Chapter 4

Environmental impact assessment: the ecology of South-Eastern Tajikistan

4.1 Introduction

4.1.1 Background and methodology

In addition to the obvious potential humanitarian implications, the range of possible flood scenarios also presents significant threats to biodiversity, land use, and geomorphological processes at local, national, and regional levels. These will have both short- and long-term impacts.

This chapter summarises the findings of an initial assessment mission, bringing together results from field interviews and surveys, along with published information. It is important to recognise that this presentation represents only a starting point in coming to terms with the enormous possible implications of any breach in the environment of large areas of Central Asia.

In assessing environmental impacts, this chapter highlights key issues of biodiversity and pollution risks. It considers mainly the implications of a breach of the Usoi landslide dam in the context of the effects on Tajikistan, but also identifies potential regional concerns that will require additional research. Geomorphological and landscape impacts are covered in the chapter by Dr. Teiji Watanabe (Chapter 5).

The aim of this study was to produce a broad overview that will provide a context for policy decision-making and a starting point for continued research to refine the understanding of the implications of a flood in the Bartang and Panj River valleys, originating from Lake Sarez.

Interviews were held during the mission with government specialists, NGO representatives, and scientists. Although the mission had the task of reviewing the potential implications of a breach of the Usoi dam and uncontrolled release of water from Lake Sarez, it is important to recognise that this is not an isolated phenomenon. Landslide- and glacier-dammed lakes such as Lake Sarez are found in many mountain areas, and it is possible that risks similar to those faced at Sarez are equally applicable to other locations within Tajikistan and in other mountain nations.

4.1.2 Sources of information

Natural sciences studies are well developed in the region, and there is a wealth of background information and local expertise available. Significant strides have been taken in the cataloguing of biodiversity, the best example of this effort being the first Tajik Red Data Book (Tajikistan Academy of Sciences, 1988). The Ministry for Nature Protection is the lead government agency in this field, but considerable academic expertise exists in the Academy of Sciences of Tajikistan, as well as in active local environmental NGOs, such as Man & Nature, the Pamir Biological Institute (including the Khorog Botanical Gardens), the Association of Guards, Woods and Wild Animals of Tajikistan, and the Kuhiston International Foundation. Therefore, there is adequate baseline information within Tajikistan to provide an initial assessment of potential impacts.

The author has reviewed the Red Data Book for Tajikistan (Tajikistan Academy of Sciences, 1988) to identify potentially affected species of national and international significance. Annex 4-1 provides a full listing of animals and plants found along the river valleys, which could be significantly affected in the event of an overtopping or breach of the Usoi dam. This book is currently in the process of being updated and, although a revised copy was not available at the time of the mission, it is inevitable that the level of understanding will have improved over the last 10 years. The analysis of the existing book should therefore be seen as illustrative rather than definitive

4.1.3. Scenario assumptions

Two failure scenarios are considered here: the worst case scenario of a total breach of the Usoi dam and the alternative scenario of overtopping of the dam without a total breach. If the worst-case scenario occurs, on the basis of available information, impacts are likely to occur as far downstream as the Amu Darya River and into the Aral Sea Basin. Therefore, this report has been divided into local, national, and regional contexts Both scenarios assume that the prime impact driver would be a large-scale debris flow.

4.2 Local description - the Bartang valley

4.2.1 General Description

The Bartang River valley winds for some 150 km from the Usoi landslide dam to the confluence with the Panj River valley at Rushan.

Lake Sarez is a relatively young feature and is not an ecologically rich habitat in itself; however, the surrounding mountain and valley features are extremely important habitats, providing a range of niches that, like many remote mountain areas, could provide suitable conditions for high levels of endemism (Blagoveschenskaja, 1999). The Ministry for Nature Protection has confirmed that the area surrounding Sarez would meet national criteria for conservation protection (Latifi, 1999).

The Bartang valley has been described by Rachkovskaja et al. (1997) as being primarily "Mid-Mountain semi-arid open woodland with leaved forests and shrubs" in the basin of the valley, with "Mid Mountain Juniper Forest" and then "High Mountain Cryophytic Friganoid" habitats farther upslope.

The river varies in width along the valley depending on the slope profiles. Where steep rock cliffs are the main geological features, the river is deep and constrained in movement, with little opportunity for vegetation to grow along the sides and on the unstable talus slopes at the base of the slopes. At some lower reaches of the valley, the flood plain widens to more than a kilometre wide. The river meanders considerably and significant deposits of silt and sand have been deposited in these areas, providing limited opportunities for stable sediments to be produced. However, many of the low-lying areas of riverine and wind-blown silt are subject to flooding in the summer, thus restricting potential long-term niche development in the river bed.

Areas that are more stable sustain low scrub vegetation. The largest range of floral diversity appears to be concentrated in the areas surrounding tributary alluvial fans and on old river terraces. In these areas, soil has started to form and a relatively wide range of vegetation can be found

These areas also are the sites of the human settlements in the valley; so natural biodiversity is also enriched with anthropogenic planting, including crops such as wheat, potatoes, and trees, such as poplar, which is widely used in construction.

4.2.2 Key features

The entire Pamir region is extremely important in biological, geological, and cultural terms. Like many mountain regions, the environment can provide unique pressures and opportunities with which species must evolve to exploit. Therefore, it is not surprising that there are many examples of endemic flora that by definition are of enormous value at the international level (Blagoveschenskaja, 1999).

