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CONCEPT OF AN INTEGRATED APPROACH TO TRANSBOUNDARY DISASTER RISK MANAGEMENT CONSIDERING CLIMATE CHANGE

Almaty, 2024

CONTENTS

I. INTRODUCTION

Contemporary society is increasingly confronted with the challenge of ensuring security and protection in the context of global climate change. Natural disasters and man-made accidents are becoming particularly acute, as they simultaneously affect multiple sectors of state activity, threaten national security, and may have transboundary, interregional, or global consequences, directly or indirectly causing damage to one or more states.

In this regard, the issue of coordination among the authorized bodies of Central Asian countries responsible for managing transboundary disaster risks has become particularly relevant. The problem arises from the need to organize effective cooperation between the competent authorities of neighboring states in addressing transboundary disaster risks. Coordination among the countries of Central Asia in the field of disaster risk management is primarily determined by the fact that this area of cooperation is becoming an increasingly important component of the modern system of international relations in the context of ongoing global climate change.

Issues related to the effectiveness of disaster risk management are discussed at various intergovernmental meetings. However, the organization of coordinated cooperation remains unresolved in cases where, in order to reduce the risks of transboundary disasters, it is necessary to involve forecasting services, as well as the forces and resources of rescue units from neighboring states.

Cooperation in managing transboundary disaster risks includes coordinating the exchange of forecast data on natural and man-made disasters, ensuring early warning in the event of emergencies, as well as coordinating joint actions and procedures for providing mutual assistance in carrying out tasks aimed at reducing the risks of transboundary disasters. To ensure effective coordination of these factors, it is necessary to develop conceptual approaches based on international standards and best practices.

An analysis of natural disasters and man-made accidents in Central Asian countries shows that many crisis situations have the potential to escalate to a transboundary level. The success or failure of responses to such situations largely depends on the completeness and effective organization of cooperation during both the preparation phase and the implementation of joint response actions.

At present, taking into account global climate change and the resulting increase in the number of transboundary disasters, the development of a unified and comprehensive approach to disaster risk management in Central Asia has become increasingly important in order to minimize the impact of climate change on the population, territories, and economic infrastructure.

1.1 Overview of the Concept's Objectives and Target Audience

This paper examines potential vulnerability factors, risks, and threats to the socio-economic development and stability of the Central Asian region (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan) arising from natural disasters and man-made accidents associated with global climate change.

It proposes development of a comprehensive approach to managing the risks of transboundary disasters in Central Asian countries to mitigate the consequences of natural disasters and man-made accidents caused by climate change.

The disaster risk profile for Central Asian countries, taking into account climate change, was developed with the support of the United Nations Office for Disaster Risk Reduction (UN ODRR).
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developed with the support of the United Nations Office for Disaster Risk Reduction (UNISDR).
The concept of integrated management of transboundary disaster risks has been developed for the national authorities of Central Asian countries in the areas of civil protection (defense), environmental protection, agriculture, water resources, and the economy.

1.2. Justification for the need for a comprehensive approach to disaster risk management taking into account climate change

The risks of transboundary natural disasters affecting the livelihoods of the population and the economies of Central Asian countries are growing faster than measures are being taken to mitigate them. To increase the resilience of Central Asian countries to the negative impacts of disasters caused by global climate change, it is necessary to join forces to develop a unified comprehensive approach to managing the risks of transboundary disasters.
Comprehensive transboundary disaster risk management by the countries of Central Asia is a key element in preparing for natural and man-made disasters that affect the reduction of transboundary disaster risk and in responding to them.
Comprehensive disaster risk management is a complex undertaking, as it involves coordinating the actions of multiple actors at the national and transboundary levels. To assist Central Asian countries in these efforts,it is proposed to develop a methodology for integrated risk management of transboundary disasters, taking into account climate change.
The application of integrated transboundary disaster risk management will support the implementation of the Sustainable Development Goals, the Paris Agreement on climate change, and the Sendai Framework for Disaster Risk Reduction 2015-2030.

II. CONTEXT AND ANALYSIS

2.1. Description of the region and its vulnerability to transboundary disasters

The Central Asian region, consisting of five states—Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan—is home to more than 75 million people..

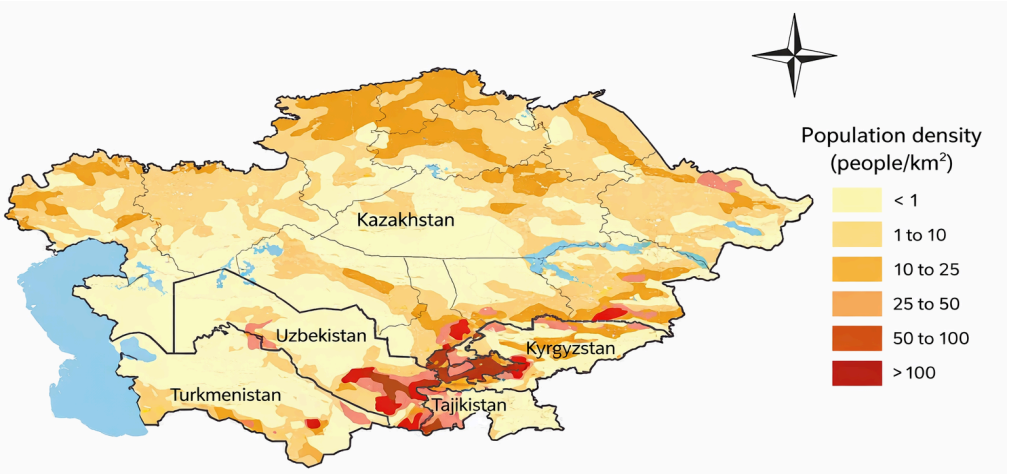

Figure 1 – Population Density of Central Asia

From a geographical point of view, Central Asia is very diverse, encompassing vast, relatively young mountain ranges such as the Tien Shan and Pamir, numerous eternal glaciers, large deserts and semi-deserts, endless steppes zones, thousands of small and dozens of large rivers and lakes, including the Amu Darya and Syr Darya, the Caspian and Aral Seas, Balkhash, Issyk-Kul, large reservoirs, very densely populated valleys such as Fergana, as well as some of the most sparsely populated areas in the world.
The geographical location of the region is determined by a sharply continental climate with low and unevenly distributed precipitation. The Central Asia region is characterized by large daily and seasonal temperature ranges, high solar radiation, and relatively low humidity. The Central Asian region is

exposed to virtually all types of natural hazards disasters (with a few exceptions, such as tsunamis, tornadoes, volcanic eruptions, and some others) of a natural (geological, geophysical, meteorological, agrometeorological, hydrological), man-made, environmental, and biological-social nature
The region is most characterized by vast territories with high seismic activity, with probable strong earthquakes of 7-8-9 and more points, mudslides,floods, flash floods, landslides, snow avalanches, flooding, rising groundwater levels groundwater levels, strong hurricane-force winds and even tornadoes, desertification, dust and sand storms, prolonged and torrential rains, hail, heavy snowfalls and blizzards, droughts, frosts, landslides and rockfalls, steppe, forest and mountain fires, extreme temperatures, environmental, man-made industrial and transport accidents, explosions, major fires, epidemics, mass infectious diseases in humans and animals, damage to agricultural crops diseases, weeds, and pests, as well as the presence of artificial reservoirs, and reservoirs prone to rupture, nuclear and chemical waste storage facilities, enterprises with toxic and highly potent poisonous substances, and dangerous technological processes.

It is well known that the scale of economic damage does not always correspond to the number of disasters. For example, the number of earthquakes in Central Asia is significantly lower than the number of floods; however, the economic damage caused by earthquakes is considerably greater than that caused by floods.

The quantitative risk assessment conducted in this study identified the following disaster risk patterns:

- **Kazakhstan:** earthquakes represent the main risk factor, followed by floods;
- **Kyrgyzstan:** earthquakes are the primary risk factor, followed by landslides and floods;
- **Tajikistan:** floods represent the main risk factor, followed by earthquakes and landslides;
- **Turkmenistan:** earthquakes are the main risk factor, followed by floods;
- **Uzbekistan:** earthquakes represent the main risk factor, followed by droughts.

Over the past 40 years, rapid population growth and the expansion of irrigation systems in Central Asian countries have significantly increased the demand for land and water resources in the region. At the same time, more than 46% of the population lives in urban areas.

The Republic of Kazakhstan, with a total area of 2.74 million km², is the largest country in Central Asia. The country has a population of approximately 20.1 million people, and its GDP in 2023 amounted to **US$224.3 million** (GFDRR).

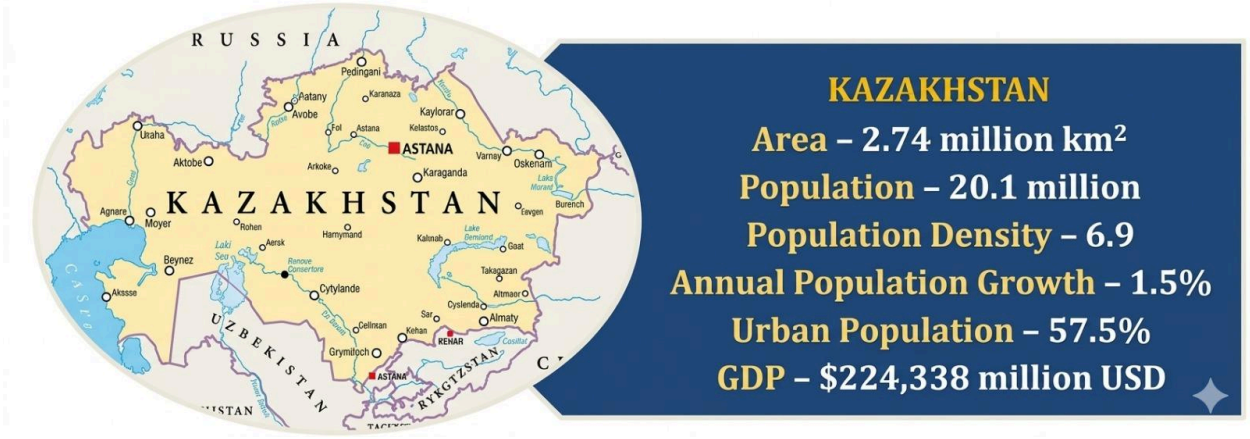

Figure 2 – Key Statistical Indicators of the Republic of Kazakhstan

The country has a significant elevation range, from 7,010 m in the southeast to −132 m in the Caspian Depression. Most of the territory consists of desert or semi-desert landscapes. However, Kazakhstan has an extensive river network.In fact, floods are the predominant natural hazard in the country. These river floods, caused mainly by rainfall and snowmelt, result in average annual damages estimated at US$726 million. Earthquakes cause 7 times less damage than floods, but are highly concentrated in the southern and southeastern regions of the country (GFDRR).

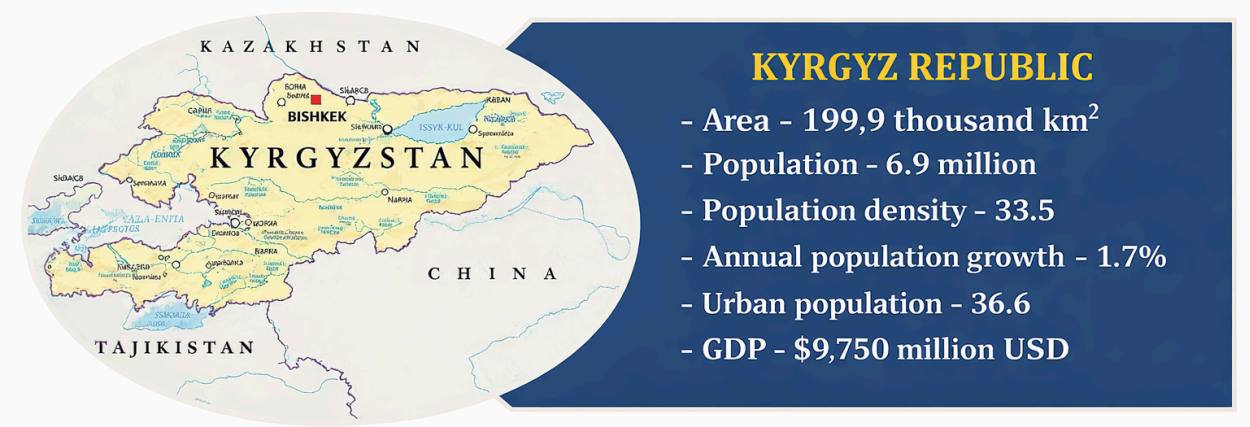

Figure 3 – Overview of statistical data of Kyrgyz Republic

The Kyrgyz Republic is a landlocked country. It has a population of 6.9 million and a GDP of US$9.750 million in 2023.
Mountains cover most of the country, with only about 6% being lowlands, where most agricultural work is carried out. According to the risk profile, the country is highly vulnerable to earthquakes, floods, and landslides. Floods are the most frequent hazard. However, the economic losses from earthquakes are greater than those from floods, with average annual losses amounting to approximately US$190 million (GFDRR).

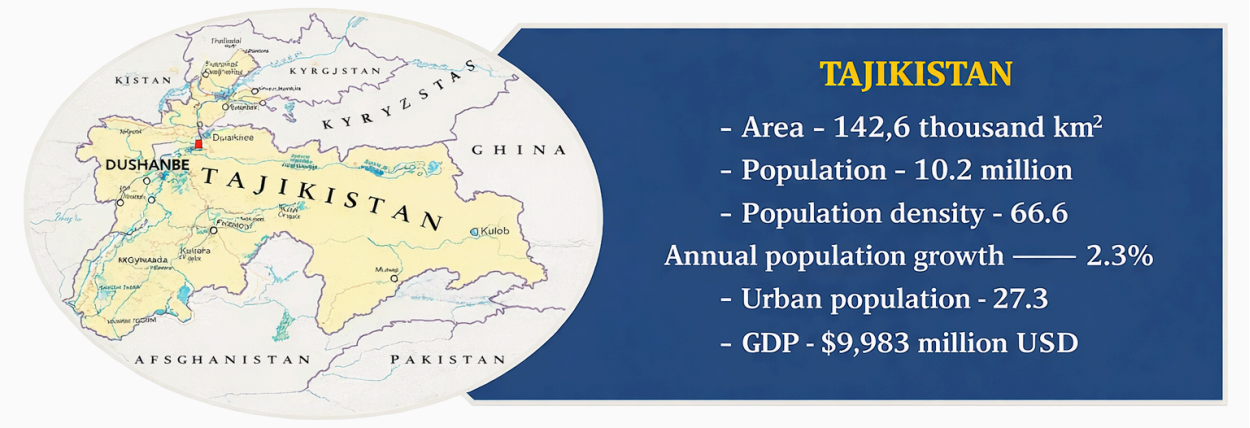

Figure 4 – Overview of statistical data of Tajikistan

The Republic of Tajikistan is a country with a population of approximately 10.2 million people, with a GDP of US$9.983 million in 2023. As in the Kyrgyz Republic, 90% of the country's territory is mountainous, and it is located in a highly seismic area. However, due to its relatively low percentage of urbanization, it is less prone to earthquakes The population is mainly concentrated in the low-lying areas of the country. That is, in the northern and southern parts of the country, where agriculture is mainly

practiced. Due to the terrain, in addition to earthquakes, the country is prone to flash floods, as well as mudslides and landslides as precipitation falls and snow melts (GFDRR).

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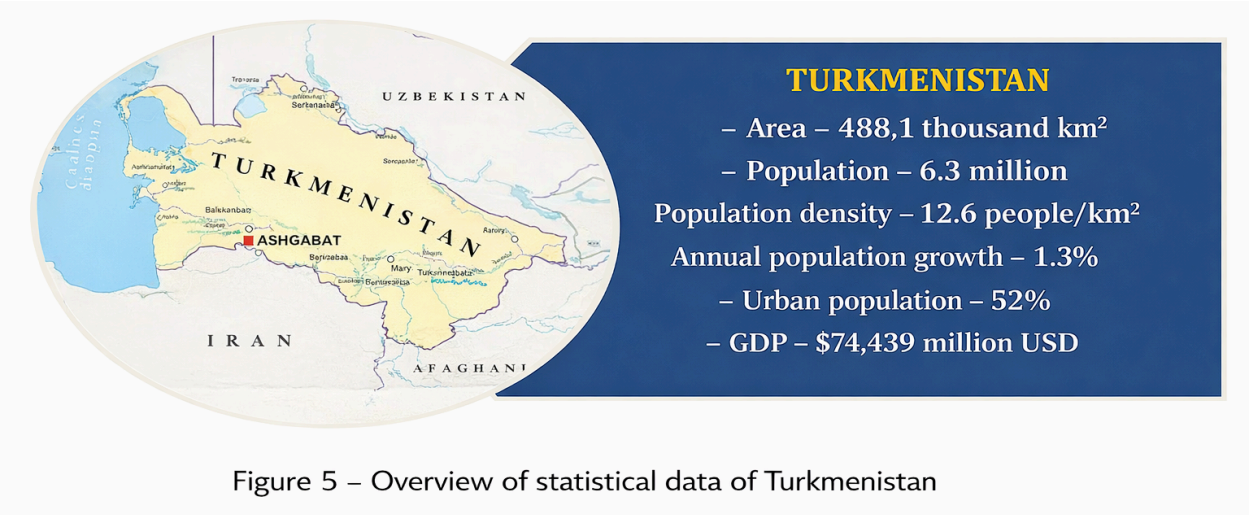

Figure 5 – Overview of statistical data of Turkmenistan

Turkmenistan has a population of over 6.3 million and a GDP of US$74.439 million in 2023. It is the second largest country in Central Asia, with about 50% of the population living in rural areas.

