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Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

DESCRIPTIVE REPORT on field studies conducted in the transboundary Zarafshan River basin in the Republic of Tajikistan

Project Title:	Enhancing 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:	Zarafshan River basin, Sughd Region, Penjikent and Gorno-Matchinsky Region
Dates of the field studies:	July 29 – August 6, 2025

General Information

The Zarafshan River basin is located in the central-western part of Tajikistan, between the Turkestan and Gissar mountain ranges. The Zarafshan Valley stretches from east to west between high mountain ranges: the Turkestan Range to the north and the Gissar Range to the south. Between these ranges, the Zarafshan mountain range extends almost parallel. The Tajik part of the basin covers mountainous areas where the main water resources are formed, while the downstream (valley) part of the basin lies in neighboring Uzbekistan, where the river's flow is fully utilized for irrigation, water supply, and other economic needs.

The water resources of the Zarafshan River are of significant economic importance for both Tajikistan and Uzbekistan, where major cotton-growing areas are located. The total length of the main canals diverting water from the Zarafshan is about 2,500 km, with the largest of them having a capacity exceeding the discharge of many rivers in Central Asia.

The glaciers of the Zarafshan serve as an important source of river feeding. The river originates in the mountains of Tajikistan at an altitude of 2,800 meters and flows into Uzbekistan. Approximately 6 million people live within the Zarafshan basin, and the river supplies water to the historic cities of Samarkand and Bukhara, as well as irrigates around 0.5 million hectares of land.

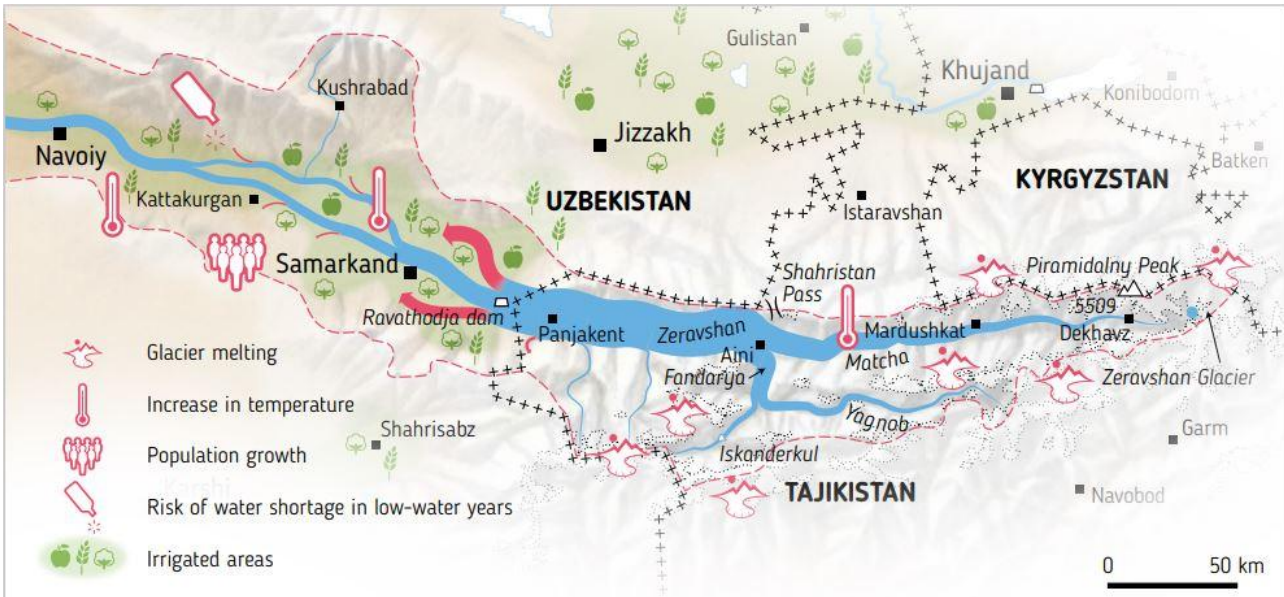
In Tajikistan, the Zarafshan flows naturally through mountainous terrain with relatively few water intakes, whereas in Uzbekistan, water demand is high and the available water is fully utilized.

