Climate Change and Desertification, Land Degradation and Drought in North-East Asia

Part II

Acknowledgement

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Executive Summary

Desertification, land degradation, and drought (DLDD) pose formidable challenges to the sustainable development goals, particularly SDG 15 – life on land, in North-East Asia. Approximately 77.8 per cent of Mongolia's land area, 34.6 per cent of China's land area, and 7 per cent of the Russian Federation's land area are dryland and prone to desertification and land degradation. Drought also profoundly impacts the people and their livelihoods with a high economic burden in North-East Asia.

Climate change is likely to add desertification, land degradation, and drought risks in many parts of North-East Asia. In the most eastern part of North-East Asia, the temperature has substantially increased in the past decades. In the arid areas of northwest China, the temperature has risen by 0.34ºC per decade during 1960-2010. Mongolia has also experienced rapid warming between 1940 and 2015, with an average temperature increase of 2.24ºC. According to the Intergovernmental Panel on Climate Change (IPCC) sixth assessment report, the global surface air temperature rises across all emission scenarios. A higher increase in temperature is projected for most parts of the subregion. Arid and semi-arid regions are also very likely to experience further increases in temperature and intense heat stress.

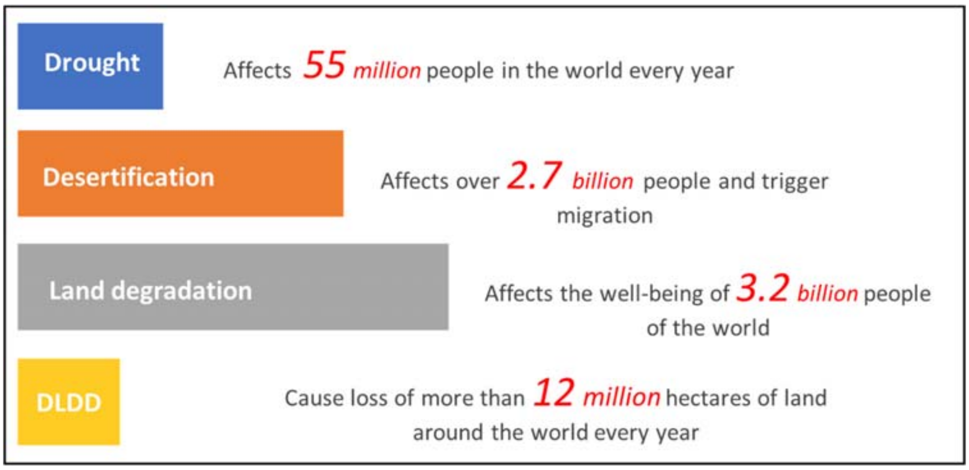
With this purview, this report is to understand the impacts of climate change on desertification, land degradation, and drought characteristics in North-East Asia. Based on the most recent IPCC climate projections under two different scenarios, namely SSP2-4.5 (intermediate emission) and SSP5-8.5 (high emission), the report assesses desertification, land degradation, and drought risks and studies their potential socio-economic impacts in North-East Asia. Population exposure, as a proportion of the total population, to intensifying risk of desertification is highest in Mongolia. Also, more than half of agricultural production and livestock in arid areas of Mongolia is likely to be exposed to increasing desertification risk. Drought risk is also expected to increase in some previously drought-affected regions in North-East Asia. Exposure of population, agricultural production, and livestock to intensifying drought risk is highest in the Russian Federation, followed by China, Japan, and Mongolia in both climate scenarios.

It is necessary to promote science-based, policy-oriented cooperation and adopt long-term proactive measures reflecting risk assessment based on climate projections. As desertification, land degradation, and drought risks are transboundary; subregional cooperation is essential to address the shared risks. The NEASPEC strategic plan 2021- 2025 recognises the need to address desertification and land degradation, focusing on climate change. Subregional cooperation can promote efficient utilisation of resources through strengthening coordination and facilitating technical cooperation and knowledge sharing in addressing these risks.

Chapter I. Overview

The land is one of the world's vital geo-resources, which is the basis of many life support systems. Land resources facilitate the provision of several ecosystem goods and services, and hence, human well-being and sustainable livelihood depend upon their health and productivity. While the growing population and associated demands pose severe pressure on the land resources, climate change also adds stress to the health of the land ecosystem. Desertification, land degradation and drought events affect many people (Figure 1), and thus it is essential to address these hazards to achieve the 2030 Agenda for Sustainable Development.

Figure 1 Global impacts of desertification, land degradation and drought events[1]



1.1 Overview of the risk in North-East Asia

Desertification, land degradation and drought (DLDD) are severe problems in North-East Asia.[2] Desertification is primarily contributed by environmental pollution, land-use change, expansion of agriculture and unsustainable agriculture management practices, deforestation, and overgrazing, which may be further aggravated by climate change and its impacts.[3,4] A recent estimate shows that 77.8 per cent of Mongolia's land area is undergoing degradation, of which 9.9 per cent is highly degraded and prone to desertification.[5] For example, time-series analysis in the Khogno Khaan protected area in central Mongolia shows a significant increase in the area under severe desertification between 1990 and 2011.[6] In China, the dryland, which is prone to desertification, is estimated to cover 34.6 per cent of its land area, mainly spreading across the northern and north-western parts. In response, China has launched an integrated policy

[1] Le et al 2016
[2] UNCCD 2019
[3] Yulin et al. 2011
[4] UNCCD 2019
[5] UNCCD 2019
[6] Lamchin et al 2016

and legal framework to combat desertification from the early 2000s. This has contributed to reducing the degrees and areas under desertification between 2004 and 2014. However, around 90 per cent of grassland and many other natural systems are still undergoing different degrees of degradation.[7] In the Russian Federation, about 7 per cent of the total area were reported prone to desertification primarily due to degradation in pastureland vegetation. Most desertification prone areas are concentrated in the south-eastern end of the Russian Federation.[8]

Soil erosion in arable or intensively grazed lands can be 100 to 1,000 times higher than natural erosion, reducing land productivity.[9] In the Democratic People's Republic of Korea (DPR Korea) and the Russian Federation, land degradation through soil erosion is a significant threat to agriculture, especially in areas with a slope above 10 degrees. The DPR Korea Environment and Climate Outlook in 2012 estimated around 40-60 tonnes/ha of soil is lost through erosion every year in DPR Korea, which may increase up to 100 tonnes/ha per year in severe cases.[10] In the Russian Federation, around 50 per cent of the land area is prone to degradation, of which 13 per cent is already either moderately or strongly degraded due to soil erosion.[11,12] In Japan, 30 per cent of agricultural land is already degraded.[13]

Droughts affect millions of people and large areas of land worldwide. From 1961 to 2013, drought events have increased by more than 1 per cent per year in arid and semi-arid areas and is also projected to increase in many arid and semi-arid regions under climate change scenarios.[14] **This is not much different in North-East Asia.** Mongolia has been affected by frequent drought in the summer season, followed by China and the Russian Federation.[15] The impact of drought in Mongolia is amplified when summer drought combines with harsh winter conditions (dzud), affecting people and livestock.[16] Drought events significantly affect agricultural production and water supply in Mongolia, China and the Russian Federation, with a high average annual loss (AAL) (Figure 2).[17] In Mongolia, drought was responsible for 84.7 per cent of total AAL from natural hazards, followed by China and the Russian Federation at 80 per cent and 60 per cent, respectively.[18]

[7] UNCCD 2019

[8] Kust et al. 2011

[9] FAO n.d.

[10] MoLEP, DPRK 2012

[11] State report 2017

[12] Tsymbarovich and other 2020

[13] UNCCD n.d.

[14] Ranasinghe et al.2021

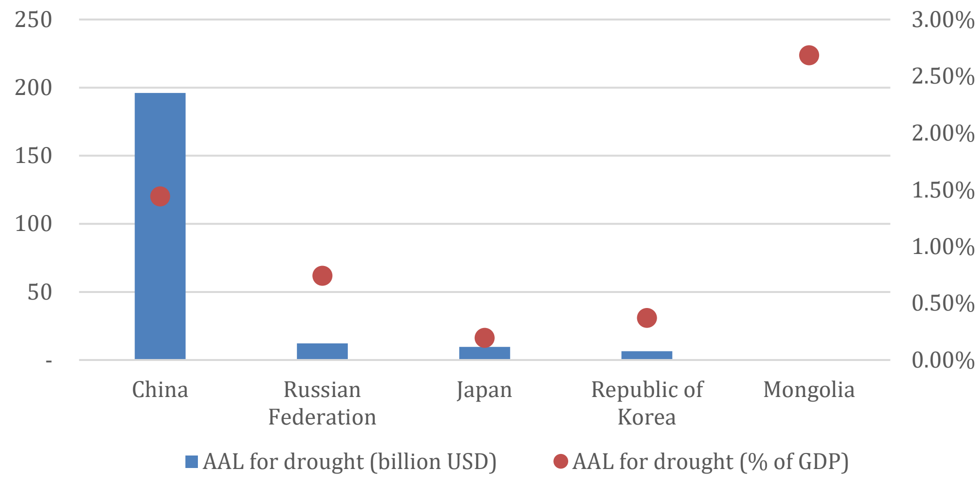
[15] UNESCAP 2020

[16] UNCCD 2019

[17] UNESCAP 2020

[18] UNESCAP 2020

Figure 2 Average annual loss for drought in North-East Asian countries



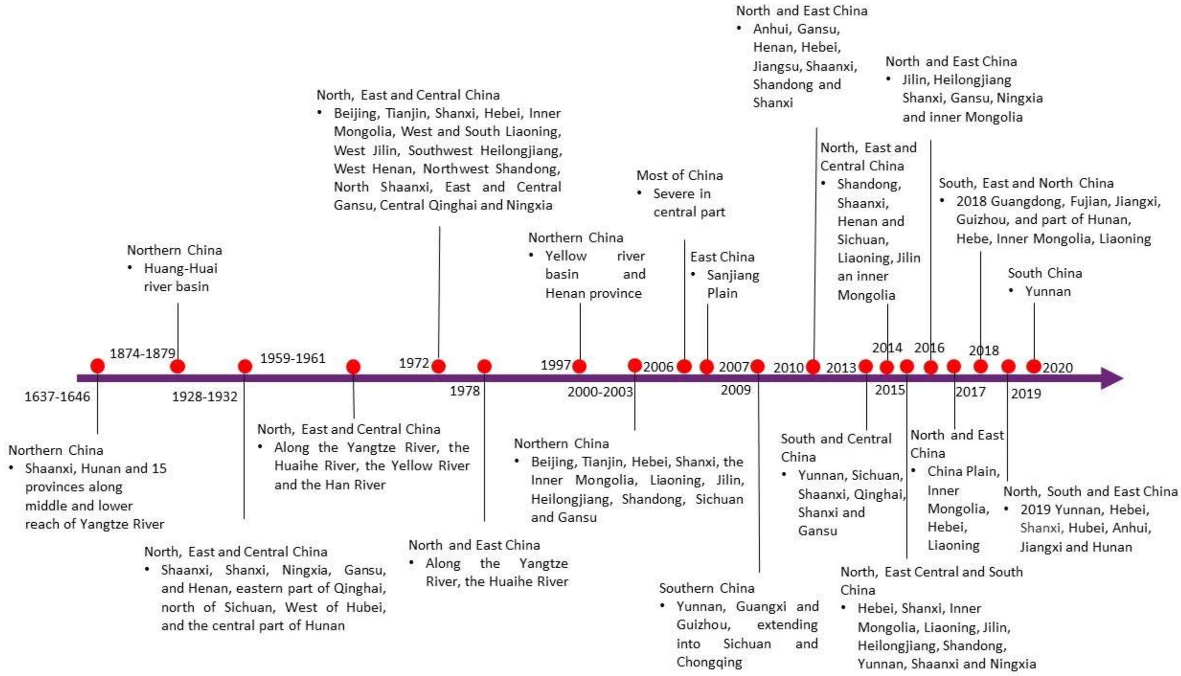
Data source: ESCAP (2020) Asia-Pacific Disaster Report 2019 – East and North-East Asia

There has been a limited increase in the frequency and the span of areas affected by drought in most parts of China,[19] but a significant increase is observed in some parts.[20] The chronological order of droughts in China shows that major drought events were primarily recorded in provinces in north, east and central China before the 2000s (Figure 3). Arid or semi-arid conditions prevail in this region, making the region drought-prone. However, since 2006, there has been an expansion of drought-affected areas in China, including dry sub-humid or humid areas such as southern China.

