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OVERVIEW DOCUMENT ON THE STATE OF EARLY WARNING SYSTEMS IN CENTRAL ASIAN COUNTRIES

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I. INTRODUCTION

Natural and man-made hazards remain one of the most pressing challenges affecting the security and sustainable development of nations. Climate change, increasing urbanization, and man-made risks make early warning systems a critically important tool in emergency management. The frequency and scale of natural disasters, such as floods, earthquakes, hurricanes, and droughts, continue to increase. At the same time, man-made risks, including industrial accidents, transportation disasters, and hazardous material leaks, pose a serious threat to human life and health. These threats have a significant impact on the economy, the environment, and social stability, making the need for early warning evident.

Effective early warning systems ensure the collection and analysis of data using advanced technologies such as satellite monitoring, hydrometeorological and seismic systems, enabling real-time detection and assessment of potential threats. Based on this data, forecasting and risk assessment are carried out to predict the development of events and their possible impact. One of the key functions of early warning systems is the notification of the population and emergency services. This is achieved through various communication channels, including mobile applications, mass media, and sirens, allowing people in risk zones to be warned quickly. Timely alerts, in turn, support rapid preparedness, evacuation, and damage reduction.

Global practice demonstrates the effectiveness of early warning systems in saving lives and minimizing the consequences of disasters. For example, Japan has one of the most advanced earthquake and tsunami warning systems, enabling the country to reduce losses through rapid response. In Bangladesh, a strong cyclone early warning system has been implemented, significantly reducing the number of casualties over recent decades.

In Central Asia, with its diverse natural landscapes and climate zones, the development of early warning systems is of particular importance.

Vulnerability of Central Asian countries

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

From a geographical perspective, Central Asia is extremely diverse, encompassing vast, relatively young mountain ranges such as the Tien Shan, the Pamir, numerous permanent glaciers, large deserts and semi-deserts, endless steppe zones, thousands of small and dozens of large rivers and lakes, including the Amu Darya and Syr Darya, the Caspian and Aral Seas, Lake Balkhash, Issyk-Kul, large reservoirs, densely populated valleys such as the Fergana Valley, as well as some of the most sparsely populated areas in the world.

The Central Asian region is exposed to almost all types of disaster risks (with a few exceptions such as tsunamis, tornadoes, volcanic eruptions, and some others), The Central Asian region is exposed to almost all types of disaster risks (with a few exceptions such as tsunamis, tornadoes, volcanic eruptions, and some others),

including natural (geological, geophysical, meteorological, agrometeorological, and hydrological), technological, environmental, and biological-social hazards.

The region is particularly characterized by vast areas with high seismic activity, with the likelihood of strong earthquakes of magnitude 7–8–9 and higher, as well as mudflows, floods, flash floods, landslides, snow avalanches, waterlogging, rising groundwater levels, strong and hurricane-force winds, and even tornadoes, desertification, dust and sandstorms, prolonged and heavy rainfall, hail, heavy snowfall and blizzards, droughts, frosts, rockfalls and landslips, steppe, forest and mountain fires, extreme temperatures, environmental and technological hazards, industrial and transport accidents, explosions, large fires, epidemics, mass infectious diseases among humans and animals, and others.

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

II. Assessment of the Current State of Early Warning Systems in Central Asia

In Central Asia, monitoring and forecasting systems are generally well developed, cover a wide range of hazards, use equipment adapted to local conditions, and rely on trained personnel. Scientific and technological methods are being implemented, access to regional data sources is ensured, and the systems comply with international standards for data and forecasting.

Institutional mechanisms and regulatory frameworks are functional; however, vertical standard operating procedures are needed to clearly define roles and responsibilities and to improve coordination. Existing agreements ensure consistency in warning terminology, but additional protocols are required to simplify communication. Cooperation with international organizations is carried out through both multilateral and bilateral agreements.

2.1. Early Warning System in the Republic of Kazakhstan

Legislation

.The operation of the emergency warning system in the Republic of Kazakhstan is regulated by a number of legal and regulatory acts that ensure its effective functioning. The key document is the **Law of the Republic of Kazakhstan "On Civil Protection"** (dated April 11, 2014, No. 188-V), which establishes the main principles, objectives, and tasks in the field of civil protection, including the prevention and response to emergencies. The law places particular emphasis on public information and warning, as well as on coordination among various state authorities in emergency situations. It serves as the fundamental legal framework governing emergency prevention activities, evacuation procedures, and the provision of information to the population on protective measures.

Additionally, the operation of the warning system is regulated by the **Order of the Minister of Internal Affairs of the Republic of Kazakhstan (**dated December 26, 2014, No. 945**) "On approval of the Rules for organizing the civil protection**

warning system and notifying the population and state authorities in emergency situations in peacetime and wartime." This order establishes the procedures for the creation, development, and functioning of the warning system, including technical requirements for equipment and communication channels, as well as interaction procedures across different levels of governance—from national to local.

The emergency warning system includes the use of various communication channels such as sirens, mass media (television and radio), mobile communication systems, and specialized automated alert systems. Particular attention is given to the timeliness of information delivery and its accessibility to all population groups, including persons with disabilities.

In addition, the regulatory framework requires the mandatory conduct of drills and exercises to test the readiness of the warning system. This makes it possible to identify and address shortcomings in a timely manner, improve staff preparedness, and enhance coordination among various agencies.

The warning system is closely linked with other elements of civil protection, including emergency monitoring and forecasting, as well as the management of response forces and resources. Within the framework of international cooperation, Kazakhstan also participates in information exchange with neighboring countries on transboundary emergencies, which is particularly important for ensuring regional safety.

Thus, the legal and regulatory framework governing the emergency warning system in Kazakhstan represents a comprehensive set of interconnected acts aimed at ensuring public safety, minimizing the consequences of emergencies, and enhancing the readiness of state authorities and services for rapid response.

Existing monitoring and warning systems

As of today, hydrological observations are conducted at 367 hydrological posts, which carry out continuous monitoring on 208 rivers, as well as 27 lakes and reservoirs across the entire territory of the republic.

Meteorological monitoring in the Republic of Kazakhstan is conducted at:

- **347** meteorological stations;
- **43** weather stations conduct actinometric observations;
- **9** aerological stations;
- **5** meteorological stations conduct ozone measurements

Dynamics of the increase in the number of moraine lakes (2018–2022)

For mudflow monitoring purposes, in the mountainous regions of Kazakhstan there are 970 moraine-glacial lakes, which may pose a threat to populations located downstream of rivers.

Within the framework of the state program “Digital Kazakhstan” and based on the “Smart City” initiative, with the support of the Akimat of Almaty, in 2021 the implementation of an automated mudflow hazard monitoring system (ASM) was completed in the basins of the Kishi Almaty, Ulken Almaty, Kargaly, and Aksai rivers.

