Pathways to Adaptation and Resilience in East and North-East Asia

SUBREGIONAL REPORT

Asia-Pacific Disaster Report 2022 for ESCAP Subregions

ESCAP
MOVING FORWARD TOGETHER

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

The Economic and Social Commission for Asia and the Pacific (ESCAP) is the most inclusive intergovernmental platform in the Asia-Pacific region. The Commission promotes cooperation among its 53 member States and 9 associate members in pursuit of solutions to sustainable development challenges. ESCAP is one of the five regional commissions of the United Nations.

The ESCAP secretariat supports inclusive, resilient and sustainable development in the region by generating action-oriented knowledge, and by providing technical assistance and capacity-building services in support of national development objectives, regional agreements and the implementation of the 2030 Agenda for Sustainable Development.

**The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.*

Pathways to Adaptation and Resilience in East and North-East Asia

SUBREGIONAL REPORT

Printed in Bangkok
ST/ESCAP/3012

About the report

Resilience in a Riskier World: Managing Systemic Risks from Biological and Other Natural Hazards, the Asia-Pacific Disaster Report (APDR) 2021 captured a comprehensive picture of the complexity of disaster risk landscape ('riskscape') from natural and biological hazards in the Asia-Pacific region. The full-length publication is available at https://www.unescap.org/kp/2021/asia-pacific-disaster-report-2021. Following the release of the APDR at the seventh session of the ESCAP inter-governmental Committee on Disaster Risk Reduction in August 2021, the report was customized for each of the five ESCAP subregions, namely East and North-East Asia, North and Central Asia, South-East Asia, South and South-West Asia and the Pacific. The current report highlights the key takeaways for East and North-East Asia.

Photo credits
Cover: Shutterstock/humphery
Page 1: iStock/katoosha
Page 10: iStock/Spondylolithesis
Page 17: Shutterstock/mTaira
Page 31: Unsplash/Daniel Bernard
Page 41: Unsplash/Cajeo Zhang
Page 43: Unsplash/Zongnan Bao
Page 49: Unsplash/Jean Beller

Disclaimer

The designations employed and the presentation of materials on the maps do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Recommended citation

United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP) (2022).
https://www.unescap.org/kp/2021/asia-pacific-disaster-report-2021

Acknowledgments

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 2021 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, Tiziana Bonapace, Director, ICT and Disaster Risk Reduction Division (IDD) and Andie Fong Toy, Head, ESCAP Subregional Office for the Pacific provided direction and advice.

The report was prepared by Akash Shrivastav, Armita Behboodi, Fatemeh Safaripaskiaby, Heerae Lee, Joonsoo Jang, Madhurima Sarkar-Swaisgood, Maria Bernadet K. Dewi, Rahul Suman, Rijoo Kim, Sapna Dubey, Shashwat Avi, and SungEun Kim under the guidance of Sanjay Srivastava.

The report was enriched by the comments received from T.C.Lee (Hong Kong Observatory, Hong Kong, China), Mamoru Miyamoto (International Centre for Water Hazard and Risk Management, Japan), Chihun Lee, Hyung Seung Cho, Eunji Seo (National Disaster Management Research Institute, Republic of Korea).

Anoushka Ali edited, proofread and finalized the document for publication. Daniel Feary designed the layout and graphics. Natacha Pitaksereekul provided administrative assistance.

Template map production, guidance and clearance were provided by Guillaume Le Sourd and Heidi Postlewait in the Geospatial Information Section of the United Nations Office of Information and Communications Technology.

Summary

Natural hazards have imposed a huge development burden in East and North-East Asia. The subregion was accounted for 29 per cent of all fatalities from disasters and 35 per cent of the people affected in the Asia-Pacific region in the past decade. Moreover, climate change is reshaping its disaster riskscape, and disaster risk from extreme climate events is intensifying in many parts of the subregion. While the total average annual losses (AAL) is estimated at US$499 billion in the current scenario, the estimation increases up to $1,086 billion under the worst-case climate change scenario.

Climate change is also likely to exacerbate interactions between biological and other hazards. This can affect the underlying risk drivers of poverty and inequality, and further interrupt the achievement of the Sustainable Development Goals (SDGs) in the subregion. While countries in East and North-East Asia have already faced the dual challenge of managing natural hazards amid the COVID-19 pandemic, they will face an increasingly complex set of hazards from climate change and climate-related biological hazards. It is thus essential to ensure that vulnerable populations have sound social protection, before, during and after disasters have hit.

The adaptation cost to climate-related and biological hazards is estimated at less than one-fifth of the AAL, adding to only 1 per cent of the subregional GDP. Thus, economic recovery from the COVID-19 pandemic should include investing in climate adaptation to build resilient economies and populations to future crises, through making new infrastructure and water management systems more resilient, strengthening early warning systems, improving dryland agriculture, and protecting mangroves. This will help ensure the achievements of the Sustainable Development Goals in East and North-East Asia.

Frontier technologies and digital solutions can greatly support building resilience, for example, to improve risk analytics and impact-based forecasting. While strengthening multi-hazard early warning systems is essential in building resilience to natural hazards, as noted in the Sendai Framework for Disaster Risk Reduction 2015-2030, impact-based forecasting can provide valuable information for disaster management agencies, sectoral ministries and other stakeholders for better monitoring and preparation of potential disasters. The utilization of frontier technologies and digital solutions will also require investment in innovation ecosystems that fosters the implementation of resilience-related SDGs.

Contents

CHAPTER 1

The shifting contours of the East and North-East Asia disaster riskscape

Highlights

- Climate change is reshaping the East and North-East Asian disaster riskscape, and disaster risk from extreme climate events, such as extreme temperature, typhoons and droughts, is intensifying in many parts of this subregion.
- In East and North-East Asia, the total average annual losses (AAL) from the newly expanded disaster riskscape, in the current scenario, is estimated at $499 billion.[1] AAL estimation increases to $813 billion under the moderate climate change scenario, and $1,086 billion under the worst-case climate change scenario.
- Climate change, thus, not only reshapes hazard risks, but also exacerbates interactions between biological and other hazards, which in turn affects the underlying risk drivers of poverty and inequality, in a vicious circle.

The disaster riskscape of East and North-East Asia

Over the past 50 years, natural hazards have affected over 3 billion people and more than half a million people have lost their lives in East and North-East Asia.[2] The subregion accounts for 29 per cent of all fatalities from disasters and 35 per cent of the people affected in the Asia-Pacific region (Figure 1-1). Japan recorded the highest number of fatalities in the subregion with close to 20 thousand fatalities in the last decade, accounting for about 70 per cent of all fatalities in the subregion, largely due to the Great East-Japan Earthquake in 2011.[3] The picture dramatically changes when looking at the affected population, with China accounting for 90 per cent of the people affected in the subregion, with an average of 40 million people affected per year. This is then followed by the Democratic People's Republic of Korea with an average of 4 million people affected per year, accounting for 9 per cent of the subregional total.

While many people have been suffering from natural hazards, significant progress has been made in East and North-East Asia in the number of people affected by disasters in the past three decades. In the last decade, specifically, the number of people affected in East and North-East Asia has decreased by 60 per cent (Figure 1-2). Although a sudden increase in the number of fatalities was seen in the decade between 2001 and 2010, this was driven mainly by a single intensive geophysical hazard, the 2008 Wenchuan earthquake in Sichuan Province of China that caused around 87,000 fatalities.[4] Significant progress has been made in reducing the number of fatalities and people affected by hydrometeorological hazards, especially from floods and tropical cyclones in the past three decades.

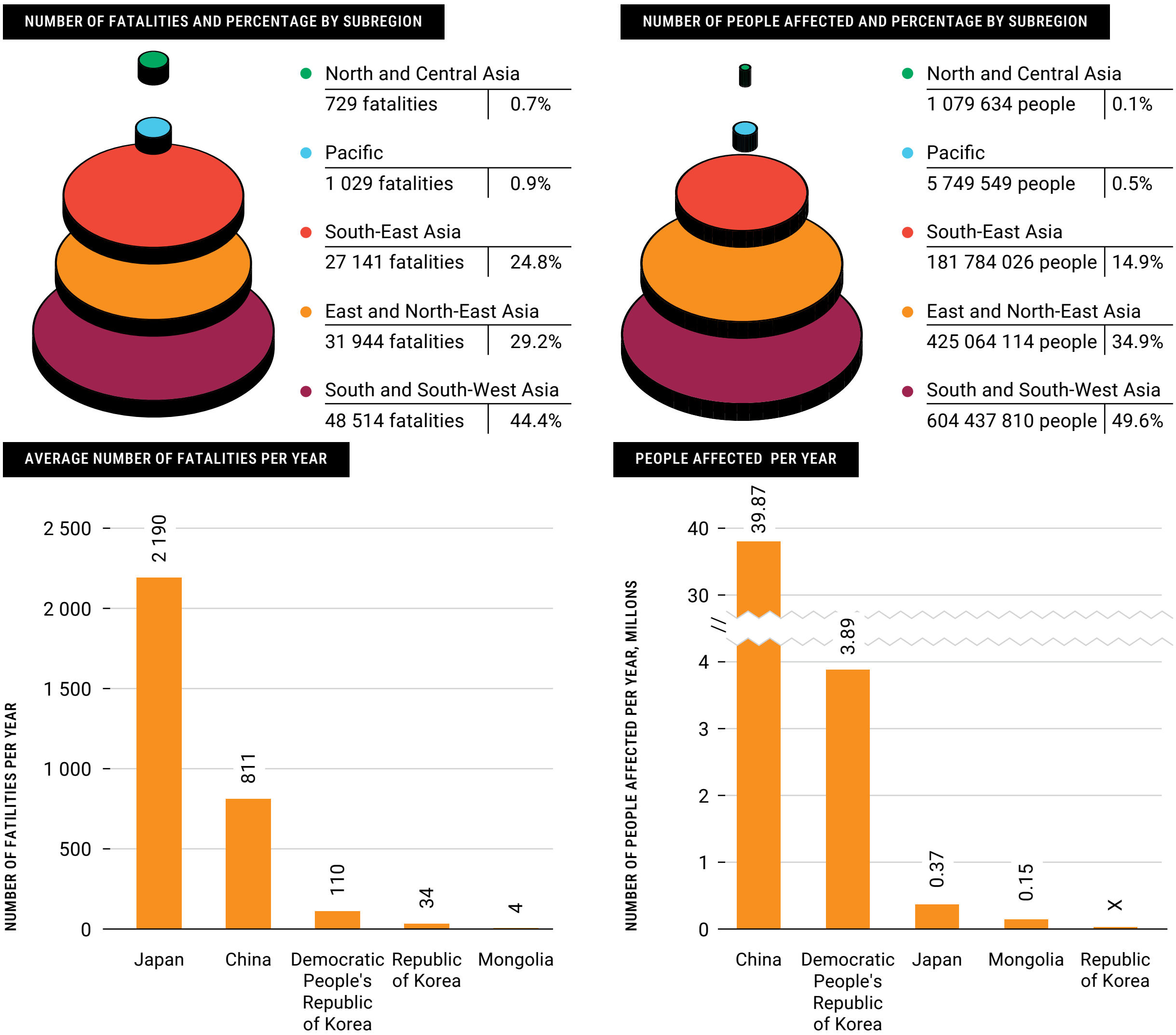
1 References to dollars ($) are to United States dollars, unless otherwise stated.

2 EM-DAT - The International Disaster Database. Available at: http://www.emdat.be (accessed on 1 December 2021).

3 Ibid.

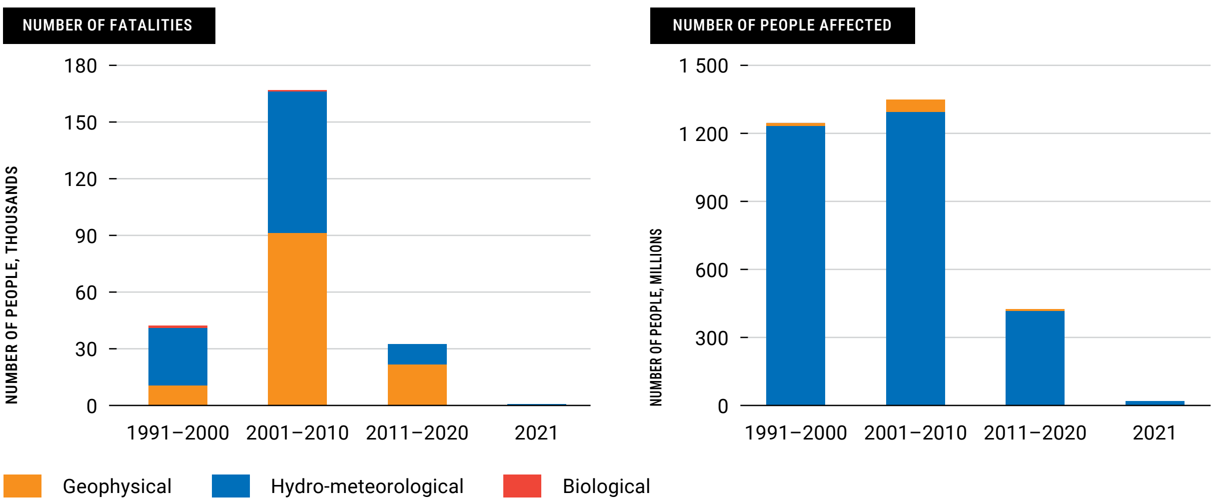
4 Ibid.

FIGURE 1-1 Number of fatalities and people affected in East and North-East Asia and across ESCAP subregions, 2011–2021



Source: EM-DAT - The International Disaster Database. Available at: http://www.emdat.be (accessed on 10 March 2022).

FIGURE 1-2 Number of fatalities and people affected by natural hazards in East and North-East Asia, 1991–2020



Source: EM-DAT - The International Disaster Database. Available at: http://www.emdat.be (accessed on 10 March 2022).

While some risks are declining, others are intensifying

Climate change is reshaping the East and North-East Asian disaster riskscape, with the risks from extreme temperatures increasing significantly. Countries in East and North-East Asia are experiencing extreme temperatures, often in the form of heatwaves. In the last three decades, the number of fatalities resulting from heatwaves has more than quadrupled to 796 deaths, in the 2011–2020 time period, from only 144 deaths between 1991 and 2000. The number of people affected by extreme temperatures is also rapidly increasing from just over 100,000 to close to 5.7 million people in the past three decades.[5] Many events in recent years highlight the increasing risk posed by heatwaves in East and North-East Asia, including:

- *2010* – In June 2010, the Russian Federation was hit by a severe heatwave, lasting two months, with temperatures soaring as high as 40˚C. The extreme temperature caused around 30,000 wildfires in more than 20 regions of the Russian Federation.[6] The record high temperatures combined with poor air quality, resulting from the wildfires, led to more than 55,000 fatalities. This occurred only a few months after two consecutive cold waves hit the country in the winter of 2010, with temperatures reaching as low as -51˚C. Not only did these events severely impact the people, but they also resulted in economic damages amounting to over $400 million.[7]
- *2018* – In July 2018, extreme high temperatures were recorded across the Korean peninsula and Japan. Across Japan and the Republic of Korea, temperatures as high as 40˚C were recorded.[8] Over 49,000 people in Japan, and almost 14,000 people in the Republic of Korea were affected by the high temperatures with agricultural producers particularly affected in southern provinces of the Republic of Korea.[9]
- *2020* – The summer of 2020 was exceptionally hot in many East and North-East Asian countries. The Siberian region of the Russian Federation experienced record-breaking high temperatures. This unusual increase in temperature is a result of climate change (Box 1-1). Hong Kong, China broke its record of most hot nights in a month, with 13 consecutive hot nights in mid-June followed by 11 consecutive nights in early July. The eastern and western parts of Japan also experienced high temperatures, with Hamamatsu tying the Japanese national record of 41.1˚C.[10]

The risk of heatwaves is likely to continue increasing, which will also substantially impact various sectors including agriculture, health and water management. Under 'RCP (Representative Concentration Pathways) 8.5', the number of summer days with a maximum temperature more than 25˚C is projected to increase in many areas, especially those in the southern part of China bordering Thailand, the Lao People's Democratic Republic, Viet Nam, and the Republic of Korea (Figure 1-3).

It is also reported that the intensity of typhoons, especially super typhoons with a high maximum surface wind speed of over 100 knots or more, has increased in the last four decades in the western North Pacific. The third assessment of the ESCAP/WMO Typhoon Committee also highlighted the plausible increases in the intensity of tropical cyclones, the precipitation rate, and storm surge/coastal inundation risks as well as changes in prevailing tropical cyclone tracks in the western North Pacific in the foreseeable future.[11] Climate change is also likely to increase the occurrence and intensity of droughts, especially in the drylands in the southern parts of East and North-East Asia, and increase flood risks in flood-prone areas and coastal areas of southern China, Japan and the Republic of Korea, assessed by maximum five-day cumulative precipitation amount projected.[12]

5 Ibid.

6 Reliefweb, "Russian Federation: Wild Fires/Heatwave - Jul 2010". Available at: https://reliefweb.int/disaster/wf-2010-000147-rus.

7 EM-DAT - The International Disaster Database. Available at: http://www.emdat.be (accessed on 1 December 2021).

8 Reliefweb, "DPR Korea: Heat Wave – Aug 2018". Available at: https://reliefweb.int/disaster/ht-2018-000126-prk

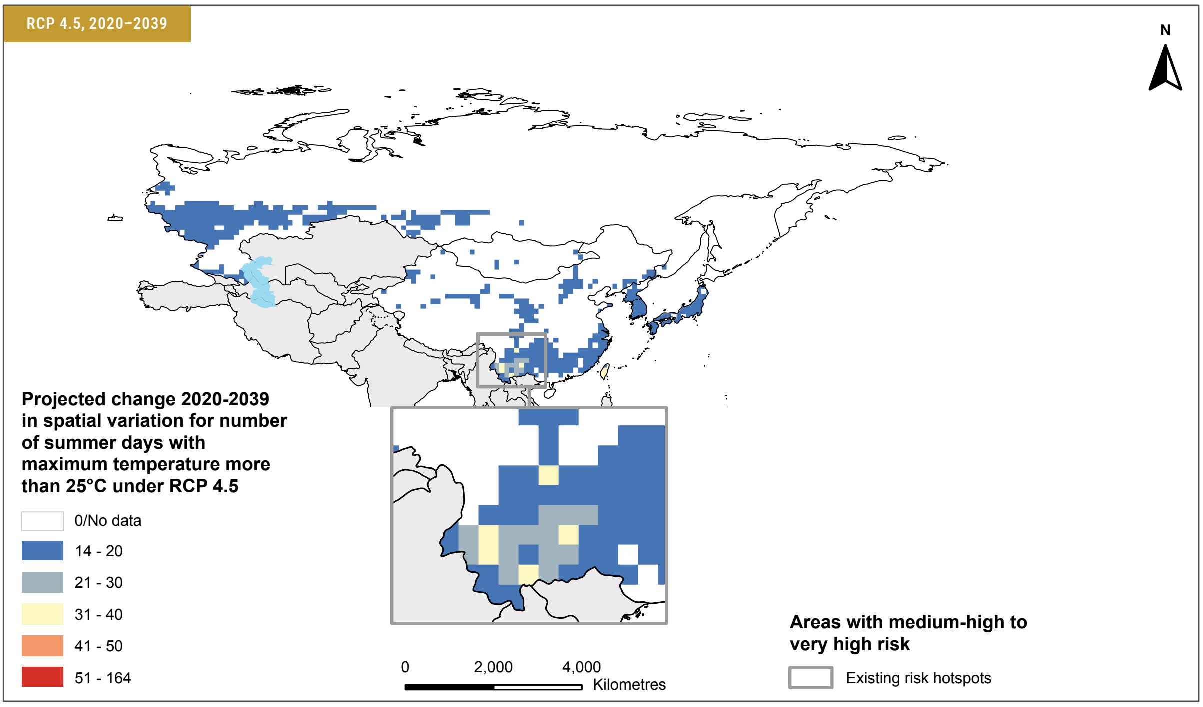
9 EM-DAT - The International Disaster Database. Available at: http://www.emdat.be (accessed on 1 December 2021).

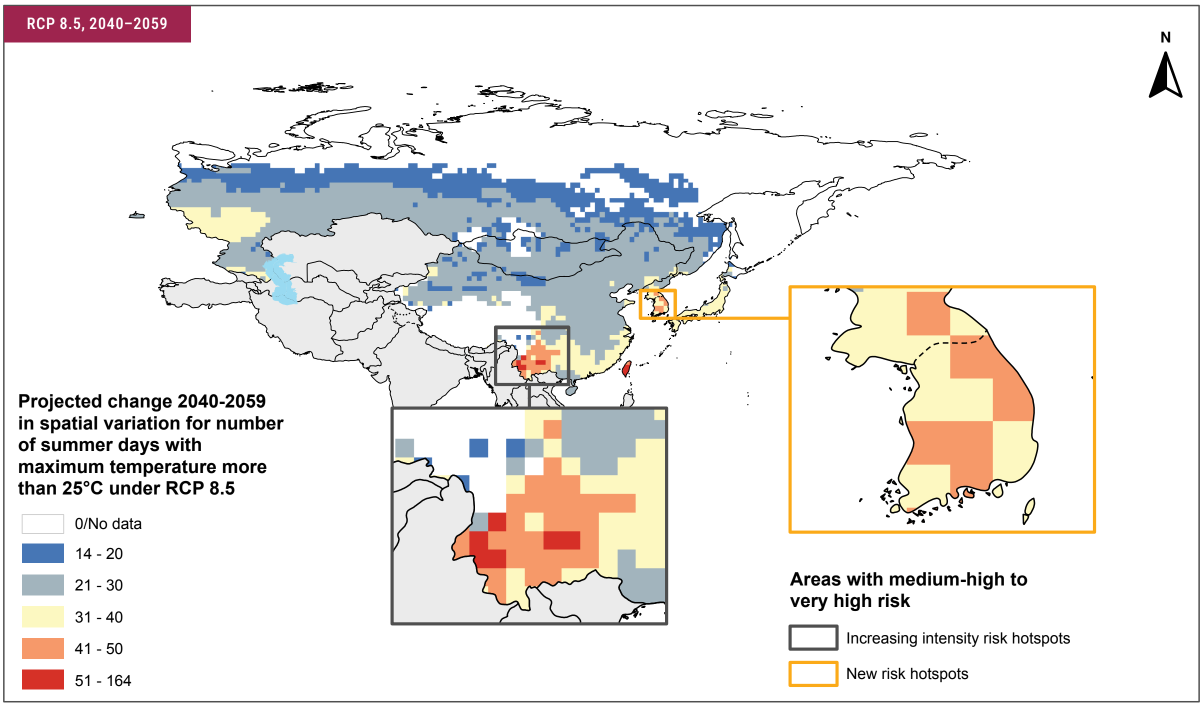
10 World Meteorological Organization (WMO), "State of the Climate in Asia", WMO-No.1273, 2020. Available at: https://reliefweb.int/sites/reliefweb.int/files/resources/1273_State_of_the_Climate_in_Asia_2020_en.pdf

11 Eun Jeong Cha, and others, "Third assessment on impacts of climate change on tropical cyclones in the Typhoon Committee Region – Part II: Future Projections", *Tropical Cyclone Research and Review*, vol. 9, No. 2 (June 2020), pp. 75-86. Available at: https://doi.org/10.1016/j.tcrr.2020.04.005

12 *Asia-Pacific Disaster Report 2021* (United Nations publication, 2021a).

FIGURE 1-3 **Projected change in the number of days with temperature over 25˚C in East and North-East Asia, RCP4.5, 2020–2039 and RCP 8.5, 2040–2059**



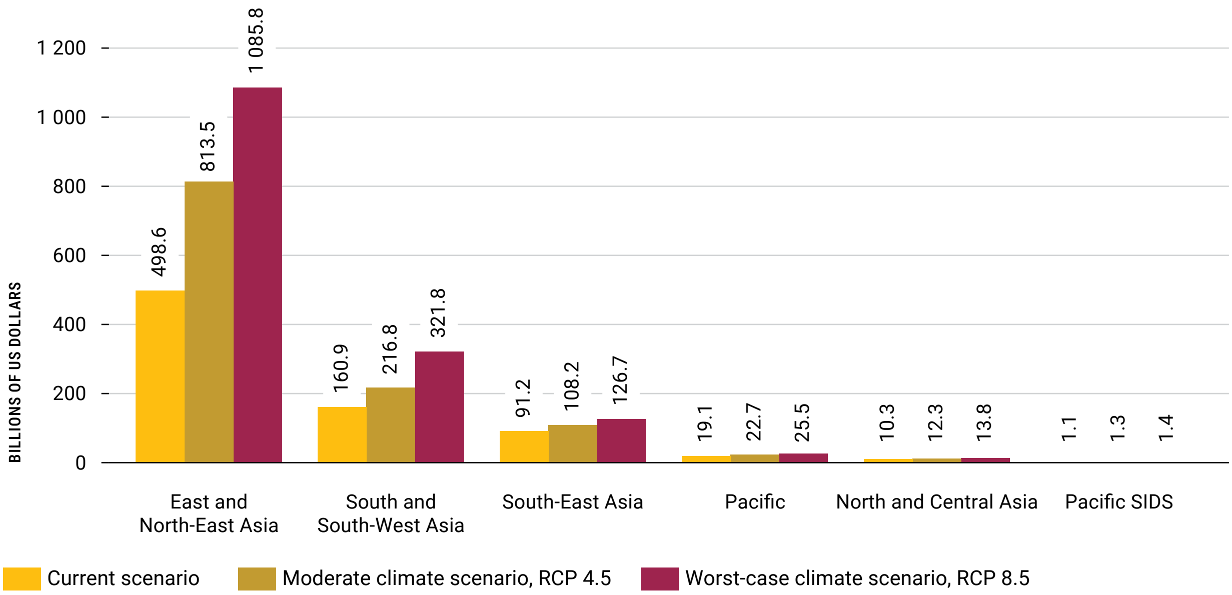


Sources: Climate Change Knowledge Portal, 2018; and UN Geospatial.
Notes: Projected Change 2020-2039 and 2040-2059 in Spatial Variation for Number of Summer Days with Maximum Temperature More than 25° under RCP 4.5 and 8.5 ranges from 14 days to maximum number of days.
Disclaimer: The boundaries and 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 economic cost of cascading hazards and climate change

ESCAP has estimated the economic costs stemming from the combined impacts of the disaster-climate-health nexus. For this purpose, it considers two climate change scenarios using 'RCPs'. **In East and North-East Asia, the total average annual losses (AAL) from the newly expanded disaster riskscape in the current scenario is estimated at $499 billion.**[13] **This estimation increases to $813 billion under the moderate climate change scenario and $1,086 billion under the worst-case climate change scenario, making East and North-East Asia the subregion with the highest total losses from disasters** (Figure 1-4).

FIGURE 1-4 **Annual Average Losses from cascading hazards in Asia-Pacific subregions**



Source: ESCAP calculation based on Disaster Risk Resilience Portal.
Note: Pacific SIDS = Pacific small island developing States

In absolute terms under the worst-case scenario, China has the highest estimated AAL at $831 billion, followed by Japan at $184 billion, and the Republic of Korea at $39 billion (Figure 1-5). However, when assessed as a percentage of the country's GDP, the picture changes. China remains at the top with AAL accounting for 6 per cent of GDP, but is now followed by Mongolia at 4.4 per cent and Japan at 3.7 per cent under the worst-case climate change scenario (Figure 1-6).

