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Integrated Policy Strategies and Regional Policy Coordination for Resilient, Green and Transformative Development: Supporting Selected Asian BRI Partner Countries to Achieve 2030 Sustainable Development Agenda

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Climate Change Adaptation in Kazakhstan

Abstract

The report is structured in five sections. Chapter 1 provides an introduction general overview of the situation with adaptation to climate change in Kazakhstan, providing with data on GHG emissions of country by sectors and consequences of climate change. Chapter 2 discusses national and regional policies adopted by the Government of Kazakhstan highlighting priority sectors in the country. Chapter 3 articulates macroeconomic modelling to assess impacts of extreme weather events like extreme precipitation and droughts on the economy of Kazakhstan and examines benefits from adaptation measures. Chapter 4 presents policy considerations and strategic recommendations for national government a the private sector, such as stakeholder engagement, integration of adaptation into national and sectoral policies, and robust monitoring and evaluation systems.

Contents

KEYWORDS: Climate Change, Adaptation, Kazakhstan

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EXECUTIVE SUMMARY

Kazakhstan is on the front lines of climate change, experiencing rising temperatures, more frequent droughts, and a drying climate, which threaten the country's well-being. To combat these challenges, the government has adopted a multi-faceted approach to adaptation reflected in its key strategic documents and programs.

The Environmental Code, a cornerstone legislation, prioritizes adaptation in critical sectors like agriculture, forestry, water management, and disaster risk reduction. For the first time, it provides a unified legal framework for strategic documents and measures in the field of adaptation throughout the country. National action plan for transitioning to a "Green Economy" is another important document, which prioritize increasing the efficiency of the use and management of natural resources, modernizing existing and building new infrastructure, improving public welfare and environmental quality through cost-effective ways of reducing environmental pressures and enhancing national security, including water security. The government plays a central role in coordinating and financing these adaptation efforts. By establishing a clear legal framework and promoting innovative solutions, Kazakhstan is taking proactive steps to build resilience and safeguard its population, economy, and environment from the harsh realities of a changing climate.

The findings in this paper confirm those in Kazakhstan's Strategy on Achieving Carbon Neutrality by 2060, which prioritizes reducing greenhouse gas emissions, but it also recognizes that adaptation is equally important. The strategy emphasizes integrating climate change adaptation into national policies and legislation and highlights how adaptation efforts directly contribute to carbon neutrality. Government planning should prioritize adaptation in vulnerable sectors and ensure collaboration across different entities. To achieve low-carbon development goals, Kazakhstan will institutionalize adaptation processes, improve climate data collection, and develop methodologies for risk assessment and economic evaluation. This integration of adaptation into the carbon neutrality strategy demonstrates a comprehensive approach, where adaptation efforts build resilience and simultaneously contribute to achieving a low-carbon economy in the long-run.

As climate change intensifies, its economic impacts are becoming increasingly severe, prompting countries worldwide to adopt innovative strategies to mitigate these effects. Consequently, nations are implementing a variety of adaptive measures to enhance resilience and reduce the economic burden of climate-related risks. The national plans and case studies of various countries given in the report highlight the effectiveness of their approaches in reducing economic vulnerabilities and promoting environmental sustainability.

In this paper, we used macroeconomic modelling to assess impacts of extreme weather events like extreme precipitation and droughts on the economy of Kazakhstan and examined benefits from adaptation measures. The overall impact of these events on economy of Kazakhstan is negative. Extreme weather events cause widespread destruction of infrastructure, which disrupts businesses, reduces productivity, and necessitates costly repairs and rebuilding efforts. Similarly, such events can devastate crops and livestock, leading to food shortages, price hikes, and decreased agricultural exports. By implementing adaptation measures, our findings show a positive impact on real production, employment and trade balance, which suggests that Kazakhstan can and must lessen the impact of these events and build resilience for a more sustainable future.

Some of the recommendations include revision of sectoral targets to reflect the latest climate projections and prioritize adaptation efforts in vulnerable areas. Establishing dedicated climate adaptation funds, focusing on community-based initiatives and technology transfer. Implementation of robust monitoring and evaluation mechanisms to track progress and adapt strategies as needed. As well as creation of a national adaptation committee with representatives from relevant ministries to facilitate a unified approach and resource allocation. Promotion of joint projects across sectors, such as integrating climate-resilient infrastructure development into agricultural planning.

In this study, we highlighted the most relevant initiatives for climate change adaptation for Kazakhstan. We recommend that, similar to the Netherlands' "Room for the River" program Kazakhstan would benefit from creating space for natural water flow to enhance flood safety and environmental quality. This approach is particularly relevant for Kazakhstan, to manage flood risks in its river systems. Another recommendation of the study is to have an integrated water management and investment in desalination and water recycling as has been done in Australia to address water scarcity.. In the area of agriculture, Kazakhstan needs to adopt Climate-Smart Agriculture (CSA) practices to enhance agricultural productivity and resilience to climate variability as done in Kenya. May be most crucially, Kazakhstan has to transition to renewable energy and reduce its heavy reliance on fossil fuels. Investing in renewable energy sources like wind and solar, which are abundant in the region, to enhance energy security will be important in ensuring this transition. Lastly, the study recommends that Kazakhstan would benefit from afforestation and reforestation initiatives which underline the role of natural climate solutions in enhancing carbon sequestration, mitigating soil erosion and improving ecosystem services to combat desertification, as practiced in China. Our analysis suggests that, most successful national plans share common characteristics such as stakeholder engagement, integration of adaptation into national and sectoral policies, and robust monitoring and evaluation systems.

Finally, it should be noted that, while various actors contribute to climate change adaptation, the government plays a leading role through significant public investments. These investments are crucial for building resilient infrastructure, supporting research and development, and implementing adaptation strategies. Public funding serves as a cornerstone, enabling private sector participation and fostering innovation in this critical endeavor.

Introduction

As the impacts of climate change continue to unfold globally, Kazakhstan finds itself increasingly vulnerable to a spectrum of environmental challenges. From extreme weather events to shifting precipitation patterns and temperature fluctuations, the country's diverse geography encompasses a range of climatic zones, each facing unique risks. Increasing temperatures and various climate-related risks, including water scarcity, desertification and glacial melting events threaten the country's infrastructure, ecosystems, and economic well-being. This report sheds lights on situation with climate change adaptation in Kazakhstan, aiming to provide a comprehensive overview of current efforts, challenges, and opportunities.

The report will discuss the following key aspects:

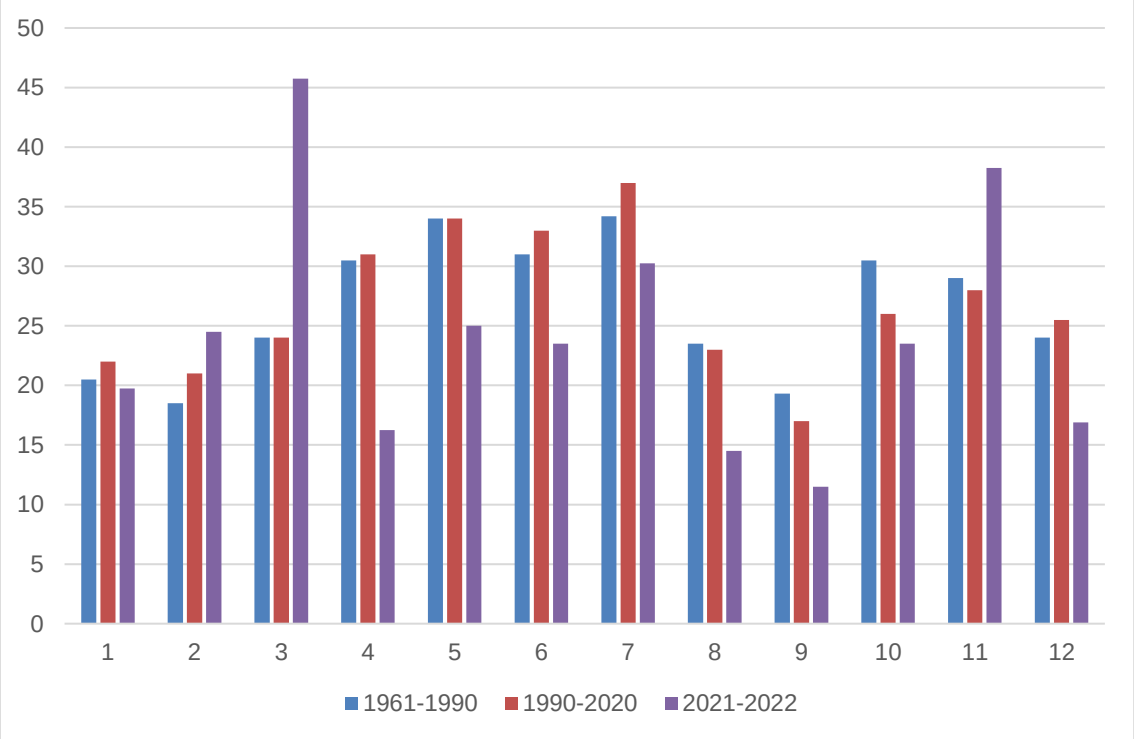
- **Overview of the climate change in Kazakhstan:** analysis of available data, reports, and scientific literature related to climate change adaptation in the country, including the trend of GHG emissions, impact of climate change on different sectors of the economy, evidences and consequences of occurred climate risks.
- **National and regional policies:** review of national and regional policies, plans, and initiatives related to climate change adaptation in Kazakhstan and discussion of opportunities for policy enhancement and integration across sectors to strengthen climate resilience. Evaluation of the performance of existing and planned adaptation strategies to address consequences from the climate risks.
- **Macroeconomic modelling:** identification of economic sectors and regions, which are the most vulnerable to extreme events and impacts of climate change. overview of the results from macroeconomic analysis of climate risks' impact and sector-specific adaptation measures.
- **Regional and international adaptation strategies:** overview of some national adaptation plans and international examples as case studies, which have the potential of reducing the economic consequences and physical damages from the climate risks.
- **Policy recommendations:** Based on the analysis, the report provides concrete recommendations for policymakers to develop and implement effective climate adaptation strategies.

By understanding the challenges and opportunities presented by climate change, Kazakhstan can take proactive steps to safeguard its environment, economy, and society. This report aims to be a valuable resource for policymakers, stakeholders, and the general public, fostering a collaborative approach towards a more climate-resilient Kazakhstan.

1. Overview of the adaptation to the climate change in Kazakhstan

Kazakhstan is a vast country, ranking 9th in the world for size at over 2.7 million km2. It is also the world's largest landlocked nation. Despite its impressive size, most of the landscape is flat, with mountains only appearing in the southeastern and eastern regions. Deserts, semi-deserts, and dry steppes cover a significant portion of the country, although the north is slightly wetter with steppes and forest-steppes.
The climate reflects Kazakhstan's distance from the ocean. It's continental, that is, hot summers and cold winters with large temperature swings throughout the day and year. Rainfall is seasonal, with most occurring between April and July and the least from August to September. The flat areas can be further categorized into four distinct landscape zones: forest-steppe, steppe, semi-desert, and desert.
According to Kazhydromet data (2023), the average volume of precipitation in 2021-2022 was below normal for most of the year. April and May were extremely dry, while March and November had average precipitation much higher than the norms for the period 1961-1990.

Figure 1. Average monthly precipitation in 2021-2022 and their norms for the period 1961-1990, 1990-2020 in mm.



Sources: Kazhydromet, 2023[1]

Data from Climate Change Action Report shows that Kazakhstan's climate is getting warm. Compared to 1961-1990, average annual temperatures rose by 0.9°C between 1991-2020. The south, southwest, and west of the country see hot days exceeding 30-

[1] Kazakhstan annual climate change and monitoring bulletin:2022, Kazhydromet, 2023.

35°C becoming more frequent. Heatwaves are increasing due to the climate change, with 2020's record-breaking temperatures (1.92°C above average) surpassing the previous high of 2013 (1.89°C).[2]

The average annual air temperature in Kazakhstan in 2021 was 1.58 °C above the climate norm for the period 1961-1990 and this is the 5th value in the ranked series of the warmest years for the period 1941-2020. With the increase of average annual air temperature, the frequency of high summer temperatures is also rising. This has a negative impact not only on vegetation, but also on human and animal life.

