

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

Slow-onset disaster: Drought

Drought is a widespread, slow-onset, creeping disaster, yet there are no probabilistic drought hazard estimates for Asia and the Pacific. Other measures are therefore used as proxies, such as those related to agriculture, the sector in which drought has the greatest impact. The countries most exposed are those that depend on agriculture for a high proportion of their GDP. Also, countries, such as Mongolia and China, with a high drought exposure index are found to have a lower human development index (Figure 4). Although agriculture in China only accounts for 9 per cent of its total GDP, amounting to $890 billion, China's agriculture AAL still represents more than 80 per cent of country's total AAL.

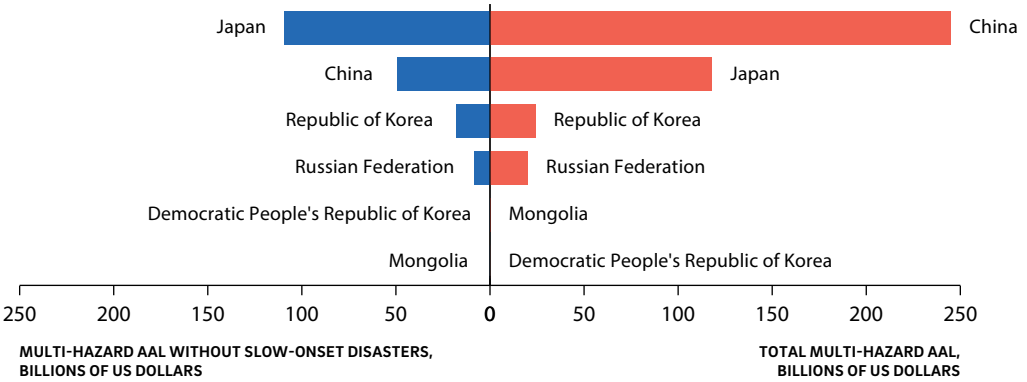
FIGURE 4 **Vulnerability index and exposure index of countries in the East and North-East Asia subregion**



Source: ESCAP based on probabilistic risk assessment.
Note: Drought average annual losses data of the Democratic People's Republic of Korea is not available.

In East and North-East Asia, Japan is expected to be at greatest risk in terms of multi-hazard AAL except slow-onset disasters, followed by China, the Republic of Korea and the Russian Federation. However, this changes when slow-onset disasters are added, the total multi-hazard AAL of China exceeds that of Japan. (Figure 5).

FIGURE 5 **Riskscape in numbers (AAL, billions of US dollars)**



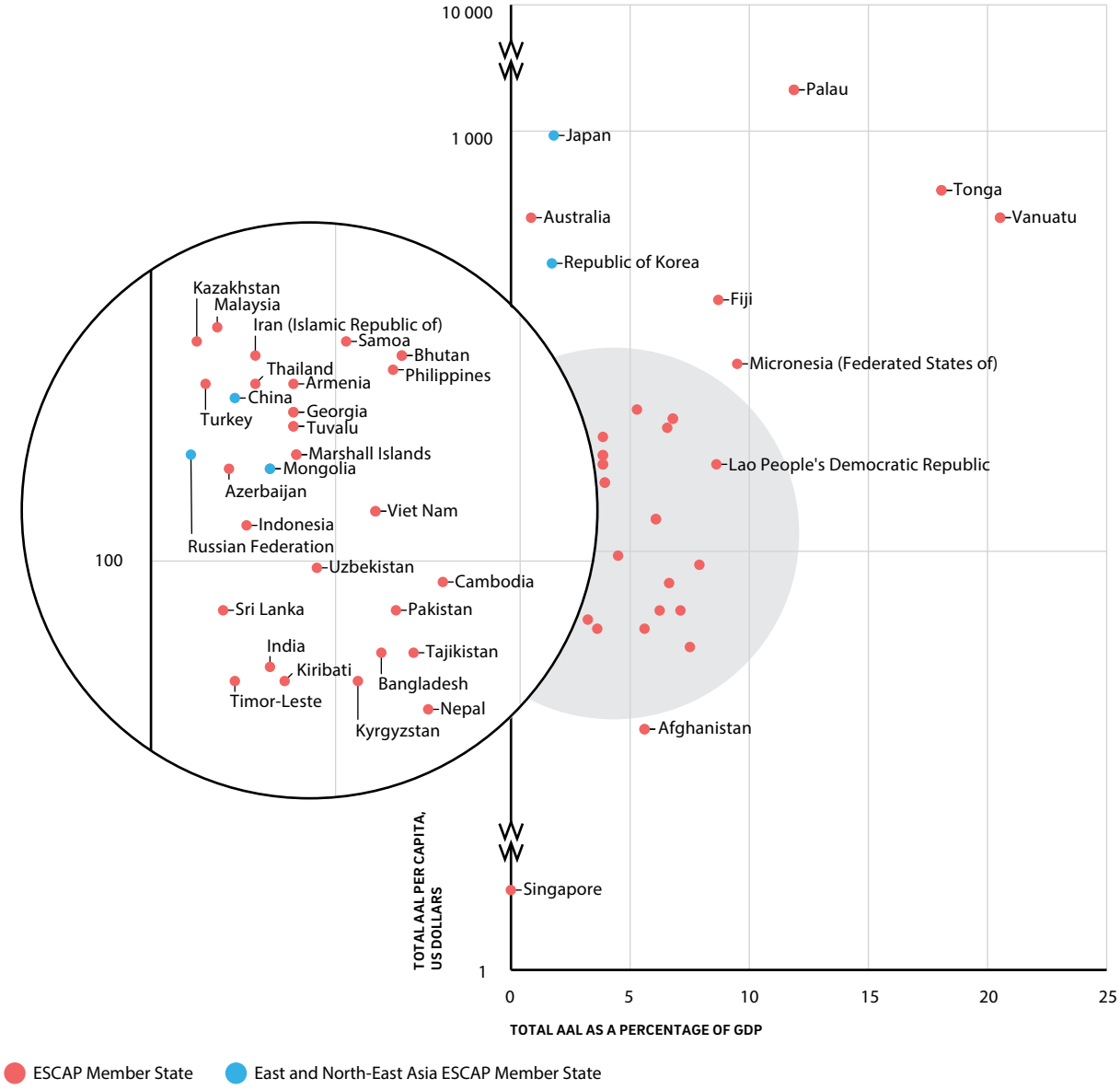
Source: ESCAP based on probabilistic risk assessment.
Note: Democratic People's Republic of Korea's drought AAL data is not available.

In East and North-East Asia, Japan and the Republic of Korea have the highest AAL per capita but lowest AAL in terms of GDP because of the size of their economies.

The ratio of total multi-hazard AAL to a country's population and national GDP represents the at risk population and economic scenarios. The analysis indicates that Japan is in the extreme range of population at risk in the region. This is followed by the Republic of Korea (Figure 6).

The Pacific SIDS and the least developed countries, such as Bangladesh, Bhutan, Cambodia, Nepal and others, have relatively large numbers of both at risk population and the economies, compared to the developed countries of East and North-East Asia.

FIGURE 6 **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.

BOX 1 **A year of surprises in historical context**

2018 – a year of surprises

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.[a] The most devastating were earthquakes and tsunamis; five of these events caused many fatalities and widespread asset losses. The events in 2018 fit into a broader historical sequence over the past half century and are the most significant, in terms of fatalities and economic impacts.

Floods in Japan, July 2018 – Japan experienced unprecedented flooding. Heavy rains triggered the deadliest floods since 1982, in which 232 people either died or went missing.[b] In south-western Japan, three times the normal amount of rainfall for the month of July led to devastating floods and mudslides, which destroyed buildings, covered land with mud, and left thousands of people stranded and displaced.

Super Typhoon Mangkhut in China, Hong Kong, China, Guam, Northern Mariana Islands, the Philippines, Thailand and Viet Nam, September 2018 – More than 1.6 million people were affected by typhoon Mangkhut (locally named Ompong). As reported, a total of 469,230 people were displaced to 3,678 evacuation centres and over 628,000 people were displaced to other locations. Over 210,000 homes were damaged, of which more than 14,000 were destroyed.[c] Super-typhoon Mangkhut swept across the Philippines, southern China, and most of South-East Asia. These water-related disasters have cascading impacts, bringing risks that are dynamically complex and challenging.