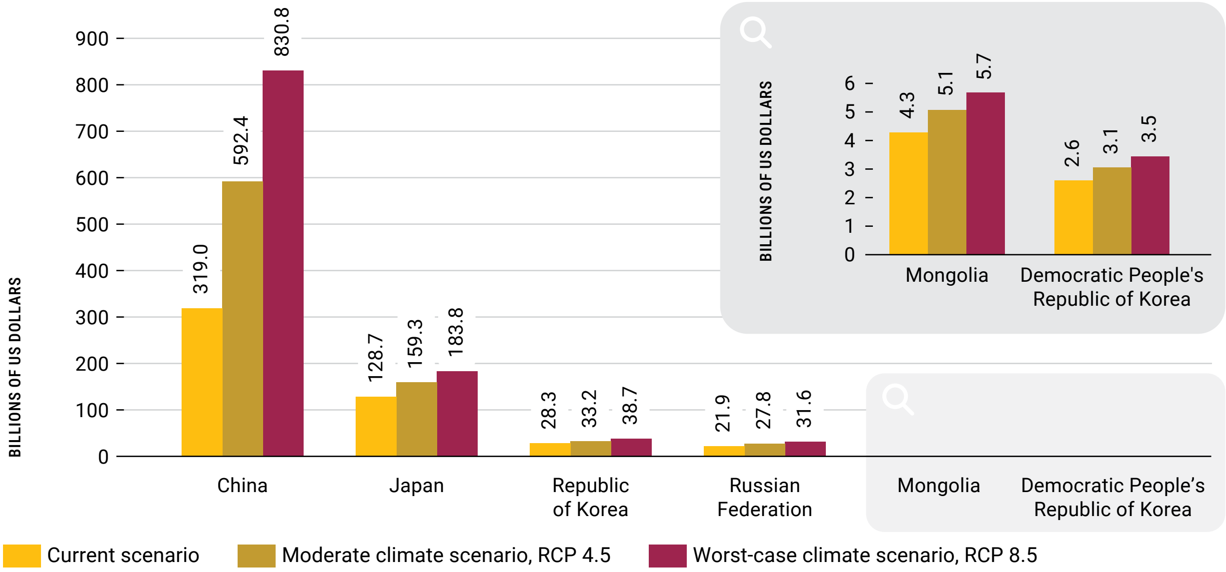
A riskscape of cascading hazards

The convergence of biological and natural hazards with climate change has added to the stresses of climate-related disasters in East and North-East Asia. The increasing frequency, intensity and unpredictability of such disasters are already battering vulnerable sectors and communities. Overlapping hazards, along with the interconnectedness of economies at different scales, are creating systemic risks that demand more sustained and rigorous approaches.[14]

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

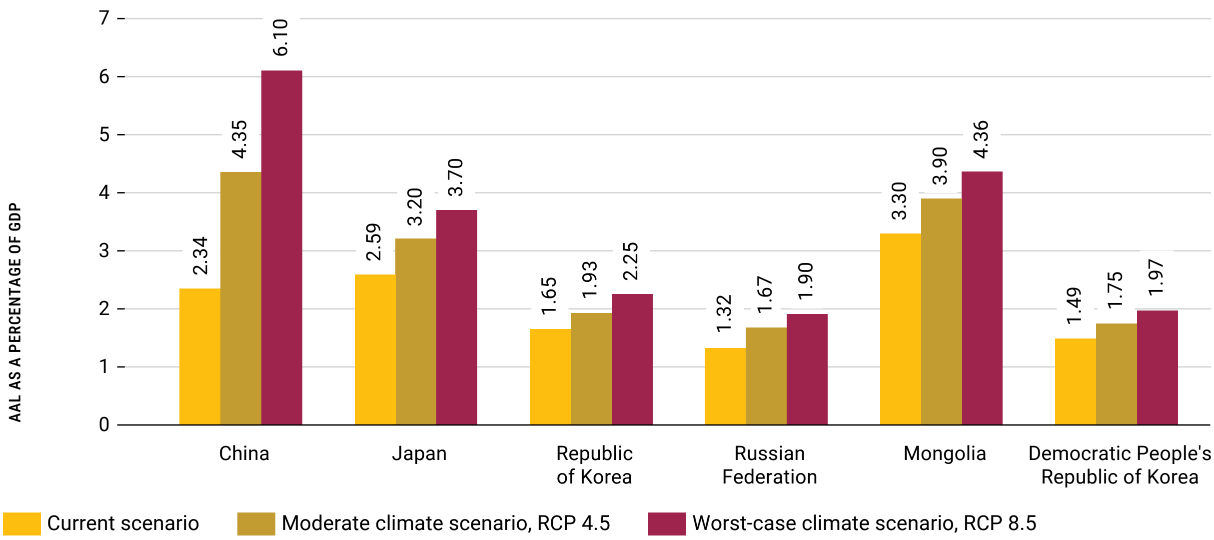
14 United Nations Office for Disaster Risk Reduction (UNDRR), "Integrating Disaster Risk Reduction and Climate Change Adaption in the UN Sustainable Development Cooperation Framework", Geneva, 2020.

FIGURE 1-5 Average Annual Loss (AAL) in East and North-East Asia from cascading risks under current, moderate (RCP 4.5), and worst-case (RCP 8.5) climate change scenarios, $ billions



Source: ESCAP calculation based on Disaster Risk Resilience Portal.

FIGURE 1-6 Average Annual Losses (AAL) as a percentage of GDP under current, moderate (RCP 4.5), and worst-case (RCP 8.5) climate change scenarios for East and North-East Asian countries



Source: ESCAP (2021) estimation based on Disaster Risk Resilience Portal.

Table 1-1 provides a snapshot of how climate change could alter the geography and intensity of natural and biological hazards and increase their combined impacts in various countries in East and North-East Asia. These challenges were already identified in the Sendai Framework for Disaster Risk Reduction 2015–2030. The framework recognized the importance of health threats, including biological hazards, which encouraged the co-development of health emergency and disaster risk management.[15] Climate change, thus, not only reshapes hazard risks, but also exacerbates interactions between biological and other hazards, which in turn affects the underlying risk drivers of poverty and inequality, in a vicious circle.

15 Natalie Wright and others, "Health emergency and disaster risk management: Five years into implementation of the Sendai Framework", *International Journal of Disaster Risk Science*, vol. 11 (2020), pp. 206–217. Available at: https://link.springer.com/article/10.1007/s13753-020-00274-x

TABLE 1-1 ## Impacts of climate change on natural and other biological hazards

Country	Climate Change Risk	Related biological and health crisis
China	Increase in drought	Undernutrition due to food insecurity
	Increase in precipitation and flooding	Increase in vector-borne disease risk
	Increase in average temperature	Increase in malaria incidences and transmission[16]
		Every 1°C increase in monthly average temperature could lead to a 1.96 times increase in the population at risk for dengue fever transmission[17]
	Increase in winter temperature	Increase range and spread of Angiostrongylus cantonensis
	Increase in average temperature and relative humidity	Increase in Japanese encephalitis
Japan	Increase in heatwaves	Increase in excess death due to heatwaves by 0.2%
	Increase in temperature	Spread of vector-borne diseases, including the spread of dengue fever to Hokkaido
		Increased allergy-related diseases from Japanese cedar pollen
	Increase in precipitation and flooding	Increase in infectious gastroenteric cases by 8%
Mongolia	Increase in temperature[18]	Increase in acute watery diarrhoea, salmonella, and under-5 mortalities, which the increased scarcity of water will exacerbate
		Decreased food security and increased vector-borne diseases
	Increase in precipitation and flooding	Increase in tick-borne encephalitis
Republic of Korea	Increase in heatwaves	Increase in excess death due to heatwave by 0.3%
	Increase in sea-level rise and flooding	Increase DAILY for cardio and cerebrovascular by 131%
Russian Federation	Climate-induced changes in habitat and migration routes of animals	Facilitated spread of infection to humans
	Climate change – Increased temperature, notably reduced number of days below -10°C affecting ixodic ticks.[19]	Increasing infectious agents of tick-borne encephalitis and borreliosis due to increased chance of survival during winter

16 Li Bai, Lindsay C. Morton and Qiyong Liu, "Climate change and mosquito-borne diseases in China: a review", *Globalization and Health*, vol. 9, No. 10 (2013). Available at: https://doi.org/10.1186/1744-8603-9-10

17 Pei-Chih Wu and others, "Weather as an effective predictor for occurrence of dengue fever in Taiwan", *Acta Tropica*, vol. 103, No.1 (July 2007), pp. 50–57.

18 World Health Organization (WHO), "Strengthen control of vectorborne diseases to lessen the impact of climate change in the Western Pacific Region with focus on Cambodia, Mongolia and Papua New Guinea: Final project report", WHO Regional Office for the Western Pacific, 2012.

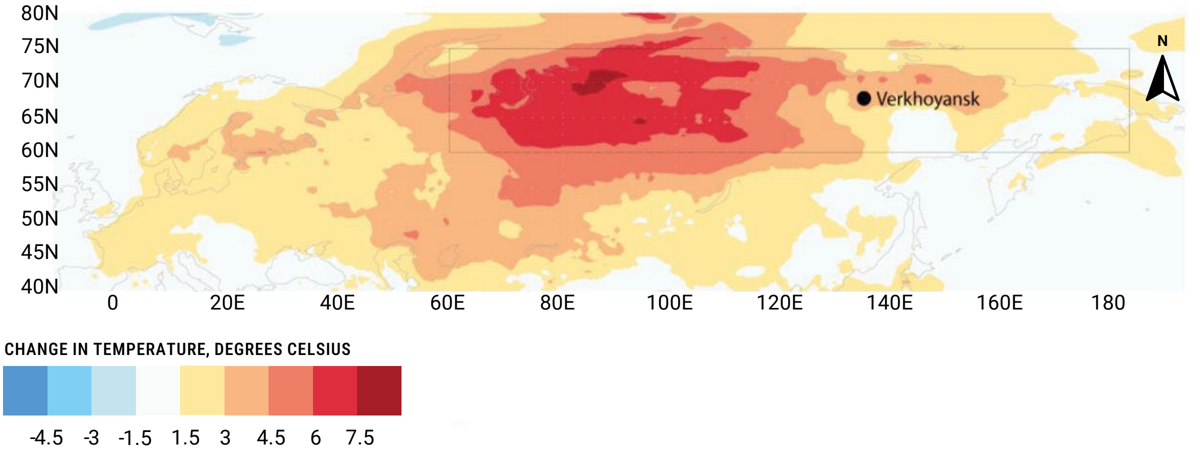
19 Boris Revich, Nikolai Tokarevich and Alan J. Parkinson, "Climate change and zoonotic infections in the Russian Arctic", *International Journal of Circumpolar Health*, vol. 71, No. 1 (July 2012). Available at: DOI: 10.3402/ijch.v71i0.18792

BOX 1-1

2020 Siberian heatwave – climate change and heatwaves[a]

Abnormally high temperatures were reported throughout Siberia, the Russian Federation, at the beginning of 2020. The average temperature, between January and May, was 5.3°C above the 1951-1980 average. The temperature reached a high of 38°C, which is a new record high for the Arctic Circle. A study by the World Weather Attribution concluded that the prolonged heat in Siberia would have been close to impossible without the influence of human-caused climate change.

FIGURE 1-A **Persistent warm anomalies across the Siberian region from January to June 2020**



Source: World Weather Attribution (2020), Prolonged Siberian heat of 2020.
Disclaimer: The boundaries and names shownand the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Source: World Weather Attribution, "Siberian heat of 2020 almost impossible without climate change", 15 July 2020. Available at: https://www.worldweatherattribution.org/siberian-heatwave-of-2020-almost-impossible-without-climate-change/

By comparing the current climate with 1°C of global warming to what it would have been without climate change through simulation, the study showed that the prolonged heat was 600 times more likely to occur due to climate change decreasing the return period to 130 years. The study warns that, by 2050, such warm periods in the first 6 months of the year will become more frequent with average temperatures being at least 0.5°C warmer, and possibly up to 5°C warmer. In addition, the increase in temperatures, particularly the increased occurrence of wildfires, can harm the environment. 7,900 square miles of Siberia burned during the 2020 heatwave, which led to the release of 56 megatons of CO_2, which is equal to more than the yearly emissions of certain countries. Thus, efforts are needed to reduce the risks of increasing temperature.

a World Weather Attribution, "Siberian heat of 2020 almost impossible without climate change", 15 July 2020. Available at: https://www.worldweatherattribution.org/siberian-heatwave-of-2020-almost-impossible-without-climate-change/

CHAPTER 2

Managing disasters during a global pandemic

Highlights

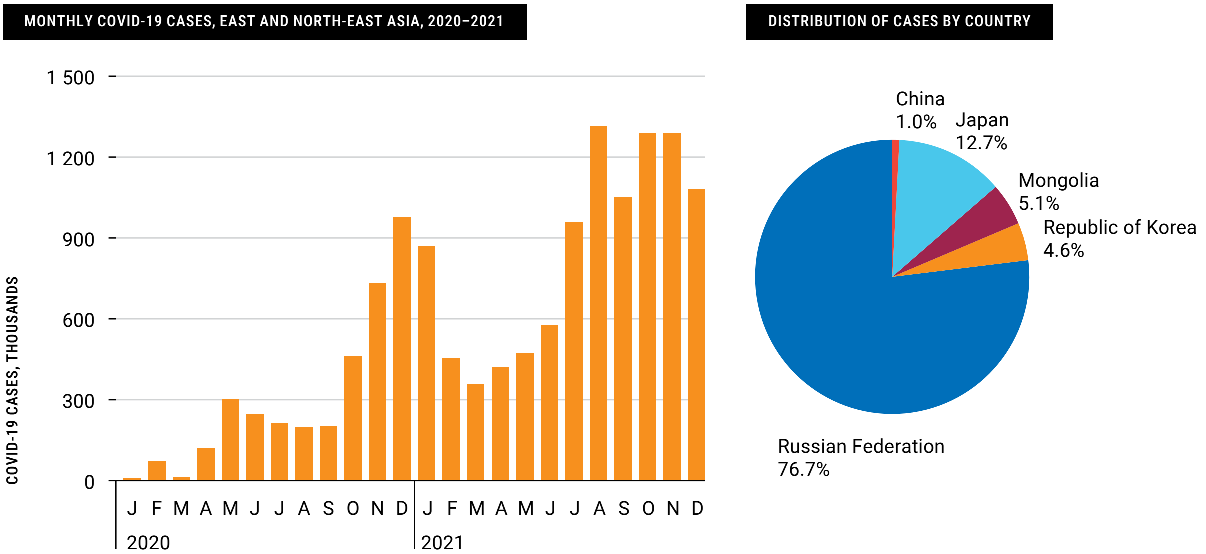
- Countries in East and North-East Asia faced the dual challenge of managing natural hazards amid the COVID-19 pandemic, which made their response very difficult.
- East and North-East Asia will face an increasingly complex set of hazards from climate change and climate-related biological hazards.

COVID-19-compounded disasters

In East and North-East Asia, like other subregions in Asia and the Pacific, countries faced the dual challenge of addressing the COVID-19 pandemic and managing natural hazards. Impacts of the biological hazard were compounded by typhoons, floods, and heatwaves, making it more difficult to respond effectively.

Concurrently, countries are still coping with the COVID-19 pandemic, a disaster of unimaginable proportions and the worst biological shock of the century. In the early stages of the pandemic, East and North-East Asia had been exemplary in managing the pandemic, resulting in the subregion being impacted the least. However, the subregion also saw sudden rises in COVID-19 confirmed cases throughout 2020 and 2021. The pandemic had the most significant impact in the Russian Federation, with 10.5 million confirmed cases followed by Japan with just over 1.7 million confirmed cases (Figure 2-1).[20]

FIGURE 2-1 **COVID-19 cases in East and North-East Asia, 1 January 2020–31 December 2021**

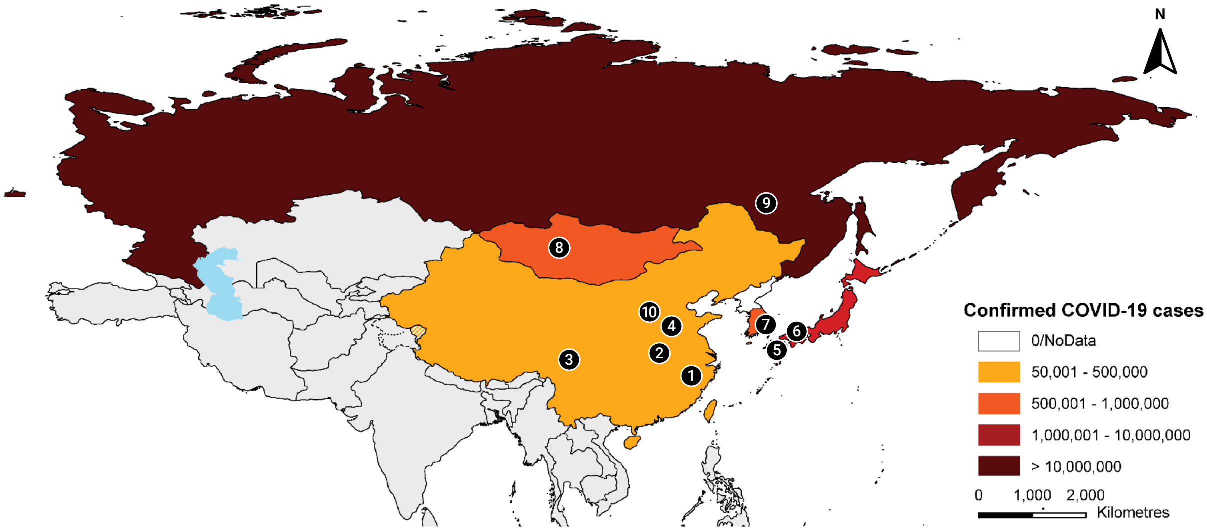


Source: World Health Organization (WHO), "WHO Coronavirus (COVID-19) Dashboard". Available at https://covid19.who.int

While the COVID-19 pandemic raged on, East and North-East Asia continued to experience other natural hazards, many of which were hydrometeorological (Figure 2-2). Typhoons hit many countries, and major flood events were reported in China, and Japan, among others. These complex and cascading disaster risks made it difficult for countries in East and North-East Asia to respond to these intersecting challenges.

20 World Health Organization (WHO), "WHO Coronavirus (COVID-19) Dashboard". Available at https://covid19.who.int (accessed 1 March 2022).

FIGURE 2-2 COVID-19 and disasters in 2020 and 2021



1 CHINA

Hazard: Typhoon 'In-Fa'
Period: 21-28 July 2021
Province: Zhejiang Province
Affected Population: 72 thousand
Damage in US $: 2 billion

2 CHINA

Hazard: Flood
Period: 21 May – 30 July 2020
Province: Yangtze River Basin
Affected Population: 4.2 million
Damage in US $: 17 billion

3 CHINA

Hazard: Flood
Period: 30 June–5 July 2020
Province: Sichuan
Affected Population: 10 million

4 CHINA

Hazard: Flood
Period: 1 June–30 August 2021
Province: Henan
Affected Population: 4.5 million
Damage in US $: 30 billion

5 JAPAN

Hazard: Flood
Period: 29 June–10 July 2020
Province: Kyushu
Affected Population: 250,114 people
Damage in US $: 5.8 billion

6 JAPAN

Hazard: Flood
Period: 11–16 September 2021
Province: Nagasaki; Hiroshima; Kyushu Isl.; Honshu Isl.
Affected Population: 30 thousand
Damage in US $: 100 million

7 REPUBLIC OF KOREA

Hazard: Typhoon Heishen
Period: 6–8 September 2020
Province: Ulsan
Damage in US $: 1.2 billion

8 MONGOLIA

Hazard: Winter storm/blizzard
Period: January 2020
Province: Bayankhongor
Affected population: 22 thousand

9 RUSSIAN FEDERATION

Hazard: Flood
Period: 24 June – 11 August 2021
Province: Transbaikal, Khabarovsk; Jewish Autonomous Region
Affected population: 24 thousand
Damage in US $: 200 million

10 CHINA

Hazard: Flood
Period: 2–10 October 2021
Province: Shanxi, Hebei Provinces
Affected population: 1.76 million
Damage in US $: 1.8 billion

Sources: ESCAP, based on World Health Organization, "WHO Coronavirus (COVID-19) Dashboard". Available at https://covid19.who.int (accessed 31 December 2021); EM-DAT - The International Disaster Database. Available at: http://www.emdat.be (accessed 31 December 2021); and Reliefweb (accessed February 2021); and UN Geospatial.

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.

Responses to disasters during the COVID-19 pandemic

Flooding in China and Japan

In July 2020, amidst the COVID-19 pandemic, Southern China experienced the worst flooding in the last two decades. Thirty-three large-scale heavy rainfalls hit the country within 62 days, mainly concentrated around the Yangtze River.[21] The number of people affected, and the evacuated population were 23 and 62 per cent higher than their five-year annual means, respectively. Japan was also hit by severe flooding, specifically on Kyushu Island.[22] As a result, millions of people were advised to evacuate their homes across both countries with an estimated 1.2 million people evacuated in Kyushu.[23] Reluctancy towards evacuation has always existed for several reasons, but the COVID-19 pandemic intensified it manifold, with people affected by the flooding having to counterweight the risk posed by the flooding and COVID-19 infection.

In response to the risk of contracting COVID-19, shelters were only able to accommodate one-fourth of their usual capacity in Japan. This meant that many people sought shelter in their cars, at friends' houses and hotels to allow space for those with no alternatives and to avoid being in congested areas, due to fear of getting infected with the virus. In addition to the issue of obtaining shelter, shelter management was also very different under the COVID-19 pandemic scenario. Preparing for the combined effects of COVID-19 and any foreseen disasters, the Government of Japan put out an updated set of guidelines for shelter management, covering various aspects of managing an emergency shelter amid a pandemic.[24] Also, due to restrictions in domestic travel, there was a severe shortage of volunteers in the first six weeks after the flooding.

Sand and dust storms

In March 2021, amidst the COVID-19 pandemic, populated areas of East and North-East Asia were hit by the worst sand and dust storms (SDS) in a decade. These extended from the Gobi Desert, and the central and western deserts over Mongolia, to some provinces in North and North-West China including Beijing, affecting 40 per cent of the city's population. The pollution level was 150 times more than the recommended limit (Figure 2-2). SDS affected 66 per cent of the population in the Republic of Korea, and 8 per cent in Mongolia.

These countries issued yellow alerts for sandstorms and followed up with necessary response measures. In Mongolia, the most impacted population group were the herders, who suffered an estimated loss of 1.6 million livestock, which they often depend on for their livelihoods. This was superimposed on the deterioration of livelihoods of agricultural workers due to the COVID-19 pandemic, with nearly 60 per cent of households in agriculture experiencing an income loss of 40 per cent or greater.[25]

The COVID-19 pandemic compounded the economic impacts of SDS, but there were significant health effects as well. The SDS, especially in northern China, led to a substantial increase in air pollution, with levels reaching more than 20 times the healthy limit,[26] increasing concerns of widespread health impacts, including respiratory problems. These new health risks were converging with the already existing health emergency caused by the pandemic.

21 Government of the People's Republic of China, National Disaster Reduction Center of China, "2020 Global Natural Disaster Assessment Report", Reliefweb, 20 October 2021. Available at: https ://reliefweb.int/report/china/2020-global-natural-disaster-assessment-report

22 Ibid.

23 JBA Risk Management Ltd., "Kyushu Island, Japan", 2020. Available at: https://www.jbarisk.com/flood-services/event-response/kyushu-flooding-japan/

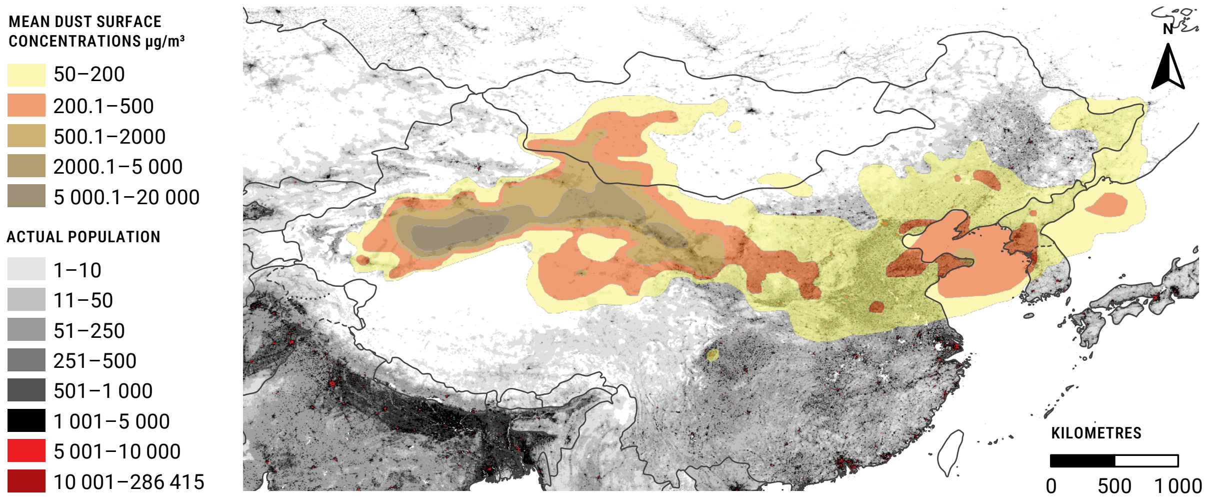
24 CWS Japan and others, "Disaster during a pandemic: Lessons from 2020 flooding in South Japan", January 2021. Available at: https://cwsglobal.org/wp-content/uploads/2021/01/Disaster-During-a-Pandemic-1.6.2021.pdf

25 World Bank Group and National Statistics Office of Mongolia, "Results of Mongolia COVID-19 Household Response Phone Survey (Round 3)", January 2021. Available at: https://thedocs.worldbank.org/en/doc/674291610418865659-0070022021/original/MNGHFphonesurveyR3Final.pdf

26 Scott Lindstrom, "Sandstorm hits Beijing China", Cooperative Institute for Meteorological Satellite Studies (CIMSS), Satellite Blog, 16 March 2021. Available at: https://cimss.ssec.wisc.edu/satellite-blog/archives/40262

FIGURE 2-3 **Populations exposed to sand and dust storms, 15–18 March 2021**

SAND AND DUST STORM FORECAST FOR 15 MARCH 2021, 21:00 UTC



Sources: ESCAP, based on Sand and Dust Storm Warning Advisory and Assessment System Asian Regional Center (SDS-WAS Asian-RC) Sand and Dust Storm Forecast for 15 March 2021, 21:00 and Worldpop Population Counts 2020.

Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

Source: Asia-Pacific Disaster Report 2021 (United Nations publication, 2021a).

Typhoons in Japan and the Republic of Korea

Typhoon Haishen, became the first super typhoon of the 2020 Pacific Typhoon season, as it intensified rapidly on 3 September while passing through Kyushu, Japan. More than 8 million people were ordered or advised to evacuate.[27] Considering the COVID-19 pandemic, the weather officials urged individuals to evacuate earlier than usual, and gave appropriate warnings of the size and strength of the typhoon days in advance. Nevertheless, there were complications in the evacuation procedures with the facilities filling up faster than usual due to the need to maintain social distancing. Given the need for physical distaincing in shelters, the authorities set up additional 10 shelters. However, even with these precautionary measures there remained an overwhelming number of people seeking shelter, leading to over 500 shelters across Kyushu and Yamaguchi Prefecture having to turn away shelter seekers.[28] Avoiding the three 'C's; 'closed spaces', 'crowded places' and 'close-contact settings', was a key priority for shelter planning during the pandemic, but also for shelter seekers, with many choosing to avoid shelters out of fear of the three 'C's and the spread of COVID-19.