The most serious consequences of climate change include increasing water scarcity and desertification. Climate stressors such as increased drought, changes in river flow and rainfall patterns, rising temperatures and more frequent extreme weather events are expected to harm the country and threaten food security across the region.

Overall, climate change harms people, wildlife, and the economy. This challenge can be addressed in two ways: **reducing greenhouse gas emissions and adapting to the changing climate.**

1.1 GHG emissions in Kazakhstan

Table 1 shows results of calculations for the greenhouse gas emissions by sectors and as a total amount for the country, taking into account and excluding emissions or absorptions in the land use, land-use change, and forestry (LULUCF) sector for the period 1990-2021.

The largest share of greenhouse gases in Kazakhstan is emitted by the energy sector. Its share decreased from 83% in 1990 to 69% in 2021. The second largest sector emitting GHG is agriculture, the share of which for the whole period on average was 12%. The least emitting sectors are industry (5%) and waste (1%). It is important to mention the impact of the LULUCF sector, which, in the first four years actually was absorbing GHG emissions, but later the amount of emissions grew rapidly. In 2006 it reached its peak with 96.3 million tons of CO2 equivalent, making the quarter of total emissions in the economy. The determining factor here was the significant increase in emissions from the “Cropland” category, while forests and pastures significantly increased the absorption of greenhouse gases over the same period. Then it tended to decline to 1% of total emissions by 2021 (Table 1).

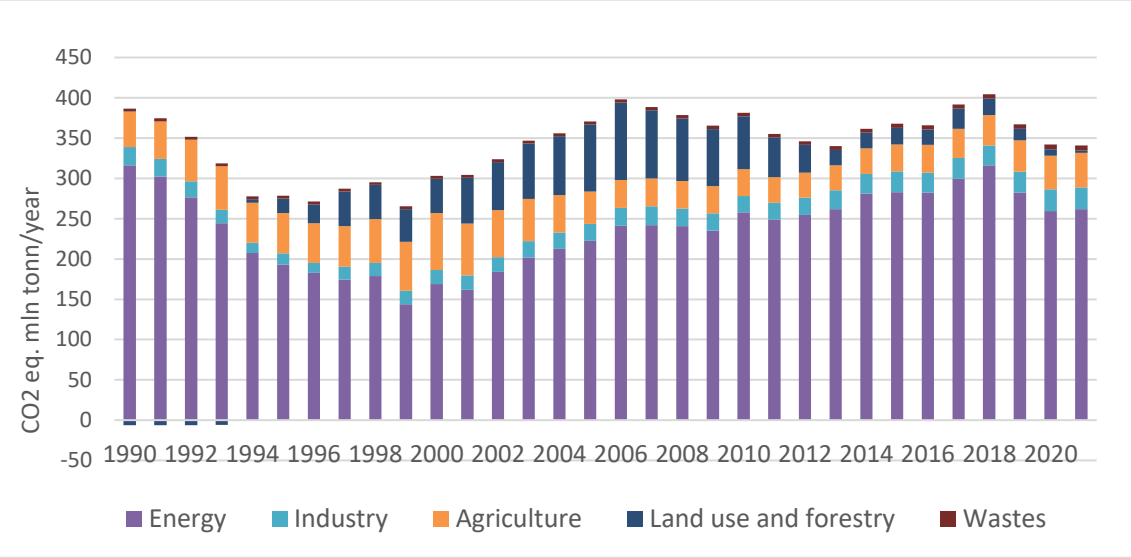
Kazakhstan's total greenhouse gas emissions have decreased slightly between 1990 and 2021. The total amount of GHG emissions including LULUCF sector in 1990 was 380.2 million tons of CO2 equivalent and in 2021 it has fallen to 340.8 million tons of CO2 equivalent. According to PIK data, share of Kazakhstan in global GHG emissions decreased from 1.23% in 1990 to 0.69% in 2021. In 1990 Kazakhstan was the 16th biggest GHG emitter country in the world, and as of 2021 it was the 28th. In terms of per capita emissions, Kazakhstan ranked 9th in 1990 with 23.67 tCO2e per capita and in 2021 country was 12th in the world with 17.8 tCO2 per capita emissions.[3]

The energy sector has seen the biggest decline, with emissions down by 17.2% since 1990 due to decrease in total fuel consumption. However, there was a small increase

[2] https://www.undp.org/kazakhstan/news/reducing-temperatures-kazakhstan-takes-action-against-climate-change
[3] https://www.climatewatchdata.org/ghg-emissions.

from this sector in 2021 compared to 2020. In contrast, emissions from industrial processes have grown by 19.1% since 1990, likely due to industrial expansion. The agriculture sector has seen a slight decrease (2.3%) in overall emissions since 1990, mainly because the number of farm animals has still not reached 1990 levels. On the other hand, there was a slight increase (3.4%) in 2021 compared to the previous year.

Figure 2. Dynamics of national greenhouse gas emissions by IPCC sectors in Kazakhstan for 1990-2021



Sources: National report of the Republic of Kazakhstan on the inventory of anthropogenic emissions from sources and removals by sinks of greenhouse gases not regulated by the Montreal Protocol for the period 1990-2021, 2023.

Table 1. Greenhouse gas emissions for 1990-2021 by sectors of economic activity in the Republic of Kazakhstan, thousand tons of CO2 equivalent and as shares in %

Years	Total emissions w/o LULUCF	Total emissions with LULUCF	Energy	Industry	Agriculture	LULUCF	Waste
1990	386 682.8	380 186.6	83%	6.0%	12%	-1.7%	1.0%
1991	374 536.0	368 300.3	82%	5.9%	13%	-1.7%	1.0%
1992	351 663.7	345 524.7	80%	5.7%	15%	-1.8%	1.1%
1993	318 608.9	312 636.5	78%	5.4%	17%	-1.9%	1.2%
1994	273 342.8	277 759.6	75%	4.6%	18%	1.6%	1.3%
1995	260 567.7	278 393.9	69%	5.0%	18%	6.4%	1.2%
1996	247 873.0	271 328.7	67%	4.5%	18%	8.6%	1.3%
1997	244 367.6	287 263.4	61%	5.5%	18%	15%	1.2%
1998	252 975.0	295 259.1	61%	5.5%	18%	14%	1.2%
1999	224 661.2	265 270.7	54%	6.3%	23%	15%	1.3%
2000	260 434.1	303 144.9	56%	5.7%	23%	14%	1.2%
2001	247 386.5	304 394.3	53%	6.0%	21%	19%	1.2%
2002	263 995.4	323 618.9	57%	5.7%	18%	18%	1.1%
2003	278 029.5	346 736.4	58%	5.8%	15%	20%	1.0%
2004	282 922.8	356 054.8	60%	5.7%	13%	21%	1.0%
2005	287 466.4	370 625.0	60%	5.6%	11%	22%	1.0%
2006	301 694.8	398 011.9	61%	5.6%	8.6%	24%	1.0%
2007	303 873.7	388 643.3	62%	6.0%	8.9%	22%	1.0%
2008	300 707.9	378 435.7	64%	5.8%	9.0%	21%	1.1%
2009	294 889.3	365 392.8	64%	5.8%	9.3%	19%	1.2%
2010	315 855.5	381 414.9	68%	5.3%	8.8%	17%	1.2%
2011	306 112.3	355 241.1	70%	5.9%	9.0%	14%	1.3%
2012	311 685.6	346 189.4	74%	6.2%	8.9%	10%	1.3%
2013	320 869.5	340 001.8	77%	7.0%	9.1%	5.6%	1.4%
2014	342 321.1	361 651.3	78%	6.7%	8.9%	5.3%	1.3%
2015	346 827.1	367 697.3	77%	7.0%	9.1%	5.7%	1.3%
2016	346 787.3	365 833.1	77%	6.8%	9.4%	5.2%	1.4%
2017	366 656.8	391 863.6	76%	6.5%	9.2%	6.4%	1.3%
2018	383 836.6	404 504.8	78%	6.1%	9.4%	5.1%	1.3%
2019	352 690.7	367 057.5	77%	7.0%	11%	3.9%	1.5%
2020	333 971.0	342 098.1	76%	7.9%	12%	2.4%	1.8%
2021	338 123.4	340 837.7	77%	7.9%	13%	0.8%	1.8%
2021 to 2020 in %	1.2	-0.4	0.9	0.2	3.4	-66.6	4.1
2021 to 1990 in %	-12.6	-10.4	-17.2	19	-2.3	141.8	63.1

Sources: National report of the Republic of Kazakhstan on the inventory of anthropogenic emissions from sources and removals by sinks of greenhouse gases not regulated by the Montreal Protocol for the period 1990-2021, 2023.

1.2 Consequences of Climate Change

Regardless of how much we can decrease our emissions, the climate has changed and will continue to change by inertia of the Earth's climate system. The climate change already has numerous negative impacts on economy, ecosystem and people and presents a major challenge for Kazakhstan. With the change of average air temperatures, the frequency and intensity of extreme weather events (EWE) are also increasing. Currently, there is not a single, comprehensive database which track data on all natural disasters in the country. Information on a disaster's strength, impact on people and property, and economic losses is scattered across different databases. Some of the data on EWEs could be find in Kazhydromet database. According to their data, number of EWE's in Kazakhstan is increasing starting from 2019, mainly due to more frequent strong wind and dust storm events in 2021. In contrast, number of heavy rains in 2021 (10) was much less than in 2017 (32).

Table 1. Extreme weather events frequency in Kazakhstan (2017-2021)

EWE	2017	2018	2019	2020	2021
Strong wind	49	50	32	48	96
Heavy rain	32	22	30	22	10
Heavy snowstorm	39	10	14	32	26
Heavy snow	10	11	8	2	11
Heavy fog	4	1	6	3	3
Hail	1	0	0	3	4
Severe dust storm	0	0	0	0	5
Slush and ice formation	3	1	1	0	1
Total	138	95	91	110	156

Sources: Kazhydromet[4]

According to the Ministry of emergency situations, Kazakhstan had 1647 human life losses and 5724 casualties due to natural hazards between2017-2021.. In terms of economic damage, data from the Bureau of National Statistics shows that costs of eliminating emergency situations and their consequences increased for natural disasters from 1 billion tenge in 2010 to 7.3 billion tenge in 2020, while in case of man-made emergencies it decreased from more than 8 billion tenge in 2010 to 2 billion tenge in 2020.[5]

As an example of recent damages from EWEs, in 2021 due to the floods in Atyrau oblast 2 bridges were destroyed, which affected transportation and logistics in the region. Another event occurred in 2020 in south of Kazakhstan, when dam breach in Uzbekistan led to flooding of 10 Kazakh villages and to over $10 million economic damage.[5]

The recent flooding, which took place in spring of 2024 was one of the most disastrous in the last 80 years. It affected mostly north and western part of Kazakhstan and resulted in evacuation of more than 75 thousand people. Damage to infrastructure, housing and business amounted to hundreds of billions of tenge. According to official data, during floods 12,450 heads of livestock died. In 9 regions, payments were made for all dead

[4] Eighth National communication and fifth biennial report of the Republic of Kazakhstan to the UNFCC

farm animals in the amount of 2.4 billion tenge.[5] The government has already provided social assistance to 2.300 families for $1.2 million and in the process of paying compensation of damage as one-time payment at around $800 per family. The Government also committed to rebuild and repair damaged houses and properties.[6]

2. National and regional policies

The climate risks threaten agriculture, infrastructure, security and health of people and require adequate strategic documents and measures. They in turn should guarantee responsible management of water resources, increase in forest cover and ecosystem protection, change of agricultural practices while protecting the population and ensuring infrastructure is prepared to withstand the increasing occurrence of EWEs and natural disasters. To combat this challenge, Kazakhstan has established a framework for climate change adaptation. However, significant opportunities exist for policy enhancement and cross-sectoral integration to strengthen the country's climate resilience.

2.1 The Strategy to reach carbon neutrality

Kazakhstan recently adopted the Strategy to reach carbon neutrality by 2060. This strategy will cut down on greenhouse gases, promote low-emission growth, and increase reliance on renewable energy. The strategy represents a positive step, demonstrating a commitment to addressing climate change. However, it requires more concrete plans for phasing out fossil fuels, securing investments, and managing the social impacts of the transition. A detailed roadmap to reduce emissions across all industries in Kazakhstan is under preparation.

