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DESCRIPTIVE REPORT on field studies conducted in the transboundary Amu Darya River basin in Turkmenistan

Project Title:	Strengthening the Capacity for Safe Management of Transboundary Water Resources in Central Asia through the Use of Innovative Information and Communication Technologies
Location of Field Studies:	Amu Darya River Basin, Kerki City, Turkmenistan
Dates of Field Studies:	November 19–21, 2025

General Information

The Amu Darya River Basin is one of the largest and most strategically important hydrological and economic regions of Central Asia. It covers the territories of **Afghanistan, Tajikistan, Uzbekistan,** and **Turkmenistan,** forming a complex system of water, climatic, environmental, and socio-economic interconnections. The river originates in the high mountainous regions of the Pamirs and the Hindu Kush, where the main water resources are formed due to the melting of snow and glaciers, and then flows through lowland areas, supplying water to millions of people and large agricultural lands.

For centuries, the Amu Darya has been a key artery of life and development in the region. Today, its importance is only increasing, but at the same time, the vulnerability of the basin to various natural and anthropogenic risks is also growing. Under conditions of climate change and increasing water consumption, preserving the water potential of the Amu Darya becomes a matter of regional stability and sustainable development.

The upper reaches of the Amu Darya are located in the mountainous regions of Tajikistan and Afghanistan, where the main water resources are formed. Most of the river is **fed by glacier and snow melt,** which makes the basin especially sensitive to rising temperatures. The basin can be conditionally divided into three zones:

1. **Mountain zone (upper reaches):** flow formation area, glaciers, and potentially dangerous moraine lakes;
2. **Foothill zone:** transitional area where floods of mixed origin are formed (snow + rain);
3. **Lowland zone (lower reaches):** area of intensive water use, dense settlement, and developed agriculture.

The Amu Darya supplies water to **millions of residents** of Central Asia, including large cities, industrial centers, and agricultural territories.

According to expert estimates, more than 12 million people live in the basin, and this number continues to grow..

The lower reaches of the river are a zone of **high water dependency**, where hundreds of kilometers of canals, irrigation systems, and fields are located, a significant part of which is used for cotton growing, vegetable farming, and horticulture. In some areas, the river is almost completely diverted for economic needs, which increases the risk of **water shortages**, especially in dry years.

In recent years, stable trends affecting the hydrological regime of the Amu Darya have been observed: a reduction in glaciers and snow cover, an increase in average annual air temperature, a growing share of rainfall instead of snowfall, a shift in the timing of peak runoff, intensified flooding in mountainous areas, and instability of river flow during the summer period.

It is expected that with further warming, **the volume of meltwater may decrease**, while water consumption is likely to increase. This creates risks for agriculture, employment, and food security in the region.

Natural Hazards and Emergencies

The Amu Darya basin is characterized by high vulnerability to hydrological and geodynamic processes. The most common risks include mudflows and sudden floods in mountainous areas, glacial lake outburst floods (GLOF), landslides in zones of seasonal moistu3re, riverbed erosion and bank deformation, water scarcity and soil degradation in the lower reaches, as well as deterioration of water quality and land salinization.

A specific feature of the basin is that **the same hydrological process may originate in one country, while its consequences may manifest in another,** which confirms the transboundary nature of natural hazards.

The Need for Interstate Cooperation

Sustainable management of the Amu Darya basin is impossible within the framework of a single country. Even today, there is a need to establish: a regional monitoring and early warning system, a unified database on hydrological risks, integrated satellite and GIS platforms, pilot zones for joint water resource management, scientific and educational projects for training specialists, and a unified strategy for responding to floods and mudflows.

The Amu Darya can become a **platform for demonstrating successful transboundary cooperation in disaster prevention**, bringing together the experience, technologies, and resources of various Central Asian countries.

