WATER-RELATED CLIMATE HAZARDS IN KAZAKHSTAN

Introduction

Kazakhstan is increasingly vulnerable to climate-related water hazards due the general exacerbating effects of global climate change and further due to its already high-water scarcity, dependency on transboundary water sources, an increasing risk of flooding due to extreme rainfall in mountainous regions and melting of glaciers. The reduction of overall water availability and quality is likely to overwhelm the water management infrastructure if sufficient adaptation measures are not implemented.

Kazakhstan's economy is significantly impacted by climate change, particularly in the agriculture, energy, and water resources sectors. Agriculture is highly vulnerable due to its reliance on irrigation, with crop water requirements projected to increase. As water resources are under pressure, reduced river flows and increased pollution will affect both agriculture and human health.

Key hazards identified

The research identified three primary climate-related water hazards: droughts, riverine floods and heatwaves. This report differentiates between three severity categories[1] of these hazards – low, medium and high – and provides a projected probability of occurrence for each of these categories for each year in the period 2024-2100. To display the range of future scenarios, three climate change scenarios are used: SSP5-8.5 (high-emission scenario), SSP2-4.5 (moderate-emission scenario), SSP1-2.6 (low-emission scenario). The risks and impacts of the climate hazards vary significantly depending on emission pathways. Detailed findings for each hazard are described in the following.

Droughts: Kazakhstan is already experiencing significant drought pressure, with the probability of low-hazard drought events at approximately 37% per annum (see Figure 1), medium-hazard events at 22%, and high-hazard events at 6% as of 2024. Under the SSP 1-2.6 scenario, the likelihood of all droughts is projected to remain relatively stable with slight variations, ending the century at around 35% (low-hazard, see Figure 1), 16% (medium), and 5% (high). The SSP 2-4.5 scenario shows similar projections, with stable drought hazard levels and a slight increase at the end of the century to 37% (see Figure 1), 22%, and 7%, respectively.

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[1]Hazard severity classification was defined based on a standardized precipitation evapotranspiration index (SPEI) for droughts, composite risk score for floods, and duration for heatwaves.