According to the Strategy, reaching carbon neutrality by 2060 will need more than $600 billion of investment for the whole period. Over $300 billion will be reoriented from the planned investments in traditional sectors to the green ones, and the rest will be an additional investment attracted from new sources.[7]

While Kazakhstan's Strategy focuses on reducing greenhouse gas emissions, it also recognizes the need to adapt to the inevitable impacts of climate change. The strategy includes a chapter on adaptation and emphasizes integrating climate change adaptation into national policies and legislation. This means considering climate risks when making decisions about infrastructure development, water management, and agricultural practices. For example, building more resilient roads and bridges that can withstand extreme weather events like floods.

The roadmap for achieving carbon neutrality is under development, but it will take into consideration suggestions and opinions of experts from different sectors. The roadmap on adaptation part will likely incorporate measures to integrate climate risk management into national legislation. This could involve creating stricter building codes for resilience against extreme weather or mandating water-saving practices in agriculture. Additionally, the roadmap might highlight the importance of local adaptation plans. By incorporating adaptation alongside emissions reduction, Kazakhstan's roadmap aims for a well-rounded strategy that prepares the country for the realities of climate change while working towards a carbon-neutral future.

[5] https://bes.media/news/navodnenie-v-kazahstane-kak-vozmeshali-usherb-za-utonuvshiy-skot/
[6] https://astanatimes.com/2024/04/kazakh-government-rolls-out-comprehensive-support-for-citizens-affected-by-catastrophic-floods/
[7] Strategy of the Republic of Kazakhstan on Achieving Carbon Neutrality by 2060

2.2 The process of adaptation to climate change

The government of Kazakhstan did not have a single official document to deal with climate change impacts until 2020. However, since the early 2000s, there was several research projects on finding the ways to fight desertification and droughts. They can now be used to improve farming practices, plant more trees, and make these areas less vulnerable.[8]

2.2.1 The Action Plan

The Action Plan for the implementation of the concept of the transition of the Republic of Kazakhstan to a “green economy” for 2021-2030 was approved in 2020.[9] It includes 62 measures, mostly on mitigation, but some are aimed at solving problems in water resources and agriculture, which can be considered as adaptation measures. The plan includes development of sustainable transport, infrastructure for electric and gas vehicles, intelligent traffic management systems; sustainable municipal waste management; transition to sustainable land use practices and organic agriculture.

The concept for the transition of the Republic of Kazakhstan to a "green economy" will be implemented in three stages:

- 2013-2020 – during this period, the state will focus on optimizing the use of resources, improving the efficiency of environmental protection activities, and creating green infrastructure;
- 2020-2030 – on the basis of the "green" infrastructure created, the transformation of the national economy will begin, focusing on the careful use of water, promoting and stimulating the development and widespread introduction of renewable energy technologies, as well as the construction of facilities based on high energy efficiency standards;
- 2030-2050 – transition of the national economy to the principles of the so-called "Third Industrial Revolution", which requires the use of natural resources on the condition of their renewability and sustainability.

2.2.2 The rules for organizing and implementing the process of adaptation

The rules approved in 2021 set up new regulations to help government officials at all levels.[10] These rules allow them to gather existing data, figure out how vulnerable different areas are to climate change, and create plans to protect key sectors like water, agriculture, forests, and disaster preparedness. The government identified these sectors as priorities. The assessment of adaptation measures is based on the following criteria:

- Effectiveness (risk reduction level);
- Feasibility (technical and institutional);
- Costs;
- Availability of financing;
- Implementation periods (short-term, long-term).

Central and local executive bodies within their competence, carry out the process of adaptation to climate change. Before implementing adaptation measures, collection of

[8] O. Dubovik et al., “Drought Hazard in Kazakhstan in 2000-2016: Perspectives from Remote Sensing, Environmental Monitoring and Assessment,” vol. 191, 510 (2019); "Kazakhstan: Challenges and Approaches to Combating Desertification", TA 5941-REG: Combating Desertification in Asia, Asian Development Bank, 2003.
[9] On approval of the Action Plan for the implementation of the Concept for the transition of the Republic of Kazakhstan to a “green economy” for 2021 – 2030
[10] On approval of the rules for organizing and implementing the process of adaptation to climate change.

data and conduction of a climate change vulnerability assessment is required. According to the rules, this process includes the following steps:

1) Establishment of the framework of impact;
2) Selection of vulnerability assessment methodology;
3) Identification of climate hazards and their impacts;
4) Identification of potential vulnerabilities to climate change;
5) Comparison of relationship of hazards with potential vulnerability;
6) Assessment of the likelihood of hazards occurring;
7) Assessment of the consequences of vulnerability;
8) Risk assessment and creation of the final risk matrix.

2.3 The Environmental Code

One of the important documents towards more sustainable future covering topic of adaptation to the climate change is Kazakhstan's key climate policy tool – the Environmental Code, which was adopted in January of 2021, replacing the previous version from 2007.

One of the basic principles of the environmental legislation is ensuring sustainable development, i.e., meeting the needs of the present generation without compromising the opportunities of future generations. In the context of climate change, it is about transitioning to a low-carbon economy and increasing climate resilience. Another important principle is about preventing environmental harm. It restricts activities that could pollute, damage the environment, or harm people's health. For instance, in 2023 activities of 31 enterprises in the country were suspended for violations of environmental legislation. 2,138 administrative fines were imposed for a total amount of 322.9 billion tenge. The largest fines for discharging pollutants without an environmental permit were collected from Karabatan Utility Solutions LLP - 7.2 billion tenge and TengizChevroil - 2.8 billion tenge.[11]

The Code's chapter on adaptation prioritizes reducing climate risks in Kazakhstan. It aims to achieve this by increasing the country's resilience to climate change, addressing its current impacts, and implementing measures for long-term adaptation across natural ecosystems, economic activities and infrastructure. For the first time, it provides a unified legal framework for strategic documents and measures in the field of adaptation throughout the country. This comprehensive document introduces several key advancements.

- The 'polluter pays' principle establishes a framework for holding polluters accountable for environmental damage.
- The adoption of best available technologies (BAT) encourages businesses to implement the most environmentally sound practices.
- A dedicated chapter on climate change adaptation lays the groundwork for Kazakhstan's national strategy to address the challenges of a changing climate.

The Environmental Code defines the fundamental principles guiding adaptation planning within the framework of a cross-sectoral approach and the integration of climate change adaptation into governmental strategic documents. The guidelines for organizing and

[11] https://primeminister.kz/ru/news/za-narusheniya-ekologicheskogo-zakonodatelstva-v-rk-priostanovlena-deyatelnost-31-predpriyatiya-27050

implementing climate change adaptation processes establish procedures for addressing adaptation requirements across various levels. These guidelines serve as a robust foundation for integrating adaptation considerations into routine planning and decision-making processes, instead of addressing threats and opportunities within specific sectors. According to general requirements, the process of adaptation shall include the following stages:

1) information gathering and assessment of vulnerability to climate change;
2) planning for adaptation to climate change;
3) development of measures for adaptation;
4) implementation of measures on adaptation;
5) monitoring and evaluating the effectiveness of adaptation measures;
6) reporting on climate change impacts and effectiveness of measures on adaptation;
7) adjusting adaptation measures based on the results of monitoring and evaluation.

It is important to mention that the Environmental code is a framework legislative act and its implementation requires by-laws, plans and programs. It is also necessary to raise awareness of the problem of climate change and adaptation measures among the population and business.

2.4 Priority sectors

There are four main cross-sectoral strategic areas determined for the adaptation component of Kazakhstan's updated NDC for 2021-2030, which are:

- Water resources management
- Agriculture
- Forestry
- Disaster risk reduction (DRR).

These sectors are public administration areas rather than economic sectors and were set by the Ministry of ecology. It does not include big sectors such as energy, infrastructure, transportation, which are also vulnerable to climate change.

With climate change causing a steady decline in **water resources**, Kazakhstan faces a pressing challenge. Sustainable water use, water conservation efforts, and pollution prevention strategies are becoming increasingly critical for the country's water sector to adapt to this new reality.

Kazakhstan has around 39,000 rivers, of which 7,000 stretching for more than 10 kilometers. There are also many lakes, but most have increased mineralization and cannot be used in agricultural or industrial purposes. The country uses an average of 24 cubic kilometers of water every year. Agricultural sector uses water the most, at over 62%, followed by industry (more than 22%) and households (around 4-5%). In 2020, farmers used 1.884 billion cubic meters more water for irrigation compared to 2019. On the other hand, 2020 saw a drop in the amount of water used for irrigation of green spaces (more than twice).[12] According to OECD report on agricultural policy monitoring

[12] Eighth National communication and fifth biennial report of the Republic of Kazakhstan to the UNFCC, 2022

and evaluation, around 10-15% of water is being lost at the transportation stage due to old water infrastructure and low cost of water services.[13]

Forecasts show that increasing air temperature will lead to the melting of glaciers and by the end of century it is expected that glaciers will be almost depleted, which will result in decrease of runoff of mountain rivers. Same reduction in runoff is expected for lowland water management basins due to high evaporation, except for the Balkash-Alakol basin. According to estimations, it is expected that water consumption will increase as a result of higher average temperature and increase in irrigated land by more than 60% by 2030.[14]

In this regard, a thorough assessment of any proposed water policies or measures is essential. Such assessments should not only consider the potential benefits but also evaluate any unforeseen negative consequences. Kazakhstan's water management approach should prioritize implementing measures that achieve significant water savings and promote responsible water use.

In this regard in September 2023 the new Ministry of water resources and irrigation was formed. Its obligation is to provide leadership in the formation and implementation of state policy, coordination of management processes in the areas of control in the field of use and protection of the water fund, water supply, sewerage and irrigation. This shows a significant focus on water problems from the state administration.

Following that, the Government of Kazakhstan has taken significant steps in implementing a policy aimed at preserving its strategic water resources. The project of **the Concept for the development of the water resources management system** of the Republic of Kazakhstan for 2024 – 2030[15] established four key priorities:

- Increasing water efficiency and promoting water conservation practices.
- Protecting and restoring aquatic ecosystems, recognizing their vital role in the health of the environment.
- Mitigating the threat of natural disasters, many of which are directly linked to water resources.
- Implementing legislative and institutional reforms to create a robust framework for sustainable water management.

The next steps in Kazakhstan's water sector adaptation plan should be focused on improving water management at both the national and basin levels. Engaging water users, including both public and private stakeholders in this process is crucial. Establishing river basin councils could play a pivotal role in coordinating adaptation efforts across different sectors and regions within each water basin. Through collaborative efforts that prioritize sustainable water use, Kazakhstan can effectively adapt to the challenges posed by climate change and ensure a healthy water future for its citizens and ecosystems.

The largest consumer of water resources in Kazakhstan is **agricultural sector**, using about two-thirds of all available water. Agriculture has a crucial role in the socio-economic development of Kazakhstan. As of 2023 agriculture, forestry and fishery sector accounts for 4.3% of country’s GDP and involves 12% of the employed population. In

[13] Agricultural Policy Monitoring and Evaluation 2020, https://www.oecd-ilibrary.org/agriculture-and-food/agricultural-policy-monitoring-and-evaluation-2020_d3c7bdcf-en
[14] Eighth National communication and fifth biennial report of the Republic of Kazakhstan to the UNFCC, 2022
[15] On approval of the Concept for the development of the water resources management system of the Republic of Kazakhstan for 2024 – 2030. Decree of the Government of the Republic of Kazakhstan dated February 5, 2024 No. 66, https://adilet.zan.kz/rus/docs/P2400000066#z12

the beginning of 2024, the number of people living in rural areas was 7.5 million, which is 37.3% of total population of Kazakhstan.[16]

Kazakhstan's agricultural sector faces a multitude of challenges that necessitate the integration of adaptation measures into national agricultural planning. These challenges stem primarily from the impact of climate change on natural and climatic conditions. With a fall in precipitation, it is expected that humid zones will shift and some areas potentially will experience a decline in grain productivity. Intensified desertification is a major concern that further threatens agricultural productivity by reducing soil fertility. This combination of factors, including altered rainfall patterns, heat extremes, and desertification, creates a heightened risk of crop pests and diseases, jeopardizing the long-term sustainability of this crucial sector.

Despite these challenges, Kazakhstan is not passively waiting for the storm to pass. The government is taking proactive steps to adapt its agricultural planning. Recognizing the urgency of the situation, they are actively developing and implementing sustainable agricultural practices. Crop diversification strategies are being implemented, and investments are being made to improve irrigation systems, ensuring water efficiency and mitigating the effects of erratic rainfall. These efforts are crucial for Kazakhstan to maintain its role as a leading wheat producer and exporter in the region.

