TAJIKISTAN: LAKE SAREZ AND THE PAMIR MOUNTAINS

Lake Sarez, high in the Pamir Mountains, was created by a massive landslide dam that was caused by an earthquake in 1911. This case study centres on the question of how to determine the likelihood of occurrence of a potentially catastrophic natural event. Geophysical considerations are at its core, although the consequence of the outbreak of this very large volume of water, in the worst case scenario, would become one of the world's most disastrous natural events in human, economic, and political terms. There are many ramifications, especially since the potential disaster would affect highland and lowland settlements and would cross several international borders. The World Bank, various agencies of the United Nations Organization, several national governmental agencies, and NGOs are already taking steps to respond to the eventuality. It is an instance whereby a **potential** highland-lowland natural event, rather than an **actual** occurrence, is causing social, economic, and political repercussions.

Lake Sarez is situated in the Pamir Mountains of Tajikistan close to 3,000 m asl. Its location is one of the most remote in the world. It formed following a very large landslide, set off by an earthquake in the winter of 1911. The landslide, with a volume of some 2-3 km^3 , plunged down a mountain side to form a dam between 500 and 600 metres in height and two kilometres wide to block the Murgab River. This river is a tributary of the Bartang River which, below the confluence with the Murgab, flows for 120 km through a gigantic mountain gorge to join the Pianj River, itself a tributary of the Amu Darya. The Amu Darya is one of the two major rivers

that drains into the Aral Sea 2,000 km below the dam site. The Pianj and Amu Darya rivers form part of the frontier between Tajikistan and Afghanistan and further downstream their combined waters flow through Uzbekistan and Turkmenistan.

The fallen mass of rock and earth was named the Usoi Dam after the village that it completely annihilated. The dammed waters of the Murgab River produced Lake Sarez, named for a village that was submerged by the rising waters. Initially, the level of the lake rose at a rate of about 75 metres a year. Today it is more than 60 km in length and has a maximum depth in excess of 500 metres. Its total volume is about 17 km^3 , approximately two-thirds the volume of Lake Geneva. The lake surface is close to 3,200 m asl, surrounded by peaks rising to more than 6,000 m. The Usoi dam is the highest dam, natural or man-made, in the world. Set in the heart of the Pamir Mountains, the lake itself and its surroundings form a magnificent mountain landscape. It is also located in a region that has been central to major political and military tensions for more than 200 years. During the 19th and early 20th centuries the three rival empires, Czarist Russia, Great Britain, and China competed on a gigantic and heroic scale that became known, following the writing of Rudyard Kipling, as the 'Great Game'. Much earlier a main branch of the Silk Road passed through the Pamir and carried Marco Polo and his uncles to the court of Kublai Khan. The present republics of Central Asia were moulded by Soviet Russia from a series of Khanates, together with territories of no clear political allegiance. Currently, with a massively disturbed Afghanistan, Pakistan, Kashmir, and India, all virtually within walking distance, and with Iran, Iraq, and Turkey as neighbours with more than a passing interest, political instability may seem the order of the day.

The Pamir Mountains, in general, represent one of the most active seismic regions on the world's geophysical map. Lake Sarez, therefore, is a focal point for a great amount of concern. A disaster of significant proportions could be triggered in several ways. A major earthquake could shatter the Usoi dam and send an enormous flood wave down the Bartang Valley and into the Pianj and Amu Darya rivers; the dam could collapse under the pressure of the water as the lake continues to rise; the piping of water through the dam, which is occurring today, could enlarge and cause the dam to collapse; or collapse could be induced by the continued rise of the lake level (by about 5 cm/yr during the 1990s) and eventually over-topping it. Finally, another large landslide, caused either by an earthquake, or the spontaneous failure of the mountain wall above the lake, could fall into the lake and generate a giant wave to over-top the dam. Even if the dam was not broken by such a wave, the wall of water rushing down the Bartang Valley could set off fast moving mudflows and trigger secondary landslides by under-cutting the talus slopes along the valley sides. This could be sufficient to eliminate all the thirty villages in the valley, and even more as the disturbance entered the Pianj Valley. It has been estimated that, in the worst case, the lives of five million people could be affected. Furthermore, the torrential flood waters could extend as far downstream as the Aral Sea itself, with the additional danger of disturbing the toxic sediments that have been exposed as the sea has dried up.