[19] UNDRR 2021

[20] Xu et al.2015

Figure 3 Drought occurrence in China[21]



Drought is also a frequent phenomenon in DPR Korea during the spring season, and it suffered greatly from prolonged droughts.[22] In 2019, a long dry spell during the first five months of the year created food insecurity, malnutrition and illness for about 40 per cent of its population.[23] The Republic of Korea is also experiencing an increasing drought frequency during the last two decades.[24] Historically, droughts occurred 1.5 times per 10 years in the Republic of Korea, but since 2000, drought has become more frequent. Although there is a high variation in drought occurrence across the nation, the central part is most frequently affected by drought.[25]

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[21] EM-DAT 2021

[22] International Federation of Red Cross and Red Crescent Societies 2019

[23] BBC 2019

[24] KOICA-UN ESCAP 2019

[25] KOICA-UN ESCAP 2019

1.2 Climate change and desertification, land degradation and drought

Global surface air temperature is on the rise. So far, a long-term warming trend in annual mean surface temperature has been observed across Asia, which was accelerated post-1970. While temperature has increased more than 0.1ºC per decade in most of the eastern part of North-East Asia, northern China experienced the most substantial warming with a 0.3 to 0.4ºC increase in temperature per decade. In the Tokyo metropolitan area, the annual mean temperature has increased by 3ºC per century between 1901-2015. In the Republic of Korea, the temperature has increased 1.9ºC from 1912 to 2014, higher than the global average.[26] Mongolia has also experienced rapid warming between 1940 and 2015, with a rise in average temperature by 2.24ºC.[27]

This trend is likely to continue across all emission scenarios resulting in the frequent occurrence of extreme temperature events such as heatwaves.[28] The higher increase in temperature is projected for southern, north-western, and north-eastern regions of China, parts of Mongolia, the Korean Peninsula, and Japan. The surface air temperature is also expected to increase further in most Russian Federation under intermediate (SSP2-4.5) and high (SSP5-8.5) emission scenarios.[29] Moreover, the increase in temperature is very likely to exceed 5ºC by the end of this century in the eastern part of the Russian Federation under the worst-case scenario (SSP5-8.5).

Precipitation trends have significant regional differences in North-East Asia. Deficient seasonal precipitation is observed in several parts of the region due to the weakening of the East-Asian Summer Monsoon since 1920, while the spatial variability of rainfall has remained high.[30] Daily precipitation extremes have increased in many parts, and heavy precipitation is expected to increase.[31] Summer rainfall in China has first shown decreasing and then an increasing trend from 1961 to 2014. In northern China, rainfall trend shows negative anomalies while in central-eastern China it had positive anomalies between 1950 and 2000 and then has decreased since 2000. In northwest China, annual precipitation has increased by about 3.7 per cent per decade, which changed the warm-dry condition to warm-wet condition between 1961 and 2015. However, in Mongolia, average annual precipitation has declined by 7 per cent between 1940 and 2015, where the decline was the highest in the central region.[32] In the Republic of Korea, summer precipitation has increased while annual and seasonal rainfall have slightly decreased in Japan.[33]

In recent climate change projections, the mean annual precipitation and heavy precipitation are likely to increase in most areas of the north-eastern part of the Russian Federation, the Tibetan plateau and eastern China. Summer precipitation in the east part of the Russian Federation may increase up to 9 per cent, while winter precipitation may increase up to 22 per cent under both SSP2-4.5 and SSP5-8.5

[26] Gutiérrez et al.20211

[27] Climate Change Knowledge Portal 2018

[28] Arias et al.2021

[29] Ranasinghe et al.2021

[30] Hijioka et al.2014

[31] IPCC WGI – The Physical Science Basis 2021

[32] Climate Change Knowledge Portal 2018

[33] Gutiérrez et al.2021

scenarios.[34] Drought has increased in some parts of southwest and northwest China, and a significant and localised increasing trend in aridity is expected under SSP2-4.5 and SSP5-8.5 scenarios for 2020-2100.

Between 1961 and 2013, the drought has increased by more than 1 per cent per year in the arid and semi-arid areas globally, and it is also projected to increase in many arid and semi-arid areas in the future.[35] With a 1.5ºC, 2 ºC and 3 ºC increase in global temperature, the global dryland population exposed to the various risks, including many in North-East Asia, is projected to reach 951 million, 1,152 million 1,285 million, respectively.[36] The persistent change in the atmospheric circulation pattern, such as El Niño Southern Oscillation (ENSO), is one of the main reasons for the global drought. However, an increase in temperature and uneven precipitation due to climate change trigger a meteorological drought event which is amplified if converged with ENSO.[37] Global warming will increase drought risks in the land areas already suffering from drought. The recent climate change projection reports that at 4ºC global warming, the eastern part of the subregion is likely to be exposed to agriculture and ecological drought under all scenarios. In contrast, at 1.5 - 2°C warming, this trend is unlikely. At higher warming conditions, the atmospheric evaporative demand increases, and this affects the projected increase in agriculture and ecological drought. The extent of meteorological drought is expected to be less than agriculture and ecological drought; however, it affects several regions even at 1.5-2°C global warming.[38]

Recurring or long-term drought events can cause irreversible changes in the extent of wetlands, soil properties, land productivity and vegetation health, leading to land degradation and desertification. Drought often causes land subsidence due to the over-extraction of groundwater and results in land degradation.[39] In drought conditions, high evapotranspiration leads to a drier climate. If such a condition converges with extreme heat events, it can lead to desertification.[40] An increasing trend in the areas of dryland annually affected by drought is observed between 1961 and 2013.[41]

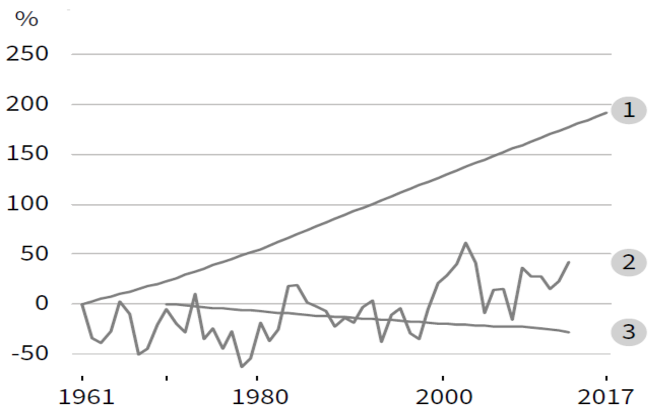
Climate change can accelerate land degradation processes such as soil erosion. This can cause a decline in soil organic matter, nutrient loss, reduced carbon storage, loss of biodiversity, and ecosystem stability. Half of the global soil erosion happens through the water.[42] Areas projected with an increase in intense precipitation events such as flooding and flash floods in the future are threatened by increased soil erosion by up to 30 per cent even in low emission scenarios (RCP 2.6), and this can lead to land degradation.[43,44] Heat stress can alter soil nutrient cycles, affect soil health, and trigger land degradation. Wind erosion can cause the removal of topsoil and loss of soil organic matter. Around 28 per cent of global land is suffering

[34] Gutiérrez et al.2021
[35] Ranasinghe et al.2021
[36] Mirzabaev et al.2019
[37] United Nations Office for Disaster Risk Reduction 2021
[38] Seneviratne et al.2021
[39] Olsson et al.2019 (IPCC land report- chapter 4)
[40] Vogel et al.2021
[41] Ziese et al.2014
[42] Borrelli et al.2017
[43] Borrelli et al.2020
[44] Olsson et al.2019

from land degradation contributed by wind erosion.[45] Biologically regulated processes such as changes in the vegetation cover and composition due to changes in precipitation also can lead to land degradation. An increase in temperature can cause an increase in the rate of evapotranspiration from shallow groundwater, leading to salinisation and land degradation.

Globally, drylands have increased by 0.35 per cent from 1951-1980 to 1981-2010, mainly in the semi-arid areas. The range and extent of desertification have also increased in some dryland areas (Figure 4). Under climate change scenarios, the extent of drylands is projected to expand further in many parts of the world because of precipitation anomalies, increase in temperature and potential evapotranspiration (PET), and decrease in soil moisture.[46,47] A study on seasonal vegetation conditions and related probability of desertification under different climate change scenarios also found the accelerated likelihood of desertification in north-western China and Mongolia in the near and far future.[48] The global population exposure to desertification has increased by around 200 per cent since 1961, and the decreasing trend in the extent of inland wetland can pose an additional threat to desertification (Figure 4).[49] The unprecedented changes in the Earth's climate system are one of the factors responsible for the increased intensity and scale of desertification, land degradation and drought events in recent times.[50]

Figure 4 Per cent change in (1) population in areas experiencing desertification; (2) dryland areas in drought annually and (3) inland wetland extent for 1961 and 1970 average [51]



While several parts of North-East Asia are already affected, increasing temperature and changing precipitation patterns will affect desertification, land degradation, and drought risks, which are closely intertwined (Figure 5). Climate anomalies can cause land degradation, which can be further aggravated by

[45] European Soil Data Centre 2021
[46] Cherlet et al. 2018
[47] Mirzabaev et al.2019
[48] Miao et al.2015
[49] Arneth et al.2019
[50] IPBES 2018
[51] Arneth et al.2019

drought and lead to desertification.[52] **As climate drivers influence the extent and intensity of desertification, land degradation and drought events, it is necessary to understand how climate change will affect the desertification, land degradation and drought risks in North-East Asia.**

Figure 5 Climate change and its implications for DLDD

52 EU Science Hub n.d.

Chapter II. Shifting ‘riskscape’ in North-East Asia

The current report is focused on understanding climate change impact on desertification, land degradation and drought ‘riskscape’ in North-East Asia.[53] For this purpose, two recent IPCC climate change scenarios are considered, namely SSP2-4.5 and SSP5-8.5. The climate change scenarios are based on the future Greenhouse Gas (GHG) emission pathways which depend on the population size, economic activity, lifestyle, energy use, land use patterns, technology, and climate policy.[54] According to the latest IPCC report, SSP2-4.5 is the intermediate scenario where the global surface temperature is likely to be higher by 1.2°C to 1.8°C compared to the pre-industrial level (1850-1900) by 2040. SSP5-8.5 is the worst-case scenario where global surface temperature is likely to increase by 1.3°C to 1.9°C compared to the pre-industrial level (1850-1900) by 2040. In this report, the future desertification, land degradation and drought risk are analysed using projected changes in temperature and precipitation in North-East Asia as the primary climate drivers under the two scenarios compared to the 1995-2014 baseline. To understand the status of desertification and land degradation, the aridity Index is used, while for drought, past drought events data is used.

Desertification and land degradation are predominantly driven by human activities, with climate drivers putting additional pressure. It is generally the result of a single or combination of multiple drivers such as agricultural expansion, rapid urbanisation due to population pressure, extensive grazing, unsustainable land management for agriculture and grazing, and deforestation.[55,56] However, it should be noted that this report only focuses on the impacts of climate drivers, such as anomalies in temperature and precipitation. The influence of human interference is out of the scope of this paper.

2.1 Desertification and land degradation

Aridity is a climate phenomenon and represents the spatial and/or temporal deficiency of water. Aridity is quantified using a ratio of long-term average precipitation and long-term average potential evapotranspiration.[57] While rainfall is on water supply, potential evapotranspiration is the climatic water demand. Hence, aridity increases when either precipitation decreases or potential evapotranspiration increases. In both cases, the dryness of land is enhanced. Arid lands are subjected to different climate-related erosion processes, enhancing land degradation and desertification risk.[58] It is estimated that by 2100, 6 per cent humid and dry sub-humid regions may become semi-arid, 15 per cent of the semi-arid region may convert into arid, and 15 per cent of arid areas are likely to become hyper-arid.[59,60]

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[53] ‘Riskscape’ refers to disaster risk landscape, as in the ESCAP’s Asia-Pacific Disaster Report 2019.