As of 2023, Kazakhstan is ranked 14th globally and 1st in Central Asia in total wheat production with 12.1 million tons in 2023, which is less than 16.4 million tons in 2022.[17] In terms of exports, Kazakhstan exported 7.2 million tons of wheat in 2023. It was 37% less than in 2022, when the value of wheat exports was $1.9 billion.[18] Estimations show that expected losses in production of wheat by 2030 can reach up to 62% in regions like Pavlodar oblast, but on average will be 35-40% across regions.[19] In this regard, thinking long-term adaptation strategies will give authorities a wider lens, so that they can address challenges and opportunities to reduce impacts from climate change.

Forests are crucial for capturing carbon dioxide and adapting to climate change. Planting new trees (afforestation) can prevent desertification, but it needs careful planning to consider water usage and natural processes. Kazakhstan aims to reforest degraded land to fight climate change and create jobs, while also protecting existing forests. According to GIZ's cost-benefit assessment, further green belt development leading to the planting of 15 million trees will cost $13.886 billion (about KZT 6,000 billion) over the period 2022-2050. Co-benefits will not only lead to protection settlements and cities from winds and storms, but will also include carbon absorption at the level of 360 kt CO2eq/year.[20] Sustainable forest management is essential to ensure these forests adapt to changing conditions and continue to provide vital ecological services. This will require informed decision-making based on scientific evidence, monitoring, and using the results to refine future plans.

Given Kazakhstan's sensitivity to extreme weather events and natural disasters, effective **disaster risk reduction** and management are important. With the escalating effects of global warming, Kazakhstan is increasingly confronted with additional natural disasters such as droughts and irregular rainfall patterns. The country increasingly suffers from abnormal heat in the summer and, at the same time, from extreme cold in the winter. For the period 1990-2021 more than 6000 EWEs were recorded, mostly strong wind, heavy

[16] The Bureau of National statistics of the Republic of Kazakhstan, https://stat.gov.kz/ru/industries/social-statistics/demography/publications/157456/
[17] https://fas.usda.gov/data/production/commodity/0410000
[18] Bureau of National Statistics of the Republic of Kazakhstan
[19] Eighth National communication and fifth biennial report of the Republic of Kazakhstan to the UNFCC, 2022
[20] GIZ 2021, https://www.international-climate initiative.com/de/infothek/publikationen/publikation/

rainfall and snowstorms. Heavy rainfall almost doubled in 2006-2021 period compared to 1990-2005, while events of heavy snowfall increased 4 times.

Table 3. Number of extreme weather events in Kazakhstan for the periods 1990-2005 and 2006-2021

EWE	Number of EWEs	
	1990-2005	2006-2021
Strong wind	57.0	59.9
Heavy rainfall	25.1	48.6
Strong blizzard	40.6	30.8
Heavy snowfall	6.0	24.7
Thick fog	18.9	7.5
Strong dust storm	1.4	1.0

Sources: Kazhydromet [21]

Diversity of climatic zones in Kazakhstan requires a range of sometimes very different responses, careful planning and prioritization of adaptation actions. For example, strengthening and establishing early warning systems for EWEs and heat waves can mitigate a big part of damage. In the framework of ongoing government efforts on adaptation and as part of vulnerability assessment it is important to have safety data sheets for regions containing information on the perceived risks of EWEs, potential losses of property and life, and the vulnerability of buildings and infrastructure. As a next step the legislative norms, laws and regulations should be reviewed in order to effectively respond to EWEs and avoid negative consequences.

3. Macroeconomic Analysis

The global problem of climate change poses challenges for Kazakhstan in two directions: preventing the consequences of climate change (mitigation) and adapting to the consequences of climate change (adaptation).

A useful tool for assessing adaptation measures in terms of their impact on the economy as a whole has become a macroeconomic analysis using the economic model E3.kz (model of economy, energy and emissions for Kazakhstan), which was developed in cooperation with the German Society for International Cooperation GIZ within the framework of the Global Program “Policy Recommendations for Climate Resilient Economic Development” (CRED).

E3.kz models Kazakhstan's economy, energy system and CO2 emissions in a holistic and consistent way, which has the advantage of calculating impacts simultaneously for each year until the end of the modeling period (until 2050). Each module is based on a comprehensive and up-to-date data set represented as a time series, allowing empirical inference of relationships between models.

[21] Eighth National communication and fifth biennial report of the Republic of Kazakhstan to the UNFCC

The E3.kz model is such a tool that helps to understand and quantify the economic consequences of climate change, as well as to conduct an economic assessment of adaptation measures through scenario analysis. By identifying appropriate indicators, adaptation options can be compared with each other to find favorable solutions or appropriate combinations of adaptation measures.

The model results show not only direct effects, but also indirect macroeconomic effects (GDP, jobs, imports, sectoral production). On the one hand, the results of climate change scenario modelling show what could happen under climate change. On the other hand, policymakers can identify those adaptation measures that are highly effective and have a positive impact on the economy and the environment (win-win options).

Selected adaptation measures for the sectors of agriculture and infrastructure were examined for their impact on the overall economy using the E3.kz model. Overall, macroeconomic analysis shows that climate change threatens food and energy security. To minimize the consequences, it is necessary to select and apply the most optimal adaptation measures. Modeling using the E3.kz model shows that preliminary adaptation measures can significantly increase benefits for the economy, as well as reduce many risks.

Table 4. Potential impacts of extreme weather events on main economics sectors

EWE	Agriculture	Energy	Infrastructure
Extreme temperatures	- Reduction in the wheat yields - Reduction in pasture productivity - Increase in sunflower yields	- Insufficient water for cooling leading to reduction in power generation - Reduction in hydro energy production capacity - Increase in demand for cooling and heating - Power outages (economic losses)	- Melting road surfaces - Buckling of railway lines - Expansion of bridge joints
Extreme precipitation, floods	- Reduction in the wheat yields - Damage to the crops and livestock - Reduction in pasture productivity	- Damage to the physical infrastructure such as power plants, leading to electricity disruptions - Change in hydro energy production capacity - Damage to transmission lines leading to efficiency losses - Power outages (economic losses)	- Damage to the roads and rails - Disruption in transportation - Losses in shipping
Droughts	- Reduction in the wheat yields - Rise of diseases and pests	- Reduction in hydro energy production capacity	- Losses in shipping
Extreme winds	Degradation of soil	- Damage to the physical infrastructure - Power outages (economic losses)	- Damage to the physical infrastructure (bridges - Suspension of airports
Wild Fire	Destruction of harvest	Damage to the physical infrastructure	Damage to the physical infrastructure

Sources: GIZ (2022)[22]

The analysis of climate change adaptation scenarios starts from collecting data on economic and physical damage from extreme weather events. This is the most challenging part, because most of the data is not available or is not provided in monetary terms. Data collection was provided by local experts and from available data sources of the Ministry of Emergency Situations, Kazhydromet and public media. The second part

[22] Climate resilient economic development in Kazakhstan, 2022.

of the modelling process requires cost-benefit analysis of different adaptation scenarios. After getting all the required data we ran the model and got the results on energy demand, emissions and macroeconomic impact.

In this section we have analyzed and made macroeconomic modelling for the economic sectors most vulnerable to climate change and extreme weather events. In our case, these sectors are agriculture, energy and infrastructure.

3.1 Macroeconomic effects of droughts

Past data show that droughts in Kazakhstan affect two-thirds of the territory, mainly North and Central Kazakhstan. Last summer (2023) as a result of drought, 170 thousand hectares of crop area were destroyed in four regions of the country.[23] According to Baysholanov (2017), the probability of droughts in Kazakhstan based on the data for the period 1966-2016 is on average once every 3 or 4 years, with higher probability in North and East Kazakhstan.[24] Research shows that the scale and duration of droughts will rise in Central Asia in the future due to climate change. [25] The consequences of droughts in Kazakhstan can be reduction of crop yields, loss of pasture lands, water scarcity, increased risk of wildfires and economic damage.

In scenario analysis of droughts' impact we make several assumptions. The purpose of modelling is to show what could happen under different scenarios. Assumptions do not include any forecasts. Our scenario is just one of many possible scenarios. It could be considered as a pessimistic scenario, because we expect that droughts will occur 2 years in a draw, then 2 years without droughts and continue in a similar pattern until the end of modelling period, which is 2050. Expected damages in terms of wheat yield losses and decline in livestock production are taken from UNDP (2020) which sum up to 778 billion KZT by 2050. Lower pasture productivity leads to reduction of livestock by 170 billion KZT by 2050. On the other hand, droughts lead to increase in sunflower seed yields (1.8 billion KZT before 2030 and 0.9 billion until 2050). International Energy Agency's (IEA) energy balance data[26] reports that, during the drought in 1998 in Kazakhstan hydro power production was reduced by 20%, which we include in our assumptions as well. Additionally, we expect a decrease in thermoelectric power by 4% as a result of water insufficiency.[27]

[23] https://www.inform.kz/ru/zasuha-unichtozhila-170-tysyach-ga-posevnyh-ploschadey-v-chetyreh-regionah-kazahstana_a4102292

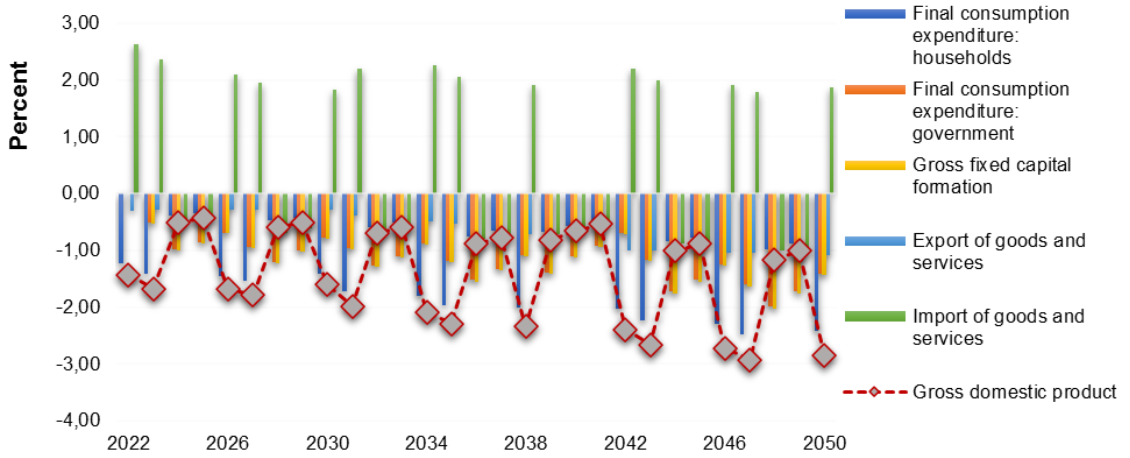
[24] Baysholanov S.S. On the recurrence of droughts in grain-growing regions of Kazakhstan // Hydrometeorology and ecology. № 3. Almaty, 2010. Kazhydromet RSE, pp. 27-38.

[25] Eighth National communication and fifth biennial report of the Republic of Kazakhstan to the UNFCC, 2022

[26] International Energy Agency (IEA). Energy Balance Kazakhstan 1998.

[27] Impacts of recent drought and warm years on water resources and electricity supply worldwide, Van Vliet et al. (2016)

Figure 2. Real GDP impact (deviations from "Baseline" scenario in %)



Scenario results show that the overall impact of droughts on economy of Kazakhstan is negative. After 2 years of drought in 2024 the real GDP is 0.5% less than in the baseline scenario. During drought years the difference in real GDP rises up to 2-2.5% on average. Exports drop to 1,1% by 2050, while imports rise by 2.6% in the initial years and by 1.9 % in 2050. We also can observe a decline in households' consumption due to lower employment and income levels.

Production in scenario with droughts will affect mostly the agriculture and energy sectors, up to a 7-12% decline by 2050. Other sectors that will experience indirect effects are production of chemicals, food and beverages.