On 7 September 2020, Typhoon Haishen made landfall in the Republic of Korea, after leaving 440,000 homes without power, injuring 90 people, damaging 100 houses and causing 2 fatalities near the island of Kyushu, in Japan. Although power outages were reported, with 75,000 households temporarily out of power, and transport infrastructure heavily affected, the Republic of Korea was quick to respond to the events, ensuring transport links were resumed within a day. Over 1,600 residents in the southern parts of the country were evacuated due to the possibility of further landslides and flooding. The typhoon caused damages amounting to $1.2 billion,[29] with 340 flights and 114 shipping routes cancelled.[30] Children were also impacted due to widespread school closure, with 6,000 schools switching to remote learning or cutting class hours.[31]

27 NHK World – Japan, "Coronavirus hampers evacuation efforts during Typhoon Haishen", 8 September 2020. Available at: https://www3.nhk.or.jp/nhkworld/en/news/backstories/1280/

28 Ibid.

29 EM-DAT - The International Disaster Database. Available at: http://www.emdat.be (accessed on 1 December 2021).

30 European Commission's Directorate-General for European Civil Protection and Humanitarian Aid Operations, "Japan, Korean Peninsula – Tropical Cyclone HAISHEN update (DG ECHO, GDACS, JTWC, FDMA, ReliefWeb, media", ECHO Daily Flash, News and Press Release, 8 September 2020. Available at: https://reliefweb.int/report/republic-korea/japan-korean-peninsula-tropical-cyclone-haishen-update-dg-echo-gdacs-jtwc-fdma

31 Sangmi Cha and Sakura Murakami, "Typhoon Haishen threatens Korea after battering Japan", *Reuters*, 7 September 2020. Available at: https://www.reuters.com/article/us-asia-storm/typhoon-haishen-threatens-korea-after-battering-japan-idUSKBN25Y00L

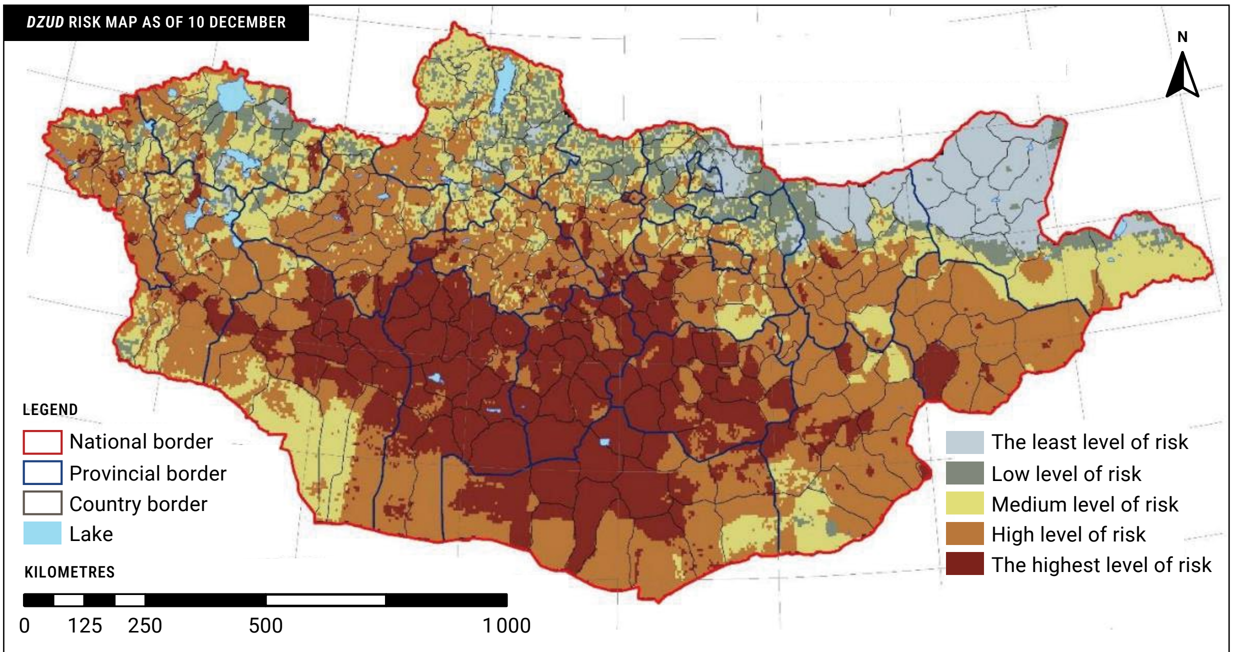
Dzud in Mongolia

Mongolia recurrently suffers from a peculiar weather phenomenon unique to the country, called *dzud,* which are severely cold and harsh winters that kill many livestock. Since 2015, the frequency of *dzuds* has been increasing due to climate change and poor environmental governance.[32]

Figure 2-4 shows the *dzud* risk map, highlighting the high exposure of Mongolia's population to *dzuds*, with 50 per cent of the population being at high risk and 16.5 per cent at very high risk.[33] Mongolia heavily relies on its animal husbandry sector, making up 10 per cent of national exports and employing one-fifth of the population.[34] Herders, and those manufacturing animal products, are often seriously damaged when *dzuds* strike, intensifying pre-existing issues, such as the multidimensional poverty rate, undernourishment and creating migratory flows to urban areas which often lead herders to occupy low-paying jobs with no social security. *Dzuds* have also been linked to increased infant mortality rates and reduced growth in children.[35]

On 2 January 2020, the National Agency for Meteorology and Environmental Monitoring (NAMEM) announced that more than 50 per cent of the country was at risk of *dzud* triggering an Early Action Plan (EAP) for Mongolia. However, by 12 January 2020, it turned out these figures underestimated the 2020 *dzud*, which covered 70 per cent of the country.[36] Cash transfers and distribution of livestock nutrition kits were slowed down due to COVID-19 restrictions that prohibited people from gathering at distribution sites, which only accepted 2–3 people at a time. However, the NAMEM was able to reach the 1,000 households targeted under the EAP.[37]

FIGURE 2-4 ***Dzud* risk map as of 10 December 2020**



Source: National Agency for Meteorology and Environmental Monitoring (NAMEM), 2020.
Disclaimer: The boundaries and names shownand the designations used on this map do not imply official endorsement oracceptance by the United Nations.

Source: National Agency for Meteorology and Environmental Monitoring (NAMEM). Available at https://www.namem.gov.mn

32 Mercy Crops, "The Legacy of Mercy Corps Mongolia: A 22 years summative report", May 2021. Available at: https://www.mercycorps.org/sites/default/files/2021-05/LegacyofMCMongolia22YearReport-ENG.pdf

33 International Federation of Red Cross and Red Crescent, "Forecast-based early action triggered in: Mongolia for Dzud (EAP2020MN02)", Situation report, 21 December 2020a.

34 Asian Development Bank and World Bank Group, "Climate risk country profile: Mongolia", Washington D.C., 2021. Available at: https://www.adb.org/sites/default/files/publication/709901/climate-risk-country-profile-mongolia.pdf

35 International Federation of Red Cross and Red Crescent, "Climate change impacts on health and livelihoods: Mongolia assessment", April 2021. Available at: https://reliefweb.int/sites/reliefweb.int/files/resources/RCRC_IFRC-Country-assessments-MONGOLIA-3.pdf

36 Reliefweb, "Mongolia: Dzud – Jan 2020", 2020. Available at: https://reliefweb.int/disaster/cw-2020-000004-mng

37 International Federation of Red Cross and Red Crescent, "Mongolia/East-Asia: Dzud, Final report early action", July 2020b. Available at: https://reliefweb.int/sites/reliefweb.int/files/resources/MDRMN010EAPfr.pdf

More complex hazards ahead

As climate change intensifies and further biological threats surely lie in wait, East and North-East Asia will face an increasingly complex set of hazards. To combat these, countries will need to take comprehensive action to protect all, especially the most vulnerable, by integrating health and disaster risk management into more robust systems for health and social protection.

BOX 2-1 Challenges on managing disasters during the pandemic — Japan volunteers

In the immediate aftermath of disasters, many countries rely on volunteers for their relief operations. Japan is no exception, with most disaster relief volunteers travelling from outside the affected area. However, the availability of volunteers declined in 2020 and 2021 mainly because of COVID-19 travel restrictions and precautionary measures.

For example, the flooding in July in Kumamoto and Kagoshima led to 83 causalities, while also damaging infrastructure, including 15,335 buildings. Following this event, both skilled and unskilled volunteers were needed to operate shelters, physical and mental care facilities, food distribution centres, aid in reconstruction efforts, and provide legal assistance for those who lost assets during the flooding. However, the restrictions on the movement of people from outside of the prefecture led to a severe shortage of volunteers during the first six weeks after the disaster. The volunteer turnout fell short of planning expectations. As a result, the initial response was led by organizations already set up locally from previous disasters, which then played an essential role in linking people affected to larger organizations outside of the prefecture.[a] In addition to the shortage of volunteers, those who did volunteer needed to be carefully assessed to ensure that they neither carried the virus nor had come in close contact with it. Volunteers were also asked to follow a series of preparatory health routines, such as checking their temperature at regular intervals, and were expected to always follow specific guidelines.

The fear of contracting COVID-19 and the related preventive measures have impeded the recovery efforts of multiple disasters during the pandemic.

a CWS Japan and others, "Disaster during a pandemic: Lessons from 2020 flooding in South Japan", January 2021. Available at: https://cwsglobal.org/wp-content/uploads/2021/01/Disaster-During-a-Pandemic-1.6.2021.pdf

CHAPTER 3

Hotspots of exposure and vulnerability to cascading risks

Highlights

- In East and North-East Asia, under the worst-case climate change scenario, over 1.3 billion people, or 74 per cent of the subregional population will be exposed to multi-hazard risks from climate-related hazards. Countries in East and North-East Asia are becoming particularly vulnerable to intensifying risks from heatwaves and related diseases, and desertification.
- The elderly population and people with disabilities, among others, are acutely vulnerable in the face of cascading hazards. Also, natural hazards have triggered internal displacements. It is essential to ensure that vulnerable groups have sound social protection, before, during and after disasters have hit.
- A significant proportion of energy and transport infrastructure is exposed to multi-hazard risk.

Climate change and expanding hotspots of cascading hazards

East and North-East Asia has several risk hotspots mainly from earthquakes, floods and tropical cyclones, with the most exposed populations concentrated in the eastern part of China, Japan, and the Republic of Korea. **With changing climate variables, the risks from climate-related disasters are increasing in many parts of the subregion.** The areas, already vulnerable to natural hazards, are now faced with a more complex riskscape from changing climate conditions and associated risks from biological hazards.

Multi-hazard risks (from climate-related hazards)

Figure 3-1 illustrates the population exposure to risks associated with climate-related hazards and related diseases. **Under the worst-case climate change scenario, over 1.3 billion people or 74 per cent of the subregional population will be exposed to multi-hazard risks from climate-related hazards.** In this scenario, not only will existing hotspots expand and become more complex in China, Japan, the Democratic People's Republic of Korea, and the Republic of Korea, but new hotspots will emerge in the Russian Federation and Mongolia.

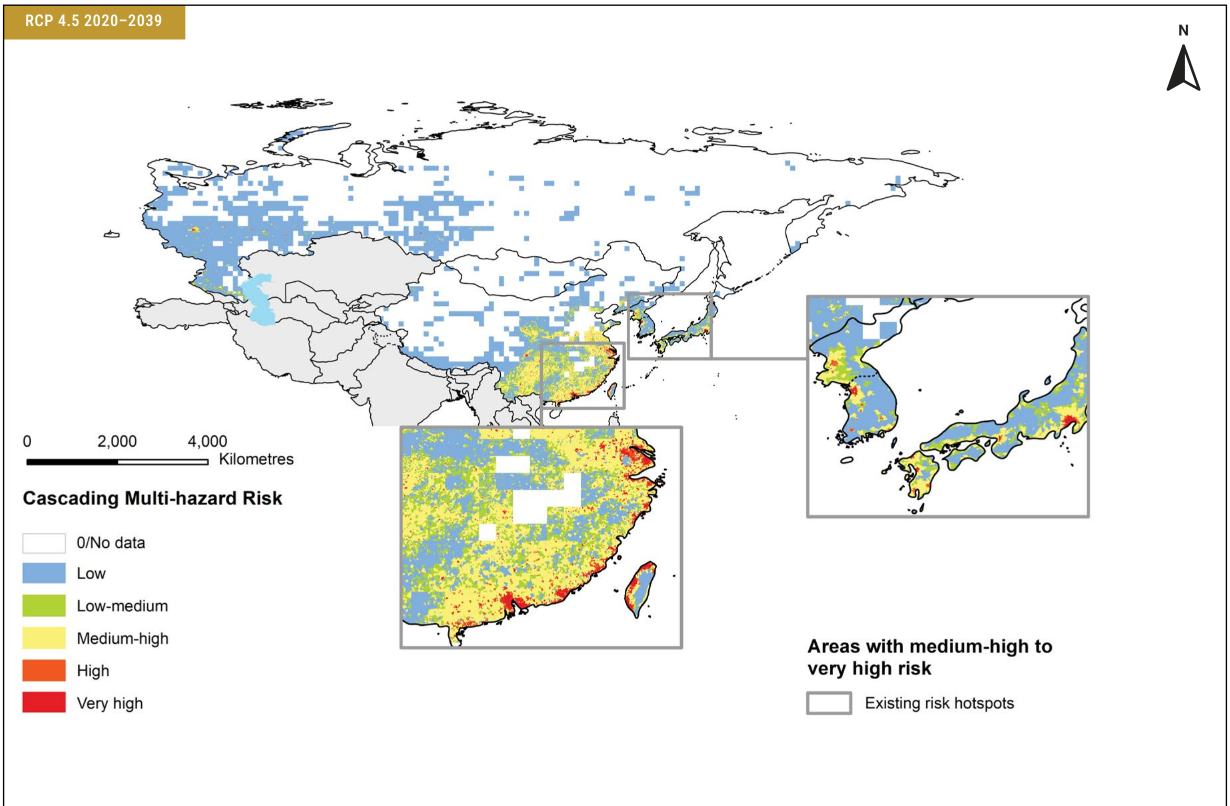
Heatwaves and climate-related diseases

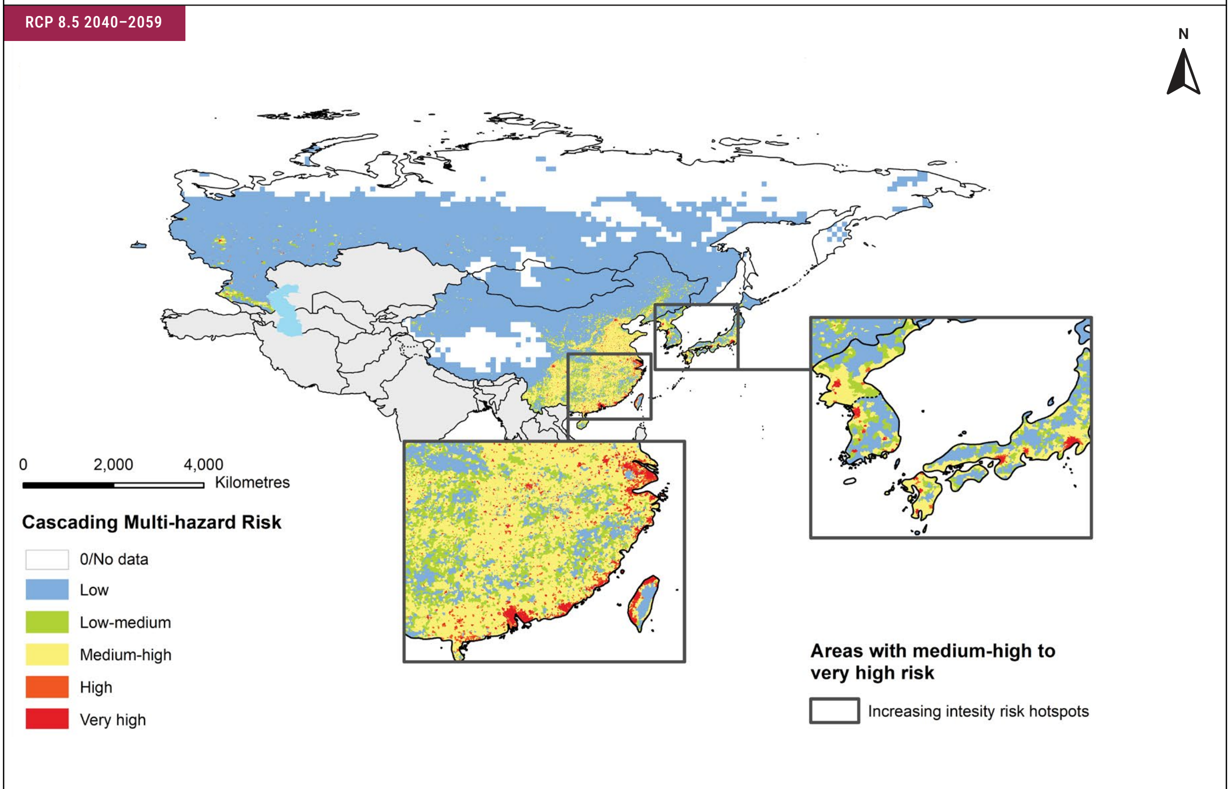
Countries in East and North-East Asia are becoming more vulnerable to additional risks from heatwaves and its related diseases, which directly affect human health and have high economic and social costs. Under the worst-case climate change scenario, the number of people exposed to heatwaves will increase by 841 million in this subregion (Figure 3-2).

Climate change will have the highest absolute effect on population exposure to heatwaves and related diseases in China, with exposure increasing from 601 million people under the current scenario to 1.4 billion people under the worst-case climate scenario (Figure 3-3). This is partly due to the sizeable population in China; the number changes significantly when assessing a country's population exposure as a percentage of the national population.

When assessing risk as a percentage of the total population, the impact of heatwaves in most countries in East and North-East Asia is very significant and it will only continue to increase with climate change. Under the worst-case scenario, China, Japan, the Republic of Korea, and the Democratic People's Republic of Korea will have over 90 per cent of their populations exposed to heatwaves. The Russian Federation and Mongolia, although at slightly lower amounts, still have above 60 per cent of their population exposed to heatwaves (Figure 3-4).

FIGURE 3-1 **Emerging multi-hazard risk hotspots from climate-related hazards and climate change in East and North-East Asia**





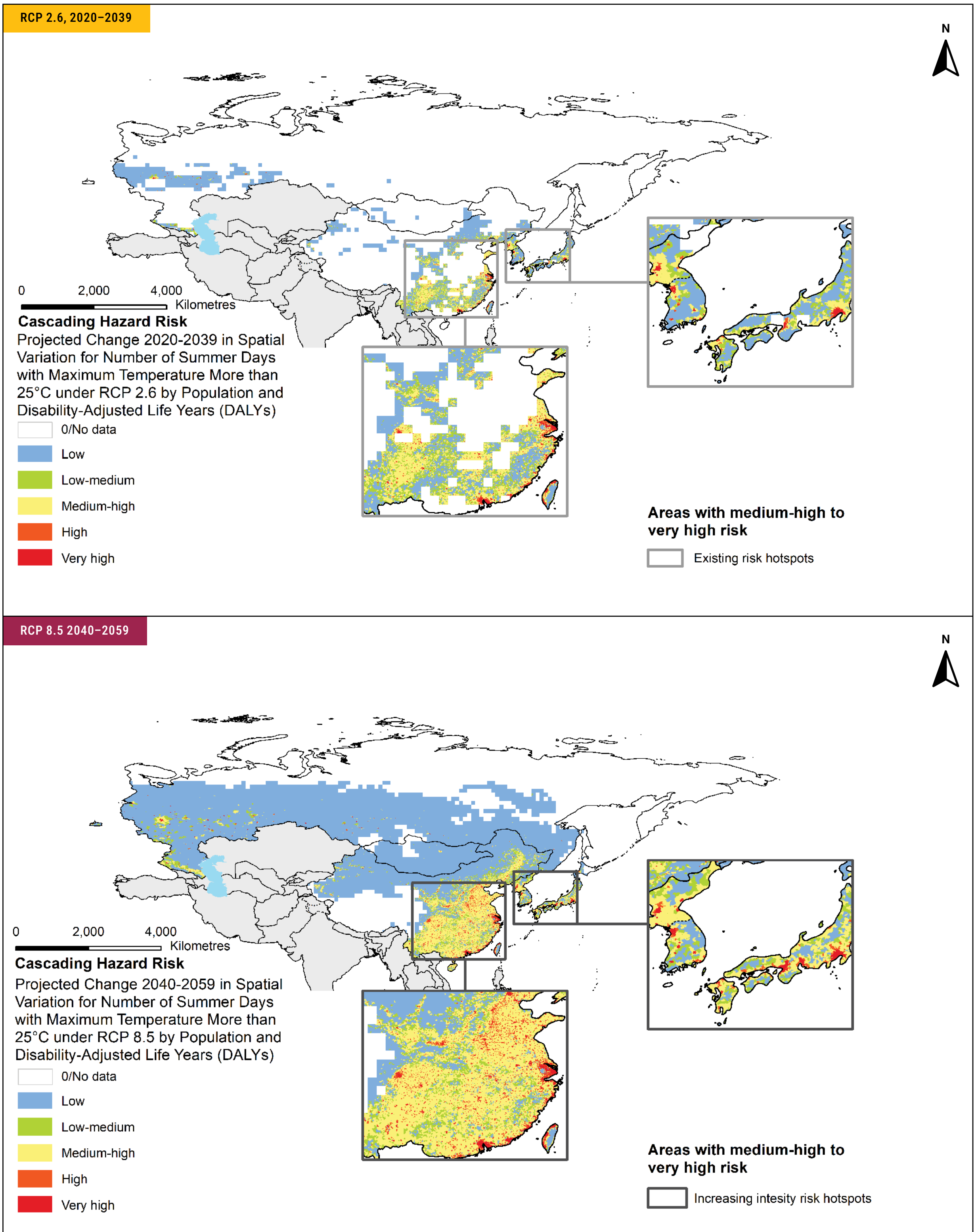
Sources: ESCAP calculations, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015; Climate Change Knowledge Portal, 2018; UN WPP-Adjusted Population Density 2020, v4.11; and Disability-Adjusted Life Years (DALYs) estimates 2000-2019; and UN Geospatial.

Note: 1. Cascading Hazard Risk is obtained from multi-hazard file that consists of highest intensity of GAR Cyclone Wind within 100 year return period; Climate projection data for flood, drought and heatwaves under RCP 4.5 in 2020–2039 and under RCP 8.5 in 2040–2059 by Population and DALYs for related multi-hazard.

2. Current scenario refers to RCP 4.5 in 2020-2039. The worst case scenario refers to RCP 8.5 in 2040–2059.

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 3-2 **Population exposure to heatwaves and related diseases current and under the worst-case (RCP 8.5) scenarios in East and North-East Asia 2040-2059**



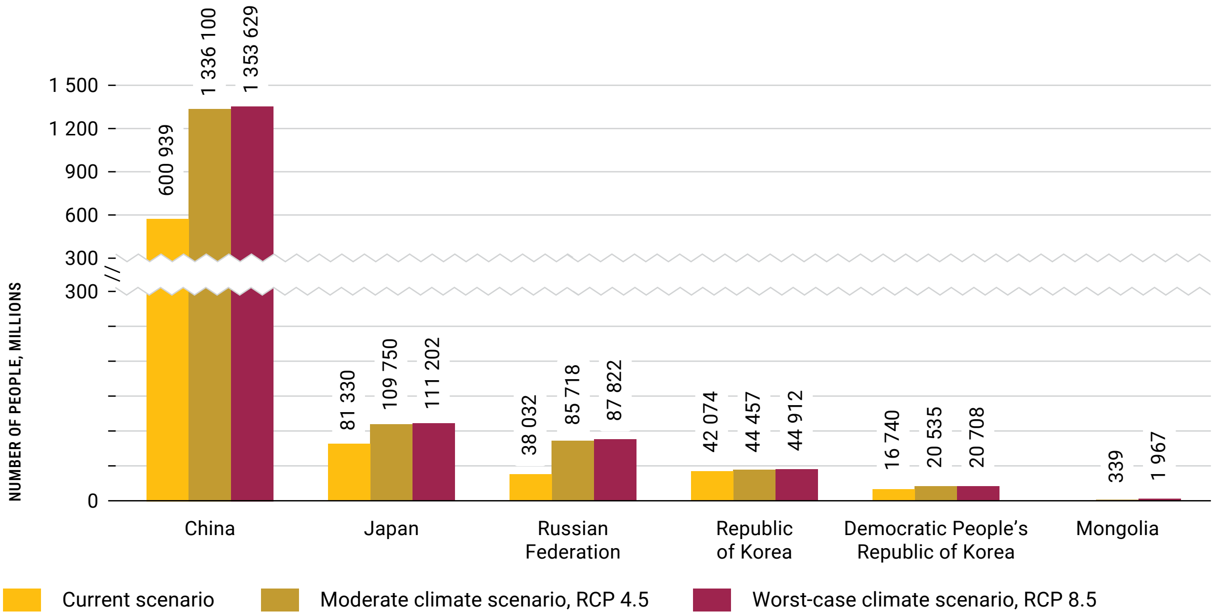
Sources: ESCAP calculations, based on Climate Change Knowledge Portal, 2018; UN WPP Adjusted Population Density 2020, v4.11; and Disability-Adjusted Life Years (DALYs) estimates 2000-2019; and UN Geospatial.

Note: 1. Cascading Hazard Risk is obtained from Projected Change in Spatial Variation for Maximum Number of Summer Days with Maximum Temperature More than 25°C by Population and Disability-Adjusted Life Years (DALYs).
2.Projected Change in Spatial Variation for Number of Summer Days with Maximum Temperature More than 25°C under RCP 2.6 and RCP 8.5 ranges from 14 days to maximum number of days.
3. DALY indicators for drought related diseases consist of nutritional and vitamin deficiencies.

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 3-3 Population exposure to heatwaves and related diseases

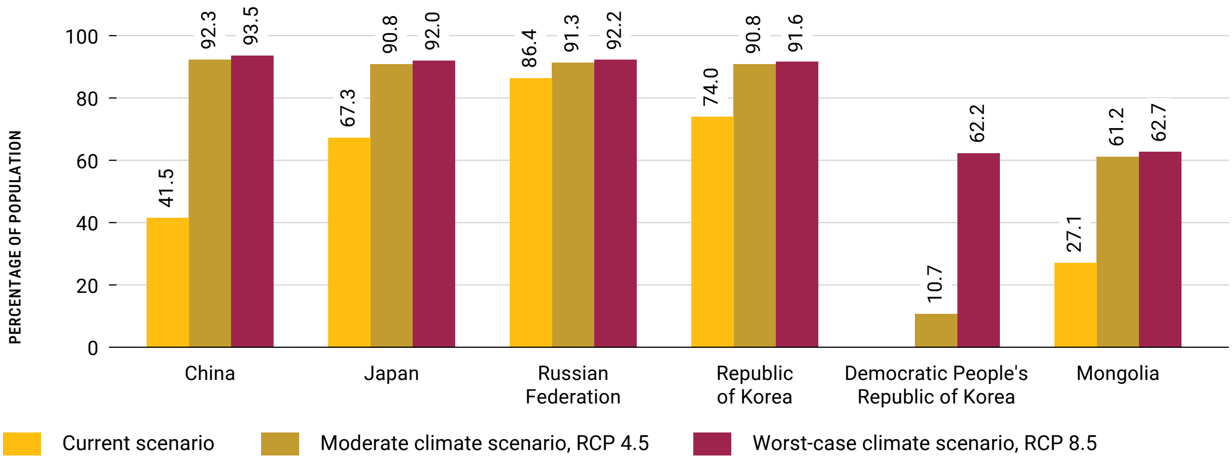
POPULATION EXPOSURE TO HEATWAVES AND RELATED DISEASES, 2020–2059



Source: ESCAP calculations, based on Climate Change Knowledge Portal, 2018; UN WPP-Adjusted Population Density 2020, v4.11; and Disability-Adjusted Life Years (DALYs) estimates 2000–2019.