The country is exposed to various hazards, of which floods cause the most damage (the average annual loss is approximately US$90 million). The country is also located in a highly seismic zone. However, the risk of this hazard is lower than that of floods, which are estimated to cause average annual losses of approximately US$34 million. In line with the topography, landslides are also part of the hazards existing in the country, with these landslides mainly located in the Akhal region in the south of the country (GFDRR).

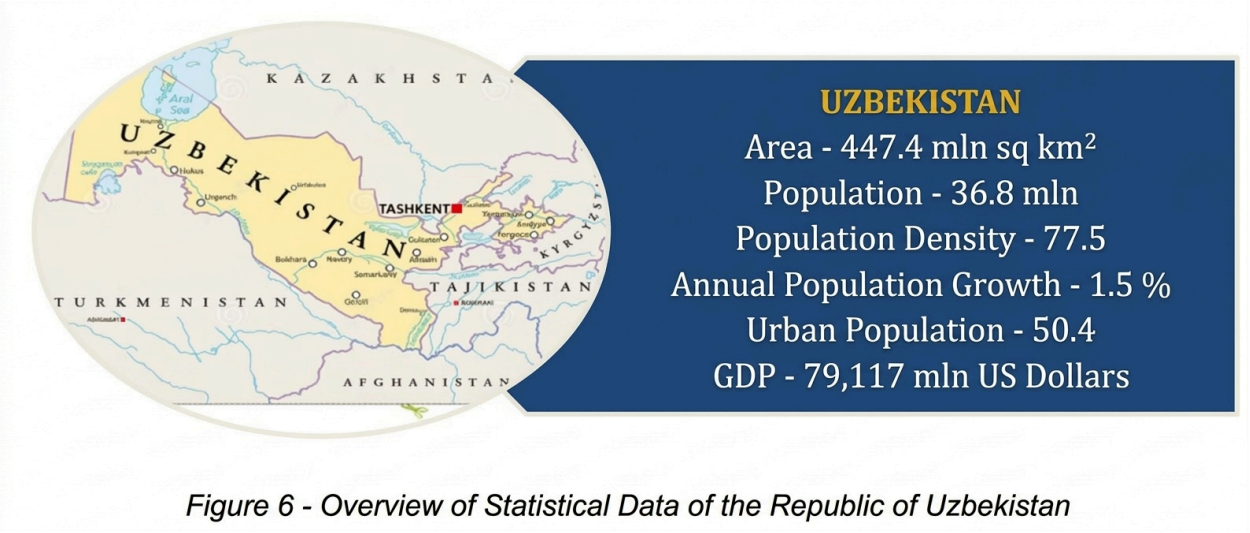

Figure 6 - Overview of Statistical Data of the Republic of Uzbekistan

The Republic of Uzbekistan has a population of over 36.8 million people, and its GDP in 2023 amounted to US$79.117 million, with agriculture accounting for the largest share. The country's main export is cotton, which accounts for 30% of its total exports.

Studying the history of Uzbekistan, it is evident that the country is prone to earthquakes, droughts, floods, mudslides, and landslides. It is worth noting that only about 15% of the country’s territory lies in

seismically active areas. However, approximately 80% of the population resides in these regions, primarily in the eastern part of the country, where the capital, Tashkent, is located (GFDRR).

2.2 Analysis of Previous Disasters and Their Impact on the Region

Central Asia is susceptible to a wide range of natural and man-made disasters, including fires, earthquakes, floods, and landslides. Over the past two decades, climate change, population growth, and urbanization have contributed to an increase in both the frequency and severity of losses resulting from man-made accidents and natural disasters (UNISDR).

Figure 7 – Hazard and Exposure Map: Average National Values for Central Asian Countries

The greatest threats to the Central Asian region in terms of potential loss of life and economic damage are earthquakes and floods.

A significant part of Central Asia, including nearly all major cities, lies within zones of high seismic risk.

Over the past 100 years, strong earthquakes have occurred in every Central Asian country, claiming hundreds of thousands of lives and causing damage amounting to billions of dollars (Central Asian Bureau for Analytical Reporting).

Table 1 – Significant Earthquakes in Central Asia

Date	Name	Number of Affected	Economic Damage (million USD)
03.01.1911	Kemin Earthquake, Kazakhstan, Kyrgyzstan	450	20
05.10.1948	Ashgabat Earthquake, Turkmenistan	176000	6000
26.04.1966	Tashkent Earthquake, Uzbekistan	100000	300
13.10.1985	Earthquake in Tadjikistan	8080	200

19.08.1992	Jalalabad Earthquake, Kyrgyzstan	86806	130

Even in the absence of major earthquakes, up to 200 people die each year in the region due to seismic events. This indicates the persistent seismic hazard present in the daily lives of every resident of Central Asia.
The region of Central Asia loses approximately half a billion dollars annually from earthquakes alone.

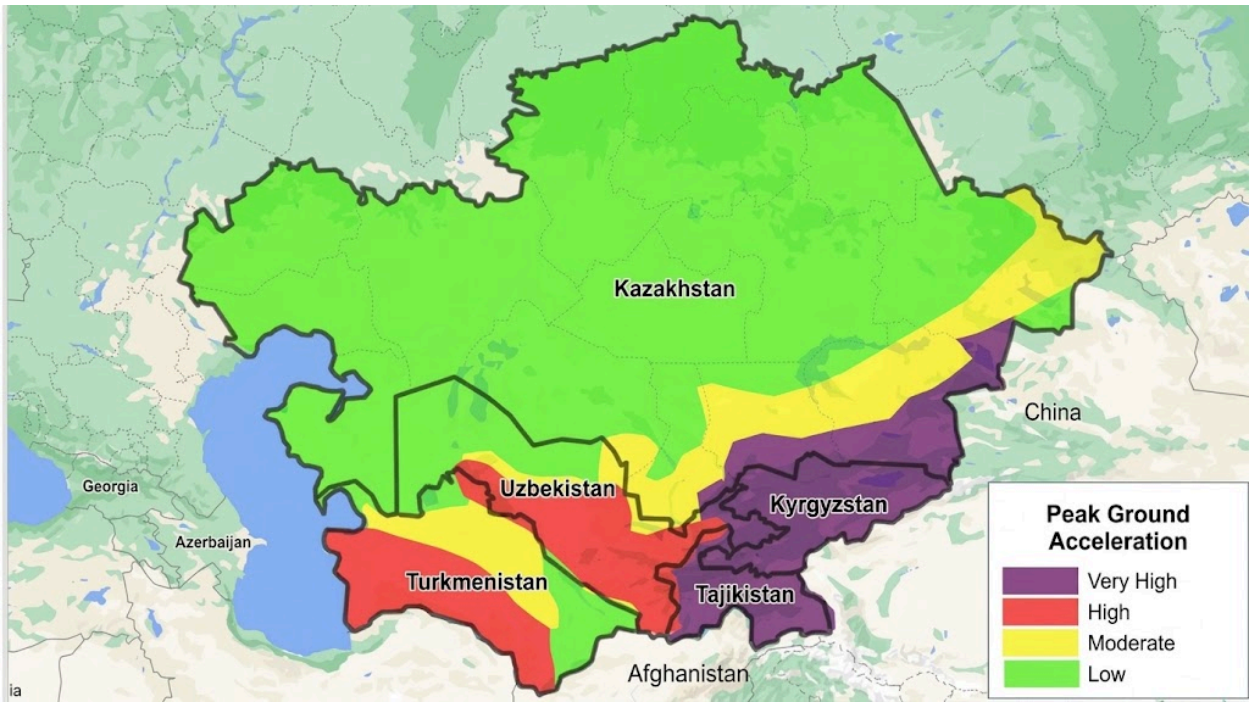

Figure 8 – Seismic Hazard Map of Central Asia

Catastrophic earthquakes in Central Asia can lead to transboundary disasters, as seismic activity in the region generally occurs from south to north. In addition, strong earthquakes can trigger avalanches, landslides, and the breaching of high-mountain lakes.

The greatest threat in the region is the potential breach of Sarez Lake in Tajikistan (with a volume of over 17 billion m^3) as a result of a strong earthquake, which could have catastrophic consequences for several countries in the region. In the event of the failure of the natural Usoi Dam, which holds back Sarez Lake, billions of cubic meters of water could be released, causing devastating floods downstream along the Murghab River. The flooding would affect areas in Tajikistan, Afghanistan, Turkmenistan, and Uzbekistan, causing damage to the population, infrastructure, agriculture, and industrial facilities.

Central Asia contains more than 100 sites associated with mining operations that store radionuclides, heavy metal salts (cadmium, lead, zinc), and other toxic substances such as cyanides, acids, silicates, nitrates, and sulfates. There is a persistent threat of potential environmental disasters due to the failure of storage facilities located in areas with high seismic and landslide activity. In some cases, the negative impacts of these potentially hazardous sources may result in transboundary environmental pollution.

In this context, the speed of transboundary emergency warning transmission between Central Asian countries is of particular importance. Large rivers in the region, such as the Amu Darya, Syr Darya, Chu, Talas, Tarim, and others, along with the hydraulic structures built on them, have the potential to cause

catastrophic transboundary flooding. A notable example is the breach of the Sardob Dam in Uzbekistan on May 1, 2020, which resulted in the flooding of extensive transboundary areas in Uzbekistan and Kazakhstan.

Analysis indicates that between 1997 and 2021, more than 167,400 natural and man-made disasters occurred across the Central Asian countries (Academy of Civil Protection of the Ministry of Emergency Situations of the Republic of Kazakhstan, 2023). The dynamics of man-made accidents and natural disasters in the Central Asian countries over this period are presented in Figure 9.

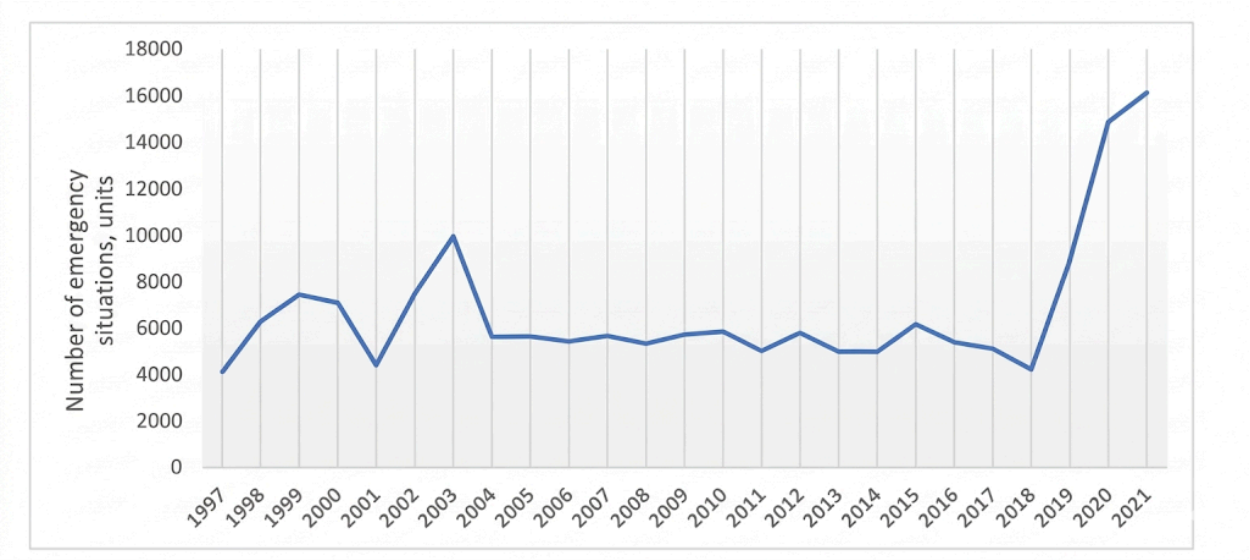

Figure 9 – Dynamics of Disasters in Central Asian Countries, 1997–2021

Figure 10 illustrates the dynamics of natural and man-made disasters in Central Asian countries.

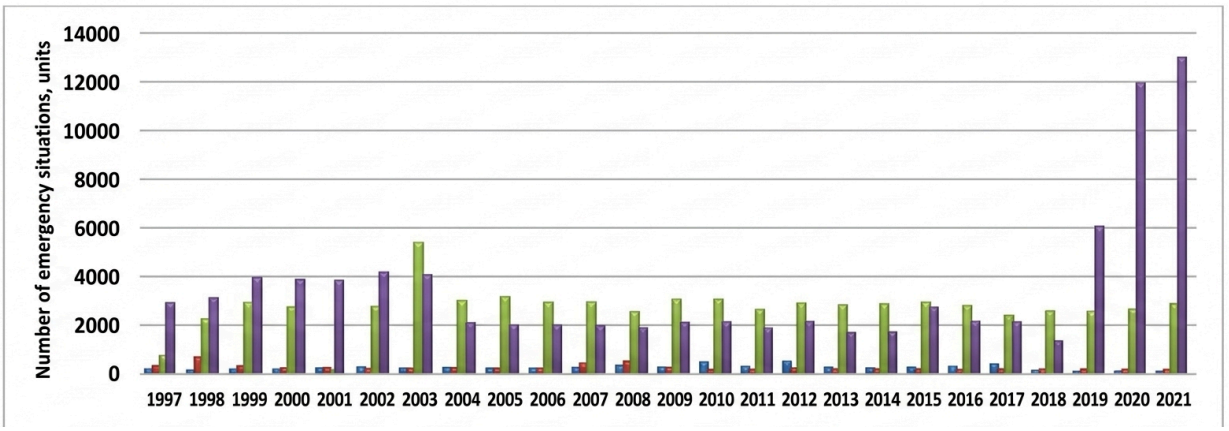

Figure 10 – Disaster trends in Central Asian countries, 1997–2021

Figure 10 shows that the largest number of natural disasters and man-made accidents occurring in Central Asian countries are in the Republic of Kazakhstan and the Republic of Tajikistan.
The dynamics of the number of victims of natural disasters and man-made accidents in Central Asian countries (Kazakhstan, Kyrgyzstan, Tajikistan) in the period from 2000 to 2021 is shown in Figure

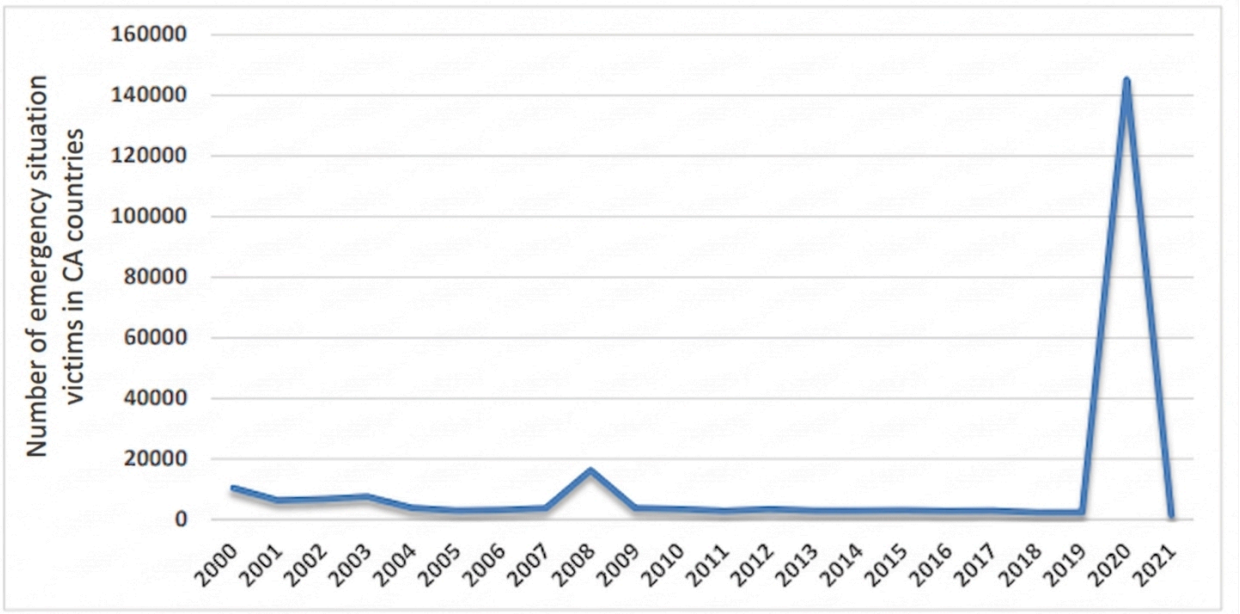

Figure 11 – Dynamics of the number of disaster victims in Central Asian countries, from 2000 to 2021

Figure 11 indicates that between 2000 and 2021, more than 240,600 residents of Central Asia fell victim to natural disasters and man-made accidents.
The highest number of victims occurred in 2020. This circumstance is associated with the coronavirus pandemic (COVID-19).
Of all the disasters occurring in the region, up to 91.6% are man-made accidents,
i.e., caused by humans *(Figure 12) (Academy of Civil Protection of the Ministry of Emergency Situations of the Republic of Kazakhstan, 2023).*

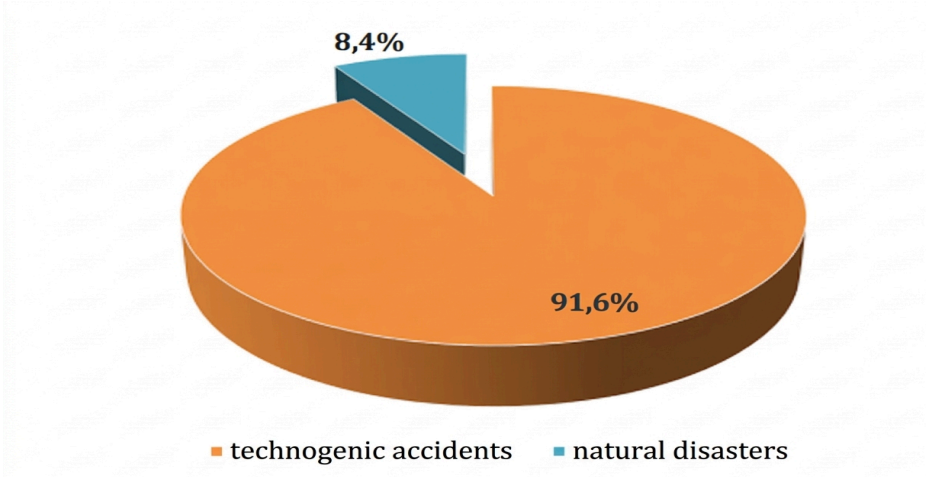

Figure 12 — Ratio of technogenic accidents to natural disasters in Central Asian countries during the period from 1997 to 2021

The ratio of man-made accidents to natural disasters in Central Asian countries is shown in Figures 13-16.