According to the Hydrometeorological Service of Tajikistan, the Zarafshan glaciers are retreating and have already significantly decreased in size. Rising temperatures may increase climate risks for agriculture in the lower parts of the basin, particularly in the densely populated Samarkand and Bukhara regions.

The catchment area of the Zarafshan River is approximately 42,000 km^2, and the length of the river exceeds 800 km. The name of the river translates as "gold-bearing," and although little extractable gold remains in the main riverbed, the tributaries of the Zarafshan and the surrounding geological formations are indeed rich in gold, and some of the largest gold mining operations in Tajikistan and Uzbekistan are located in this region.

The average annual precipitation in the Zarafshan River basin is about 500 mm and is unlikely to change significantly; however, it is expected that there will be less snowfall and more rainfall. The current average annual temperature in the basin, which is around 5°C, is projected to increase to 8°C under moderate warming and up to 10–12°C under severe warming. This substantial warming will lead to glacier shrinkage and a reduction in snow and ice cover within the basin.

As a result, the decrease in meltwater entering the river will reduce overall river discharge. At the same time, disruptions in the hydrological cycle will increase both the variability of river flow and the frequency of potentially more destructive floods in mountainous areas. In the lower parts of the basin, cotton yields are likely to decline unless water-saving technologies and other adaptation measures are implemented.



Existing risks

The Zarafshan River basin in Tajikistan is highly vulnerable to various hydrological hazards due to its complex mountainous terrain, intensive snow and glacier melt, and changing climatic conditions. The most common hazardous processes include mudflows, landslides, and flash floods caused by heavy precipitation, rapid snowmelt, or the outburst of moraine lakes. In the upper reaches of the river, where a large number of glaciers and potentially dangerous lakes are concentrated, there remains a high risk of glacial lake outburst floods (GLOFs), which can trigger destructive debris flows. During the spring–summer period, floods with mixed rain and snow feeding are also frequently observed, leading to the flooding of settlements and damage to transport and engineering infrastructure.

Field Studies

From July 29 to August 6, 2025, a team of experts from the Center conducted field studies of the Zarafshan River in the Republic of Tajikistan with the aim of developing a transboundary early warning system for hydrological disasters in Central Asia.

The expert group included early warning systems (EWS) expert V.V. Kuchkin, Chief Expert of the Center B.M. Ospanov, and System Administrator A.G. Ospanov. Organizational and logistical support within Tajikistan was provided by the local project expert, hydrologist Jafar Niyazov.

From the perspective of transboundary risks, the most significant threats in the Zarafshan River basin are mudflows and landslides. In the upper reaches of the basin, which extend across Tajikistan and Uzbekistan, several moraine lakes are located that are potentially dangerous due to the risk of outburst. Their failure may trigger debris flows and floods, posing a threat to populations and infrastructure located downstream.

In this context, the expedition began with an assessment of conditions near the source of the Zarafshan River in the Gorno-Matchinsky Region of the Sughd region, a remote and hard-to-access area. Special attention was given to the village of Vodif, which is particularly vulnerable to disasters. Local residents face mudflow threats every year. For example, in July 2021, meltwater washed away the only road, damaged potato fields, and disrupted the irrigation canal, resulting in the loss of approximately half of the harvest. Under such conditions, access to the outside world can be cut off for months.