FIGURE 3-4 Population exposure to heatwaves and related diseases, as a percentage of the total population

PERCENTAGE OF POPULATION EXPOSED TO HEATWAVES AND RELATED DISEASES, 2020–2059



Source: ESCAP calculations, based on Climate Change Knowledge Portal, 2018; UN WPP-Adjusted Population Density 2020, v4.11; and Disability-Adjusted Life Years (DALYs) estimates 2000–2019.

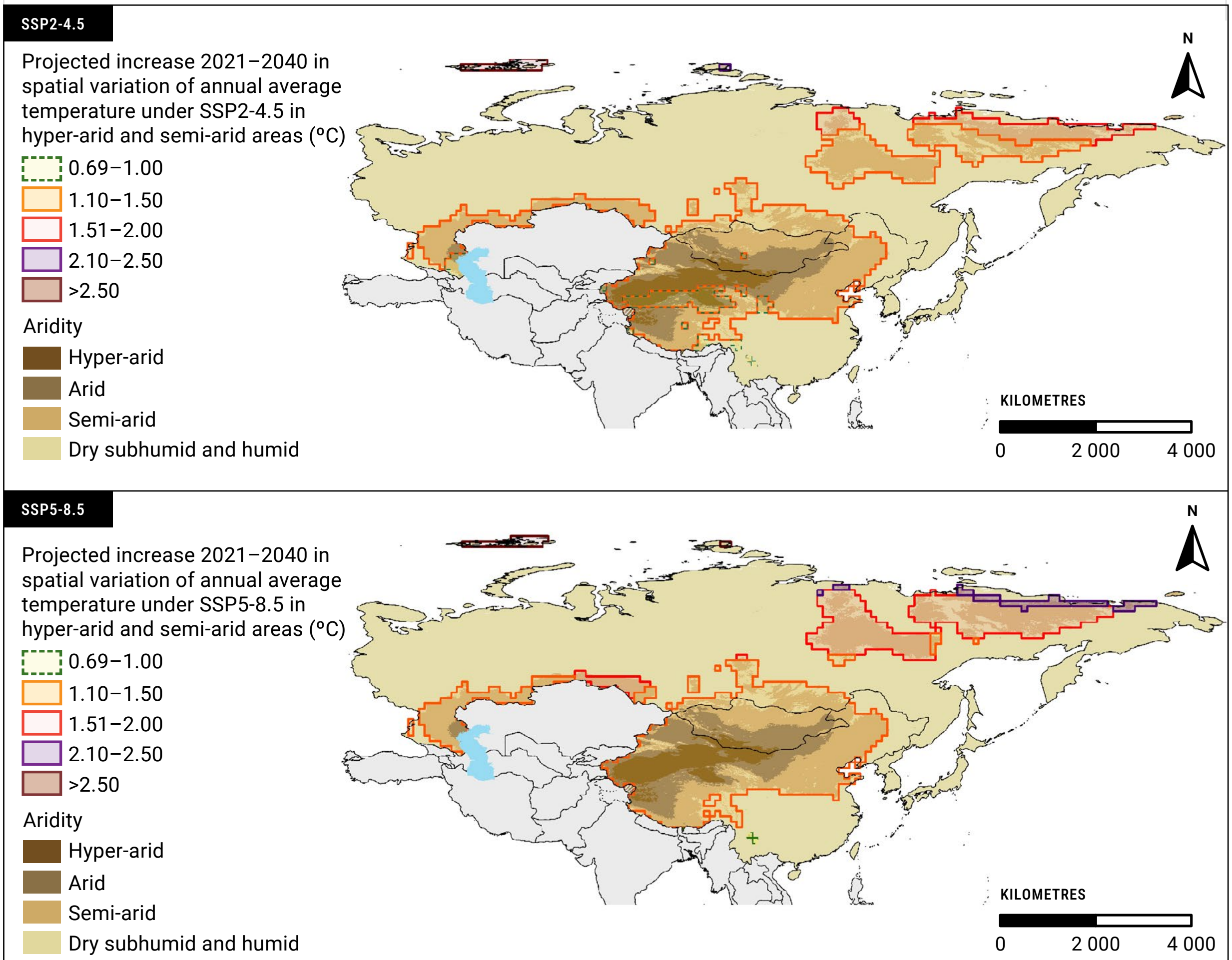
Desertification risk

Climate change is also likely to intensify the risks of desertification in arid and semi-arid areas of East and North-East Asia. The expected increase in temperature in hyper-arid, arid and semi-arid areas is likely to increase potential evapotranspiration, further increasing the aridity of these areas and accelerating desertification. Although many of these areas are likely to receive slightly more precipitation in the next two decades, it is unlikely to make any meaningful change in the prevailing dry conditions. Human activities also drive desertification, but climate drivers are likely to put additional pressure on the risk (Box-3-1).

BOX 3-1 Desertification risk in East and North-East Asia under SSP 2-4.5 and SSP 5-8.5b

In East and North-East Asia, the annual average temperature is expected to increase by more than 1°C in most hyper-arid, arid and semi-arid areas of the subregion by 2040 (Figure 3-A).

FIGURE 3-A Projected increase in annual average temperature in hyper-arid, arid and semi-arid areas under SSP2-4.5 and SSP5-8.5, 2021–2040

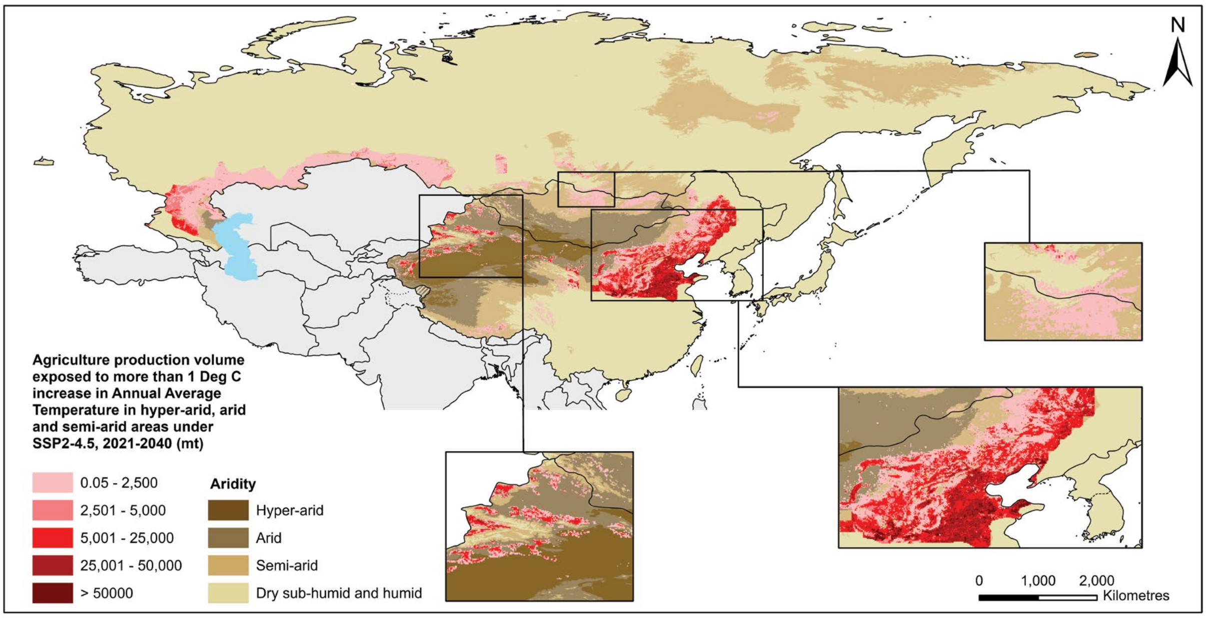


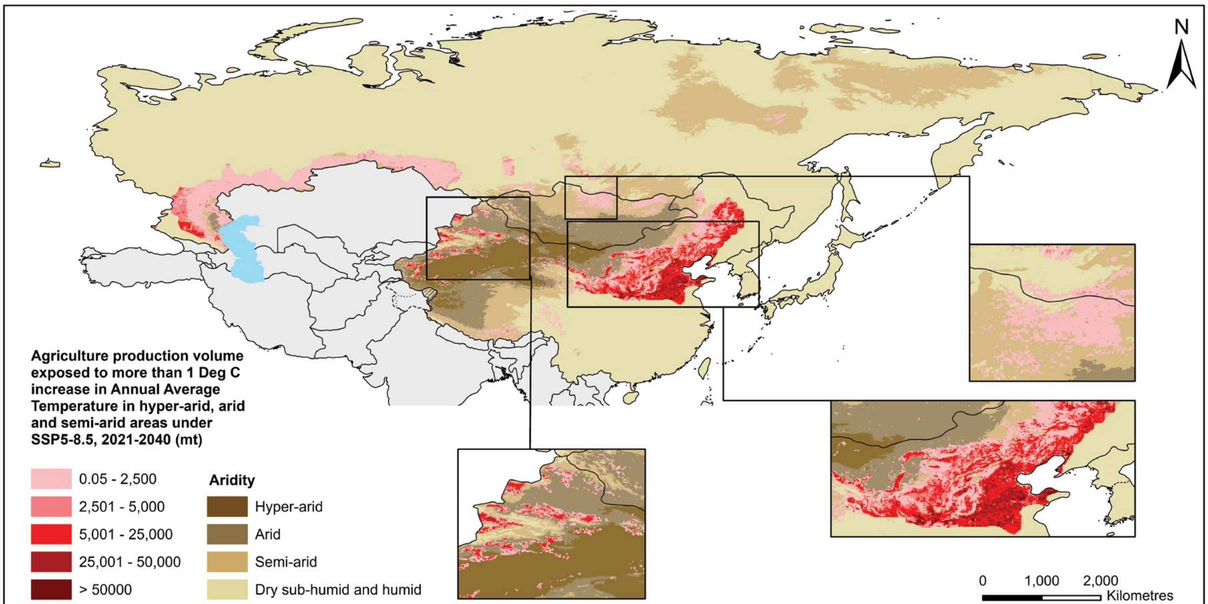
Source: ESCAP calculations, based on IPCC WGI Interactive Atlas, 2021; The Global Aridity Index, 2019; and UN Geospatial.
Note: The reference period for the projected change 2021–2040 in Spatial Variation of Annual Average Temperature under SSP2-4.5 and SSP5-8.5 is 1995–2014.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

Source: United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "NEASPEC Study on interlinkage of DLDD and climate change in ENEA", (forthcoming).

The likely intensification of the risk of desertification impacts food security, health and critical infrastructures, among others. For example, large areas responsible for agricultural production volume in China, Mongolia and the Russian Federation are located in semi-arid areas and are susceptible to desertification and land degradation from climate drivers (Figure 3-B). These include the areas responsible for around 15 to 18 per cent of agricultural production volume in China, 49 to 59 per cent of agricultural production volume in Mongolia, and 16 to 19 per cent of agricultural production volume in the Russian Federation.[a]

FIGURE 3-B **Agricultural production volume in hyper-arid, arid and semi-arid areas exposed to the projected increase in temperature under SSP2-4.5 (up) and SSP5-8.5 (down), 2021–2040**





Source : ESCAP calculations, based on IPCC WGI Interactive Atlas, 2021; The Global Aridity Index, 2019; Global Spatially-Disaggregated Crop Production Statistics Data (MapSPAM) V2r0 2020; and UN Geospatial.

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.

Source: United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "NEASPEC Study on interlinkage of DLDD and climate change in ENEA", (forthcoming).

a United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "NEASPEC Study on interlinkage of DLDD and climate change in ENEA", (forthcoming).

b Shared Socioeconomic Pathways (SSP).

Identifying vulnerable groups

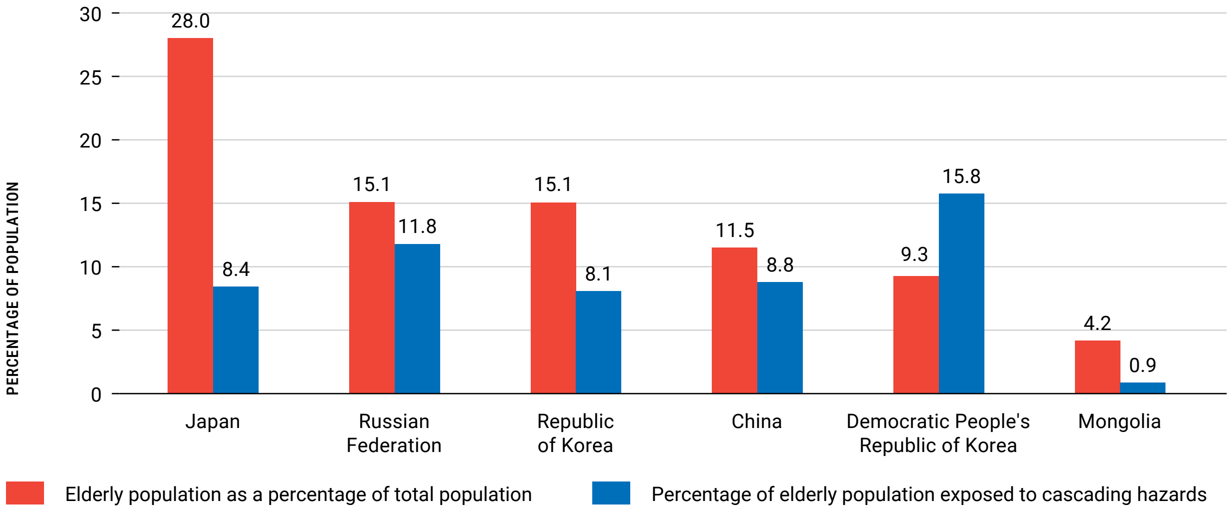
One of the key principles of disaster risk management is identifying the most vulnerable and protecting them. Often, vulnerable populations face cascading multi-hazard risks. Climate change is bound to worsen this situation in many parts of East and North-East Asia. In this subregion, the circumstances of the elderly population, and the people with disabilities, among others, are precarious in the face of cascading hazards. Exposure to hazards intensifies the multidimensional vulnerabilities of at-risk populations, making it critical for countries to include these groups into their disaster risk reduction (DRR) strategies.

Elderly populations

The elderly population can be at greater risk during slow-onset or sudden disasters due to lack of mobility, accessibility and speed of evacuation. **In East and North-East Asia, in 2019, more than 234 million people were aged 65 and older, accounting for over half of the elderly population in the Asia-Pacific region.**[38] **Moreover, countries in the region are experiencing rapid ageing**, and by 2030, one in four people in East and North-East Asia will be 60 years and older, and this figure will increase to one in three by 2050.[39]

Japan has the world's highest proportion of elderly population, at 28 per cent of the population, leaving many vulnerable to cascading hazards (Figure 3-7). In July 2019, for example, torrential flooding hit the island of Kyushu, affecting more than 50 nursing homes leading to several deaths. Although a warning was issued, it was difficult to evacuate older people.[40] With the perils of climate change, a more significant portion of the subregion's elderly population will be exposed to cascading hazards. In particular, the Democratic People's Republic of Korea will have the highest exposure at 16 per cent of its elderly population.

FIGURE 3-7 **Percentage of the elderly population (60 and above) and the elderly population at risk from natural hazards under a worst-case climate scenario in East and North-East Asia**



Source: ESCAP based on data from NASA, Socioeconomic Data and Application Centre, "Gridded Population of the World (GPW), v4". Available at: https://sedac.ciesin.columbia.edu/data/collection/gpw-v4/maps/gallery/search.

38 SDG Gateway Asia-Pacific Data Explorer. Available at: https://dataexplorer.unescap.org

39 United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Disability-Inclusive Disaster Risk Reduction in Asia and the Pacfic", Note for the secretariat prepared for the Asia-Pacific Meeting on Disability-inclusive Disaster Risk Reduction: Changing Mindshets through Knowledge, Sendai, Japan, 22–23 April 2014. Available at: https://www.unescap.org/sites/default/files/DiDRR_Backgound-note.pdf

40 Motoko Rich, Makiko Inoue and Hisako Ueno, "Japan's Deadly Combination: Climate Change and an Aging Society", *New York Times*, 18 September 2020. Available at: https://www.nytimes.com/2020/07/09/world/asia/japan-climate-change-rains-elderly.html

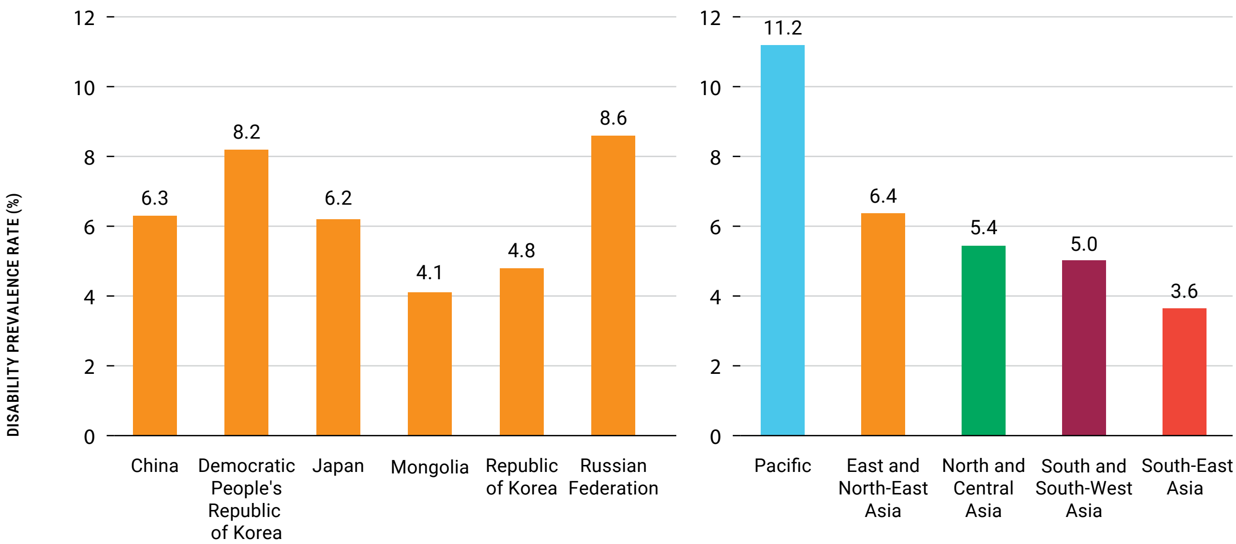
People with disabilities

People with disabilities are particularly vulnerable to disasters, as seen in the case of the Great East Japan Earthquake, where the mortality rate for people with disabilities was 2.7 per cent higher than the general population. **East and North-East Asia has the second-highest disability prevalence amongst Asia-Pacific subregions at 6.5 per cent** (Figure 3-8). The Russian Federation and the Democratic People's Republic of Korea have disability prevalence rates of over 8 per cent, signalling the importance of disability-inclusive DRR approaches. For example, after the 2008 Wenchuan earthquake in Sichuan Province, the Government of China provided priority resettlement to persons with disabilities affected by the disaster. It also provided medical care and rehabilitation services to those who became disabled during the disaster. In Japan, an accessible evacuation manual in Digital Accessible Information System (DAISY) multimedia format for tsunami and heavy rain disasters was created for persons with intellectual disabilities to allow users to easily recognize the planned evacuation route.

In addition, the rapidly ageing population in East and North-East Asia is also intersecting with the number of people with disabilities. In China and the Republic of Korea, it is estimated that 80 per cent of persons with disabilities will be aged over 60 years by 2050.[41] The convergence of these two vulnerabilities will increase disaster risk in the subregion.

To best respond to the needs of people with disabilities when disasters hit, desegregated data is essential. Once desegregated disability data is gathered, countries can implement need-based prevention systems, rescue and recovery measures, and capacity-building activities.[42]

FIGURE 3-8 **Disability prevalence rate in Asia-Pacific subregions and East and North-East Asian countries**



Source: Disability statistics taken from *Disability at a Glance 2019: Investing in Accessibility in Asia and the Pacific* (United Nations publication, 2019b). Available at https://www.unescap.org/publications/disability-glance-2019.

41 United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Disability at a Glance 2012: Strengthening the evidence base in Asia and the Pacific", 2012. Available at: https://www.unescap.org/sites/default/d8files/knowledge-products/SDD_PUB_Disability-Glance-2012_1.pdf

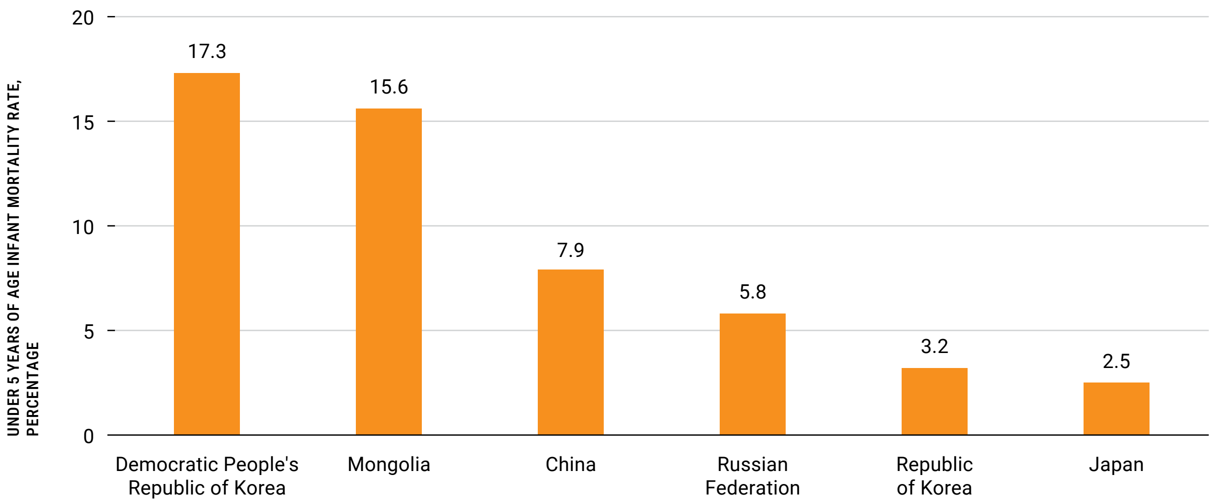
42 Ha Nguyen, Camille Pross and Jenny Yi-Chen Han, "Review of Gender-Responsiveness and Disability-Inclusion in Disaster Risk Reduction in Asia and the Pacific", UN Women, 2020. Available at: https://www2.unwomen.org/-/media/field%20office%20eseasia/docs/publications/2020/10/ap-drr-sendai-report-final-s.pdf?la=en&vs=3742

Children

Disasters from natural hazards negatively affect children physically and mentally, causing long-lasting effects on children's health. This is particularly relevant in the case of Mongolia since the country already has pre-existing high under-5 mortality rates as compared to other countries in the subregion (Figure 3-9). In Mongolia, it was reported that natural hazards not only impact children physiologically, but are linked to long-lasting effects on children's health and education as well. With limited social protection for poorer families, children from the worst socioeconomic backgrounds are most impacted, for instance, when a *dzud* hits. Measured by height-for-age, an indicator used for malnutrition, children living in less affected districts in Mongolia had significantly better health than those living in most affected areas.[43] A survey conducted in Japan, following the Great East Japan Earthquake in 2011 that displaced around 100,000 children, found that 78 per cent of teenagers in Japan felt anxious about natural hazards.[44, 45]

Therefore, it is essential to ensure that children are included in disaster risk management planning to minimize the long-term impacts of natural hazards. Japan has, in recent years, put exemplary efforts in ensuring that children are prepared for natural hazards through preparedness training in schools as well as teaching children at home.

FIGURE 3-9 Under-5 mortality in East and North-East Asia



Source: World Bank, "World Bank Development Indicators", 2021. Available at: https://databank.worldbank.org/reports.aspx?source=2&series=SH.DYN.MORT&country= (accessed 10 December 2021).

Displaced populations

In East and North-East Asia, natural hazards have triggered significant numbers of internal displacement. In the last decade, countries in the region reported that 53.4 million people were displaced from natural hazards (Figure 3-10). Hydrometeorological hazards, namely floods, storms and landslides, were mainly responsible for the displacement of 50.1 million people during this period. In 2020, more than 5 million people were displaced due to natural hazards in China, followed by Japan with 186,000 displaced people.[46]

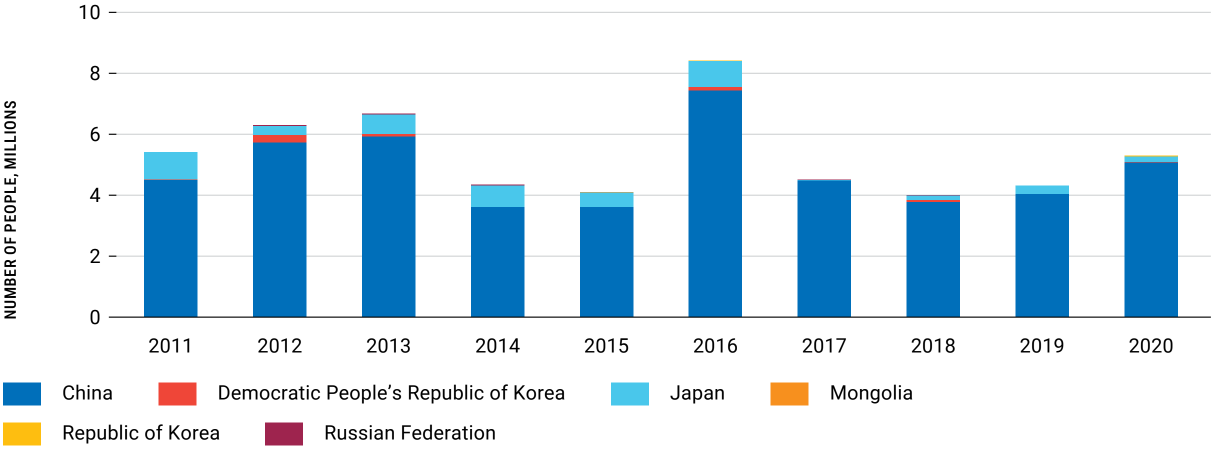
43 Valeria Groppo and Kati Kraehnert, "Extreme Weather Events and Child Height: Evidence from Mongolia", *World Development*, vol. 86 (October 2016). Available at: https://www.sciencedirect.com/science/article/abs/pii/S0305750X15303120

44 The Guardian, "Japan earthquake: 100,000 children displaced, says charity", 15 March 2011. Available at: https://www.theguardian.com/world/2011/mar/15/japan-earthquake-children-displaced-charity

45 Magdalena Osumi, "78% of older teenagers in Japan anxious about natural disasters, survey says", UNDRR Prevention Web, 7 March 2019. Available at: https://www.preventionweb.net/news/78-older-teenagers-japan-anxious-about-natural-disasters-survey-says

46 Internal Displacement Monitoring Centre (IDMC), "2020 Internal Displacement", Global Internal Displacement Database. Available at https://www.internal-displacement.org/database/displacement-data (accessed on 29 November 2021).