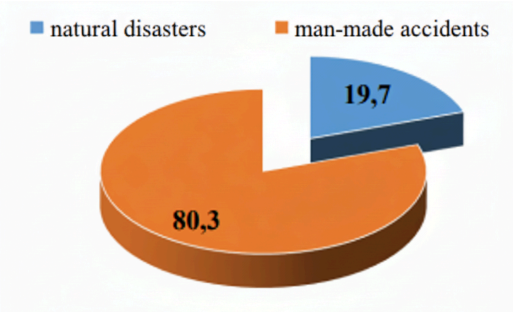

Figure 13. Kazakhstan

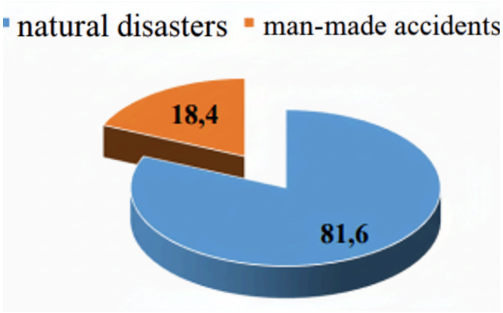

figure 14 Kyrgyzstan

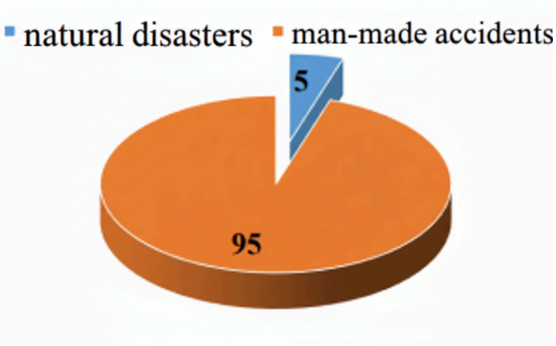

figure 15 Tajikistan

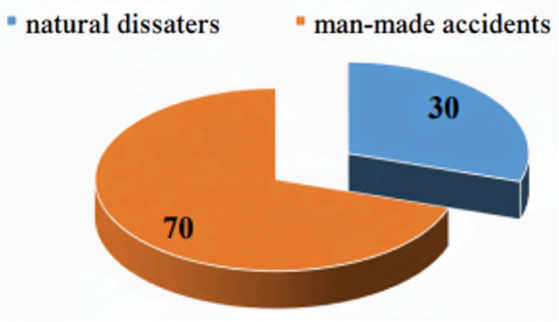

figure 16 Uzbekistan

Figures 13–16 indicate that, in Central Asian countries, the majority of disasters are man-made, with the exception of the Kyrgyz Republic, where over 81% of disasters are attributed to hazardous natural phenomena (Academy of Civil Protection of the Ministry of Emergency Situations of the Republic of Kazakhstan, 2023).
The dynamics of man-made accidents are shown in Figure 17.

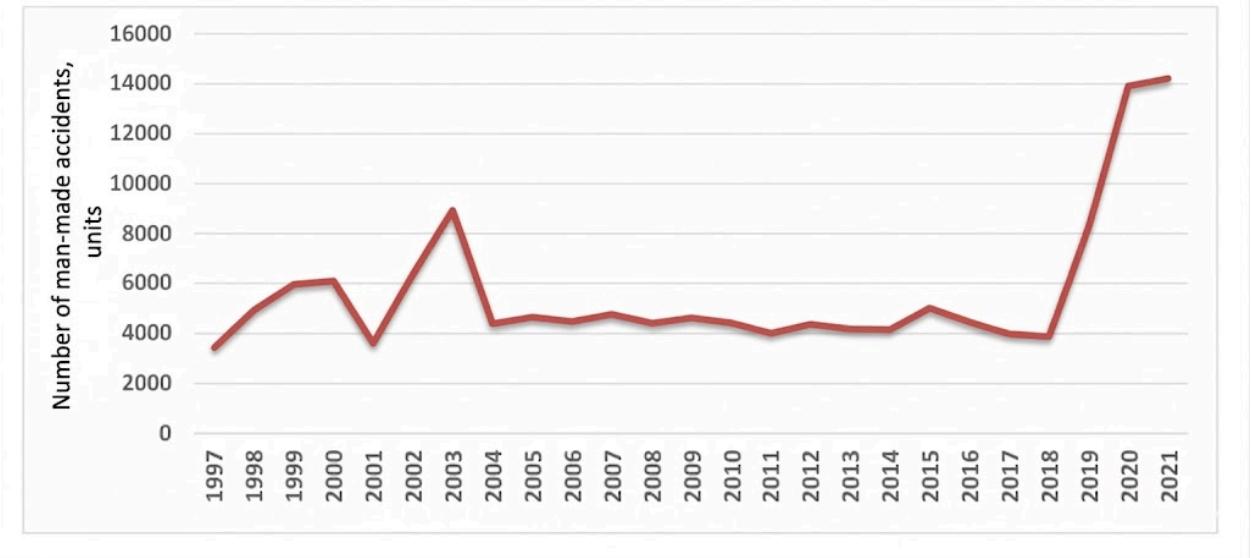

Figure 17 – Dynamics of man-made accidents in Central Asian countries, 1997–2021

Figure 17 indicates that an average of approximately 5,600 man-made accidents occur annually across Central Asian countries.

Figure 18 illustrates the dynamics of man-made accidents in Central Asian countries between 1997 and 2021.

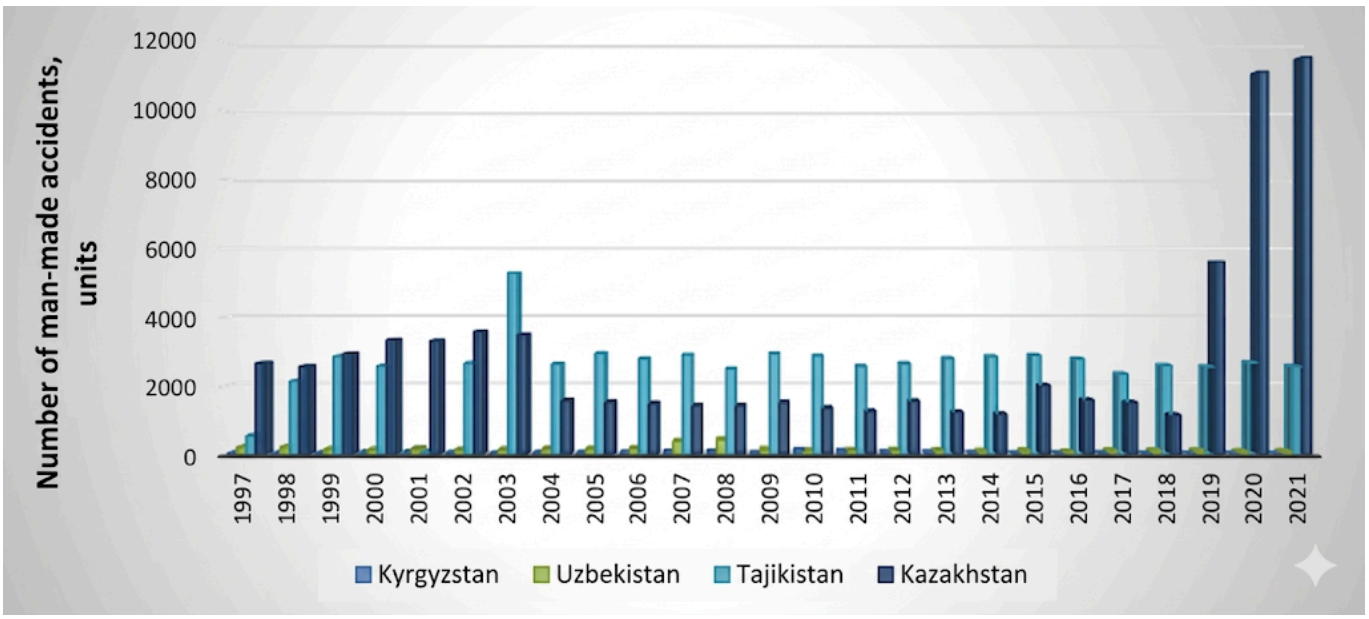

Figure 18 – Dynamics of man-made accidents in Central Asian countries, from 1997 to 2021

Figure 18 illustrates that in recent years there has been an increase in man-made accidents in the Republic of Kazakhstan.

Figure 19 presents the dynamics of the number of casualties resulting from man-made accidents in Central Asian countries (Kazakhstan, Kyrgyzstan, and Tajikistan) between 2000 and 2021.

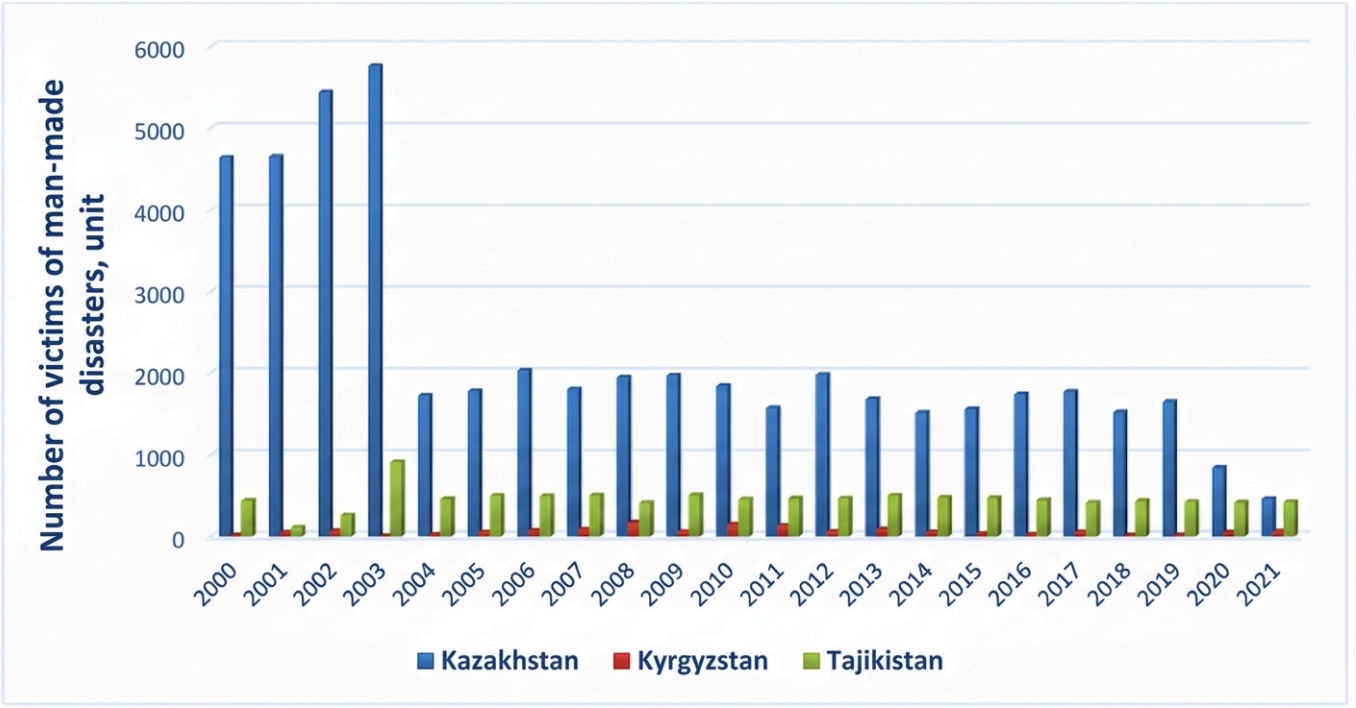

Figure 19 – Trends in casualties from man-made accidents in Central Asian countries, 2000–2021

Figure 20 – Dynamics of natural disasters in Central Asian countries,from 1997 to 2021

Figure 20 illustrates that, in recent years, there has been a rising trend in natural disasters across Central Asian countries. This trend is associated with global climate change, which also affects the Central Asian region.

The annual number of natural disasters in Central Asia has increased from approximately 10 to 15 per year, while the number of floods has risen from 1 to 3 per year.

Figure 20 shows that in recent years there has been a trend of increasing natural disasters in the countries of Central Asia. This phenomenon is associated with climate change occurring worldwide, including in Central Asia.

Figure 21 shows the dynamics of natural disasters by Central Asian countries.

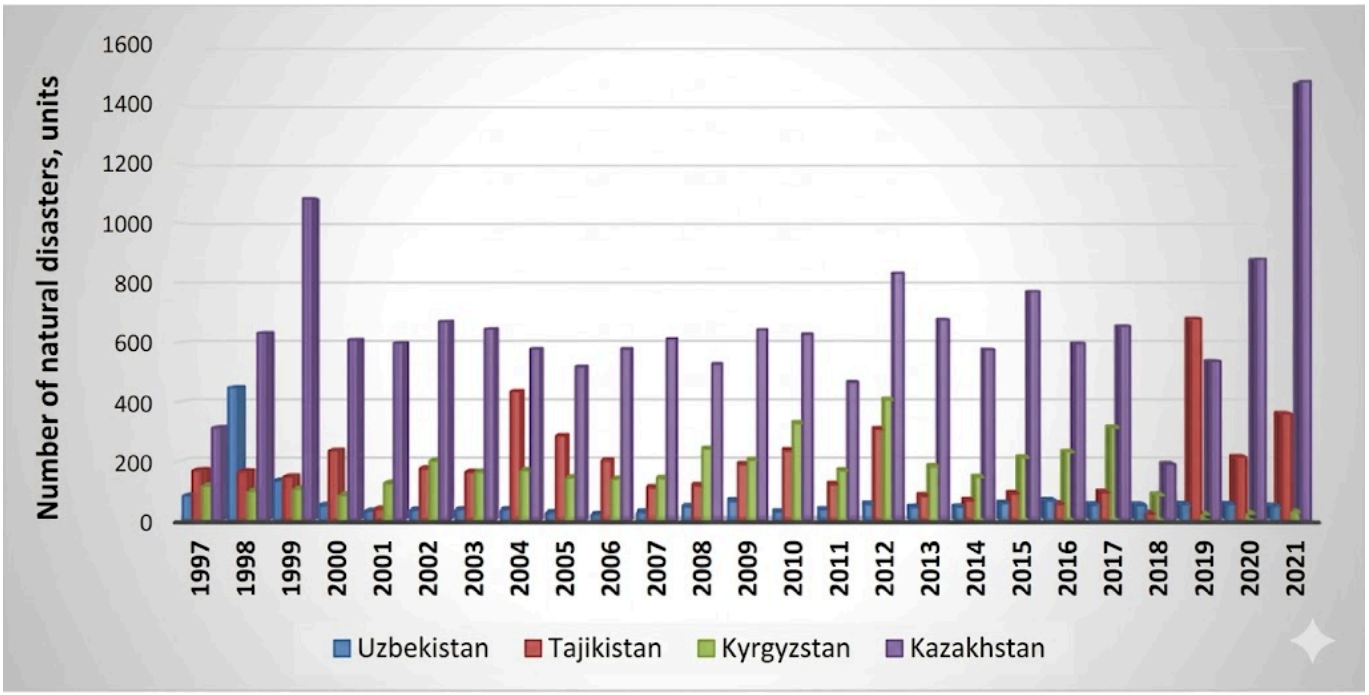

Figure 21 – Dynamics of Natural Disasters by Country in Central Asia, 1997–2021

Figure 21 indicates that natural disasters in the countries of Central Asia during the period under review occurred in waves. The largest number of disasters falls on the Republic of Kazakhstan.