The value of the Pamirs is well recognised within the scientific community in Tajikistan. Recommendations have been put forward by the Ministry of Nature Protection to designate areas as UNESCO Biosphere Reserves. In addition, plans are well advanced to declare a large area in the northern Pamirs as a National Park. NGOs are pushing to establish larger areas as National Parks (Kasirov, 1999), but the Government has noted that while much larger areas would meet criteria for establishing such protection measures, the resources available to implement such policies are modest and are being targeted to key sites only (Latifi, 1999). Therefore, the Bartang valley must be seen in the broader context of a very large area of Tajikistan being of national and possibly international environmental significance.

The Bartang valley has very rich floral resources. The site has been studied since 1882, and more than 1200 plant species have been recorded in the valley. Researchers at the Pamir Biological Institute have reported that some 166 endemic plant species can be found in the Province of Gorno-Badakshan. Key endemic plant species include *Clematis saresica, Betula murgabica, Pleurospermum badachschanicum, Kudrjaschevia pojarkovae, K. nadinae,* and *Acantholimon hilariae* (Navrouzshoev, 1999).

There are no specifically-protected wildlife habitats in the valley, although some areas would meet the national criteria. There is relatively little human interference in natural habitat and the Ministry for Nature Protection report that they try to concentrate their resources in areas of potential conflict between conservation and human uses (Latifi, 1999).

4.2.3 Risks of impact

Any breach in the Usoi landslide dam has the potential for significant impacts in the Bartang valley. In addition to the large amount of material comprising the dam, the valley contains large amounts of loose and unstable slope debris; both of these masses would be carried by the flood, forming an extensive debris flow. Depending on the height of the flow, it is almost certain that the main areas of both human habitation and richest floral diversity would be devastated.

4.2.3.1 Short-term impacts

- Complete destruction of habitats, human settlements, and infrastructure.

4.2.3.2 Long-term impacts

- Some endemic species may become extinct.
- Erosion of the toes of rock walls could leave the entire valley system unstable, resulting in new rock falls and mud flows in unpredictable places.
- Agricultural land would be destroyed and the surface covered with the associated debris of the flow.
- In broad terms, entire valley areas would probably be rendered uninhabitable for generations.
- Revegetation will proceed slowly, depending on the level and type of sediment deposited, speed of stabilisation of the sediments, and time of year. Opportunistic species will probably predominate in the early phases,

and it is likely that the species composition will change. Food -web impacts will also be likely, e.g , because prey species such as rodents on the valley floor will be greatly affected by the floods, predators such as raptors will be forced to move to find alternative prey sources.

Annex 4-1 highlights the Red Data Species that are found within the Bartang valley and therefore will be most affected by a breach of the Usoi dam. It also highlights the possible Red Data Species that are found along the route of the Panj River. However, while these data highlight the most endangered or rare species in the country, they do not reflect the enormous richness that habitats represent. From this basic analysis of the Red Book, it suggests that some 7 animal species and 13 plant species found in the Bartang valley would be affected by flooding. In total, for the worst case scenario, it is likely that some 13 invertebrates, 3 fish, 9 reptile, 3 bird, 14 mammal, and 65 plant species would be affected in varying degrees. Therefore, more than 100 Red Data Species could be impacted by a worst-case flood scenario, ignoring the thousands of other species that would also be impacted upon.

4.3 National description — Panj River valley

4.3.1 General description

The Bartang River meets the Panj valley at Rushan The Panj River then forms the Tajik/Afghan border for more than 500 km west of Rushan

The Panj valley is generally wider than the Bartang valley, with greater distance between the river and the valley walls. There are also more extensive areas of sediment that provide suitable conditions for both humans and a wide range of wildlife

The following land-use trend (table 1) was recorded during field surveys, and illustrates the range of land uses within settled areas on the valley floors that would be impacted by flood scenarios

Within the village areas there is limited opportunity for development of natural habitats, given that the villagers try to make the best use of available resources. Main wildlife habitats are therefore on the village margins and on inaccessible or uncultivable land.

Table 1. Observed Land Use in the Upper Panj River Valley

Features	Comment
River	Width varies considerably: from 30m - >1km
Bank habitat	Variable: from rock cliffs to gently sloping silt/sand beaches and agricultural terraces.
Agricultural Areas	Wheat and potato fields, fields small, generally < 1 ha; some extensive grazing land noted.
Road	Good quality, two-lane tarmac road close to Rushan; then increasingly rugged, single track with passing zones downstream.
Homes/Agricultural Areas	Many small villages noted; houses are small and often laid out in linear patterns following the road. Homes often include small fields/vegetable patches and poplar trees for construction purposes, along with walnut and mulberry trees for food.
Marginal Agricultural Slopes	Above the villages, as the slope increases, there appears to be relatively marginal land, often requiring irrigation from channels cut into the slopes. Best use appears to be made of all available cropland.
Slope Habitat	Varies from gently rising slopes to solid rock cliffs; most common appear to be high-angle talus slopes providing possible high-frequency/low-impact hazards to homes, especially during the rainy season.

Table 2. Relationship between altitude and vegetation belts in the Rushan area
(source Patchadjanov et al., 1997)

Altitude	Vegetation Belt
1800-2700 m above sea level	Mountain Deserts with *Artemisia sp.*
2700-3700 m	Mountain Steppe-Deserts with *Artemisia Korzinskii*
3700-4200 m	Deserts with *Artemisia Lemarini* and Pamir Prickly Thrift *Acantholimon pamiricu*
4200-4800 m	Belt of Pulvinates

4.3.2 Habitats

The Panj River valley includes a number of important habitat features, these vary, depending on the extent of human influence, altitude, and geological conditions. The broad vertical variation of vegetation types in the mountainous areas around Rushan and Shugnan is indicated in table 2.