Asia and the Pacific is also facing disasters of greater complexity as seen with Typhoon Mangkhut, which affected people in China, South-East Asia and in the Pacific Island countries. The typhoon, formed in the North-West Pacific Ocean reached a maximum wind speed of 287 kilometres per hour.[d] Its transboundary impact was felt across the southern parts of China and Hong Kong, China and other South-East Asian countries.[e] The final landfall of the typhoon in southern China, Hong Kong, China and Macau, China caused category 2 hurricanes, on 16 September 2018.[f] The complexity of the typhoon can be understood by seeing its impact on other countries. Mangkhut brought heavy rains, big waves and tidal surges that flooded the coastlines in Hong Kong, China.[g]

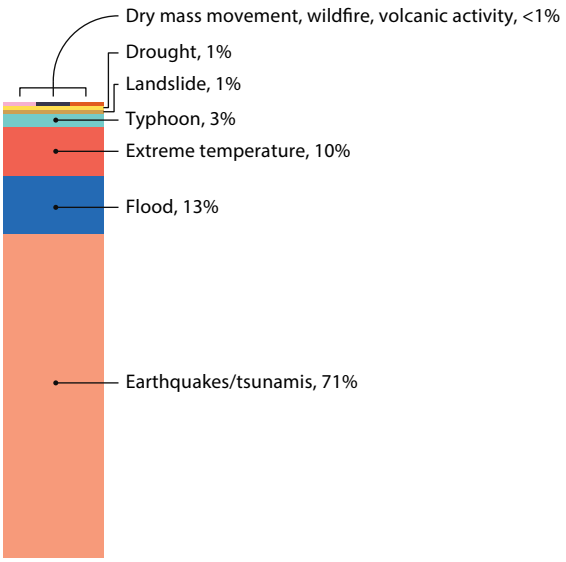
a D. Guha-Sapir (2019).
b ICHARM (2019).
c ReliefWeb (2018).
d GDACS (2018).
e ReliefWeb (2018).
f Weather Channel (2018).
g Hong Kong Observatory (2018).

Earthquakes and tsunamis are the biggest killers.

It is estimated that between 1970 and 2018, the total deaths in the East and North-East Asia subregion amounted to 564,946 people. Earthquakes/tsunamis contribute to 71 per cent of the total deaths in the subregion, while only 46 per cent in the Asia-Pacific region. This is followed by floods in East and North-East Asia, which contributes to 13 per cent of the fatalities whereas, in the Asia-Pacific region, the second-highest fatalities are caused by storms, which amount to 37 per cent of the deaths (Figure 7). Floods took a greater share of fatalities with multiple incidents in China, the Democratic People's Republic of Korea and Japan, but overall the number of fatalities has decreased over the decades.

While the number of disaster events and affected population are on the rise, associated fatalities are declining.

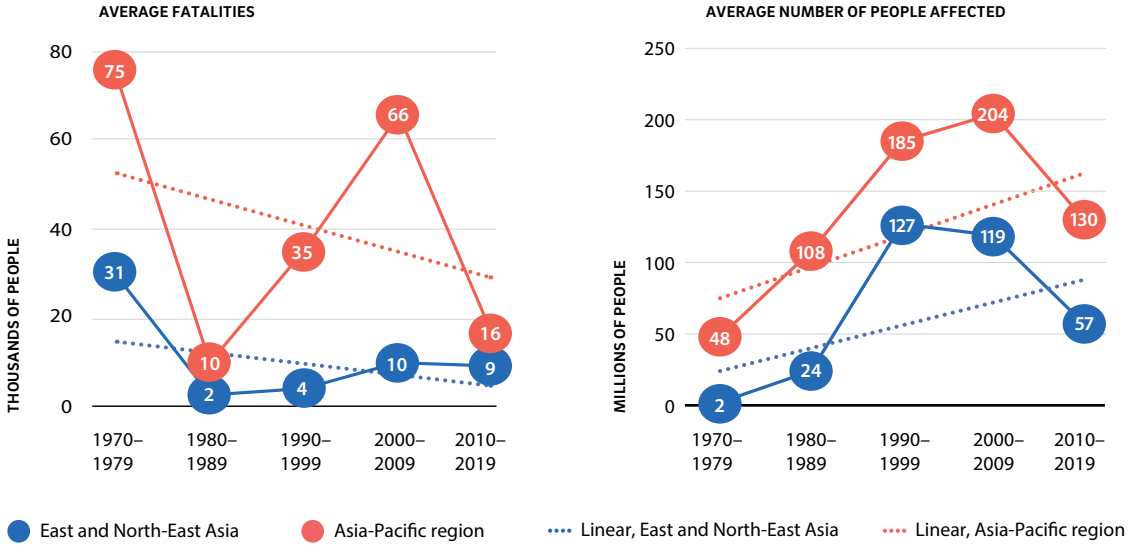
FIGURE 7 Fatalities from natural disasters in East and North-East Asia, 1970–2018



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

Disaster events related to the weather and climate are on a steep rise in comparison to those having seismic origins since 1970. Consequently, the number of people affected is also on the rise. However, the good news is that the trend in disaster-related fatality is on a decline (Figure 8). The trend is clearly reflected with the analysis of annual averages as well as decadal data sets.

FIGURE 8 Average fatalities and people affected from natural disasters



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

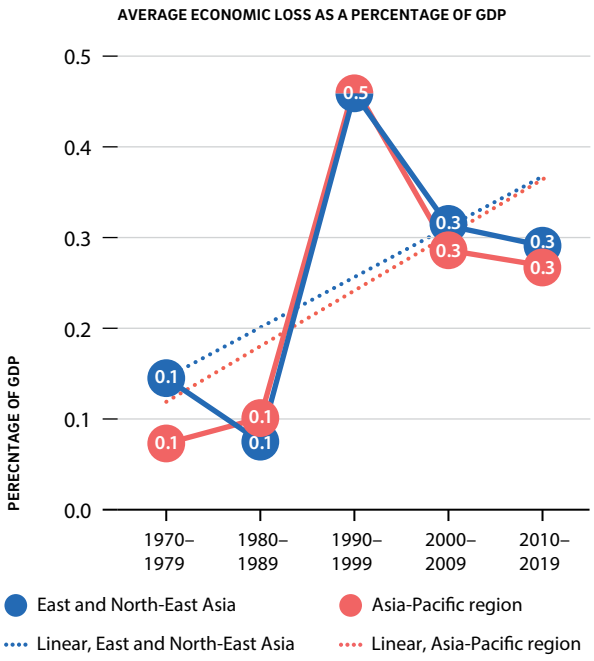
Disaster losses outpace economic growth.

Disasters also cause large-scale economic damage, which is measured in current US dollars as the value of all damages and economic losses directly or indirectly related to the disaster.[1] As seen in Figure 9, the trend clearly shows that the damage caused as a percentage of GDP in East and North-East Asia is the same as in the Asia-Pacific region, highlighting the magnitude of its impact on the subregion. East and North-east Asia largely contributes to the region's economic growth.

The intensification and changing geography of disaster risks are the new normal.