Natural disasters and man-made accidents can simultaneously affect different countries; for example, seismic events in the Fergana Valley (Namangan Region, Uzbekistan) impact the territories of Uzbekistan, Kyrgyzstan, and Tajikistan.

The transboundary nature of natural disasters in Central Asia requires an integrated regional approach for support, planning, and coordination of emergency risk management strategies.

Approximately 75% of fatalities in the countries of Central Asia are caused by natural disasters *(Figure 22) (Academy of Civil Protection, Ministry of Emergency Situations of the Republic of Kazakhstan, 2023)*

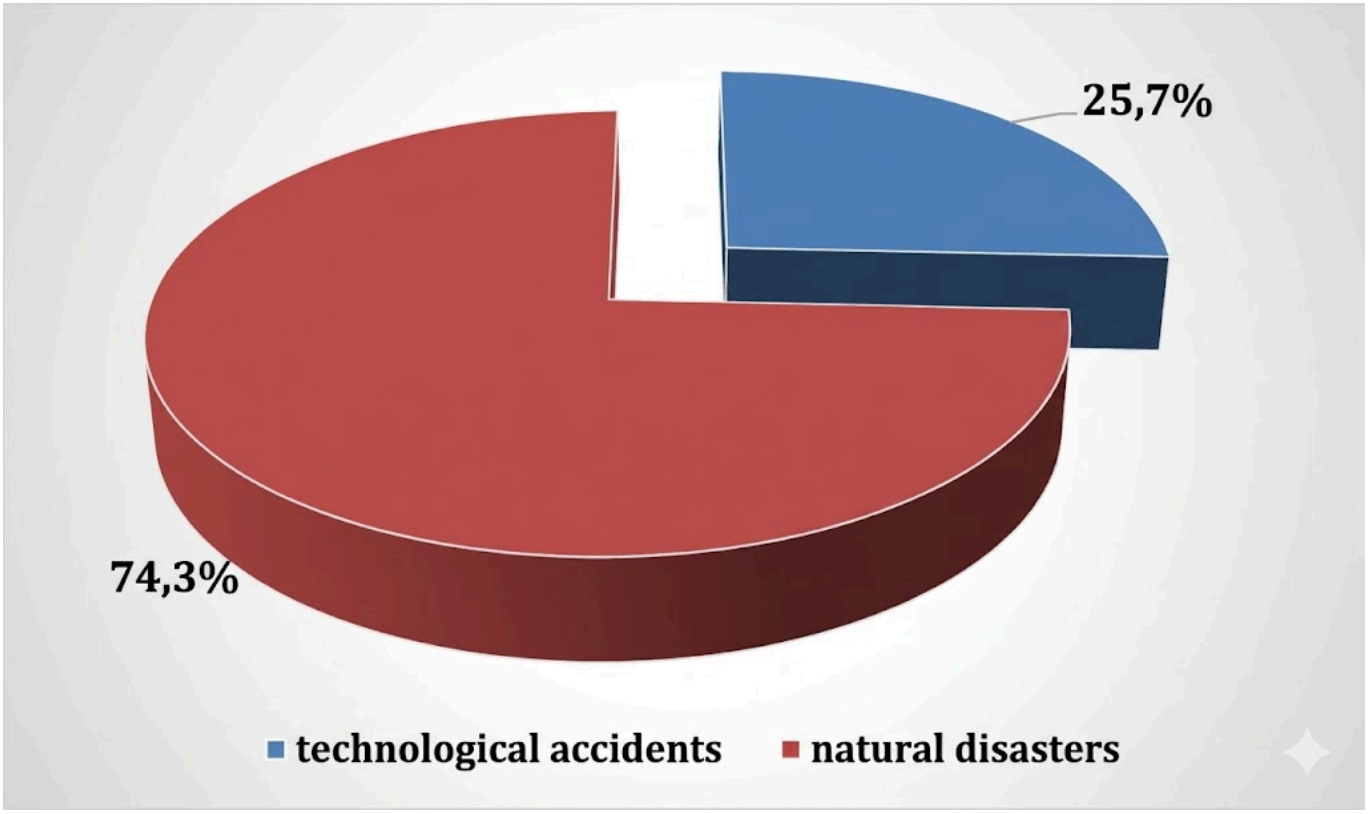

Figure 22 – Ratio of Fatalities from Man-Made Accidents and Natural Disasters in the Countries of Central Asia, 2000–2021

The dynamics of the number of victims of natural disasters in Central Asian countries (*Kazakhstan, Kyrgyzstan, Tajikistan*) between 2000 and 2021 is shown in Figuкy 13

Figure 23 – Dynamics of natural disaster victims in Central Asian countries, 2000–2021

Figure 23 shows that during the period under review, the Republic of Kazakhstan had the highest number of victims of natural disasters in the Central Asian countries (Academy of Civil Protection of the Ministry of Emergency Situations of the Republic of Kazakhstan, 2023).

2.3. Analysis of the vulnerability of Central Asian countries to natural disasters

Climate change, as well as the natural and geographical features of the Central Asian region, are leading to an increase in the frequency and intensity of climate-related natural disasters, including snowmelt and rain floods, landslides, mudslides, and snow avalanches.

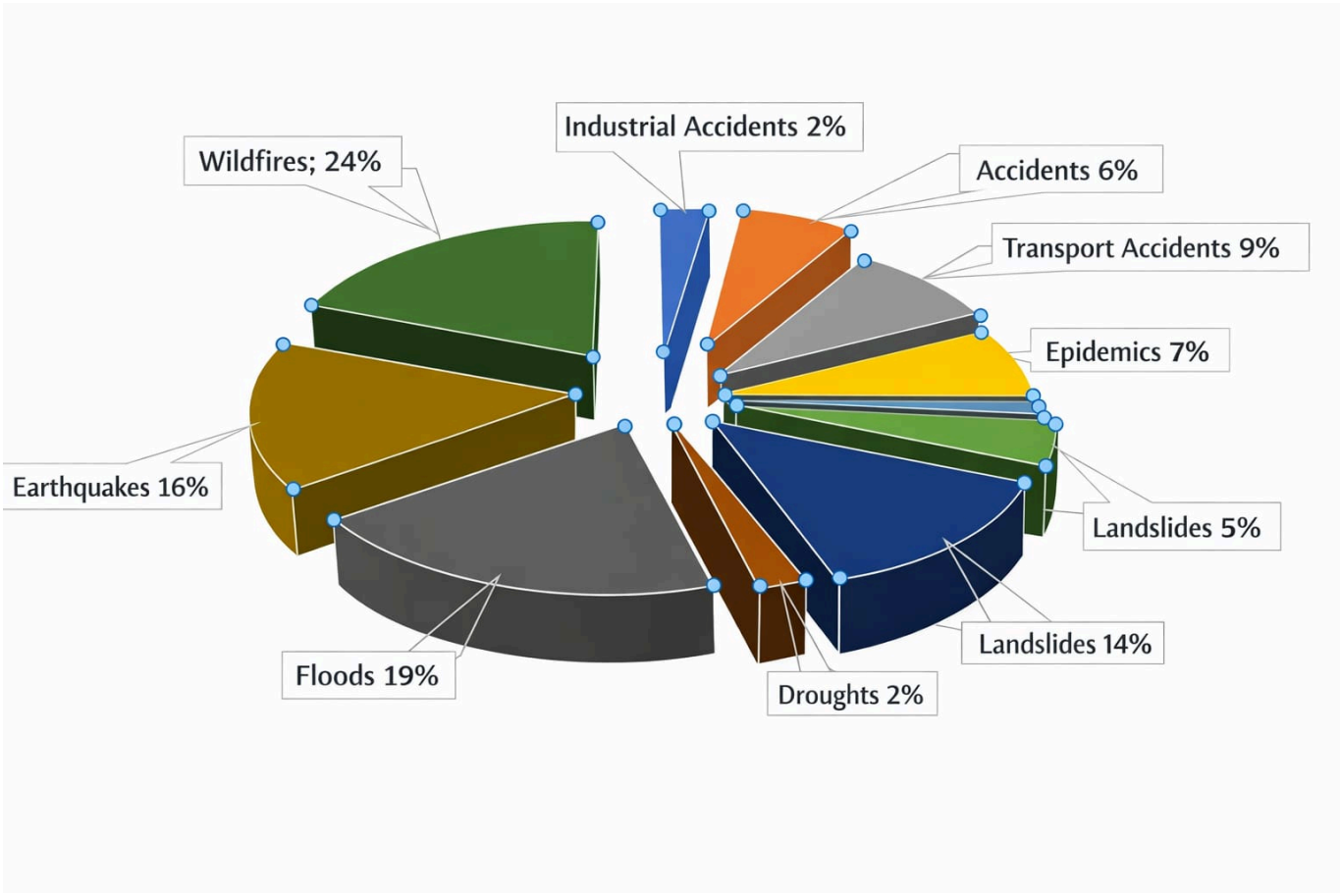

Figure 24 – Percentage distribution of registered natural disasters in the Central Asian region.

The dynamics of natural disasters that occurred in the countries of Central Asia from 2019 to 2021 are presented in Figure 25.

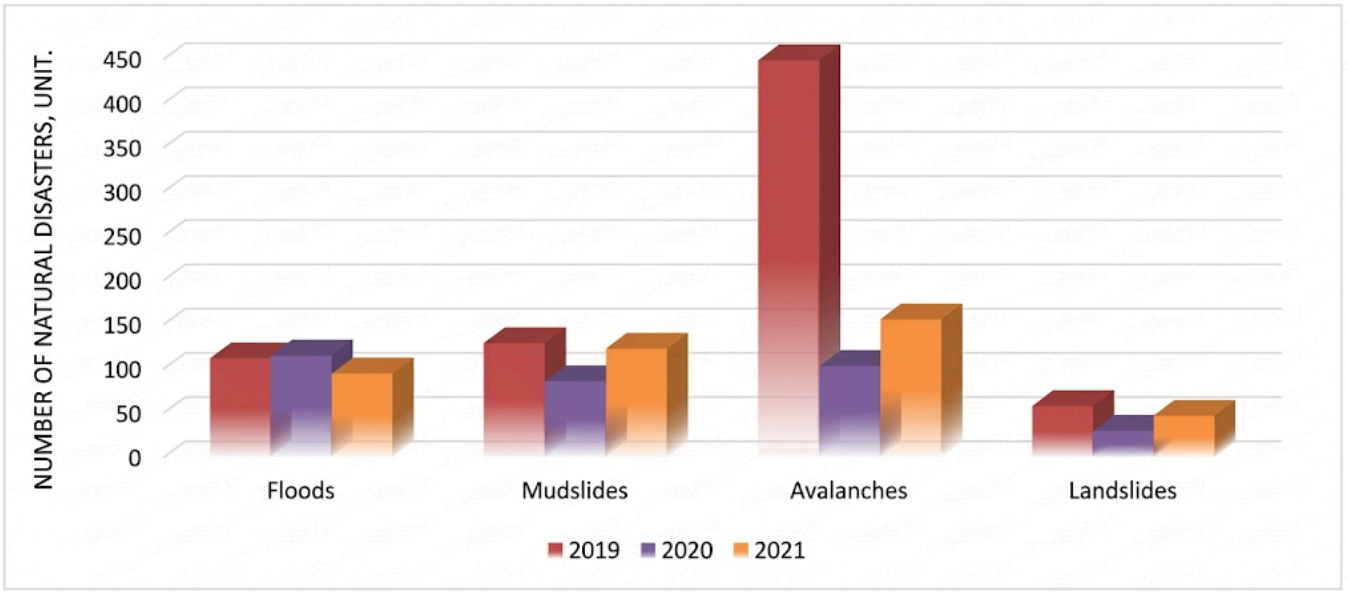

Figure 25 – Dynamics by types of natural disasters that occurred in the countries of Central Asia in the period from 2019 to 2021.

From Figure 25 it can be seen that during the period from 2019 to 2021 in the countries of Central Asia there were 135 landslides; 319 snowmelt and rain floods; 338 mudflows; and 708 snow avalanches

(Academy of Civil Protection of the Ministry of Emergency Situations of the Republic of Kazakhstan, 2023).

The dynamics of snowmelt and rain floods that occurred in the countries of Central Asia from 2019 to 2021 are presented in Figure 26.

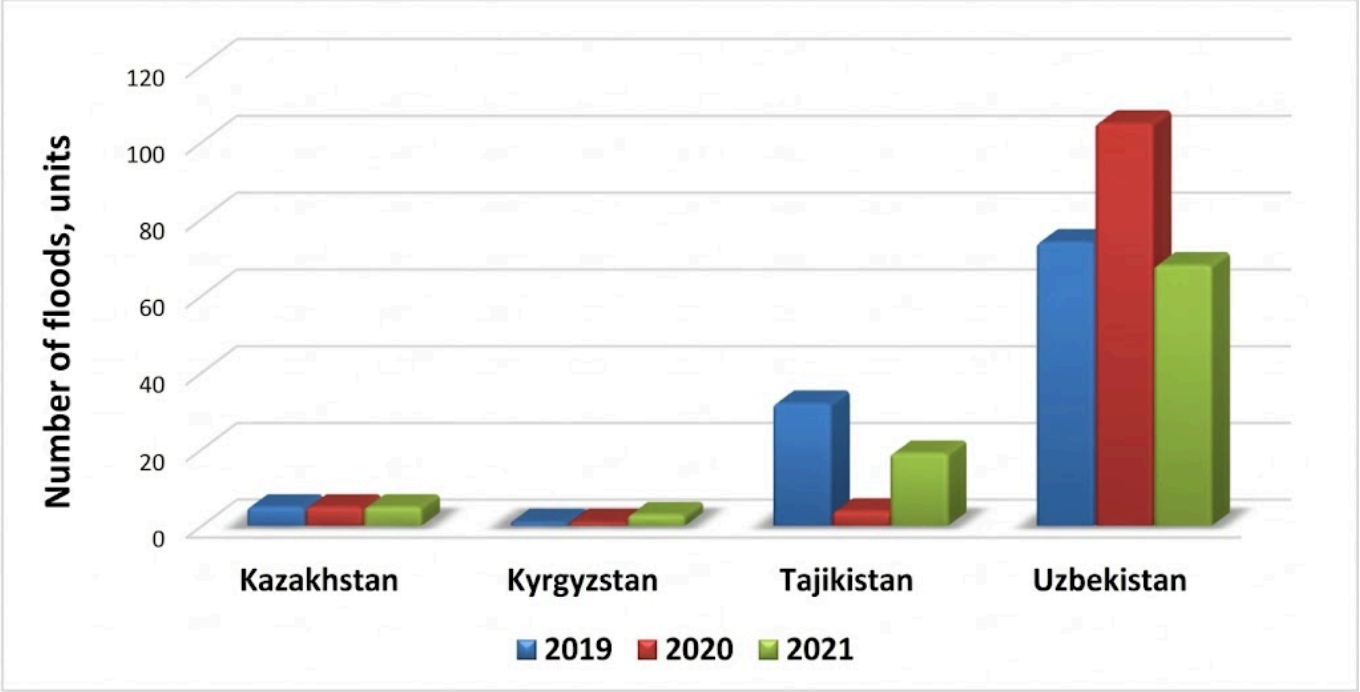

Figure 26 – Dynamics of snowmelt and rain floods that occurred in the countries of Central Asia in the period from 2019 to 2021.

Figure 26 indicates that in recent years the countries of Central Asia have experienced an increase in the number of snowmelt and rain floods (Academy of Civil Protection of the Ministry of Emergency Situations of the Republic of Kazakhstan, 2023).

The dynamics of mudflow events that occurred in the countries of Central Asia from 2019 to 2021 are presented in Figure 27.