[54] IPCC 2014

[55] Mirzabaev et al.2019

[56] IPBES 2018

[57] Cherlet et al. 2018

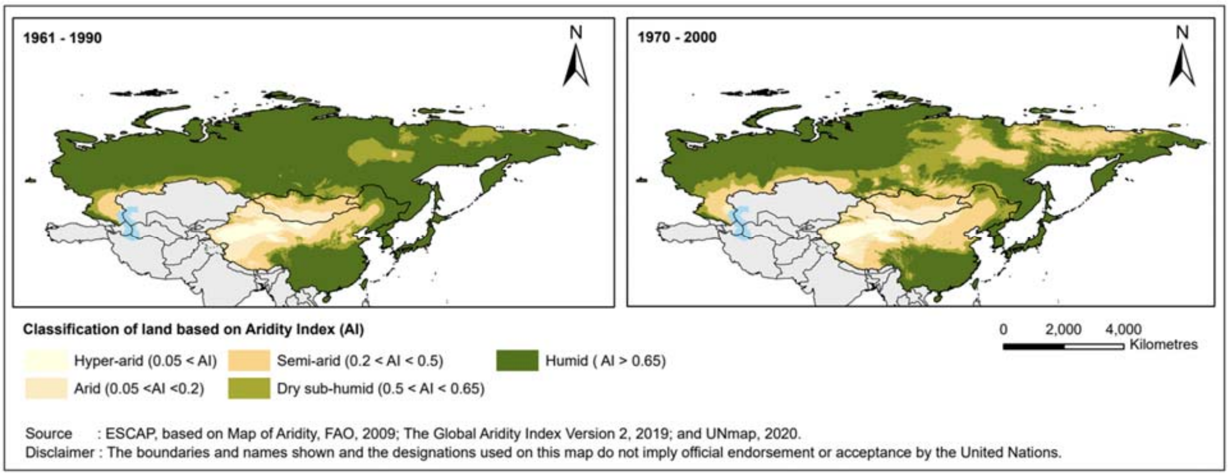
[58] Mirzabaev et al.2016

[59] Huang et al.2016

[60] Feng and Fu 2013

Figure 6 represents the changes in the aridity in North-East Asia between 1961-1990 to 1970-2000. Although there has not been much change in the span of the arid region except in the north and east Mongolia and northern China, the semi-arid region is showing a significant increase between the two periods, especially in the north-eastern China and eastern part of the Russian Federation. It is estimated that around 74 per cent expansion of areas has occurred in the semi-arid region, whereas the arid region has expanded by 14 per cent between the periods. The hyper-arid area, which was primarily limited to western China, has expanded towards the north-east till the southern part of Mongolia with a 49 per cent increase in area between the two time periods.

Figure 6 Land classification based on Aridity Index (AI) in North-East Asia



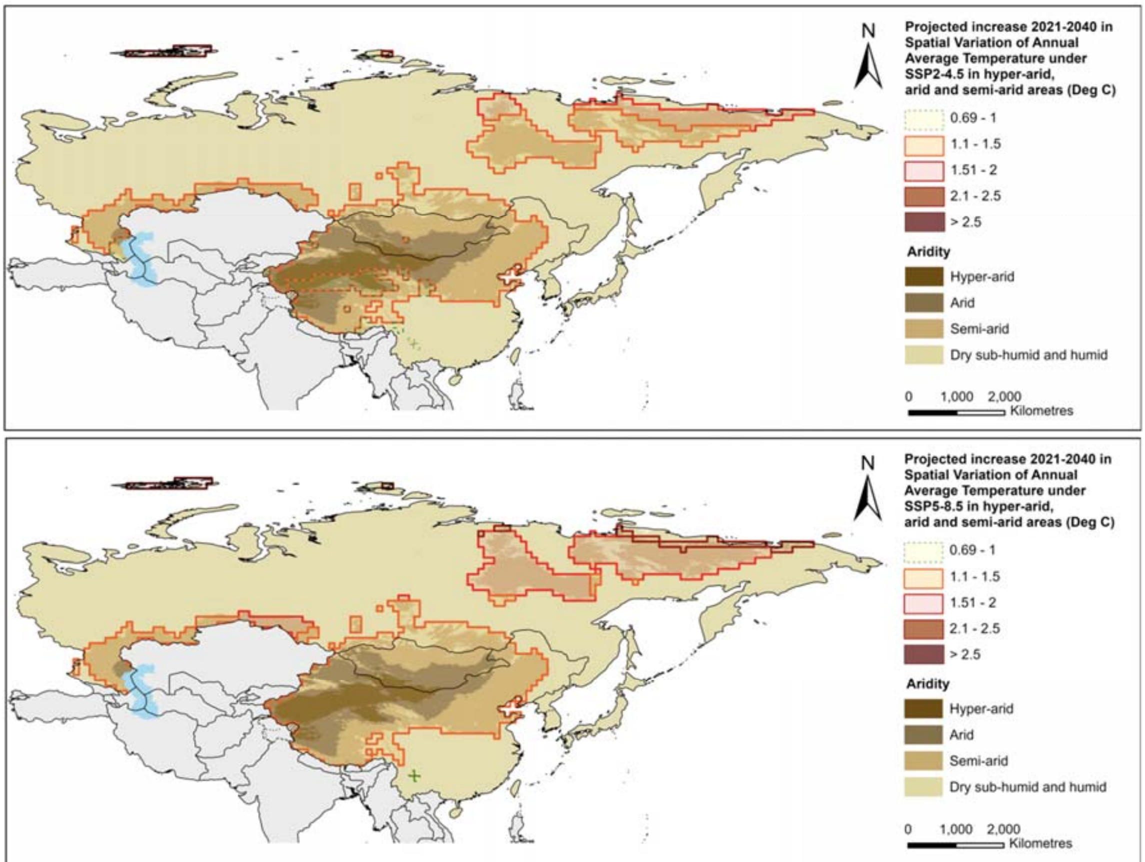
Global surface temperature is expected to increase under all IPCC (AR6) emission scenarios in the coming decades.[61] An increase in temperature leads to an increase in evaporative demand of the atmosphere and increases soil moisture loss due to evapotranspiration, thus increasing aridity. Feng et al. (2015) observed that an increase in mean annual temperature contributes significantly to the desertification rate in north-western China.[62]

In North-East Asia, by 2040, the annual average temperature is expected to increase more than 1°C across most of the hyper-arid, arid and semi-arid areas, except for some parts of the Tibetan plateau, under both climate change scenarios (Figure 7). In northern China, Mongolia, and the eastern and south-western part of the Russian Federation, the annual average temperature may increase up to 1.5°C, while in the north-eastern part of the Russian Federation, it may increase up to 2°C under intermediate scenario (SSP2-4.5) from the 1995-2014 baseline. In the worst-case scenario (SSP5-8.5), entire dry areas under China and Mongolia may experience up to 1.5°C rise in temperature. The areas up to 2°C increase in temperature may expand across the entire arid region of the eastern part of the Russian Federation and cover some parts of its south-western parts.

[61] IPCC 2021 (SPM)

[62] Feng et al.2015

Figure 7 Projected increase of annual average temperature in hyper-arid, arid and semi-arid areas under SSP2-4.5 (up) and SSP5-8.5 (down), 2021-2040



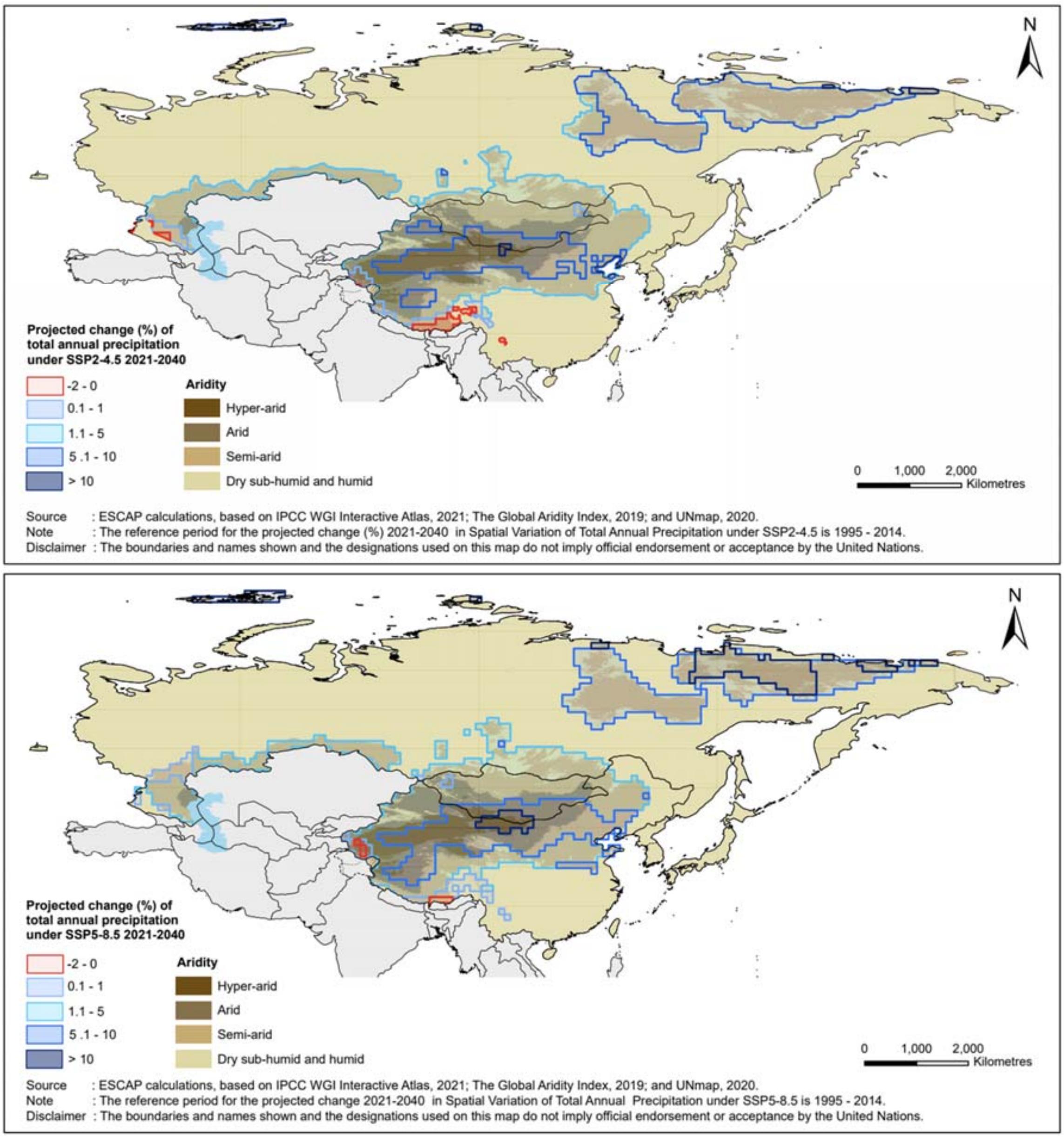
Source : ESCAP calculations, based on IPCC WGI Interactive Atlas, 2021; The Global Aridity Index, 2019;and UNmap, 2020.
Note : The reference period for the projected change 2021-2040 in Spatial Variation of Annual Average Temperature under SSP5 - RCP 8.5 is 1995 - 2014.
Disclaimer : The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Climate change is also expected to change the precipitation pattern. Heavy and extreme daily precipitation is likely to increase globally with additional global warming.[63] Figure 8 depicts the projected change in the total precipitation under two different climate change scenarios during 2021-2040 in the hyper-arid, arid, and semi-arid areas of North-East Asia. **It is observed that most of the hyper-arid, arid and semi-arid areas in North-East Asia are expected to receive slightly more precipitation than the long-term average under climate change conditions.** Most dry regions are expected to receive around 1-5 per cent more rainfall under both scenarios. More than a 5 per cent increase in precipitation is expected in the hyper-arid regions of western China and southern Mongolia and the semi-arid areas of the eastern part of the Russian Federation under SSP2-4.5. Precipitation is expected to decrease by up to 2 per cent in some parts of the Tibetan plateau. Under SSP5-8.5, the areas with a 5-10 per cent increase in precipitation expand, covering semi-arid regions in the eastern part of the Russian Federation and most of the hyper-arid and arid areas of northern China and southern Mongolia. The areas to receive more than a 10 per cent increase in total annual precipitation also expand in the eastern part of the Russian Federation and some parts of the Gobi Desert area. The semi-arid regions in northern China and the rest of Mongolia are expected to receive

[63] IPCC 2021 (SPM)

1-5 per cent more precipitation than the long-term average. Only a tiny part of the Tibetan plateau is expected to receive less rainfall by up to 2 per cent.