Patchadjanov et al. (1997) described the habitats subject to human influence as "Anthropogenic Landscapes," where species composition will vary depending on the degree of human activity as well as the natural conditions. It is likely that large portions of the Panj River valley can be described as this "Anthropogenic Landscape."

The broad habitat description along the Panj valley moving downstream from the confluence with the Bartang River is described in Patchadjanov et al. (1997) as starting out as "Mid Mountain Semi-Arid Open Woodland with Leaved Forests and Shrubs". Approximately 80 km from the confluence, the habitat changes to "Mid and Low Mountains with Arid Open Woodland Pistachio Forests " This continues for an additional 200 km, interspersed with a further section of "Mid Mountain Semi-Arid Open Woodland." In the lower reaches of the river, before reaching the border with Uzbekistan, the habitat changes to "Piedmont Savannoids" with a small but extremely important section of "Tugai" complex and then a section of "Piedmont Desert " Throughout these broad habitat descriptions there are large areas that can be classified as "Anthropogenic Landscapes" in that the base habitat has been subject to considerable human influence, through agriculture, road and infrastructure development, and settlements. The general faunal species composition of the anthropogenic areas in the river valleys of southern Tajikistan include the following: Water Frog *Rana ridibunda*, Green Toad *Bufo viridis*, Water Snake *Natrix natrix*, Rapid Fringe-Toed Lizard *Eremias velox*, Glass Lizard *Pseudopus apodus*, Tree Sparrow *Passer montanus*. Spanish Sparrow *Passer hispaniolensis*, Common Myna *Acridotheres tristis*, Eurasian Rook *Corvus frugilegus*, Jackdaw *Corvus monedula*, Magpie *Pica pica*, Rufous-Backed Shrike *Lanius schach*, Blue Cheeked Bee-eater *Merops superciliosus*, and Common Swift *Apus apus* (Patchadjanov et al., 1997).

4.3.3 Key features

The Panj River valley includes two of the three Zapovednik Nature reserves established in all of Tajikistan. The Zapovednik designation is the highest form of conservation designation. It is reserved for the most important natural habitats where human interference is banned. Usually the only human presence is that of scientists. Unfortunately, during the recent Tajik civil war, some areas of nature reserve were seriously damaged, but the designation remains a reflection of their potential significance (Blagoveschenskaja, 1999)

a) **Dashtidzhumsky** mountain forest reserve on the bank of the Panj River occupies 53,400 ha; it includes pistachio, juniper, and maple forests, as well as providing habitats for key faunal species such as the Markhor *Capra falconeri*, Snow Leopard *Pantera unica unica*, Jungle Cat *Felis chaus oxiana*, Brown Bear *Ursus arctos* Siberian Ibex *Capra siberica*, and Otter *Lutra lutra seistanica*. Reptiles found in the reserve include several species of gecko and the Himalayan Rock *Agama Stelio himalayanus*. Birds in the reserve include White-Caped water Redstart *Chaimarrornis leucocephalus*, Little Forktail *Enicurus scouleri*, and Chuckar Partridge *Alectoris chukar* (Patchadjanov et al., 1997).

b) ***Tigrovaya Balka*** reserve protects one of the largest remaining tugai forests in Central Asia. The tugai ecosytem in Tajikistan is extremely important because the remnants of this florally-rich habitat located farther downstream on the Amu Darya River have been significantly degraded by the impacts of hydrological and pollution conditions in the Aral Sea basin. The tugai habitat typically contains some 576 superior plants, including 29 endemic to Central Asia. Owing to desertification downstream, 54 species have been reported as being on the verge of extinction, and remaining remnants of the habitat are highly stressed. (Glazovsky, 1995). Tigrovaya Balka, with an area of 49,786 ha, is therefore extremely significant. This Zapovednik was the main habitat of the Turan Tiger *Panthera tigris virgata*, which was last seen in Tajikistan in 1954 It remains the key habitat of several Red Data Book species, such as the Bukhara Red Deer *Cervus elaphus bactrianus*, Pheasant *Phasianus cochicus bianchii*, Goitred Gazelle *Gazella subgutturosa*, and fish species, such as the Shovelnose - *Pseudoscaphirhynchus* spp. Amphibians in the reserve include the Green Toad *Bufo viridis* and Water Frog *Rana ridibunda*. Reptiles include the Turkestan Plate-Tailed Gecko *Teratoscincus scincus*, Toad-Headed Agama *Phrynochalus mystaceus*, Desert Monitor *Varanus griseus*, Rapid Fringe-Toed Lizard *Eremias velox*, Sand Racerunner *Eremias scripta*, geckos *Teratoscincus sp* and *Alsophylax sp*, Steppe Ribbon Snake *Psammopnis lineolatus*, Oxus (Central Asian) Cobra *Naja oxiana*, Levantine *Viper Vipera lebetina* and Saw-Scaled Viper *Echis carinatus* Other mammals in the reserve include the Wild Boar *Sus scrofa*, Striped Hyaena *Hyaena hyaena*, Jackal *Canis aureus*, Marbled Polecat *Vormela peregusna*, Tolai hare *Lepus tolai*, and Indian Crested Porcupine *Hystrix leucura satunini* (Patchadjanov et al., 1997).

4.3.4 Risks of impact

Both reserves are extremely important habitats at both national and international levels. Damage to the sites would be a disastrous loss of biodiversity. Although the sites have been damaged by the civil war and reportedly as a result of neighbouring agricultural and hunting activities, the importance of these areas must not be compromised if at all possible (Blagoveschenskaja, 1999).