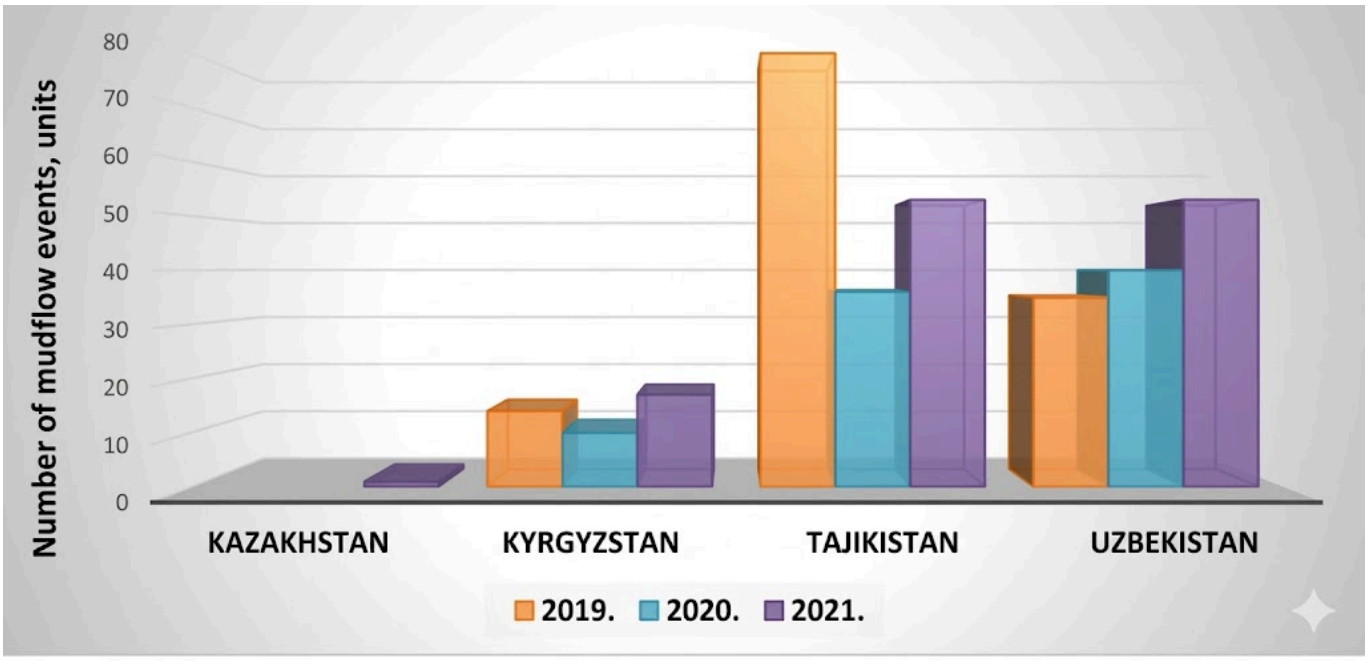

Figure 27 – Dynamics of mudflow events that occurred in the countries of Central Asia in the period from 2019 to 2021.

From Figure 27 it can be seen that the largest number of mudflow events during the period under consideration occurred in the Republic of Tajikistan and the Republic of Uzbekistan (Academy of Civil Protection of the Ministry of Emergency Situations of the Republic of Kazakhstan, 2023).

The dynamics of snow avalanches that occurred in the countries of Central Asia from 2019 to 2021 are presented in Figure 28.

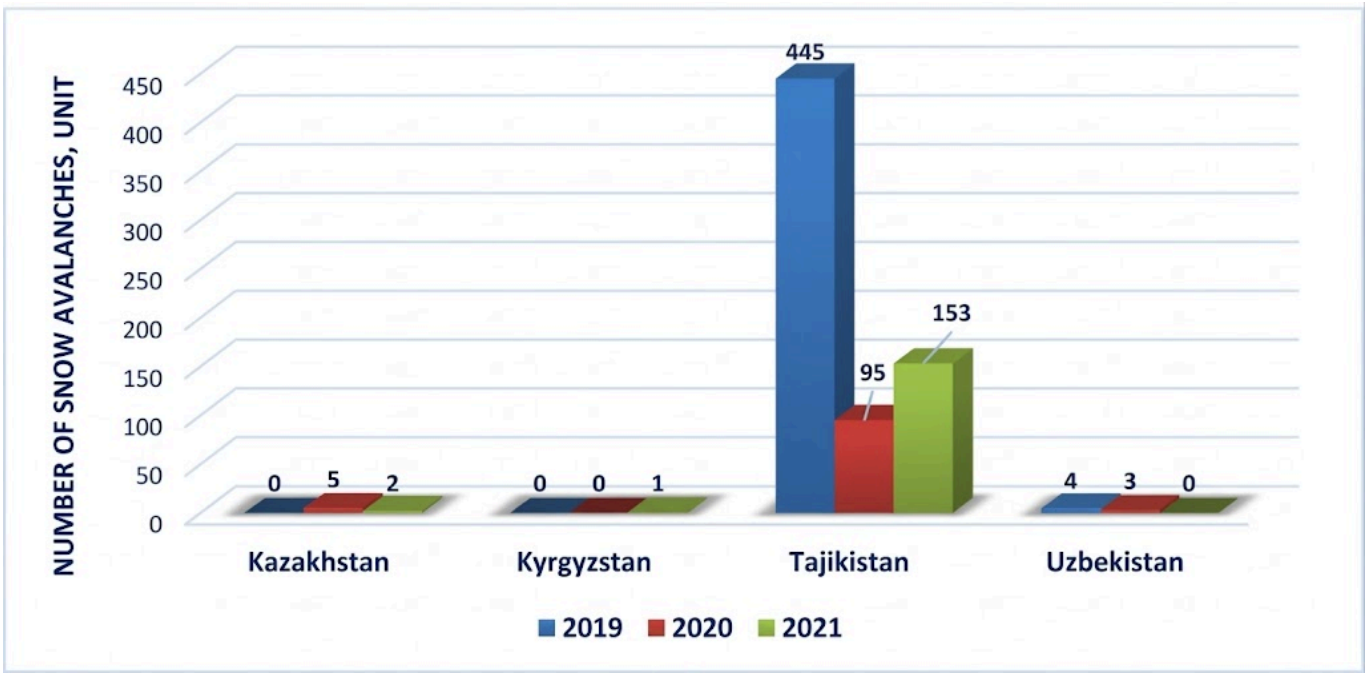

Figure 28 – Dynamics of snow avalanches that occurred in the countries of Central Asia in the period from 2019 to 2021.

From Figure 28 it can be seen that the largest number of snow avalanches during the period under consideration occurred in the Republic of Tajikistan (Academy of Civil Protection of the Ministry of Emergency Situations of the Republic of Kazakhstan, 2023).

The dynamics of landslide processes in the countries of Central Asia from 2019 to 2021 are presented in Figure 29.

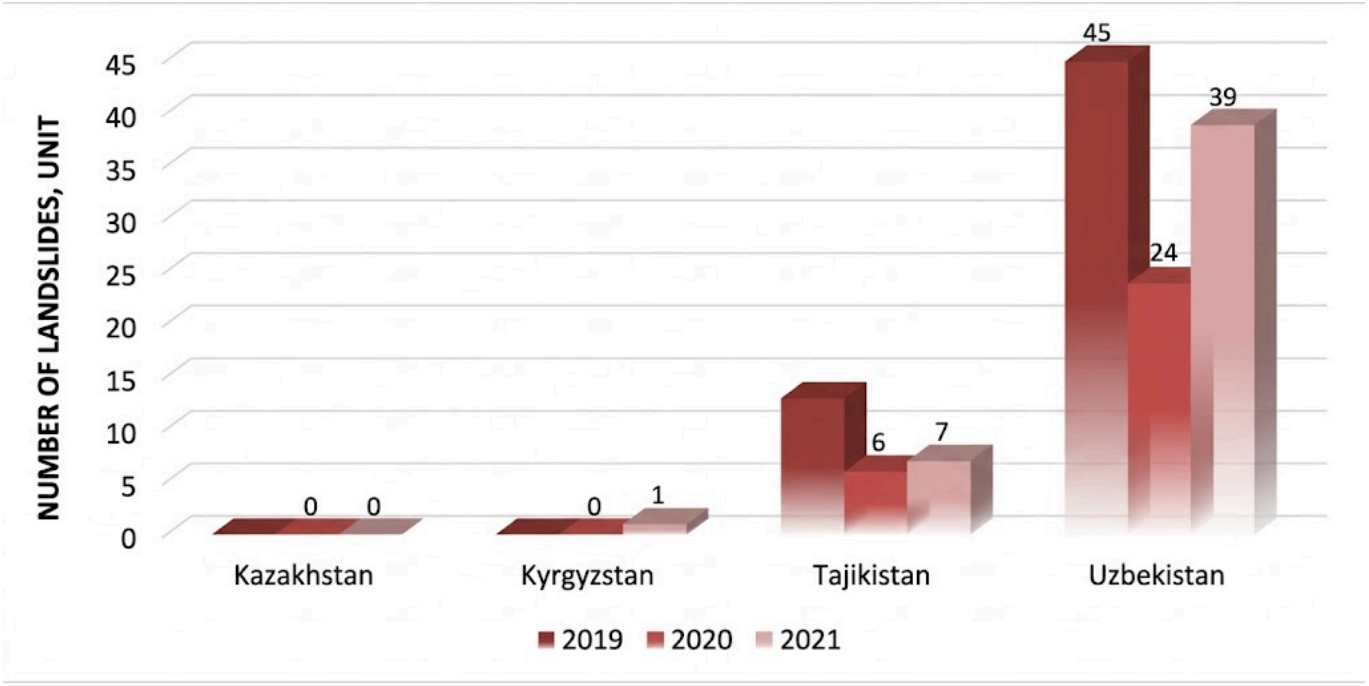

Figure 29 – Dynamics of landslides that occurred in the countries of Central Asia in the period from 2019 to 2021.

Figure 29 indicates that the largest number of landslide processes during the period under consideration occurred in the Republic of Uzbekistan.

III. IDENTIFICATION AND FORECASTING OF CLIMATIC FACTORS CONTRIBUTING TO DISASTER RISK

In recent years, ongoing global climate change has led to human casualties, economic losses, destruction of infrastructure, disruptions in supply chains, and degradation of vital natural and ecological systems.

According to data from the United Nations, in 2022 alone disasters worldwide caused the deaths of nearly 31 thousand people and resulted in economic losses amounting to 223.8 billion US dollars, affecting more than 185 million people.

Climate modelling projections indicate that by the end of the century the temperature across Central Asia may increase by 2.5–6.5 °C compared with the baseline period of 1961–1990 (CAREC, 2020). At the same time, precipitation in the future is likely to be distributed unevenly across the region: north-eastern areas are expected to become wetter, while south-western areas will become drier. This trend has been observed over the past 40–50 years (CAREC, 2020).

Central Asia faces serious challenges in addressing the adverse consequences of climate change. In particular, the impact of climate change on water-related disasters in the region has been recognized as

one of the key threats. For example, over the past 45 years the average temperature has increased by 1°C in Kyrgyzstan, 1.6°C in Turkmenistan, 1.4°C in Kazakhstan and Uzbekistan, while Tajikistan has warmed by 0.7°C.

According to projections, Central Asia will increasingly face periods of abnormal heat, fire-hazardous weather conditions, and droughts, especially in areas with arid and semi-arid climates (Intergovernmental Panel on Climate Change, 2022).

Extreme droughts, which historically occur once every 100 years, are projected to occur 4–10 times more frequently in the region depending on the level of global warming (Naumann et al., 2018).

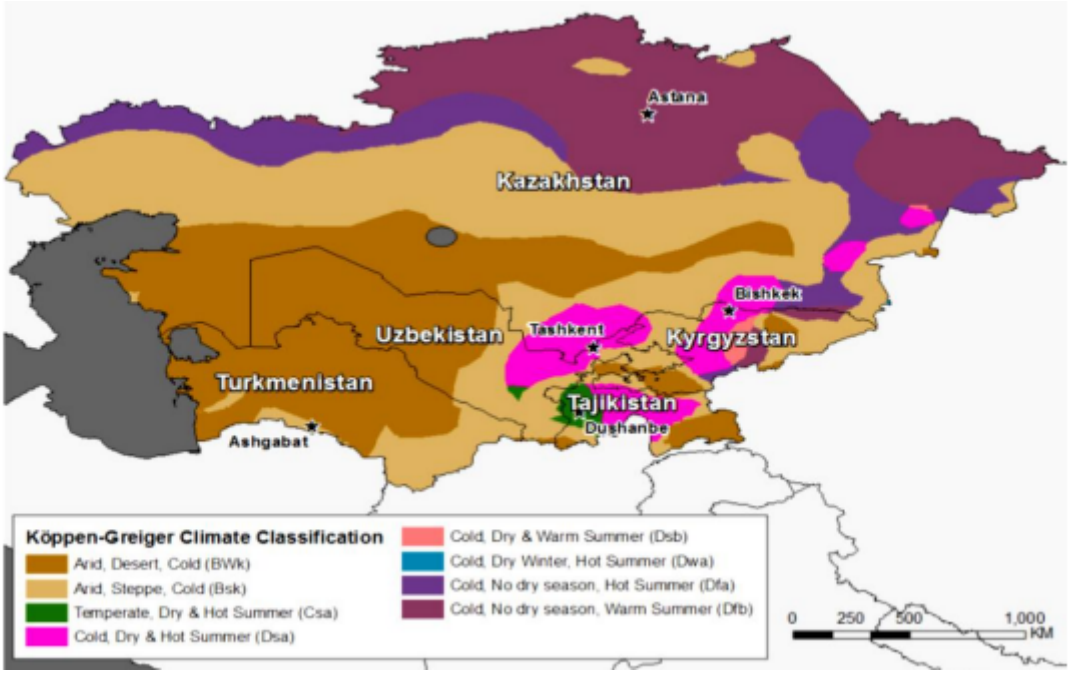

Figure 30 – Climatic classification of Central Asia.

These projections also predict an increase in water scarcity, with a reduction in river flow expected in the basins of major rivers such as the Amu Darya and Syr Darya (International Alert, 2021). It is forecasted that by 2050, the annual river flow of the Amu Darya will decrease by 26–35% (Government of the Republic of Tajikistan, 2022).

Figure 31 – Changes in precipitation in Central Asia

Similar trends are expected for other rivers in the region: projections indicate that in Turkmenistan, the two largest rivers after the Amu Darya — the Murghab and Tejen — will experience a reduction in flow due to rising temperatures and decreased precipitation *(Ministry of Water Resources of Turkmenistan, 2015).*

The consequences of these trends are particularly evident in mountainous areas. In high-altitude zones across Central Asia, reductions in snow-covered areas and snow volumes are projected throughout the 21st century, along with a likely decrease in glacier mass and thawing of permafrost *(IPCC, 2021).* In Uzbekistan, in the basins of several rivers such as the Pskem, Surkhandarya, Kashkadarya, and Chatkal, a sustained reduction in glacial coverage is expected by 2050 *(UzHydromet, 2016*). At the same time, increases in temperature and precipitation may lead to a higher frequency of glacial lake outburst floods and landslides above moraine-dammed lakes *(IPCC, 2021).*

Due to its continental climate, the region is also subject to periodic cold waves and snowstorms in winter. For instance, in early 2023, adverse winter weather in Central Asia, including the lowest recorded temperatures in the region's meteorological history, had a significant impact on infrastructure and the economy, *causing disruptions in gas, electricity, and water supply, failures at critical facilities, and major roads blocked by snow*, as well as affecting livelihoods and human health *(some households resorted to burning waste as fuel, resulting in severe air pollution) (Eurasianet, 2023).*

It is generally accepted that climate change exacerbates extreme weather events (*Buchholz, 2023)*; however, the influence of climate change on the increasing intensity of extremely cold natural phenomena remains debated (*Brown, 2022).*

Global climate change can affect security and stability in Central Asia in a variety of ways.

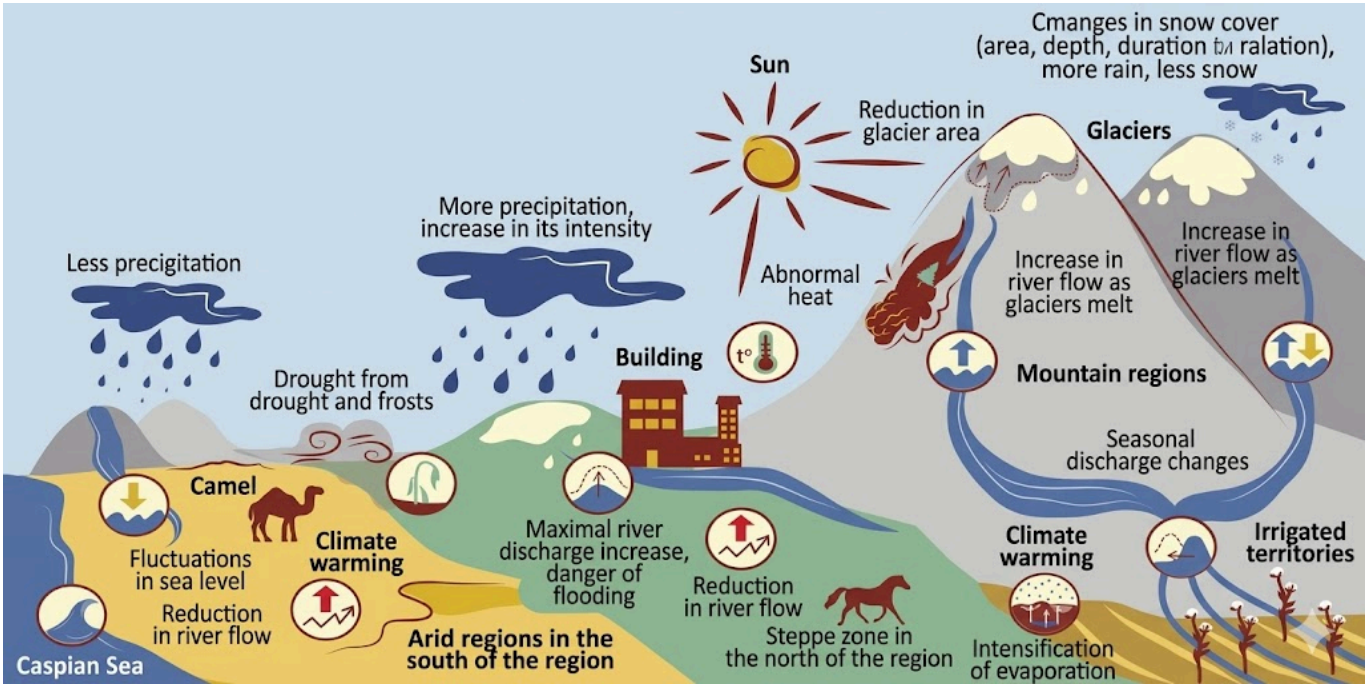

Figure 32 – Climate Change Trends and Projections in Central Asia

Let us consider the likely scenarios of climate impact on disaster risk in Central Asia.