In total, the ASM system of this project includes 31 monitoring stations, which are divided into 4 types according to their location:

- *Lake monitoring stations;*
- *Source (focus-area) monitoring stations;*
- *Channel (riverbed) monitoring stations;*
- *Dam monitoring stations.source (focus-area) monitoring stations;*

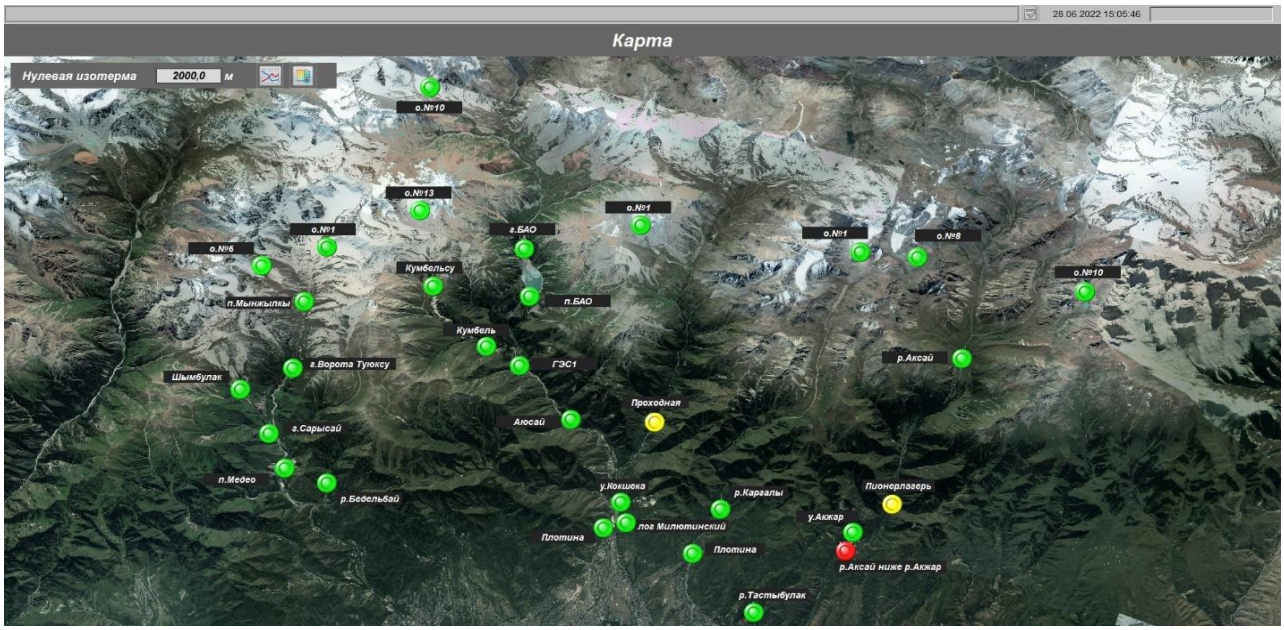


Photo and video cameras installed at monitoring stations allow real-time observation of moraine lakes and rivers.

Visual monitoring of the condition of moraine lakes

For the visualization of data from mudflow hazard monitoring stations, automated workstations (AWS) with computers and software were created at two locations: at the branch of the "Almaty Municipal Operational Management Department" under "Kazselezashchita", and at the Department for Emergency Situations of Almaty.

To ensure the timely activation of alert and emergency modes, threshold values for the measured parameters were defined at all monitoring stations.To ensure the timely activation of alert and emergency modes, threshold values for the measured parameters were defined at all monitoring stations.

Thus, when the threshold values of sensor readings installed at the monitoring stations are exceeded, alerting devices are automatically activated at the dispatch center (light and sound alarm signals).

The implemented automated mudflow hazard monitoring system made it possible to ensure monitoring and assess the outburst risk of moraine lakes, to improve protection against mudflow threats through comprehensive control of mudflow-related processes, to remotely conduct real-time monitoring of the hydrometeorological situation, and overall to reduce the level of risk of emergencies caused by mudflow phenomena.
At the same time, in other mountainous regions of Kazakhstan, there are no similar automated monitoring systems for mudflow-, landslide-, and avalanche-prone areas.
Seismic monitoring and forecasting are carried out by the LLP National Scientific Center for Seismological Observations and Research, which includes 98 seismological stations, most of which are technologically outdated.

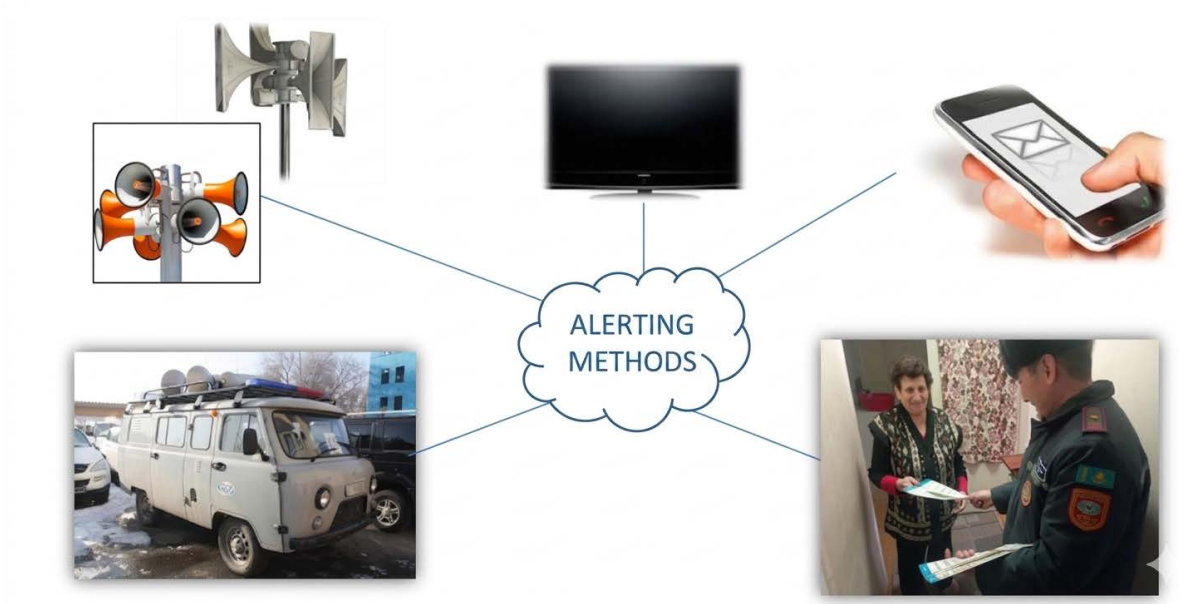
At present, in the Republic of Kazakhstan, monitoring and forecasting of hazardous natural phenomena are conducted by the following scientific and research-production organizations:

- *LLP National Scientific Center for Seismological Observations and Research of the Ministry of Emergency Situations of the Republic of Kazakhstan and RSE Institute of Geophysical Research of the Ministry of Energy of the Republic of Kazakhstan (seismic, geophysical, hydrogeological, biological observations, and observations of crustal movement, etc.);*
- RSE Kazvodkhoz (hydrological monitoring, forecasting, etc.);
- Central Asian Regional Glaciological Center (CARGC) (monitoring and forecasting of mudflows, landslides, and avalanches);
- JSC National Center for Space Research and Technology of the Ministry of Digital Development, Innovations and Aerospace Industry of the Republic of Kazakhstan (monitoring the passage of floodwaters and floods; reservoir filling regimes; the condition of forested areas; geodynamic safety in seismically hazardous regions; rapid detection of forest and steppe fire hotspots, etc.);
- RSE Kazavialesookhrana (forest fire monitoring);
- and other scientific organizations.

The centralized public warning system of Kazakhstan was inherited from the Soviet Union and introduced in the 1970s. Today it is morally and physically outdated.

Therefore, Kazakhstan is carrying out a planned modernization of its warning system with due regard to modern technologies.