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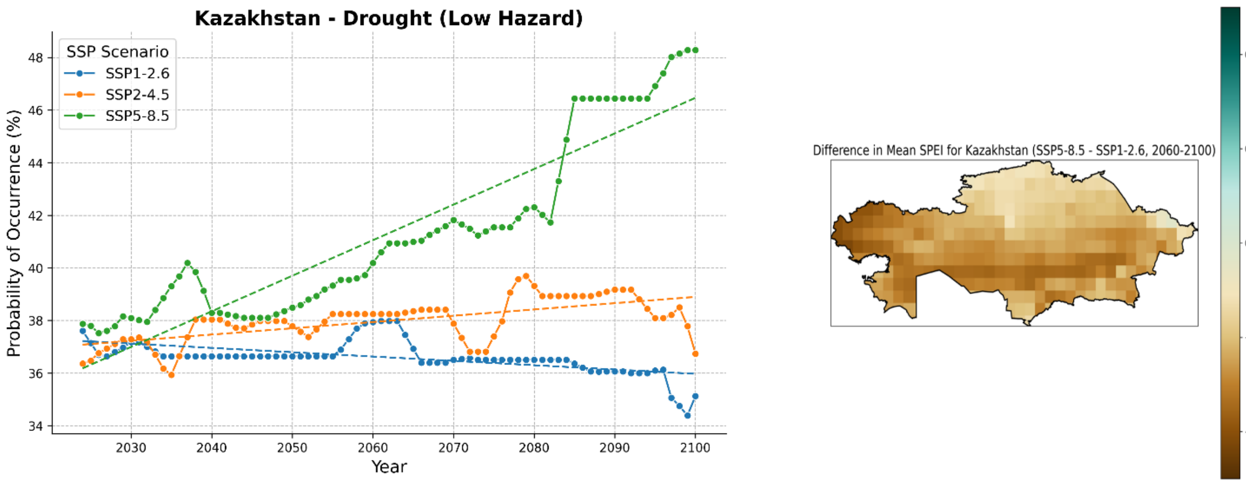
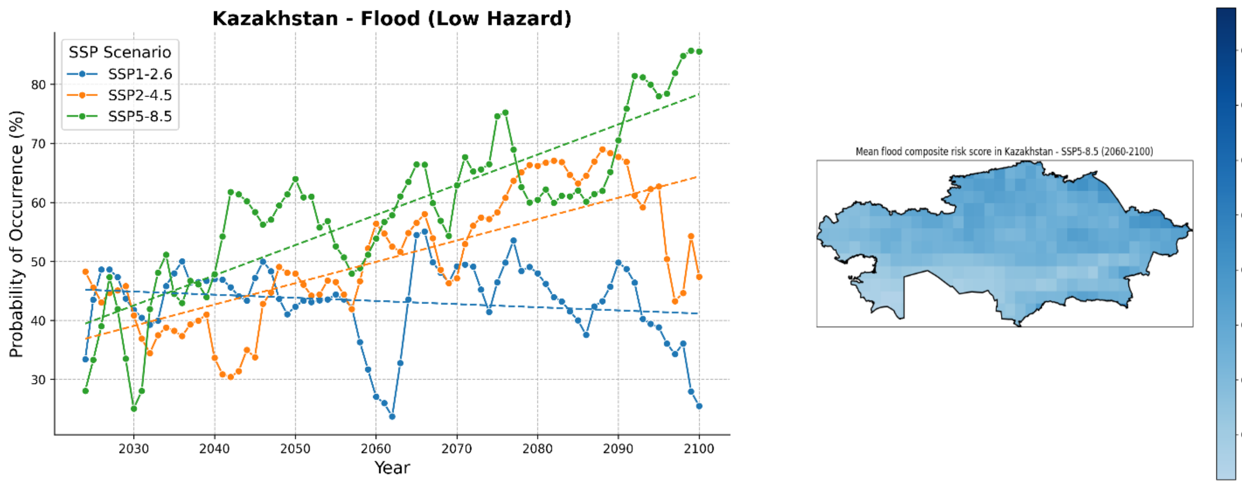
However, under the SSP 5-8.5 scenario, the probability of occurrence increases significantly, with 50% (Figure 1), 31%, and 15%, respectively. Hence, this high-emission scenario will lead to more severe drought conditions and greater damage compared to the other scenarios.

