Kazakhstan - Climate Change and Disaster Risk Profile

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1. Kazakhstan – country overview

Kazakhstan is the largest landlocked country in the world. It is an an upper-middle-income country with a population of 18.7 million. Nursultan (capital) and Almaty are the country's major cities. The geographical terrain is 90% flat with high mountains located only in the South Eastern and Eastern parts of the country. A leading producer and exporter of wheat in the region, the country is the largest economy of Central Asia, generating 60% of the region's GDP (USAID, 2017). More than 50% of its employment is generated by 4 economic sectors: 16 % by agriculture, forestry and fishery; 15% from repair of vehicles and motorcycles; 13% from the industry sector and 12% from the education sector (Third Biennial Report, 2017).

Kazakhstan is rich in natural resources such as coal, oil and natural gas. Due to its high dependence on coal and oil, the country's GDP growth is closely correlated with greenhouse gas (GHG) emissions. The geographical location and climatic conditions of Kazakhstan make it prone to natural disasters such as floods, mudflows and landslides. According to a World Bank assessment, 75% of the country is at an increasing risk of adverse climate change impact (CCKP World Bank, 2021).

Figure 1: Map of Kazakhstan
Source: https://geology.com/

2. Present and future climate change trends

Overview

Kazakhstan is a land-locked country with a continental climate featuring hot summers, harsh winters and a scanty rainfall. The country is largely covered by arid climatic zones such as deserts, semi-deserts or Mediterranean continental. Only the Northern region of the country experiences a humid climate, forming humid continental and temperate continental zones.

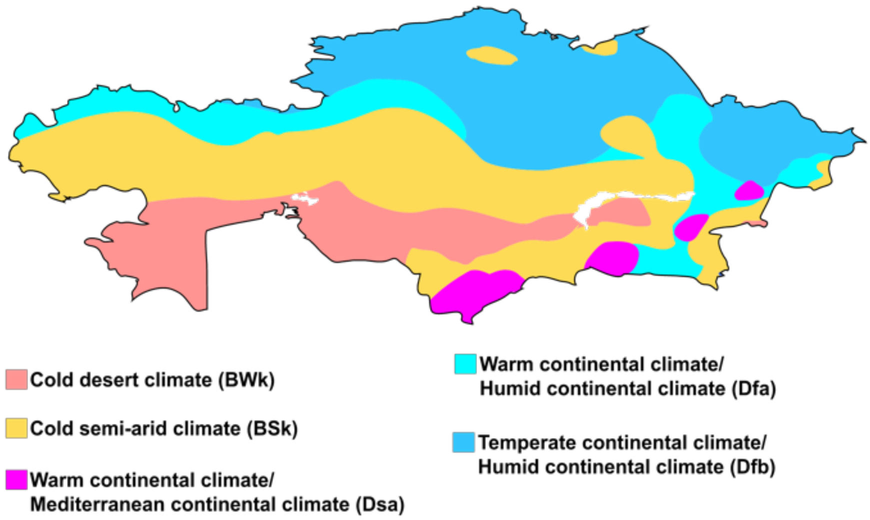

Figure 2: Climate classification map of Kazakhstan
Source: https://commons.wikimedia.org/

The country experiences 4 distinct seasons, but summers and winters are especially pronounced. The Northern part of the country experiences very harsh winters that can last up to 6 months. Strong winds and blizzards affect the entire territory of the country. Average temperatures during winter (coldest month: January) vary from -20°C in the North to -5°C in the extreme South (USAID, 2017). **Nearly 45% of the country's area falls under the cold desert and semi-arid climatic zones.** The Central and Western region of the country, part of the cold desert and semi-arid climatic zones, experience long hot summers, cold winters and high aridity. Average summer temperatures range from 19°C in the North to 29°C in the South.

Precipitation is very low in the South Eastern plains while the mountains in the South and South East receive the country's highest precipitation amount. **Annual average rainfall in the region ranges from 200 mm to 4500 mm** in the Western and Northern flatlands and up to 1600 mm in the Southern foothills (Climate Service Center Germany, 2018).

Historical climate trends

Historical climate observations for the climatological normal period of 1961-1990 show an increase in the **near-surface annual average temperature** of 0.14°C per decade. Over a more recent historical climate period of 1991-2016, this **increase reached 0.43°C per decade** (CCKP World Bank, 2021). This acceleration in the temperature increase leads to such negative impacts of climate change as a rapid glacial melting with a **loss of nearly 30% of Tien Shan glaciers since 1950.** Besides, such an increase in temperature likely affects the vulnerable hydro - economic basins of Ural-Caspian and Shu-Talas regions.

The **total annual precipitation** in the country shows a slight increase of 2.7mm per decade for the climatological normal period of 1961-1990, and a more **pronounced increase of 17.1mm per decade** for a more recent climate period of 1991-2016 (CCKP World Bank, 2021). This increase, accentuated in most precipitation prone areas, may affect the transport and ICT sectors through floods, mudflows and landslides.

Future climate trends

Summary

Under the median range of simulations for RCP 4.5 and RCP 8.5, future climate projections demonstrate:

- A warming trend across the country with an **annual average temperature rise of 2.2 - 2.7°C** by mid-century in comparison with a reference period of 1986-2005. This increases the risks of heatwaves, droughts, and glacial melting, especially in such vulnerable regions as South, South-East and South-West;

- A **1.8 – 1.7mm increase in monthly precipitation** by 2040-2059, mainly in winter and spring. This *increases the risks of floods, landslides, mudslides and mudflows, especially in the mountainous regions*. *A* projected decrease in precipitation during the summer season, on the other hand, may lead to droughts.