FIGURE 3-10 Internal displacement from natural hazards in East and North-East Asian countries, 2011–2020



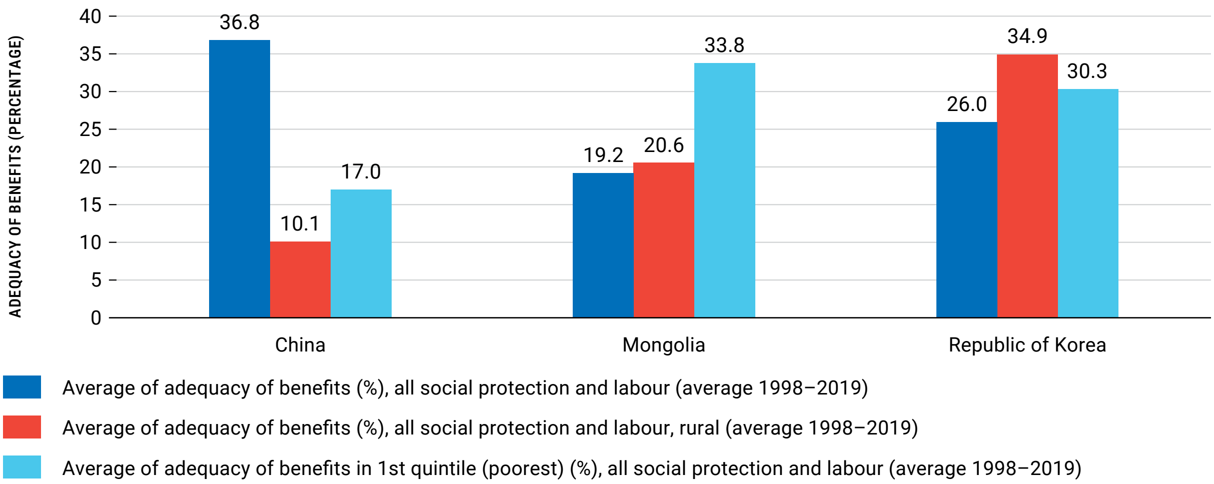
Source: Internal Displacement Monitoring Centre (IDMC), "2020 Internal Displacement", Global Internal Displacement Database. Available at https://www.internal-displacement.org/database/displacement-data (accessed on 29 November 2021).

Social protection: moving from being shock-responsive to being shock-prepared

Although the inclusion of vulnerable groups in DRR strategies is vital to ensure the inclusiveness of disaster responses, **it is equally important for countries to ensure that vulnerable groups have sound social protection before, during and after disasters have hit.** In East and North-East Asia, governments have worked continuously to ensure their population is well-protected. This can be seen, for example, in Mongolia and the Republic of Korea, where the average adequacy of all social protection offered to vulnerable groups, such as the rural population and the poorest quantile, is higher than the average for the entire population, signalling that social protection is targeted to these vulnerable groups (Figure 3-11).

However, there remains work to be done. In China, for example, there are still some gaps between the adequacy of social benefits, on average, for the entire population versus the rural and poor population groups. The percentage of adequate services decreases from 37 per cent for the whole population to 10 per cent when isolating for the rural population and 17 per cent when isolating for the poorest quantile of the population. The risks of cascading hazards posed to vulnerable groups are likely to increase with the effects of climate change, making it critical for governments to ensure that their vulnerable population groups are well-protected.

FIGURE 3-11 Social protection for vulnerable groups in selected East and North-East Asian countries



Source: ESCAP calculations based on GAR Risk Atlas (2015); *Global Assessment Report on Disaster Risk Reduction 2015* (United Nations publication, 2015). Available at https://www.undrr.org/publication/global-assessment-report-disaster-risk-reduction-2015

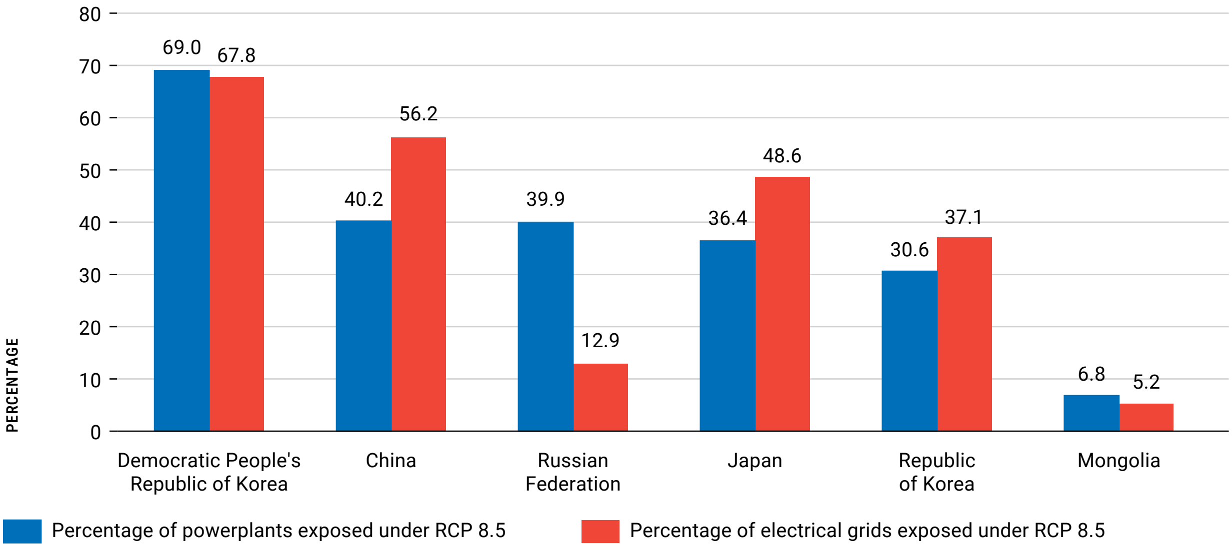
The risks to critical infrastructure

Energy infrastructure

Energy infrastructure is considered essential for raising people's quality of life, making it vital for countries to prioritize building resilient infrastructure. Extreme weather events can damage energy infrastructure and reduce the capacity of transmission lines, transformers, substations, and water volumes for hydropower plants. Also, the links between energy consumption and socioeconomic disadvantage are generally underappreciated, but shutoffs and power outages can directly impact health sectors, in the most severe cases, leading to either hypothermia or heat stress.

Figure 3-12 presents the exposure of energy infrastructure. Overlaying the multi-hazard risk and energy infrastructure data enables the identification of the most exposed areas in East and North-East Asia. **On average, countries in East and North-East Asia will have 37 per cent of their power plants and 38 per cent of their electrical grids exposed to multi-hazard risk under the worst-case climate change scenario.** The Democratic People's Republic of Korea will have the highest percentage of its energy infrastructure at risk, with 69 per cent of its power plants and 68 per cent of its electrical grids exposed to multi-hazard risk.

FIGURE 3-12 **Percentage of energy infrastructure exposed to multi-hazard risks under the worst-case climate change scenario (RCP 8.5) in East and North-East Asia countries**



Source: ESCAP calculations, based on Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015; Climate Change Knowledge Portal, 2018; and Global Electricity Transmission and Distribution Lines, 2020.

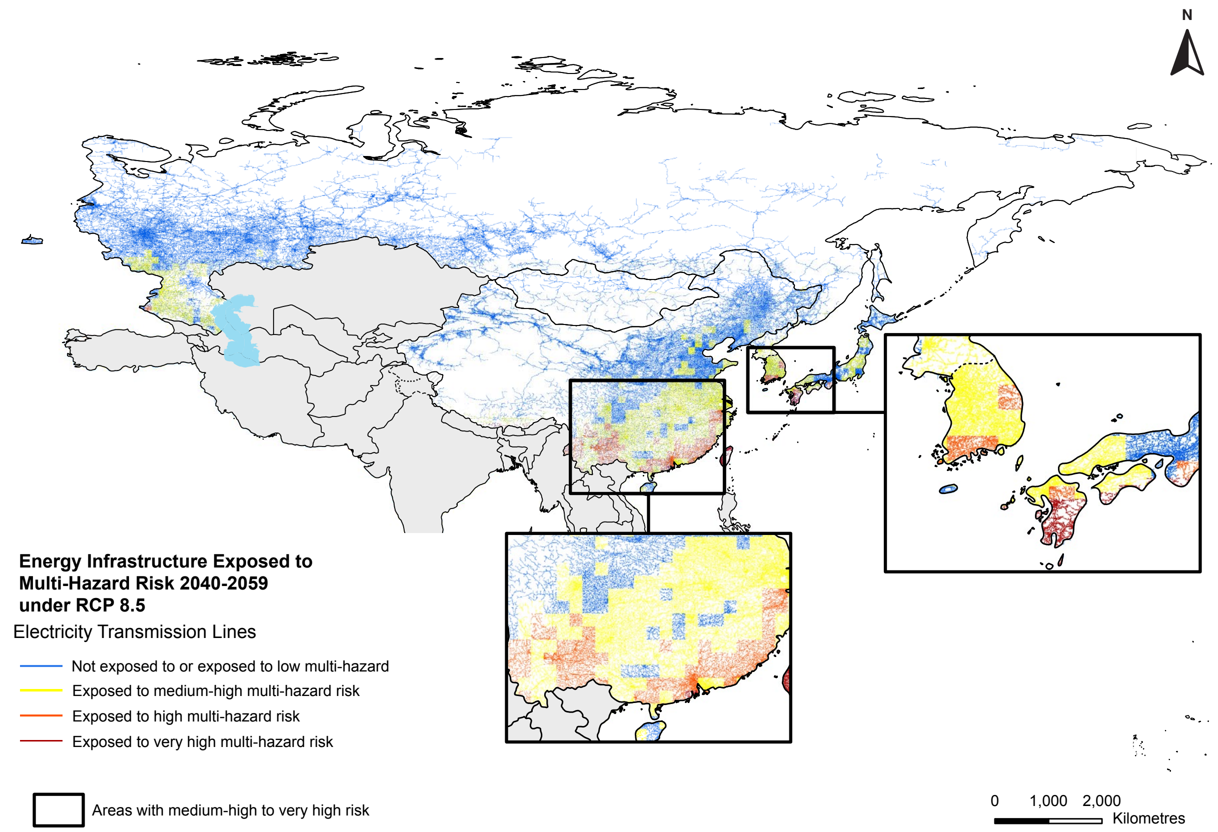
Transport infrastructure

The resilience of transport infrastructure plays a vital role in the socioeconomic development of countries and their ability to respond when disasters hit. Especially, roads play crucial roles in ensuring the successful operation of post-disaster evacuation, provision of emergency health services and distribution of emergency relief. The resilience of transport infrastructure is also critical in ensuring healthy economic performance post-disasters, as damage or abstraction to airports and ports can lead to disconnection between trade routes. For example, in the aftermath of Typhoon Haishen in the Republic of Korea, 340 flights and 114 shipping routes were cancelled, disrupting trade flows in and out of the country.[47] Thus, it is essential to assess disaster risk to transport infrastructure and build resilience to natural hazards.

47 European Commission's Directorate-General for European Civil Protection and Humanitarian Aid Operations, "Japan, Korean Peninsula – Tropical Cyclone HAISHEN update (DG ECHO, GDACS, JTWC, FDMA, ReliefWeb, media", ECHO Daily Flash, News and Press Release, 8 September 2020. Available at: https://reliefweb.int/report/republic-korea/japan-korean-peninsula-tropical-cyclone-haishen-update-dg-echo-gdacs-jtwc-fdma

Figure 3-14 presents transport infrastructure exposed to multi-hazard risk in East and North-East Asia under the worst-case climate change scenario. It is, therefore, imperative for governments to invest in maintaining and upgrading current infrastructure and ensuring that new infrastructure developments are resilient to disaster risks faced by their respective countries.

FIGURE 3-13 **Energy Infrastructure Exposed to Multi-Hazard Risk 2040–2059**



Sources: ESCAP calculations, based Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015; Climate Change Knowledge Portal, 2018; and Global Electricity Transmission And Distribution Lines, 2020; and UN Geospatial.

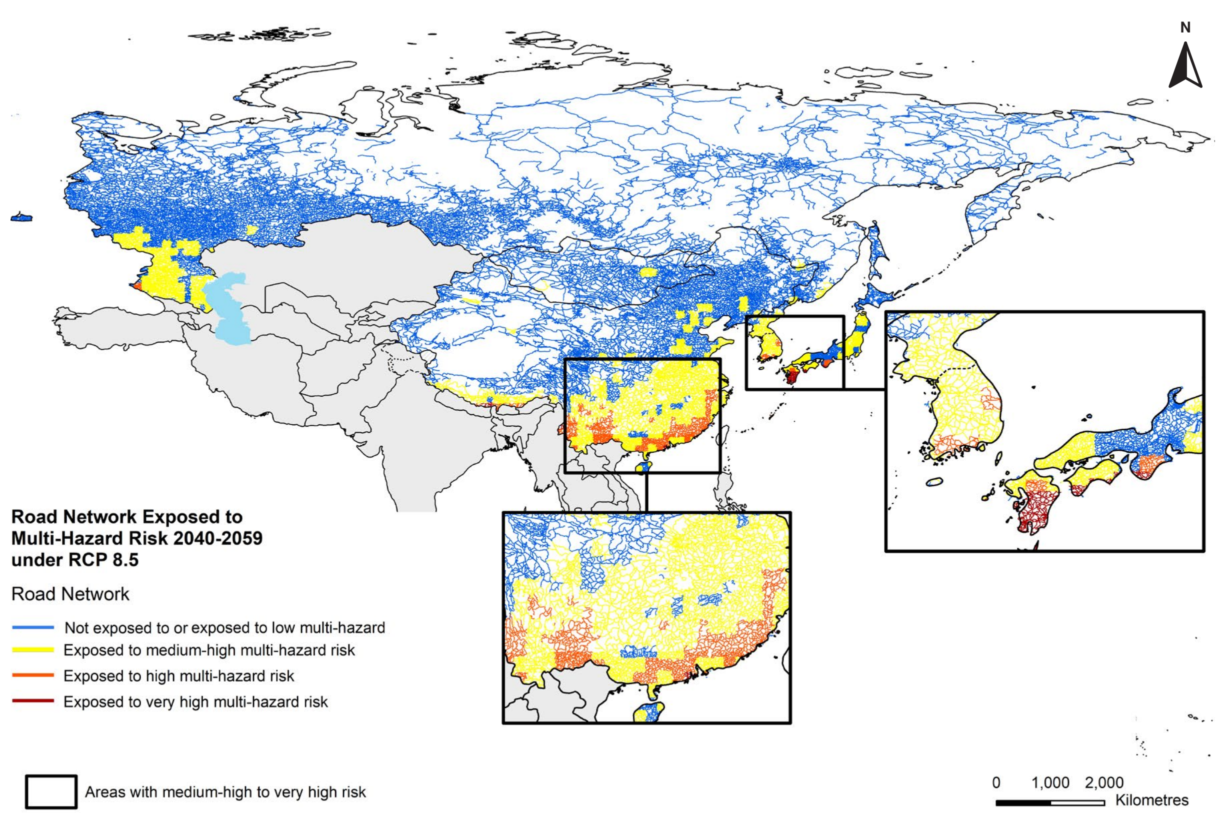
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

Out of the silos

The COVID-19 pandemic has been a stark reminder of the links and intersections between health and other natural hazards. However, Governments often treat various types of emergencies separately, through different departments, each operating in its own 'silo', which has resulted in gaps in preparedness.

The Sendai Framework for Disaster Risk Reduction 2015–2030 envisages, instead, a paradigm shift from managing disasters to managing risk. In this regard, the following chapter discusses how East and North-East Asia can best respond to the growing disaster-climate-health nexus.

FIGURE 3-14 **Transport Infrastructure Exposed to Multi-Hazard Risk 2040–2059**



Sources: ESCAP calculations, based Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015; Climate Change Knowledge Portal, 2018; Digital Chart of the World, 1992; and UN Geospatial.

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.

CHAPTER 4

A greener and more resilient recovery from the COVID-19 pandemic

Highlights

- The estimated cost of adapting to climate-related and biological hazards in East and North-East Asia is less than a fifth of the average annual losses estimated, adding to only 1 per cent of the subregional GDP.
- The economic recovery from the COVID-19 pandemic must include investing in climate adaptation to build resilient economies and populations to future crises and to meet the targets of the Sustainable Development Goals.
- ESCAP's Risk and Resilience Portal shows that the top adaptation solutions for East and North-East Asia in order of preference are:
  - Making new infrastructure resilient;
  - Strengthening early warning systems;
  - Improving dryland agriculture;
  - Making water management systems more resilient; and
  - Protecting mangroves.

SDG progress and resilience of East and North-East Asia

Significant progress has been made towards achieving several of the Sustainable Development Goals in East and North-East Asia (Figure 4.1). Nevertheless, gaps remain, especially in the achievement of SDG 13 (Climate action) and SDG 14 (Life below water), where a regression in the achievement of the goals has been seen in the past year. Target 13.2, Resilience and Adaptive Capacity, is an example of the negative trend in achieving SDG 13, signalling the need for proper adaptation measures to ensure that progress is achieved.[48]

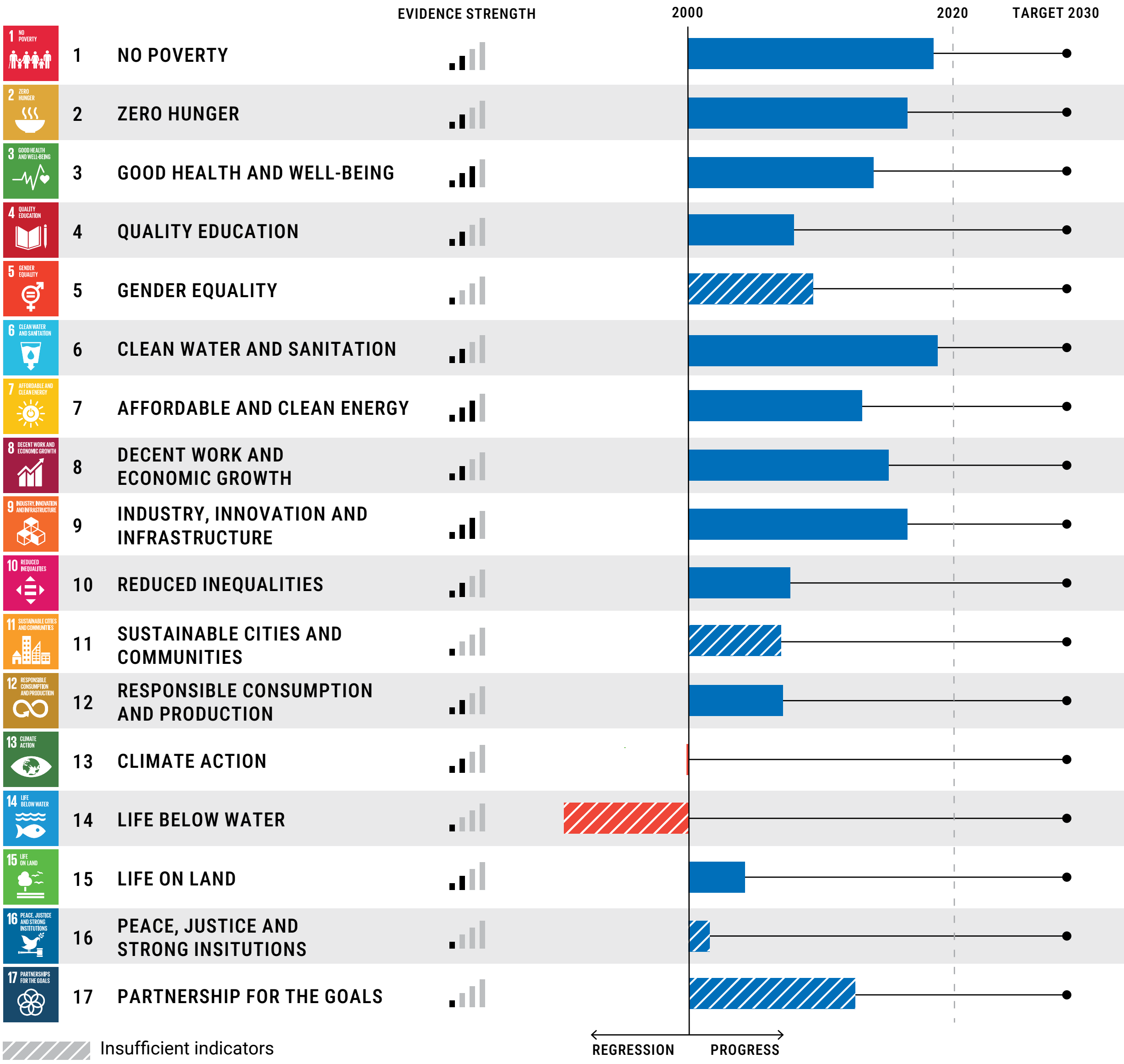
ESCAP has estimated the total cost of adaptation for climate-related and biological hazards under the worst-case climate scenario (RCP 8.5) for each country. **For East and North-East Asia, the total annual adaptation cost is estimated at $203.9 billion, with $143.4 billion as the adaptation cost for climate-related hazards and $60.5 billion as the adaptation cost for biological hazards.** At the country level, the highest total adaptation cost is estimated for China at $175.1 billion, followed by Japan with $20.2 billion and the Republic of Korea with $8.4 billion. Figure 4-2 presents the costs of adapting to climate change as a percentage of GDP, which varies from almost 1.3 per cent for China to less than 0.4 per cent for the Democratic People's Republic of Korea and the Russian Federation.

Understanding the risks and building partnerships

Successful climate adaptation requires a strong understanding of current and future risks posed by climate change and strong partnerships between national and subnational governments, the private sector, and individuals to implement adaptation measures. In support of this, ESCAP's Risk and Resilience Portal, developed under the Asia-Pacific Disaster Resilience Network, aims to deepen policymakers' understanding of cascading risks from the disaster-climate-health nexus, and support evidence-based and risk-informed decision-making. The APEC Climate Centre is another useful resource, providing Governments of Asia and the Pacific access to the latest predictions and analyses through readily-available data through the online platform, and through capacity-building workshops to increase the understanding of the risks posed by climate change.

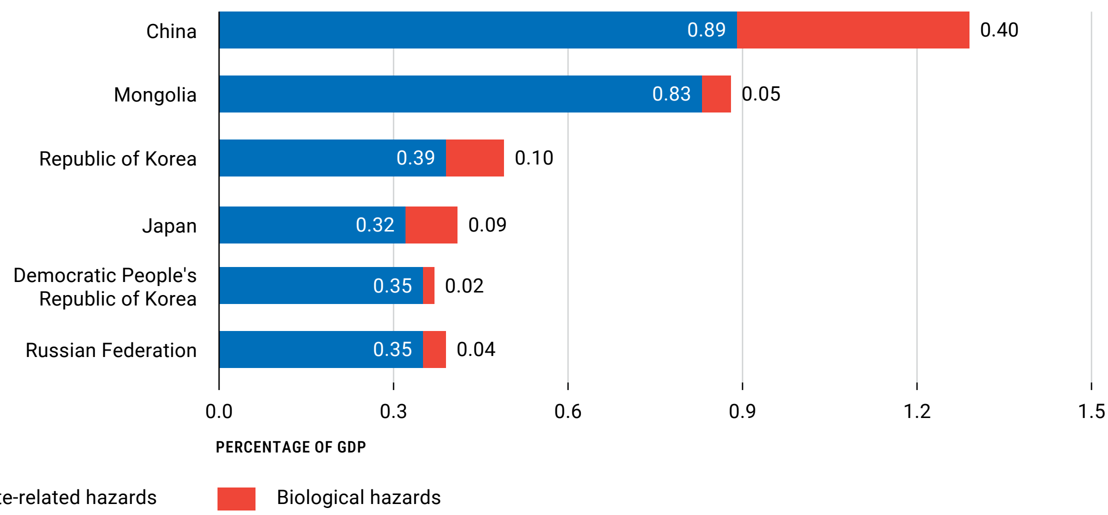
48 *Asia and the Pacific SDG Progress Report 2021* (United Nations publication, 2021b).

FIGURE 4-1 **Snapshot of SDG progress in East and North-East Asia, 2020**



Source: *Asia and the Pacific SDG Progress Report 2021* (United Nations publication, 2021b).

FIGURE 4-2 **Cost of adapting to climate-related and biological hazards in East and North-East Asia, as a percentage of GDP**



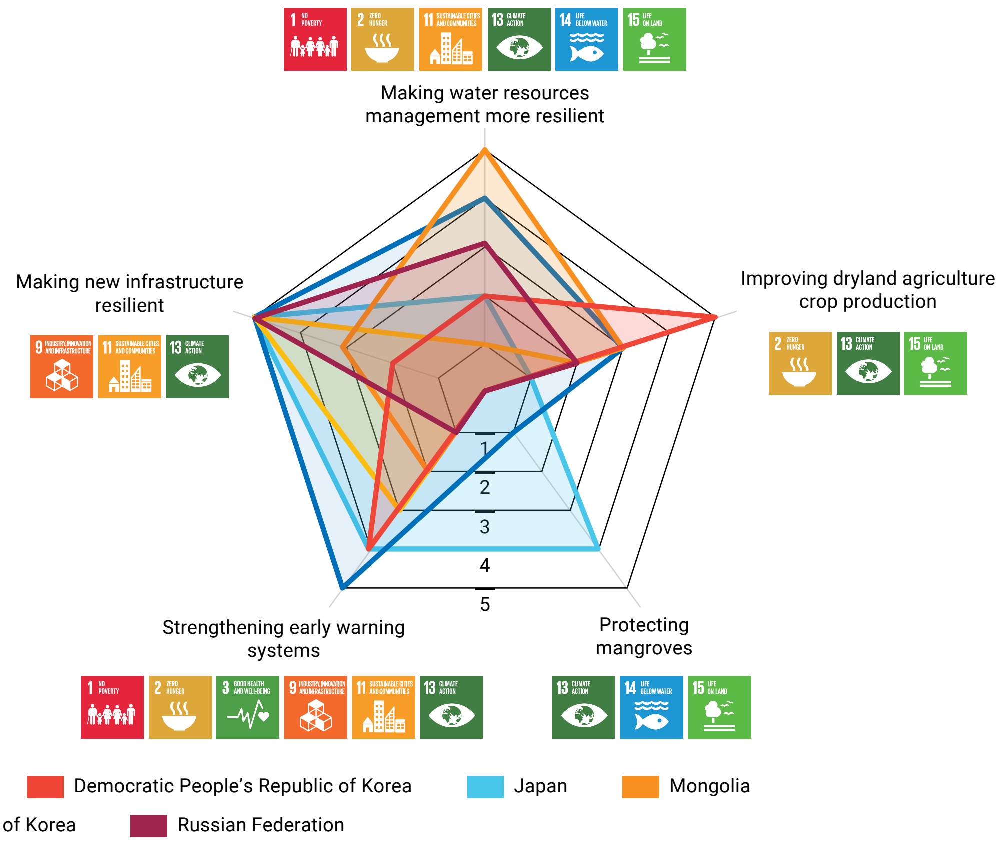
Source: ESCAP calculations based on the Asia-Pacific SDG Gateway, "Is Asia-Pacific on track to achieve the SDGs?" Available at https://data.unescap.org/home.