Figure 8 Projected change (%) of total annual precipitation in hyper-arid, arid and semi-arid areas under SSP2-4.5 (up) and SSP5-8.5 (down), 2021-2040



Dryland areas are characterised by scarce and variable rainfall, making them susceptible to land degradation and desertification. High temperature aggravates the prevailing condition. Although a slight increase in precipitation is expected in many parts of the region, precipitation is already scarce in many of these areas, varying from less than 50 mm annual average precipitation in the west to 200 mm in the northeast.[64] **A 5-10**

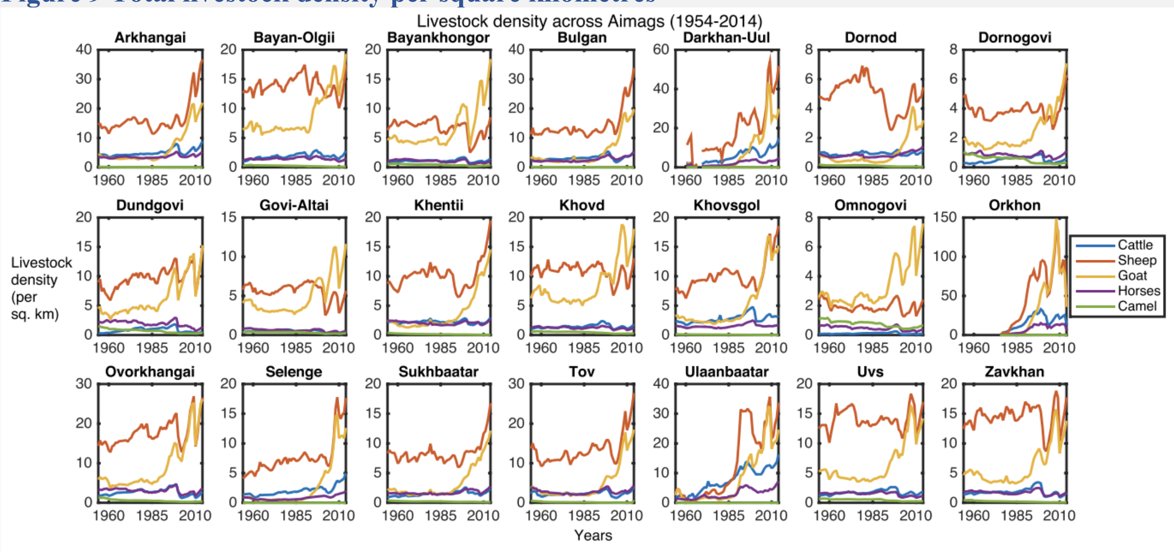
[64] Britannica n.d.(a)

per cent increase in total annual precipitation is only around 2.5mm-20mm and is thus unlikely to make significant changes in prevailing dry conditions. On the other hand, an increase in temperature up to 1.5ºC and the resultant increase in potential evapotranspiration may significantly impact the aridity of this region and accelerate desertification.

Impacts of desertification on the pastoralism: in Mongolia

Gobi Desert spans around 1,295,000 square kilometres in northern China and southern Mongolia.[i] Despite being a cold desert, the arid lands support significant wildlife, unique biodiversity and many endangered species. The desert grassland areas are home to nomadic pastoralists and their livestock. The number of livestock has increased in this region since the 1990s. Pastoralism contributes significantly to the GDP of developing countries with dryland, and for example, 30 per cent of the GDP of Mongolia comes from pastoralism.[iii] This dryland ecosystem depends heavily on natural resources, among which precipitation is the most important. Annual rainfall is less than 40 mm in the arid region with wide interannual and spatial variability, and most of the rain is received in summer. Desertification expands in the Gobi Desert by transforming extensive grasslands into a wasteland and threatening the nearby civilisation.[iv] Hence, precipitation deficiency can accelerate desertification and cause disastrous impacts on the marginal population and livestock. An increase in temperature may increase the threat.

Figure 9 Total livestock density per square kilometres



Source: Rao et al. 2015

During 2000-2002 and 2009-2010, around 20 million livestock perished in Mongolia, triggered by a summer (July-September) drought and precipitation deficit before harsh winter (November-February). Summer drought depleted pastures and increased the vulnerability of animals to the following harsh winter. In 2010, the livestock population dropped by 20 per cent in some areas. While a large proportion of the population depends on herding as the primary source of income, such an event increased economic hardship and poverty of the locals and caused population migration. [v]

Source:

i. Rechtschaffen, D. 2017
ii. Heiner and others 2020
iii. WISP 2008
iv. Rechtschaffen, D. 2017
v. Rao et al. 2015

2.2 Drought

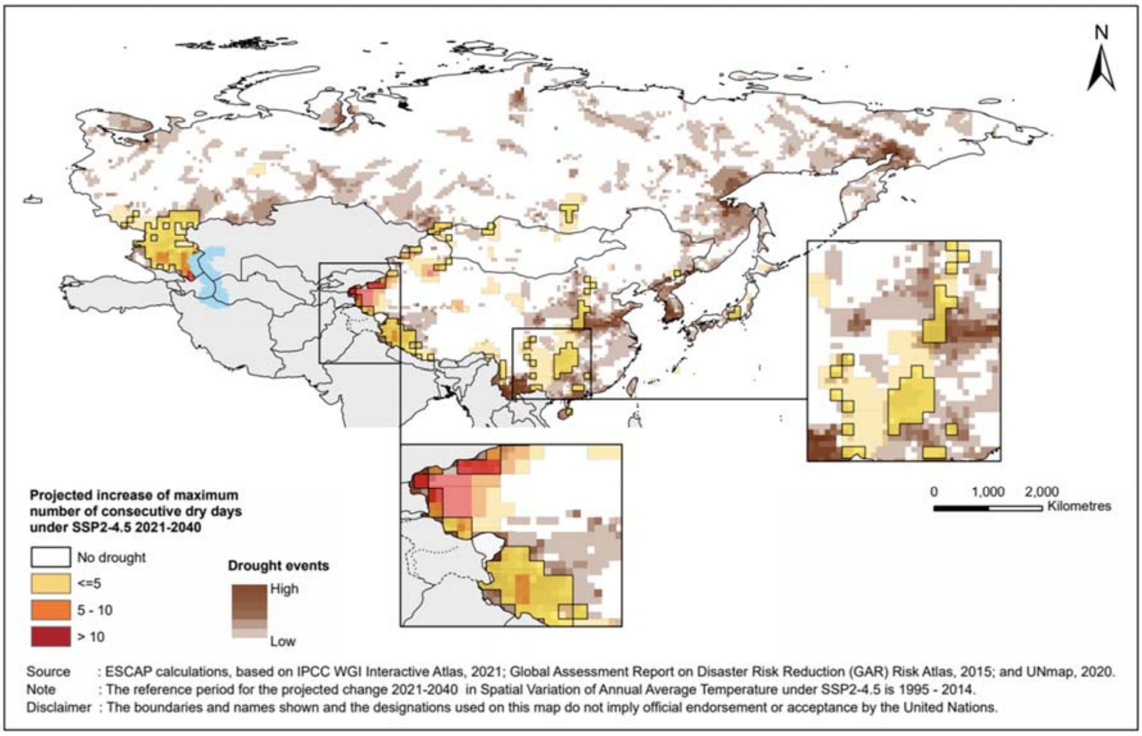
The summer monsoon brings about the most significant rainfall in North-East Asia. Robust monsoon precipitation provides most water required for population, agriculture, and ecosystem, while a weak monsoon often leads to droughts.[65] With a warming climate, precipitation variability increases, and this can contribute to the occurrence of droughts. High temperatures and heatwaves often trigger meteorological droughts.[66] An increase in atmospheric evaporative demand increases plant water stress and leads to agricultural and ecological drought. Warming over land enhances the atmospheric evaporative demand and increases the severity of drought and aridity.[67]

The surface temperature over North-East Asia is likely to increase for both intermediate (SSP2-4.5) and worst-case (SSP5-8.5) climate scenarios, while heavy precipitation is also projected to increase both in frequency and intensity.[68] To assess the probability of drought occurrence, the maximum number of consecutive dry days (CDD), as well as increase of annual average temperature, has been used as the proxy driver of drought.[69,70]

Figures 10 depicts the projected increase of the maximum number of CDD in drought-prone areas of North-East Asia under the intermediate (SSP2-4.5) scenario for the next two decades. **It is observed that many of the currently drought-stricken regions in the sub-tropical parts are likely to experience increasing numbers of CDD.** Parts of central, northern and southern provinces of China, western part of Tibetan plateau and Xinjiang Uygur Autonomous Region (Xinjiang), parts of western Mongolia, parts of central Japan and western and southern parts of the Russian Federation are expected to experience an increase in CDD by up to 14 days.

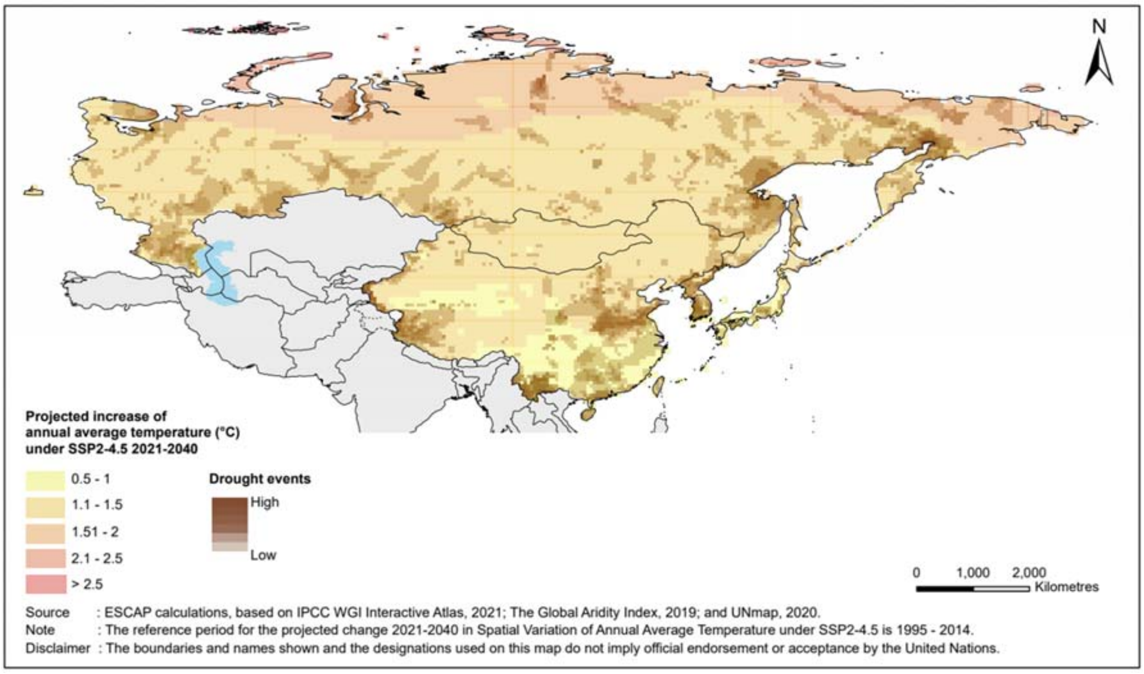
[65] Zhang and Zhou 2015
[66] UNDRR 2021 (GAR)
[67] Douville and other 2021
[68] IPCC 2021
[69] Sieck et al.2021
[70] Duan et al.2017

Figure 10 Projected increase of the maximum number of consecutive dry days in North-East Asia under SSP2-4.5, 2021-2040



The annual average temperature is also very likely to increase across the drought-prone areas of North-East Asia (Figure 11). A higher increase (1.5ºC-2 ºC) is likely in the northern part of the Russian Federation. In the southern Russian Federation, Mongolia, north of China and DPR Korea, the annual average temperature may increase up to 1.5ºC. The probability of drought is likely to increase in the drought-prone areas where both CDD and average annual temperature increase. For example, the western parts of Xinjiang and southwestern Tibetan plateau are expected to experience more droughts. Provinces in central China and west Mongolia may also experience more drought due to climate change.

Figure 11 Projected increase of average annual temperature in North-East Asia under SSP2-4.5, 2021-2040



Under the worst-case scenario (SSP5-8.5), the picture is not very different from the above. Parts of southern China, southwestern Tibetan Plateau and western part of Xinjiang provinces of China, parts of central Japan and western Mongolia may experience an increase in CDD up to 15 days (Figure 12). In Hubei, Sichuan, southwestern Tibetan Plateau and western Xinjiang provinces of China and west Mongolia, the annual average temperature may increase up to 1.5ºC (Figure 13). Drought risk is expected to intensify further in these areas.