Figure 3. Real production (BOTTOM 10) impacts of "Drought" scenario in 2050 (deviations from "Baseline" scenario)

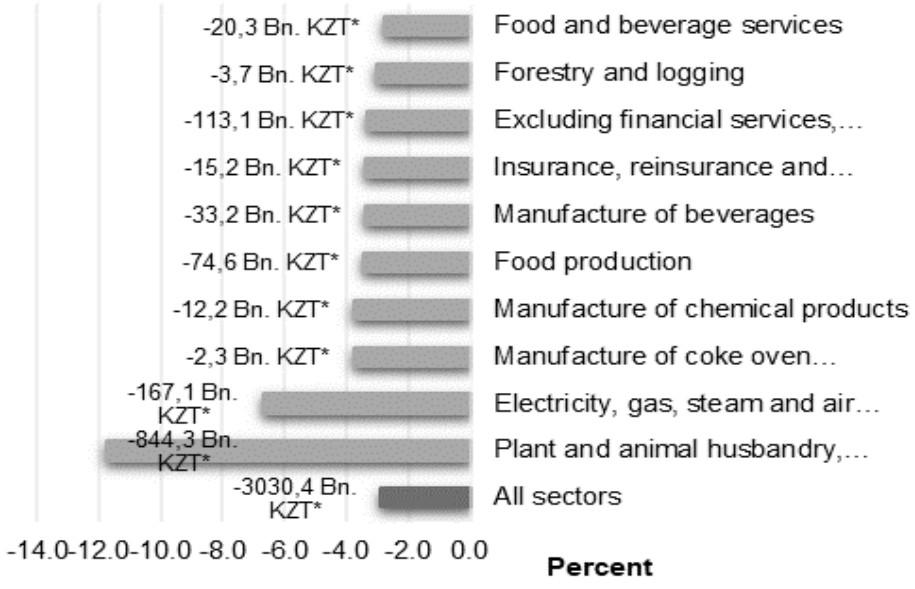
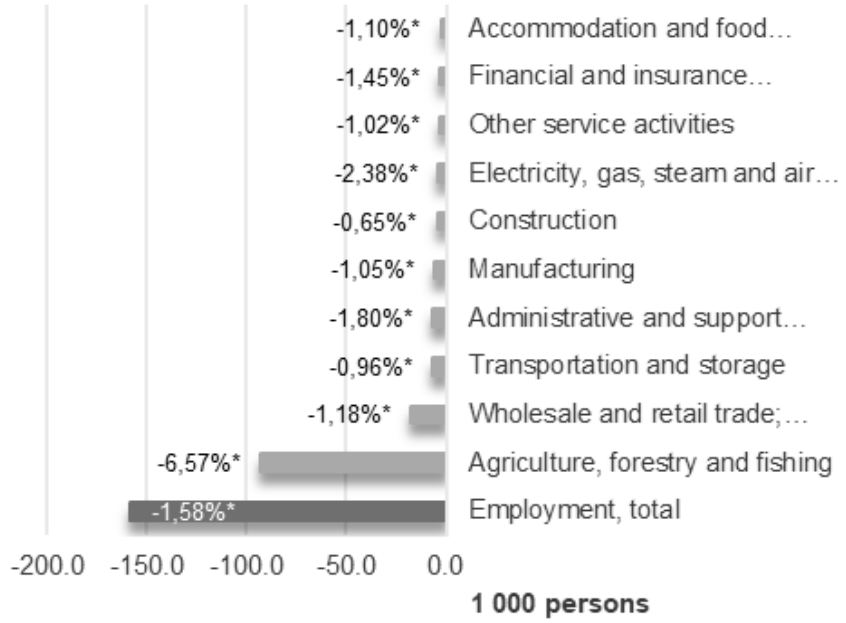


Figure 4. . Employment (BOTTOM 10) impacts of "Drought" scenario in 2050 (deviations from "Baseline" scenario)



The highest fall in employment will be in the agriculture and retailing, as expected, which are more labor-intense sectors and are very vulnerable to droughts. Contraction of labor by 90 thousand people or 6.6% seems to be very high compared to other sectors, but it shows high level of vulnerability of agriculture to the droughts. Overall employment will decline by 1.6% in 2050 compared to baseline scenario. This is because demand for chemicals as well as supply of agricultural products declines, affecting the supply in relevant sectors, and thereby employment.

3.2 Macroeconomic effects of extreme precipitations (EP)

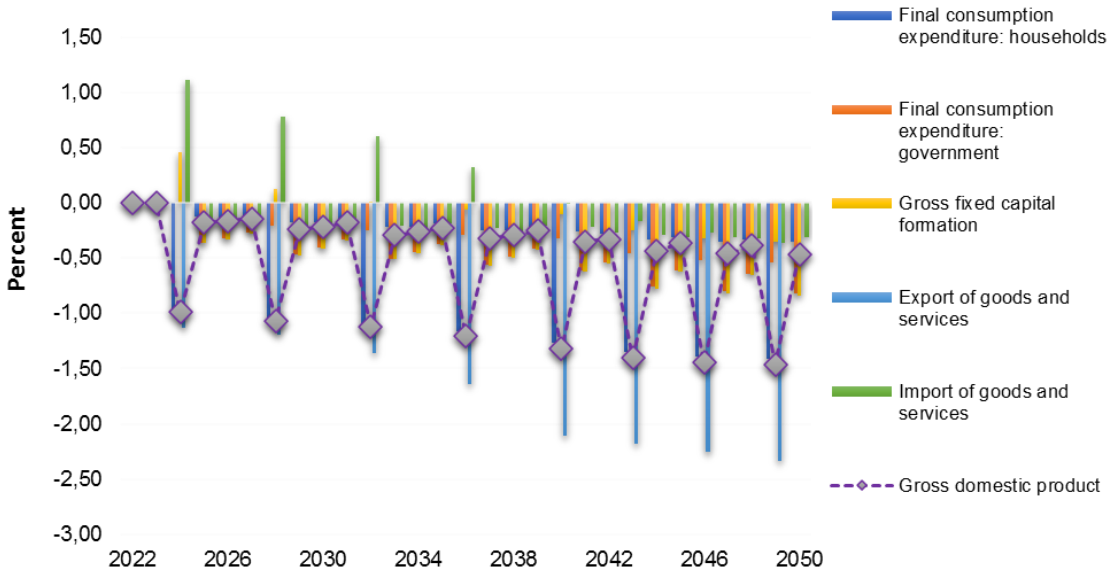
Kazakhstan's climate presents a complex challenge. While droughts are a frequent concern, the country also experiences periods of extreme precipitation leading to devastating floods, which we observed in the Spring of 2024. Kazakhstan witnessed some of its worst flooding in decades. Abrupt warm weather triggered rapid snowmelt, overwhelming rivers and causing widespread inundation. This may be a harbinger of the upcoming floods as rising temperatures will likely lead to more frequent and intense precipitation events, increasing flood risks, which in turn has negative economic impacts such as destruction of crops, livestock and property.

Over the past century, there have been many mudflows of varying severity, with some causing deaths. Climate change is having a significant impact on mudflow intensity. In the first half of the 20th century, severe mudflows caused by heavy rain occurred about every 15 years. This timeframe has shrunk to just 6 years in the late 20th and early 21st centuries.[28] So, our assumptions for the frequency of extreme precipitations and floods in the scenario will be once in 4 years starting in 2024. After 2040, we assumed the frequency will increase to once in 3 years. The major impacts are damage to housing

[28] Yafyazova R. K. Assessment of mudflow activity and predicting its changes in the global warming climate: author's abstract of the Doctor of Technical Sciences. - Almaty, 2009. - p. 36.

and other household assets such as cars, as well as infrastructure such as roads and energy infrastructure, and water systems. Addressing such damage requires reconstruction and replacement. Additionally, extreme precipitations may lead to production losses due to power outages. All these result in lower export potential and higher imports. Respective data for assumptions are provided by GIZ[29]

Figure 5. Real GDP impact (deviations from "Baseline" scenario in %)



Scenario results show that the overall impact of extreme precipitation on the economy of Kazakhstan is negative. The first EP event in 2024 decreases the real GDP by 0.9% compared to the reference scenario. By 2050 the difference in real GDP rises up to 1.5%. The main factor lowering GDP is fall in exports, which goes down by 2.3% in 2050, when compared to the baseline in 2022 , while imports rise by 1.1% in the initial years and decline by 0.3 % as economy slows down in later years. Investment in capital are higher in the beginning, because of the need for reconstruction and repairment of infrastructure, but later with lower economic growth, investment also declines.

Several economic sectors suffer from power outages caused by floods. Lower consumer demand leads to reductions in retail sector, while agriculture also suffers from extreme precipitations. The number of employed people in these sectors decreases by 0.21% compared to the baseline scenario. The biggest reduction is observed in the construction sector, with a 0.33% decline in 2050.

[29] Climate resilient economic development in Kazakhstan, 2022

Figure 6. Real production impacts of "EP" scenario in 2050 (deviations from "Baseline" scenario)

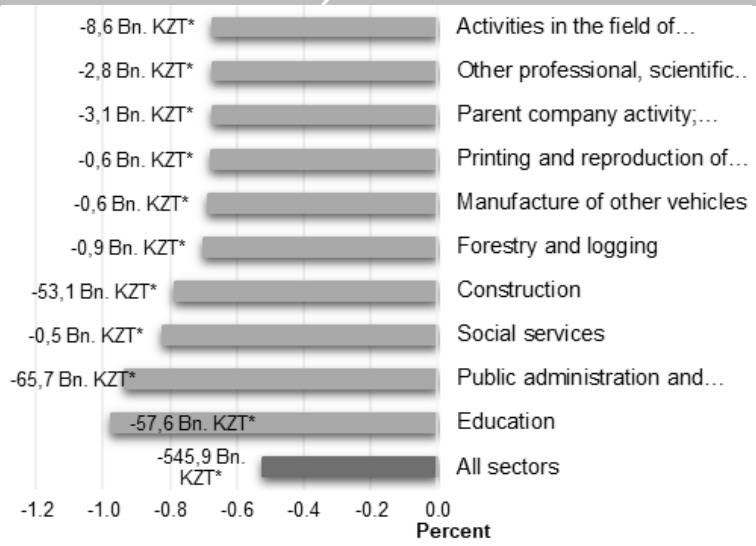
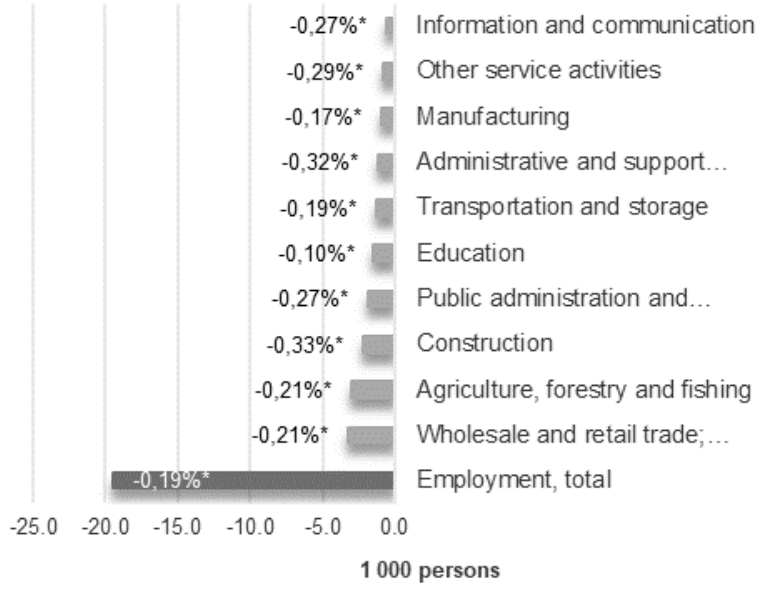


Figure 7. Employment impacts of "EP" scenario in 2050 (deviations from "Baseline" scenario)