Climate adaptation will not occur at a singular level. National governments are needed to provide the legal framework under which they can implement and monitor adaptation frameworks which can then be used by subnational governments to address the particular needs of their regions and communities. However, resilience to climate change cannot be built through isolated actions of governments, but requires involving the private sectors and individuals. A-PLAT, a climate change adaptation information platform, provides countries of East and North-East Asia a space that can help guide partnership building between countries in the subregion, making efforts to adapt to climate change and build resilience against disasters from natural hazards.

Building a more resilient East and North-East Asia through key adaptation measures

Based on a sound understanding of risks, countries need to invest in key adaptation priorities specific to their respective disaster riskscape. The Global Commission on Adaptation has established five key priorities that yield a high cost-benefit ratio for building resilience; strengthening early-warning systems, making new infrastructure resilient, making water resource management more resilient, improving dryland agriculture crop production and protecting mangroves.[49] Building on these 5 priorities, ESCAP's Risk and Resilience Portal presents the adaptation priorities at the subregional and national levels.[50] Figure 4-3 presents these adaptation priorities with a country-level overview reflecting their risk profile, together with their linkages to Sustainable Development Goals.

FIGURE 4-3 **How the five priority adaption measures support SDGs in East and North-East Asia**



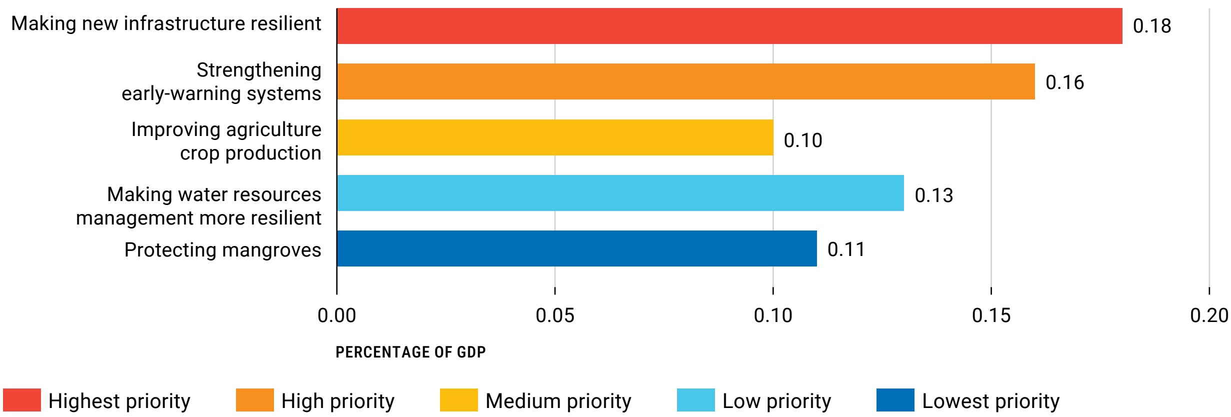
Source: ESCAP, based on Risk and Resilience Portal, "Adaptation Cost and Priorities for East and North-East Asia". Available at: https://rrp.unescap.org/adaptation-and-priorities/enea

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

50 ESCAP, "Risk and Resilience Portal". Available at: rrp.unescap.org.

The top adaptation priority for East and North-East Asia is making new infrastructure resilient. The associated estimated adaption cost is marginal at 0.18 per cent of subregional GDP (Figure 4-4). The second priority is strengthening early warning systems with an estimated adaptation cost of 0.16 per cent of subregional GDP.

FIGURE 4-4 Estimated adaptation cost and priorities for East and North-East Asia



Source: ESCAP, "Risk and Resilience Portal". Available at: rrp.unescap.org

Making new infrastructure more resilient

According to ESCAP's Risk and Resilience Portal, making new infrastructure more resilient is the top adaptation priority for 4 countries in East and North-East Asia. Adapting infrastructure to ensure that it is resilient to disasters is key to achieving the Sustainable Development Goals. In the subregion, more than half of solar and wind infrastructure is at risk of typhoons. Around 70 per cent of airports and 75 per cent of ports are also exposed to typhoons.[51] The most vulnerable countries are China, Japan, and the Republic of Korea. Therefore, existing and new infrastructure will need to be more resilient, and infrastructure investment must be risk-informed to address disaster risks and climate change and ensure sustainable development. Specifically, it would support the achievement of **SDG 9: Industry, innovation and infrastructure**, **SDG 11: Sustainable cities and communities**, and **SDG 13: Climate action**.

Infrastructure covers not only discrete assets, such as roads and buildings, but also collective sets of systems and services that can be synchronized to provide essential services. In this regard, the "Global Risks for Infrastructure" report recommends a three-pillar approach: dynamic scenario planning, lifecycle assessments and multi-stakeholder engagement – with multiple interdependencies among the three pillars (Figure 4-5).[52] Dynamic scenario planning should combine all technical innovations, analytics and expertise to understand the sensitivity and exposure of infrastructure and related services in the face of climate-related hazards. For example, all new infrastructure should consider sea-level rise and the potentially increased frequency of storms in coastal cities. Effective climate risk integration should engage all stakeholders in short- medium- and long-term scenario planning, and in lifecycle infrastructure assessments.

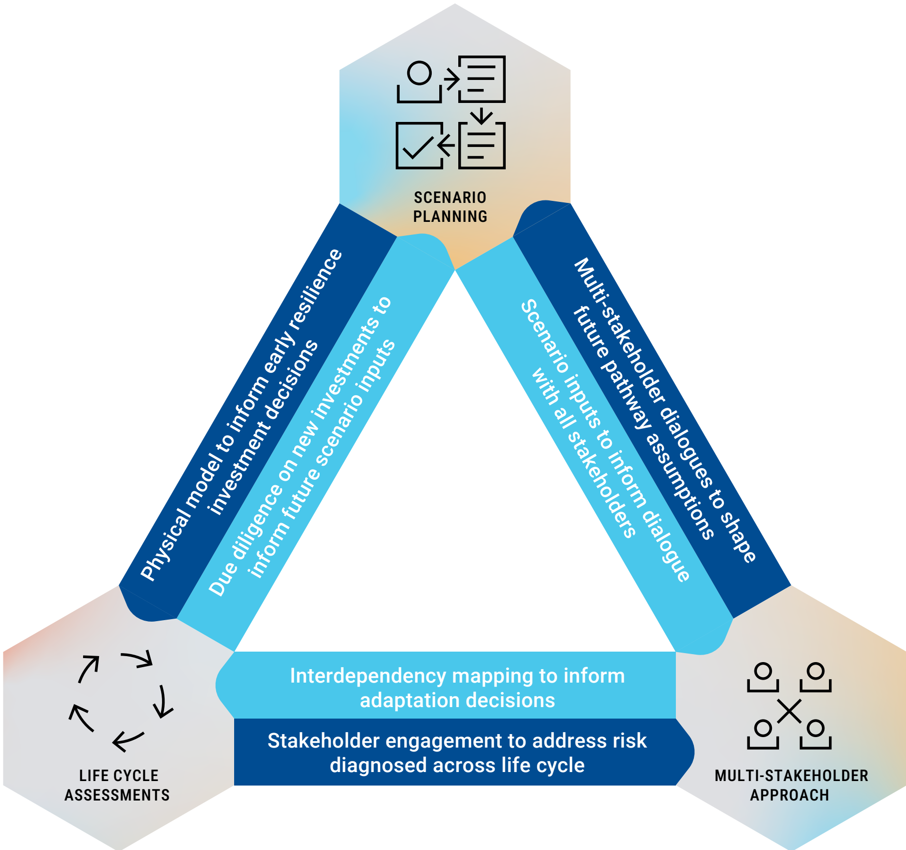
In addition, **new infrastructure and retrofits to existing infrastructure must consider changing natural ecosystems by combining traditional grey infrastructure with green infrastructure**. For example, for water resource management, grey infrastructure components would include building reservoirs, pipe networks and treatment plants, while complementary green infrastructure would include watersheds

51 ESCAP calculations, based Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015; Climate Change Knowledge Portal, 2018; and Global Electricity Transmission And Distribution Lines, 2020.

52 Marsh & McLennan Advantage, "Global Risks for Infrastructure: The climate challenge", 2020. Available at: https://www.mmc.com/content/dam/mmc-web/insights/publications/2020/august/Global-Risks-for-Infrastructure_The-Climate-Challenge_Final.pdf

that improve source water quality and wetlands to filter wastewater effluents. This is not only a cost-effective approach, but also empowers communities by engaging local stakeholders and incorporating longer-term flexibility for responding to changing climate conditions.

FIGURE 4-5 **A three-pillar approach to risk-informed infrastructure**



Source: Adapted from Marsh & McLennan Advantage, "Global Risks for Infrastructure: The climate challenge", 2020. Available at: https://www.mmc.com/content/dam/mmc-web/insights/publications/2020/august/Global-Risks-for-Infrastructure_The-Climate-Challenge_Final.pdf

Strengthening early warning systems

Disaster risk reduction and climate change adaptation will largely rely on effective early warning systems. As highlighted in the Sendai Framework for Disaster Risk Reduction 2015–2030, strengthening multi-hazard early warning systems is essential not only for disaster management agencies but also related-sectoral ministries and all stakeholders, including the public, to identify risk from natural hazards and prepare mitigation and response measures in advance. Ensuring that early-warning systems are effective and in place for the health sector is directly in line with SDG 3 Target 3d; improve early warning systems for global health risks.

Strengthening early warning systems will offer better protection and services to the vulnerable while directly supporting **SDG 1 (No poverty) and SDG 3 (Good health and well-being)**. It will allow workers in the agricultural sector and other primary industries to take early actions **(SDG 2: Zero hunger)**, and critical infrastructure exposed to hazards can be identified **(SDG 9: Industry, innovation and infrastructure, SDG 11: Sustainable cities and communities)**, especially from extreme weather events **(SDG 13: Climate action)**. As such, establishing effective early warning systems is identified as a top priority in climate action plans of many countries with special needs (CSNs), yet, countries often lack the capacity or financial resources to implement them.

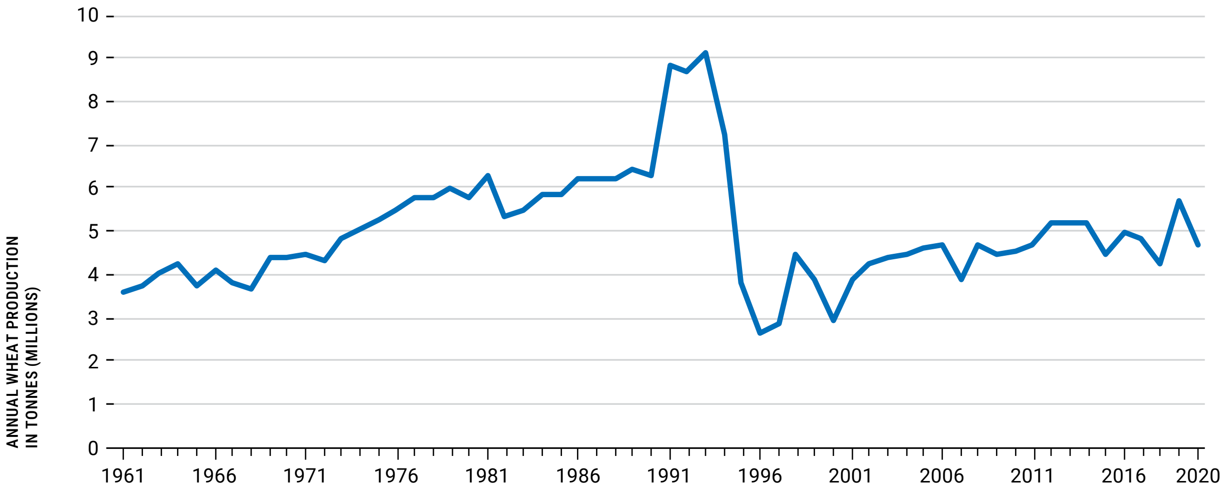
In this regard, ESCAP has facilitated technical cooperation on contextualizing and strengthening multi-hazard early warning systems under the Asia-Pacific Disaster Resilience Network. Specifically, ESCAP developed a methodological approach for impact-based forecasting and supported member States in building the capacity for impact-based forecasting. Also, in Mongolia, ESCAP has supported the development of tailored tools for using geospatial information for drought monitoring. In strengthening early warning systems of typhoons and related hazards, ESCAP/WMO Typhoon Committee has promoted and coordinated planning and implementation of measures required for minimizing the loss of life and material damage caused by typhoons. It facilitated sharing knowledge and experiences in forecasting and early warning of typhoons and related coastal hazards among its 14 members, including China, the Democratic People's Republic of Korea, Japan and the Republic of Korea.

Improving dryland agriculture

Countries in East and North-East Asia frequently experience droughts, which have often led to significant impacts on the agricultural sector. For example, droughts in the mid-1990s substantially decreased agricultural production in the Democratic People's Republic of Korea. Between 1993 and 1997, cereal production levels in the Democratic People's Republic of Korea had substantially decreased, resulting in a nationwide food crisis and famine (Figure 4-7).

In the Democratic People's Republic of Korea, many major agricultural areas are in flood- and drought-prone areas (Figure 4-8). Climate change will add uncertainty and climate-related disaster risks, in different parts of the country, will likely intensify. **Improving dryland agriculture with better management of water resources and irrigation systems, establishing well-functioning early warning systems, and improving crop and soil management is a high priority.** This will also contribute to the achievement of the SDGs, including **SDG 2: Zero hunger**, **SDG 13: Climate action**, and **SDG 15: Life on land**, among others.

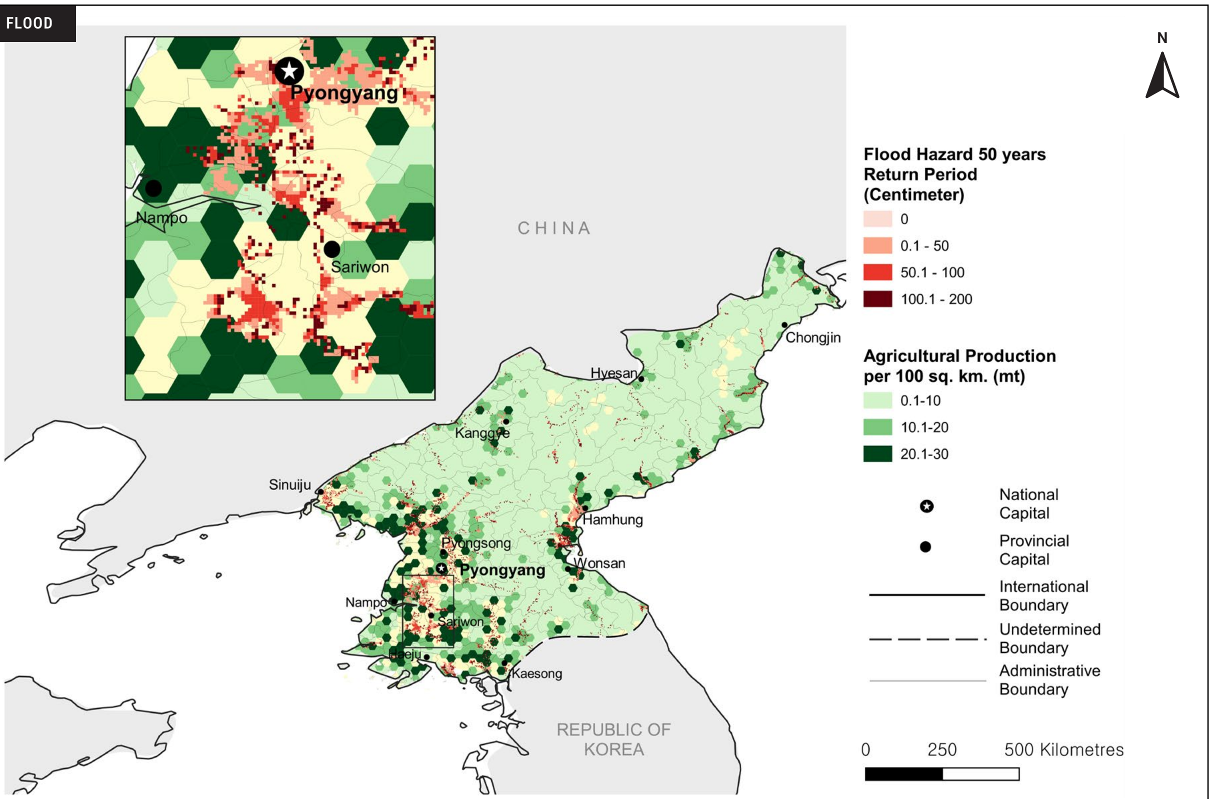
FIGURE 4-7 **Total cereal production in the Democratic People's Republic of Korea, 1961–2020**



Source: Food and Agriculture Organization of the United Nations, "FAOSTAT: Democratic People's Republic of Korea". Available at: https://www.fao.org/faostat/en/#country/116 (accessed on 24 February 2022).

FIGURE 4-8 **Agriculture exposure to flood and drought risks in the Democratic People's Republic of Korea**

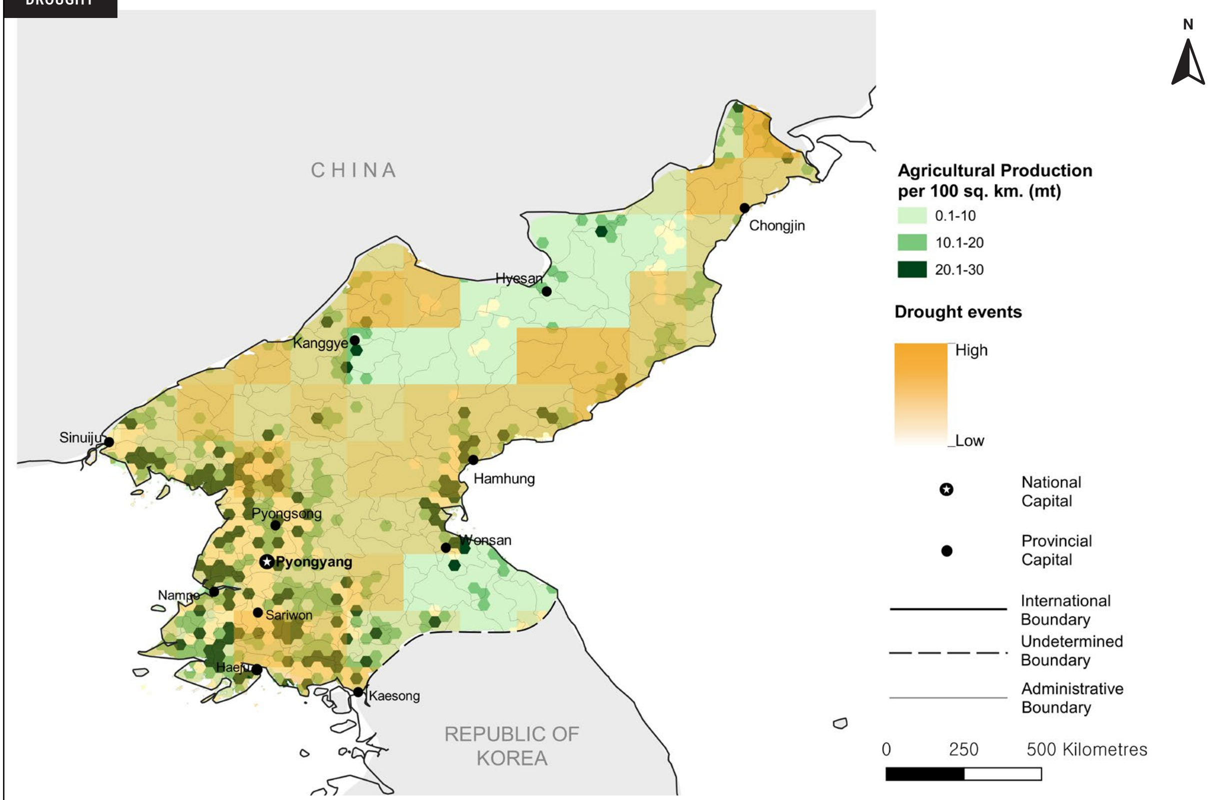
FLOOD



Sources: ESCAP calculations based on WorldPop 2020 Population Estimates and Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas, 2015 and FAO Global Spatially-disaggregated Crop Production Statistics Data of 2020 (MapSPAM) v2r0 2020; and UN Geospatial.

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

DROUGHT



Sources: ESCAP calculations based on WorldPop 2020 Population Estimates; Global Assessment Report on Disaster Risk Reduction (GAR) Risk Atlas; and UN Geospatial.

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

Making water management systems more resilient

Many parts of East and North-East Asia are exposed to high flood and drought risks. About 20 per cent of the population in the subregion is exposed to floods, while droughts account for 55 per cent of annual average losses of the subregion.[53] **Making water management systems more resilient is thus essential in East and North-East Asia** through sustainable year-round water resource management solutions, including rainwater harvesting and the reuse of wastewater. It will also be essential to strengthen traditional water management systems. In agrarian societies, these have generally been developed for water harvesting in arid or semi-arid areas or irrigation water management.

Building resilience in water management systems will help to reduce the risk from water-related natural hazards, especially floods and droughts (**SDG 2: Zero hunger, SDG 14: Life below water, and SDG 15: Life on land**), and protect the most vulnerable (**SDG 1: No poverty, SDG 11: Sustainable cities and communities**). It will also help adapt to climate change (**SDG 13: Climate action**).

Protecting mangroves

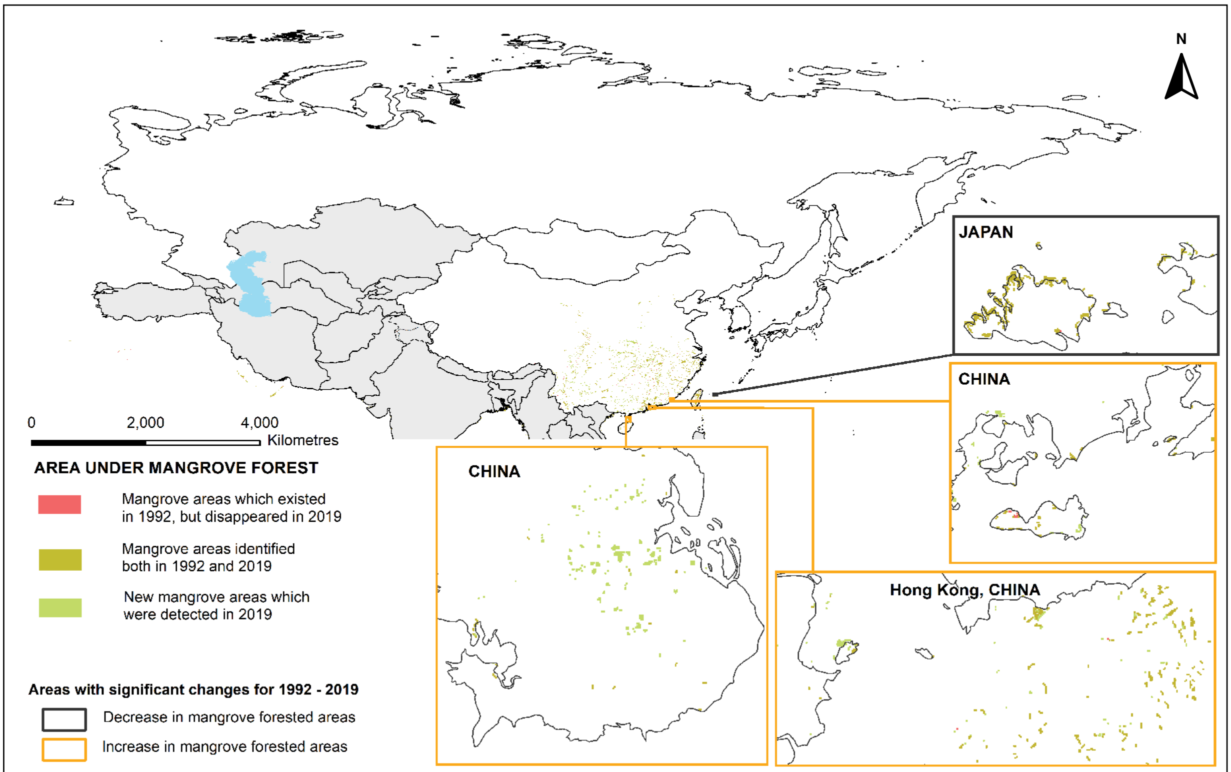
One of the most critical nature-based forms of climate adaptation is the conservation and restoration of mangroves. Mangroves reduce the impact of tropical cyclones, storm surges, coastal flooding and erosion (**SDG 14: Life below water**), and thus support adaptation to climate change (**SDG 13: Climate action**).

Across Asia and the Pacific, however, mangrove cover is under threat as forests have been converted for aquaculture or coastal development (Figure 4-9). A recent study coupling hydrodynamic and economic models assessed the amount of property damage avoided each year due to mangrove cover.[54] China has the most significant avoided losses due to mangrove coverage in the Asia-Pacific region, with an estimated saving of US$ 8.6 billion. However, while a substantial increase of mangrove areas was reported in China between 1992 and 2019, mangrove areas in Japan decreased by 5.7 per cent during this period (Figure 4-10). Thus, protecting mangroves has been identified as one of the investment priorities for Japan.

53 *Asia-Pacific Disaster Report 2019: The Disaster Riskscape across East and North-East Asia* (United Nations publication, 2019a).

54 Pelayo Menéndez and others, "The Global Flood Protection Benefits of Mangroves", *Scientific Reports*, vol. 10, No. 4404 (10 March 2020). Available at: https://www.nature.com/articles/s41598-020-61136-6

FIGURE 4-9 **Mangroves in East and North-East Asia in 1992 and 2019**



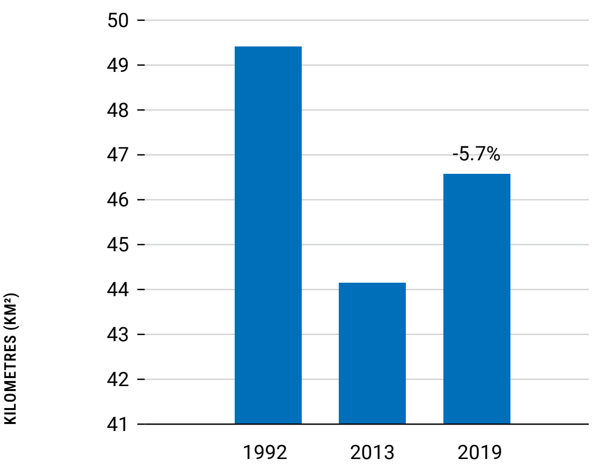
Source: ESCAP calculations based on Climate Change Initiative Land Cover, 2019; World Water Bodies, 2021; and UN Geospatial.

Note: All pixels under land cover class "Tree cover, flooded, saline water" was counted as coastal mangrove. The overall accuracy of the source data is 75.4%.