Methodology

Climate Change Knowledge Portal (CCKP) data

The analysis utilises climate anomalies data from the World Bank's Climate Change Knowledge Portal (CCKP) unless otherwise indicated. Climate change projected anomaly in selected climate variables and indicators for an **intermediate future period from 2040 to 2059** in comparison with a reference period of **1986 to 2005** has been selected as optimal for this analysis because it provides a remote enough perspective while remaining within a reasonable policy planning timeframe. CCKP's projections were developed utilising an ensemble of 16 to 27 General Circulation Models (GCMs)[1], constituted under the Coupled Model Intercomparison Project, Phase 5 (CMIP5), in accordance with the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5).

Representative concentration pathways **RCP 4.5 (moderate scenario) and RCP 8.5 (business as usual scenario)** have been selected to present a range of possible variations likely to affect the country depending on how future international climate change mitigation efforts could evolve.

The **50th percentile**, or the middle - temperature value in the range of all projected temperatures in the GCMs' ensemble, is used for the analysis to present a moderate and a most likely (as per the climate models) future scenario. However, the projected climate data table (Table 1) includes the 90th percentile data, or the GCM ensemble extremes, to showcase the maximum possible extremes anticipated for the country.

While projections from the CCKP source help identify most likely climate change trends, they also present **a number of limitations**:

- The reference period used by the CCKP data source is 1986 to 2005, which means that, as of today, the anomaly could be slightly lower;
- Model biases reveal particularly strong for mountainous countries. The country analysis hence does not indicate absolute values but presents only variations of selected climate change variables and indices;
- The low resolution of GCMs (1 degree or about 100 km) produces uncertainties in precipitation due to the country's complex topography;
- CCKP does not segregate data by regions.

Selected climate variables and indices

The following climate variables and indices have been considered as most relevant for the three infrastructure sectors considered under the present profile:

- Annual average temperature (Tas);
- Annual average maximum temperature (Tasmax);
- Annual average minimum temperature (Tasmin);
- Annual average maximum of daily maximum temperature (TXx);
- Number of summer days (Tmax > 25°C);
- Number of hot days (Tmax > 35°C);
- Annual average precipitation (Pr);
- A number of days with rainfall > 20mm.

High variations of these variables and indices may negatively affect the energy, ICT and transport infrastructure and increase the frequency and intensity of natural hazards such as landslides, mudflows, glacial melting or heatwaves, which may further affect these sectors.

Climate variables and indices	RCP 4.5	RCP 4.5	RCP 8.5	RCP 8.5
	50th percentile	90th percentile	50th percentile	90th percentile
Temperature (°C)				
Tas annual anomaly	2.2	3.7	2.7	4.4
Tasmax annual anomaly	2.2	3.8	2.7	4.4
Tasmin annual anomaly	2.3	4.0	2.8	4.7
TXx annual anomaly	2.3	5.6	2.9	6.3
Number of Summer Days (Tmax > 25°C)	16	34	23	38
Number of Hot Days (Tmax > 35°C)	12	32	16	39
Precipitation (mm)				
Average monthly precipitation	1.8	10.2	1.7	11.0
Number of Days with Rainfall > 20mm	0.04	0.49	0.09	0.59

Table 1: Climate indicators change for the period 2040 - 2059 under RCP 4.5 and RCP 8.5 for the 50th percentile (ensemble median) and the 90th percentile (ensemble extremes)
Source: World Bank (2021)

Analysis of climate variables and indices

Average annual temperature (Tas)

Under the 50th percentile, CCKP climate projections for the selected intermediate future period of 2040-2059 (reference period of 1986 - 2005) anticipate a Tas increase of 2.2°C under a moderate RCP 4.5 emissions scenario, however this increase goes up to 2.7°C under a business-as-usual scenario RCP 8.5. Under the 90th percentile, this increase goes further up to 3.7°C (RCP 4.5) and 4.4 (RCP 8.5). **The temperature rise is higher during winter and spring**: it reaches 2.8°C under the 50th percentile and 4.6°C under the 90th percentile for RCP4.5 scenario; and 3.2°C under the 50th percentile and 5.5°C under the 90th percentile for RCP8.5 scenario. According to the Third Biennial report, **this increase is likely be relatively uniform across the different country's**

regions (Figure 3). This rise will influence the speed of snow melting and increase the risks of floods and landslides, which can lead to a stronger negative impact on the infrastructure.

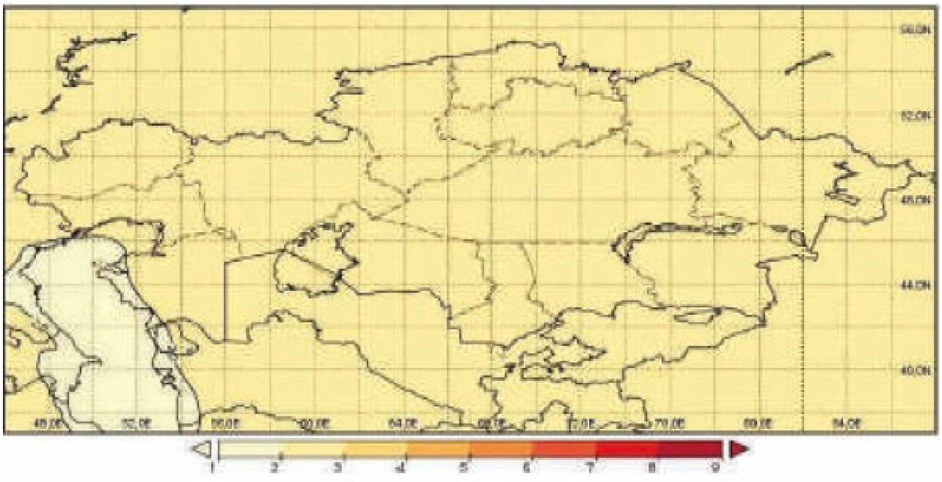

Figure 3: Changes in monthly air temperature (°C) in 2040-2059 under RCP 4.5
Source: (Third Biennial Report, 2017)