Figure 12 Projected increase of the maximum number of consecutive dry days in North-East Asia under SSP5-8.5, 2021-2040

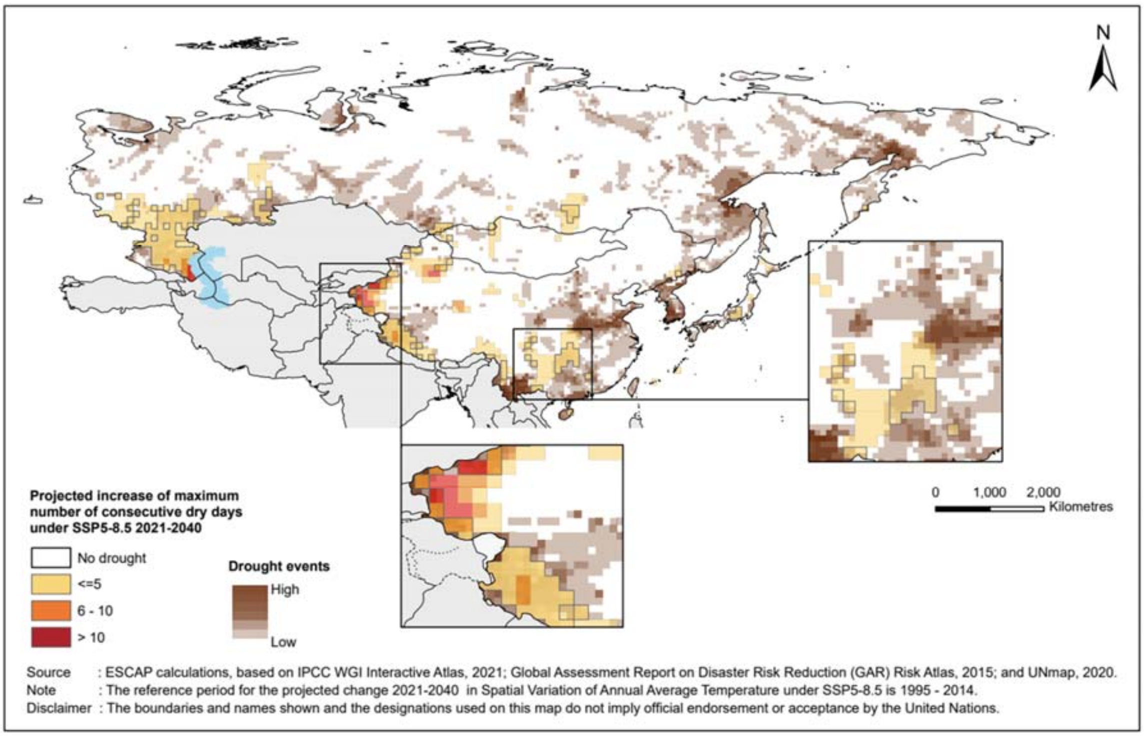
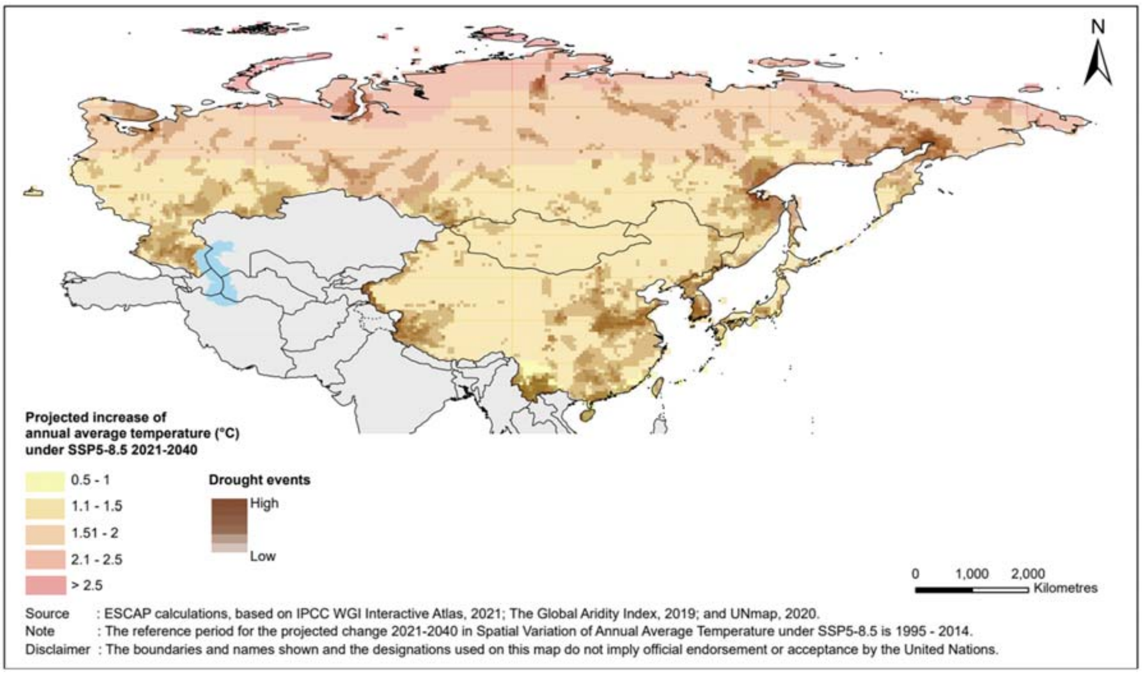


Figure 13 Projected increase of average annual temperature in North-East Asia under SSP5-8.5, 2021-2040



Climate change and drought scenario in southern China

Yunnan province, located in the humid region in southwest China, is relatively a water-rich area with annual precipitation of more than 800 mm and 62 per cent of forest cover.[i] However, over 80 per cent of the total annual rainfall is received during the summer monsoon season from May to October. The summer monsoon season starts relatively late in southwest China, compared to the other region in the same latitude. Further delay in the onset of the rainy season can thus lead to a drought event which can be extended to the winter season. Moreover, the subsurface runoff is high, leading to a low groundwater recharge rate. 70 per cent of all droughts in this area occur due to the late onset of the summer monsoon.[ii]

Droughts have increased in Yunnan province since 2000, primarily due to climate change and related precipitation anomalies. The drought cycle in this region has shortened from previously 2-3 years to now 1-2 years.[iii] For example, in 2019, Yunnan province was exposed to a spring-summer drought. This impacted 1.35 million hectares of crop and resulted in 6.5 billion Yuans of direct economic loss.[iv] 34 per cent below average precipitation coupled with 1.9°C above average temperature for five consecutive months (February to June) led to complete depletion of water flow in 15 rivers and drying of many reservoirs. The drought also affected 290,000 people and 100,000 livestock.[v,vi]

Source:

i. Ying, Z. 2020
ii. Ding and Gao 2020
iii. Jinghao, Y. 2019
iv. Ding and Gao 2020
v. Embassy of the People's Republic of China in the Kingdom of Thailand 2020
vi. Ding and Gao 2020

KEY FINDINGS

Under climate change scenarios SSP2-4.5 and SSP5-8.5, the annual average temperature will likely increase in entire North-East Asia by 2040. The increase is more towards the higher latitude than the sub-tropical region.

- Compared to 1995-2014, annual average temperature may increase by up to 1.5°C in most of the hyper-arid, arid and semi-arid regions of China, Mongolia and the Russian Federation under SSP2-4.5 scenario, excluding some hyper-arid and arid areas.
- Under the SSP5-8.5 scenario, annual average temperature in hyper-arid, arid and semi-arid regions of China and Mongolia and parts of the Russian Federation is projected to increase by 1.5°C. Higher latitude drylands of the Russian Federation may see up to a 2°C increase in annual average temperature.

Under climate change scenarios SSP2-4.5 and SSP5-8.5, the annual average precipitation is expected to increase slightly in most parts of North-East Asia. However, the increase in rainfall may not be significant to overcome the existing dry condition. Increasing temperature in the dry areas may intensify the existing risk of desertification.

- Annual average precipitation is expected to decrease in tiny areas in the arid and semi-arid regions of eastern Russian Federation, western China and south-western Tibetan plateau under SSP2-4.5 scenario.
- Under the SSP5-8.5 scenario, only some parts of western China and the south-western Tibetan plateau may experience a decrease in annual average precipitation.

The maximum number of consecutive dry days is expected to increase in some of the previously drought-affected areas of North-East Asia.

- CDD is likely to increase up to 14 days in some previously drought-affected areas of central and southwestern China, western Mongolia and central Japan under SSP2-4.5.
- Under SSP5-8.5, the spatial distribution of CDD remains almost the same but excludes the areas in central China. The projected increase in days is likely to reach up to 15 days.
- Additionally, most of the previously drought-affected areas are projected to experience increasing temperature under both SSP2-4.5 and SSP5-8.5.
- Increasing the maximum number of consecutive dry days and the annual average temperature may intensify the existing drought risk in the drought-prone areas of the region.

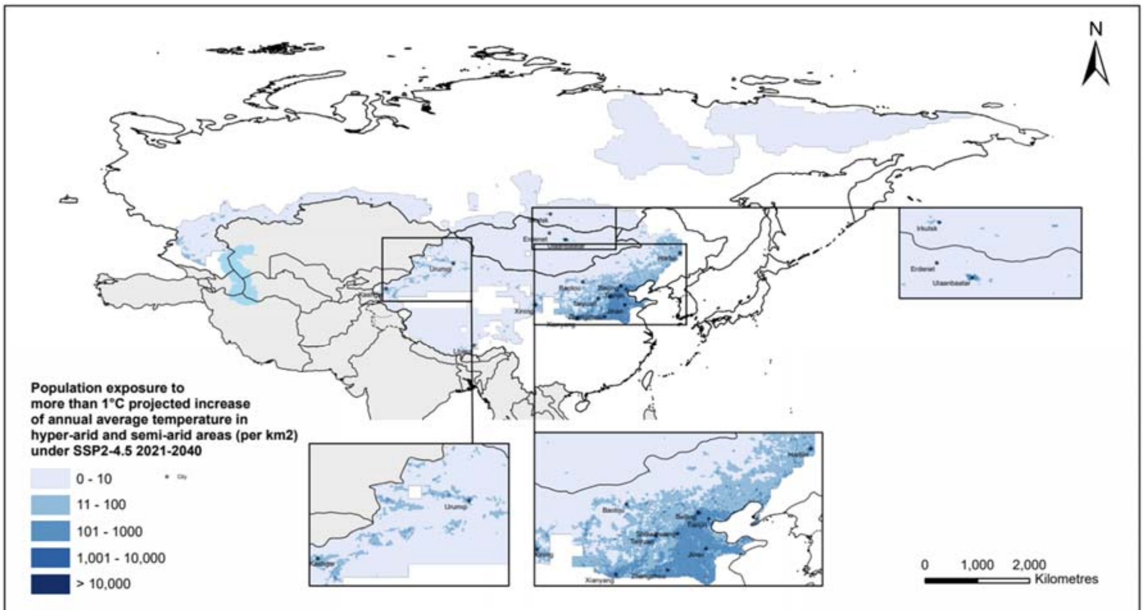
Chapter III. Potential impacts of Intensifying Risks in North-East Asia

Climate change and associated events influence social and economic activities. Although impacts of desertification, land degradation and drought events may not be visible as clearly as those of intensive disasters such as earthquakes, floods and tropical cyclones, their long-term impacts on agriculture and food security, human health and critical infrastructures, among others, can result in substantial social, economic and environmental cost. In this regard, this section discusses the potential impacts of intensifying risk of desertification, land degradation and drought in North-East Asia under future climate change scenarios.

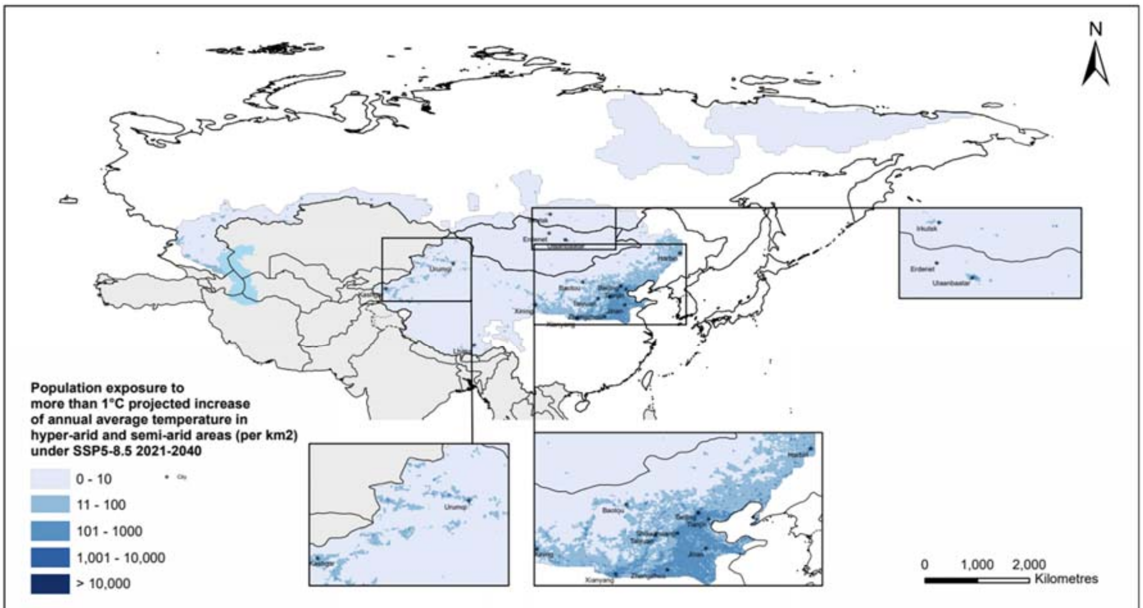
3.1 Population Exposure

The North-East Asia region has varied demographic distribution. The Republic of Korea, one of the most densely populated countries, Mongolia, one of the sparsely populated countries and China, the most populated country globally, are all in this region. Therefore, desertification and drought will have a wide-ranging impact. Although most of the arid and semi-arid areas are sparsely populated, some densely populated areas are likely under the threat of desertification. Figure 14 depicts the population exposed to intensifying desertification risk, measured by the number of people living in hyper-arid, arid and semi-arid areas and expected to experience more than 1ºC projected increase in annual average temperature between 1995-2014 and 2021-2040.