These reserves would be affected by a full breach of the Usoi landslide dam, and species dependent on water quality would be seriously affected by an overtopping if high sediment loads were released into the Panj River.

The basic impacts would be similar to those for the Bartang valley (above), but, in addition, there is the potential for some pollutants to be released along the length of the valley. Although current pesticide and nitrate usage is reportedly low because of the economic difficulties in the region, historically there have been records of considerable pesticide and fertilizer loadings. Glazovsky (1995) noted that both fertilizer and pesticide usage was higher in the Central Asia areas than in the remainder of the former USSR DDT, now banned, was widely used in the region until 1982, and high DDT concentrations remain within the soils. Furthermore, the use of chemical fertilizers grew enormously from 1960 to 1985. In 1960, Tajikistan, on average, applied fertilizer at a rate of 78.2 kg/ha; by 1985 this had risen to

249 kg/ha (Glazovsky, 1995). However, it is likely that, while the levels of fertilizer application have fallen dramatically given the security and economic conditions in the country over the last 10 years, there remains potential for pollution.

Any remaining soil contamination could possibly be released and spread by a flood reaching this far downstream. This could provide an acute pollution shock compared to the historical chronic releases with which such intensively farmed areas normally have to cope.

There appear to be no major human settlements, factories, power stations, pipelines, chemical stores, or waste facilities along the flood route that could present a significant pollution threat. However, there are mines high in the mountain areas, reportedly for wolfram, gold, and uranium. While the mines would probably be sufficiently high above the river to escape any initial flood, it is possible that damage to deep mines as well as access routes would need to be considered.

It is not known if there are any major military facilities along the possible flood route, but large military facilities often contain potentially contaminating materials, such as fuel, ammunition, chemicals, etc , that would need to be taken into account in any national contingency plan.

4.4 Regional description - Aral Sea basin

This review is not intended to extend beyond Tajikistan, but it is vital to consider the potential regional implications of a major flood scenario. In addition to downstream impacts, it is also important to recognise that the Panj River forms the border with Afghanistan and, although beyond the scope of this assessment, impacts across the border along the entire length of the Panj River flood path would need to be considered in any regional context.

Tajikistan, and particularly the areas potentially affected by a breach of the Usoi landslide dam, are major contributors to the water balance in Central Asia. It is inevitable that any problems experienced in the riverine regime in Tajikistan will be transmitted across borders, potentially affecting even more vulnerable communities farther downstream.

The Amu Darya River, together with the Syr Darya River, is a major contributor to the Aral Sea basin. The problems specifically associated with the Aral Sea are well documented (e.g., Glazovsky, 1995; Kobori and Glantz, 1998; Shestakov and Streletsky, 1998). In addition to the reductions in water supplies reaching the Aral Sea as a result of massive increases in cotton crop irrigation over the last 60 years, downstream water quality is a key regional issue. Problems include contamination from agrochemicals, increasing salinisation, and impacts on groundwater, as well as surface water. The system is already extremely stressed, people living downstream of the Amu Darya are reported as saying: "people at the entry of the "pipe" drink water, but we Karakalpaks, at its exit, drink a poison" (Shestakov and Streletsky, 1998). Ecological resources are also highly stressed; reports note that, in some areas around the Aral Sea, diversity of mammal species has dropped from 60 to 30 species and the number of bird species from 319 to 168 (Glazovksy, 1995)

Under the most likely failure scenario presented for Lake Sarez, due to overtopping of the dam, the immediate downstream cross-border impacts would probably not be very significant. It is predicted that a debris flow would travel as far as the Rushan district. However, although the flow front might not travel past the border downstream, any sediment load and contamination that is collected will be flushed downstream, making an already-stressed water-supply system even more difficult to manage.

However, in the worst-case scenario, it is possible that a debris flow would reach beyond the Tajik

border and affect downstream countries as far as the Aral Sea basin itself. In addition to the immediate damage such a flow would cause to settlements and infrastructure in the path of the flood, it is important to recognise the potential for secondary disaster impacts. These could include the destruction of strategic resources, such as oil pipelines, chemical plants, factories, and agrochemical warehouses. In such a scenario, there is a very real threat of a "cocktail" of chemicals being released, which could further complicate recovery from the debris-flow impact by polluting water sources, irrigation systems, agricultural land, and habitat areas.

Furthermore, the impact of a catastrophic debris flow could change the course of river flows in low-lying areas where there might be more room to change flow patterns. This could affect areas that had already been dried out and had become heavily salinised, thereby re-releasing the salts into the changed hydrological regime.

4.5 Conclusions

The areas that are potentially at risk from a flood from Lake Sarez are extremely important natural habitats of local, national, and international significance. The area exhibits a high level of endemism, and it is possible that important species would be endangered by any of the flood scenarios. It is vital that the habitats be given the recognition and protection they deserve, and that every effort be made to protect those species that can be seen as a common heritage of mankind. The concerns are more than just of national-level conservation. The species and habitats under threat are unique and irreplaceable. Damage to people and infrastructure from any disaster would be appaling enough; at least people can be given early warning and infrastructure can be rebuilt. If and when rare and endangered species and habitats are expunged, they are gone forever and there can never be recovery from the impact of the disaster. There are basic measures that can be undertaken to identify and protect these habitats and species both in-situ and ex-situ. It is important that all such measures be undertaken if the riches of this area of the Pamirs are to be protected for the international community and future generations.

4.6 Recommendations

The following recommendations are based on the gaps in information available to the current assessment. Anticipated costs are not provided for these items because it is felt that much of the work can be carried out by national and regional authorities and by NGOs. It would benefit such work if it could be conducted under the direct supervision and management of the UN family to ensure that full levels of objectivity are assured.