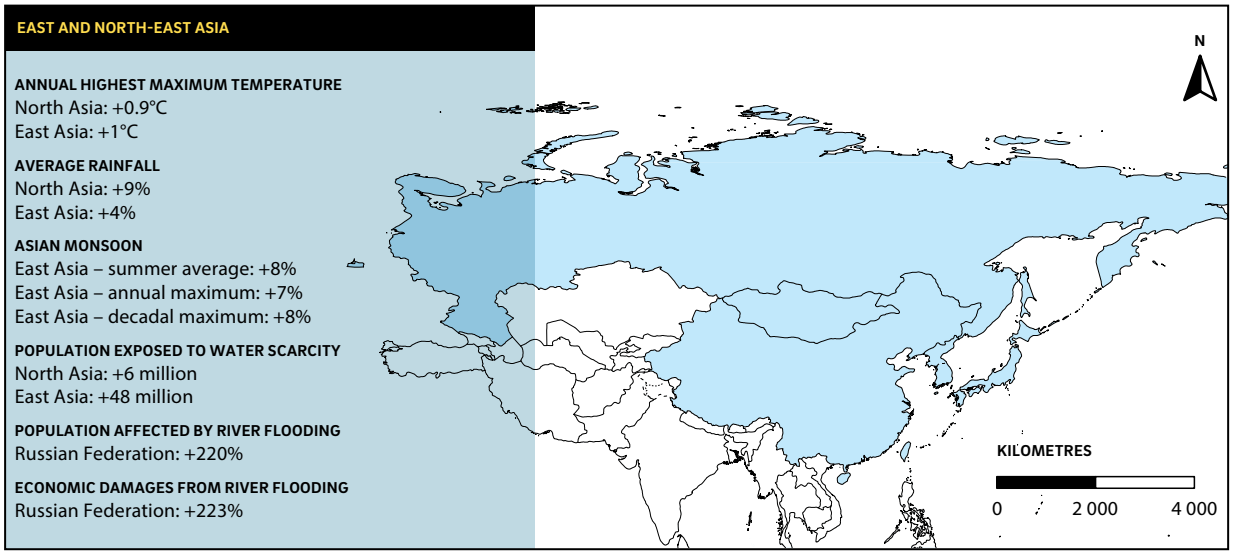
In October 2018, the Intergovernmental Panel on Climate Change (IPCC) reported that if global warming continues to increase at the current rate, global temperatures are likely to increase by 1.5°C between 2030 and 2052.[2] Weather that was once considered extreme is now becoming the new normal. However, the impact of climate change may vary within the subregion. The increase in temperature is more likely to impact semi-arid and arid regions. The estimated rise in temperature is likely to increase the duration of heat waves, droughts and floods. It will also affect average rainfall, which is likely to increase by 9 per cent and risks exposing nearly 50 million people to water scarcity in the subregion (Figure 10). The economic damage from river floods is expected to rise substantially in the Russian Federation.

FIGURE 9 Average economic losses from natural disasters



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

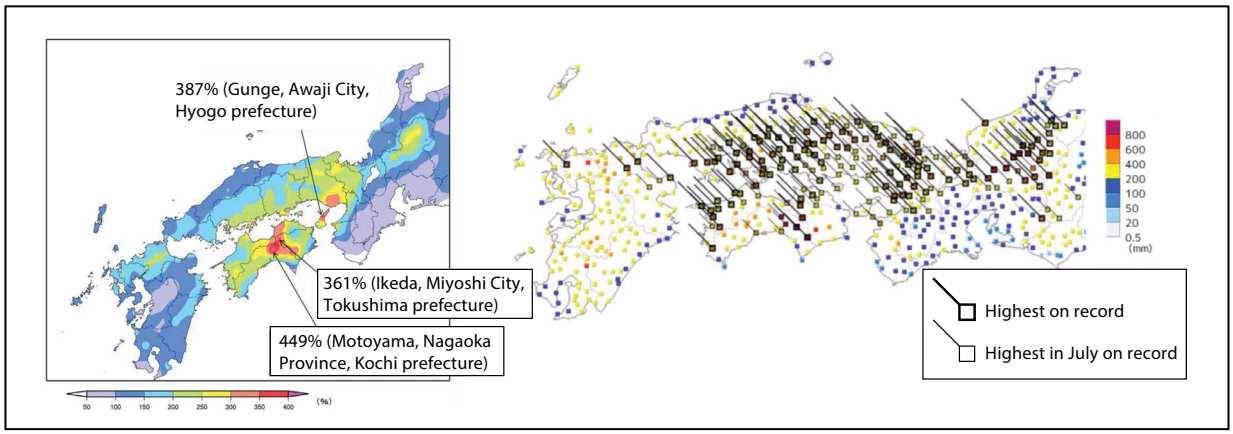
FIGURE 10 Impact of global warming of 1.5°C in East and North-East Asia



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

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 the extreme events of heavy rainfall and floods in Japan, in 2018 (Figure 11).

FIGURE 11 Heavy rainfall and floods in Japan, 2018



Source: JMA, 2018.
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In July 2018, record-breaking rainfall, ranging 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.[3] The heavy rain was followed by heat waves, formed because 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.[4] The anomaly mean temperature was +2.8°C. The heat wave, that took place during the flood response phase, hospitalized tens of thousands of people with heat-related illnesses.

Some areas in Japan experienced two to four times the normal precipitation for July.[5] Flooding caused rivers to breach their banks, carrying debris and causing urban inundations.[6] 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.

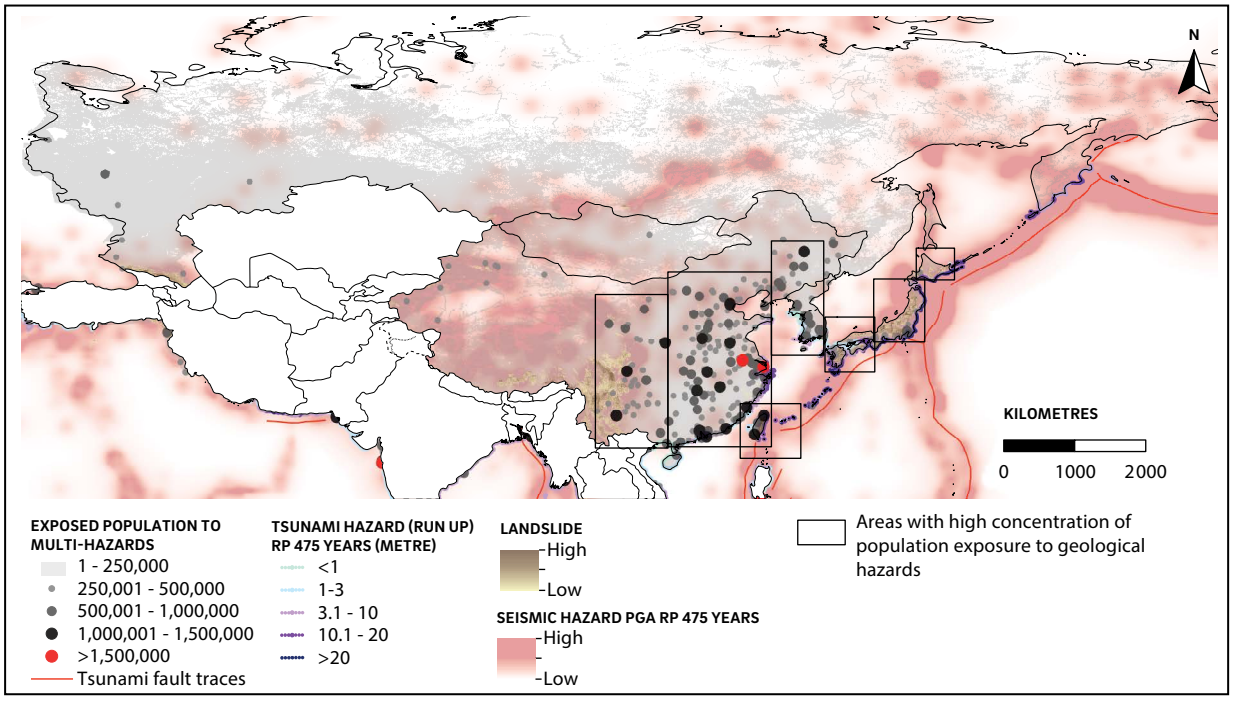
Japan, among other countries, is now experiencing more complex disasters that are occurring with greater frequency. These are typically induced by multiple causes with confluences in certain zones and with huge and simultaneous flows of water and sediment. These water-related disasters are also happening at a time when Japan must respond to an ageing population.[7]

East and North-East Asia is the most disaster-exposed subregion.

East and North-East Asia is highly exposed to typhoons and floods as well as earthquakes and tsunamis.

A large cross-section of the people living in East and North-East Asia are located in high risk, multi-hazard areas. For example, the populations most exposed to seismic risks, such as earthquakes and tsunamis, are in Japan and in the western part of China (Figure 12). The populations exposed to these seismic hazards amount to 23 per cent of the population of East and North-East Asia.