Available methods of public warning



Timely informing and alerting of the population is achieved through a set of measures that includes launching electric sirens and siren-loudspeaker devices, interrupting television and radio broadcasts, sending mass SMS messages, posting information on government websites, using mobile applications, and also deploying operational transport of emergency response services.

For the purpose of alerting government authorities and the personnel of the central office of the Ministry of Emergency Situations of the Republic of Kazakhstan, the software-hardware complex “Rupor” has been deployed, which also makes it possible to transmit commands to the regional duty services of the territorial divisions of the Ministry of Emergency Situations to launch the warning system.

At present, for alerting the country’s population, there are 3,303 electric sirens and siren-loudspeaker devices (of which 1,655 are sirens and 1,648 are siren-loudspeaker units)

The control consoles of 14 regions are connected to the national centralized warning system control console (Almaty, Shymkent and the Almaty, Akmola, Zhetysu, Atyrau, Aktobe, Ulytau, Karaganda, Kyzylorda, Mangystau, Turkistan, North Kazakhstan and East Kazakhstan regions). This makes it possible to transmit commands to the regional duty services of the Departments for Emergency Situations and to centrally launch sirens while simultaneously broadcasting voice messages.

Another tool for organizing timely public notification is the interruption of television and radio operators’ channels.

At present, the digital over-the-air television signal can be interrupted in 13 regions of the country (Almaty and Shymkent cities, and the Zhetysu, Aktobe, Akmola, Atyrau, Zhambyl, Karaganda, West Kazakhstan, North Kazakhstan, Kyzylorda, Pavlodar and Mangystau regions), where modern equipment for interrupting digital television channels has been installed and is functioning at the regional emergency departments and divisions of JSC Kazteleradio.

In addition, the use of mobile applications installed on smartphones, tablets, and other communication devices of citizens with Internet access is currently relevant.n addition, the use of mobile applications installed on smartphones, tablets, and other communication devices of citizens with Internet access is currently relevant.

Residents of the country also use the mobile application "Darmen," which is managed at the national level and in the duty services of the regions, making it possible to provide timely public information within a specific selected region within 4 seconds.

The Darmen application also includes a function for automatically sending relevant messages to citizens' smartphones during seismic tremors in the event of an earthquake of magnitude 6 and above. Work is currently underway to integrate Darmen with the automated earthquake early warning system in Almaty (ASPRO). This system is undergoing calibration and integration with a complex of siren-loudspeaker devices and the Mass Alert public warning system implemented in Almaty. MassAlert was introduced this year and ensures the sending of short messages to smartphones via the Cell Broadcast protocol.

Interagency and international cooperation

Within the framework of constant interagency cooperation, the Ministry of Emergency Situations of the Republic of Kazakhstan has established close cooperation with the Ministry of Emergency Situations of the Kyrgyz Republic. In particular, an algorithm for information interaction between the duty shifts of the Crisis Management Centers of the Ministry of Emergency Situations of the Kyrgyz Republic has been concluded regarding the operational exchange of information on emergencies, incidents, and accidents.

At the territorial level, Departments for Emergency Situations in regions bordering the Kyrgyz Republic have concluded similar cooperation plans for transboundary territories.

As part of implementing the Action Plan for cooperation with the Ministry of Emergency Situations of the Republic of Uzbekistan, regulations were concluded on the organization of interaction and information exchange between crisis management centers, as well as an algorithm for information interaction with the operational duty services of the Ministry of Emergency Situations of Uzbekistan and the Ministry of Emergency Situations of Kazakhstan.

2.2. Early Warning System in the Kyrgyz Republic

Legislation

The emergency warning system in the Kyrgyz Republic is regulated by a number of legal acts that ensure the organization, functioning, and development of this important area of public administration.

The main legal basis is the **Law of the Kyrgyz Republic** (dated May 24, 2018, No. 54) **"On Civil Protection,"** which defines the rights and obligations of state authorities, local self-government bodies, organizations, and citizens in the field of civil protection. This law establishes the procedure for the creation and functioning of the civil protection system, including mechanisms for warning the population about emergencies. It emphasizes the importance of timely and reliable informing of citizens and responsibility for compliance with the established norms.iable informing of citizens and responsibility for compliance with the established norms.

An important role is also played by the Decree of the President of the Kyrgyz Republic (dated July 2, 2024, No. 176) **"On approval of the Regulation on the State Civil Protection System,"** which defines the structure of the civil protection system, the procedure for interaction among various bodies, and requirements for technical warning facilities.

The warning system is also regulated by government resolutions. The Resolution (dated January 28, 2019, No. 16) **"On the Civil Protection Services of the Kyrgyz Republic"** establishes the powers of various bodies and structures participating in the implementation of warning measures. This document sets the responsibilities of the Ministry of Emergency Situations, local authorities, and organizations for maintaining the readiness of the warning system and ensuring its effective functioning.

Thus, the legal and regulatory framework of the emergency warning system in the Kyrgyz Republic is a comprehensive set of legislative, organizational, and technical measures aimed at protecting the population and territory. It ensures rapid response to emergencies and timely informing of citizens, which is an important element of the state civil protection system.

Existing monitoring and warning systems

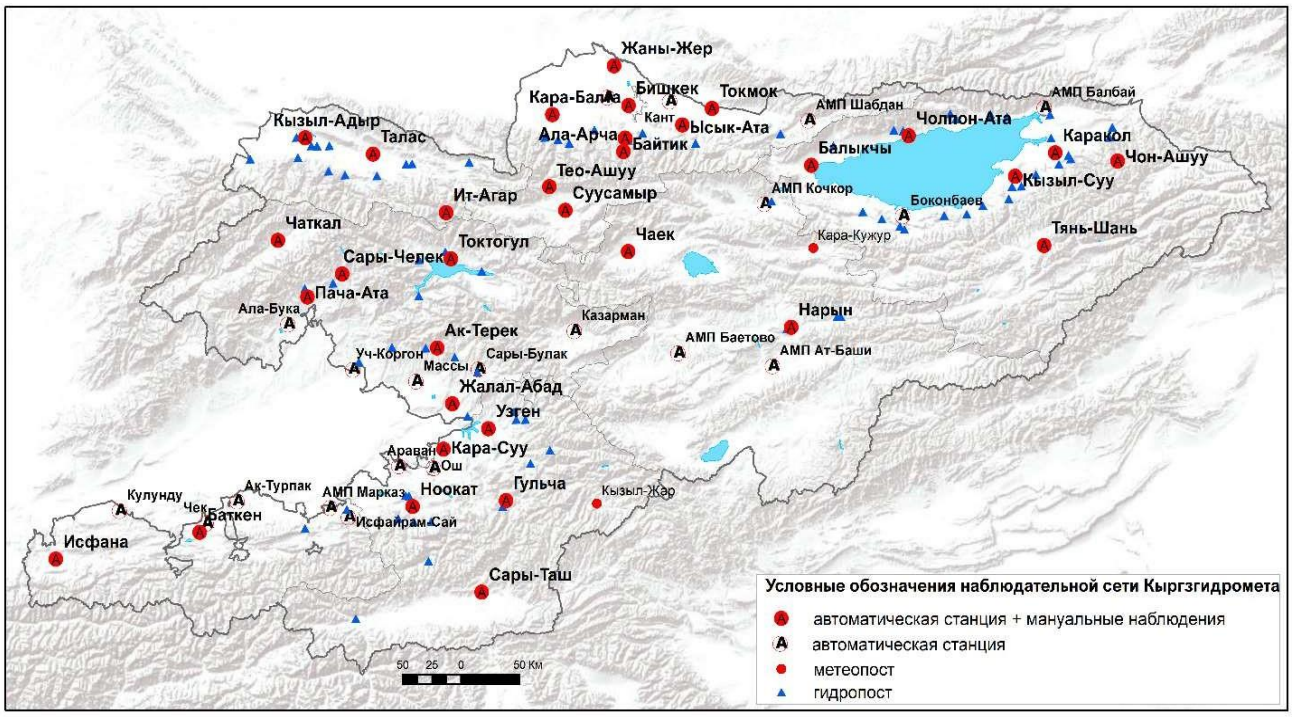
Taking into account the specifics of its geographical location and natural conditions, the republic is actively modernizing its risk management approaches, focusing on modern technological achievements and best international practices. This work is coordinated by the Ministry of Emergency Situations of the Kyrgyz Republic (MES KR), which is implementing comprehensive measures to minimize damage from emergencies and improve public safety