4.6.1 Regional priorities

Further attention must be given to the identification of potential pollution sources in the region downstream from Tajikistan, including the border areas of Afghanistan along the Panj River. This will require a regional perspective to examine the full route of the Amu Darya River basin in regard to the following issues:

- Baseline survey of settlements, infrastructure, socio-economic resources, and habitat characteristics.
- Comparison of the baseline against the developing flood-path analysis.
- Identification of key points of concern where primary and secondary impacts are most likely, or where impacts would be most significant.
- Estimation of the possible value of flood damage along the entire length of the vulnerable area. This would allow cost/benefit comparison of flood prevention and mitigation schemes to be seen in the appropriate context that potential donors can appreciate.
- Review of opportunities to prepare national/regional contingency plans to cope with the threat scenarios.

These operations could be completed relatively quickly by an organisation with a regional mandate.

4.6.2 Tajikistan priorities

- Risk assessments for any mineral and military establishments near the flood route should be carried out. This would be a national governmental responsibility.

- Key habitat areas, such as those in the Pamirs, should be given the full legal and practical protection their international conservation value warrants. This could help the Government of Tajikistan make the case for international assistance under the various UN conventions to which the nation is signatory. It would possibly make the donor community more amenable to assist if it is clear that internationally-important habitats are afforded the full level of available national protection, yet remain significantly endangered.

- Ecological monitoring programmes should be expanded to ensure that the best possible level of scientific information is available against which policy decisions can be taken. Local and international NGOs should work with Governmental agencies to provide the most effective approaches to covering this large area of outstanding work. The World Wide Fund for Nature (WWF) has worked with local experts to produce a range of biodiversity projects outlined in their report *"Biodiversity Conservation*

of Tajikistan: analysis of recent situation and project portfolio" (Patchadjanov et al., 1997). Such efforts would be endorsed by the author. Even though none of these projects has been specifically targeted to impact the Sarez issue, the information and infrastructure that could be provided from such efforts would aid more-targeted studies. It appears that the level of technical expertise is very high in Tajikistan, like many countries, the key limiting factor for environmental research is access to resources. In a nation recovering from a civil war and the implications of the relatively new political situation in Central Asia, it is perhaps not surprising that resources that would assist in nature conservation have been channelled elsewhere. However, it is important to note that cutting environmental research will have possibly significant long-term implications in terms of sustainable management of limited resources. Assistance from the international community should be sought to ensure that joint research projects can be developed to re-establish the vital monitoring and protection work that sustainable development requires.

- As a contingency measure, consideration should be given to ex-situ conservation methods for those endemic species that are especially endangered by flooding. This would at least preserve the gene pool of such species. This could be carried out locally, e.g., at the Pamir Botanical Gardens, or internationally, if required. The Pamir Botanical Garden in Khorog works under the Pamir Biological Institute of the Tajikistan Academy of Sciences. The Garden is undertaking important botanical conservation measures and warrants support in developing possible ex-situ conservation projects, such as establishing seed banks. One of the key researchers on the botany of the Bartang valley is the Director of the Gardens, and he is in an ideal position to ensure that such activities are targeted to key species and sites.

- Tajikistan is a signatory to the UN Convention on Biological Diversity. This Convention provides, *inter alia*, for mechanisms to cope with impact assessment threats. It is recommended, without prejudice, that the Government of Tajikistan should explore the possibilities of gaining financial support to undertake measures to secure necessary biological studies under the terms of the Funding Mechanism of the UN Convention on Biological Diversity.

Article 14 of this Convention says that each Contracting Party, as far as possible and appropriate, shall:

"In the case of imminent or grave danger or damage, originating under its jurisdiction or control, to biological diversity within the area under jurisdiction of other States or in areas beyond the limits of national jurisdiction notify immediately the potentially affected States of such danger or damage, as well as initiate action to prevent or minimise such danger or damage; and promote national arrangements for emergency responses to activities or events, whether caused naturally or otherwise, which present a grave and imminent danger to biological diversity and encourage international cooperation to supplement such national efforts and where appropriate and agreed by the States or regional economic integration organisations concerned, to establish joint contingency plans "

There is, therefore, a clear obligation for Tajikistan to take action on this very real threat to biodiversity. However, Article 20 of the Convention states that:
"The developed country Parties shall provide new and additional financial resources to enable developing country Parties to meet the agreed full incremental costs to them of implementing measures which fulfill the obligations of this Convention. .The developed country Parties may also provide, and developing country Parties avail themselves of, financial resources related to the implementation of this Convention through bilateral, regional and other multilateral channels....Consideration shall also be given to the special situation of developing countries, including those that are most environmentally vulnerable, such as those with arid and semi-arid zones, coastal and mountainous areas "

Chapter 5

Environmental impact assessment: geomorphology of the Bartang and Kudara valleys

5.1 Introduction

The Environmental Impact Assessment Sub-team, focusing on landforms and biodiversity, worked in two different geographic areas in determining the environmental impact of possible breaching of the Usoi landslide dam leading to an outburst flood. One area was the upper stretch of the Bartang and Murgab River valleys, immediately downstream from the lake, and the lower end of the Kudara River valley where it enters the Bartang. These stretches of these river valleys would experience the most direct impact of a flood from Lake Sarez, regardless of the size of the flood. The other area was downstream along the Panj River, which would be impacted in the worst-case scenario. The lower part of the Vanj River basin, a tributary basin of the Panj River, could also be damaged; however, because of time constraints, the sub-team was unable to visit this basin.

