Sarez Lake: the latest achievements and unsolved problems
The United Nations International Strategy for Disaster Reduction (UN/ISDR) is the focal point in the UN System aiming at building disaster resilient communities by promoting increased awareness of the importance of disaster reduction as an integral component of sustainable development, with the goal of reducing human, social, economic and environmental losses due to natural hazards and related technological and environmental disasters.

To this end, the UN/ISDR promotes links, synergies and coordination among disaster reduction activities in the socio-economic, humanitarian and development fields. It serves as an international platform for risk reduction, contributing to policy integration, information sharing and developing awareness campaigns, and producing articles, magazines, and other publications and promotional materials related to disaster reduction. The ISDR-Secretariat headquarters in Geneva conducts outreach programs through its regional units in Latin America, Africa, Asia and Central Asia. The outreach office covering Central Asia is located in Dushanbe, Tajikistan. UN/ISDR in Central Asia aims to facilitate national adaptation and adoption of the guidelines outlined in the Hyogo Framework for Action (HFA), and by so doing to strengthen coordination at regional and national levels of activity.

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“On February 6 (18), 1911, at 23:15 a strong tremor was felt in Khorog. In the village of Sarez, people rushed out of houses screaming with horror. Two houses collapsed, four gave cracks. A wild rumble was heard from the west. It merged with the howl of falling avalanches. The moon above Mardjanai got pale. In the morning, everything was covered with dust hanging in the air, and the land continued to shake. When the boys reached Usoy, they did not see the village. A huge mountain of rock was in its place.”
That was the beginning of the Lake Sarez story.

Photo of 1913.

It has been over 95 years already that Lake Sarez keeps experts of many countries on alert. The perspective reclamation of the hydropower resources of the Pianj River attaches the utmost importance to the issue of the stability of Usoy Dam and Lake Sarez. The safety of future downstream hydropower constructions fully depends on the safety of Lake Sarez. Moreover, the Lake contains 17 km3 of clean water which presents a substantial interest for neighboring states.

Practically immediately after the disaster, the scientific circles of Russia began discussing the stability of the new dam and a probability of a catastrophic flood from the growing lake. It is worth noting that forecasts - both favorable and terrifying – were made not only by scientists and experts but also by people with little in common with the problem.

Among the early investigators of Lake Sarez are the names of P. Zaimkin, G. A. Schpilko, D.D. Bukinich, I. A. Preobrazhenski, V. S. Kolesnikov, O. K. Lange, V. A. Afanasiev, V. I. Razek and many others. Two points of view exist with regard to the Lake
Sarez problem. One of them – the newly formed dam is unstable and a catastrophic flood from the lake is a probability involving all the imaginable consequences. Another one – the Usoy dam is a natural stable formation and the lake will exist for quite a long time similarly to other conformable lakes: Yashilkul Lake in the Pamirs, Iskanderkul Lake in Central Tajikistan and many others.

Photo of 1913

First topographic map of the lake, made by Schpilko’s expedition in 1913.
Since 1967, after the collapse of a significant part of the Right Bank Landslide that resulted in human casualties, the area of Lake Sarez had been subjected to a systematic research that continued till 1991 and was stopped due to the dissolution of the Soviet Union. The results of all 20 years of research conducted in the area of Lake Sarez present a mixture of miscellaneous facts interpreted differently by different authors, a confusion of various hypotheses and suppositions. Despite the enormous amount of data, the problem of Lake Sarez and the stability of Usoy Dam still cause a lot of argument. Practically all researchers agree that the Usoy Dam is a stable formation that cannot collapse under the pressure of the lake water and that the dam erosion due to the raise of the water level will not be disastrous.

**Usoy Dam**

- volume - 2.2 km³; mass – 6 billion tons; length – 5 km; average width – 3.2 km; surface – 10.8 km²; height from the lake bottom – 567 m; height of the lowest point from the lake surface – 38 m; maximum height – 3,496 m; minimum height – 2,963 m; absolute lowest elevation in the right contiguity – 3,290-3,300; height elevation difference between the lake surface and the filtration point – 148.2 m; distance from the upper pool to the head of the canyon – 1,700 m.