Among the main natural threats characteristic of the Kyrgyz Republic are earthquakes, landslides, mudflows and floods, glacial lake outbursts, snow avalanches, waterlogging, as well as rockfalls, screes, and collapses. Earthquakes reaching **9** points pose a danger throughout the country. More than **4,554** landslide-prone areas, **2,503** mudflow- and flood-prone areas, as well as **367** outburst-prone lakes require constant monitoring and preventive measures. **779** avalanche-prone districts require continuous observation, and waterlogging affects an area of over **3,200** km^2. In addition, **571** sites have been registered where there is a risk of rockfalls, screes, and collapses.

To minimize risks and prevent catastrophic consequences, the Ministry of Emergency Situations of the Kyrgyz Republic has introduced a Unified System of Comprehensive Monitoring and Forecasting of Emergencies (ESKMP ES), which covers the main areas of natural hazards.

Within this system, a hydrometeorological monitoring network is operating, provided by **79** automatic stations, including **34** weather stations, **10** agrometeorological stations, and **78** hydrological posts. Specialized equipment is also used, including automated complexes and posts for air pollution monitoring. In landslide-prone areas, local monitoring systems are installed to track the dynamics of slopes. An important element of the system is the use of satellite data, which makes it possible to remotely assess the risks of avalanches, landslides, and possible outbursts of high-mountain lakes.

Hydrometeorological observation network of the KR



A key tool for emergency prevention is the nationwide integrated public information and warning system (OKSION). It provides automatic activation of sirens, interruption of television and radio broadcasting for the transmission of emergency messages, as well as the use of mobile applications capable of promptly notifying citizens of emergencies within a few seconds. In addition, voice warning systems have been installed in places of mass gathering and in administrative buildings.

For full coverage of the country's territory, it is planned in the coming years to install another **450** hardware-software complexes.

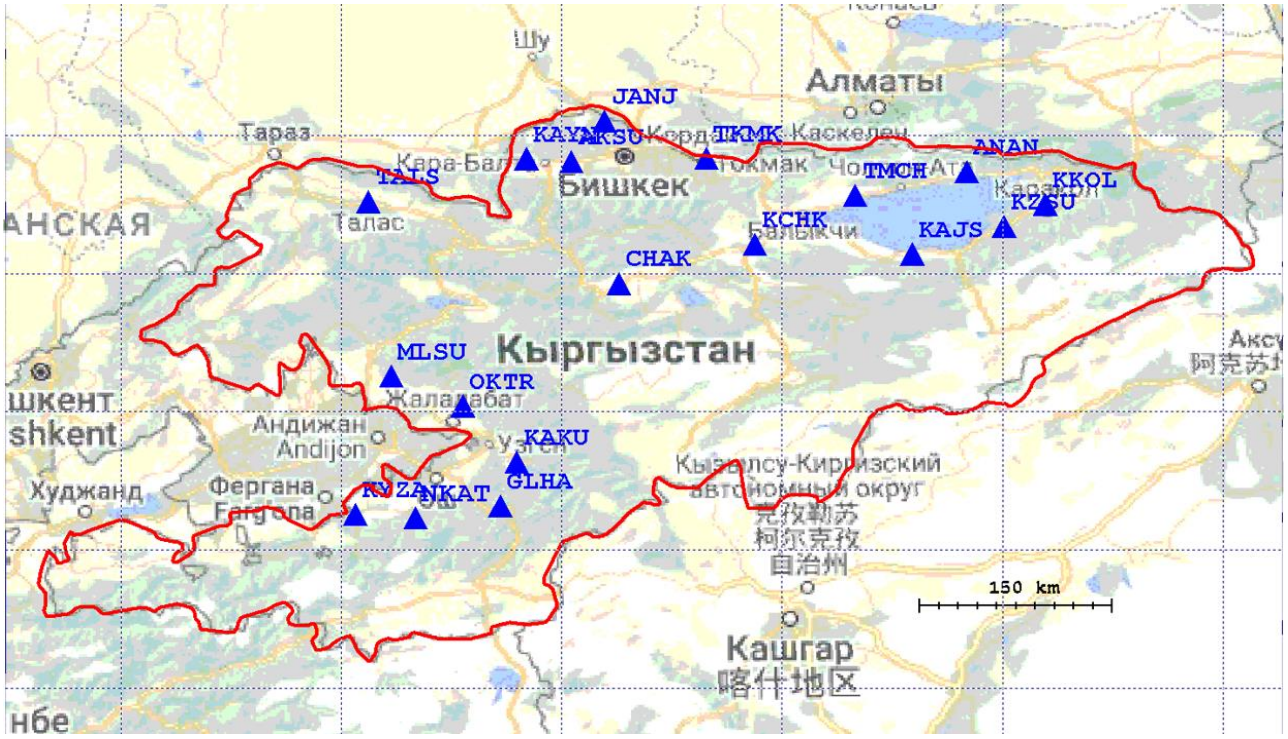
Modern technologies play an important role in improving the monitoring and forecasting system. Radar data and cartographic materials are used to model hazards. Geospatial databases containing more than 40 layers of information make it possible to analyze threats and develop more accurate forecasts. The SCADA system has been introduced for monitoring landslides and crisis management, as well as various measuring instruments, including piezometers and extensometers for monitoring groundwater, precipitation, and seismic activity.

Earthquake monitoring system in Kyrgyzstan based on the ACROSS network

The earthquake early warning system in the Kyrgyz Republic was developed by the Central Asian Institute for Applied Geosciences (CAIAG) jointly with the Helmholtz Center Potsdam.

In 2014, a network of strong-motion seismic stations ACROSS was deployed in Kyrgyzstan. This network includes **18** three-component accelerometers that provide high accuracy in recording strong ground motions. The system is designed to monitor seismic activity and promptly warn the population of potential threats.

ACROSS strong-motion seismic station network



Seismic data collected by the stations are transmitted to the information processing center using the SeedLink protocol. For rapid earthquake detection and warning transmission, the PRESTo system developed by Federico II University of Naples (Italy) is used. This software package analyzes incoming data in real time and transmits information about earthquakes via the Internet, making it possible to respond quickly to dangerous events.