5.2 Geomorphology and biology of the upstream area (Bartang, Kudara, and Murgab River basins)

The Murgab River meets the Kudara River near the village of Bartang (elevation ca. 2,660 m); at that point, the river name changes to Bartang River. Lake Sarez is located in the Murgab River basin. Lake Sarez and the Bartang, Kudara, and Murgab River basins are situated in a typical dry alpine area. According to Yablokov (1997), the mean annual ambient temperature at the Irkht hydrometeorological station at Lake Sarez (elevation 3,290 m) is 1.0 °C, and the annual precipitation at the station is 108 mm, with little snowfall (average annual maximum snow depth ~ 58 cm).

In order to assess the direct environmental impacts that could be created by a Lake Sarez outburst flood, it is necessary to examine landforms, fauna, and flora in the Bartang, Kudara, and Murgab River basins, immediately downstream from the lake

5.2.1 Previous environmental studies

Local experts have conducted general geomorphic studies in the valleys, including studies of slope instability related to tectonic activity. However, the impacts of an outburst flood on the geomorphology of the downstream valleys had not been assessed thus far. Moreover, relationships between landforms and fauna and flora were yet to be assessed in these valleys. For these reasons, the field observations of the Environmental Impact Assessment Sub-team were conducted along the Bartang, Kudara, and Murgab Rivers.

5.2.2 Environmental impacts

The precise impact assessment will be possible only after a potential outburst-flood analysis is completed. Nevertheless, the sub-team found the following important aspects that have to be considered regardless of the size of the flood.

5.2.2.1 Geomorphology

The landforms observed in the valleys were classified into the following six elements:
(1) glacial moraines,
(2) river terraces,
(3) alluvial fans/cones,
(4) flood plains,
(5) talus slopes, and
(6) bedrock cliffs/walls

On the slopes at higher elevations, glaciers and rock glaciers were observed. However, these features have been excluded from this discussion because they would not be impacted by a flood. Figure 1 is a schematic diagram showing the major landforms observed in the valleys. Among these, landform elements (1) to (5) are especially important in terms of debris (mixture of rock fragments, sand, and mud) to be transported downstream by an outburst flood from the lake.

1) Glacial moraines — Moraine deposits can be found extensively in the Bartang, Kudara, and Murgab River valleys A terminal moraine is located near the confluence of the Bartang and Panj Rivers. This is correlated with the maximum advance of the QII stage of glaciation some 400,000-600,000 years ago. In the upper reaches of these valleys, an ice cap had covered a wide area, and the deep valleys had not been formed at that time. Younger moraines from the tributary valleys are located at the higher altitudes. The chronological correlation of the glacial moraines and the relationships between the moraines and river terraces should be studied in detail.

2) River terraces — Eight to ten river terraces have been formed in the uppermost valley of the Bartang River. Although the results of local studies of the ages of these terraces seem to be contradictory, one study has suggested that some of the terraces were formed about

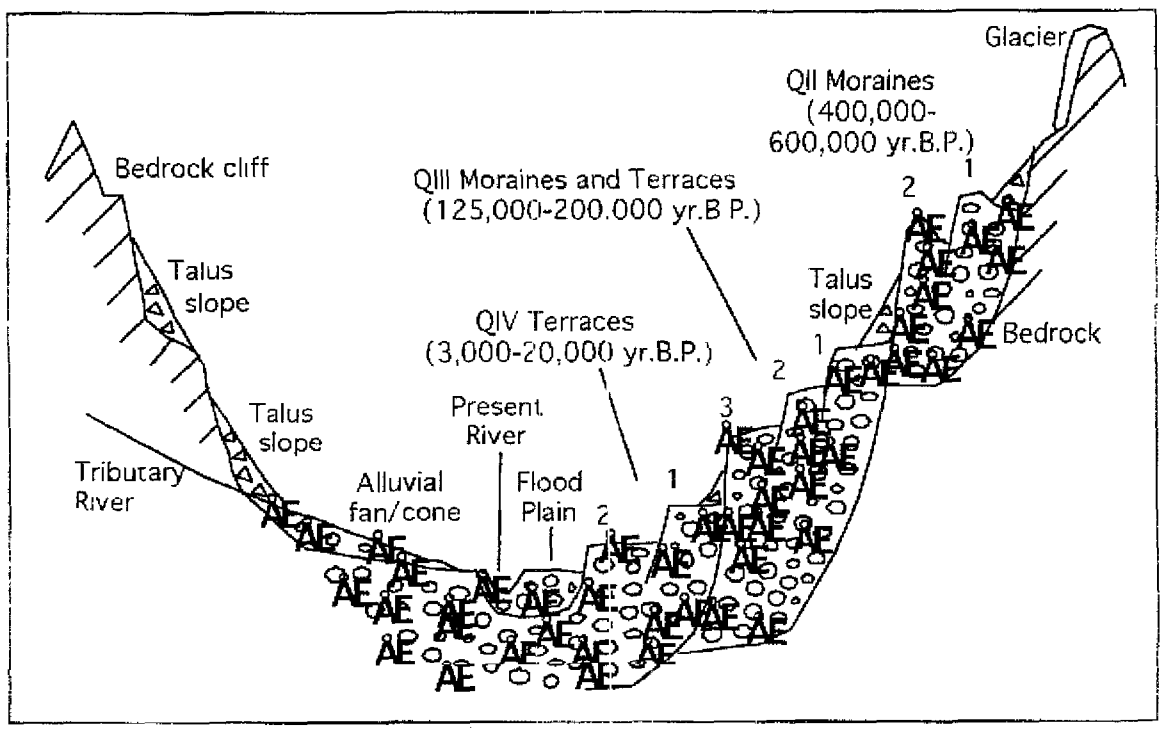

Figure 1. Schematic diagram showing the major landforms in the Bartang, Kudura, and Murgab valleys.