The above Tas trends may affect the energy sector. A higher air temperature decreases the difference between ambient and combustion temperature in coal power plants, hence reducing the efficiency of boilers and generators and reducing coal power plants generation capacity. In gas power plants, a temperature increase directly affects the power output.
The ICT sector may face a decreased conductivity and performance of underground cables as well as by a reduced signal range and quality of wireless transmissions.
The transport sector may face a road surface deterioration, an expansion of joints and a buckling of railway tracks.

Annual maximum temperature (Tasmax)

Extreme temperatures are particularly likely to negatively affect the energy, transport and ICT sectors. Under the 50th percentile, climate projections for the selected intermediate future period of 2040 - 2059 (reference period of 1986 - 2005) show a Tasmax increase of 2.2°C under a moderate RCP 4.5 emissions scenario and an increase of 2.7°C under a business-as-usual RCP 8.5 scenario. Under the 90th percentile, this increase goes further up to 3.8°C (RCP 4.5) and 4.4 (RCP 8.5). **Under the RCP 4.5** scenario, **the Tasmax rise is the highest in February and March**: by 2.4 and 2.8°C respectively under the 50th percentile, and by 4.4 and 5.1°C respectively under the 90th percentile. **Under the RCP 8.5, the Tasmax rise is the highest in March** (by 3.1°C under the 50th percentile, and by 6.0°C under the 90th percentile).

The Tasmax rise is likely to generate an earlier snow melting hence increasing the risks of floods and landslides, which can lead to a stronger negative impact on the transport, energy and ICT infrastructure.

Annual minimum temperature (Tasmin)

Under the 50th percentile, climate projections for the selected future period indicate a Tasmin increase of 2.3°C under the RCP 4.5 emissions scenario and an increase of 2.8°C under the RCP 8.5 scenario. Under the 90th percentile, this increase goes further up to 4.0°C (RCP 4.5) and to 4.7 (RCP 8.5). **The temperature rise is the highest for the winter and spring seasons**: the highest annual absolute values are projected to be up to 3.1°C in February for the 50th percentile, and up to 5.1°C in March for the 90th percentile under the RCP 4.5; up to 3.8°C in January for the 50th percentile, and up to 6°C in December for the 90th percentile under the RCP 8.5.

The Tasmin increase may affect the permafrost zone and can lead to a negative impact on the infrastructure (e.g. thawing permafrost caused due to rising temperatures can damage substation and transmission towers).

Average annual maximum of daily maximum temperature (TXx)

TXx is an important indicator for the physical infrastructure sectors that are vulnerable to high temperature peaks and variations over a short time span. In Kazakhstan, the TXx projections for the period 2040 – 2059 show an increase of 2.3°C (50th percentile) and of 5.6°C (90th percentile) under RCP 4.5; or of 2.9°C (50th percentile) and 6.3°C (90th percentile) under RCP 8.5. For the month of July, the hottest month of the year in the country, TXx is projected to increase by 2.1°C (50th percentile) and 5.4°C (90th percentile) under RCP 4.5, or by 2.7°C (50th percentile) and 6.1°C (90th percentile) under RCP 8.5. **This increase in TXx, especially for the 90th percentile, will most likely affect the three considered sectors.**

An increase in TXx may affect the energy sector (e.g. reduce the availability of water resources for power plants' cooling systems; reduce efficiency and power generation capacity of coal power plants; an increase of 5.5°C in ambient air temperature can reduce the power output of gas turbines by approximately 3%*), the ICT (e.g. high temperatures decrease performance and conductivity of underground cables) and the transport sectors (e.g. high temperatures contribute to thermal expansion of bridge joints and of the pavement surface).*

Number of summer days

The number of summer days is the temperature index that indicates the annual number of days with a maximum temperature of over 25°C. The selected GCMs ensemble indicates an increase in summer days of about 16 days (50th percentile) and 34 days (90th percentile) under RCP4.5 and of 23 days (50th percentile) and 38 days (90th percentile) under RCP8.5 (World Bank, 2021). **Such an increase in summer days is significant, especially for the Southern and Western regions with a semi-arid and arid climates.**

An increase in summer days in summer is likely to affect the energy sector through water availability for hydropower generation in the Southern region of the country, through decreasing the thermal power generation capacity and the ICT sector through potential damages to the physical infrastructure such as transmission lines.

Number of hot days

The number of hot days is the temperature index that indicates the annual number of days with a maximum temperature of over 35°C. The GCMs ensemble assessment anticipates an increase of 12 days (50th percentile) and 32 days (90th percentile) under RCP 4.5 and of 16 days (50th percentile) and 39 days (90th percentile) under RCP8.5 (World Bank , 2021).