Agricultural Sector

The impact on ecosystems presents a particular challenge for the local population, whose livelihoods depend directly on agriculture and natural resources. It is expected that the habitat range of the Italian locust (*Calliptamus italicus*) will expand in Central Asia, while in Kazakhstan, drought is already causing slowed tree growth and forest regeneration, as well as increased tree mortality *(IPCC, 2022)*.

Changes in river flow regimes may affect irrigation systems in the region *(IPCC, 2022)*, thereby threatening food security in lowland areas that heavily depend on irrigation *(Novikov and Kelly, 2017).*

Furthermore, the projected increase in heat stress is expected to lead to a reduction in the area of arable land in Central Asia, which, combined with worsening water scarcity, will negatively affect agricultural productivity in the region.

However, the impact of these factors varies across the countries of the Central Asian region, depending on the type of farming operations *(large or small)*, as well as the agricultural technologies and water use practices employed *(IPCC, 2022).*

Energy Sector

Security threats may also arise from the impact of climate change on the energy sector. Changes in glacial and river flow regimes may affect the operation of hydropower plants *(IPCC, 2022)*. For example, projections indicate that with a 2°C warming, the potential of small hydropower plants is expected to decrease by 13% in Turkmenistan and by 19% in Kyrgyzstan by 2050 *(Reyer et al., 2017).* Out of 300 small hydropower plants in Tajikistan, less than 20 percent remain operational *(United Nations Economic Commission for Europe, n.d.).* The hydropower sector is also highly vulnerable to floods, and most hydraulic structures in the region require technical maintenance to ensure their safe operation *(OSCE, 2022).* This makes mountainous areas of Kyrgyzstan and Tajikistan particularly vulnerable to climate

change, given their dependence on hydropower to meet their energy needs *(Adler et al., 2022; Novikov and Kelly, 2017).*

Countries dependent on hydropower are increasingly turning to coal as a short-term solution to energy security challenges. For example, Kyrgyzstan relies on coal to cope with increased electricity demand during winter months, when reservoir water levels are low and electricity demand is high (*OSCE, 2022).* In Kazakhstan, coal accounts for 50 percent of energy consumed from primary sources and 70 percent of electricity production *(IEA, 2020).* However, continued coal use has serious negative impacts on the environment and human health, and if this practice persists long-term, it may increasingly impede the achievement of current climate goals and sustainable development plans *(OSCE, 2022).*

Regarding the Caspian regions of Kazakhstan and Turkmenistan, oil and gas infrastructure located there remains vulnerable to sea level fluctuations, storm surges, and other extreme events *(Novikov and Kelly, 2017; Tehran Convention Secretariat, 2021)*, with potential consequences for energy security and the revenues of countries dependent on these resources.

Health Sector

Increasing concern also arises from the impact of climate change on human health. The growing frequency and intensity of hazardous natural events across Asia, such as periods of abnormal heat, floods, and droughts, may lead to an increase in transmissible and waterborne diseases, malnutrition, mental health disorders, and allergic conditions *(IPCC, 2022).*

In areas of Central Asia with non-compliant water supply and sanitation systems, heavy rainfall may increase the risk of waterborne disease transmission, such as typhoid fever, salmonellosis, and dysentery *(Novikov and Kelly, 2017).*

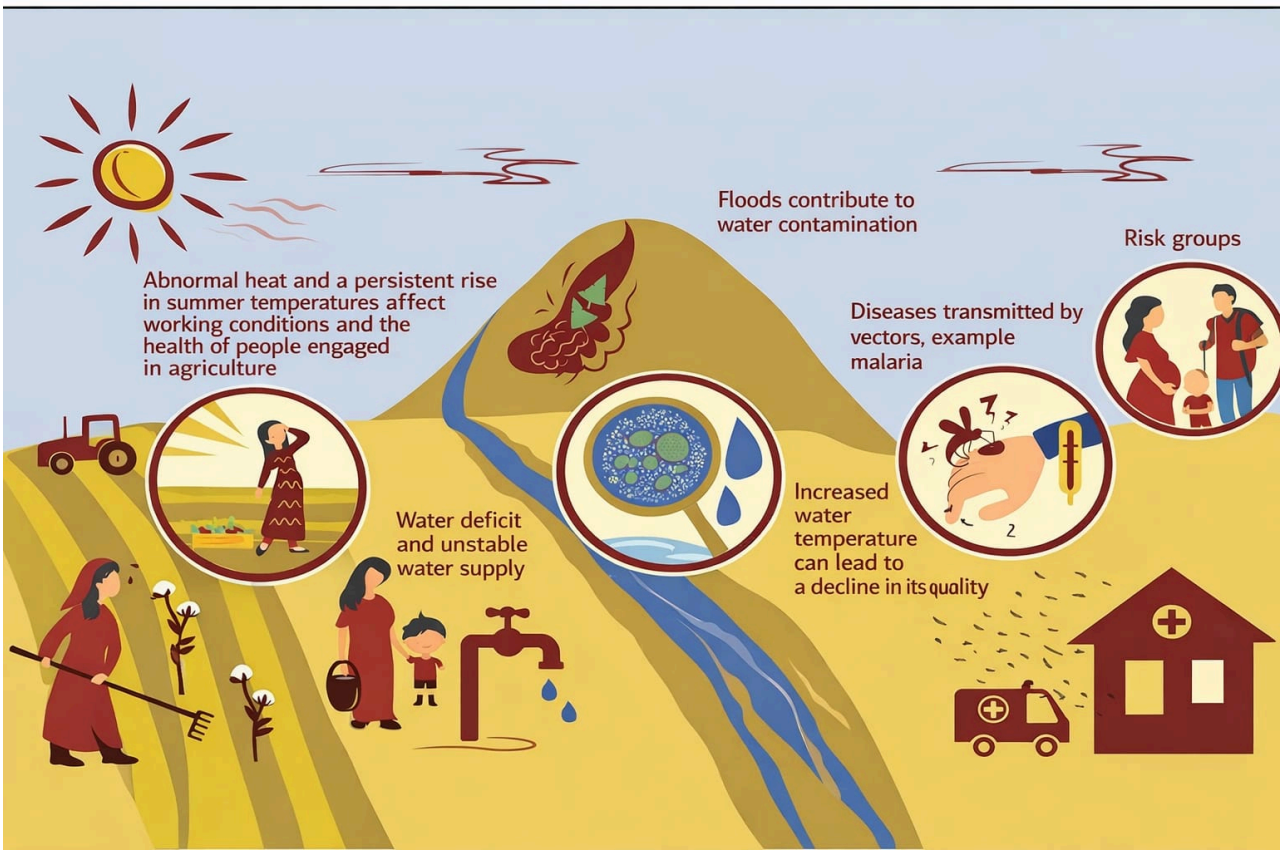

Figure 33 – Climate Change and Risks to Human Health

In addition, as a consequence of abnormal heat and higher temperatures, there may be an increase in deaths related to heat, as well as deaths from cardiovascular, respiratory, diabetic, and infectious diseases, along with a rise in infant mortality rates *(PCC, 2022).*

In the region, urban populations and agricultural workers are particularly vulnerable under such conditions *(Novikov and Kelly, 2017).* Furthermore, dust storms, the frequency of which is expected to increase with rising aridity, may increase the exposure of populations in Central Asia to dust and exacerbate respiratory problems, as well as skin and eye diseases *(Reyer et al., 2017).*

Population Mobility

Various forms of population mobility, including short-term displacement due to climate-related disasters, as well as seasonal and long-term migration, are increasingly affected by climate-related impacts.

The projected increase in the frequency of extreme weather events may lead to a further rise in short-term population movements in Central Asia, particularly in mountainous areas, due to rapidly occurring weather and climate-related catastrophes, such as floods, mudflows, and landslides *(Blondin, n.d.).* For example, in May 2020, the collapse of the Sardoba Reservoir dam on the Uzbek side of the Syr Darya River caused severe flooding, resulting in six fatalities and the displacement of more than 100,000 residents of the border areas of Kazakhstan and Uzbekistan *(IDMC, 2021; Radio Free Europe/Radio Liberty, 2021; Xiao et al., 2022).*

Seasonal and long-term migration is already common in Central Asia and has significant socio-economic importance for the areas of origin of migrants due to remittances. Among the various drivers of migration, ecosystem degradation and loss of livelihoods due to climate change impacts, especially in the agricultural sector, represent an important motivating factor *(Novikov and Kelly, 2017; Reyer et al., 2017)*. For instance, in the past, drought and water scarcity repeatedly caused cyclical migratory movements in the Aral Sea region during the 1990s and early 2000s *(Novikov and Kelly, 2017).*

By exacerbating the degradation of vulnerable ecosystems, including the Aral and Caspian Seas, the Tian Shan and Pamir Mountains, and the basins of the Amu Darya and Syr Darya rivers, climate change is likely to accelerate migration flows and influence the drivers of migration in the region (*IOM, 2021).* It is estimated that by 2050, 2.4 million people may be forced to migrate from Central Asia due to the impacts of climate change *(ICMPD, 2022).* This trend takes different forms for different population groups in the region. In rural mountainous areas, for example, there is usually large-scale labor migration of men and working-age youth, which increases the burden on the most vulnerable groups, including women, children, and the elderly, who often remain in the area and are therefore disproportionately exposed to climate risks *(Novikov and Kelly, 2017).*

Human Security

Disasters such as floods, hurricanes *(including snowstorms and dust storms*), and wildfires pose a direct threat to the security of individuals and populations, the severity of which depends on their level of preparedness as well as access to assistance and services in the post-disaster period. Residents of mountain villages are particularly vulnerable to landslides, mudflows, and avalanches, the risk of which is increased by rising temperatures and glacial melt *(CAREC, 2020)*, as well as relatively higher levels of poverty and isolation compared to lowland populations *(Novikov and Kelly, 2017).*

Transboundary Natural Resources

Central Asia has already experienced several instances of tension over transboundary natural resources, primarily water and related infrastructure, such as dam construction. Tensions have also arisen due to competition for access to land and water resources, particularly in border areas such as the Fergana Valley, where boundaries are not fully delimited *(Climate Diplomacy, n.d.)*. This situation, combined with the impacts of climate change, may further limit the availability and accessibility of these resources *(Mirimanova et al., 2018).*

IV. TRANSBOUNDARY COOPERATION IN DISASTER RISK MANAGEMENT

The governments of Central Asian countries are taking steps to strengthen regional cooperation in various areas related to disaster risk reduction and technological accident management.

The basis for developing cooperation on transboundary issues in this field among Central Asian countries is provided by various multilateral intergovernmental agreements on cooperation in disaster risk management, technological accident management, and mitigation of their consequences (Table 2).

Table 2 – List of Multilateral International Agreements in the Field of Disaster and Technological Risk Management

№	Name of the Document	Date and Place of Signing
1	Agreement between the Governments of the CIS Member States on Cooperation in the Field of Prevention and Elimination of the Consequences of Natural and Technogenic Emergencies	22 January 1993, Minsk
2	Decision of the Council of Heads of Governments of the Commonwealth on the Commonwealth of Independent States Forces for the Elimination of the Consequences of Natural and Technogenic Emergencies	9 December 1994, Moscow
3	Agreement between the Governments of the CIS Member States on Cooperation and Interaction in the Study of Earthquakes and the Forecasting of Seismic Hazards	24 September 1993, Moscow
4	Agreement between the Republic of Kazakhstan, the Kyrgyz Republic, the Republic of Tajikistan, and the Republic of Uzbekistan on Cooperation in the Prevention and Elimination of Emergencies	17 September 1998, Cholpon-Ata
5	Agreement between the CIS Member States on the Use and Development of the Transport Network for the Needs of the Economy, Military, and Humanitarian Transport of the CIS Member States	31 January 2001, Minsk
6	Decision of the Council of Heads of Governments of the CIS Member States on the Procedure for Organizing the Elimination of the Consequences of Natural and Technogenic Emergencies	29 November 2001, Moscow
7	Agreement between the Governments of the CIS Member States on Mutual Assistance in Cases of Accidents and Other Emergencies at Power Facilities of the CIS Member States	30 May 2002, Moscow
8	Agreement between the CIS Member States on the Exchange of Information on Natural and Technogenic Emergencies, and on Information Interaction in the Elimination of Consequences and Assistance to Affected Populations	18 September 2003, Yalta

9	Decision on the Establishment of a Reserve Fund of the CIS Member States to Assist States Affected by Natural and Technogenic Emergencies	16 April 2004, Cholpon-Ata
10	Agreement on Cooperation of the CIS Member States in the Field of Prevention and Elimination of Emergencies	16 October 2015, Burabay
11	Protocol on Amendments and Additions to the Agreement on Cooperation in the Field of Prevention and Elimination of the Consequences of Natural and Technogenic Emergencies dated 22 January 1993	30 October 2015, Dushanbe
12	Agreement between the Governments of the Member States of the Shanghai Cooperation Organization on Cooperation in Providing Assistance for the Elimination of Emergencies	26 October 2005, Moscow
13	Protocol to the Agreement between the Governments of the Member States of the Shanghai Cooperation Organization on Cooperation in Providing Assistance for the Elimination of Emergencies dated 26 October 2005	5 December 2012, Bishkek
14	Agreement on Cooperation in Ensuring Industrial Safety at Hazardous Production Facilities	28 September 2001, Moscow
15	Agreement on the Collective Rapid Reaction Forces of the Collective Security Treaty Organization	14 June 2009, Moscow
16	Decision on the Statement of the Heads of States – Members of the Commonwealth of Independent States on Cooperation in the Climate Sphere	11 October 2022, Astana
17	Astana Declaration of the Council of Heads of States – Members of the Shanghai Cooperation Organization	4 July 2024, Astana
18	Agreement between the Governments of the Member States of the Shanghai Cooperation Organization on Cooperation in the Field of Environmental Protection	4 July 2024, Astana

Taking into account that none of the regional agreements cover all Central Asian countries, it should be noted that there are a number of bilateral agreements aimed at ensuring cooperation in disaster risk reduction, preparedness, and response. The table below, Table 3, lists some bilateral agreements that are legally binding for the countries of the Central Asian region; however, this list is not exhaustive and continues to expand.

Table 3 – List of Bilateral International Agreements in the Field of Disaster Risk and Technological Accident Management

№	Name of the document	Dane and place of Signing
1	Agreement between the Government of the Republic of Kazakhstan and the Government of the Kyrgyz Republic on Cooperation in the Field of Civil Defense, Prevention, and Elimination of Emergencies	16 June 2009, Astana
2	Agreement between the Government of the Republic of Kazakhstan and the Government of the Kyrgyz Republic on the Establishment of a Center for Emergency Situations and Disaster Risk Reduction	17 May 2013, Almaty
3	Agreement between the Government of the Republic of Kazakhstan and	6 September

	the Government of the Republic of Tajikistan on Cooperation in the Field of Civil Defense, Prevention, and Elimination of Emergencies	2014, Almaty
4	Agreement between the Government of the Kyrgyz Republic and the Government of the Republic of Tajikistan on Cooperation in the Field of Civil Defense, Prevention, and Elimination of Emergencies	27 May 2013, Bishkek
5	Agreement between the Government of the Republic of Tajikistan and the Government of the Republic of Uzbekistan on Joint Measures and Interaction Regarding Timely Alerts in Case of the Breakthrough of Lake Sarez	30 May 2000, Tashkent
6	Agreement between the Government of Turkmenistan and the Government of the Republic of Uzbekistan on Cooperation in the Field of Prevention and Elimination of Emergencies	25 November 2013, Tashkent
7	Agreement between the Government of the Kyrgyz Republic and the Government of the Republic of Tajikistan on Cooperation in the Field of Civil Defense, Prevention, and Elimination of Emergencies	27 May 2013, Bishkek
8	Agreement between the Government of the Republic of Tajikistan and the Government of Turkmenistan on Cooperation in the Field of Civil Defense, Prevention, and Elimination of the Consequences of Emergencies	2 November 2017, Dushanbe

Taking into account that the Central Asian region is prone to transboundary disasters, existing multilateral and bilateral international agreements on disaster risk management do not address issues of early warning of disasters and hazards between Central Asian countries, operational response to them, and the provision of international assistance. This circumstance determines the need for the adoption of international agreements by the Central Asian countries on disaster early warning, disaster response, and regulation of the provision of international assistance.