The Amu Darya is not just a river, but a **factor of stability and development for the entire region.** In the context of climate change, population growth, and increasing water withdrawal, the management of the basin requires a transition to a **systematic, scientifically grounded, and cooperative approach.**

Preserving the water potential of the Amu Darya and reducing hydrological risks is possible only through: the development of transboundary cooperation mechanisms, the creation of new monitoring technologies, the training of specialists and data exchange, as well as joint work of scientific institutions and emergency agencies.

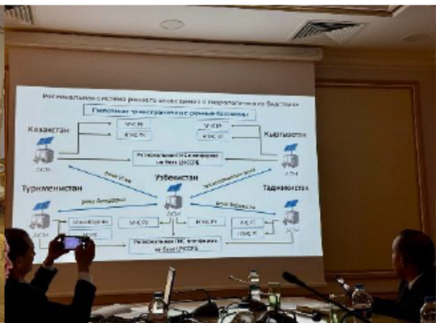
Such an approach can serve as a foundation for the long-term sustainability of the region and as an example of **effective international cooperation in the field of disaster risk reduction and climate adaptation.**

Field Studies

From 17 to 21 November 2025, a group of experts from the Center for Emergency Situations and Disaster Risk Reduction conducted the fourth phase of field studies of the Amu Darya River in Turkmenistan, in the vicinity of the city of Kerki. The purpose of the studies was to further develop the transboundary hydrological monitoring system and to prepare recommendations for the establishment of early warning mechanisms for potential hazards.

The expedition included: V.V. Kuchkin — Expert in Early Warning Systems; A.K. Akparov — Head of the Emergency Situations Department of the Center; A.G. Ospanov — System Administrator of the Center; D. Babylov — National Consultant in Turkmenistan.

On 18 November 2025, the working group held a meeting to present the implementation of the project “**Strengthening the Capacity for Safe Management of Transboundary Water Resources in Central Asia through the Use of Innovative Information and Communication Technologies,**” with representatives of the Hydrometeorological Service of the Ministry of Environmental Protection and the Ministry of Defense of Turkmenistan. During the meeting, the participants exchanged views on the implementation of the project, and recommendations on conducting field studies were provided to the expedition team.


From the perspective of transboundary risks and in line with the previously approved project concept, the greatest threat in the Amu Darya River basin is posed by **mudflows and flash floods** originating in the upper reaches of the basin in Tajikistan and Uzbekistan.

In this regard, the expedition examined the situation at the first operational hydrological station located in the vicinity of the city of Kerki. This station represents a strategically important point for studying hydrological processes in the Amu Darya basin, as it is situated in the lower reaches of the river, allowing for effective monitoring of the impacts of mudflows and flash floods originating upstream (Tajikistan and Uzbekistan).

Geographical Characteristics of the Basin

The Amu Darya River is formed by the confluence of the Panj and Vakhsh rivers and flows into the Aral Sea, forming a delta. In its middle course, the Amu Darya receives three major right-bank tributaries (Kafirnigan, Surkhandarya, and Sherabad) and one left-bank tributary (Kunduz). Beyond this point, and all the way to the Aral Sea, the river does not receive any additional tributaries, including within the territory of Turkmenistan.

The main runoff of the Amu Darya is formed in Tajikistan (approximately 80%), with a smaller contribution from northern Afghanistan. The river then flows along the border between Afghanistan and Uzbekistan, crosses Turkmenistan, re-enters Uzbekistan, and ultimately discharges into the Aral Sea.