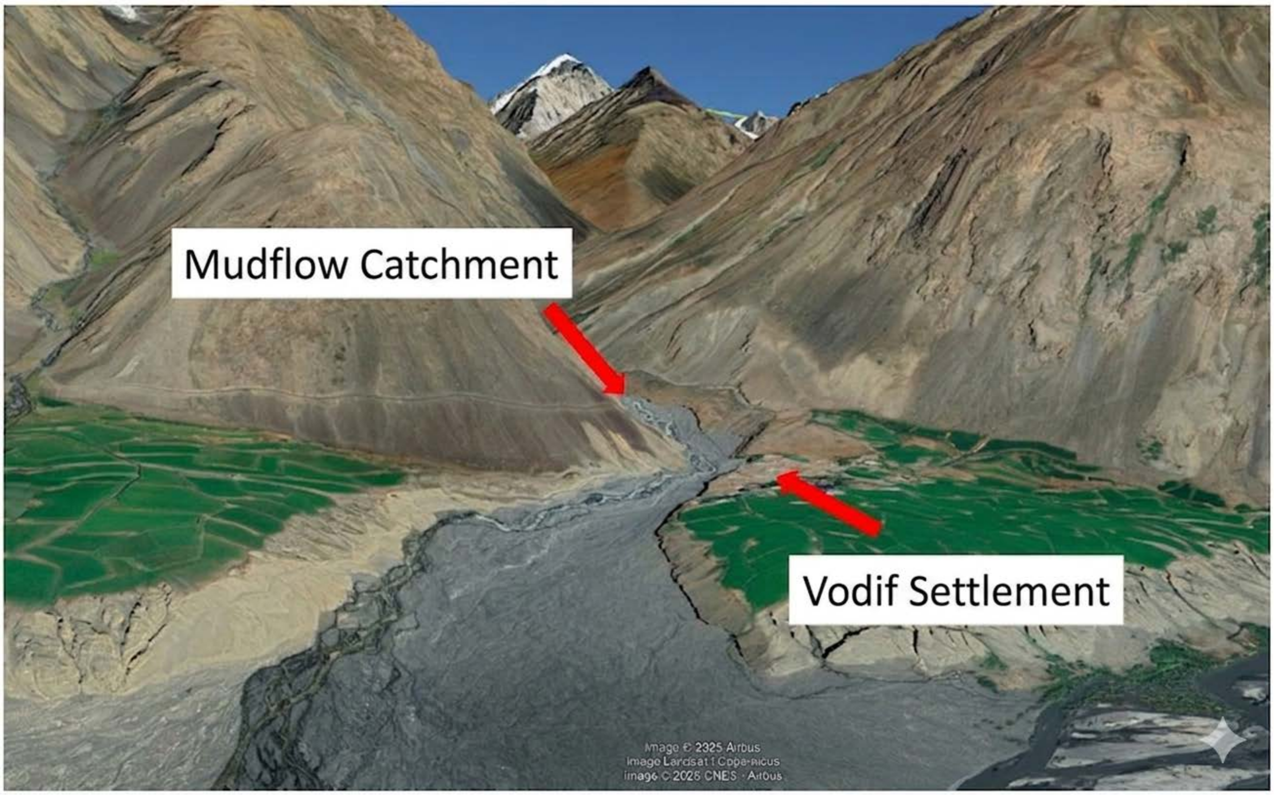


Fig. 1. The village of Vodif in the Gorno-Matchinsky District of Sughd Province

The existing hydrological station near the village of Khudgif in the upper reaches of the Zaravshan River was also examined in detail.

Fig. 2. Khudgif hydrological post, Gorno - Matchinsky District, Sughd Region

In the lower reaches, near the border with Uzbekistan, the expert group examined the Dupuli hydrological post, located 14 km from the city of Penjikent.

Special attention was given to the village of Amandara, located 24 km from the district center of Penjikent in the Sughd Region, with a population of over 3,000 people. It is one of the settlements most exposed to mudflows in the area. In 2021, heavy rainfall triggered landslides that destroyed three houses, damaged 29 household plots, 10 hectares of agricultural land, and 10 km of rural road. One person was killed.