During the 4th Consultative Meeting of the Heads of Central Asian States in July 2022, all five countries adopted the “Roadmap for the Development of Regional Cooperation (2022–2024)”. This document provides for the creation of a number of interagency cooperation mechanisms focused on environmental protection, energy, education, and culture.

In addition, the meeting adopted the Central Asian Regional Program “Green Agenda”, which aims to strengthen cooperation in green economic growth and sustainable development through the implementation of joint projects, technology transfer, and knowledge exchange (Ministry of Foreign Affairs of the Kyrgyz Republic, 2022).

Together with international partners, the governments of the Central Asian countries also implement a number of regional-level projects and initiatives aimed at addressing various climate change-related challenges and strengthening regional cooperation in tackling these issues.
The Center for Emergency Situations and Disaster Risk Reduction is actively operating in the Central Asian region. During its relatively short period of existence, the Center has succeeded in creating a high-level regional platform for disaster risk reduction – the Regional Forum – Meeting of Heads of Emergency Services of Central Asian Countries, whose members are the top officials of the authorized civil protection agencies. It is important to note that the Center has ensured the sustainable functioning of this platform, which currently maintains active dialogue between the governments of the countries on regional disaster risk reduction.

Within the framework of the Regional Forum, important strategic documents have been adopted, aimed at strengthening regional and international cooperation in disaster risk reduction and enhancing the capacity of emergency response services of the authorized agencies of Central Asian countries. One of the most significant documents is the Strategy for the Development of Cooperation of Central Asian Countries in Disaster Risk Reduction for 2022–2030.

This strategic document reflects the key problem areas in the region, identifies trends in disaster risk management, and outlines directions for effective regional cooperation in this field. The document also formulates specific tasks that need to be addressed to achieve the set objectives:

- *Strengthening the institutional foundations for regional and transboundary cooperation of countries in the field of disaster risk reduction.*
- *Development of a common information space for the assessment and forecasting of disaster risks and the occurrence of emergencies.*
- *Support for the development of human resource capacity in the countries of the region in the field of disaster risk reduction.*
- *Support for the development of National Platforms for Disaster Risk Reduction in Central Asian countries to develop and implement strategies for disaster risk reduction at national and local levels.*
- *Support and mobilization of investments in the field of disaster risk reduction, involving the private sector, international and regional organizations, and partners.*

In addition, for the practical implementation of the aforementioned tasks at the regional level, a Roadmap for the Implementation of the Strategy for 2023–2024 was adopted. In 2024, the Center is developing a draft Roadmap for 2025–2026, which will be submitted for consideration to the heads of emergency services of the Central Asian countries. This document is aimed at moving from the stage of risk awareness to concrete and effective measures that contribute to improving emergency preparedness and strengthening sustainable development.

Furthermore, the United States Agency for International Development (USAID) is implementing a number of initiatives and projects in Central Asia aimed at addressing environmental and water-related issues. For example, its activities on the restoration of the Aral Sea ecosystem (2021–2024) are aimed at improving soil and vegetation conditions in certain parts of the Aral Sea through afforestation activities, which will enhance landscape resilience and the livelihood resilience of local populations (USAID, 2021).

An analysis of transboundary cooperation among Central Asian countries allows the conclusion that, although there are a number of agreements between neighboring countries on disaster and technological risk management, information is exchanged regarding threats and the occurrence of disasters, and joint exercises and training are conducted, there remains a problem with joint response to transboundary natural disasters. This problem is due to the lack of clarity in organizational coordination, the exchange of forecast information, and other factors, which hinders the ability to respond promptly and take joint actions to reduce disaster risks.

This problem could be addressed through the development of a more detailed methodology for comprehensive management of transboundary disaster risks in Central Asia, taking into account ongoing climate change.

V. GOALS, OBJECTIVES, AND PRINCIPLES OF RISK MANAGEMENT

5.1. Definition of the Main Goals and Objectives of Disaster Risk Management

The goal of disaster risk management is to assess the comprehensive safety characteristics of the territories of Central Asia, which are exposed to natural and technological disaster risks, and to develop proposals for their reduction and prevention based on existing and newly incoming data and operational information on disasters, as well as the results of their studies.

Disaster risk management has several main goals, which help to ensure the safety and resilience of the Central Asian countries. The primary goals of disaster risk management are:

1. **Monitoring and forecasting of risks and threats**: This includes a comprehensive observation of the state of the environment (atmosphere, hydrosphere, other geospheres, soil and vegetation cover, wildlife, and technosphere objects), as well as anticipatory assessment of the probability of occurrence and development of an emergency based on the analysis of possible causes, both historical and current.

2. **Elimination of factors contributing to risk:** By identifying and addressing factors that contribute to the emergence of risks in advance, it is possible to minimize the likelihood of disasters.

3. **Crisis decision-making:** The development of strategies and action plans aimed at minimizing the consequences of disasters.

4. **Financing of disaster risk:** This approach complements other elements of a comprehensive disaster risk management strategy, ranging from investments in risk reduction to improving disaster preparedness and ensuring sustainable recovery and reconstruction.

Financial protection involves advance planning, which helps to better manage the cost of disasters, ensure predictable and timely access to necessary resources, and ultimately mitigate the long-term financial impact of disasters.

The objectives of disaster risk management in Central Asia are:

- Collection, processing, and archiving of information on natural and technological disasters;
- Physical and statistical analysis of the collected disaster information;
- Classification of disasters according to their sources and the scale of their negative impact;
- Assessment of hazards and disaster risks, as well as the vulnerabilities of populations, facilities, and territories;
- Development of the most probable and extreme scenarios for the occurrence, development, and negative impact of single and multiple disasters;
- Ranking of priority disasters according to significance and justification of transboundary risk profiles;
- Formulation of systemic proposals for disaster risk reduction.

5.2. Identification of the Principles Underlying the Concept

The main principles underlying the concept of comprehensive disaster risk management are:

1. **Governance:** This principle encompasses the organizational, legal, and political frameworks. It involves the development of strategies, policies, and plans that ensure effective management of transboundary disaster risks while taking global climate changes into account.

2. **Identification, assessment, and monitoring of risks:** This principle focuses on the continuous analysis and evaluation of natural and technological transboundary risks. Potential threats are identified in advance, their likelihood and impact on populations and economic facilities are assessed, and situational monitoring is conducted to enable timely response.

3. **Understanding risk:** This principle provides for the creation of a knowledge base on natural and technological transboundary risks and the mechanisms for their management. Education and training play a key role in raising awareness in the field of transboundary disaster risk management.

4. **Risk reduction:** This principle aims at reducing vulnerability and eliminating factors that contribute to the emergence of transboundary risks. It includes measures for risk retention, avoidance, and transfer.

VI. MECHANISMS OF COMPREHENSIVE RISK MANAGEMENT

6.1. Analysis of existing risk management mechanisms in the region

The governments of Central Asian countries play a key role in implementing disaster risk management and post-disaster recovery measures. Given the presence of real risks of large-scale and transboundary disasters, whose negative consequences cannot always be mitigated by the forces and resources of a single country, and considering the need for coordinated and harmonized actions in disaster prevention and response, the governments of Central Asian states seek to combine their efforts in disaster risk reduction based on further strengthening bilateral, multilateral, regional cooperation and global partnerships.

Central Asian countries have recently intensified the coordination of joint actions to create sustainable mechanisms for the implementation of bilateral and multilateral interstate and/or interagency agreements, the Sustainable Development Goals for 2030, the priorities of the Sendai Framework for Disaster Risk Reduction for 2015–2030, the UN Framework Convention on Climate Change, the Paris Climate Agreement, and other international programmatic documents.

Currently, dialogue among governments in the field of disaster risk reduction at the regional level has been activated based on the implementation of the Frameworks for Strengthening Regional Cooperation in Disaster Risk Reduction and within the established permanent regional consultative platform in the format of the Regional Forum – Meeting of the Heads of Emergency Agencies of Central Asian countries.

Based on the decisions of the Regional Forums – Meetings of the Heads of Emergency Agencies of Central Asian countries, interstate (intergovernmental) disaster councils, and joint bilateral and multilateral boards of emergency agencies, technical working groups and expert specialists have been established and their activities are being carried out. Within the framework of the newly established Regional Scientific and Technical Council, measures are being implemented to strengthen regional scientific and technical cooperation.

At the regional level, joint actions have also been intensified to enhance the capacity of the emergency agencies of the countries in the region in disaster risk reduction, including studies and exchange of experience, implementation of innovative information and communication technologies, and improvement of mechanisms for coordination, interaction, and emergency response.

Currently, in order to prevent new and reduce existing disaster risks, the emergency agencies of Central Asian countries are undertaking joint coordinated measures to identify, assess, map, and model disaster risks, improve monitoring, forecasting, early warning, and alert systems, enhance response capacities, and strengthen regional and national capabilities for the implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030, as well as measures for climate change adaptation and mitigation of its impacts.

Strategic documents of Central Asian countries in the field of disaster risk reduction indicate that the development and improvement of regional cooperation to implement joint coordinated actions for risk reduction remain highly relevant.

Although there are intergovernmental agreements between neighboring states in the region on ensuring safety from natural and man-made disasters, including information exchange on threats and disaster occurrences, as well as joint exercises and trainings, problems still exist in joint responses to transboundary disasters. These problems are mainly related to the lack of clarity in organizational coordination, information exchange, and other mechanisms, which prevents rapid response and coordinated actions.

The provisions of most existing regulatory and legal documents do not fully provide for the implementation mechanisms of international cooperation in the prevention and elimination of transboundary disasters, as defined by these agreements and treaties.

In order to create an effective regional mechanism for the implementation of in-force bilateral and multilateral intergovernmental and intergovernmental international agreements/treaties, strengthen the readiness of emergency and rescue units to carry out operations in their territories during disasters, and define permanently ready emergency units to be dispatched to affected countries for emergency and rescue operations in disaster zones, a Regional Registry of Forces and Means of Central Asian Countries has been established for conducting emergency and rescue operations on their territories during disasters.

At the same time, there is no effective mechanism for the rapid mobilization of forces and resources from neighboring Central Asian countries for the elimination of the consequences of natural and man-made disasters.

In Central Asian countries, based on the adoption of regulatory legal acts, national systems for disaster monitoring and forecasting, comprehensive information and alert systems, unified state duty-dispatch services, crisis management centers, and early warning systems using television, radio, internet, print media, SMS messages, and so on, have been created and are operational. However, at present, there is no unified integrated system for monitoring and forecasting transboundary disasters and issuing early warnings to the population.

VII. DEVELOPMENT OF AN INTEGRATED APPROACH TO RISK MANAGEMENT

Understanding the importance of regional-level measures for managing transboundary disaster risks, for a region with a high level of agricultural activity and a large proportion of rural population, and also based on the objectives reflected in the Agenda for the XXI Century, there is a significant need for regional integration actions to establish the foundations for creating a regional database of meteorological, hydrological, geophysical, geodynamic, and other indicators for regional monitoring, forecasting, early warning, or prevention of natural and man-made disasters.

The main directions and objectives for establishing a regional process of integrated management of transboundary disaster risks, taking into account climate change, will be:

Direction 1: Strengthening the capacity for monitoring and forecasting, and for disaster risk assessment:

- **Creation of an integrated automated system for monitoring and forecasting transboundary disaster risks:** To organize conditions that allow for the monitoring, assessment, and forecasting of transboundary disasters, it is necessary to create a unified automated geoinformation platform (digital atlas) for the collection and processing of forecast information.
- **Development of scientific-methodological manuals and tools for profiling transboundary disaster risks:** Strengthen the legal, institutional, and technical basis for monitoring, assessment, and planning of actions to reduce transboundary disaster risks, especially taking into account the tasks and needs of decision-makers.
- **Enhancement of cooperation between the expert community, political authorities, and providers of forecast information:** To improve the effectiveness of monitoring, assessment, and forecasting of transboundary disasters, establish an information flow between potential information providers, the analytical and expert community, and the main beneficiaries.

Direction 2: Reduction of transboundary disaster risks, development of disaster risk management plans:

- Integration of innovative solutions into interstate and national plans for reducing transboundary disaster risks: Increase the resilience of countries to disasters by integrating innovative solutions.

- Enhancing climate change resilience: Study, adapt, and disseminate best practices in transboundary disaster risk management.

- Raising public awareness of transboundary disasters, mitigation measures, and planning methods: Provide reliable and tailored knowledge and data, including methods for assessing impacts, damages, losses, and vulnerabilities for specific economic sectors in disaster-prone areas.

Direction 3: Capacity Building and Awareness Raising:

- **Establishment of a regional early warning system for transboundary threats:** Support the initiative of the Center for Emergency Situations and Disaster Risk Reduction (DRR) to create a Regional Early Warning and Mutual Information System on Threats and Occurrence of Emergencies, approved by all heads of emergency agencies of Central Asian countries.

- **Capacity building for national institutions and decision-makers in monitoring, forecasting, assessing, and understanding the direct and indirect impacts of transboundary disasters**

on the socio-economic development of the region: In close cooperation with international development partners, ensure comprehensive enhancement of knowledge and expertise of representatives from national institutions and line ministries responsible for developing national climate adaptation and disaster risk reduction plans and projects, with a focus on fostering proactive disaster prevention thinking.

- **Support for women and other particularly vulnerable groups:** Central Asia has significant potential to increase overall public awareness on climate change issues and measures to reduce transboundary disaster risks through capacity-building activities for local communities, with particular attention to women.

Direction 4: Regional Integration

- **Institutional reform:** Develop where necessary, and further strengthen where it already exists, **political support and the regulatory framework** for regional cooperation on the monitoring, forecasting, assessment, and data exchange regarding transboundary natural and man-made disasters.

- **Creation of a Regional Database on Transboundary Natural and Man-Made Disasters:** This will provide **national authorized disaster risk reduction agencies** with the ability to work with the most verified and reliable data, on the historical basis of which trends and forecasts can be generated that correspond to the region's climate and vulnerability.

VIII. COOPERATION AND COORDINATION

8.1. Development of a Model for Transboundary Disaster Risk Reduction Cooperation

The existing model for protecting the Central Asian countries from transboundary disasters does not ensure the full safety of the population and territory from crisis situations, since its main task is the containment and elimination of disasters that have already occurred. At the same time, the protected objects still suffer social, economic, and environmental consequences.

In this regard, it is proposed to improve the disaster risk management system for transboundary disasters from a reactive emergency response system toward early identification of potential threats and hazards, in order to implement appropriate measures to minimize them (Figure 34).

Comprehensive management of transboundary disaster risks includes:

1. *Selection of approach, planning, and execution of operations for managing natural and technological disaster risks;*

2. *Identification of which risks (natural, technological) may have an impact and documentation of their characteristics;*

3. *Prioritization of risks for further analysis or processing by evaluating and summing the probability of their occurrence and impact;*

4. *Quantitative analysis of the potential impact of identified risks;*

5. *Analysis of the consequences in case the identified risks materialize;*

6. *Development of engineering, technical, organizational, and other measures to reduce disaster risk and enhance the resilience of the population;*

7. *Monitoring of identified risks, tracking residual risks, identification of new risks, and implementation of disaster risk management plans.*

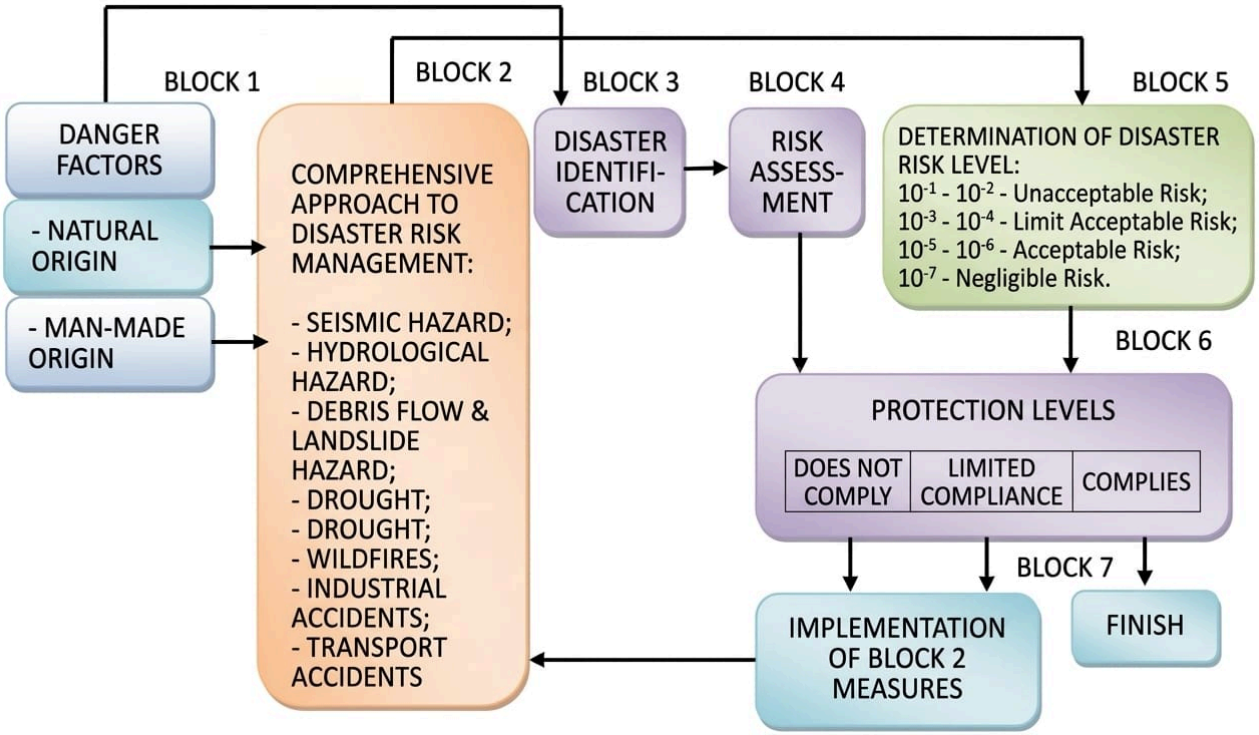

Figure 34 – Flowchart of Comprehensive Management of Transboundary Disaster Risks

A comprehensive approach takes into account all possible risks:

1. *Natural risks: the vulnerability of the territory to natural disasters (earthquakes, floods, mudflows, landslides, karst formations, soil subsidence, etc.);*

2. *Technological risks: possible accidents and catastrophes (fires, explosions, failures in life-support systems, radiation, chemical, and biological contamination, etc.);*

3. *Environmental disasters.*

Comprehensiveness in transboundary disaster risk management allows for the integration of all possible levels of safety (fire safety, industrial, environmental, energy, economic), thereby ensuring reliable and highly effective protection while reducing financial costs for countering various threats and hazards.