400,000-600,000 years ago (QII). Terraces formed about 125,000-200,000 years ago (QIII terraces) were deposited when glaciers covered the upstream half of the Bartang River. The QIV terraces (photo1) were formed between 3,000 and 20,000 years ago.

3) Alluvial fans/cones — An alluvial fan or cone can be defined as a fan-shaped landform created by frequent debris flows from a tributary valley. A fan has a gentler surface slope than that of a cone. Some parts of the fans and cones are still active (photo 2).

Photo 1: A river terrace formed about 3.000-5.000 years ago. Darjmozh village (elevation about 2.170 m) is located, which is 0-40 m higher thant the present riverbed. Photo credit: Teiji Watanche.

Photo 2. An alluvial cone. The village of Misau is located on the cone, parts of which are still covered by fresh debris. Vetation covers the superface.

4) Flood plains — Flood plains, including those covering the old lake deposits, can be observed in the valleys. Vinnichenko (1997) stated that the downstream stretch of the Kudara River has been fully dammed six times and partially dammed four times. The Murgab River has been blocked at six sites The Bartang River has been dammed at least three to five times. Some of these old flood deposits are covered by modern flood-plain deposits when the old deposits are located on the valley bottom. The depths of such deposits are not known. At least four to five old lake deposits have been recognized on the valley floor of the Bartang River.

5) Talus slopes — Rock fragments derived from rock falls have been deposited on the slopes that form the valley walls. These rock fragments commonly originated from fallen bedrock (i.e., from rock falls). Most talus slopes are currently active.

These five depositional landform elements are composed of soft, loose geologic materials. The origins of most of these deposits can be divided into two parts. The first group of deposits was formed by glacial erosion. The area hosted large glaciers in the past; these produced enormous amounts of debris that was available to be transported downvalley. In the QII stages (400,000 – 600,000 years ago), the glacier in the Murgab-Bartang valley reached the confluence with the Panj River valley In the QIII stages (125,000 – 200,000 years ago), the

deposits formed as glacial moraines at the higher elevations, and as river terraces at lower elevations. The second group of deposits has been attributed to rock fall. Talus slopes have developed as a result of frequent freeze-thaw cycles combined with continuing tectonic activity. Moreover, because this area is extremely dry, the ground surface is not heavily vegetated. As a result, the surfaces of the slopes remain unstable.

Photo 3. Thick alluvial deposits near Yapsho (lower center of the photo) on the uppermost reaches of the Bartang river.

These deposits could easily be incorporated into the flood waters/debris flows because they consist of loose, unconsolidated materials. Because these deposits are distributed from the present river beds to the higher slopes, even a small flood could transport the lower-elevation deposits. It should be noted that the deposits are extremely thick near the confluence of the Murgab and Kudara Rivers (photos 3 and 4). In addition, old lake deposits on the valley bottom would probably be eroded away and transported downstream by a Lake Sarez outburst flood. All of these valley-bottom materials could be incorporated into a debris flow, causing damage downstream. Also, the toes of the talus slopes and alluvial cones would become much more unstable as a result of removal of downslope debris. Thus, continuous, slow retreats of the toes of terraces and fans/cones, on which most fauna and flora live, are expected.

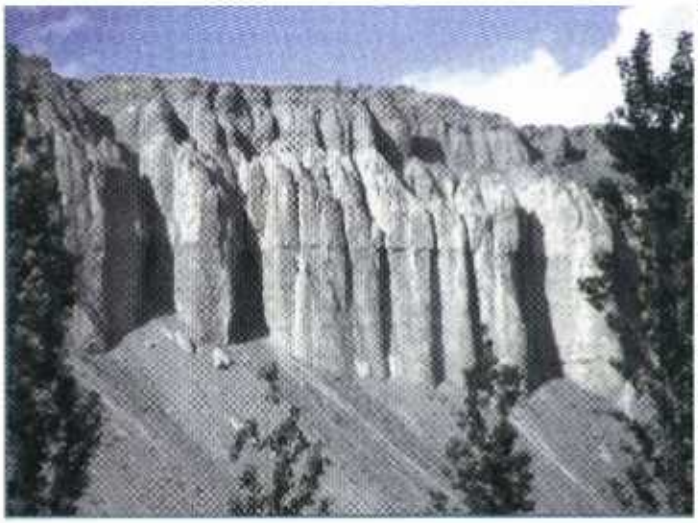

Photo 4. A close-up view of the thick deposits (more than 100 m thick) near Yapsho.

5.2.2.2 Fauna and flora

Most fauna and flora, as well as most human settlements, have been observed either on the alluvial fans/cones or on the younger river terraces formed about 3,000-5,000 years ago (photos 1 and 2). Only two settlements, Dasht and Nisur, are located on the glacial moraines. The alluvial fans/-cones and younger terraces have formed near the valley bottoms. These depositional landforms, serving as homes for most fauna, flora, and human settlements, could easily be washed away.

According to the director of the local botanical gardens in Khorog, there are 166 endemic floral species in Gorno-Badakshan Province and the surrounding Pamir mountains. Among these, some 70 species are found only in Gorno-Badakshan Province.

The major types of vegetation in the Bartang, Kudara, and Murgab River basins are *Artemisia vachanica, A. lehmaniana, A. korshinski, Acantholimon sp.*, and *Carex pachystylis. Acanthlimon Hilun, Kobresia pamiroalaica,* and *Allium fedchencoii* characterize elevations above 3,000 m.