An increase in the number of hot days is a major cause of natural hazards such as droughts or heatwaves. This is especially crucial for the Southern and Western parts of the country. Such weather events may affect the energy (e.g. water scarcity causing water shortages to cool thermal systems in coal power plants), the ICT (e.g. increase in the number of hot days causing overheating of mobile towers) and the transport (e.g. overheating of rail electrical systems and communications equipment creating signalling problems; increases in temperature in very cold areas causing road subsidence and weakening of bridge supports due to thawing of permafrost) sectors.

Average monthly precipitation (Pr)

The CMIP5 GCMs ensemble shows an increase in monthly precipitation (Pr) in the future period of 2040 – 2059 in comparison with the reference period of 1986 – 2005 by an average of 1.8 mm per month (50th percentile) and of 10.2 mm per month (90th percentile) under RCP 4.5; of 1.7 mm per month (50th percentile) and of 11 mm per month (90th percentile) under RCP 8.5. A seasonal increase in monthly precipitation occurs mainly in the winter and spring seasons (by 2.7 to 4.7 mm for the 50th percentile under RCP 4.5, and by 3.3 to 3.9 mm for the 50th percentile under RCP 8.5). A change in precipitation patterns increases the risks of floods and climate-related natural disasters such as landslides, mudslides and mudflows in the mountainous regions.

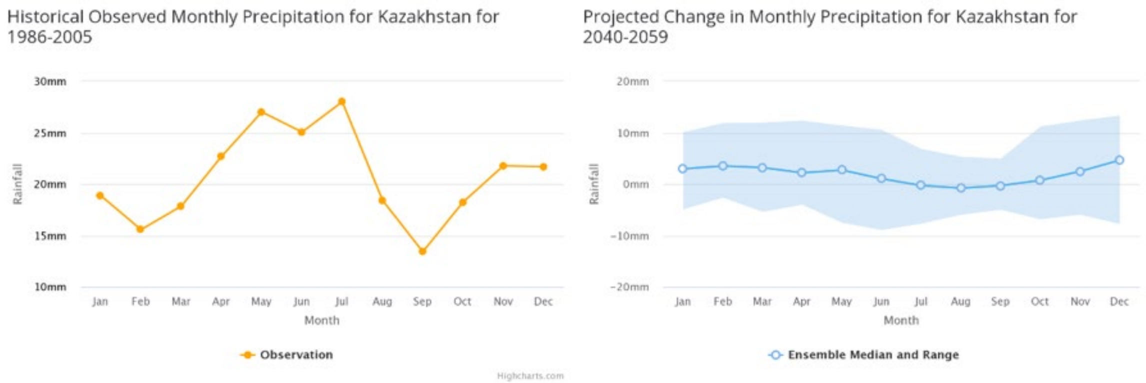

Figure 4: Historical monthly precipitation (left) for Kazakhstan and precipitation change (right) for the period 2040 – 2059 under RCP 4.5

Source: World Bank, 2021

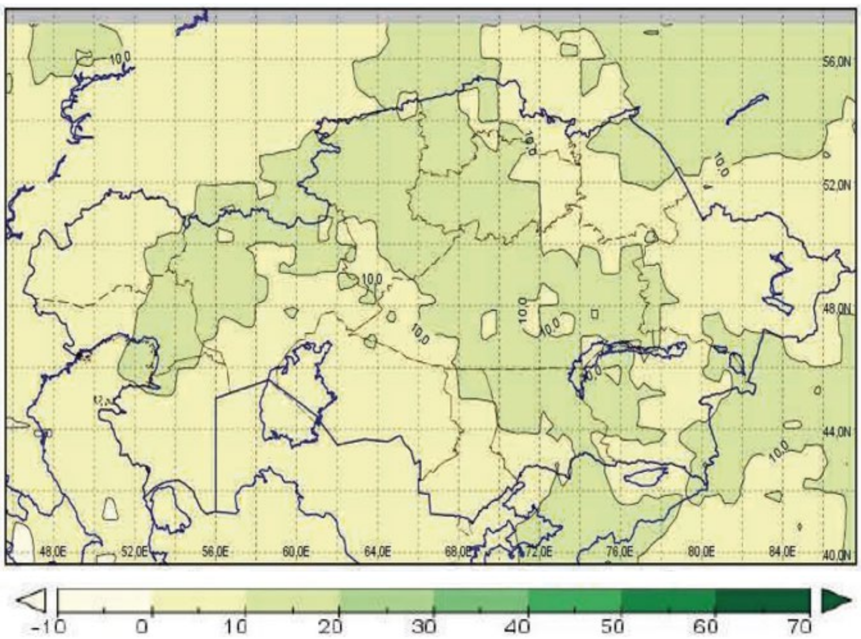

Figure 5: Changes in annual precipitation (%) in 2040-2059 under RCP 4.5
Source: (Third Biennial Report, 2017)

Under the RCP 4.5, the projected annual precipitation increase is likely to affect half the country's territory – more precisely its **Northern and Central regions – by 10 to 20%, which is relatively significant for Kazakhstan.** The Western, South-Western and Eastern parts of Kazakhstan, on the other hand, are projected not to face any precipitation increase or to face a decrease of up to 10% (Figure 5).

A concentration of the precipitation increase in winter and spring is likely to lead to an increase in floods, mudflows and landslides, especially in the mountain regions that are vulnerable to such hazards. These natural hazards may affect the ICT and transport sectors by damaging physical infrastructure such as transmission towers, distribution lines and substations, terrestrial cables disrupting ICT broadband services, road networks and transportation connectivity.