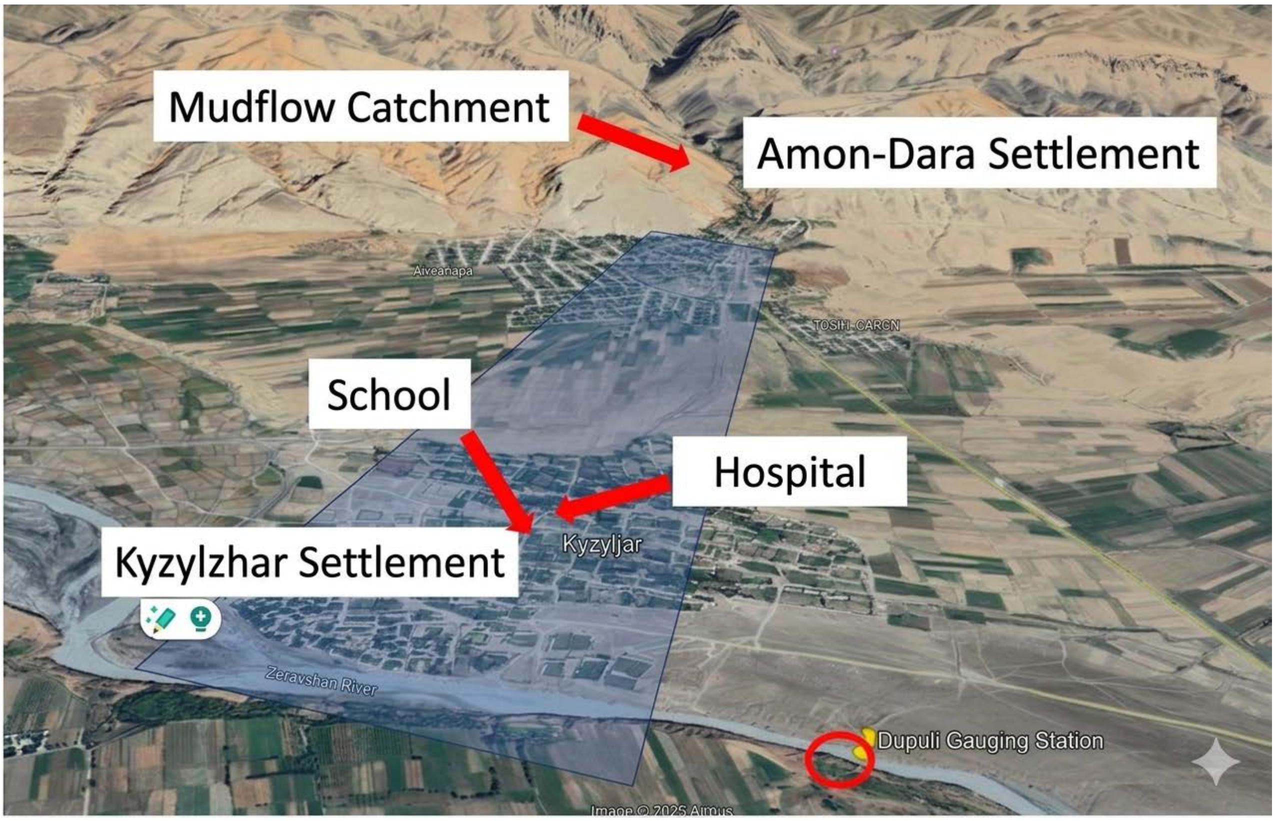


Fig. 3. Amandara and Kyzyljar settlements, Penjikent district, Sughd Region

Based on the results of the field studies and in order to improve the hydrological monitoring system, the expers proposed installing automated stations at the locations of the existing hydrological posts of Dupuli and Khudgif.

Current Condition of Hydrological Posts and Recommendations for Improvement

Dupuli Hydrological Post

The Dupuli hydrological post is equipped with basic instruments for measuring water levels and precipitation. However, its technical condition and level of automation do not meet modern requirements for continuous monitoring and real-time data transmission.

The main shortcomings of the existing post include the lack of an integrated system for automatic data collection and online transmission, outdated or partially non-functioning equipment, as well as a low level of protection and power supply reliability for the instruments.

The radar water level sensor likely operates in a semi-automated mode and requires periodic manual control or data retrieval from a data logger. The mechanical precipitation gauge (Tretyakov type) does not allow real-time measurement of precipitation and requires regular maintenance. Data transmission appears to be carried out manually or using outdated GSM-modems that do not support modern communication protocols.

