Extreme environmental conditions in a breathtaking landscape

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The Pamir Mountains, or Pamirs, also known as the Roof of the World, extend across parts of Afghanistan, China, Kyrgyzstan, Pakistan and Tajikistan. The heart of the Pamirs is located in Tajikistan’s mountainous province of Gorno Badakhshan (GBAO) and comprises about 63,700 km², with the highest peak (7495 m) in the Commonwealth of Independent States (CIS). Population has increased sharply in the last 50 years, and the territory today is home to 220,000 people.

The Pamir Mountains demarcated to the north by the Trans Alai valley in Kyrgyzstan and the Wakhan Corridor in the South. The eastern margin of the Pamirs is bound by the Sarykol Range in China, while the south-western valleys draining into the Pandezh mark the western boundary. The Pamirs are generally divided into the Eastern and Western Pamirs, largely along the 73° longitude line. Owing to their location, high altitude, and extreme bio-physical conditions, the Tajik Pamirs have developed into a most remarkable landscape, with moon-like high plateaus (3000–4000 m), rounded massifs, and large valley floors in the east, and deeply incised valleys with stunning glaciers and numerous traditional settlements nestled on alluvial fans in the west.

Land resources

Arable land is the scarcest resource in the Tajik Pamir environment. Most territory is barren, rocky mountain terrain with permanent snow, glaciers and debris, and only very limited biomass production. Landscapes have been shaped by topography in combination with climatic patterns. These dominant factors influence the natural potential and create risks for human use.

In the Western Pamirs arable land accounts for approximately 240 km², or as little as 0.4% of the total area of the GBAO. Arable land and areas of settlement are located for the most part on alluvial fans and river banks. Given the minimal precipitation and the temperature regime, the vegetation period is limited to 200 to 230 days annually. Irrigation is necessary to achieve good yields, labour inputs are high, and the potential for mechanisation is very limited.

High mountain desert soils predominate in the Eastern Pamirs, allowing only very extensive forms of land use such as livestock grazing. Total pastureland area has been roughly estimated at 7,730 km²; few areas with mountain steppe soils along meandering rivers can be used for fodder production.

Following Tajik independence from the Soviet Union, a highly subsidised local economy that had been dependent on external resources was forced to turn to subsistence farming. Hunger relief was secured only through support from agencies of the Aga Khan Development Network, while agricultural production increased gradually. However, intensified agricultural production exceeded the natural carrying capacity in some areas, leading to degradation of soil and vegetation cover.

Limited fuelwood resources have been particularly negatively affected by economic transformation. Interruptions of the external fuel supply following the collapse of the Soviet Union put a heavy strain on forest lands in the Western Pamirs and on slow-growing tereken shrubs in the Eastern Pamirs, leading to an alarming degree of exploitation and clear-cutting of this vegetation.

Climate

The ridges of the highest mountain systems in the Western Pamirs, Hindukush, and Himalaya form a barrier against moisture borne by winds from the Indian and Atlantic Oceans, thus shaping a continental climate characterised by sharply contrasting temperature regimes and markedly seasonal precipitation. Great variability, particularly of rainfall, is a specific characteristic of the Pamir climate. This almost exclusively allows for irrigated farming only, using melt-water from snow and ice accumulated on the mountains in winter.

In the Western Pamirs the climate is characterised by moderately warm summers and moderately severe winters, with minimal rainfall in the summer months. The high plateaus in the Eastern Pamirs are part of the dry climate zone, with cold summers and severe winters with little snow (Badenkov 1992). The weather in the western valleys is influenced by the Afghan winds, which are responsible for summer dust storms and subsequent rainfall. The rainfall pattern in the Western Pamirs is characterised by a steep north-south gradient with more than 600 mm of rainfall from Ishkashim to the Darvaz mountain ridge. Similarly, the altitudinal increase in rainfall is exceptional: the long-term mean at the Fedchenko Glacier measurement station, at an altitude of 4300 m, is 2234 mm. However, the Irkht station (3290 m) at Lake Sarez, some 50 kilometers further south, measured average precipitation of just 110 mm between 1980 and 1998.

By contrast with the Western Pamirs, rainfall in the Eastern Pamirs increases during summer, whereas in most winters the high plateaus get no snow. Since total
annual rainfall is generally less than 100 mm, combined with high radiation, strong winds, and sub-zero average temperatures from October to March, the Eastern Pamirs must be regarded as a mountain desert.

**Water resources**

It is estimated that the Tajik Pamirs provide approximately 60% of the freshwater reserves of Central Asia. The vast majority of the 8492 mountain glaciers in Tajikistan are located in the Pamirs. They cover an estimated area of 7900 km² or about 12% of the GBAO.