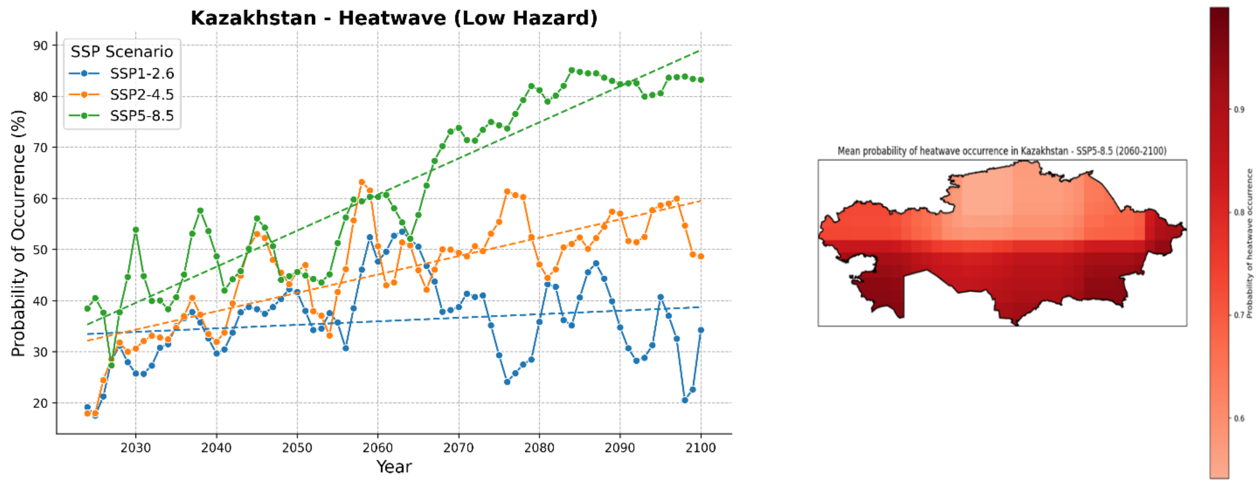


Floods: Kazakhstan is under substantial flood pressure, with the historical baseline showing a mean probability of occurrence of 20% for low-hazard floods, 10% for medium-hazard floods, and around 2% for high-hazard floods. By 2024, these numbers change to around 35% (Figure 2), 18%, and 2%-3% respectively. Floods and heavy precipitation events are projected to increase in Kazakhstan. Under SSP1-2.6, the probability of occurrence decreases by the end of the century to around 25% (Figure 2), 11%, and 1% respectively. Under SSP2-4.5, the likelihood of floods increases significantly, finishing at around 47% (Figure 2), 30%, and 8%. Under SSP5-8.5, the probability of floods rises dramatically to around 85% (Figure 2), almost 65%, around 6%, respectively.



Heatwaves: Kazakhstan is currently facing significant heatwave pressure, with the historical baseline showing a mean probability of occurrence of 11% for heatwaves lasting longer than five days (low hazard), 2% for heatwaves longer than seven days (medium hazard), and less than 1% for heatwaves longer than ten days (high hazard). All projections show an extreme increase compared to the historical baseline period. Under the SSP 1-2.6 scenario, the probability of occurrence for low-hazard events rises significantly at first but decreases again towards the end of the century, finishing at approximately 30% likelihood (see Figure 3). Medium-hazard and high-hazard events follow a similar pattern, ending at around 10% and 4% respectively. The average and maximum temperatures in Kazakhstan have already been increasing more than the global average, making it less surprising that even the best-case scenario results in a higher likelihood of heatwaves. Under the SSP 2-4.5 scenario, the probability of occurrence for all three hazard levels is projected to increase significantly and steadily until the end of the century, finishing at around 50%

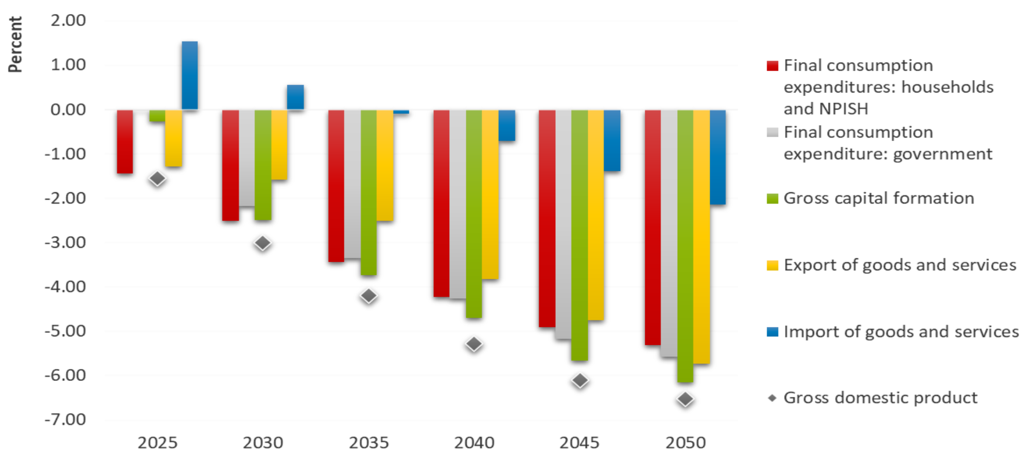
(Figure 3), 25%, and 6%, respectively. Correspondingly, under the SSP 5-8.5 scenario, the likelihood of all three hazard classifications is projected to increase dramatically throughout the entire projection period with 80% (Figure 3), 60% and 40% respectively.