Number of very heavy precipitation days

The number of very heavy precipitation days is a climate index that indicates the annual number of days with a daily rainfall of over 20mm. The number of very heavy precipitation days is a climate index that can affect the transport and ICT sectors through floods, mudflows and landslides.

The GCMs ensemble does not show significant changes: +0.04 days (50th percentile) and +0.49 days (90th percentile) under RCP 4.5; +0.09 days (50th percentile) and +0.59 days (90th percentile) under RCP 8.5. (World Bank , 2021).

3. Present and future vulnerability to climate change related natural hazards

Due to its geographic location, Kazakhstan is highly exposed to earthquakes, floods, mudflows, landslides and droughts. Natural disasters and extreme weather events threaten human lives, damage livelihoods and the country's infrastructure. During the period between 1990 and 2002, the frequency of heavy snowfalls in Kazakhstan increased by 150% and that of heavy showers by 170%. River floods in mountainous regions increased by 100% and mudslides doubled over the same period (The Economist, 2018). **Climate change impacts on the temperature and precipitation are likely to further increase the intensity and frequency of these natural disasters.**

Methodology

ThinkHazard is a tool providing an overview of natural disasters affecting a given location. It uses best available data from published public reports as well as from private, academic and governmental institutions. Regional level data is used over global data when available. Natural disasters affecting the study area are classified as very low, low, medium and high based on assessed hazard intensity threshold, hazard frequency threshold, susceptibility as well as considering which damage may occur. The portal also provides guidance on how to diminish the impact of these disasters, and where to find additional information (ESCAP, 2020).

In comparison, multi-hazard risk analysis based on the Average Annualised Loss (AAL) risk metric considers mainly social and economic risk (ESCAP, 2019). The present report utilizes data from the ThinkHazard portal, unless otherwise indicated, in order to **take into consideration natural hazard intensity, frequency and susceptibility under climate change**, which are most likely to affect the energy, transport and ICT sectors in the country.

Floods

Due to an increase in temperatures in the mountainous regions, a water level increase in the mountain rivers has been observed over the recent years. This increase is generated by an increased water loss from glacier melting. Consequentially, mountain and piedmont areas of the country are most vulnerable to floods: the South Kazakhstan, Zhambyl, Almaty and East Kazakhstan regions. In the East Kazakhstan region, the flood risk has increased nearly 4.7 times while in the Almaty oblast riverine flooding increased by 35% between 1991 to 2015 (Third Biennial Report, 2017).

Climate change and air temperature increase result in earlier ice break-up on the upper reaches while downstream is still covered with ice. Ice jams raise the water level and cause waterside floods. From 1991 to 2015, the occurrence of ice jams in the Almaty region has increased by 33% while the total number of ice jams in the country has increased 3 times (Third Biennial Report, 2017).

For a more detailed assessment, Hydromet could generate flood projections by using hydrological models (e.g. HBV model) and hydrographs (Third Biennial Report, 2017).

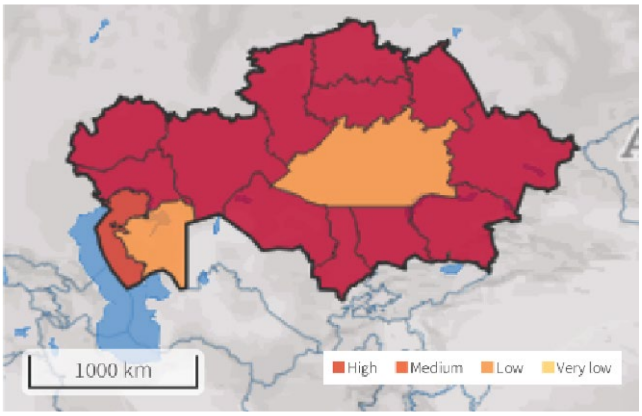

Figure 6: Riverine flood risk in Kazakhstan
Source: UNISDR , GFDRR, ThinkHazard,2020

Droughts

A decrease in precipitation during summer months combined with an increase of surface air temperature can have important implications such as rapid depletion of soil moisture leading to drought conditions.

Rapidly melting glacial ice and precipitation decrease in summer (July to September) further increase the **risk of water scarcity and droughts in the country, especially in the Western, Southern and South Eastern parts.** The number of hot days may increase by up to 16 days for the period 2040 – 2059 under the RCP 8.5 pathway (World Bank , 2021). Considering that Southern and Western parts of Kazakhstan are already highly vulnerable to droughts (Figure 7), the projected climate change patters may enhance the present situation.

A more detailed drought risk assessment could be undertaken to predict the probability of drought occurrence by using soil moisture data and examining shifts in drought incidence across various GCM climate scenarios. Drought indices such as the Palmer Drought Severity Index (PDSI), Integrated Drought Index (IDI), Aridity Anomaly Index (AAI) and the Standardized Precipitation Index (SPI) are developed to quantify meteorological, agricultural and hydrological droughts (WMO, Global Water Partnership, 2018). *These indices require multiple inputs for drought calculation such as humidity, precipitation, temperature, soil moisture under different GCM scenarios and give more realistic and accurate drought prediction* (Jehanzaib, 2020). *Hydromet could calculate the drought index using local climate indicators and analyse the drought risk across different regions of the country.*