At the same time, one of the principal problems of Lake Sarez is the existence of the so-called “Right Bank Landslide” 4 km east of the dam. The present data contains information on its structure, mechanism of displacement, estimated volumes and displacement speed, the size of overflow waves above the Usoy Dam caused by the landslide fall into the lake, etc. At the same time, there is no instrumental proof of the gliding surface as well as of any justified calculation of the displaced mass volumes, its velocity and the volume of overflow waves. Even the same authors provide contradictory data. Arguments regarding the inevitability or high probability of full collapse of the Usoy Dam and a gigantic flood sweeping down the valleys of the Bartang, Panj, and Amudaria rivers and demolishing everything on its way are not based on any serious scientific instrumental studies, and are in fact guesses of “experts” who are far from understanding the real scope of the problem.
In October 1997, the First International Conference on Lake Sarez Problems was convened by the International Organization for Migration (IOM) in Dushanbe, Tajikistan, with the main goal to attract the attention of the government and the international community to the problem that still presented the main hazards for four neighboring countries – Tajikistan, Uzbekistan, Turkmenistan, and Afghanistan. It was one of those rare occasions when in a little over one year most of the Conference recommendations have been fully implemented. Thus, in June 1998, an international assessment mission to the area was conducted with the support of the World Bank and the International Decade for Natural Disaster Reduction (IDNDR, now ISDR). Experts and consultants from 8 countries participated in the mission and came up with a unanimous verdict – before any long-term solutions are considered, it is most important to ensure the safety of the downstream communities.
In 1999, the non-governmental organization FOCUS Humanitarian Assistance USA, with the funding made available by ECHO, implemented a number of measures aimed at assessing the nature of the hazard and the development of emergency communication system for the settlements located in close proximity to the lake. The project resulted in:

1. the implementation of *preparedness activities* targeting vulnerable and other groups of people, including local communities, local administration, Ministry of Emergency Situations and Civil Defense staff, nongovernmental and international humanitarian organizations with a mandate of disaster response;

2. an assessment of human resources and institutional infrastructure for the development of a detailed plan of action in emergency situations;

3. a series of workshops in remote villages and towns, local and provincial khukumats with the objective of raising awareness and developing the capacity of the project beneficiaries, their involvement in the planning process, creation of local search and rescue teams, and emergency training;

4. Elaboration and installation of a two-way emergency communication system. The system consists of 11 HF radio stations located at the Usoy Dam, Dushanbe, Khorog, the regional center of Rushan and seven villages of the Bartang Valley immediately downstream of Lake Sarez.
In 2000, an international “Lake Sarez Risk Mitigation Project” was launched under the auspices of the World Bank with the funding made available by the USAID, AKF, the Governments of Switzerland and the Republic of Tajikistan. The Tajik counterpart for the project was represented by the Ministry of Emergencies and Civil Defense. The main project objectives included the elaboration and installation of a monitoring and early warning system in the area of Lake Sarez and Usoy Dam. These rather challenging tasks were implemented with the assistance of the Swiss companies STUCKY Engineering Ltd. and FELA Planung AG. The project consisted of four components.

- **A – Design and installation of a monitoring and warning system.** This system will be able to (i) sense the beginning of an outburst flood or a substantial increase of the danger, and (ii) send a signal that will trigger alarms in the most vulnerable villages below the dam, and (iii) provide long-term data needed to understand better the technical options for reducing the likelihood of a flood.

- **B – Social training and safety related supplies.** This part is also known as the Social Component.

- **C – Studies to assess possible long-term solutions** to the Sarez outburst flood hazard.

- **D – Institutional strengthening.** Consultants’ services, incremental operating costs and equipment to strengthen the capacity of the GoT organizations responsible for implementing the project.
The project was successfully implemented by December 2006 and had fully achieved its objectives. What is most important, the project achieved its main goal aimed at ensuring safety of the population and communities residing in close proximity to Lake Sarez. The unique monitoring and early warning system (M&EWS) has been tested for almost three years providing valuable data that could be used at the construction of high artificial dams and hydropower facilities. The experience and practices gained under the LSRMP could be used for the design and installation of M&EWS at other natural and artificial dams both in Tajikistan and other countries of the region since many of the functioning hydropower plants built in the past were either not been equipped with adequate monitoring systems, with the exception of Nurek – and even this one has considerably deteriorated and became obsolete. At the same time, according to the international requirements (see Regulatory Framework for Dam Safety – A Comparative Study, the World Bank, 2003), each dam – whether natural or artificial – if it is higher than 15 meters, should be equipped with a monitoring and early warning system (MS&EWS).