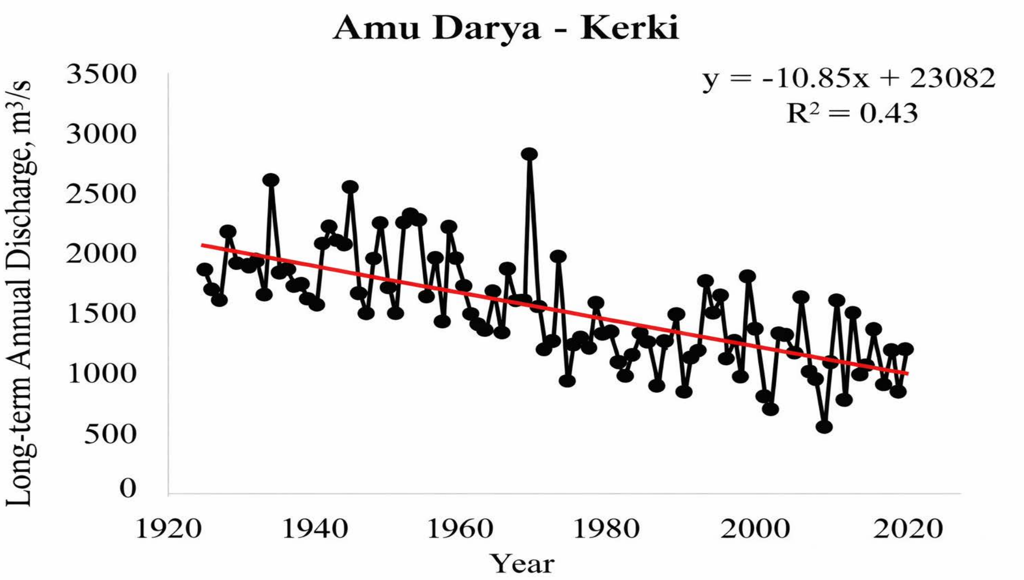
The city of Kerki is located in Turkmenistan along the Amu Darya River. The Amu Darya is the largest river in Central Asia, with a length of approximately **1,415** km. It flows through several countries, including Afghanistan, Tajikistan, Turkmenistan, and Uzbekistan. The area of its drainage basin reaches approximately 309,000 square kilometers up to the city of Kerki.

Distribution and Use of Water Resources in the Basin

The river is primarily fed by snowmelt and glacial waters. Therefore, peak discharge occurs in summer, while the lowest levels are observed in January–February. As the Amu Darya flows across the plains, from Kerki to Nukus, it loses a significant portion of its discharge due to evaporation, infiltration, and irrigation. In terms of sediment load (turbidity), the Amu Darya ranks first in Central Asia and among the highest in the world.

Spring–summer floods, caused by the melting of snow and ice in high mountain regions, along with a relatively stable inflow throughout the year, determine the river's hydrological regime. The high-water period (flood season) typically begins in late March to early April, with peak discharge occurring in July–August. The intra-annual distribution of runoff is favorable for agriculture. During the growing season of major cultivated crops (May–August), when water demand is at its highest, the river provides approximately 61.2% of its annual flow. The average annual discharge of the Amu Darya in the area of the city of Kerki is about 1,940 m^3/s. The maximum average annual discharge can reach up to 2,540 m^3/s, while the minimum may decrease to 1,580 m^3/s. At the same time, peak discharge values may range from 4,160 to 9,060 m^3/s, while minimum discharge values can vary between 410 and 721 m^3/s. The average annual runoff volume is approximately 68.1 km^3/year, while the runoff with 90% reliability (dependability) is estimated at 55.2 km^3/year.

Below is the trend of average annual water discharge, which indicates a decreasing tendency in runoff of approximately 10.85 m^3/s per year, associated with upstream water withdrawals, as well as infiltration and evaporation.



Average Annual Water Discharge at the Hydrological Station of the Amu Darya River – Kerki (Turkmenistan).

Significance of the Water Resources of the Amu Darya Basin (Kerki) for the Region