Some of the flora, especially *Climates saresica* and *Pleuraspermum Badackschanica,* are endemic species. Endangered species in the valleys include *Climates saresica, Pleuraspermum Badackschanica, Betula muroabica, Kudrjascheva pojarkovi, K. nadinae, Cousinie rajkovii, Acantholimon Hiluri,* and *Populus pamirica.* These species, and others, could be devastated by an outburst flood.

Wild animals and birds in the valleys include ground squirrels, mountain goats, snow leopards, bears, hares, and magpies. Mountain goats and snow leopards are included in the Red-Data Book. Downstream transport of the deposits would also lead to high suspended-sediment loads, which could damage fish populations in the downstream reaches, as described elsewhere for glacial-lake outburst floods in the Himalaya (Watanabe and Rothacker, 1996).

5.2.2.3 Geomorphology and settlements

Most settlements have developed on either alluvial fans/cones (10 settlements confirmed) or on the younger terraces (eight settlements confirmed). Two settlements are located on glacial moraines. Figure 2 illustrates a cross-sectional profile of a geologically young terrace, on which the village of Darjomzh (elevation about 2,170 m) is located. The relative elevation difference between the present river bed and the houses and agricultural field ranges from 5 to 38 m. This demonstrates that even small-scale flooding could damage fauna and flora as well as settlements.

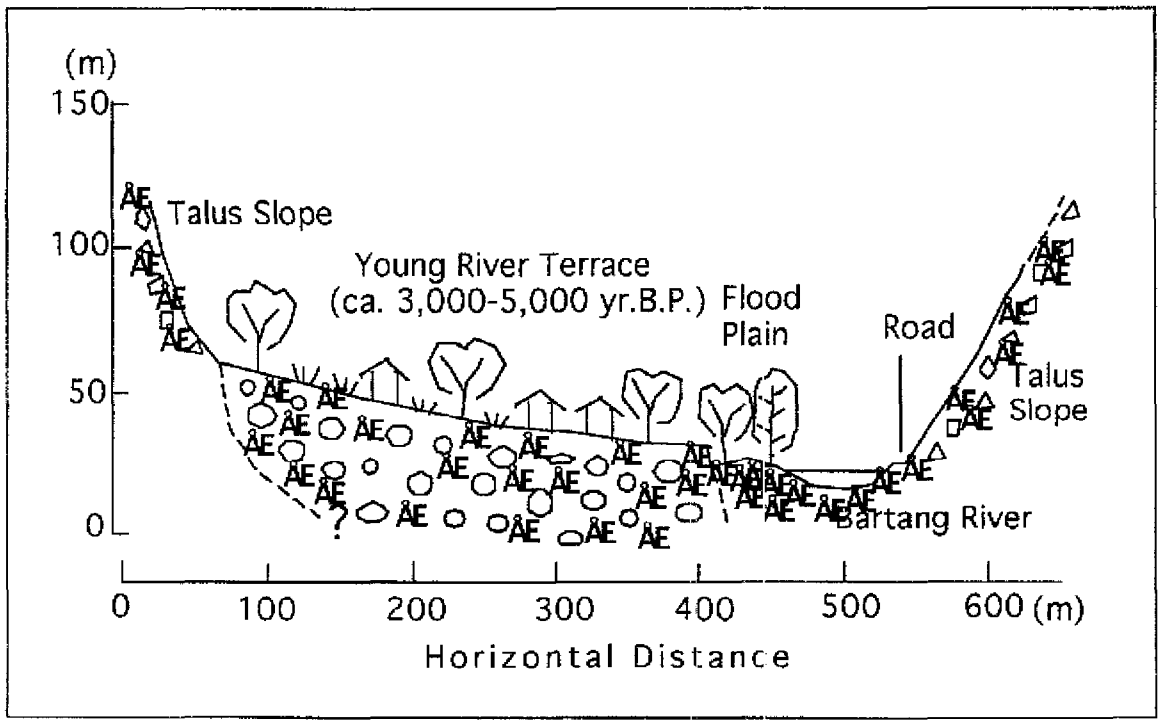

Figure 2. Cross.sectional profile of the young river terrace (QIV-2) on witch the village of Darjomzh (ca. 2,170 m) is located.

5.2.2.4 Long-term response and recommendations

Revitalization of fauna and flora is strongly related to geomorphic stabilization. Revegetation following an outburst flood will be possible only after stabilization of the new landforms. Geomorphic response will begin immediately after the flood. However, full development of landforms, such as new alluvial fans/cones and river terraces, may require hundreds to thousands of years.

Biodiversity in the area largely depends upon the availability of water on the landforms. Most fauna and flora are distributed on the landforms near the present river bed. In addition, conservation of biodiversity will depend on protection of habitats from flooding.

It is important to examine impacts of debris-rich water to the lower reaches of these valleys. Detailed distribution of the deposits should be mapped and the volumes of the deposits should be estimated

5.3 Geomorphology of the downstream area (Panj River basin)

The Panj River basin would very possibly be impacted by an outburst flood if the lake were to drain completely in a short period of time. The Panj River from Rushan to Shuroabad has dissected the mountains and formed a narrow V-shaped valley. The river has deposited an enormous amount of debris on the flat surface downstream from Shuroabad, mainly in Khatlon Province.

The floodwater would flow rapidly down the narrow Panj valley. Then, the water would erode and transport the low-lying alluvial and terrace deposits, which would be deposited farther downstream.