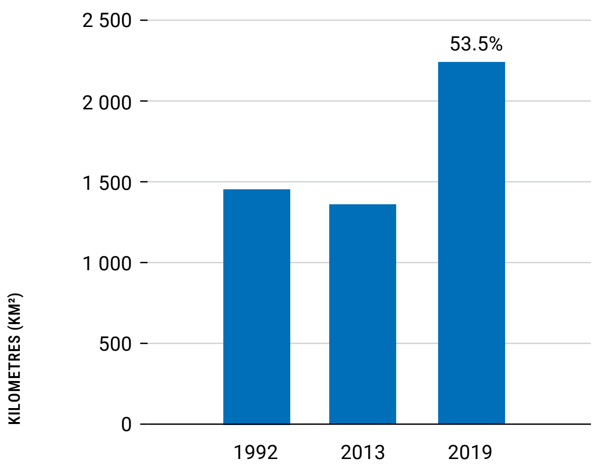
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

FIGURE 4-10 **Changes in mangrove area in Japan and China (1992–2019)**

CHANGES IN MANGROVES AREA FROM 1992 TO 2019 IN JAPAN



CHANGES IN MANGROVES AREA FROM 1992 TO 2019 IN CHINA



CHAPTER 5

Transformative actions to building resilience

Highlights

- Frontier technologies and digital solutions can greatly support disaster risk reduction and health sector management. Especially, it can contribute to improved risk analytics and impact-based forecasting.
- While strengthening early warning systems is critical in building resilience to natural hazards, impact-based forecasting can provide valuable information for disaster management agencies, sectoral ministries and other stakeholders for better monitoring and preparation of potential disasters.
- Utilization of frontier technologies and digital solutions for building resilience requires investment in innovation ecosystems that accelerate progress towards resilience-related SDGs.

Frontier technology and digital solutions

For managing their COVID-19 responses, countries in East and North-East Asia have taken advantage of several 'frontier technologies' used in disaster risk reduction and the health sector. These include Artificial Intelligence (AI), Big Data, machine learning, 5G technologies, drones, automated vehicles, and robotics.

These technologies continue to transform disaster risk reduction and health sectors, and thus address some of the deep uncertainties in managing systemic risk. This will be done by:

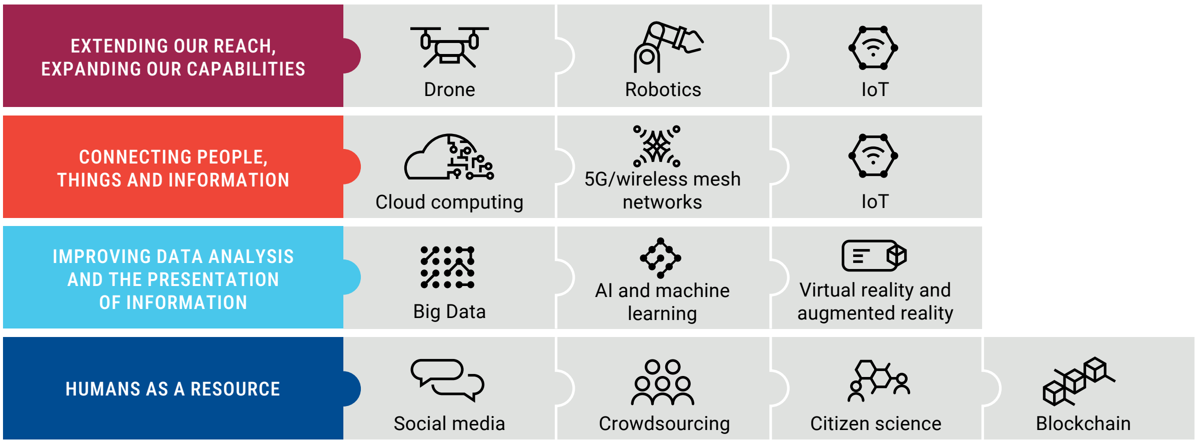
- Extending the reach and expanding the capabilities of unmanned vehicles, robotics, remote, and in-situ sensing;
- Transforming production and acquisition processes through additive manufacturing and innovative materials;
- Connecting people, things and information, for example, in cloud computing, 5G Mobile Technology, wireless mesh networks, mobile messaging, the internet of things, and blockchain; and
- Improving presentation through augmented or virtual reality.

Users should interactively communicate and contribute to these systems through social media, crowdsourcing, and citizen science.[55] Frontier technologies, thus, open up the prospect for dealing better with disasters, but also of empowering people and encouraging more democratic and inclusive societies (Figure 5-1).

Frontier technologies and digital solutions can support and extend the provision of social protection. Countries in East and North-East Asia took advantage of frontier technologies and digital solutions for social protection during the COVID-19 pandemic. In China, robots were used in public places and hospitals to minimize human contact, as well as to perform tasks, such as taking temperatures, delivering food, and disinfecting various places. In 2018, a robotic surgical assistant, called ROSA, was installed to help neurosurgery. A logistic robot was used to disinfect isolation wards during the initial COVID-19 period. China also took advantage of AI technologies to detect and diagnose COVID-19 cases, limiting the contact between potentially infected individuals and health practitioners. AI has been used in other instances in the health sector, for example, in the Russian Federation for clinical testing of computer vision algorithms and neural network models which can interpret and analyse images (Table 5-1).

55 United Nations Department of Economic and Social Affairs, Division For Public Institutions and Digital Government, and United Nations Office of Disaster Risk Reduction Global Education and Training Institute, "Risk-informed Governance and Innovative Technology for Disaster Risk Reduction and Resilience", Training Module, 2020.

FIGURE 5-1 **Frontier technologies for disaster risk reduction and healthcare**



Source: Revised from United Nations Department of Economic and Social Affairs, Division For Public Institutions and Digital Government, and United Nations Office of Disaster Risk Reduction Global Education and Training Institute, "Risk-informed Governance and Innovative Technology for Disaster Risk Reduction and Resilience", Training Module, 2020.

Frontier technologies and digital solutions can also be utilized to accelerate disaster early warning, surveillance and impact assessment. Cross-sectoral collaboration is essential in embedding the latest technologies into the disaster management strategies of governments. For example, tracking and mapping movement behaviour can be beneficial in responding to disasters amid the pandemic. The latest technology, such as the open-source software, called Mobipack, in Japan, and the Smart Management System, in the Republic of Korea, can be used for contact tracing using telecommunications' big data (Box 5-2).

TABLE 5-1 Frontier technologies in the disaster risk reduction and health sectors

Technology	Disaster risk reduction	Health sector
Big Data	**China – Climate Intelligent Prediction and Analysis System** A new-generation Climate Intelligent Prediction and Analysis System (CIPAS2.3) is a crowdsource-driven innovative network based on big data technologies. The CIPAS2.3 data application environment, based on the China Integrated Meteorological Information Service System (CIMISS), is deployed on a cloud sharing platform.[56]	**The Republic of Korea –Smart Management System – Contact tracing system** This system analyses the movement routes and contact tracing of COVID-19 cases. It also eases coordination by allowing real-time information exchange. It allows officials real-time access to the whereabouts of COVID-19 patients and the time spent by them at each location.[57, 58]
Robotics		**China – Mechanical robots in the health sector** Robots were used in public places and hospitals to minimize human contact as well as to perform tasks, such as taking temperatures, delivering food and disinfecting various places. In 2018, a robotic surgical assistant, called ROSA, was installed to help neurosurgery. A logistic robot was used to disinfect isolation wards during the initial COVID-19 period.[59]
Artificial Intelligence	**Hong Kong, China – SWIRLS nowcasting system** The Short-range Warning of Intense Rainstorms in Localized Systems (SWIRLS) nowcasting system developed and operated by the Hong Kong Observatory is primarily based on using computer vision techniques to track the movement of radar echoes in successive radar images. Forecasts of rainfall and thunderstorms for the next few hours are then obtained by extrapolating the radar image using the motion field. In recent years, novel, deep learning models have been developed and put into a real-time trial that improves the forecast intensity of radar echoes and hence the rainfall areas in the next couple of hours.[60] **China – Rapid detection of COVID-19** An AI-based COVID-19 diagnostic tool can read and analyse a patient's CT scans in three seconds. The device has reportedly detected all confirmed cases, and had a recall rate of 90 per cent for lesion detection. Many hospitals in China have started using AI to diagnose COVID-19.[63]	**The Russian Federation – AI in health care** The Russian Federation has been developing and implementing innovative technologies. Along with the introduction of medical decision-support systems, AI is being used for clinical testing of computer vision algorithms and neural network models which can interpret and analyse images.[61, 62]
Internet of Things	**Japan – Real-time GEONET analysis system for rapid deformation monitoring** This system uses the global navigation satellite system with continuous operating reference stations to estimate ground movements and earthquake magnitudes in real-time. It is expected to improve the accuracy of tsunami simulations, especially for earthquakes of magnitude greater than 8.[64, 65]	
Satellite data	**China – CASEarth Data Platform** CASEarth, approved in 2018, developed a data-sharing platform for big data and cloud services. CASEarth Data Platform promotes technological innovations in Big Earth Data for developing major strategies for regional or global sustainable development. **Japan – JAXA climate rainfall watch website** Satellite-based global rainfall data are used to produce highly accurate measurements for understanding the changing climate. They are also used to improve forecasts of severe weather events such as floods and droughts, to mitigate damage, and strengthen early warning systems.[66, 67]	

56 Beijing Climate Centre, "A New-Generation Crowdsourcing Innovative Platform: Climate Intelligent Prediction and Analysis System (CIPAS)" 12 October 2020. Available at: http://bcc.ncc-cma.net/news/index/1179

57 Ministry of Land, Infrastructure and Transport (MOLIT), Republic of Korea, "MOLIT, MSIT and KCDC launch the COVID19 data platform", *MOLIT News*, Press release, 26 March 2020. Available at: http://www.molit.go.kr/english/USR/BORD0201/m_28286/DTL.jsp?id=eng_mltm_new&mode=view&idx=2931

58 Sanghoon Lee, "COVID-19: Smart Management System (SMS) in Korea", Ministry of Land, Infrastructure and Transport and Korea Agency for Infrastructure Technology Advancement, 22 April 2020. Available at: https://events.development.asia/system/files/materials/2020/04/202004-covid-19-smart-management-system-sms-republic-korea.pdf

59 Sarah O'Meara, "The robot recruits in China's health-care system", Nature, 24 June 2020. Available at: https://www.nature.com/articles/d41586-020-01793-9

60 Wong wai-kin, "From machine learning to nowcasting", Hong Kong Observatory Educational Resources, September 2020. Available at: https://www.hko.gov.hk/en/education/weather/data-and-technology/00552-from-machine-learning-to-nowcasting.html

61 Elena Aksenova, Natalia Kamynina, and Nadia Vosheva, "Sustainability and Resilience in the Russian Health System", The Partnership for Health System Sustainability and Resilience (PHSSR). Available at: http://www3.weforum.org/docs/WEF_PHSSR_Russia_Report.pdf

62 Webiomed, "The map 'Artificial Intelligence in Russian Health Care'", 2019. Available at: https://webiomed.ai/en/blog/the-map-artificial-intelligence-in-russian-health-care/#:~:text=Other%20examples%20of%20AI%20application,%2Fhospital%2Foncology%2Dsurgical%2F

63 Deepali Roy, "COVID effect: Medical AI takes prominence in Asia Pacific", Geospatial World, 5 May 2020. Available at: https://www.geospatialworld.net/blogs/covid-effect-medical-ai-takes-prominence-in-asia-pacific/

64 Satoshi Kawamoto and others, "REGARD: A new GNSS-based real-time finite fault modeling system for GEONET", Advancing Earth and Space Science, 2 February 2017. Available at: https://agupubs.onlinelibrary.wiley.com/doi/10.1002/2016JB013485

65 Cabinet Secretariat, Government of Japan and Disaster Management Bureau, Cabinet Office, Government of Japan, "Guide to disaster management measures (technologies, know-how, infrastructure, institutions etc.) in Japan". Available at: http://www.bousai.go.jp/kaigirep/catalog/pdf/Guide_to_Japanese_tech_EN.pdf (accessed on 8 April 2021).

66 Earth Observation Research Center (EORC) and Japan Aerospace Exploration Agency (JAXA), "Global Extreme Heavy Rainfall and Drought detected by GSMaP 'JAXA Climate Rainfall Watch' website is now available", 9 March 2020. Available at: https://www.eorc.jaxa.jp/en/news/2020/nw200309.html

67 United Nations Office for Outer Space Affairs, UN-Spider Knowledge Portal, "New JAXA website provides hourly global measurements of precipitation", 15 April 2020. Available at: https://un-spider.org/news-and-events/news/new-jaxa-website-provides-hourly-global-measurements-precipitation

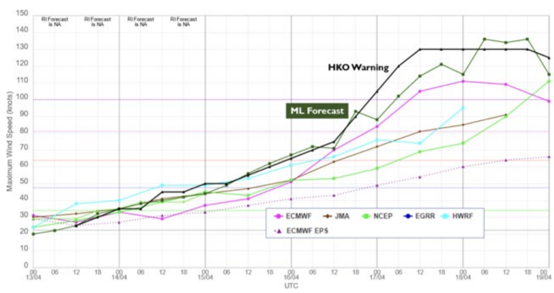
BOX 5-1 Application of machine learning in tropical cyclone forecasting

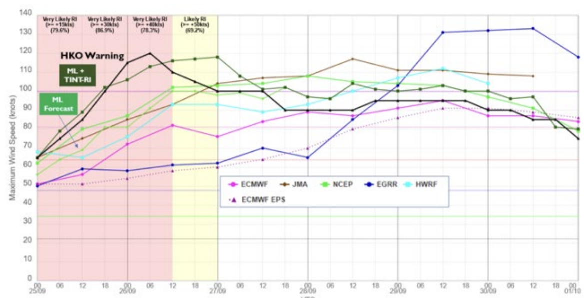
With the rapid development of Artificial Intelligence (AI), countries have begun to incorporate machine-learning techniques in tropical cyclone (TC) forecasting. Such techniques have enhanced the capacity of countries to monitor and forecast TC activities. Machine-learning techniques contribute positively to enhancing forecasts of TC intensity, extreme rainfalls under various scenarios, and synoptic weather patterns.

The National Meteorological Center (NMC) of China explored the application of machine learning in TC vortex detection by utilizing satellite images and tracking data from China Meteorological Administration. Machine learning detects the location of the typhoon vortex centre in satellite infrared images by capturing the characteristics of TC, and the model is trained and tested. As a result, the recognition rates of typhoons are highly accurate, especially with high-intensity TCs. This tool effectively supports real-time and precise monitoring of tropical cyclones.a

The application of machine learning to improve the intensity forecast of TC has also been put into operational trial by the Hong Kong Observatory (HKO) since 2020. The machine learning (ML) algorithm combines outputs from European Centre for Medicum-Range Weather Forecasts (ECMWF) Ensemble Prediction System (EPS) on various TC parameters to generate a calibrated intensity prediction and demonstrated promising performance in capturing the intensity change and rapid intensification of tropical cyclones compared to other models. Figure 5-A below depicts the machine-learning forecast (ML forecast), which is similar to the HKO warning, confirming the accuracy of machine-learning forecasts. Further improvements have been made by introducing a blending scheme that combines the ML forecast with a statistical-dynamic model of rapid intensification, which enhances the overall intensity guidance from the short-term to the next few days. The continual advancement of machine learning techniques is expected to further develop impact-based forecasts and risk-based warnings.b

FIGURE 5-A Forecasts of maximum wind speed (in knots) for tropical Cyclone Surigae (top) and Mindulle (bottom) based on machine learning forecast and various numerical weather prediction models.





Source: ESCAP/WMO Typhoon Committee, Members Report of Hong Kong, China for the 16th Integrated Workshop. Available at: http://www.typhooncommittee.org/16IWS/Members16IWS.html

a ESCAP/WMO Typhoon Committee, "Member Report of China", 16th Integrated Workshop. Available at: http://www.typhooncommittee.org/16IWS/Members16IWS.html

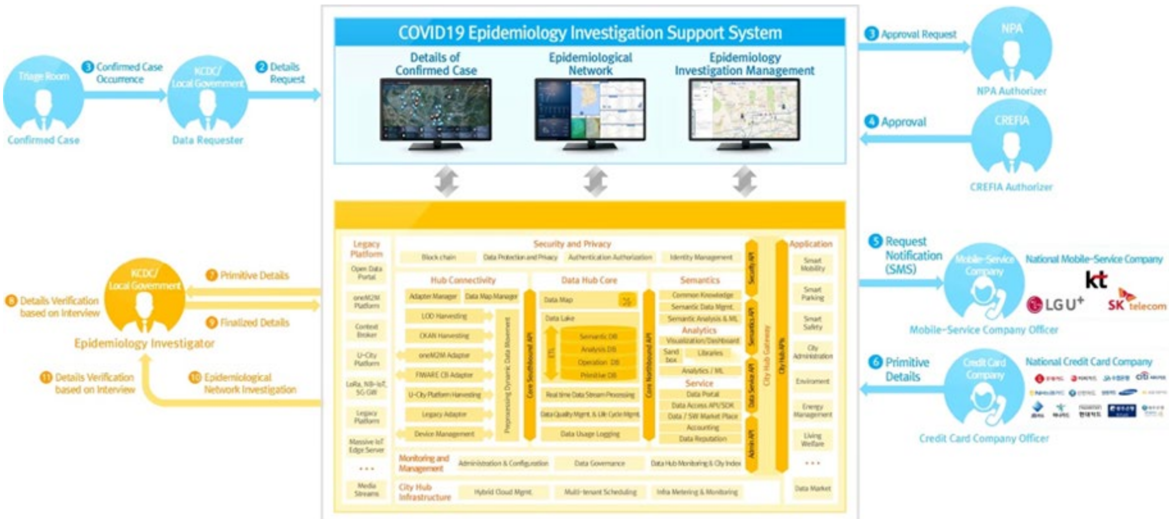
b ESCAP/WMO Typhoon Committee, "Member Report of Hong Kong, China", 16th Integrated Workshop. Available at: http://www.typhooncommittee.org/16IWS/Members16IWS.html

BOX 5-2 Big Data for COVID-19 contact tracing in the Republic of Korea[a]

In response to the COVID-19 pandemic, the 'COVID-19 Smart Management System' was developed to help speedy contact-tracing processes. During the early stage of the outbreak, contact tracing was done where an Epidemic Intelligence Service (EIS) officer contacted all necessary organizations to obtain the data to trace the movement patterns of coronavirus patients. However, as the number of infected persons rapidly increased, this quickly overburdened EIS officers and the system reached its capacity limit. Also, it could not detect false information given by the infected and thus often jeopardized the entire contact tracing process.

In response, the Ministry of Land, Infrastructure and Transport (MOLIT), Ministry of Science and ICT (MSIT), and Centers for Disease Control and Prevention (KCDC) jointly developed a COVID-19 data platform that could automate the contact tracing process. It was developed based on the 'Smart City Data Hub Platform', a city data analysis tool that analyses data on traffic, energy use, environment and safety. With the new system, the movement of a new patient could be recreated within 10 minutes using the Big Data collected from the patient's mobile phone location information and credit card transaction history. The system can also analyse areas with cluster infections and provide overviews into how such massive breakouts began.

FIGURE 5-B Contact tracing using COVID-19 data platform in the Republic of Korea



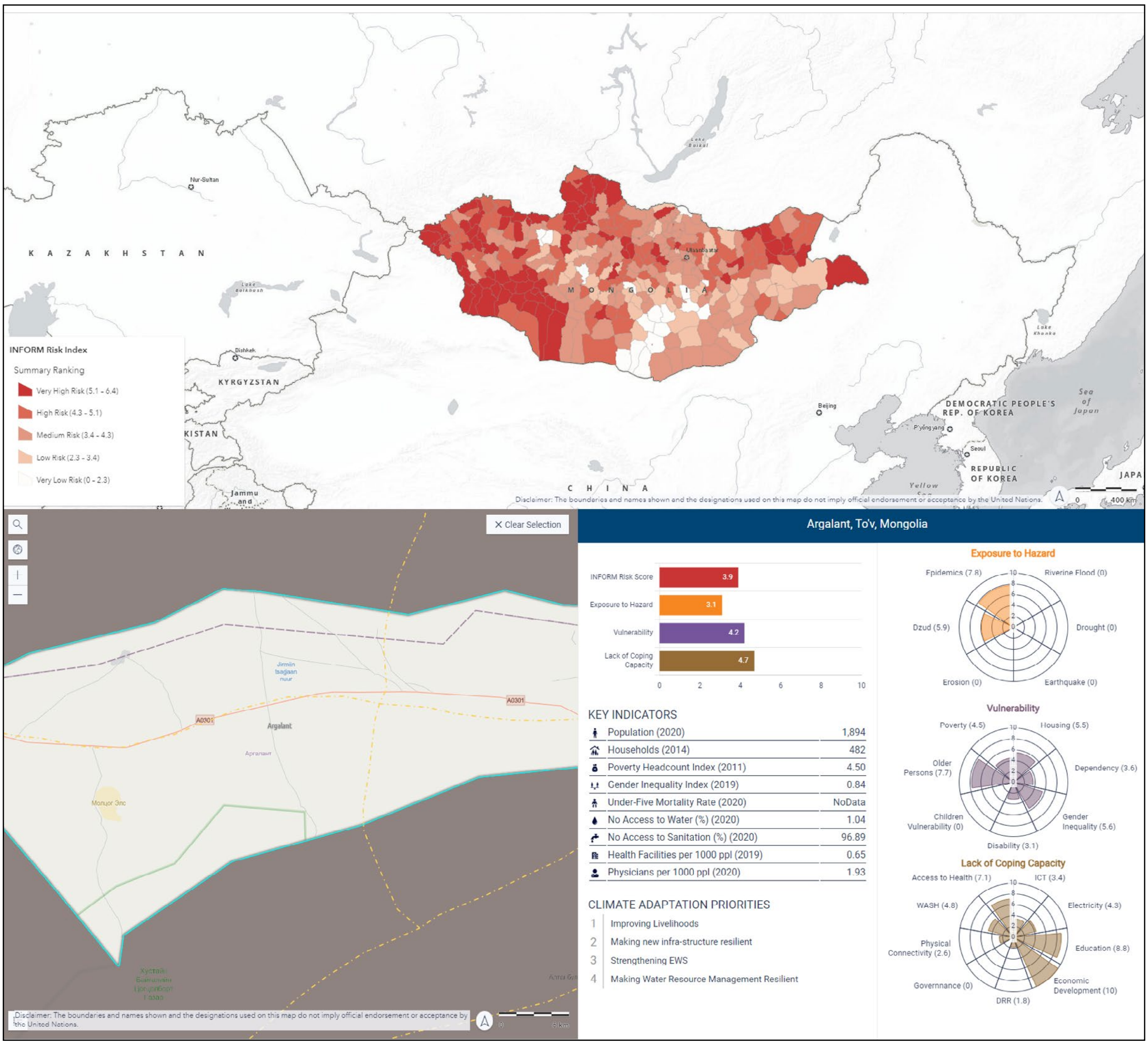
Sources: Ministry of Land, Infrastructure and Transport (MOLIT), Republic of Korea, "MOLIT, MSIT and KCDC launch the COVID19 data platform", *MOLIT News*, Press release, 26 March 2020. Available at: http://www.molit.go.kr/english/USR/BORD0201/m_28286/DTL.jsp?id=eng_mltm_new&mode=view&idx=2931

a Ministry of Land, Infrastructure and Transport (MOLIT), Republic of Korea, "MOLIT, MSIT and KCDC launch the COVID19 data platform", *MOLIT News*, Press release, 26 March 2020. Available at: http://www.molit.go.kr/english/USR/BORD0201/m_28286/DTL.jsp?id=eng_mltm_new&mode=view&idx=2931

Risk analytics

Sound understanding of risk is essential for disaster risk management and building resilience. Risk analytics can now utilize large volumes of data collected on exposure to hazard, vulnerability, and lack of coping capacity from various sources. The decision support system of ESCAP's Risk and Resilience Portal provides a contextual analysis of risk based on INFORM Sub-National Risk Index to support informed decision making of selected countries (Figure 5-2).

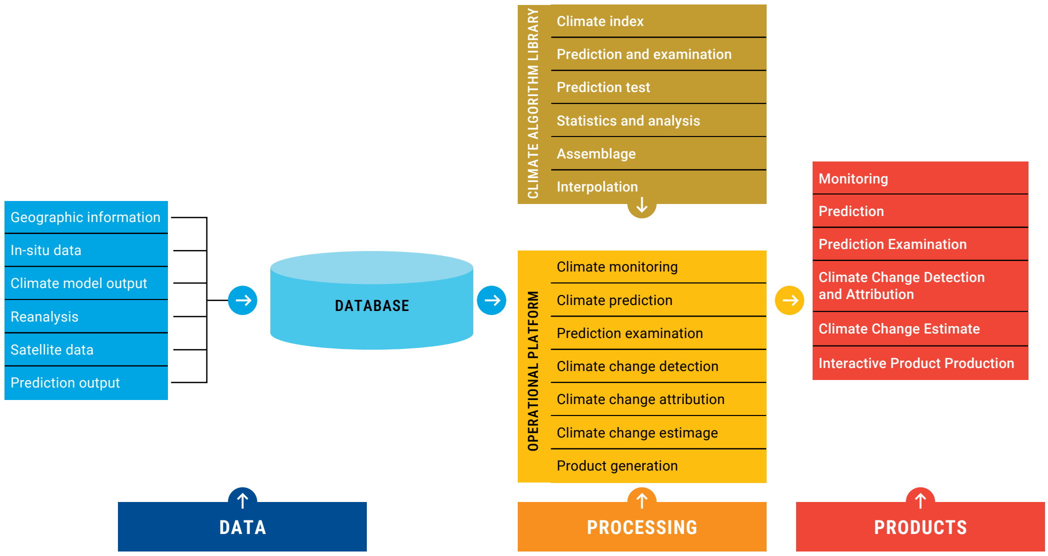
FIGURE 5-2 Risk and Resilience Portal – Decision support system for Mongolia



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

Risk analytics can benefit from frontier technology. For example, China recently developed a new-generation Climate Intelligent Prediction and Analysis System (CIPAS2.3), a crowdsource-driven innovative network based on big data technology (Figure 5-3). The CIPAS2.3 combines observed, climate index, reanalysis, satellite, and numerical forecast data, available through a cloud sharing platform. From data collected from geographic information, in-situ data, climate model output, reanalysis, satellite data, and prediction output, this system will support risk analytics through various products on climate monitoring, prediction and examination, among others.

FIGURE 5-3 **Climate Intelligent Prediction and Analysis System (CIPAS2.3)**



Source: Beijing Climate Centre, News and Events. Available at: http://bcc.ncc-cma.net/ (accessed on 9 March 2022).