Figure 14 Population exposed to intensifying desertification risk, 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; UN-WPP Adjusted Population Density 2020, v4.11; and UNmap, 2020.
Note : The reference period for the projected change 2021-2040 in Spatial Variation of Annual Average Temperature under SSP2-4.5 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.



Source : ESCAP calculations, based on IPCC WGI Interactive Atlas, 2021; The Global Aridity Index, 2019; UN-WPP Adjusted Population Density 2020, v4.11; and UNmap, 2020.
Note : The reference period for the projected change 2021-2040 in Spatial Variation of Annual Average Temperature under 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.

Under both the climate change scenarios, the eastern provinces of China located in the semi-arid region have the most population exposed to intensifying desertification risk. The populated cities in western China, such as Urumqi and Kashgar, is also located in areas with intensifying desertification risk. Many people in the Baotou and Huimin districts in inner Mongolia are also exposed to the higher temperature associated with the arid condition. In Mongolia, Ulaanbaatar, the most densely populated city, and the surrounding areas are exposed to intensifying risk of desertification from climate drivers. Table 1 presents the population exposed to intensifying desertification risk in North-East Asia. **As a proportion of the total population, Mongolia has the highest per cent of people exposed, followed by China and the Russian Federation under both climate scenarios.**

Table 1 Population exposed to intensifying desertification risk in North-East Asia

Country	% of the total population	
	SSP2-4.5	SSP5-8.5
China	18.24	15.70
Mongolia	58.13	49.24
Russian Federation	11.83	11.74

Vulnerability to intensifying desertification risk: Mongolia

The human development index (HDI) can assess population vulnerability to climate change, and associated desertification risk can be assessed with the human development index (HDI). Mongolia has comparatively high population exposure to intensifying desertification risk as a proportion to the total population. A closer look at the spatial distribution of HDI in Mongolia, along with a projected increase in annual average temperature, reveals that people in western Mongolia (Dornod, Hentiy and Suhbaatar provinces) and northern Mongolia (Hovsgol and Bulgan Orhon provinces) are potentially more vulnerable to the intensifying desertification risks. In comparison, the capital and the surrounding region have comparatively higher HDI and are expected to be more resilient to the impacts of climate change.

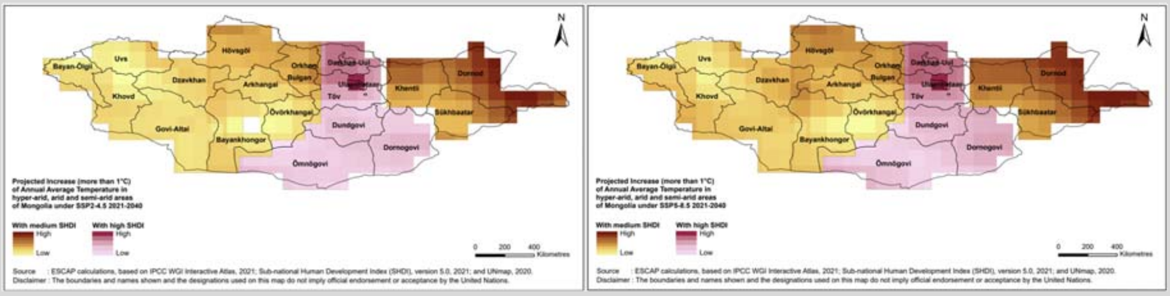
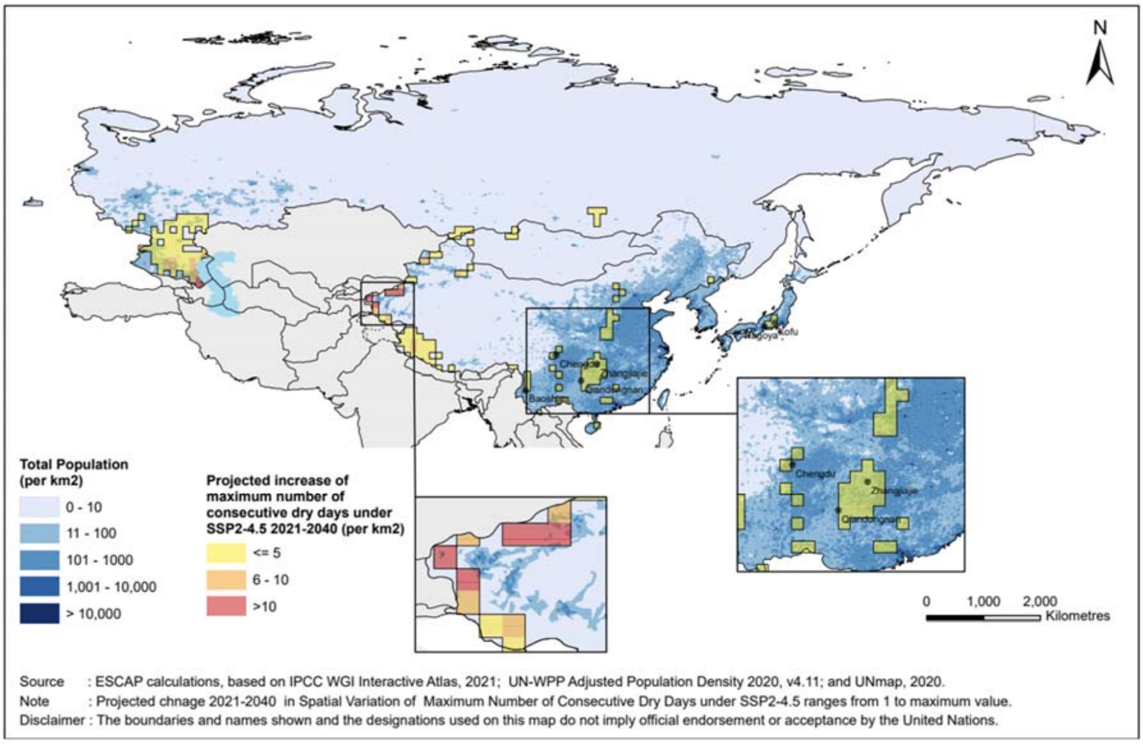


Figure 15 locates the potential population clusters exposed to intensifying drought risk under two climate change scenarios, measured by an increase in a maximum number of consecutive dry days in drought-prone areas. It shows that several densely populated cities such as Zangjiakou, Nanyang, Huaihua, Zangjiajie, Tongren, Dali and Kashgar, may be exposed to intensifying drought risk under SSP2-4.5 scenario. The result was similar under the worst-case climate change scenario, except for the cities in northern China. **The proportion of the population likely to be exposed to intensifying drought risk is highest in the Russian Federation, followed by China, Japan and Mongolia** (Table 2).

Figure 15 Population exposed to intensifying drought risk, under SSP2-4.5 (up) and SSP5-8.5 (down), 2021-2040



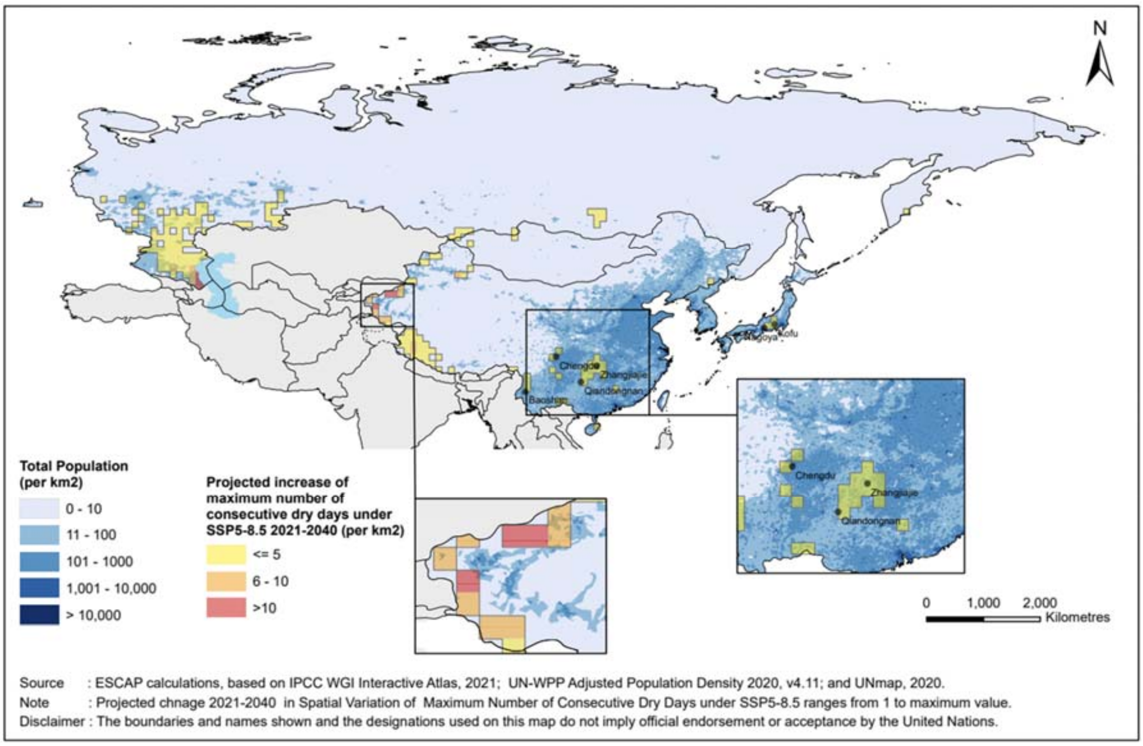


Table 2 Population exposed to intensifying drought risk in North-East Asia

Country	Number of people (% of the total population)			
	SSP2-4.5		SSP5-8.5	
Japan	699,715	(0.58%)	719,717	(0.60%)
China	14,465,304	(1.00%)	6,979,442	(0.48%)
Mongolia	5,373	(0.17%)	3,721	(0.12%)
Russian Federation	5,337,157	(3.80%)	5,691,665	(4.06%)

3.2 Exposure of Agriculture

Most agriculture activities in North-East Asia are carried out in the humid and dry sub-humid region. China is the largest agriculture producer, consumer and trader in this region.[71] It contributes to the lion share (around 87 per cent) of the subregion's agriculture production, followed by the Russian Federation, Japan, the Republic of Korea, and DPR Korea. Countries in the subregion are also significant producers and consumers in the global market.

Intensifying desertification and drought risks in North-East Asia are likely to affect some major agricultural areas in North-East Asia. Figure 16 represents the spatial distribution of agriculture production exposed to intensifying desertification risk under intermediate (SSP2-4.5) and worst-case (SSP5-8.5) scenarios. Agricultural production in arid Xinjiang province in north-western China and parts of Shandong, Henan and Anhui provinces in the fringe of the semi-arid region in eastern China are expected to experience temperature increase under the intermediate climate change scenario. Xinjiang province is the largest cotton producer in China,[72] which is a high-value crop and water-intensive. Although the water supply for cotton cultivation usually comes from irrigation, increase in the irrigated area since the 1950s resulted in a decrease in river runoff in this area.[73, 74] A potential increase in annual average temperature may increase crop water demand and reduce soil water content due to increased potential evapotranspiration, especially the young plants. This may affect the production volume. Likewise, in the east coast of China, Shandong province is one of the essential agricultural producers as well as exporters of peanuts, wheat, corn, soybean, millet and sweet potato.[75,76] Intensifying desertification risk is likely to impact the production of these products profoundly. At the same time, maize production in Shaanxi province is also expected to be affected due to an increase in temperature.[77] In Mongolia, agriculture is concentrated in the northern semi-arid part, where predominantly wheat and potato are grown domestically.[78] This area is undergoing light

[71] Ministry of Agriculture and Rural Affairs of The People's Republic of China n.d.
[72] Li et al.2020
[73] Rouzi et al.2018
[74] Liwen et al.n.d.
[75] Baixin and Zhenguo 2002
[76] Britannica n.d.(b)
[77] Wei et al.2017
[78] Ganbaatar and Lee 2013

desertification,[79] and temperature is expected to increase up to 1.5°C, aggravating the current desertification condition and affecting agriculture production. This may hamper the domestic supply chain of wheat and potato.