During the period from February 2017 to October 2022, the system registered 189 events. Of these:

- ***104** events were confirmed by data from the Institute of Seismology of the National Academy of Sciences of Kyrgyzstan and the International Seismological Centre (ISC).*
- ***50** events that occurred outside Kyrgyzstan were erroneously localized within the country.*
- ***35** cases turned out to be false detections.*

These data highlight the need for further improvement of information-processing algorithms in order to minimize false alarms.

A system has been created that combines data from seismic stations and transmits it to users via the UDP protocol. Earthquake notifications are distributed through audio signals and Telegram, ensuring rapid public notification and informing of services. This helps reduce emergency response time and improve safety.

The system operates in real time, analyzing earthquake phases with minimal delay. To determine epicenters, an error-minimization method is used, which increases accuracy. It is also capable of recording events outside the station network, which is especially important for border areas.

Earthquake magnitude is calculated based on the amplitude of P-waves, taking into account the distance to the epicenter, while intensity is assessed using the MSK-64 scale, which helps evaluate possible impacts on populated areas. The system makes it possible to consider additional seismic sources for more accurate risk assessment.

Since June 2023, the system has been successfully used in test mode, detecting earthquakes with magnitudes of 3.5 and above. It has proven its effectiveness and reliability, and is recommended for wider use by the Kyrgyz emergency services to provide timely public warning and reduce risks.

Main challenges and prospects

Despite significant successes, the monitoring and warning system faces a number of problems. Among the main challenges are the limited geographical coverage of automated stations, the need to improve the accuracy of forecasts, and the integration of advanced technologies such as artificial intelligence.

To overcome these difficulties, the Ministry of Emergency Situations of the Kyrgyz Republic is actively working to expand the monitoring network, develop highly detailed maps, and strengthen cooperation with international organizations and countries of the region.

In cooperation with the Ministry of Emergency Situations of the Republic of Uzbekistan and the Central Asian Institute for Applied Geosciences (CAIAG), integration of seismological stations located in the territory of the Republic of Uzbekistan has been carried out, and data exchange between Kyrgyzstan and Uzbekistan has been organized.

2.3. Early Warning System in the Republic of Tajikistan

Legislation

The emergency warning system in the Republic of Tajikistan is regulated by an extensive legal and regulatory framework that includes basic laws, government resolutions, acts of specialized bodies, and international agreements.

A key element of the legal framework is the Law of the Republic of Tajikistan **"On the Protection of the Population and Territories from Natural and Technogenic Emergencies."** This law defines the legal and organizational foundations for protecting the population, establishes the basic principles of the functioning of the emergency warning system, and regulates the responsibilities of state authorities, organizations, and citizens in the field of prevention and liquidation of emergency consequences.

Resolutions of the Government of the Republic of Tajikistan play an important role in the development of the warning system. They approve the procedure for creating and operating the monitoring and early warning system and regulate interaction among different management bodies and levels.

Acts of the Committee for Emergency Situations and Civil Defense under the Government of the Republic of Tajikistan (CoES) are also an important part of the legal framework. These internal documents specify the operating procedures of the warning, monitoring, and response system. They cover such aspects as the use of moblie mobile operators to transmit...

emergency messages, interaction with local authorities, and the organization of preventive measures

Special attention is given to **international agreements and treaties**, in which Tajikistan participates. These documents are aimed at developing cooperation in the field of emergency prevention and exchanging experience with other countries. They contribute to improving the warning system, integrating international standards, and introducing modern technologies.

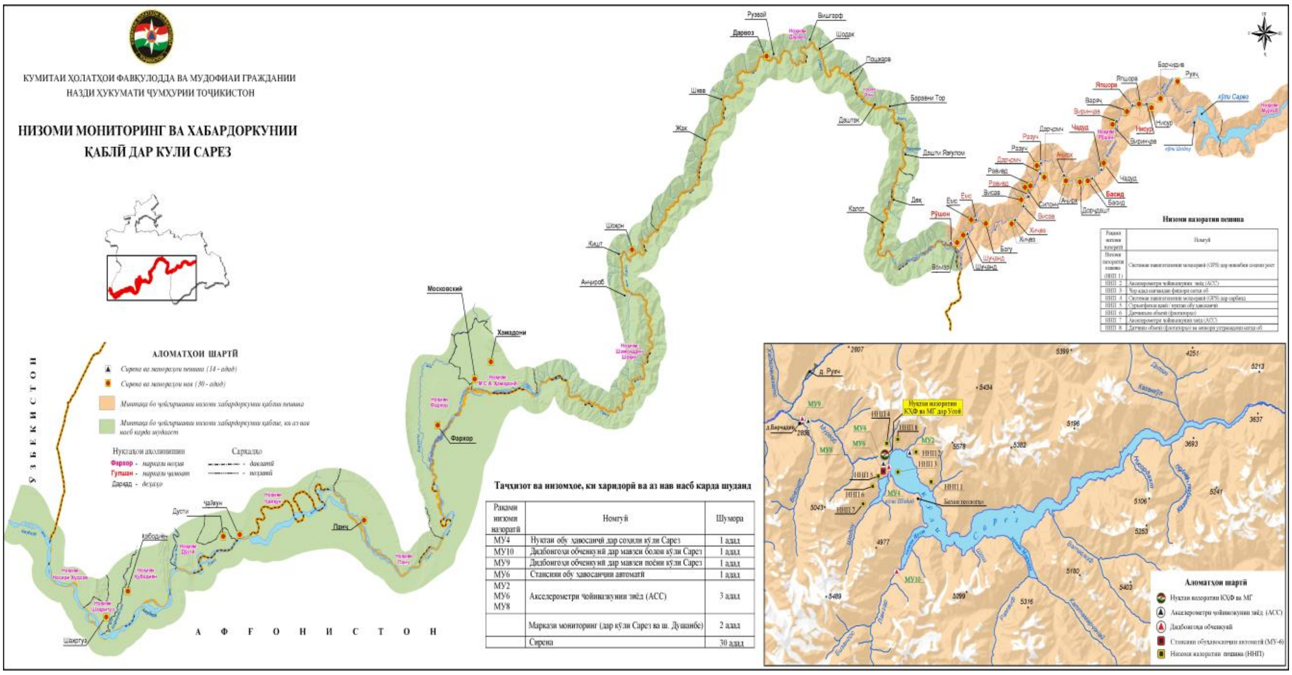
Thus, the emergency warning system in Tajikistan is based on a comprehensive legal framework, including laws, regulations, and international agreements.

Existing monitoring and warning systems

The emergency early warning system in the Republic of Tajikistan, coordinated by the Committee for Emergency Situations and Civil Defense under the Government of the Republic of Tajikistan (CoES), represents a multi-level structure aimed at reducing risks and consequences of natural disasters. This system takes into account the country's geographical and climatic characteristics, which contribute to frequent emergencies of natural origin, such as heavy rains, mudflows, landslides, snowfalls, cold waves, avalanches, droughts, and floods.