FIGURE 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.
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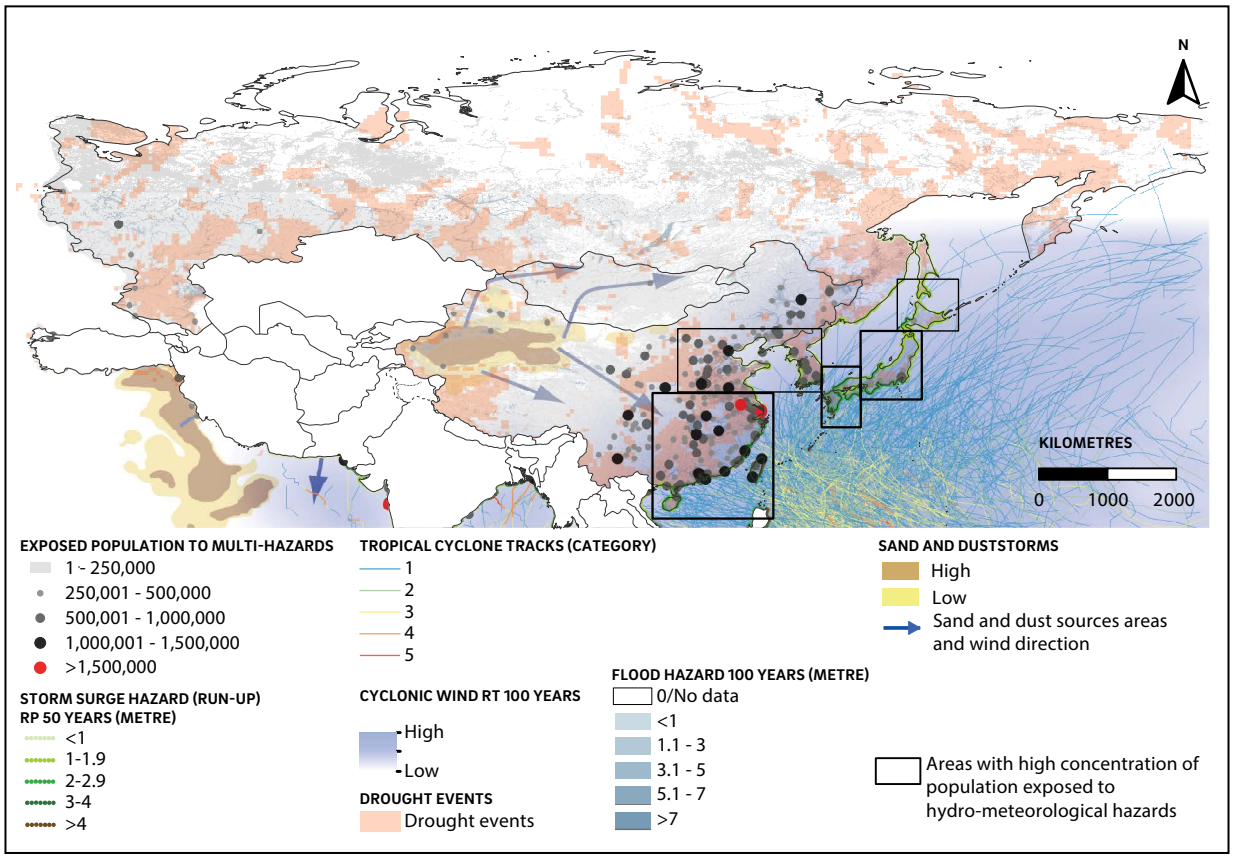
Note 1: Peak Ground Acceleration (PGA) Return Period (RP) 475 years is the seismic hazard with a return period of 475 years expressed in peak ground acceleration. This means that a level of ground shaking is expected to occur once in 475 years. Tsunami hazard RP 475 years is a tsunami hazard run-up height with a return period of 475 years.
Note 2: The value of PGA 475 years used in this quantification is from 90 to 334 cm/s^2.

Figure 13 shows the areas of high human density exposed to climate-related hazards. In coastal areas, residents are prone to climate-related disasters such as typhoons, floods, storm surges and sand and dust storms. About 45 per cent of the population in the subregion is exposed to typhoons, while 20 per cent is exposed to floods.

FIGURE 13 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.
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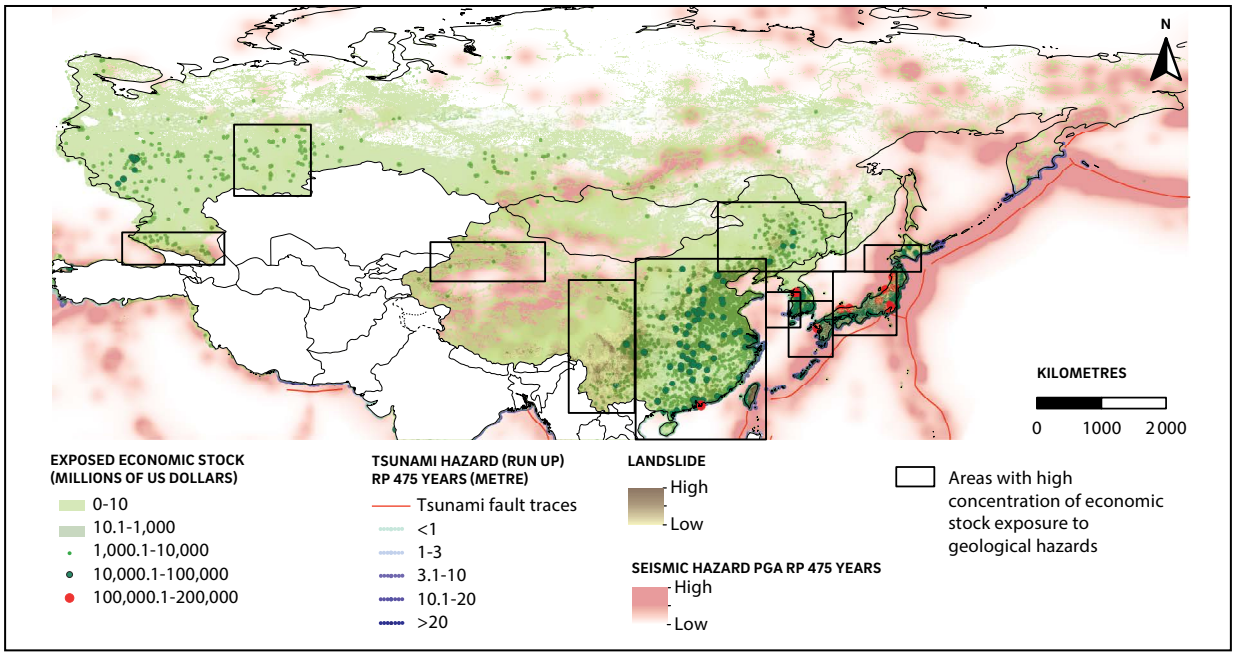
Note: Cyclone data consist of all cyclone wind categories with a return period of 100 years and an intensity of 119 km/h to more than 252 km/h.

A large volume of the economic stocks in East and North-East Asia is located in high multi-hazard risk areas.

East and North-East Asia is a region of rapid economic development, with its capital stock accounting for more than 70 per cent of the economic stock of the Asia-Pacific Region. Thus, with disaster risk, its infrastructure is more exposed to hazards. Furthermore, these areas are impacted by disasters that follow each other in quick succession. That is, floods are followed by typhoons, an earthquake is followed by a tsunami, and drought followed by sand and dust storms. It is estimated that 73 per cent of the sub-regional economic stock is exposed to typhoons, 10 per cent is exposed to riverine floods while 34 per cent of East and North-East Asia's economic stock is exposed to seismic hazard. (Figure 14).