The problem is rendered the more complex by a number of other factors. The vicinity of Lake Sarez is extremely remote and physical access along the Bartang Valley is a challenge. The final approach to the dam involves a difficult ascent on

foot along steep mountain slopes, with a gain in altitude of more than 1,000 metres. This would render road construction, if heavy equipment would be needed, extremely expensive and technically difficult to maintain. The regional approach also constitutes a challenge; there are two main roads into the upper Pianj Valley and Khorog, the regional capital. One of these is very long and involves transit through a small part of the territories of Uzbekistan and Kyrgyzstan and a high-altitude section (above 4,000 m) across the Pamir Plateau. The other, more direct, requires passage of the Pianj gorge, with very unstable slopes and a narrow road bed subject to rockfall, mudflow, landslide, and avalanche. Both roads are closed by heavy snow for several months of the year.

The difficulty of access alone would appear to eliminate large-scale engineering solutions, such as reinforcing the dam artificially, or attempting a controlled partial drainage and lowering of the lake level.

Below the Usoi dam there are more than 30 small villages in the Bartang Valley, with a total population of about 7,000 mountain people (Ismaili). Most villages (*kishlaks*) are sited on alluvial cones near to the river and use all available gently sloping land. Many of the villages are subject to floods, landslides, mudflows, and avalanches annually; while these natural hazards are individually of small magnitude, compared to that posed by a potential failure of the Usoi dam, they are frequent in occurrence and constantly restrict access to the valley and would constrain any needed evacuation. Any landslide-induced flood wave capable of over-topping the dam would place all or most of the villages at risk.

Soviet and Tajik scientists became aware of the threat posed by Lake Sarez some decades ago. Early warning and lake-level monitoring systems were established. The warning signals, however, were only directed to Moscow and Dushanbe. Thus, in the event of a medium- or large-scale flood, any secondary warning to reach the Bartang villages from either Moscow or Dushanbe would likely arrive after the event, if at all. With the collapse of the USSR even this approach to early warning and lake-level monitoring ended. Then followed the civil war of 1992-1997 when the problem of Lake Sarez was put aside.

Over the last three years, the dangers posed by Lake Sarez have begun to be taken seriously. Various reconnaissance visits have been made to the lake and dam and to the Bartang Valley. Several high-level planning meetings have been held: in Dushanbe, Geneva, and Washington, DC. The involved Asian republics, and especially Tajikistan, appear to favour a development approach based on the assumption that the worst case scenario (total collapse of the Usoi dam) was credible. A major investigation was mounted during June 1999. This was financed primarily by the World Bank, with additional support from the UN disaster relief organization, Focus Humanitarian Assistance (one of the Aga Khan family of organizations), and the government of Tajikistan. An international group of engineers, geophysicists, geologists, and geographers visited Lake Sarez and examined all the approach routes. There was unanimous agreement that the prospect of a worst case scenario was sufficiently remote that it should be accorded a low level of priority. However, there was strong support for installation of monitoring and early warning systems. Unlike the earlier Soviet approach, the new approach would relate to all the villages

in the Bartang Valley and ensure the direct input of the local people. Concurrently, it was recommended that computor mapping and simulation of the potential impacts of various levels of natural disaster be undertaken. It was also pointed out that further, and much more detailed, studies should be undertaken of the cultural and socioeconomic situation of the local people. Sites for safe havens should be located and equipped, and a full accounting made of the attitudes of the local people toward the various levels of possible danger. One additional, and very important point, is that steps should be taken to ensure that the likelihood of actual large-scale disaster (worst case scenario) not be over-stated, so that the risk of any government-ordered forced evacuation of the Bartang Valley could be avoided.

By February 2000 it appeared that, under the leadership of the World Bank and with contributions from several major donors, the recommendations of the June 1999 reconnaissance team were to be acted upon (United Nations, 2000). A year later, at time of this writing, significant planning progress has been made. Thus, the case of Lake Sarez, while representing one of the largest ever potential disasters based upon a natural situation in a high mountain region, embraces many complex inter-relations between highlands and lowlands. Ultimately, the challenging task of seeking collaboration amongst several independent countries on the use and management of a large international river, the Amu Darya and its headstreams, will have to be faced. Given the international rivalries prevailing in the region, this might well be the single most difficult task. Nevertheless, while the magnitude of the problems emanating from the potential instability of Lake Sarez may be an order of magnitude, or more, higher than other mountain hazards in the same region, their

identification, evaluation, and treatment should provide a formula for ways in which other hazardous situations could be approached.