3.3 Adaptation in agriculture

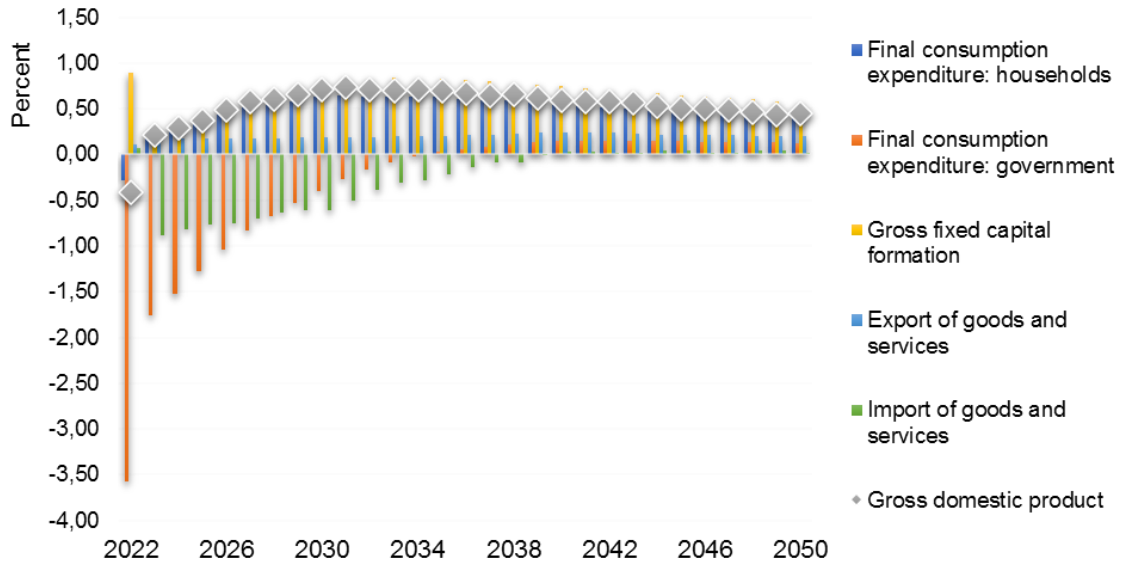
There are two main approaches to dealing with climate change: planning ahead (proactive) or fixing things after the fact (reactive). Proactive measures involve taking steps now to prepare for future problems, like building stronger infrastructure to withstand extreme weather events. Reactive measures involve repairing damage after a climate disaster and making improvements then, like rebuilding more flood-resistant homes after a flood. No matter which adaptation strategy is used, all efforts should focus on reducing the risks climate change poses to the well-being of people and to specific economic sectors.

To assess macroeconomic impact of specific adaptation measures, it is required firstly to provide cost benefit analysis (CBA) of the adaptation project. In this assessment we use CBA for certain adaptation measures conducted by GIZ. Another important criterion

is that adaptation measures can be mapped into the model. They should have a measurable impact. Policy measures and regulations are difficult to model in that sense. After selecting adaptation measures, we input them into the model and compare them with the climate change scenario with no adaptation measures to see the impact on the economy.

To fight with droughts, especially in agriculture, some of the adaptation measures can be water-saving technologies, developing and cultivating drought-resistant crops, building new water reservoirs, etc. For some of the measures, there are already assessed CBAs, which can be used in modelling. As an example, for examining macroeconomic impact of adaptation measures against droughts we will use expansion of **irrigation and drainage systems** as a measure. This measure, helps to increase water efficiency and improve crop yields, leading to a higher level of agricultural production. Assumptions include investment in reconstruction of canals and reservoirs and in drip irrigation systems, by the farmers. However, to prevent passing costs to consumers, the government subsidize these investments, which leads to cuts in other public spending areas. On the benefit side, we expect such spending will result in increase in output in agriculture, which will result in higher agricultural exports and lower imports.

Figure 8. Real GDP impacts of "Adaptation" scenario



Scenario results show that the overall impact of investment in rehabilitation and expansion of irrigation and drainage systems on economy of Kazakhstan is positive. In the first year of modelling, we observe a fall in real GDP by 0.4% compared to the no adaptation scenario due to reduction in government expenditures in other areas as it highly subsidizes investments in irrigation systems. However, in the following years, the impact on government consumption gets smaller. On average for the whole period, the real GDP is higher by about 0.5% than in scenario with droughts and no adaptation. Mostly, growth is driven by investments and increase in households' consumptions.

Investment in irrigation as we expected results in 1.9% higher output production in agriculture (117.3 bn.KZT) by 2050 compared to the scenario with droughts and no adaptation. Increase in construction activities stimulates demand for construction materials. The rest of the industries like insurance, manufacture of chemical products,

other non-metallic minerals are also indirectly and positively impacted from adaptation measures.

Figure 9. Real production impacts of "Adaptation" scenario in 2050 (deviations from "Drought" scenario)

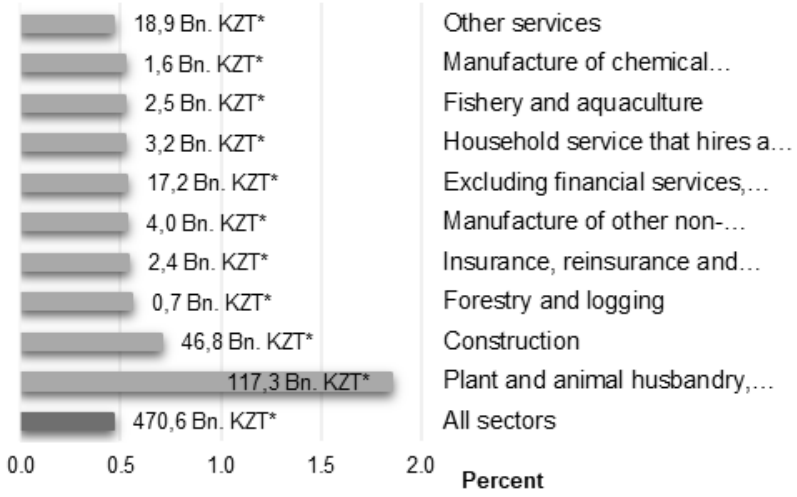
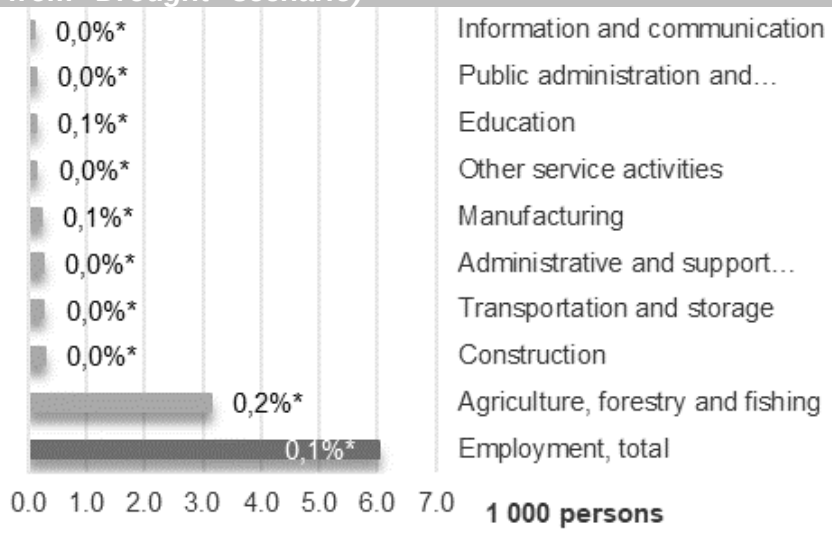


Figure 10. Employment impacts of "Adaptation" scenario in 2050 (deviations from "Drought" scenario)



In terms of employment, main sectors with positive outcomes are agriculture and construction, where additional jobs will be created. According to the model, the overall impact of investments in irrigation systems on employment will be 0.2% increase or 24 thousand additional jobs by 2050 compared to the scenario with droughts and no adaptation.

3.4 Adaptation in infrastructure

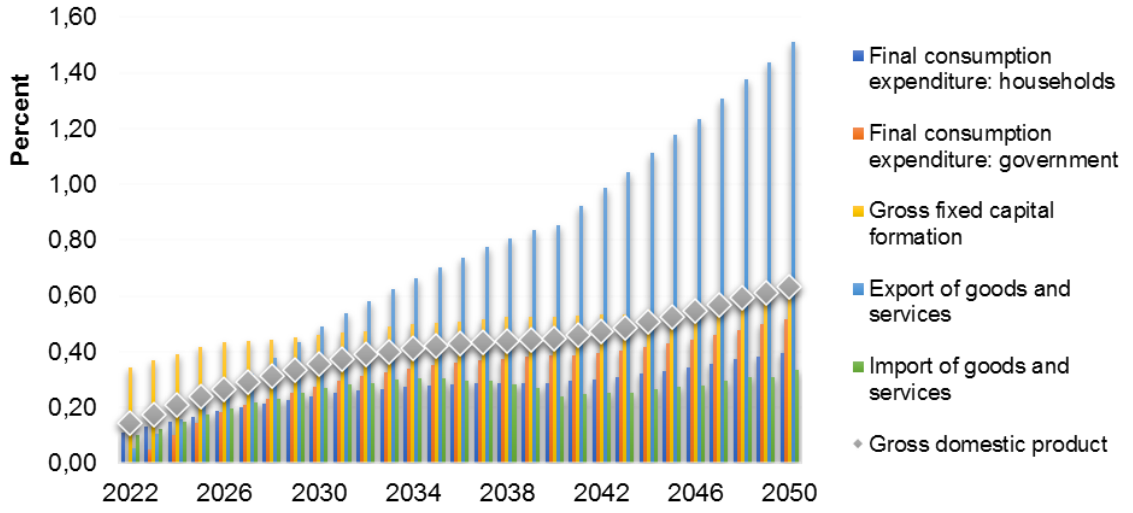
Adaptation in infrastructure is crucial for ensuring that our infrastructure systems can continue to function and support society in the face of a changing climate. Increasing events of extreme precipitation and floods can harm existing infrastructure and lead to higher costs in transportation, which in turn will result in higher costs of final goods and

services. One of the key measures in this area is to modernize transportation infrastructure.

Trade activities, which constitutes 18% of Kazakhstan's GDP (2023), highly depend on transportation, which together with storage sector make up 5.6% of country's GDP. More than 20% of total workforce are accounted in these sectors. Development of transportation infrastructure set as one of the goals of Kazakhstan's long-term strategy. One of the biggest infrastructure projects is the Nurly Zhol 2020-2025 State Infrastructure Development Program, which requires in total 5.5 trillion tenge of investment. According to financing plan 13.7% of the budget is covered by international organizations, 12.9% by private sector and rest 73.4% by public sector.[30]

Building infrastructure that can handle future floods is a type of proactive adaptation measure. While the exact benefits are unclear, we will be optimistic and make an assumption of at least a 50% reduction in flood damage. Upgrading roads with better drainage and stronger surfaces will make them more resistant to extreme weather, but it will cost 7% to 9% more. Luckily, international organizations like ADB are currently funding the cost of adaptation in road projects in Kazakhstan.[31] In our scenario, for simplicity we will assume outside sources like ADB and other international donors will cover the cost of these climate-proof roads.

Figure 11. Real GDP impacts of "CRR" scenario (deviations from "EP" scenario in %)



The result of modelling demonstrates that the overall impact of investment in climate-resilient roads on economy of Kazakhstan is positive. From the figure, we observe an increasing positive difference in real GDP reaching 0.6% by 2050 compared to the no adaptation scenario due to investments in the first years and increasing export potential for the rest of the period. Better roads improve travel time and cost, thus leading to a rise in exports by more than 1% on average.

Intense construction works in the transportation sector positively affect not only the sector itself, but also trade, insurance and real estate sectors. Land transportation is

[30] https://adilet.zan.kz/rus/docs/P1900001055

[31] ADB (2019) https://www.adb.org/sites/default/files/project-documents/52286/52286-001-rrp-en.pdf. World Bank (2012). East-West Roads Project (Almaty-Korgos Section): Western Europe - Western China International Transit Corridor (CAREC - 1b) (P128050).

predicted to grow by 1.2% (85.5 bn KZT) in 2050 compared to no adaptation scenario because of the higher exports.