FIGURE 14 Concentration of exposed economic stock to seismic 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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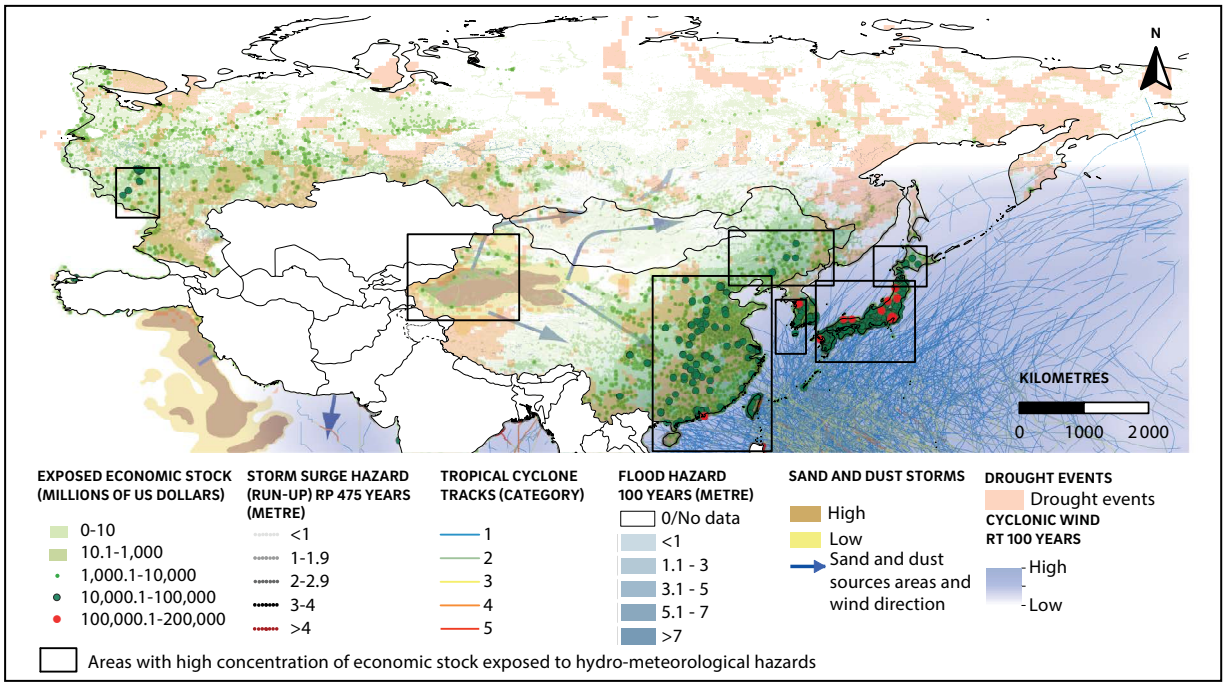
Note 2: The value of PGA 475 years used in this quantification is from 90 to 334 cm/s^2.

Many economically developed coastal regions, such as Japan, the Republic of Korea and the coastal areas of China, are exposed to typhoons and storm surges (Figure 15). The economic stock exposed to typhoons in the subregion comprises approximately 53 per cent of the entire economic stock in the Asia-Pacific region.

FIGURE 15 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.
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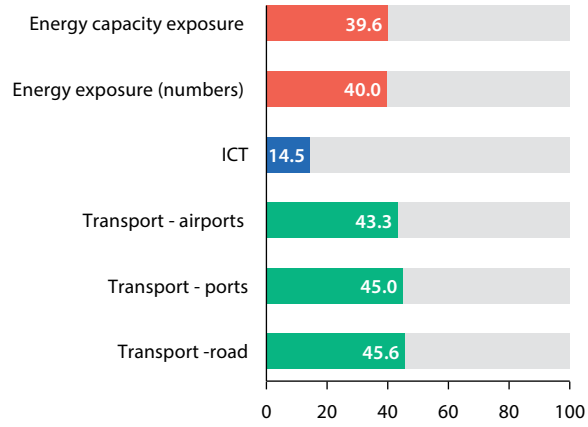
Note: Cyclone data consist of all cyclone wind categories with a return period of 100 years and an intensity of 119 km/h to more than 252 km/h.

The Ring of Fire hotspots are exposing critical infrastructure to risk.

East and North-East Asia is a part of the Ring of Fire, a hotspot for earthquakes, landslides and tsunami tracks. The Pacific Ring of Fire experiences around 90 per cent of the world's earthquakes, with the potential for associated tsunamis. This hotspot is characterized by very a high exposure of economic stock and energy infrastructure to risk. Figure 16 illustrates the subregion's exposure of critical infrastructure to multi-hazards.

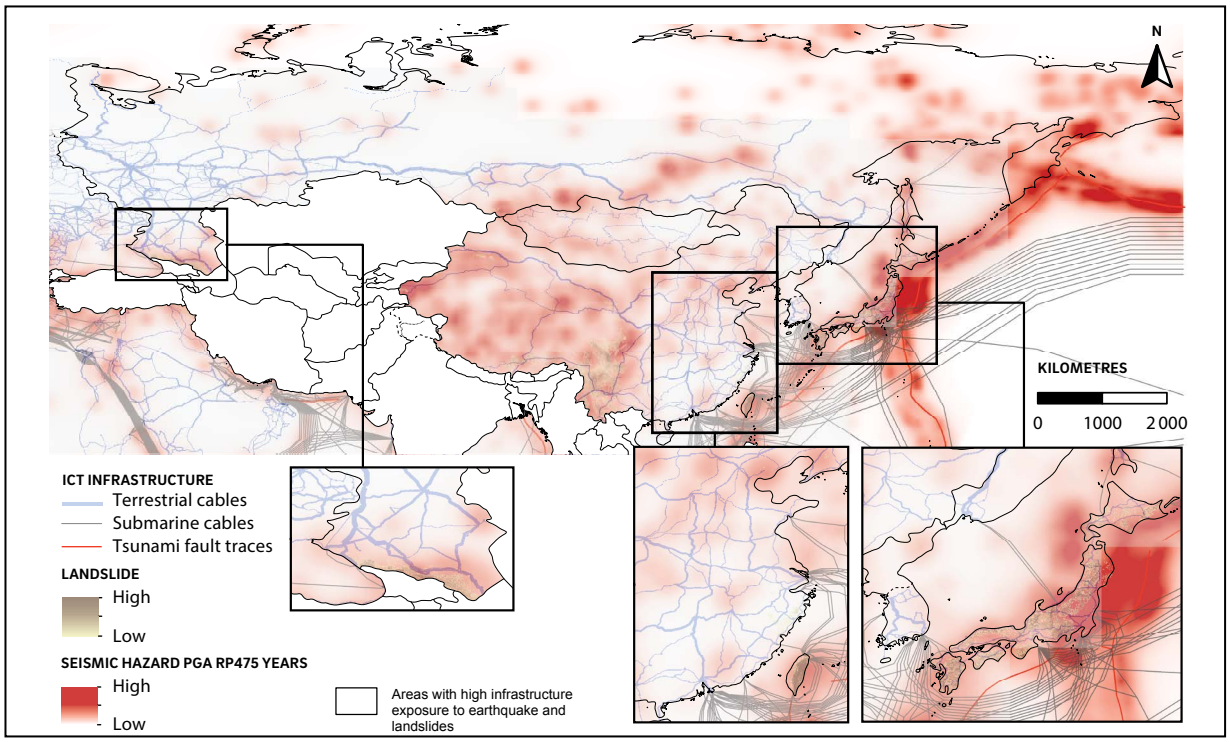
The seismic fault lines threaten ICT infrastructure, particularly in technologically advanced countries, such as Japan, the Republic of Korea and China (Figure 17). Of the subregion's ICT infrastructure, 16.7 per cent is exposed to earthquakes. These countries also depend on submarine fibre-optic cables that are vulnerable to typhoons. Access to well-functioning road networks, airports and ports are essential for evacuations and the distribution of supplies, especially in the emergency phases of a disaster. Energy failure can have cascading impacts on health services and ICT.

FIGURE 16 Percentage of infrastructure at risk to multiple hazards



Source: UNEP (2013), Global Risk Data Platform; Global Landslide Hazard Distribution v1 (2000); ESCAP (2018b), Asia-Pacific Information Superhighway; ESCAP (2018), Asia-Pacific Energy Portal; ESCAP (2018c) Transportation Data.
Note: The risk comprises of multi-hazard: a) Geological hazard (earthquake) and b) Climate-related hazards (flood and typhoon).