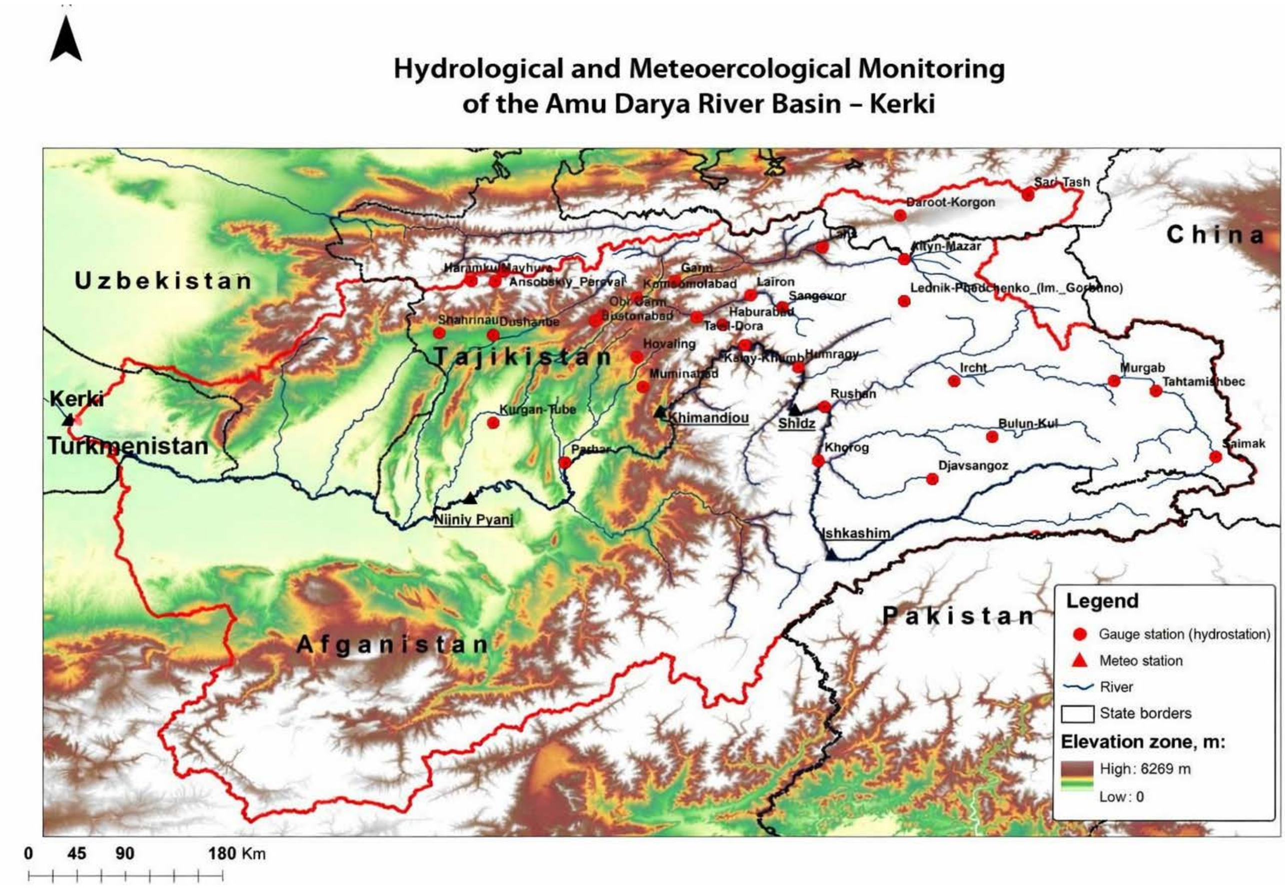
The water resources of the Amu Darya are utilized by five countries: Afghanistan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. Turkmenistan's share, in accordance with existing transboundary agreements, amounts to **22 km^3 per year.**

Approximately 80% of the Amu Darya's flow is generated within the territory of Tajikistan. More than 35 reservoirs with a capacity exceeding 10×10^6 m^3 have been constructed within the basin, with a total storage capacity of over 29.8 km^3. Of this, around 17 km^3 is attributed to reservoirs located directly on the Amu Darya, including the Tuyamuyun Reservoir (7.27 km^3). Along the Karakum Canal in Turkmenistan, there are four reservoirs with a combined capacity of 2.5 km^3, and the Zeid Reservoir (3.2 km^3) is currently under construction. Smaller reservoirs located within complex canal systems—such as the Talimardjan and Tudakul reservoirs in Uzbekistan—serve primarily for seasonal water storage. The flow of the Vakhsh River is regulated by the Nurek Reservoir (10.5 km^3), whereas the Panj River remains weakly regulated, which results in frequent flooding in the section between the confluence of these rivers and the Tuyamuyun Reservoir.