From the very beginning, the Lake Sarez Mitigation Project has been viewed as Phase I of the overall goal and has reduced vulnerability of the population of the Bartang and Pianj river valleys to natural disasters, including the potential outburst of Lake Sarez. It is expected that Phase II will be aimed at the selection and implementation of a long-
term solution that will ensure full safety of the Lake and, at the same time, will make it possible to save this unique reservoir of clean water and to use it for the benefit of the country and its people. This, however, requires additional research and investment as well as the scientific and financial support of the international community.

Following is the summary of the LSRMP investigations and findings that should be taken into consideration during the development and implementation of Phase II of the project, provided it finds the support of the Government and international donors.

Three main problems have been identified that might result in the collapse of or a serious damage to the Usoy Dam:

1. Overtopping the dam crest with the following collapse caused by the increased water level.

2. Collapse of the Usoy Dam caused by the growing ravine downstream.

Displacement of the Right Bank Landslide resulting in the overtopping wave that again can cause a collapse of the Usoy Dam.

All experts agree that the dam is stable, although none provides any scientific justification – all conclusions are based on their personal experience and estimations.

“Usoy” primary substation
“Usoy” primary substation (helicopter view)

Solar panels installed at “Usoy” primary substation
Early Warning System for inhabitants of Bartang Valley

Lake water level on August 3, 2006
Automatic weather station data, August 3, 2006

Mounting radio communication equipment at Sarez Lake
Seismic data collection

Maximal lake level of 3,267 m, September 2005
Installation of the early warning system in Bardara village
С 1914 г. по 1934 год голова каньона продвигалась в глубину покрова со средней скоростью 100-140 м в год (при объеме размыва за год 250-300 тыс. м³), с 1939 года по 1956 год — со скоростью 6,6-7,4 м в год. С 1956 года каньон практически не растет. В августе 1994 г. каньон вырос на 42 м.

West view

East view
Condition of the new spring, 2 October 2006

Therefore, there are still a few pending issues which include the following:

- No one can present reliable evidence of both the stability of the Usoy Dam or a possibility of its catastrophic collapse
- Most data is still at the level of 1926: none of consecutive research added anything of significance, and the research needs to be continued.
Of all the main possible reasons of the potential collapse of the dam, only one such reason has been properly researched – the Right Bank Landslide. Additional investigations carried out by the engineering company STUCKY Ltd. (Switzerland) proved that the Landslide presents no particular danger. The size of the actual landslide is much less than it had been initially thought – 0.25 km$^3$ instead of 2.2 km$^3$: the displacement relates to the loose alluvial cover of the slope which moves with the speed compatible with that of the background movement of loose deposits of mountain slopes; that is, there has not been observed any displacement of deep earth materials.

The solution of the two remaining problems requires a detailed study of the Usoy Dam structure. This includes:

1. A GIS-based topographic survey aimed at the precise measurement of the dam and creation of a digital model of the area.
2. Drilling of at least 3 boreholes of 200 m deep along the dam crest to precisely define its composition and the depth of lake water seepage.
3. A series of geo-physical research aimed at the identification of deep structure of the dam, building on the findings received from bored holes.
4. Installation of a seismic digital station in the area of Lake Sarez to monitor the seismological regime and study the seismic impact on the dam.

All these works will allow receiving an analytical model of the Usoy Dam to be used in further stability analysis and the behavior of high artificial dams under earthquakes. At the same time, the implementation of the selected long-term solution will make it possible to lower the lake water level, thus ensuring its safety for the population and infrastructure downstream and will allow using the lake waters for the economic development.
Lake Sarez

length – 55.8 km; absolute surface height – 3,263 m; maximum width – 3.3 km; maximum depth – 500 m; maximum water volume – 16,074 km$^3$; received balance – 47.1 m$^3$/sec = 1,487 million m$^3$/year; surged balance – 47.7 m$^3$/sec = 1,505 million m$^3$/year; maximum seasonal fluctuation of the lake level – 12 m.