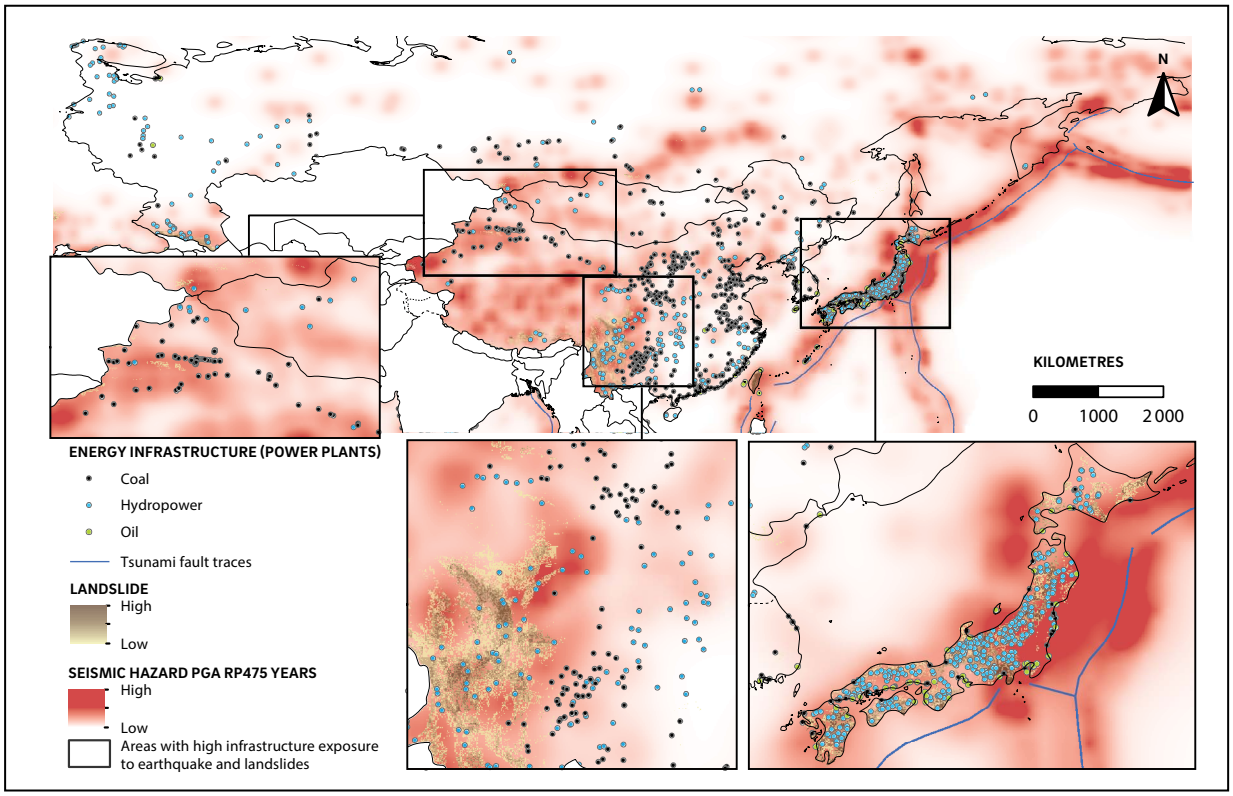
FIGURE 17 Hotspots of ICT infrastructure exposed to earthquakes and landslides



Sources: ESCAP, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015; Global Landslide Hazard Distribution v1, 2000; ESCAP Asia-Pacific Information Superhighway, 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.
Note 1: Peak Ground Acceleration (PGA) Return Period (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.
Note 2: The value of PGA 475 years used in this quantification is from 90 to 334 cm/s^2.

There are also seismic and climate risks to energy resources. Many coal, oil and hydropower generation plants, especially in Japan, are exposed to earthquakes and tsunamis, as shown in Figure 18. Of the total 1,437 coal, oil and hydropower energy resources, 46.4 per cent is exposed to earthquakes and 34.7 per cent of the total capacity (MWe) of these power plants is exposed to earthquakes. In China, the types of power plants which are highly exposed to earthquakes are coal and hydropower. While Japan's hydropower, oil and coal power plants are highly exposed to earthquakes.

FIGURE 18 **Hotspots of energy infrastructure exposed to earthquakes and landslides**



Sources: ESCAP, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015; Global Landslide Hazard Distribution v1, 2000 and ESCAP Asia-Pacific Energy Portal, 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.
Note 1: Peak Ground Acceleration (PGA) Return Period (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.
Note 2: The value of PGA 475 years used in this quantification is from 90 to 334 cm/s^2.

Approximately 52 per cent of solar and wind infrastructure is at risk of typhoons in East and North-East Asia. The most vulnerable countries include China, Japan, and the Republic of Korea. The capacity (MWe) of solar and wind infrastructure exposed to typhoons in the subregion is about 52 per cent.

There are also significant transport infrastructures exposed to earthquakes throughout the subregion. Approximately, 27 per cent of the road networks are exposed to seismic hazards, while 49 per cent of airports and 51 per cent of ports are at risk to earthquakes in the Ring of Fire hotspot. Airports and ports in Japan and in the Republic of Korea are highly exposed to the risk of typhoons. Approximately 70 per cent of airports and 75 per cent of ports are exposed to typhoons and at risk in East and North-East Asia.

East and North-East Asia is also a part of the sand and dust storms risk corridors.

Sand and dust storms constitute a phenomenal environmental concern in the East and North-East Asian subregion. Originating principally in the arid areas of Inner Mongolia in China and in the Gobi Desert in Mongolia (as well as increasingly from north-eastern China), windborne dust particles are carried eastward to affect not only China but also the Korean Peninsula and Japan (Figure 19).[8]

FIGURE 19 True-colour image of a dust storm over the Taklimakan Desert on 5 March 2018

Source: Jeff Schmaltz, Moderate Resolution Imaging Spectroradiometer (MODIS) Land Rapid Response Team, National Aeronautics and Space Administration (NASA) Aqua Satellite.

In East and North-East Asia, slow-onset disasters largely contribute to widening inequalities in outcomes and opportunities.

Inequality of income refers to how income generated in the production of goods and services is unequally distributed across a population. The best-known measure is the Gini coefficient.[9] Inequality of opportunities is measured by the D-index that measures access to education, childhood nutrition and household access to basic services. China, Mongolia and the Russian Federation fall within the quadrant of High Gini and Low D-index countries. Mongolia has a higher D-index and greater disaster risks than China and the Russian Federation, but a comparatively lower Gini coefficient, which means that the inequality of opportunities is lower.

Slow-onset droughts have caused significant losses in agricultural production, have depleted fresh water supplies, and increased both inflation and poverty. They have also widened inequalities in outcomes and opportunities. For example, the risk associated with drought and the agricultural sector represent a very significant proportion of overall multi-hazard risk. As seen in Figure 2, Mongolia's drought AAL is 84.7 per cent of the country's AAL, while China's drought AAL is 80 per cent of the country's AAL. As seen in Figure 4, East and North-East Asia subregion' countries have a considerably higher Human Development Index (HDI) and lower drought vulnerability, as well as drought exposure index, compared to other subregions of Asia and the Pacific. Amongst the East and North-East Asia countries, Mongolia has the highest drought vulnerability index and drought exposure index.

The East and North-East Asia subregion is leading social policy innovations for breaking the link between disaster risk and inequality.

Disasters slow down any progress made in the reduction of inequalities. However, governments can mitigate this by implementing comprehensive sectoral investments and policies. Strategic investments are required in key sectors 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. Whilst this is a daunting challenge, the additional amounts are still small as 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 inequality.

Laws and plans related to disaster risk reduction (DRR) need to ensure the active participation of marginalized groups. Countries can lift the financial burden of disasters from the poor with disaster risk finance and insurance. Mongolia, for example, has an innovative index-based insurance scheme for *dzud*, where droughts and pasture shortage lead to mass livestock deaths. By establishing an index that automatically activates, the cost of providing insurance can be lowered. Lower costs to insurers can help build a profitable and sustainable business model that provides affordable insurance.

Being the most exposed, the subregion recognizes a $4 benefit for each dollar invested in resilient infrastructure.