Based on data for Tajikistan (Badenkov 1992), it has been estimated that the glaciers in the Tajik Pamirs contain approximately 425 km³ of water. This huge reservoir, along with considerable quantities of snow accumulated in winter, is a major asset for the arid Central Asian lowlands.

The maximum water discharge is observed from June to August, when snow and glacial melting is most intense. The melt-water peak during summer coincides with the growing period of cotton in the Tajik lowlands, and with the driest season in this region. Thus storage capacity and seasonal regulation of streamflow in the Pamirs are vital, not only for the local land-use system, but also for the ecological and socio-economic welfare of downstream users.

Water resources in the Pamirs, with an average discharge from the Pandzh River of 540 m³/sec after confluence with the Vanch River, combined with high relief energy, represent a great potential for hydropower generation. However, since markets are far away, natural hazards abundant, and investment costs high, the economic potential will remain limited.

Today growing concern is being voiced about the effects of climate change in the Tajik Pamirs. Between 1961 and 1990, an average temperature increase of more than 0.5°C was measured. Rainfall, on the other hand, showed a declining tendency in the Western Pamirs, but increased in Murgab District in the east. These changes are corroborated by the retreat of various large glaciers in the Pamirs. The Fedchenko Glacier, with a current length of over 70 km, has shrunk by almost 1 km, losing 11 km² of its area and about 2 km³ of ice in the 20th century. If these trends continue, the Pamirs’ function as a water tower is likely to diminish in the lowlands of Central Asia. In directly affected uplands, natural disasters will probably increase in scale and frequency, while the fragile mountain ecosystem is expected to degrade. This will threaten the agricultural production base, which is already marginal.

**Geology**

Geologically the Pamir Mountains constitute the bend of the Himalaya-Hindukush mountain massif, and were formed by the northward drift of the Indian craton and its final collision with Eurasia. Although there are no volcanic phenomena, strong convergence rates produce intensive seismic activity along the large fault systems in this region. Over 500 earthquakes with a magnitude greater than 5 on the Richter Scale have been registered since the beginning of the 20th century. The ongoing processes of orogeny and denudation are the driving force of modern relief processes in the Pamirs.

The Pamirs can be subdivided into 5 larger geological units: the Northern Pamirs, the Central Pamirs, the Rushan-Pshart Zone, the Southwestern Pamirs, and the Southeastern Pamirs. The Northern Pamirs are bordered by a Late Paleozoic suture, which wraps around the Pamirs from the western Hindukush through the Trans Alai Valley to the Kunlung. In lithological terms, the Northern Pamirs consist of Precambrian to Paleozoic metamorphica, basaltic series, and marine sediments; ophiolith complexes and melanges are present in minor parts. The Central Pamirs contain a deformed and metamorphosed Precambrian to Paleozoic basement, covered by marine sedimentary rocks of the Paleozoic-Mesozoic era; terrigenous sediments and volcanoclastica are intercalated. The Rushan-Pshart Zone, with its complex tectonic structure, consists of Paleozoic terrigenous sediments in the northern part, followed by a transition of marine shallow to deep water deposits during the Mesozoic. Ophiolitic series are exposed in the southern parts. The Rushan-Pshart Zone reveals the remains of a small Mesozoic ocean basin. The lithology of the Southwestern Pamirs consists of metamorphosed Precambrian rocks (amphibolite-granulite facies) and Jurassic-Miocene granite complexes. The Southeastern Pamirs contain no igneous basements but only sediment successions. The Southeastern Pamirs probably represent the detached sediment cover of the southwestern basement.

Pamir tradition has always included the mining and cutting of minerals for jewellery. The Tajik Pamirs have a large number of proven metallic ore deposits (gold, silver, molybdenum, mercury), building stones (marble, clay and loam), evaporates (mineral salt), gemstones (rubies, lazulite), and two coal deposits. Although the qualitative and quantitative features of certain mineral deposits are considerable, they will probably be of only minor economic significance (with the exception of coal deposits), owing to the high costs of exploitation.

1 This section is based on a contribution by Wolfgang Schatz.
Demographic development

Under Soviet rule the Tajik Pamirs experienced rapid population growth in all of its 8 districts: from 56,000 inhabitants in 1926 to 220,000 by the end of 2000. Growth rates ranged from 250% for the Rushan district to 330% for the Vanch district. Despite this impressive increase, in relation to the total surface of the GBAO, the population density is still very low (3.5 persons per km²). Moreover, a closer look at the distribution of the population within the area reveals that settlements are markedly concentrated in the few fertile areas in the narrow valleys. The Soviet authorities actively promoted strong population growth to increase their presence in strategically important border areas. This policy did not take into account the limitations of natural resources in the Pamirs, which made it necessary to heavily subsidize the livelihoods of the GBAO population.