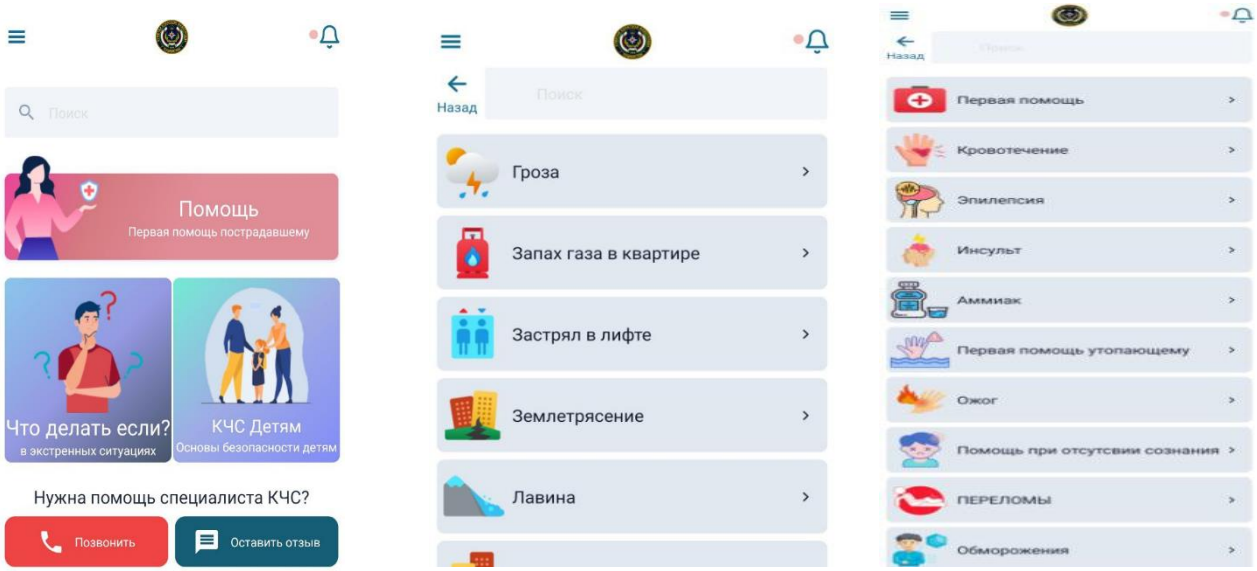
The system operates based on a hierarchical structure covering four levels: national, regional, district, and facility level. At the national level, the Committee for Emergency Situations and Civil Defense (CoES) coordinates nationwide efforts in emergency prevention, including monitoring and warning management. At the regional and district levels, tasks are carried out jointly with local government authorities, while the facility level covers enterprises and institutions.

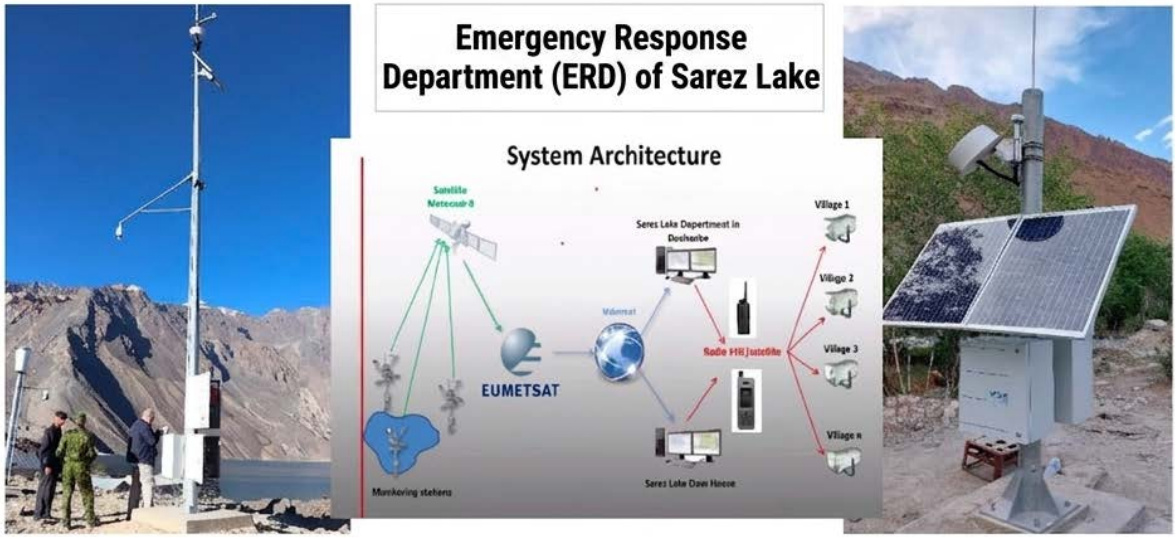
Sarez Lake Monitoring and Early Warning System



An important element of the system is monitoring and early warning of the population, carried out through various communication channels, including mobile operators sending SMS alerts. Within the early warning program, a system has been developed related to Lake Sarez, which poses a potential risk.

In addition, the Committee for Emergency Situations of Tajikistan has developed the “SOS” mobile application, containing useful and necessary information for the population in emergency situations.





The monitoring system also includes the work of the Hydrometeorological Agency, which analyzes data on hazardous phenomena and transmits it to CoES. (The agency includes **98** hydrological stations: **92** river stations and **6** lake/reservoir stations.) Information is delivered to the population through a structured system involving local authorities, communities, and rural areas, ensuring even distribution of information and rapid response.

Public Warning Tools

A key function of the system is not only to provide early warning but also to conduct a follow-up analysis of the effectiveness of the measures taken. After information about potential emergencies is communicated, local authorities are required to take appropriate actions to prevent or minimize their impact. Upon completion of response activities, reports are prepared and submitted to the Committee for Emergency Situations and Civil Defense (CoES) for analysis and further improvement of response mechanisms.

Thus, the early warning system in Tajikistan is based on the use of modern technologies, multi-channel communication systems, and structured coordination among different levels of government.

2.4. Early Warning System in the Republic of Uzbekistan

Legislation

The operation of the emergency warning system in the Republic of Uzbekistan is regulated by a number of legal and regulatory acts. The key document is the Law of the Republic of Uzbekistan "**On the Protection of Population and Territories from Natural and Technogenic Emergencies**" (dated August 17, 2022, No. ZRU-790), which establishes the legal foundations for protecting the population, defines the powers of state authorities, and sets out the procedures for their interaction in the prevention and response to emergencies.

The Resolution of the Cabinet of Ministers of the Republic of Uzbekistan (dated August 11, 2023, No. 361) "**On the Development of the Automated System for Warning of Emergency Threats or Occurrences and Its Effective Use**" approves the provisions that define the objectives, levels, and functioning procedures of the warning system, including the use of modern technologies to inform the population.

The Resolution of the Cabinet of Ministers dated August 8, 2017, No. 601 defines the organizational and functional structure of the automated system for warning and informing the population of the Republic of Uzbekistan, as well as its technological framework, including the use of radio broadcasting, television, and mobile communication. The document outlines the procedures for informing the population at all stages of emergencies, from preparedness to response and recovery.

Operational issues are regulated by orders of the Ministry of Emergency Situations, which establish procedures for conducting drills, applying technologies to improve forecast accuracy, and coordinating with other agencies.

Thus, the emergency warning system in Uzbekistan is based on a comprehensive legal and regulatory framework that ensures its effective functioning and development through the use of modern technologies and interagency cooperation.

Existing monitoring and warning systems

The early warning system for emergencies in Uzbekistan, coordinated by the Ministry of Emergency Situations of the Republic of Uzbekistan (MES UZ), plays a key role in ensuring public safety and reducing damage from natural, technological, and environmental disasters. The main objective of the system is the timely detection of potential threats, warning the population, and the prompt organization of measures to prevent and mitigate the consequences of emergencies.