Economic impacts

Kazakhstan's agriculture sector, which heavily relies on irrigation, faces severe productivity declines due to prolonged droughts and heat stress, threatening food security, economic stability and employment opportunities. Water quality is also a significant concern for the economic development, with pollution from industrial waste and agricultural runoff degrading water resources. Extreme events such as floods lead to the displacement of rural and urban populations, increase poverty, and result in lost livelihoods. All these factors create high economic costs and risks. Additionally, climate-induced migration is expected to rise, with estimates suggesting that between 3.1 to 4.6 percent of the population may need to migrate internally due to climate change by 2050.

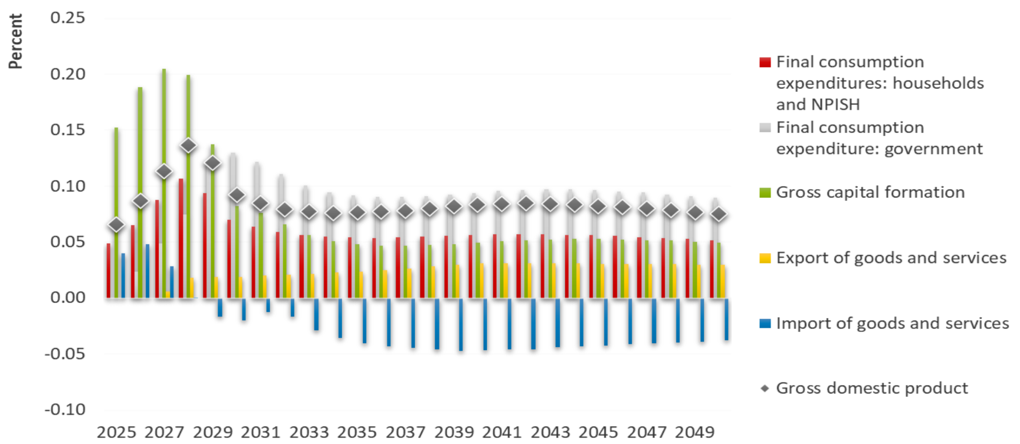
Economic impacts of climate change – SSP5-8.5 scenario (Source: GWS based on e3.kz)



Adaptation strategies

Immediate action is recommended to both mitigate greenhouse gas emissions and adapt to the most likely climatic hazards riverine floods, heatwaves and droughts, to prevent further economic damages. Kazakhstan is planning investments in multi-purpose water infrastructure such as counter-regulatory reservoirs that reduce the risks of flooding by collecting excess water and increase benefits for the agriculture sector by increasing water availability for irrigation during droughts and for additional cultivable land. A macroeconomic analysis carried out by GIZ in collaboration with the Kazakh Economic Research Institute (ERI) evaluated the broader economic benefits of these adaptation measures. The findings demonstrate that strengthening resilience to flooding while increasing benefits for agriculture can drive job-rich economic growth, with GDP increasing by up to 0.14% annually and employment by up to 6,900 annually until 2050.

Economic benefits of counter-regulatory reservoirs – SSP5-8.5 scenario (Source: GWS based on e3.kz)



According to an analysis of the literature and expert interviews, further possible adaptation measures are the following. Agroecological practices such as crop diversification, no-till farming, and rainwater harvesting will enhance soil health, combat desertification, and improve water use efficiency. The modernization of irrigation systems and the implementation of integrated water management will be essential to reduce water waste and ensure sustainable agricultural productivity. Investments in early warning systems for floods and climate-resilient infrastructure will provide critical lead time for disaster response, minimizing damage and loss of life. The establishment of riparian buffer zones around major water bodies can improve water quality, reduce flood risks, and regulate microclimates. These measures will be crucial for reducing economic losses and ensuring long-term sustainability in the face of accelerating climate risks.

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