With substantial exposure of subregion's economic stocks including its critical infrastructure such as energy, transport, and telecommunication services which are universally considered to be essential for raising the quality of life of people, building the resilient infrastructure is the key. There are many examples, around the subregion, of investments that make infrastructure more resilient and more economically robust. A report that examines four essential infrastructure systems; power, water and sanitation, transport, and telecommunications, highlights that the extra cost of building resilience into these systems is only 3 per cent of the overall investment needs. Thanks to fewer disruptions and reduced economic impacts, the overall net benefit of investing in the resilience of infrastructure in developing countries would be $4.2 trillion over the lifetime of new infrastructure. That is a $4 benefit for each dollar invested in resilience.[10]

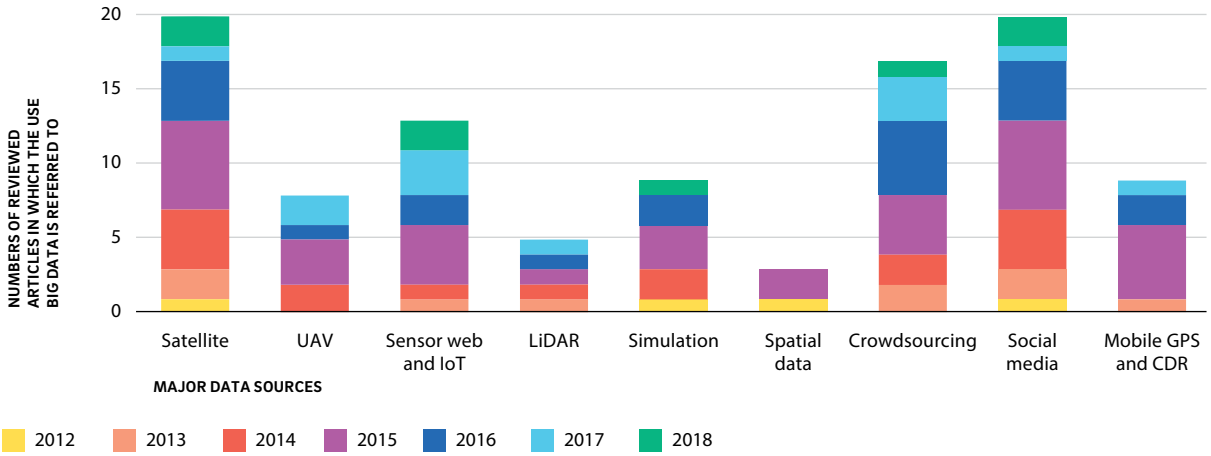
The subregion is leading the trend in building resilient infrastructure. Japan led the G20 Action Agenda on Adaptation and Resilient Infrastructure. The Priority plan for Japan's infrastructure development (2015) includes adaptation measures, notably for the protection against flood and sediment disaster. The Ministry of Trade, Industry and Energy (MOTIE) of the Republic of Korea has been implementing a support program to evaluate vulnerability levels of various industrial sectors to climate change and facilitate those sectors to establish adaptation measures. China's resilient cities are shaping up with the long-term trajectory of energy and climate securities protection. The 'Energy Strategy of the Russian Federation until 2035' contains a special section entitled, "Environment protection and mitigation of climate change impacts". The 'Russian Transport Strategy until 2030' also provides for special measures focused on the strengthening of resilience of transport infrastructure to climate change especially in the Arctic and sub-Arctic zones.[11]

Emerging technologies are game changers and the subregion is capitalizing on this.

Managing disaster risk is data intensive.

Big data has opened up promising approaches for disaster resilience. Mobile phone data, for example, can provide an incredibly detailed view of a population's behaviour and movement in areas previously observed only infrequently and indirectly. Social networks like Twitter, Facebook etc., are already improving the ability of humanitarian and other organizations to monitor and respond to disasters. Further opportunities are increasing as mobile phone penetration and internet access is increasing significantly in developing countries with high disaster risk. On this basis, the fastest-growing sources are satellite imagery, crowdsourcing, and social media (Figure 20).

FIGURE 20 Use of big data sources for disaster management, 2012–2018



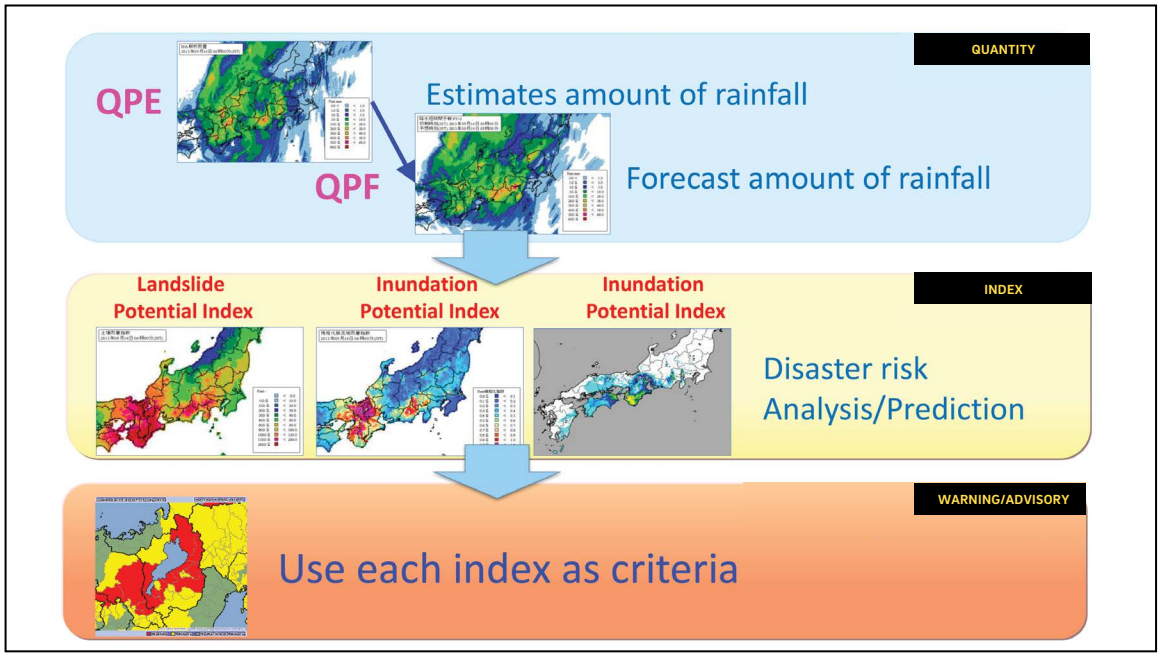
Source: Manzhu Yu and others, 2018.
Note 1: Based on distribution of reviewed article by major data sources and year of publications.
Note 2: CDR: Call Data Records, IoT: Internet of Things, LiDAR: Light Detection and Ranging, UAV: Unmanned Aerial Vehicle.

New data analytics help to manage cascading disasters and impact-based forecasting.

Big Data fills in the critical data gaps in multi-hazard early warning systems and enables the provision of second-generation early warning products such as impact-based, risk-informed, people-centred and end-to-end early warning services at different regional, sub-regional, national, local, and community levels. It also helps the transition from early-warning to early-action, such as forecast-based financing, forecast-based social protection and risk prevention.

The Japan Meteorological Agency (JMA) uses quantitative precipitation estimation (QPE) and quantitative precipitation estimation (QPF) as warning criteria to identify risk levels of flood inundations and landslides in certain locations.[12] 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 to issue severe weather warnings. The JMA has built a comprehensive disaster database to determine proper warning criteria (Figure 21).

FIGURE 21 Big data used for flood forecasting in Japan



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.

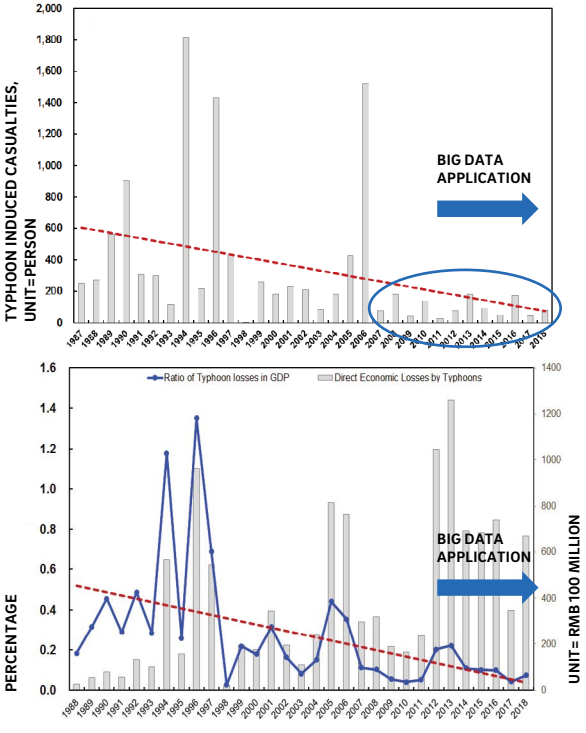
Big data makes bigger impacts.