Figure 16 Agricultural production volume exposed to intensifying desertification risk, under SSP2-4.5 (up) and SSP5-8.5 (down), 2021-2040

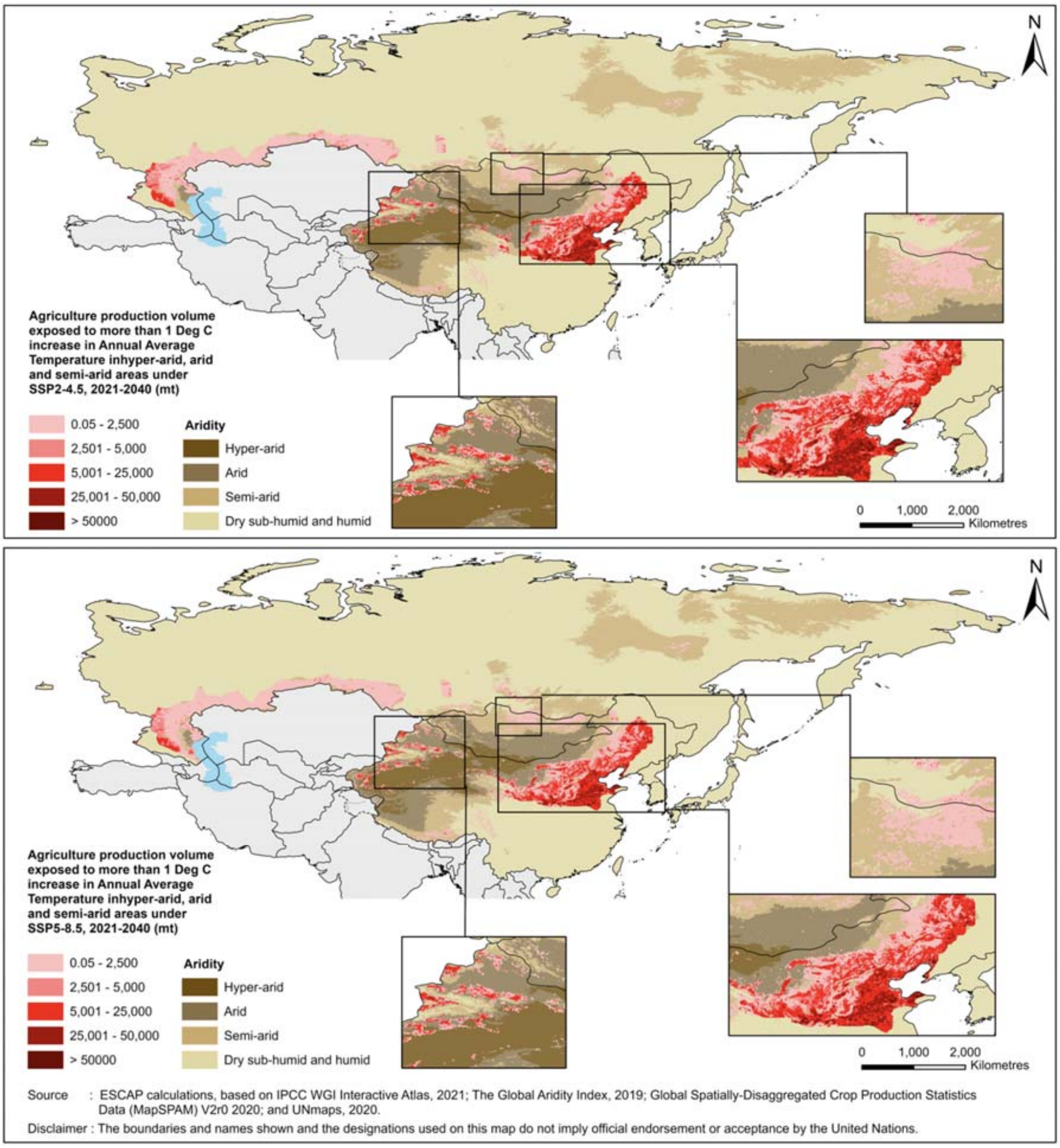


Table 3 shows agricultural production exposed to intensifying desertification risk in North-East Asia. In both scenarios, **Mongolia is expected to have the highest proportion of production volume and value exposed**

[79] Meng et al.2021

to intensifying desertification risk, followed by the Russian Federation and China. In Mongolia, more than 50 per cent of agricultural products and their values are exposed to intensifying desertification risk under both scenarios. Although only around 1 per cent of Mongolia's land is cultivable,[80] Mongolia's agriculture sector (including livestock) employs nearly one-third of Mongolia's population and contributes more than 10 per cent of GDP.[81] Thus, any impact on the agriculture sector may have significant implications on its economy and people's livelihood.

Table 3 Agriculture production volume and values exposed to intensifying desertification risk in North-East Asia, 2021-2040

Country	Agriculture production volume (% of total)		Agriculture production value (% of total)	
	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
China	17.92	15.42	19.54	16.72
Mongolia	58.29	49.28	58.23	49.27
Russian Federation	18.72	16.75	20.72	18.79

Besides food grains, livestock products are an important agricultural commodity for food security. Intensifying desertification risk can also affect livestock regarding availability of natural resources, quality and quantity of feed crops, and livestock health.[82] In water constraint arid and semi-arid areas, further temperature increases, leading to an increase in evaporation, will affect the water availability in the lakes, rivers, and springs for animal drinking and decrease the number and health of pasture plant species feeding the livestock. This may result in lower productivity of livestock and an increase in their mortality rate.[83]

Table 4 presents the estimated proportion of livestock population exposed to intensifying desertification risk under the two climate scenarios. In general, the exposure of livestock population is expected to be higher under the intermediate climate change scenario (SSP2-4.5) than in the worst-case scenario (SSP5-8.5) in all three countries. **It is estimated that over 50 per cent of the livestock population of Mongolia is exposed to intensifying desertification risk, followed by China and the Russian Federation.** Agri-pastoralism is one of the main economic sectors of Mongolia, which is already under threat due to the sharply increasing number of livestock and exceeding the ecological capacity.[84] Additional pressure from the projected increase in temperature is likely to exacerbate the stress on the natural resources required for the livestock population.

Table 4 Livestock population exposed to intensifying desertification risk, 2021-2040

Country	Livestock (% of total)

[80] USAID and MANAGE N.D.

[81] Enkhbold 2016

[82] Melissa et al.2017

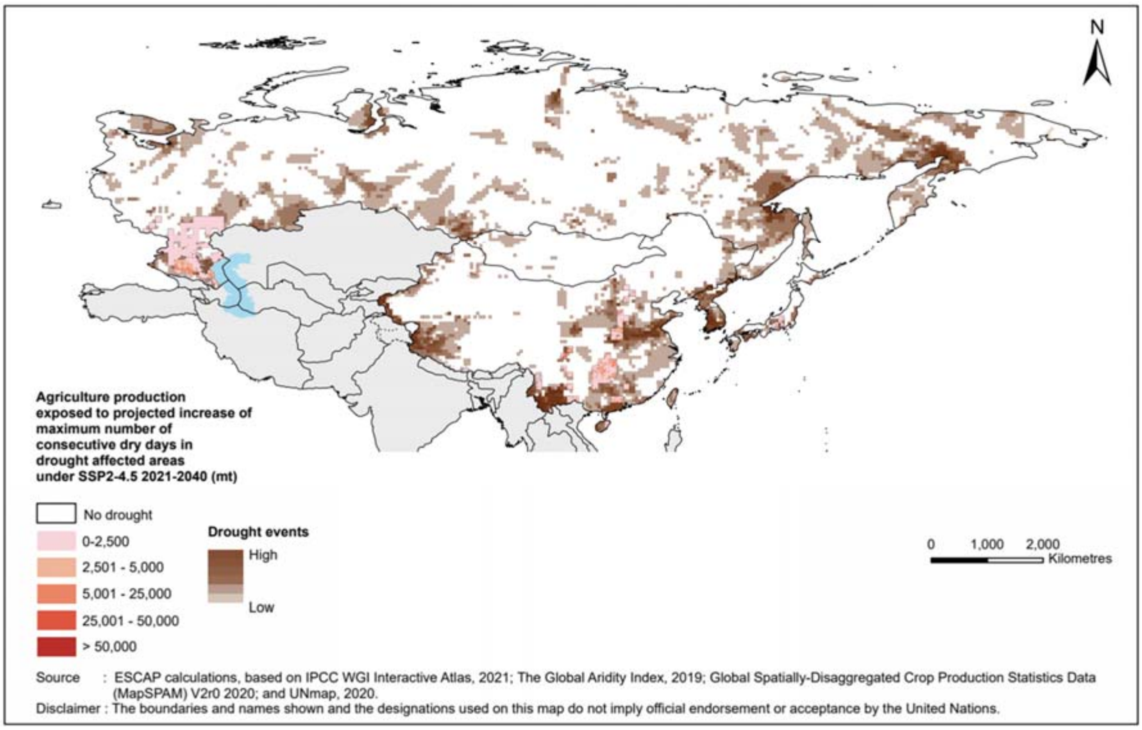
[83] Asian Development Bank 2013

[84] Darbalaeva 2020

	SSP2-4.5				SSP5-8.5			
	Cattle	Goat	Pig	Sheep	Cattle	Goat	Pig	Sheep
China	21.99	27.93	13.71	46.55	18.94	23.91	11.75	41.43
Mongolia	57.66	56.64	58.62	57.31	48.98	48.25	49.65	48.59
Russian Federation	18.14	19.14	12.65	23.51	17.99	20.54	11.41	31.64

Figure 17 represents the spatial distribution of agriculture production exposed to intensifying drought risk under intermediate (SSP2-4.5) and worst-case (SSP5-8.5) climate change scenarios. The agriculture production in parts of Hebei, Shanxi and Inner Mongolia provinces in northern China, parts of Sichuan and Hubei provinces in central China, parts of southern China, southwestern Tibetan Plateau and western Xinjiang Uygur province of western China, and central Japan are expected to have more CDD and thus increase in drought risk. Under the worst-case scenario, the high impact of drought is likely to concentrate mainly in Guangdong, Guizhou, Yunnan, Hainan, Sichuan and Hunan provinces in southern and central China. However, the impact is expected to be far more pronounced under the intermediate scenario. The agricultural product value follows the same spatial distribution as the agriculture production.

Figure 17 Agricultural production exposed to intensifying drought risk, under SSP2-4.5 (up) and SSP5-8.5 (down), 2021-2040



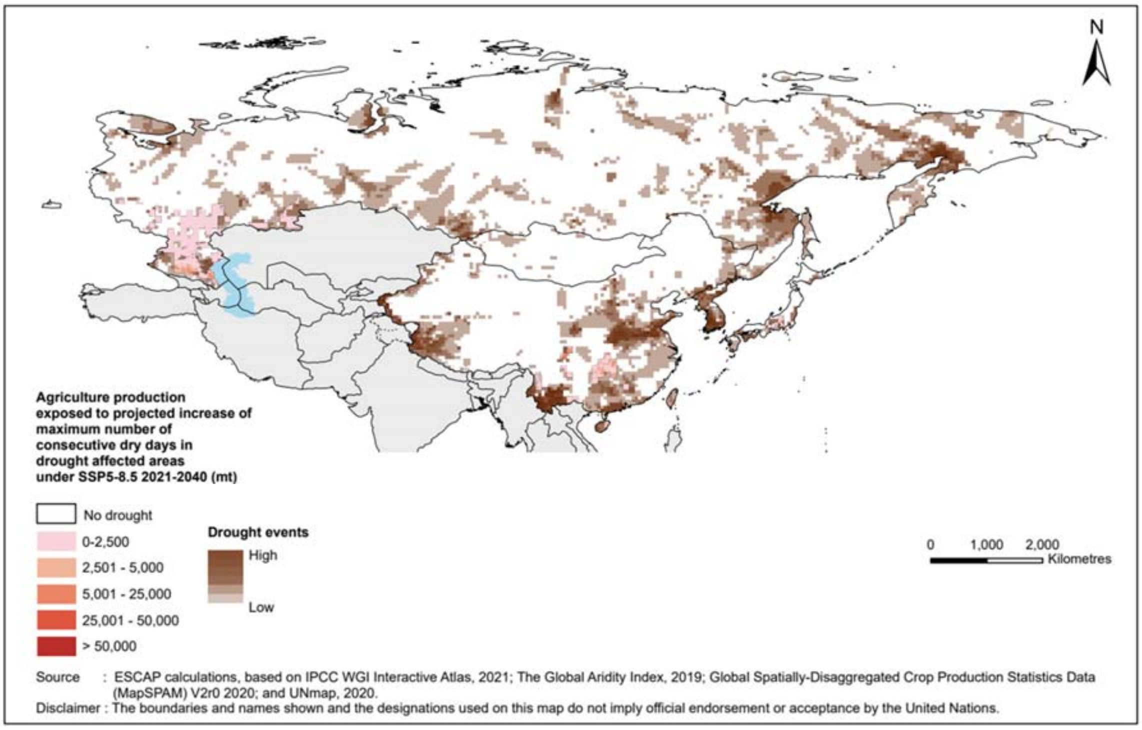


Table 5 shows agricultural production volume and value in the areas where drought risk is expected to increase. **The Russian federation tops the list with around 5 per cent of agricultural production volume and value exposed to intensifying drought risk under both climate scenarios, followed by China, Japan, Mongolia and DPR Korea.** Drought affects, among others, soybean during the flowering period, inhibit the growth of sprouts of finest Tea leaves, affect the production of cherries and peaches and declines the quality of Japanese rice.[85]