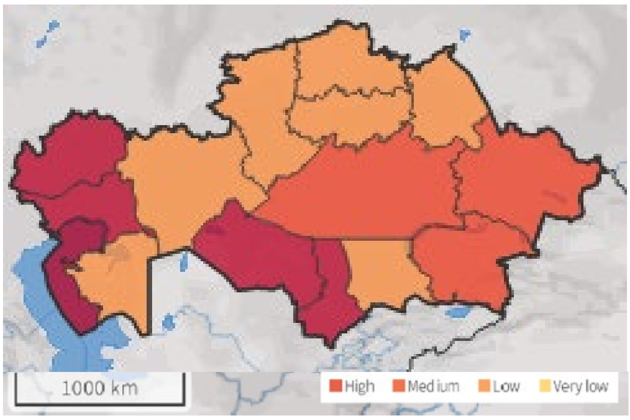

Figure 7: Water scarcity risk in Kazakhastan
Source: UNISDR , GFDRR, ThinkHazard,2020

Landslides and mudflows

Landslides and mudflows can be triggered by accelerated glacial melts or extreme rainfall events. Intense rainfall events and rapid glacial melts destabilise mountain slopes, triggering **landslides in mountainous regions.** In Kazakhstan, **mudflows are mainly triggered by extreme rainfall events.** Between 1967 and 1990, major landslide and mudflow events were recorded only in the Almaty region, however between 1991 and 2015 the frequency of mudflows in the country has increased by 82% (Third Biennial Report, 2017).

The country's vulnerability to landslides is shown in Figure 8 (ThinkHazard,2020). The South Eastern parts of Kazakhstan are highly vulnerable to landslides due to hosting mountainous areas. Typical triggers of landslides in the country are heavy rainfalls, glacier melts, mudflows, floods, earthquakes, landslide-prone vegetation cover and soil types on slopes.

Changing precipitation patterns are likely to alter the slope and bedrock stability. Based on historical observed data on rainfall and landslide events, empirical methods such as logical regression and quantile regression can determine what rainfall threshold conditions can result in slope failures (landslides). This analysis can be used to identify the most vulnerable regions, predict potential future occurrence of landslides in specific areas and develop early warning systems (Shuangshuang He, 2019)*. Hydromet could undertake this assessment and develop an early warning system for landslides and mudflows in the country.*

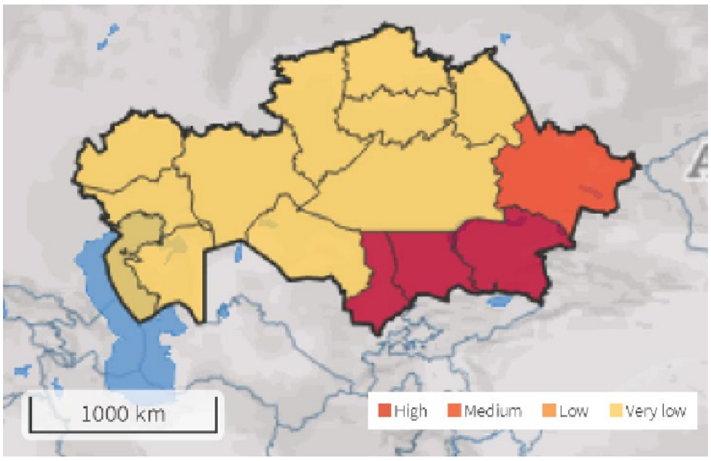

Figure 8: Landslide risk in Kazakhastan
Source: UNISDR , GFDRR, ThinkHazard,2020

4. Climate change impacts on the energy, ICT and transport sectors

Climate change may affect the energy, ICT and transport infrastructure in two ways: by gradual or incremental climate change patterns (such as gradually increasing average surface mean temperature) and by changing extreme weather events patterns (such as intensified and more frequent heat waves). Climate change may intensify some natural disaster risks (drought, floods) or have a less direct relationship to them (earthquakes).

Climate change vulnerability of the infrastructure sectors depends not only on climate change patterns themselves, but as much on the **specifics of each infrastructural asset.** Indeed, the asset's specific location, the asset's age, quality and maintenance, the assets safety parameters accounted influence the extent to which it may be affected by climate change. Understanding how exactly and to what extent infrastructural assets are likely to be affected by climate change hence requires a thorough engineering analysis of each specific asset. However, there are a number of **well identified cause-to-effect patterns** for each of the considered infrastructural sectors that can be taken into consideration when looking into climate proofing them. The present section aims to list them and highlight broad directions to further explore when devising climate proof policies and interventions for the energy, ICT and transport sectors.

The table below summarises these cause-to-effect patterns relevant for the specifics of the climate change and the energy, ICT and transport sectors in Kazakhstan:

Climate change pattern	Potential impact on the energy sector in Kazakhstan
Increased average and extreme temperatures	▪ Decreased thermal power generation capacity ▪ Reduced efficiency of transmission lines ▪ Reduced hydro power generation capacity
Changes in precipitation patterns	▪ Associated increased frequency and intensity of extreme weather events damaging the physical infrastructure
Climate related natural disasters	
Floods	▪ Damage to physical infrastructure such as transmission lines, coal extraction mines and power plants
Landslides and mudslides	▪ Damage to physical infrastructure causing failure of transmission networks and loss of power supply
Droughts	▪ Water scarcity may affect hydro power generation capacity and impact thermal power cooling systems
Climate change pattern	Potential impact on the ICT sector in Kazakhstan
Increased average and extreme temperatures	▪ Decreased conductivity and performance of underground cables ▪ Reduced efficiency of wireless transmission ▪ Overheating of data centres ▪ Health risk to maintenance staff
Changes in precipitation patterns	▪ Heavy rainfall can weaken quality and reliability of wireless transmission signals
Climate related natural disasters	
Floods	▪ Damage to physical infrastructure
Landslides and mudslides	▪ Can damage physical infrastructure causing failure of network and loss of connectivity
Climate change pattern	Potential impact on the transport sector in Kazakhstan
Increased average and extreme temperatures	▪ Deteriorated road surface asphalt ▪ Expansion of bridge joints and buckling of railway tracks