The structure of the comprehensive disaster risk management system includes the following main elements:

- *Definition of acceptable risk levels based on economic and social factors, and the development of mechanisms for interstate safety regulation;*

- *Environmental monitoring, risk analysis, and disaster forecasting for both natural and technological hazards;*

- *Decision-making on the feasibility of protective measures;*

- *Rational allocation of resources for preventive measures to reduce risk and actions to mitigate the scale of disasters;*

- *Implementation of preventive measures to lower disaster risks and minimize their impacts;*

- *Conducting emergency rescue and recovery operations in the event of disasters.*

IX. DEVELOPMENT OF A RESPONSE ALGORITHM FOR TRANSBOUNDARY DISASTERS

At present, the participation of emergency rescue services in disaster response within the territories of Central Asian countries is regulated exclusively by international treaties and agreements. However, these international legal mechanisms for decision-making in the field of disasters do not provide detailed guidance on the actions of management authorities in the event of disasters in border areas.

The main legal act addressing issues of cross-border cooperation in disaster prevention and response is the Convention on Cross-Border Cooperation of the Member States of the Commonwealth of Independent States (Bishkek, 2008).

Article 1 of this Convention defines the following terms:

- **Cross-border cooperation** – coordinated actions aimed at strengthening and promoting good-neighborly relations between border territories, including agreements concluded in accordance with the legislation of the Parties as necessary to achieve these goals;

- **Border territories** – territories or parts of the territories of administrative-territorial units of the Parties adjacent to the state border of the Parties and defined as such in accordance with their national legislation or international treaties to which they are parties;

- **Competent authorities** – governmental bodies of the Parties vested with the relevant competence and powers in the field of cross-border cooperation.

One of the main directions of the Parties' activities, according to Article 7 of the Convention, is the development of joint programs to protect populations and territories from natural and technological disasters, as well as the integration of disaster prevention and response systems for border territories, in order to improve the efficiency of response to disasters with transboundary consequences.

To support and strengthen interaction, cooperation, and coordination between the emergency services of Central Asian countries, as well as international and non-governmental organizations operating in the field of emergency response at the regional level and providing international humanitarian assistance, the Center for Emergency Situations and Disaster Risk Reduction (hereinafter – the Center) has developed a Regional Coordination Mechanism for Emergency Response. This mechanism was approved by all heads of emergency services of Central Asian countries in 2021.

The organization of the activities of the Regional Coordination Mechanism is carried out by the Center. The working bodies of the mechanism are the relevant divisions of the emergency services responsible for crisis management and disaster response, as well as representatives of international organizations included in regional coordination groups for humanitarian emergency response and international cooperation.

Overall, the issue of the timely mobilization of forces and resources to respond to transboundary disasters in Central Asia remains highly relevant.

Based on the analysis of the aforementioned multilateral agreements, it is proposed to develop an algorithm for the mobilization of forces and resources in the event of large-scale and transboundary disasters in Central Asian countries (Figure 35).

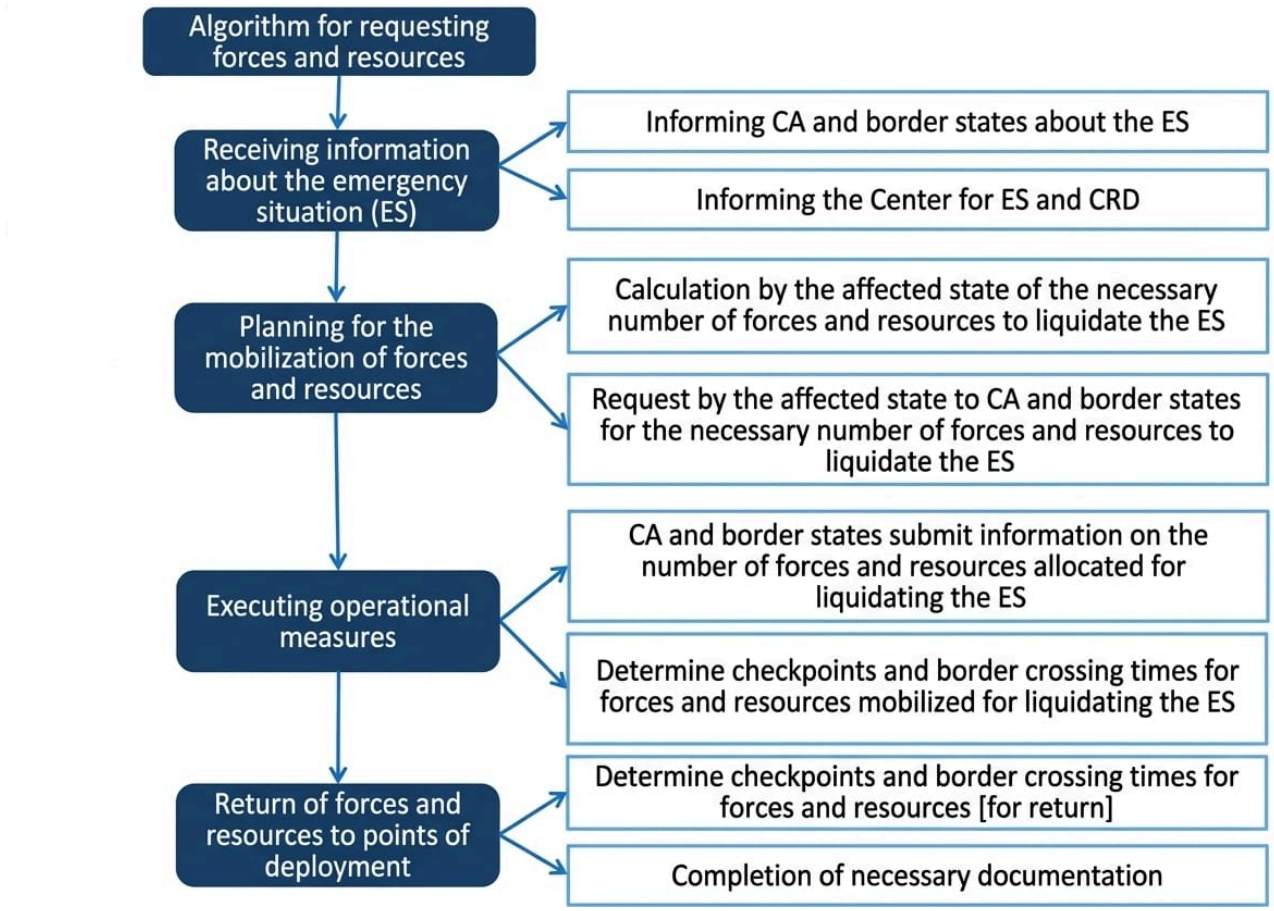

Figure 35 – Algorithm for Requesting Forces and Resources in Large-Scale and Transboundary Emergencies

At the first stage, upon receipt of information about a large-scale and transboundary disaster that has occurred, the affected state informs the countries of Central Asia, neighboring states, and the Center. The message specifies the location and time of the disaster's occurrence; the type of disaster and its inherent characteristic features; the estimated number of dead and injured, destroyed buildings, and other information about the consequences of the disaster; trends in the disaster's development; and actions taken for the localization and liquidation of the disaster.

At the second stage, the affected state conducts a calculation of the necessary number of forces and means to be attracted from the countries of Central Asia and neighboring states. According to the calculations performed, a request is made for the necessary quantity of forces and means from the countries of Central Asia. The request specifies the type of assistance required (conducting emergency rescue or search and rescue operations, delivery of humanitarian cargo) that the affected state needs; a list of necessary supply materials for distribution among the affected population; and the number of required forces and means.

The Center informs international and non-governmental organizations and works out with them, jointly, the issues of providing humanitarian, medical, and other assistance to the affected state.

At the third stage, after submitting the request for the allocation of forces and means, the countries of Central Asia inform the affected state about the possibility (or impossibility) of allocating the corresponding amount of forces and means.

Information is also provided about the leader, a list of members of the group allocated to provide assistance, and its material and technical equipment.

Next, the affected state coordinates with the sending party the checkpoints and the time of crossing the state border by the forces and means sent to provide assistance in the liquidation of the disaster.

At the fourth stage, after the completion of the work to liquidate the disaster, the forces and means are sent to the places of permanent deployment. For these purposes, the affected state determines the checkpoints and the time of crossing the state border by the forces and means departing to the places of permanent deployment.

All necessary documents are completed, including acceptance-transfer acts for supply materials, financial expenditure reports for assistance provided, etc.
Transit, entry, the procedure and conditions for the temporary presence of forces and resources on the territories of the CA countries, as well as their status, social, and legal guarantees for personnel, are determined by international agreements.

During disaster response and mitigation operations, the deployed rescue units from the CA countries are required to comply with international treaties and agreements, national legislation, including bilateral agreements, and follow the orders and instructions of the authorities managing the forces and resources in the disaster zone.

The request for the required number of forces and resources by the affected Party is carried out according to the conducted calculations.

For effective management of transboundary disaster risks, it is necessary to develop an information and management system to support decision-making.

The information-management system includes the following subsystems:

- *data collection;*
- *situation forecasting;*
- *situation assessment and control;*
- *locations of emergency-rescue services;*
- *preparation of data for decision-making and planning its implementation;*
- *monitoring of the execution of decisions taken;*
- *provision of necessary data (batch, interactive).*

The subsystem for preparing data for decision-making is intended to manage the deployed emergency-rescue units.

For example, in the event of a transboundary disaster, it is necessary to ensure the delivery of forces and resources from the nearest locations of emergency-rescue services to the area of rescue operations. This task can be represented as follows: the objective is set — to move forces and resources from the deployment location — point A — to the area of rescue operations — point B; various means are available.

$$U=\{UM,UT\}, \quad (1)$$

where:

- UM = {M1, M2 } – maritime emergency-rescue services;
- UT={T1,T2} – emergency-rescue units equipped with appropriate rescue equipment

It is necessary to find such $u* \in U$ that ensures the achievement of the goal.

As the criterion Q for the considered task, the time τ is used. The following criteria are obtained:

- $Q=\tau set$ – reach point B within the set time
- $Q \leq \tau set$ – reach point B by the set time;
- $Q \rightarrow min$ – reach point B in minimal time.

To solve the task, it is necessary to determine the relationship between the goal and the means to achieve it:

Q=F(U).Q = F(U). Q=F(U).

The criterion for achieving the goal is the time interval from the occurrence of the accident to the start of emergency-rescue operations at point B.

The timeliness of concentrating the required number of forces and resources is an important factor affecting the risk of damage to the population, territory, and economic facilities.

The duration of this interval is determined by the formula:

$$Tset=Talert+Tready+Tmobil+Ttransfer+Trescue$$

Where:

- Talert– time for alerting the units;
- Tready– time required for units to prepare;

  Tmobil– time for mobilization;
- Ttransfer – time for transfer to the incident site;
- Trescue – time for conducting emergency-rescue operations.

The result of identifying all alternatives can be presented in the form of a **decision matrix**, which requires further analysis using criteria to select the necessary forces and resources. This matrix is part of the decision-making subsystem (Table 4), where:

- AnA_nAn – alternatives of emergency-rescue units;
- SmS_mSm – equipment and arrival time of the emergency-rescue units;
- w(Sm)w(S_m)w(Sm) – probability of occurrence of state SmS_mSm;
- pnmp_{nm}pnm – outcome that will be achieved if alternative AnA_nAn is selected.

If a most acceptable alternative exists, it is assumed to become the planned decision.

Table 4 – General view of the decision matrix

Альтернативы	$w(S_1)$	$w(S_2)$	$w(S_m)$
	S_1	S_2	S_m
A_1	p_{11}	p_{12}	p_{1m}
A_2	p_{21}	p_{22}	p_{2m}
A_n	p_{n1}	p_{n2}	p_{nm}

To identify the most optimal alternative and further rank them in order of preference, a **multi-criteria optimization problem** is solved, resulting in a set of vector values of event occurrence probabilities:

F(A) = (f(A1),....., f(A_n)) (3)

Automation of the management activities of emergency-rescue units in the Central Asian countries will reduce the time required for processing information, assessing the current emergency situation, and determining the nearest rescue units for rapid deployment in disaster response.

Automation of the management process of emergency-rescue units will help avoid subjective errors in decision-making by the decision-maker (DM).

To ensure timely response to transboundary disasters in Central Asian countries, it is proposed to establish a Regional Coordination Center for Emergency Response, using as examples the European Emergency Response Coordination Centre (ERCC) in Brussels and the ASEAN Coordinating Centre for Humanitarian Assistance (AHA Center) in Indonesia.

The main tasks of this Center will be:

- determining the priority needs and requirements of the Central Asian countries;
- coordinating actions between regional emergency agencies and international organizations during humanitarian assistance;
- ensuring rapid data and information exchange in case of threat or occurrence of disasters (MFOKK, Carlo De Stefano, 2023).

The creation of such a center will enhance the level of cooperation and preparedness for emergency response, which will ultimately lead to risk reduction and minimization of disaster consequences in the region.

X. FINANCING AND RESOURCES

10.1. Development of a methodology for allocating investments aimed at disaster risk reduction based on priorities and needs

The economy of Central Asia is highly vulnerable to natural and man-made disasters. The World Bank estimates that potential losses for Central Asian countries from disasters range from 5% to 70% of GDP.

Most Central Asian countries have specialized, export-dependent economies, which are vulnerable to global climate changes, exacerbating the deficit of funding for implementing comprehensive measures to reduce disaster risks.

At present, Central Asian countries do not have a specifically allocated budget for adaptation measures and mitigation of the consequences of climate change. However, national budgets and strategic documents of Central Asian countries indirectly contribute to ecosystem restoration, promote rational use of natural resources, and facilitate the transition to a “green” economy, which in turn contributes to reducing disaster risks.

Therefore, the development of a methodology for allocating investments aimed at disaster risk reduction based on priorities and needs is highly relevant.

The investment allocation methodology should be aimed at strengthening financial resilience and accelerating disaster risk reduction in Central Asia, taking into account the priorities and needs of the population.

The investment allocation methodology will allow for advanced planning and management of disaster-related costs, ensure predictable and timely access to necessary resources, and ultimately mitigate the long-term financial impact of disasters.

XI. CONCLUSION

Experts of the United Nations Framework Convention on Climate Change (UNFCCC) have noted that global climate change will have negative impacts on all sectors of the economy worldwide.

For the countries of Central Asia, climate change primarily implies an increase in the frequency of transboundary natural and technological disasters.

Climate and socio-economic risks become transboundary security risks in cases where there is no clear concept and algorithm for interaction between the countries of the region to maintain an acceptable level of livelihood at the transboundary level.

Natural disasters such as earthquakes, floods, droughts, and others do not recognize borders and affect the safety and health of the population, as well as the socio-economic development of the Central Asian countries.

Disasters have no national boundaries; therefore, when developing disaster risk management strategies, it is advisable to adopt a comprehensive regional approach. To reduce disaster risk, a Concept of a Comprehensive Approach for Managing Transboundary Disaster Risks with Consideration of Climate Change has been developed.

This Concept is aimed at developing conceptual approaches based on international norms and best practices for reducing transboundary disaster risks associated with climate change.