Table 5 Agriculture production volume and value exposed to intensifying drought risk in North-East Asia, 2021-2040

Country	agriculture production volume (% of total)		agriculture production value (% of total)	
	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
Japan	0.54	0.54	0.70	0.71
China	1.04	0.54	1.05	0.54
DPR Korea	0.01	0.01	0.01	0.01
Mongolia	0.03	0.02	0.03	0.02
Russian Federation	4.97	4.61	5.45	5.08

85 Ministry of Agriculture, Forestry and Fisheries, Government of Japan 2015

Drought also affects the nutritional sources of livestock. If the quality and quantity of available forage decline below a certain level, animal performance reduces.[86] Table 6 presents exposure of different livestock in drought-prone areas in North-East Asia, where drought risk is expected to increase. **The Russian Federation is expected to be most affected in terms of livestock exposure to increasing drought risk, followed by China, Japan, Mongolia and DPR Korea.** The exposure of studied livestock to increasing drought risk was generally higher under the intermediate climate change scenario (SSP2-4.5) than in the worst-case scenario (SSP5-8.5).

Table 6 Livestock population exposed to intensifying drought risk in North-East Asia, 2021-2040

Country	% of total livestock							
	SSP2-4.5				SSP5-8.5			
	Cattle	Goat	Pig	Sheep	Cattle	Goat	Pig	Sheep
Japan	0.47	0.56	0.59	0.31	0.46	0.56	0.57	0.32
China	1.47	1.34	1.41	1.56	0.81	0.80	0.81	1.09
DPR Korea	0.02	0.01	0.01	0.05	0.02	0.01	0.01	0.05
Mongolia	0.45	0.51	0.28	0.53	0.30	0.33	0.21	0.33
Russian Federation	5.83	9.41	2.35	20.28	5.93	9.52	2.73	19.35

Mongolia: sub-national scenario

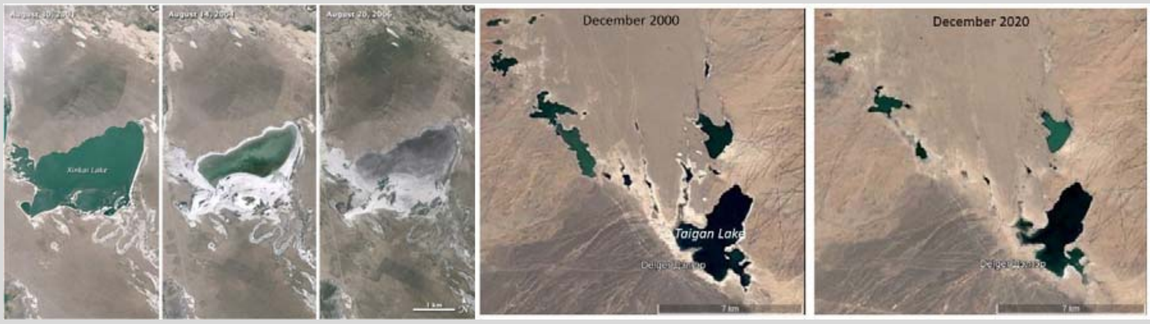
Mongolia is in the arid and semi-arid regions, where the annual average precipitation varies. The southern and central part receives much lower rain (100-200mm), and the Gobi Desert area receives less than 100mm. The aridity and associated desertification and land degradation process have increased in Mongolia in decades. The local climate and anthropogenic activities are responsible for Mongolia's desertification and land degradation. Apart from anthropogenic drivers, changing climate conditions has also contributed to the desertification and land degradation of 51 per cent of its territory. In Mongolia, the temperature was rapidly increased by 2.24°C between 1940 and 2014, while there was a decrease of annual precipitation by 7 per cent between 1940 and 2015.[i] Especially, the summer season (June-August), which receives most of the rainfall, has become drier. As a result, land areas under desertification significantly increased from 1990 to 2005. This has also impacted agriculture, animal husbandry and forestry sectors and was partially responsible for the poverty and internal migration from rural to urban areas.[ii]

Under recent climate change projections by IPCC (2021), although the precipitation is expected to increase in Mongolia slightly, the annual average temperature is projected to increase by 1.5°C across the country. An increase in temperature is likely to decrease soil moisture and increase the plant's evapotranspiration. These areas are sparsely populated, but their poor socio-economic condition makes them more vulnerable to climate change.

[86] National Drought Mitigation Center n.d.

Mongolia's inland water resources (rivers, springs and lakes) could mitigate the impacts of anticipated increasing temperature and aridity under climate change conditions. However, they are unevenly distributed. Mongolia has around 4,000 lakes and water bodies, of which 70 per cent are confined in 30 per cent of land areas. Furthermore, about 450 lakes and 700 perennial rivers dried out in the last two decades, primarily due to climate change.[iii] For example, Xinkai lake, situated on the Mongolian Plateau, has decreased by 30 per cent between 1980-2010.[v] Similarly, Taigan lake in the Gobi Desert area in southwestern Mongolia shows a shrinking pattern over two decades.

Figure 18. Satellite imagery of Xinkai Lake in 2001, 2004 and 2006,[iv] and Taigan lake in 2000 and 2020[v]



Source:

i. Ministry of Environment and Tourism, Mongolia, 2018
ii. Meng and other 2021
iii. Garmaev and other 2019
iv. NASA Earth Observatory n.d.
v. Google Earth: Image Landsat/ Copernicus

Key findings

Population exposure, as a proportion of the total population, to intensifying risk of desertification is highest in Mongolia. More than half of Mongolia's agricultural product volume and value and livestock in arid areas are likely exposed to increasing temperature.

Population exposure to the intensifying risk of drought is highest in the Russian Federation, followed by China, Japan, and Mongolia under SSP2-4.5 and SSP5-8.5. The projected exposure of agricultural production and livestock to intensifying drought risk follows the same pattern**.**

Some hyper-arid, arid and semi-arid areas in northern and western China and western Mongolia are projected to have intensifying drought risk. The persistent drought in these dry regions may aggravate the existing desertification risk in this region.

Chapter IV. Recommendations

Understanding climate risks for adaptation

Desertification and land degradation is one of the programmatic areas of the NEASPEC strategic plan 2021-2025 to address SDG 15 (Life on land). Reducing the impacts of drought and reversing desertification and land degradation at different scales can provide cost-effective and long-term benefits to communities and support the achievement of SDGs. NEASPEC strategic goals are to enhance science-based, policy-oriented cooperation to address desertification, land degradation and drought risks in the subregion. The NEASPEC strategic objective focuses on understanding the interlinkage between climate change, desertification, and land degradation to develop an integrated approach for adaptation.[87]

- **For addressing the desertification, land degradation and drought risks, it is necessary to learn and understand the nature, extent, and magnitude of the risk and vulnerability of the society, the environment, and the economy from these risks.** Climate change adaptation requires a good understanding of climate change and its potential impacts at a suitable spatial and temporal scale. This will support taking appropriate climate actions and help optimise resource utilisation, especially in resource-scarce areas. Understanding threats arising from the nexus of drought, land degradation and desertification, and projected changes of their drivers are also essential to identify adaptation priorities.

- **Risk-informed decision process is required to build resilience against evolving complex 'riskscape'.** Based on a good understanding of climate change, a sound risk assessment should be conducted to support the risk-informed decision-making of various levels of stakeholders, from government officials to the private sector and the public. This should consider the dynamics of socio-economic development that determine the extent of exposure, vulnerability and coping capacity to complex threats like desertification, land degradation and drought. Risk assessment is especially important for high-risk and low-capacity countries that are often highly dependent upon climate-sensitive sectors such as agriculture.

- **Long-term proactive measures should be taken to address intensifying risks of desertification, land degradation and drought, reflecting climate projections**. Desertification, land degradation, and drought events are slow-onset hazards. Managing these risks will require a significant time frame (e.g., 5 -10 years) to plan and design adaptation strategies and implement appropriate measures, considering other climate drivers.

Opportunities for subregional cooperation

The impacts of climate change, desertification, land degradation, and drought events are transboundary. Subregional solutions should reflect teleconnections of climate patterns and linkages of transboundary natural resources and their ecosystem services, and linkages of economy through trade and human mobility. If national adaptation planning processes do not reflect and address these

[87] NEASPEC Strategic Plan 2021-2025

teleconnections and linkages, adaptation efforts may not be able to achieve intended outcomes. However, there is a lack of recognition of climate change impacts on transboundary natural resources in the international climate change regime and related processes. There are gaps in the governance of common resources, lack of reliable estimates on how, and to what extent, countries are benefiting from these resources, and how climate change can impact these resources.[88]

Regional adaptation planning through regional and subregional cooperation provides an important opportunity to address the gaps. Such cooperation should be able to identify opportunities to collaborate and design interventions for addressing common threats, while also recognizing sub-regional diversities and differences priorities between countries. While financing regional initiatives is a challenge as many bilateral and multilateral donors focus on country-specific programmes, regional cooperation mechanisms should promote innovative regional and subregional programmes, clearly attributing the consequences of climate change impacts on teleconnections of climate patterns and interlinkages of natural resources, ecosystem services and the economy.

In this regard, the NEASPEC strategic plan 2021- 2025 recognises subregional cooperation among the member States for addressing desertification and land degradation, focusing on their interlinkages with climate change. North-East Asian countries are diverse in their landmass, population, socio-economy, culture, resources, and ethnic homogeneity. In addition, the difference in their political and geopolitical outlook and priorities hinders the efficiency of the institutionalised regional cooperation mechanism, although bilateral cooperation is relatively well established.[89] Table 7 presents some of the existing subregional mechanisms on climate change, desertification, land degradation, and drought in North-East Asia.

Table 7 Existing subregional mechanism in North-East Asia [90]

Mechanism	Members	Governance	Secretariat	Relevant Areas
NEASPEC	All six countries	Senior officials meeting	ESCAP	Desertification and land degradation
TEMM	China, Japan, ROK	Ministers' Meeting	Host ministry of annual meeting	Climate change
DLDD-NEAN	China, Mongolia, ROK	Steering committee meeting	Korea Forest Service of ROK	Subregional implementation platform for achieving land degradation neutrality target (LDN) and enhancing the implementation of UNCCD

NEASPEC: North-East Asian Subregional Programme for Environmental Cooperation
TEMM: Tripartite Environment Ministers Meeting among Japan, Korea and China

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Most existing mechanisms are advisory and do not lead to joint policy formulation. Therefore, the following intergovernmental cooperation measures are proposed to address the intensifying risks of desertification, land degradation and drought in North-East Asia.

- To tackle the common subregional challenges, **it is necessary to scale up the subregional environmental cooperation.** Desertification, land degradation, and drought events can negatively affect the economy and inequalities and trigger migration, social unrest, and conflicts across the region. Therefore, multilateral cooperation for long term adaptation and resilience to these risks is necessary.
- **Public-private partnership can be encouraged.** Addressing intensifying risks of desertification, land degradation, and drought will require the engagement of all stakeholders. Together with other stakeholders, governments should provide institutional and financial support in addressing the risks by implementing appropriate adaptation measures.
- **Subregional cooperation can ensure rational utilisation of resources through strengthening coordination.** NEASPEC and other regional mechanisms can promote subregional cooperation in addressing the shared risks. Sharing knowledge and experiences among neighbouring countries will also help build adaptive capacity.
- **Technology has great potential in addressing desertification, land degradation and drought risks.** Technological cooperation is essential to build subregional resilience. For example, drought monitoring and early warning system, seamless rainfall forecasting system across timescale, a network of meteorological and hydrological stations for data collection, Big Data, IoT, etc., can help identify and monitor the risks.
- **It is essential to establish a connection between the national actors with the regional experts** (either individual or institutional) on desertification, land degradation and drought. These networks can be utilised to support capacity building of local communities promote the integration of climate scientists and social scientists for taking a holistic approach to the risks.

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