Changes in precipitation patterns	▪ Threatens transportation through inland waterways
	▪ Wash out of road surfaces, damage to railway networks, flooding in tunnels ▪ Increased seepage and infiltration into pavement and subgrade, reduced structural stability of roads and pavements
Climate related natural disasters	
Floods	▪ Water-logging due to overload on roadside drainage ▪ Water logging in tunnels ▪ Damage to rail and road infrastructure
Landslides and mudslides	▪ Damage to physical infrastructure blocking circulation on roads and railways.

Table 2: Climate change impact on the transport, ICT and energy sectors

In addition, the following points will need to be incorporated at a more detailed infrastructural sectors' screening stage:

- To effectively mainstream climate change into infrastructural investments, **climate change projections need to be as viable as possible.** Indeed, climate proofing an infrastructural asset may often come to an additional adaptation cost. It is therefore important to correct climate models' biases and use high resolution climate models. This means that the CCKP's data used for the present assessment may be helpful to analyse general climate change trends at the national level, but it may not be precise enough to take infrastructure investment decisions. For the latter, it is recommended to use an ensemble of Regional Climate Models (RCM);
- Climate proofing the infrastructure often comes to **climate proofing future investments**, in particular for the infrastructure sectors in which most of the assets are reaching the end of their lifecycle;
- When most of the future infrastructural assets are to be built for the considered climate change time period, it is of a critical importance to **align the spatial planning of the infrastructural assets with high resolution climate change projections** and associated natural disasters' maps in order to avoid locating future assets in most climate vulnerable areas.

Energy sector

Energy sector overview

Kazakhstan is rich in primary energy sources - large reserves of oil, natural gas and coal - and a net energy exporter. The country is the largest oil producer in Central Asia and possesses 12th highest crude oil reserves in the world. In 2018, **the oil and gas sector accounted for 21.3% of the GDP and 70% the country's total export earnings.** The country's oil production is expected to grow: projections foresee a production of 450 thousand barrels per day (kb/d) by 2025 and of 955 kb/d by 2040 (IEA, 2021).

In 2018, the energy mix of the country was composed by 50% of coal, followed by 25% of oil and 25% of natural gas. The electricity generation of the country is heavily dependent on coal-fired power plants. **In 2018, 70% of the country's electricity was generated from coal** (IEA, 2021). As part of its Green Economy Concept, adopted in 2013, the country set an **ambitious target of 50% of the national electricity generation from sources other than coal or oil by 2050** (such as natural gas, nuclear and renewable energy). Kazakhstan is rich in natural resources, however the **power sector infrastructure is outdated and needs considerable rehabilitation and upgrading** to reduce generation losses and increase the sector's overall efficiency.

Figure 9:Tengiz: oil production expansion project in Kazakhstan
Source: https://www.upstreamonline.com/, Photo: SICIM

Potential climate change impacts on the energy infrastructure

The energy sector is at the core of the country's economic development. The climate change impact on the sector hence needs to be taken into careful consideration. Climate projections anticipate an annual average temperature increase of 2.2°C to 4.4°C for the analysed future time period across the country. Such an increase can affect the quality and the performance of the energy infrastructure. A rise in the ambient temperature reduces the efficiency of boilers and generators in coal power plants. Gas turbines may generate a reduced power output: an increase of 5.5°C in ambient air temperature can reduce the power output by nearly 3%. This may have a tangible negative impact on the electricity sector, largely dominated by coal and gas generation. In addition, a 1°C rise in temperature may cause up to 4.5 cm sagging in transmission lines.

The anticipated temperature and precipitation increase is also likely to increase the frequency and intensity of natural disasters such as floods, landslides and mudflows. For example, an early snow melting and heavy precipitation may intensity floods, which will trigger more pronounced landslides and mudslides in mountainous areas. Floods may typically affect physical infrastructure such as coal storage facilities and coal generation plants, underground oil and gas pipelines as well as power transmission and distribution networks. The 2015 flood and consequential mudflows in Almaty caused extensive damage to the latter.

The Green Economy Concept adopted in 2013 aims to increase electricity generation from sources other than coal or oil by 50%, by 2050. To achieve this goal, the country plans to increase power generation through renewable energy sources. In this respect, the country's hydropower potential is likely to be reduced due to a potentially increased water shortage. Indeed, Tien Shan glaciers have already lost nearly 30% of their volume since 1950.

ICT sector

ICT sector overview

In 2017, the country approved the program Digital Kazakhstan, which aims to accelerate economic development, enhance quality of life and promote digital economy. In particular, the program targets to:

- Digitalize all economic sectors
- Develop e-commerce
- Increase coverage of communications and ICT infrastructure

- Develop smart cities

To achieve these targets, the country a robust ICT infrastructure and, in particular, a robust broadband internet access. According to an ESCAP assessment, a 10% increase in broadband access leads to a 1% increase in GDP and doubling the average broadband speed can increase the country's GDP by 0.3% (ESCAP, 2020). Broadband access is provided by wired technologies such as fibre optic cables (FTTx), wireless technologies such as 3G or 4G, and satellite communications. A lag in the development of data transmission network makes access to reliable internet services in a number of rural areas of the country a challenge. In 2016, the density of internet users was 81.3% in urban areas versus 70.9% in rural areas (Digital Kazakhstan, 2017).