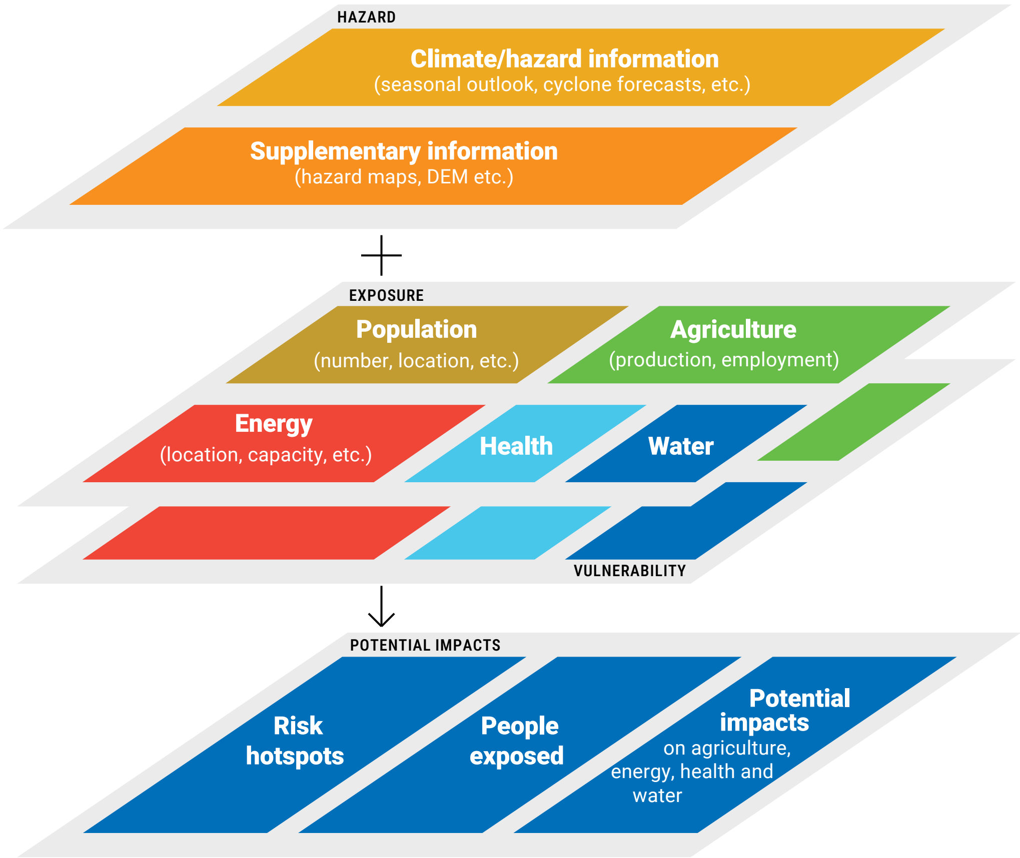
Impact-based forecasting

Establishing well-functioning end-to-end early warning systems is critical in responding to, especially climate-related, natural hazards. The importance of early warning information to reduce disaster risks by allowing stakeholders to make an early decision and take early action has been recognized, and countries in East and North-East Asia have also made efforts in strengthening multi-hazard early warning systems, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030.

Building on these efforts, further operationalizing impact-based forecasting can significantly increase the efficiency of early warning systems. Moving from broadcasting what the weather will be to what the weather will do by combining hazard, exposure and vulnerability data can better support early action (Figure 5-4).

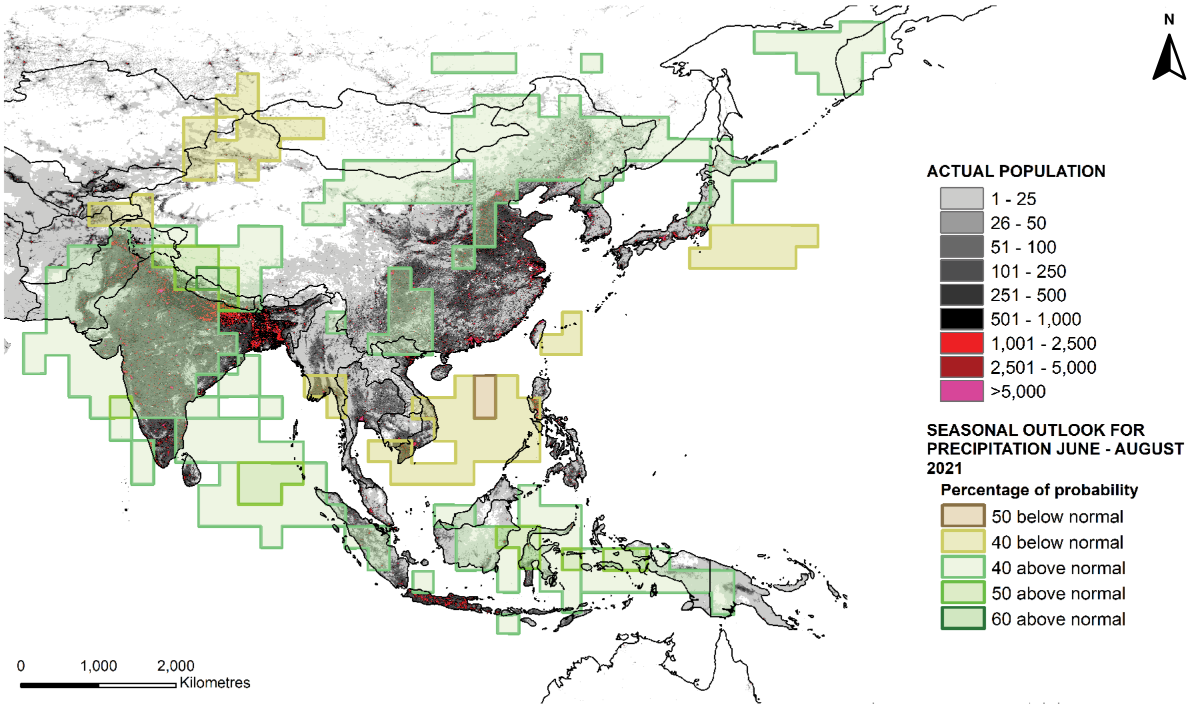
Analysing exposure and vulnerability data, from key sectors providing climate and hazard information, can help identify potential impact information, such as the number of people who have likely been exposed to a hazard, whether critical infrastructure has been exposed, the potential impact on agricultural areas, and any other considerations for disaster risk management, like the COVID-19 pandemic. Figure 5-5 presents an example of population data and confirmed COVID-19 cases with seasonal forecasts for June to August 2021. When further assessed with related risk information, such as flood and drought risks of the areas and current vegetation condition index, such data can provide advance information on potential flood or drought events for further monitoring, assessment, and preparation.

FIGURE 5-4 **ESCAP's approach for impact-based forecasting**



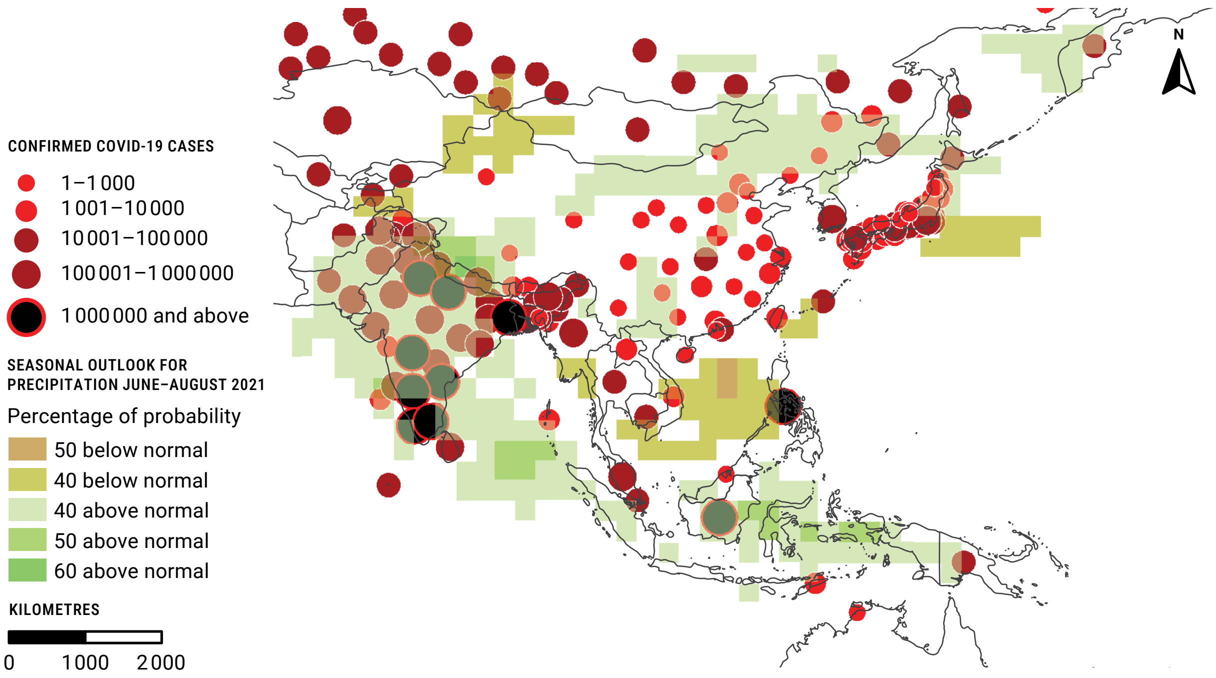
Source: See ESCAP/CDR/2021/INF/1.

FIGURE 5-5 **Exposure of population (up) and confirmed COVID-19 cases (down) with seasonal forecasts for June-August 2021**



Sources: ESCAP, based on Worldpop 2020 Population Estimates; WMO Asia Pacific Seasonal Outlook Precipitation Data for June to August 2021; and UN Geospatial.

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.



Sources: ESCAP, based on Johns Hopkins University Coronavirus COVID-19 Cases V2, 12 May 2021 and WMO Asia Pacific Seasonal Outlook Precipitation Data for June to August 2021.

Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

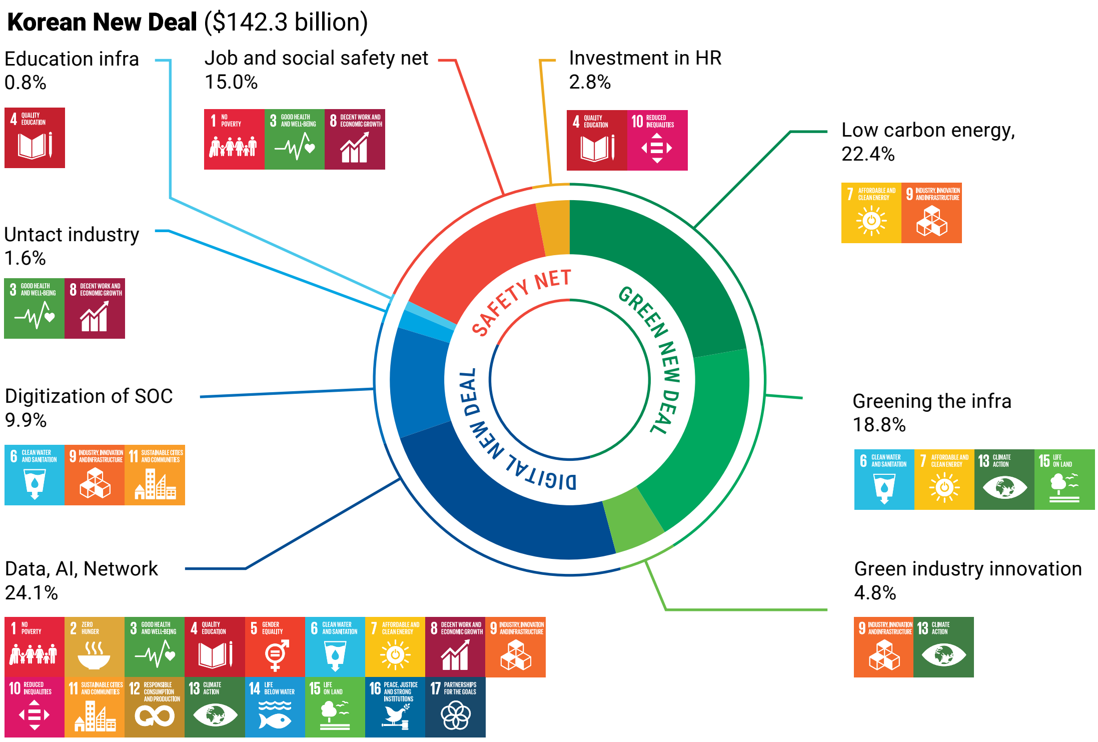
Source: ESCAP presentation at the 17th session of the Forum on Regional Climate Monitoring, Assessment and Prediction for Asia, May 2020.

Innovation ecosystems

Utilizing frontier technology and digital solutions for resilient recovery from the pandemic will also require innovation ecosystems that support the implementation of the 2030 Agenda for Sustainable Development. This would involve, among others, significant investment in digital infrastructure, the innovation industry, social overhead capital, and human resources.

The Republic of Korea, for example, plans to invest around $142 billion, by 2025, in its 'Korean New Deal' (Figure 5-6). In this initiative, digital infrastructure is seen as vital for resilient recovery, including disaster risk management through enhanced early warning systems and real-time monitoring of water resources. For digital technology, it plans to invest $52 billion across four areas: sectoral databases, a 5G network and Artificial Intelligence technology; digital infrastructure for education; contact-free, 'untact' industry; and digitization of social overhead capital, such as transportation, communication, and power.

FIGURE 5-6 **The Korean New Deal supports the SDGs**



Source: ESCAP, based on Korean New Deal, Korea Meteorological Administration.

References

Aksenova, Elena, Natalia Kamynina, and Nadia Vosheva. Sustainability and Resilience in the Russian Health System. The Partnership for Health System Sustainability and Resilience (PHSSR). Available at: http://www3.weforum.org/docs/WEF_PHSSR_Russia_Report.pdf

Asian Development Bank and World Bank Group (2021). Climate risk country profile: Mongolia. Washington D.C. Available at: https://www.adb.org/sites/default/files/publication/709901/climate-risk-country-profile-mongolia.pdf

Bai, Li, Lindsay C. Morton and Qiyong Liu (2013). Climate change and mosquito-borne diseases in China: a review. *Globalization and Health*, vol. 9, No. 10. Available at: https://doi.org/10.1186/1744-8603-9-10

Beijing Climate Centre (2020). A New-Generation Crowdsourcing Innovative Platform: Climate Intelligent Prediction and Analysis System (CIPAS). 12 October. Available at: http://bcc.ncc-cma.net/news/index/1179

Beijing Climate Centre, News and Events. Available at: http://bcc.ncc-cma.net/channel/index/2/0 (accessed on 9 December 2021).

Cabinet Secretariat, Government of Japan and Disaster Management Bureau, Cabinet Office, Government of Japan. Guide to disaster management measures (technologies, know-how, infrastructure, institutions etc.) in Japan. Available at: http://www.bousai.go.jp/kaigirep/catalog/pdf/Guide_to_Japanese_tech_EN.pdf (accessed on 8 April 2021).

Cha, Eun Jeong and others (2020). Third assessment on impacts of climate change on tropical cyclones in the Typhoon Committee Region – Part II: Future Projections. *Tropical Cyclone Research and Review*, vol. 9, No. 2 (June). Available at: https://doi.org/10.1016/j.tcrr.2020.04.005

Cha, Sangmi and Sakura Murakami (2020). Typhoon Haishen threatens Korea after battering Japan. *Reuters*, 7 September. Available at: https://www.reuters.com/article/us-asia-storm/typhoon-haishen-threatens-korea-after-battering-japan-idUSKBN25Y00L

CWS Japan and others (2021). Disaster during a pandemic: Lessons from 2020 flooding in South Japan. January. Available at: https://cwsglobal.org/wp-content/uploads/2021/01/Disaster-During-a-Pandemic-1.6.2021.pdf

Earth Observation Research Center (EORC) and Japan Aerospace Exploration Agency (JAXA) (2020). Global Extreme Heavy Rainfall and Drought detected by GSMaP 'JAXA Climate Rainfall Watch' website is now available. 9 March. Available at: https://www.eorc.jaxa.jp/en/news/2020/nw200309.html

EM-DAT - The International Disaster Database. Available at: http://www.emdat.be (accessed on 1 December 2021).

European Commission's Directorate-General for European Civil Protection and Humanitarian Aid Operations (2020). Japan, Korean Peninsula – Tropical Cyclone HAISHEN update (DG ECHO, GDACS, JTWC, FDMA, ReliefWeb, media). ECHO Daily Flash, News and Press Release, 8 September. Available at: https://reliefweb.int/report/republic-korea/japan-korean-peninsula-tropical-cyclone-haishen-update-dg-echo-gdacs-jtwc-fdma

Food and Agriculture Organization of the United Nations. FAOSTAT: Democratic People's Republic of Korea. Available at: https://www.fao.org/faostat/en/#country/116 (accessed on 24 February 2022).

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

Government of the People's Republic of China, National Disaster Reduction Center of China (2021). 2020 Global Natural Disaster Assessment Report. Reliefweb. 20 October. Available at: https ://reliefweb.int/report/china/2020-global-natural-disaster-assessment-report

Groppo, Valeria and Kati Kraehnert (2016). Extreme Weather Events and Child Height: Evidence from Mongolia. *World Development*, vol. 86 (October). Available at: https://www.sciencedirect.com/science/article/abs/pii/S0305750X15303120

Internal Displacement Monitoring Centre (IDMC). 2020 Internal Displacement. Global Internal Displacement Database. Available at https://www.internal-displacement.org/database/displacement-data (accessed on 29 November 2021).

International Federation of Red Cross and Red Crescent (2020a). Forecast-based early action triggered in: Mongolia for Dzud (EAP2020MN02). Situation report. 21 December.

__________ (2020b). Mongolia/East-Asia: Dzud, Final report early action. July. Available at: https://reliefweb.int/sites/reliefweb.int/files/resources/MDRMN010EAPfr.pdf

__________ (2021). Climate change impacts on health and livelihoods: Mongolia assessment. April. Available at: https://reliefweb.int/sites/reliefweb.int/files/resources/RCRC_IFRC-Country-assessments-MONGOLIA-3.pdf

JBA Risk Management Ltd. (2020). Kyushu Island, Japan. Available at: https://www.jbarisk.com/flood-services/event-response/kyushu-flooding-japan/

Kawamoto, Satoshi and others (2017). REGARD: A new GNSS-based real-time finite fault modeling system for GEONET. Advancing Earth and Space Science. 2 February. Available at: https://agupubs.onlinelibrary.wiley.com/doi/10.1002/2016JB013485

Lee, Sanghoon (2020). COVID-19: Smart Management System (SMS) in Korea. Ministry of Land, Infrastructure and Transport and Korea Agency for Infrastructure Technology Advancement, 22 April. Available at: https://events.development.asia/system/files/materials/2020/04/202004-covid-19-smart-management-system-sms-republic-korea.pdf

Lindstrom, Scott (2021). Sandstorm hits Beijing China. Cooperative Institute for Meteorological Satellite Studies (CIMSS), Satellite Blog. 16 March. Available at: https://cimss.ssec.wisc.edu/satellite-blog/archives/40262

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

Menéndez, Pelayo and others (2020). The Global Flood Protection Benefits of Mangroves. *Scientific Reports*, vol. 10, No. 4404 (10 March). Available at : https://www.nature.com/articles/s41598-020-61136-6

Mercy Crops (2021). The Legacy of Mercy Corps Mongolia: A 22 years summative report. May. Available at: https://www.mercycorps.org/sites/default/files/2021-05/LegacyofMCMongolia22YearReport-ENG.pdf

Ministry of Land, Infrastructure and Transport (MOLIT), Republic of Korea (2020). MOLIT, MSIT and KCDC launch the COVID19 data platform. *MOLIT News*, Press release, 26 March. Available at: http://www.molit.go.kr/english/USR/BORD0201/m_28286/DTL.jsp?id=eng_mltm_new&mode=view&idx=2931

NASA, Socioeconomic Data and Application Centre. Gridded Population of the World (GPW), v4. Available at: https://sedac. ciesin.columbia.edu/data/collection/gpw-v4/maps/gallery/search

National Agency for Meteorology and Environmental Monitoring (NAMEM). Available at https://www.namem.gov.mn

Nguyen, Ha, Camille Pross and Jenny Yi-Chen Han (2020). Review of Gender-Responsiveness and Disability-Inclusion in Disaster Risk Reduction in Asia and the Pacific. UN Women. Available at: https://www2.unwomen.org/-/media/field%20office%20eseasia/docs/publications/2020/10/ap-drr-sendai-report-final-s.pdf?la=en&vs=3742

NHK World – Japan (2020). Coronavirus hampers evacuation efforts during Typhoon Haishen. 8 September. Available at: https://www3.nhk.or.jp/nhkworld/en/news/backstories/1280/

O'Meara, Sarah (2020). The robot recruits in China's health-care system. Nature. 24 June. Available at: https://www.nature.com/articles/d41586-020-01793-9

Osumi, Magdalena (2019). 78% of older teenagers in Japan anxious about natural disasters, survey says. UNDRR Prevention Web. 7 March. Available at: https://www.preventionweb.net/news/78-older-teenagers-japan-anxious-about-natural-disasters-survey-says

Reliefweb. Russian Federation: Wild Fires/Heatwave - Jul 2010. Available at:

https://reliefweb.int/disaster/wf-2010-000147-rus

Reliefweb. DPR Korea: Heat Wave – Aug 2018. Available at: https://reliefweb.int/disaster/ht-2018-000126-prk

Reliefweb. Mongolia: Dzud – Jan 2020. Available at: https://reliefweb.int/disaster/cw-2020-000004-mng

Revich, Boris, Nikolai Tokarevich and Alan J. Parkinson (2012). Climate change and zoonotic infections in the Russian Arctic. *International Journal of Circumpolar Health*, vol. 71, No. 1 (July). Available at: DOI: 10.3402/ijch.v71i0.18792

Rich, Motoko, Makiko Inoue and Hisako Ueno (2020). Japan's Deadly Combination: Climate Change and an Aging Society. *New York Times*, 18 September. Available at: https://www.nytimes.com/2020/07/09/world/asia/japan-climate-change-rains-elderly.html

Roy, Deepali (2020). COVID effect: Medical AI takes prominence in Asia Pacific. Geospatial World. 5 May. Available at: https://www.geospatialworld.net/blogs/covid-effect-medical-ai-takes-prominence-in-asia-pacific/

SDG Gateway Asia-Pacific Data Explorer. Available at: https://dataexplorer.unescap.org

The Guardian (2011). Japan earthquake: 100,000 children displaced, says charity. 15 March. Available at: https://www.theguardian.com/world/2011/mar/15/japan-earthquake-children-displaced-charity

United Nations Department of Economic and Social Affairs, Division For Public Institutions and Digital Government, and United Nations Office of Disaster Risk Reduction Global Education and Training Institute (2020). Risk-informed Governance and Innovative Technology for Disaster Risk Reduction and Resilience. Training Module.

United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). Asia-Pacific SDG Gateway. Is Asia-Pacific on track to achieve the SDGs? Available at https://data.unescap.org/home.

__________ (2012). Disability at a Glance 2012: Strengthening the evidence base in Asia and the Pacific. Available at: https://www.unescap.org/sites/default/d8files/knowledge-products/SDD_PUB_Disability-Glance-2012_1.pdf

__________ (2014). Disability-Inclusive Disaster Risk Reduction in Asia and the Pacific. Note for the secretariat prepared for the Asia-Pacific Meeting on Disability-inclusive Disaster Risk Reduction: Changing Mindsets through Knowledge. Sendai, Japan, 22-23 April. Available at: https://www.unescap.org/sites/default/files/DiDRR_Background-note.pdf

__________ (2019a). *Asia-Pacific Disaster Report 2019: The Disaster Riskscape across East and North-East Asia*. United Nations publication.

__________ (2019b). *Disability at a Glance 2019: Investing in Accessibility in Asia and the Pacific*. United Nations publication. Available at https://www.unescap.org/publications/disability-glance-2019

__________ (2021a). *Asia-Pacific Disaster Report 2021.* United Nations publication.

__________ (2021b). *Asia and the Pacific SDG Progress Report 2021*. United Nations publication.

__________ Risk and Resilience Portal. Available at: rrp.unescap.org

__________ Risk and Resilience Portal. Adaptation Cost and Priorities for East and North-East Asia. Available at: https://rrp.unescap.org/adaptation-and-priorities/enea

__________ (forthcoming). NEASPEC Study on interlinkage of DLDD and climate change in ENEA.

United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) and WMO Typhoon Committee. Member Report of China. 16th Integrated Workshop. Available at: http://www.typhooncommittee.org/16IWS/Members16IWS.html

United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) and WMO Typhoon Committee. Member Report of Hong Kong, China. 16th Integrated Workshop. Available at: http://www.typhooncommittee.org/16IWS/Members16IWS.html\

United Nations Office for Disaster Risk Reduction (UNDRR) (2020). Integrating Disaster Risk Reduction and Climate Change

Adaption in the UN Sustainable Development Cooperation Framework. Geneva.

United Nations Office for Outer Space Affairs, UN-Spider Knowledge Portal (2020). New JAXA website provides hourly global measurements of precipitation. 15 April. Available at: https://un-spider.org/news-and-events/news/new-jaxa-website-provides-hourly-global-measurements-precipitation

Wai-kin, Wong (2020). From machine learning to nowcasting. Hong Kong Observatory Educational Resources. September. Available at: https://www.hko.gov.hk/en/education/weather/data-and-technology/00552-from-machine-learning-to-nowcasting.html

Webiomed (2019). The map 'Artificial Intelligence in Russian Health Care'". Available at: https://webiomed.ai/en/blog/the-map-artificial-intelligence-in-russian-health-care/#:~:text=Other%20examples%20of%20AI%20application,%2Fhospital%2Foncology%2Dsurgical%2F

World Bank (2021). World Bank Development Indicators. Available at: https://databank.worldbank.org/reports.aspx?source=2&series=SH.DYN.MORT&country= (accessed 10 December 2021).

World Bank Group and National Statistics Office of Mongolia (2021). Results of Mongolia COVID-19 Household Response Phone Survey (Round 3). January. Available at: https://thedocs.worldbank.org/en/doc/674291610418865659-0070022021/original/MNGHFphonesurveyR3Final.pdf

World Health Organization (WHO). WHO Coronavirus (COVID-19) Dashboard. Available at https://covid19.who.int

__________ (2012). Strengthen control of vectorborne diseases to lessen the impact of climate change in the Western Pacific Region with focus on Cambodia, Mongolia and Papua New Guinea: Final project report. WHO Regional Office for the Western Pacific.

World Meteorological Organization (WMO) (2020). State of the Climate in Asia. WMO-No.1273. Available at:

https://reliefweb.int/sites/reliefweb.int/files/resources/1273_State_of_the_Climate_in_Asia_2020_en.pdf

World Weather Attribution (2020). Siberian heat of 2020 almost impossible without climate change. 15 July. Available at: https://www.worldweatherattribution.org/siberian-heatwave-of-2020-almost-impossible-without-climate-change/

Wright, Natalie and others (2020). Health emergency and disaster risk management: Five years into implementation

of the Sendai Framework. *International Journal of Disaster Risk Science*, vol. 11, pp. 206–217. Available at https://link.springer.com/article/10.1007/s13753-020-00274-x

Wu, Pei-Chih and others (2007). Weather as an effective predictor for occurrence of dengue fever in Taiwan. *Acta Tropica*, vol. 103, No.1 (July).

Pathways to Adaptation and Resilience in East and North-East Asia **demonstrates how the East and North-East Asian subregion is being affected by various risk parameters, and where new hotspots of exposure and vulnerability to climate-induced, cascading multi-hazard scenarios are being created. Moving forward, ESCAP recommends that East and North-East Asia implements customized adaptation and resilience pathways with emphasis on risk-informed development policies and investments, technological innovations and subregional cooperation approaches. These measures can accelerate the progress of countries in achieving the Sustainable Development Goals and the targets of the Sendai Framework for Disaster Risk Reduction.**