In the lowland sections, part of the Amu Darya's flow is lost due to evaporation, infiltration, and water abstraction for irrigation. Irrigated agriculture accounts for approximately 90% of the river's total water consumption. While cotton cultivation has somewhat declined, the production of food crops has increased. Drainage water from irrigation systems negatively affects water quality, leading to increased mineralization and higher concentrations of major ions from the upper reaches to the plains. In particular, drainage water contains sulfates, chlorides, sodium, pesticides, as well as nitrogen and phosphorus compounds. Water losses also occur within irrigation canals.

Information on the Availability and Condition of Hydrological Monitoring Systems at the National and Local Levels. Hydrological and meteorological monitoring is primarily carried out in Tajikistan, within the runoff formation zone.

A schematic map of hydrometeorological monitoring in the Amu Darya River basin up to the Kerki gauging station is presented below.



Its strategic location and the presence of infrastructure, including a combined railway and road bridge, facilitate access to the study area, **making the work of the expedition team more efficient and enabling prompt field research activities.**

The hydrological gauging station provides essential hydrological data that can be used to analyze changes in the water balance and assess flood-related risks, thereby contributing to the improvement of early warning systems and water resource management. Moreover, the selection of this particular site promotes strengthened international cooperation between Turkmenistan and neighboring countries, which is crucial for enhancing resilience to transboundary risks and for protecting both the ecosystem and the population living near the river.

In light of the above, the study of the hydrological gauging station in the vicinity of Kerki represents a justified and strategically sound decision for achieving the objectives of the project aimed at strengthening the capacity for the safe management of transboundary water resources.


Kabasakal
Керкичи
Keikchi
gauging station
Керки
Atamurat
Амударья

Current Condition of the Hydrological Gauging Station and Recommendations for Improvement

Kerki Hydrological Gauging Station

Despite its strategic importance, the Kerki hydrological gauging station operates in a **traditional (manual) mode,** which does not meet the objectives of the project aimed at implementing modern information and communication technologies (ICT) and ensuring efficient resource management.

At present, the station is equipped with the following:

- ✓ a staff gauge (water level measuring scale);
- ✓ a motorboat;
- ✓ a sounding rod for measuring river depth from the boat;
- ✓ a GR-70 remote hydrometric installation mounted on the boat;
- ✓ a mobile profiler OTT Qliner2 (a portable acoustic Doppler system for measuring water discharge, capable of determining flow velocity, depth, and consequently calculating discharge in water bodies);
- ✓ an acoustic Doppler profiler WHRZ 1200 (a non-contact ultrasonic device for profiling the riverbed, as well as measuring water depth and flow velocity). The device is currently not in use and requires staff training.

The existing equipment is capable of monitoring key hydrological parameters—**water level, flow velocity, and calculated discharge**—but does so with significant limitations:

- **Lack of online telemetry:** The main constraint is the **complete absence of an integrated system for automatic data collection and real-time transmission.** Water level measurements are conducted visually using a staff gauge, while discharge is determined through periodic **manual measurements from a motorboat or suspended platform**, which prevents **continuous monitoring** and limits the ability for timely hydrological forecasting.
- **Obsolescence and physical wear: Outdated, morally obsolete, or partially non-functional equipment** has been identified, raising concerns about the **accuracy and reliability** of the collected data.
- **Methodological limitations:** The absence of a fixed **cableway system** for measurements results in discharge observations being conducted from a motorboat, which is **less efficient, more labor-intensive, and potentially increases measurement error.**

Recommendations for Comprehensive Modernization and Automation

To improve the efficiency of observations, ensure continuous data collection, and establish a fully functional early warning system for hydrological hazards, it is recommended to carry out a **comprehensive modernization** of the Kerki station, transitioning to an a**utomated system for data measurement and transmission (ASDMT).**