Hydrometeorological monitoring is an important component of the early warning system. Currently, more than **80** meteorological stations are in operation, **63** of which are automated. These stations monitor climatic conditions and provide data for forecasting hazardous weather events such as heavy rainfall, droughts, and floods.

The system also includes a network of **131** hydrological posts that monitor the condition of water bodies, which is especially important for managing flood risks and ensuring the safety of hydraulic structures.

Seismological monitoring. The Republican Seismological Monitoring Center (RSMC) of the Ministry of Emergency Situations of Uzbekistan (MES UZ) is the key body responsible for monitoring and forecasting seismic activity across the country. Its activities are aimed at preventing and minimizing the consequences of earthquakes.

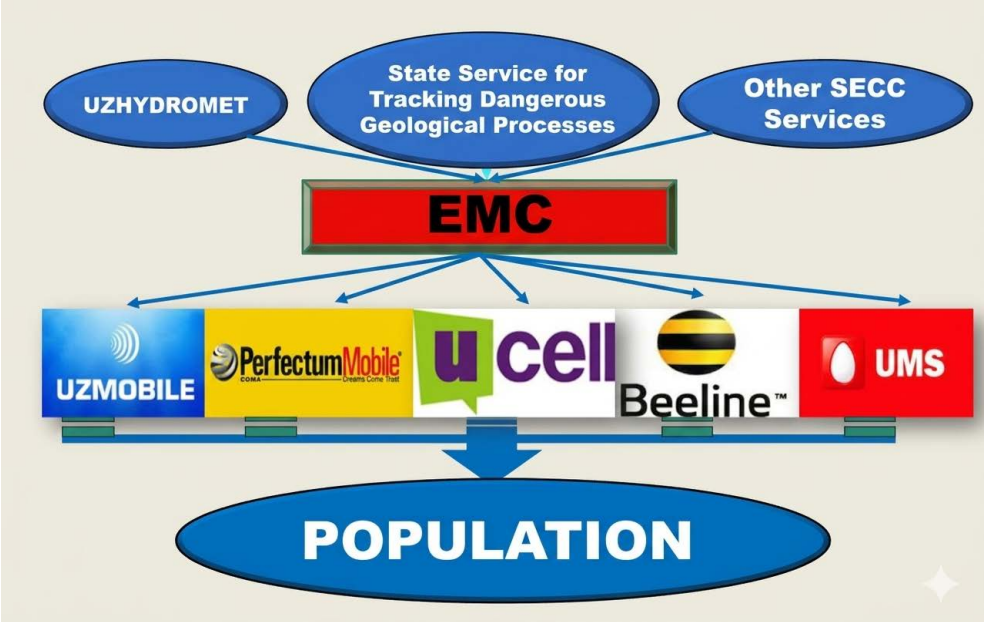
A network of seismic monitoring stations has been deployed across Uzbekistan, recording strong ground motions and enabling rapid assessment of risks to the population and infrastructure.

Since 2023, the phased implementation of a National Earthquake Early Warning System has begun. This system monitors seismic activity in real time. In the event of strong tremors (magnitude 5 and above), the population will receive alerts via mobile applications and other communication channels.

By 2025, it is planned to deploy **200** ETNA-2 Kinemetrics stations, capable of recording strong ground motions within a radius of up to 200 km from the epicenter. The arrival time of the first alerts for major cities such as Tashkent and Samarkand will range from 20 to 50 seconds, depending on the distance.

Key measures include strengthening the network of seismic stations by increasing their number and upgrading equipment, introducing modern technologies such as accelerographs to improve forecast accuracy, and enhancing international cooperation for data exchange with neighboring countries. In particular, in cooperation with the Central Asian Institute for Applied Geosciences (CAIAG), seismic stations located in the Kyrgyz Republic have been integrated, and data exchange between Kyrgyzstan and Uzbekistan has been established.

Public and authorities notification

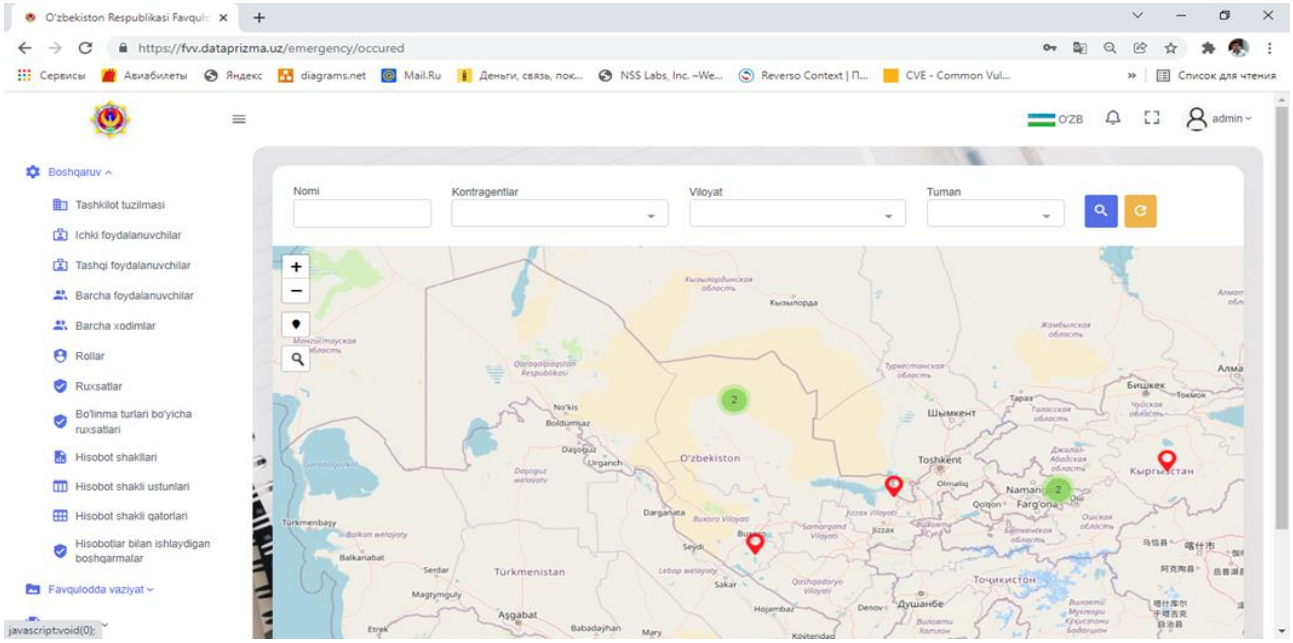


Various communication channels are used to inform the population and authorities about emerging threats:

- **SMS alerts** enable fast and mass transmission of information about emergencies directly to citizens' mobile devices;
- **Television and radio channels** are widely used to broadcast emergency messages, reaching a broad audience;
- **Sirens and loudspeakers** are effectively used in densely populated areas, providing rapid alerts and evacuation instructions when response time is limited.

Interagency coordination

A key element of the system's effectiveness is **interagency coordination**. Data exchange between the Ministry of Emergency Situations, UzHydromet, seismological services, and other relevant agencies is carried out through an integrated information platform. This enables timely data processing, rapid dissemination of information on natural and technological threats, and coordinated response actions on the ground.