The design of the cableway mechanism used for measuring water discharge is physically outdated, does not ensure personnel safety, and is not compatible with modern automated flow meters.

There is no backup power supply, making the system vulnerable under adverse weather conditions and interruptions in solar radiation. In addition, no protection is provided against lightning strikes, dust, and moisture, which increases the risk of equipment failure.

Fig. 3. Dupuli hydrological post

To improve the station, it is recommended to carry out a comprehensive modernization with a transition to an automated system for measurement and data transmission.

First of all, it is advisable to replace the existing water level sensor with a modern radar or ultrasonic device with digital interfaces, ensuring high measurement accuracy and enabling remote control.

The mechanical rain gauge should be replaced with an electronic tipping-bucket rain gauge with automatic data transmission for each precipitation event.

It is necessary to install a new telemetry data logger with an integrated GSM/4G or satellite modem, capable of operating with multiple sensors simultaneously.

To ensure uninterrupted operation, the power supply system should be upgraded by installing a solar panel with a capacity of at least 90–120 V, along with a 65–100 Ah battery and an MPPT charge controller. It is also essential to include lightning protection, grounding systems, and sealed enclosures with a protection rating of at least IP65.

Khudgif Hydrological Post

The Khudgif hydrological post, located on the Zarafshan River in the Gorno-Matchinsky Region, is equipped with standard instruments typical of manual hydrometric stations. The post is fitted with a metal cableway crossing with a suspended platform (hydrometric cradle), which allows specialists to measure water levels and flow velocity at different sections of the river cross-section. This system is used for sampling, measuring depth, and determining water discharge manually using portable devices such as hydrometric current meters (e.g., GR-21 or GR-23).

Due to the absence of automated sensors, the station operates in a traditional mode without continuous telemetry. Water level measurements are carried out visually or using a fixed staff gauge, while discharge is determined through periodic manual measurements from the suspended platform. This provides basic monitoring of hydrological parameters but does not allow for real-time data acquisition.

Thus, the Khudgif hydrological post is capable of monitoring the main parameters of the water regime—water level, flow velocity, and calculated discharge, and, with additional equipment, also water temperature and turbidity.

To improve monitoring efficiency and establish a full-fledged early warning system for hydrological hazards, it is recommended to modernize the station by transitioning to an automated data collection and transmission system. First, it is advisable to install a radar or ultrasonic water level sensor capable of continuous measurements with data transmission every 10–15 minutes. Water discharge measurement can be automated using an acoustic Doppler current profiler, which will record flow velocity and generate discharge data across the entire river cross-section. To assess turbidity and water temperature, an optical sensor can be installed to monitor the concentration of suspended particles and detect early signs of mudflows.

In addition to hydrological parameters, it is recommended to equip the station with an automatic weather station that records precipitation, air temperature, humidity, pressure, and wind direction. The integrated use of these data will allow for more accurate flood forecasting, account for precipitation intensity and snowmelt, and assess the risks of sudden water level fluctuations. All sensors should be integrated into a unified data collection system using a telemetry data logger and a communication module via GSM or satellite channels. Power supply can be ensured through an autonomous solar system with a battery and a charge controller, enabling year-round automatic operation of the station.

At the same time, it is necessary to additionally coordinate with the Committee for Emergency Situations of the Republic of Tajikistan on identifying settlements (villages) and determining the number of siren and voice alert systems to be installed, especially in the Gorno-Matchinsky Region, which is most exposed to mudflow and landslide risks.

Conclusion

Thus, the installation of automated hydrological monitoring stations on the Zarafshan River is a key element in the creation of a transboundary early warning system, as it will enable real-time data collection, timely identification of critical conditions, automated data processing and analysis, integration with digital forecasting models, and transmission of information to the servers of the Agency for Hydrometeorology under the Committee for Environmental Protection of the Government of the Republic of Tajikistan, as well as to the Committee for Emergency Situations and Civil Defense under the Government of the Republic of Tajikistan.

Based on the processing of data obtained during the field studies, an interactive map will be developed, including relevant attribute information on affected objects, which will be published on the Center’s website.