Potential climate change impacts on the ICT infrastructure

ICT infrastructure such as underground fibre optic lines, cable ducts, mobile towers, power transmission pillars, telecommunication equipment and networks are vulnerable to climate impacts and natural disasters. With the rise in ambient temperature, the surface soil temperature increases, decreasing the conductivity and performance of underground cables. It is estimated that for temperatures above 55°C the underground cable capacity is lost by 29%.

The projected 2.2°C to 4.4°C average temperature rise for the analysed future time period can negatively impact the ICT infrastructure and connectivity in Kazakhstan. It may reduce the signal range and affect the quality of wireless transmissions. It may also cause a rise in the telecommunication equipment's operating temperature, which may affect stability of operation and cause hardware failure. High temperature peaks and an increased number of hot days may cause overheating of data centres and increase health risks for the outdoor maintenance staff (ITU, 2018).

An increase in precipitation and intensified rainfall events may increase the risk of floods and associated landslides and mudflows. Landslides may in turn damage terrestrial cables, mobile towers and underground ducts causing network failure and disruption of ICT broadband services (ITU, 2014).

Transport sector

Transport sector overview

Due to the country's strategic location connecting Europe and Asia, transport is an important economic sector contributing to over 9% of the country's GDP. The transport sector of Kazakhstan includes roads, railways, inland waterways and aviation, however roads and railways dominate the sector. The country currently has a 138,700 km total length of hard surface roads and a 16,000 km total length of railways (Third Biennial Report, 2017). Inland water transport takes a small share of transport services in Kazakhstan. The country has over 4,000 km of inland waterways and an access to the Caspian Sea. Cargo transportation by inland water transport is carried out in several parts of the country.

Between 2013 and 2016, freight transportation has increased by 4.5% and passenger transportation by 11.6 %. The share of railway transportation decreased by 2% while passenger turnover in motor vehicles increased by 1.9%. In freight transportation, the share of air transport decreased by 32 %. Railways provide over 70% of the cargo turnover while freight transport by road increased by 12%. Growing dependences of both freight and passenger transportation on the road network highlights the importance of the road transportation segment. In addition, the transport infrastructure in many rural areas and territories with low population density, such as the Western and Central regions of the country, are still underdeveloped. The railway infrastructure requires repairs and upgrades.

Figure 10: Kazakh Roads
Source: https://idaoffice.org/

Potential climate change impacts on the transport infrastructure

Increasing extreme temperatures may impact all modes of transportation across the country. Exposure to high temperatures may lead to a road surface deterioration, cause expansion of bridge joints and paved surfaces, and buckling of railways tracks.

In the mountainous regions, a rising temperature may accelerate the speed of glacial melting, which may in turn increase the risk of slope failures that can trigger landslides. In the long run, loss of glacial ice can reduce the river water flow, which may increase water scarcity in the country and decrease inland river flows, which is likely to affect waterways related transportation.

Rainfall patterns Impacts soil moisture levels, increase in soil moisture levels affects the structural integrity of roads, bridges and tunnels.

According to the Third Biennial Report (2017), Kazakhstan will face a 9% increase in annual precipitation under RCP 4.5 during the future period of 2040 to 2059 in comparison with the reference period of 1980 to 1999. As a consequence, an increased frequency and intensity of rainfalls may affect piedmont and mountainous areas of Kazakhstan. An excess of a rainfall runoff may increase seepage and infiltration into pavement and subgrade, reduce structural stability of roads and pavements. Heavy rainfalls may wash out road surfaces and damage tunnels and railway tracks. Triggered landslides and mudflows may halt road and rail transport.

The most climate vulnerable infrastructure sector

Based on the analysis above, the energy and transport sectors appear to be most sensitive to changes in temperature and precipitation as well as to related extreme weather events in Kazakhstan. Both these sectors are critical to the country's economy and need to include climate change adaptation measures in order to minimise potential future socio-economic vulnerabilities.

5. References

CCKP World Bank (2021)

Climate Service Center Germany. (2018). Climate Fact Sheet

Digital Kazakhstan. (2017)

ESCAP. (2020). Risk-informed Infrastructure Planning, Central Asia Pilot in Kazakhstan and Kyrgyz Republic

IEA. (2021). Retrieved from https://www.iea.org/reports/kazakhstan-energy-profile

ITU. (2014). Resilient pathways - the adaptation of ICT sector to climate change

ITU. (2018). Framework of climate change risk assessment for telecommunication and electrical facilities

Jehanzaib, T.-W. K. (2020). Drought Risk Analysis, Forecasting and Assessment under Climate Change

Shuangshuang He, J. W. (2019). Rainfall Event–Duration Thresholds for Landslide Occurrences in China

The Economist. (2018). Retrieved from http://country.eiu.com/article.aspx?articleid=576992241&Country=Kazakhstan&topic=Economy

ThinkHazard. (2020). Kazakhstan Report

Third Biennial Report. (2017). Seventh National Communication and Third Biennial Report of the Republic of Kazakhstan

USAID. (2017). Climate Risk profile Kazakhstan

WMO, Global Water Partnership. (2018). Retrieved from https://www.droughtmanagement.info/indices/

World Bank . (2021). Retrieved from https://climateknowledgeportal.worldbank.org/country/kazakhstan