Key Challenges and Prospects

Despite the progress achieved, the early warning system faces a number of challenges:

- The need for further **technological modernization**, including the automation of monitoring networks and the installation of additional equipment such as accelerographs and meteorological stations;
- **Data integration** and strengthening coordination among various services remain a priority to improve the speed and effectiveness of response.

- **Public awareness and training.** The effectiveness of the system will significantly increase if citizens know how to respond properly when receiving warnings.

The Ministry of Emergency Situations of Uzbekistan continues to actively develop the early warning system, with a particular focus on the introduction of advanced technologies, such as ultra-early warning systems, and the expansion of international cooperation. Strengthening cooperation with neighboring Central Asian countries is especially important in the context of shared transboundary threats, including floods and earthquakes.

The early warning system in Uzbekistan is currently undergoing active modernization and improvement. Efforts are focused on strengthening the monitoring network, automating stations, and improving communication channels for timely information delivery. However, to achieve maximum effectiveness, it is necessary to continue strengthening interagency coordination and increasing public awareness. These measures will significantly reduce the impact of emergencies and improve overall national safety.

2.5. Early Warning System in Turkmenistan

In Turkmenistan, the operation of the emergency warning system is regulated by a set of legal and regulatory acts aimed at ensuring the safety of the population and territory. Key documents include the Law of Turkmenistan "On Civil Defense," which defines the organizational foundations of civil defense, including measures for the prevention and response to emergencies, as well as procedures for public warning, and the Law of Turkmenistan "On Prevention and Response to Emergencies," which establishes the legal and organizational framework in this field. The authorized body responsible for emergency prevention and response is the Ministry of Defense of Turkmenistan.

The warning system also includes measures for informing the population. For example, evening news broadcasts at 21:00 provide information on air quality, introduced during the COVID-19 pandemic. In addition, Turkmenhydromet performs functions related to hydrometeorological support and provides necessary information to ministries, agencies, public organizations, and the population. The organization regularly issues warnings about adverse weather conditions, such as heat, cold, or storm winds. These warnings are distributed through local authorities (provincial municipalities) to key stakeholders such as hospitals, schools, and public utilities. However, the general public often receives this information only through informal or verbal channels, which limits its coverage and timeliness.

III. TRANSBOUNDARY RISKS

The Central Asian region is highly vulnerable to the impacts of climate change. One of the most significant consequences of global warming in the region is glacier melting and the associated formation of moraine lakes.

Throughout the history of Central Asia, the countries in the region have repeatedly suffered from devastating disasters that have caused economic damage and loss of life. This region is subject to virtually all types of natural and man-made hazards, including earthquakes, floods, landslides, mudslides, avalanches, droughts, and extreme temperatures. Nevertheless, earthquakes pose the most dangerous threat, leading to both loss of life and the destruction of buildings and infrastructure, while also triggering secondary effects such as landslides, mudslides, high-altitude lake outbursts, avalanches, and others.

These threats often have a transboundary nature, with impacts affecting multiple countries simultaneously. Such cases have already been recorded in the region's history (for example, the Sardoba dam failure in Uzbekistan). In the future, strong earthquakes combined with the potential failure of dams or moraine lakes (such as the risk associated with Lake Sarez) may pose significant risks to border areas of Central Asian countries.

In this regard, governments of Central Asian countries are taking steps to strengthen regional cooperation in areas related to disaster risk reduction and the prevention of technological accidents.

The basis for the development of cooperation among Central Asian countries on transboundary issues in this field is formed by various multilateral interstate agreements on disaster risk management and technological accident prevention, as well as on response and recovery measures.

However, given that the Central Asian region is exposed to transboundary disasters, existing multilateral and bilateral agreements on disaster risk management do not sufficiently address early warning of hazards between countries, rapid response coordination, or the provision of international assistance.

An active role in the region is played by the Center for Emergency Situations and Disaster Risk Reduction (CESDRR). Despite its relatively short period of operation, the Center has succeeded in establishing a high-level regional platform for disaster risk reduction—the Regional Forum – Meeting of Heads of Emergency Authorities of Central Asian countries—bringing together senior officials responsible for civil protection. It is important to note that the Center has ensured the sustainable functioning of this platform, which now supports active dialogue between governments on disaster risk reduction at the regional level.

In 2021, in Tashkent, within the framework of the Regional Forum, the Center presented a prototype for integrating earthquake early warning systems of Kazakhstan and Kyrgyzstan. This initiative was supported by ministers of Central Asian countries, who proposed expanding the system to the entire region by integrating not only seismic sensors but also meteorological, hydrological, and other sensors used in existing emergency monitoring systems.

Thus, the ministers of Central Asian countries confirmed the need to establish a regional early warning system for transboundary threats.

At present, the Concept of a transboundary early warning system is being actively promoted by CESDRR. This initiative has attracted interest from several international organizations, such as UNDP, OSCE, and the UN Office for Disaster Risk Reduction (UNDRR), which are considering options for its financial support.

IV. Key Issues and Solutions

Monitoring and evaluation of operational processes ensure the quality of forecasts, with potential for further improvement. Although forecasts are mainly related to weather conditions and have limited localization, they still inform the population about potential threats and their duration. Forecasting information provides a clear basis for operational decision-making, such as evacuation.

However, numerous challenges have been identified across all countries in the region. For example, national hydrometeorological services do not include disaster risk management within their core functions. In addition, warnings are issued by different agencies—often without a single authority responsible for their release. Alerts are disseminated without sufficient assessment of their impact and with limited localization and consequence forecasting. Typically, forecasts and warnings are sent to government institutions, ministries, national emergency management bodies, businesses, and media, and are also distributed through various channels (radio, television, social media, etc.) to inform the public and local communities.

Overall, early warning systems in Central Asian countries face a number of issues that reduce their effectiveness in preventing and minimizing the consequences of emergencies. A key challenge is the limited geographical coverage of monitoring and warning systems. Automated monitoring stations are often absent in remote or mountainous regions, making timely warning difficult. In addition, many systems, including centralized warning systems, are morally and physically outdated, as they were installed decades ago and do not meet modern technological standards.

Existing transboundary threats require a high level of coordination and data exchange between countries in the region. However, current agreements do not always cover operational warning and response, leading to fragmentation of systems. Within countries, there is often no single authority responsible for issuing warnings, resulting in duplication and delays. Moreover, forecasts are often generalized, with limited localization and detail, reducing their practical value for local communities. A major issue is the low level of public awareness: many citizens do not know how to respond to warnings, which significantly reduces system effectiveness.

Significant investments are needed to modernize early warning systems, including upgrading equipment and introducing modern technologies. However, financial support in this area remains limited. One key solution is to expand the geographical coverage of monitoring systems by installing additional automated stations in remote and mountainous areas. It is also necessary to modernize outdated warning systems using digital technologies such as mobile applications and satellite monitoring.

It is equally important to actively educate and inform the population about how to act in emergency situations. This requires regular training exercises and awareness campaigns. Attracting international investment and partnerships with organizations such as UNDP, OSCE, and UNDRR will provide additional financial and technical support. Monitoring systems should be integrated with additional sensors—meteorological, hydrological, and others—to create a comprehensive early warning approach. Automating response processes through data-processing algorithms and alert activation mechanisms will reduce response time.

To address transboundary threats, promoting the concept of a regional early warning system remains a key step toward improving safety in Central Asia. Such a system will ensure coordination at the regional level, integration of advanced technologies, and strengthening of cross-border cooperation, significantly reducing the impact of emergencies and supporting sustainable regional development.