Installation of Modern Automated Sensors

- **Water level:** Existing measurement methods should be replaced with a modern **radar or ultrasonic device** with digital interfaces. This will ensure high accuracy and continuous measurements, with data transmission every **10–15 minutes.**
- **Discharge:** Water discharge measurements should be automated using an **Acoustic Doppler Current Profiler (ADCP).** This device enables the measurement of flow velocity and the calculation of discharge across the entire cross-section, replacing manual measurements.
- **Precipitation:** An **electronic rain gauge** with automatic data transmission for each precipitation event should be installed.
- **Water quality:** It is recommended to install an **optical sensor** to monitor **turbidity and water temperature,** enabling the tracking of suspended sediment concentrations and the early detection of mudflow-related processes.

Implementation of a Data Collection and Transmission System

- **Telemetry: A new telemetry data logger** should be installed, integrated with a **GSM/4G or satellite modem,** and capable of simultaneous operation with multiple types of sensors.
- **Autonomous power supply:** To ensure **continuous year-round operation** of all sensors and telemetry equipment, it is recommended to use a **standalone solar power system with a battery and charge controller.**

Expansion of Monitoring to a Meteorological Station

- **Comprehensive risk analysis:** To improve the accuracy of flood forecasting, snowmelt assessment, and the evaluation of risks related to sudden water level fluctuations, it is advisable to equip the station with an **automated meteorological station**. The station should record key parameters: **precipitation, air temperature, humidity, atmospheric pressure, and wind direction and speed.**

Coordination and Organizational Measures

In addition to technical modernization, achieving the project's objectives for public safety requires the implementation of organizational measures**:**

- **Alignment of warning systems: Additional coordination with the Ministry of Defense of Turkmenistan** is required to identify **specific settlements** located downstream of the Amu Darya that are exposed to flood risks.
- **Deployment planning:** Based on the results of this coordination, the required **number and locations of siren and voice alert systems** should be determined in order to establish an effective early warning system for the population.







Conclusion: The Strategic Role of Automated Monitoring and Replication of Best Practices

The installation of an **automated hydrological monitoring station** on the Amu Darya River (using the Kerki station as a case study) represents a k**ey and indispensable element** in the development of an effective **transboundary Early Warning System (EWS)** for hydrological hazards.

Moreover, the successful implementation of this project serves as a **model for replicating international and regional best practices** in hydrometeorological monitoring across Central Asia. This transition from traditional methods to an automated system not only enhances local efficiency but also lays the foundation for the standardization and integration of monitoring networks throughout the region.

The automated station provides multi-level functionality that is critically important for the Early Warning System:

1. **Real-Time Data Acquisition: Continuous collection** of high-precision hydrological data (water level, flow velocity, and discharge) at high frequency eliminates delays inherent in manual observations and ensures the timeliness of information for decision-making.
2. **Rapid Identification of Critical Conditions:** The system is capable of **instantly and automatically** detecting when predefined threshold values are reached or exceeded. This enables the **timely** generation of initial warning signals, forming the basis for triggering the entire early warning mechanism.
3. **Automated Processing and Analysis:** Built-in functionality ensures **automatic validation, processing, and aggregation** of collected data, significantly improving **data reliability** and minimizing the impact of human error.
4. **Integration with Digital Forecasting Models:** A continuous real-time data stream is essential for effectively "feeding" **advanced hydrological forecasting models.** This allows the models to operate with maximum accuracy and to generate timely and **refined flood forecasts.**
5. **Instant Transmission of Information to Key Authorities:** The system ensures automated and reliable transmission of up-to-date information to the servers of the **Hydrometeorological Service of the Ministry of Environmental Protection and the Ministry of Defense of Turkmenistan.** This guarantees that key agencies receive data **instantly** for coordination and the initiation of warning procedures.

Thus, the modernization of the Kerki station and the implementation of an automated data acquisition and transmission system (ASDMT) on the Amu Darya constitute an **integral part** of the regional strategy to enhance resilience to natural hazards and represent a **key investment** in the development of a reliable, safe, and scientifically grounded mechanism for managing transboundary water resources in Central Asia.