Figure 12. Real production impacts of "CRR" scenario in 2050 (deviations from "EP" scenario)

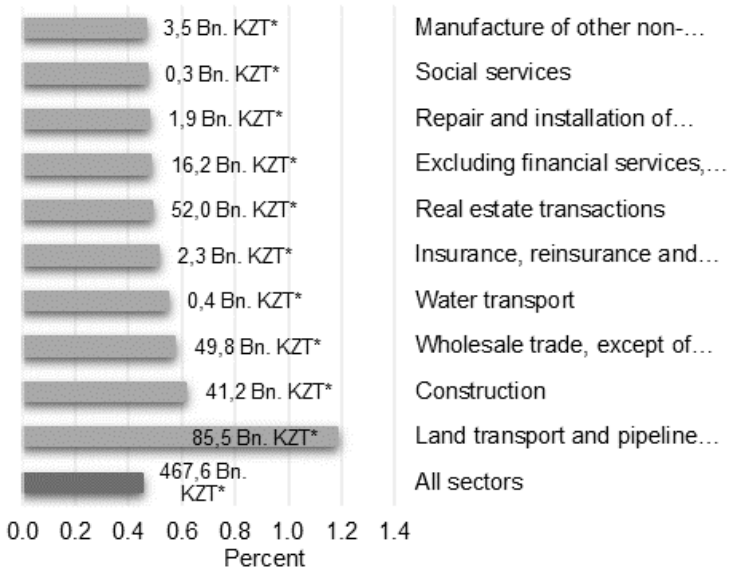
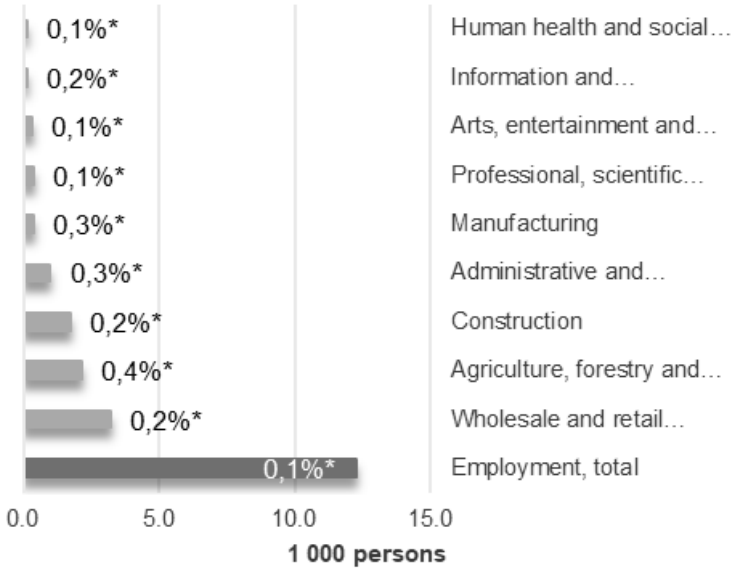


Figure 13. Employment impacts of "CRR" scenario in 2050 (deviations from "EP" scenario)



As of 2050, as a result of investments in climate-resilient roads, additional 12.000 jobs will be created. Sectors which benefit most from these measures in terms of employment are agriculture, manufacturing and construction due to intensified construction activities. In the wholesale and retail trade sector, around 4,000 additional jobs are expected to be created by 2050 compared to the scenario with extreme precipitation without adaptation.

Climate hazards are increasingly affecting transportation and building infrastructure, posing risks to jobs and income across various sectors. Policymakers need to enhance their understanding of impacts of climate change and explore opportunities to bolster infrastructure resilience. There are diverse adaptation options available to mitigate

damages from climate change, but identifying the most effective technologies requires thorough cost-benefit analyses. However, quantifying the benefits is challenging due to uncertainty. The e3.kz model aids in assessing the economy-wide impacts of adaptation measures, though results are subject to uncertainties. Nevertheless, the results from the model provide a foundation for shaping adaptation strategies.

4. Regional and International adaptation strategies

In this part, we examine national adaptation plans and successful case studies from various countries, highlighting strategies such as flood management, early warning systems, sustainable agriculture, and renewable energy adoption. By analyzing these examples, we can identify effective approaches to climate resilience that can be adapted and applied globally. The lessons learned from national adaptation plans of different countries underscore the importance of innovation, collaboration, and proactive planning in building a resilient future as climate change has no national borders. To ensure that the strategies discussed are relevant and applicable to Kazakhstan, we selected countries that share similar climate challenges or economic contexts. For instance, Canada, like Kazakhstan, has vast and diverse landscapes, necessitating comprehensive adaptation strategies that address varied regional climates and economic activities. Canada's experience in managing its natural resources and implementing large-scale adaptation initiatives provides valuable insights for Kazakhstan. Uzbekistan was selected due to its geographic and economic similarities with Kazakhstan, particularly its focus on water resources management and agriculture, which are critical sectors in both countries. Uzbekistan's approach to integrating climate adaptation into national planning and its emphasis on sector-specific strategies offer practical lessons for Kazakhstan.

We also included countries such as Thailand, Albania, Bosnia and Herzegovina, Armenia, and Germany to capture a wide range of adaptation experiences. Thailand's focus on tourism and agriculture reflects similar challenges faced by Kazakhstan, particularly in adapting these sectors to climate change. Albania, Bosnia and Herzegovina, and Armenia are smaller countries with emerging economies that, like Kazakhstan, must balance limited resources with high vulnerability to climate impacts. Germany provides a model of integrated adaptation within a highly developed economy, demonstrating how advanced infrastructure and public policy can mitigate climate risks. By studying these diverse examples, Kazakhstan can draw on a rich array of strategies and adapt them to its unique context, combining robust funding models with practical, targeted interventions.

Thailand

Thailand's National Adaptation Plan (NAP), finalized in November 2023, offers a comprehensive framework designed to enhance the nation's resilience against climate change. The development of Thailand's NAP is anchored in a participatory process involving various stakeholders, including government agencies, the private sector, academia, and civil society. The institutional arrangement for climate adaptation includes the National Committee on Climate Change (NCCC), chaired by the Prime Minister, which oversees the formulation and evaluation of national climate policies. The subcommittee provides policy integration and strategic guidance, while the working group focuses on the NAP's development, implementation, and monitoring.

The NAP's conceptual framework emphasizes integrating climate adaptation into national and sectoral policies, providing sector-specific adaptation options, and engaging stakeholders across different levels. Implementation of the NAP is structured around six priority sectors: water resources management, agriculture and food security, tourism, public health, natural resource management, and human settlements and security. Each sector has specific goals and guidelines tailored to its unique climate risks and adaptation needs. For instance, water resources management focuses on flood and drought management, conservation of watershed forests, and the development of a water security index.

The NAP includes a robust monitoring and evaluation (M&E) framework to track progress and ensure accountability. The M&E process involves regular data collection, reporting, and review mechanisms to assess the impact of adaptation actions and make necessary adjustments.

Public awareness and capacity building are critical components of the NAP. The plan aims to educate government agencies, businesses, and the general public about climate risks and adaptation strategies. The plan also emphasizes the importance of international collaboration, seeking support from global frameworks and funding mechanisms like the Green Climate Fund to enhance Thailand's adaptive capacity.

Albania

The National Adaptation Plan (NAP) of Albania, initiated by the Ministry of Tourism and Environment (MTE), is a comprehensive strategy aimed at enhancing the country’s resilience to climate change. This document, developed in close collaboration with various stakeholders, including line ministries, GIZ, UNDP, and the EU, outlines the framework, implementation, and evaluation mechanisms necessary for effective climate adaptation.

Initiated in 2014 the NAP process integrates adaptation into national planning through groundwork, formulation, implementation, and progress monitoring. Priority Actions focus on steering adaptation processes, mainstreaming initiatives, enhancing climate finance readiness, and developing a robust monitoring system. Sector-specific actions include climate-resilient irrigation, water resource management, agricultural adaptation, health strategies, coastal zone management, tourism, disaster risk reduction, and ecosystem-based adaptation. A comprehensive monitoring and evaluation framework tracks adaptation progress through regular reporting and review cycles, with progress reports every four years and thorough reviews every eight years.

The NAP addresses key vulnerabilities in hydrological systems, agriculture, energy production, health, social vulnerabilities, climate-related hazards, ecosystems, and tourism. It aims to reduce flood damage, enhance agricultural resilience to droughts, and secure drinking water quality despite climate impacts. Success depends on securing adequate financing, integrating climate considerations into budgeting, and leveraging EU pre-accession funds. The NAP overcomes challenges such as uncoordinated climate adaptation actions, insufficient integration of climate risks into planning, and limited public awareness by establishing clear governance, strategic goals, and promoting inter-sectoral cooperation for Albania's sustainable development.

Bosnia and Herzegovina

The National Adaptation Plan (NAP) for Bosnia and Herzegovina (BiH) provides a comprehensive framework for addressing the impacts of climate change through

structured and coordinated efforts. It aims to enhance the country's resilience and adaptive capacity by systematically integrating climate adaptation measures into national policies and practices in short-term (2020–2023), medium-term (2023–2027) and long-term needs (2025–2030).

The NAP's governance structure ensures effective coordination and implementation of climate adaptation strategies, with responsibilities clearly defined among various institutions, including the Ministry of Foreign Trade and Economic Relations, the Ministry of Spatial Planning, Construction and Ecology of Republika Srpska, and the Federal Ministry of Environment and Tourism. These bodies oversee the collection, analysis, and dissemination of climate-related data, ensuring transparency and accountability through regular reporting to international bodies like the UNFCCC.

The NAP's implementation involves a multi-tiered approach, assigning specific roles to various ministries and institutions. The monitoring and evaluation (M&E) system, a cornerstone of the NAP, includes detailed indicators to track progress and assess the impact on resilience. Regular reporting mechanisms submit data annually and biannually to national and international bodies. Overall, the NAP provides a comprehensive, structured approach to building resilience and adaptive capacity across Bosnia and Herzegovina.

Armenia

The National Action Program of Adaptation to Climate Change (NAP) for Armenia, covering 2021-2025, outlines a comprehensive strategy developed by the Ministry of Environment with funding from the Green Climate Fund and support from the UNDP.

Initiated under a government decree in 2021, the NAP mandates the approval and implementation of climate adaptation measures. Its governance structure includes the Inter-Agency Coordinating Council for the UNFCC, chaired by the Minister of Environment, ensuring multi-sectoral coordination and integration of climate considerations into national planning. The NAP's conceptual framework aims to create a resilient Armenia by addressing climate vulnerabilities in sectors like water, agriculture, energy, health, settlements, and tourism. Guided by principles of climate vulnerability, social equity, gender responsiveness, multi-hazard strategies, and ecosystem-based adaptation, the framework ensures inclusive, equitable, and effective measures for reducing climate risks and promoting sustainable development. Regular reporting and oversight mechanisms track progress and address challenges promptly.

Implementation of the NAP involves cross-sectoral and sector-specific measures, strengthening institutional capacities, improving public awareness, and integrating climate adaptation into policy and financial planning. The NAP addresses key barriers to effective adaptation, including governance challenges, information and technology gaps, and financial constraints. Improved coordination mechanisms and integration of climate considerations into policy frameworks tackle governance issues. Enhancing data accessibility and promoting modern technologies address information and technology gaps. Financial barriers are mitigated through the Financing Framework and Implementation Plan for Climate Change Adaptation (FFIPCCA), mobilizing resources from national and international sources. The Ministry of Environment, alongside other ministries and regional administrations, implements and monitors the NAP, with the Inter-Agency Coordinating Council overseeing coordination and ensuring alignment with national priorities and international commitments. Regular reports and evaluations allow for adjustments and improvements in adaptation strategies.

Germany (Strategy for Adaptation to Climate Change)

The German Strategy for Adaptation to Climate Change (Deutsche AnpassungsStrategie, DAS), adopted by the German federal cabinet on December 17, 2008, sets a comprehensive framework for Germany's approach to mitigating and adapting to the impacts of climate change. This strategy, formulated by the Federal Government, aims to provide guidance and support for other stakeholders, including the Federal Länder (states) and societal groups, ensuring a collaborative and integrated approach.

The strategy involves collaboration with Federal Länder and societal groups to identify risks, define objectives, and implement adaptation measures. The conceptual framework focuses on reducing vulnerability to climate change, improving adaptability of systems, and leveraging opportunities. It emphasizes an integrated approach across sectors and regions, enhancing the knowledge base, ensuring transparency and participation, supporting public awareness, and developing strategies to manage uncertainties.

Control and evaluation of the adaptation measures are primarily the responsibility of the Federal Government, in collaboration with the Federal Länder and other stakeholders. The Inter-ministerial Working Group on Adaptation will oversee the coordination and implementation of the strategy, ensuring that progress is reviewed and adaptation measures are refined based on the latest scientific data and impact assessments.