The China Meteorological Administration, for example uses big data for gridded, smart and impact-based typhoon forecasting.[13] Impact-based typhoon forecasts and warnings help to target the community at risk in a dynamic fashion and evacuate them before the typhoon makes landfall. Exposed economic assets are 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, and a reduction in disaster losses as a proportion of GDP (Figure 22).[14]

Internet of Things (IoT) makes early warnings for earthquakes more efficient.

A 'sensor web' is set of sensors connected to the internet. 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

FIGURE 22 Typhoon casualties and losses in China, 1987–2018

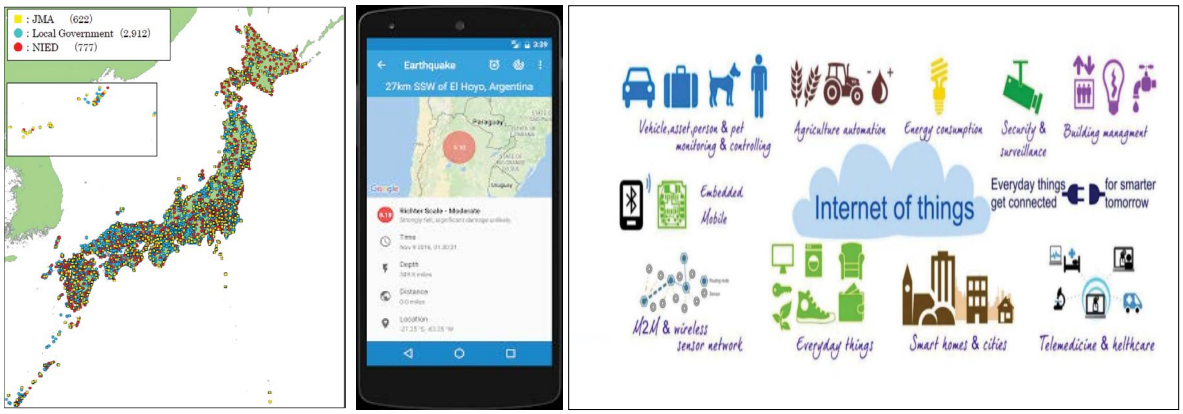


Source: China Meteorological Administration and Manzhu, and others (2018).

(IoT). Data from these sensor webs can be combined with satellite data and other sources, including user-generated data that reaches various platforms in real time, through social media, such as Twitter. These data can help predict extreme events such as earthquakes and tsunamis.[15]

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 in Japan (Figure 23). Zizmos, for example, uses smartphone apps to detect motion and serve as seismic sensors in high-risk areas.[16] This network can provide up to 90 seconds of warning.

FIGURE 23 **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.

Disability-inclusive disaster risk reduction is driven by emerging technologies.

Persons with disabilities can face barriers when communicating, interacting, accessing information, or participating in civic activities. Some of these barriers can be overcome by digital technologies that use multiple means of communication, such as voice, text, and gestures. People with visual, cognitive, learning, and mobility disabilities can benefit from voice recognition, magnification, and text-to-speech. People with hearing and speech disabilities can reduce communication barriers with SMS short message services, instant messaging, telephone relays, and video captions.[17] Hands-free navigation and gesture-controlled interfaces assist persons with severe mobility impairments in using digital devices.

But technology alone cannot overcome socioeconomic exclusion of persons with disabilities, it needs to be complemented with a supportive ecosystem, in particular the legal, policy, and regulatory foundation for accessible ICT. For disasters, public services, such as disaster warnings and communications, should ensure accessibility.

Machine learning can contribute to earthquake prediction.

Machine learning has evolved to become one of the most effective methods of processing and analysing data on major heterogeneous disasters, and speeding up all the necessary analytics to identify the optimal responses and resilience strategies.

Large and devastating earthquakes, such as the 9.0 magnitude Tohoku earthquake in 2011, in Japan, are currently considered unpredictable. 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, which are 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.[18] However, this methodology needs much more research before it can become operational.

Unlocking the potential of sub-regional cooperation

The East and North-East Asia risk hotspots are transboundary in nature that requires regional/sub-regional disaster risk reduction and resilience building strategies.

Sub-regional cooperation activities in East and North-East Asia offer opportunities.

The North-East Asian Subregional Program for Environmental Cooperation (NEASPEC), a comprehensive intergovernmental cooperation framework, has been supporting its member countries to share information, build policy and technical capacity to address the challenges related to desertification and land degradation, the root cause of sand and dust storms with cross-border impacts. The Regional Master Plan for the Prevention and Control of Dust and Sandstorms in North-East Asia and the North-East Asia Multi-Stakeholder Plan (NEAMSP) on Combating Desertification and Land Degradation are important initiatives to address slow-onset disasters that occupy larger space in subregion's 'riskscape'. Similarly, ESCAP's Regional Cooperative Mechanism for Drought Monitoring and Early Warning (i.e. the Regional Drought Mechanism) is a cooperative initiative that has helped Mongolia expand its capacity to more effectively utilize space applications. Similarly, Sentinel Asia, an international cooperation platform and an initiative of the Japan Aerospace Exploration Agency (JAXA), promotes the sharing of remote sensing data and Web-GIS technologies.

Data and information drive sub-regional cooperation.

A combination of earth observation satellites and surface-based observations do capture the transboundary origins and impacts of disasters as well as their monitoring and assessments in order to facilitate risk-informed policy actions. For example, sand and dust storm sources in China are thousands of kilometres away from the impacted regions. The policy interventions that consider the geo-spatial linkages between the source and impacted regions of sand and dust storms are having positive impacts on both adaptation as well as mitigation efforts. The ecological restoration program significantly reduced sand and dust storms from -5 per cent to -15 per cent in the impacted North China Plain.[19] Quite often, sand and dust sources and impacted regions are transboundary in nature, which requires dialogues and cooperation among the related countries for risk-informed policy interventions.[20] The ongoing effort of the Asian and Pacific Centre for the Development of Disaster Information Management (APDIM) toward establishing a regional slow-onset hazards network and sand and dust storms alert system is an important partnership building initiative. Furthermore, ESCAP joined an UN Coalition on Combating Sand and Dust Storms to deepen regional cooperation by engaging stakeholders from South and South-West, North and Central Asia and East and North-East Asia.

Asia-Pacific Disaster Resilience Network (APDRN) is yet another effort.

Building on the specificities of the region's hotspots, APDRN aims to strengthen regional resilience with a focus on innovations and partnership approaches. Pillared on ESCAP's regional platform of multi-hazard early warning systems, it capitalizes on the partnership networks with hazard cluster approach and includes all hotspots. While ESCAP and World Meteorological Organization (WMO) partnership through the Typhoon Committee, the UNESCO-Intergovernmental Oceanographic Commission (IOC) partnership supports effective end-to-end tsunami early warning systems.

UN Data and information management platform is to harness Big Data potential.

The UN Global Geospatial Information Management (UN-GGIM), particularly its Geospatial Information and Services for Disasters is customized to support the implementation of the Sustainable Development Goals (SDGs) and the Sendai Framework for Disaster Risk Reduction. The Geospatial Information and Services for Disasters promotes the concepts of Open Data, Communities and Sources, as well as Spatial Data Infrastructure. Since November 2018, ESCAP has been assigned to undertake the Secretariat of the Regional Committee of Global Geospatial Information Management for Asia and the Pacific (UN-GGIM-AP) to strengthen the capacity of Member States in geospatial information management. ESCAP promotes new data acquisition and integration approaches, including Earth observations and geospatial information, to address all local and global development challenges and support the implementation of the 2030 Agenda for Sustainable Development and its SDGs.

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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.

The *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.

The Disaster Riskscape across East and North-East Asia: Key Takeaways for Stakeholders, provides analysis from the APDR 2019 with specific reference to the East and North-East Asia subregion and comprehensively presents its sub-regional riskscape to inform policy actions.