The National Adaptation Plans of Thailand, Albania, Bosnia and Herzegovina, Armenia, and Germany provide comprehensive frameworks to enhance resilience against climate change. Thailand’s NAP involves a participatory approach across six priority sectors. Albania’s NAP focuses on national planning with sector-specific actions. Bosnia and Herzegovina ensure coordinated efforts across governance levels. Armenia emphasizes inclusive measures and international funding, while Germany integrates cross-sectoral approaches and public awareness initiatives to mitigate climate impacts. These characteristics help regulate and organize efforts effectively.

Uzbekistan

Uzbekistan's National Adaptation Plan (NAP), developed with financing from the Green Climate Fund (GCF), aims to bolster the country's resilience to climate change by establishing a robust framework for medium- and long-term adaptation planning. This project focuses on strengthening institutional and technical capacities to integrate climate change adaptation into national and subnational planning and budgeting processes. The NAP was created through an iterative and participatory process, involving key stakeholders such as government agencies, the private sector, and civil society. This collaborative approach ensured that the NAP would be sustainable and responsive to Uzbekistan's specific climate challenges.

The institutional structure supporting the NAP includes the Center of Hydrometeorological Services (Uzhydromet) under the Cabinet of Ministers, which coordinates adaptation efforts across five key sectors: agriculture, water, health, housing, and emergency management. Additionally, the National Committee on Climate Change provides oversight and strategic guidance for the implementation and monitoring of the NAP. The NAP's framework emphasizes the integration of climate adaptation into national and sectoral policies. It identifies priority sectors and regions, setting specific goals and guidelines to address unique climate risks. For instance, the water resources

sector focuses on managing flood and drought risks and developing a water security index, while other sectors, such as agriculture and public health, have tailored strategies to enhance resilience.

The implementation of the NAP is structured around key outcomes:

1. Strengthening the coordination mechanism for multi-sectoral adaptation planning.
2. Enhancing the evidence base for adaptation planning to prioritize actions within national and sectoral frameworks.
3. Developing a comprehensive adaptation financing and investment strategy to support the sustainability of adaptation efforts, including engaging the private sector.

The plan seeks to educate stakeholders across various levels, from government agencies to the general public, on climate risks and adaptation strategies. Additionally, the NAP emphasizes international collaboration, drawing on global frameworks and funding mechanisms like the Green Climate Fund (GCF) to support Uzbekistan's adaptive capacity.

Uzhydromet along with entities from five essential sectors and local governments were the primary recipients of financial support from the Green Climate Fund. The total funding provided amounted to $1,748,959.

Canada

On June 27, 2023, Minister of Environment and Climate Change, released Canada’s first National Adaptation Strategy, marking a significant milestone in the nation's climate resilience efforts. Alongside this, the Government of Canada re-released its Adaptation Action Plan, incorporating updates on new investments aimed at supporting the strategy. These efforts are designed to protect the health and safety of Canadian communities and ensure a robust response to the escalating impacts of climate change.

The strategy's implementation is supported by a multi-level institutional framework. Environment and Climate Change Canada plays a central role, working in close coordination with other federal departments, provinces, territories, and Indigenous communities. The Adaptation Action Plan complements these efforts by outlining federal contributions and coordinating investments across different sectors. Canada’s National Adaptation Strategy focuses on key thematic areas: disaster resilience, health and well-being, nature and biodiversity, infrastructure, and the economy and workers. Each area is supported by specific investments and actions designed to address Canada's unique climate challenges.

The federal government has committed substantial resources to support the strategy's implementation. Since 2015, more than CAD 6.5 billion has been invested in climate adaptation, including CAD 2 billion since the fall of 2022. Notable investments include CAD 489 million for the Disaster Mitigation and Adaptation Fund and CAD 284 million for the Wildfire Resilient Futures Initiative. These investments are aimed at building resilience in key areas and ensuring the infrastructure is prepared for future climate impacts.

Canada's strategy includes a comprehensive monitoring and evaluation framework to track progress. The Government of Canada continues to provide financial assistance to

provinces and territories through programs like the Disaster Financial Assistance Arrangements, which have contributed over CAD 7.9 billion since 1970, with the majority paid out in the last decade due to increasing climate-related disasters.

The strategy emphasizes the importance of public awareness and capacity building. Programs like Health Canada's HealthADAPT, which received CAD 13 million, aim to protect Canadians from extreme heat and other health impacts of climate change. The Canadian Centre for Climate Services also plays a crucial role in providing climate data and tools to support informed decision-making across the country.

In total, Canada's core adaptation investments amount to billions of dollars, with significant allocations across various sectors. These substantial investments demonstrate Canada's commitment to proactive adaptation, ensuring that the necessary measures are in place to protect communities and sustain economic growth in the face of climate change.

Table 5. Detailed Regulatory Processes by countries NAP

Country	Initiation and Governance	Conceptual Framework	Implementation and Coordination	Monitoring and Evaluation	Public Awareness and Capacity Building

Thailand	Participatory process, overseen by NCCC chaired by Prime Minister.	Aligns with national strategies, integrates adaptation into policies.	Six priority sectors, specific goals and guidelines.	Robust framework to track progress and measure resilience.	Educate agencies, businesses, public on climate risks.
Albania	Led by Ministry of Tourism and Environment; Inter-Ministerial Group.	Follows UNFCCC guidelines, country-driven, integrated into planning.	Priority Actions, overarching and sector-specific measures.	Framework overseen by MTE, regular reporting cycles.	Training, outreach, educational materials.
Bosnia and Herzegovina	Effective coordination, clear responsibilities among institutions.	Assess risks, implement measures, continuous monitoring.	Multi-tiered approach, specific roles for ministries.	Track progress, assess impact on resilience.	Enhance understanding among stakeholders and public.
Armenia	Initiated under government decree; Inter-Agency Coordinating Council.	Focuses on resilience, equity, ecosystem-based adaptation.	Cross-sectoral and sector-specific measures.	Integrated with national frameworks, adaptation indicators.	Communication plans, training modules.
Germany	Federal Government initiated	Reduce vulnerability, maintain adaptability, leverage opportunities.	Multi-model approach, action options for sectors.	Long-term monitoring, river basin management, knowledge networks.	Public relations, decision support, educational initiatives.
Uzbekistan	Developed with GCF financing, involved government agencies, private sector, and civil society.	Focuses on integrating climate adaptation into national and sectoral policies, identifying priority sectors and regions.	Structured around key outcomes: strengthening coordination, enhancing evidence base, and developing financing strategies.	Integrated with national frameworks, adaptation indicators.	Emphasizes educating stakeholders and the public, drawing on global frameworks like the GCF.
Canada	Released by the Minister of Environment and Climate Change, part of a broader government initiative.	Focuses on disaster resilience, health and well-being, nature and biodiversity, infrastructure, economy and workers.	Committed substantial resources since 2015, with notable investments in disaster mitigation and adaptation funds.	Includes a comprehensive monitoring and evaluation framework to track progress.	Focuses on raising public awareness and building capacity, supported by programs like HealthADAPT

Table 6. Some of the examples of adaptation measures by country

Country	Strategy	Description	Key Components

Netherlands	Flood Management ("Room for the River")	Innovative flood management to mitigate economic impacts of flooding.	- Creating space for rivers to overflow safely - Relocating dikes inland - Reducing floodplain elevation - Constructing side channels - Modifying barriers
Australia	Water Management and Drought Resilience	Comprehensive strategies focusing on effective water resource management in the Murray-Darling Basin (MDB).	- Advanced water markets - Government buy-backs - Infrastructure investment - Desalination plants - Water recycling - Environmental water allocations
Kenya	Climate-Smart Agriculture (CSA)	Enhancing productivity, resilience, and sustainability in agriculture.	- Drought-tolerant crops - Water management techniques - Agroforestry - Institutional support - Economic incentives
Germany	Renewable Energy and Energy Efficiency	Increasing renewable energy share and enhancing energy efficiency as part of "Energiewende" (energy transition).	- Investment in wind and solar energy - Policy support for renewables - Human capital development - Infrastructure targets - Green budget
China	Afforestation and Reforestation	Extensive initiatives to enhance carbon sequestration, reduce soil erosion, and improve flood mitigation.	- Programs like Three North Shelterbelt - Balancing afforestation and wetland conservation - Use of satellite data for optimization

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Table 7. Economic and Environmental impact of adaptation measures

Country	Economic Impacts	Environmental Impacts	Lessons for Other Countries

Netherlands	- Significant reduction in flood damage costs	- Enhanced flood safety and environmental quality	- Importance of natural water flow management
Australia	- Improved water security for agriculture and urban areas	- Restored river flows and wetlands - Increased biodiversity	- Integrated water management - Investment in water infrastructure
Kenya	- Increased agricultural income and productivity	- Improved soil fertility - Enhanced resilience to climate variability	- Promotion of CSA practices - Institutional and economic support
Germany	- Reduction in GHG emissions - Increased energy security	- Improved ecological quality - Reduced fossil fuel reliance	- Renewable energy investment - Human capital development
China	- Enhanced carbon sequestration - Mitigated soil erosion	- Improved flood mitigation - Wetland conservation challenges	- Balancing afforestation with ecosystem preservation

5. Conclusion and policy recommendations

To sum up, as climate change intensifies, countries around the world are adopting innovative strategies to mitigate its economic impacts, focusing on enhancing resilience to extreme weather events, rising sea levels, and prolonged droughts. These strategies include advanced flood management systems, efficient water resource management, sustainable agricultural practices, and a significant shift towards renewable energy. Some countries adopted national adaptation plans, which provide comprehensive frameworks to enhance resilience against climate change. These plans share common characteristics such as stakeholder engagement, integration of adaptation into national and sectoral policies, and robust monitoring and evaluation systems.

The global examples of adaptation measures from different countries underscore the importance of innovation, collaboration, and proactive planning in building climate resilience. Some countries like Kenya faced several challenges in implementing Climate-Smart Agriculture (CSA) practices, including limited funding, insufficient technical knowledge, fragmented responsibilities, and inadequate infrastructure. To overcome these obstacles, Kenya adopted a multi-faceted approach, with a robust governance framework, which was ensuring coordinated efforts across various ministries and stakeholders. Financial barriers were addressed by mobilizing resources from international funds, such as the Green Climate Fund's Readiness program, which supported the government's CSA initiatives. By adapting similar successful strategies, Kazakhstan can better prepare for and adapt to the adverse effects of climate change, ensuring sustainable economic development and environmental health.

While policies provided by strategic documents represent a positive step, there is a need for continuous improvement. Sectoral policies reveal varying degrees of climate adaptation integration. However, broader agricultural policies might need to go further

by incorporating drought-resistant crops, promoting water-efficient irrigation, and facilitating access to weather forecasting technologies for farmers.

Similarly, water management strategies could benefit from incorporating climate projections into water allocation plans and infrastructure development. Disaster risk reduction policies, while necessary, can be strengthened with early warning systems for extreme weather events, clear evacuation protocols, and community preparedness initiatives.

The GIZ report "Toward Climate Resilient Economic Development in Kazakhstan" identifies implementation gaps as a key challenge. Limited funding, unclear institutional mandates, and insufficient focus on vulnerable communities, particularly rural populations and pastoralists, hinder the effectiveness of existing plans.

Several opportunities exist to enhance existing policies in the country and create a more robust adaptation strategy:

- **Policy Enhancement:** revision of sectoral targets to reflect the latest climate projections and prioritize adaptation efforts in vulnerable areas. Establishing dedicated climate adaptation funds, focusing on community-based initiatives and technology transfer. Implementation of robust monitoring and evaluation mechanisms to track progress and adapt strategies as needed.
- **Cross-Sectoral Integration:** creation of a national adaptation committee with representatives from relevant ministries to facilitate a unified approach and resource allocation. Promotion of joint projects across sectors, such as integrating climate-resilient infrastructure development into agricultural planning.

Additional Considerations

In conclusion, while various actors contribute to climate change adaptation, the government plays a leading role through significant public investments. These investments are crucial for building resilient infrastructure, supporting research and development, and implementing adaptation strategies. Public funding serves as a cornerstone, enabling private sector participation and fostering innovation in this critical endeavor.

Educating communities on water conservation, sustainable land management, and disaster preparedness can significantly enhance resilience. Collaboration with the private sector can leverage investments in climate-resilient technologies and infrastructure development. Sharing best practices with regional partners and international organizations can promote knowledge exchange and access to technical assistance.

By implementing these recommendations, Kazakhstan can build a more resilient future, prepared to face the challenges of a changing climate.

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