Alpine soils and forests: securing ecosystem services in the Pamir mountains of Tajikistan

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Farming for subsistence in high-altitude locations, such as the Gunt valley in the Pamir mountains of Tajikistan, requires specific attention to managing the soils in harsh mountainous environments. While fertile soils have developed in valley bottoms and especially under forest cover, land-use changes in these semi-arid ecosystems may critically affect soil conditions and lead to desertification. However, if soils are managed well, the ecosystem can provide multiple benefits.

Cultivating potato fields in Jamoat Vanqala, Tajikistan (Marcel Reinhard)

People in the remote Pamir villages rely on food, fodder and fuel produced from their land for their livelihoods. However, they face many challenges including harsh climate, high disaster risk (*e.g.* avalanches, snowstorms, droughts), shortage of arable land, difficult access to irrigation water and lack of financial resources. Forests play a major role in providing fuelwood and non-timber forest products such as berries, mushrooms, nuts, honey, medicinal plants, foliage, seeds and seedlings. Forests are also used for grazing animals, the number of which has increased greatly over the last 20 years.

The large and dense forest covering the floodplains in the Tajik Pamirs were teeming with wildlife, as mentioned by many expeditions before and in the first decades of the Soviet era (for example Korzeniewski 1903). It is estimated that forest cover in Tajikistan in 1910 was still around 25 percent. Today, official data state that forest cover in Tajikistan is only around 3 percent.

Land-use changes affecting the high alpine natural ecosystems in the Tajik Pamirs increased with the independence of the Republic of Tajikistan in 1991 and the cut in imported goods, including wheat, fodder such as hay, but also coal and wood. Food and energy scarcity during and after the Tajik civil war in the 1990s led to severe land degradation, with a reduction in soil functions, such as regulation of soil nutrients, water and temperature. It also affected soil-related ecosystem services, such as soil nutrient availability, control of erosion by water and wind, length of the growing period and, consequently, biomass production and plant diversity. Overgrazing, deforestation and expansion of cropland to forest areas are

Riverine forests along the Gunt river, Jamoat Vanqala, Tajikistan (Bettina Wolfgramm)

the main pressures on land and, especially, forest resources. In this same period, coal imports have become rare, and therefore costly, which has led to continuous cutting of the forests, bush lands and trees along rivers and on mountain slopes. As the winter is long (October to May), there is an extremely high demand for fuelwood for heating and cooking. Climate conditions are unfavourable for fruit trees, but poplar trees and buckthorn grow well.

The information presented here resulted from an applied research study conducted in the Vanqala municipality, located in the Gunt valley at 3 100 masl, that identified limitations of agricultural production such as the need for irrigation, constant temperature fluctuations during the growing season that may cause crops to freeze, and cold winds that affect plant growth and lead to erosion. In general, local farmers who cultivate mainly fodder crops, such as lucerne (*Medicago sativa*) and sainfoin (*Onobrychis*), need to apply land management technologies to increase land productivity under these soils, water and temperature conditions, while reducing erosion processes and maintaining soil quality.

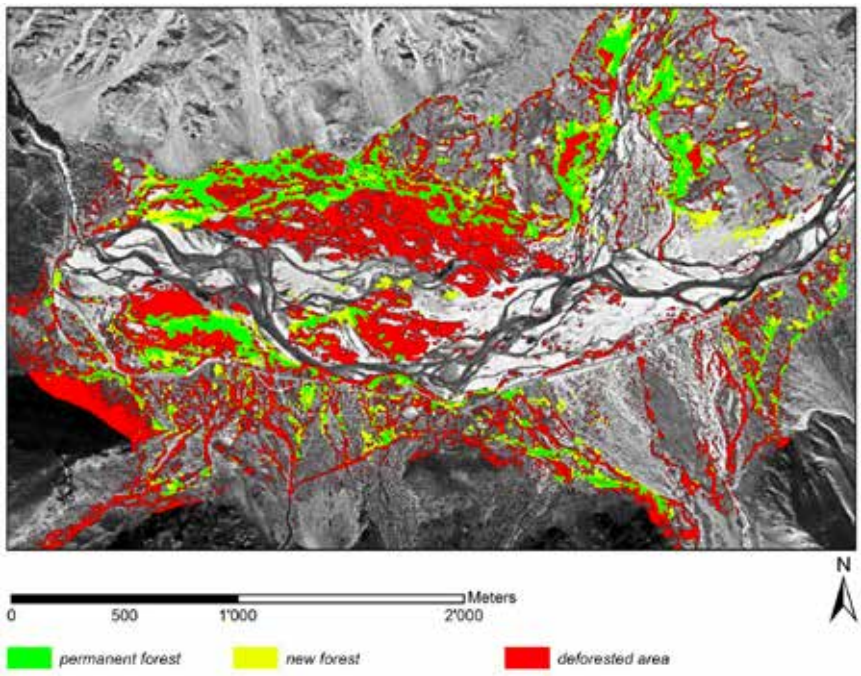
The study aimed to identify forest cover changes as well as the specific soil conservation practices in this area, and to estimate their impact on soil resources and related ecosystem services. Soil organic matter was used as a health indicator to assess the impact of the management practices. The information on sustainable land management (SLM) technologies was documented using the World Overview of Conservation Approaches and Technologies (WOCAT) standardized questionnaire. The land use change since the mid-1970s was analysed using satellite imagery, Corona imagery from 1968 and RapidEye imagery from 2010, covering around 130 km^2 of study area.

Overall, the study found a 54 percent increase in arable land and a 34 percent decrease in forest and bush land in the study area. In specific cases, such as the village of Patkhor, it detected a 53 percent forest cover change, indicating that its forest area had been reduced to less than half of the forest area in the 1960s. Other villages were able to protect their forest resources better.

While forest resources were generally heavily degraded, some families managed to improve the tree cover by, *e.g.* planting a dense buckthorn forest belt to shelter fields from temperature fluctuations, cold winds and frost or planting poplar forests in the flood plains of the high mountain river areas. The low temperature in the study area is not favourable for most trees species. The natural forest mainly consists of slow growing trees. However, plantations of poplar (*Populus Pamirico*) and willow trees (*Salix Schugnanica Coerz*) can be established fast with a good

water supply, which can be provided by rivers or by irrigation systems. Around 10 ha of low productive pasture land in alluvial sandy soils along the river was turned into a poplar forest by creating an irrigation canal and planting seedlings along it. In the first year, the area needed to be protected from grazing cattle and from neighbours cutting trees.

The soil analysis found that soil under the poplar trees has more organic matter (3.88% in the first 30 cm) compared with other surrounding plots (2.58-2.78%).



Corona imagery of the village of Pathkur, with forest cover change classification between 1968 and 2010. A misclassified area is marked with a white arrow (Selina Studer)

Lessons learned

- Agroforestry and forestry systems for producing food, fodder and fuel can also contribute to improved management of soil resources and enhance long-term provision of ecosystem services in temperate areas.
- These systems can protect soils from wind and water erosion, contributing to sustainable nutrient supplies. The tree cover creates a micro-climate and reduces the impact of temperature extremes in order to increase production in these harsh mountainous environments, it is also crucial to protect soils from cold winds and cold spells during the summer season.
- The benefits resulting from agroforestry plots are manifold and include significant improvements of soil fertility, productivity, biodiversity and carbon stocks, compared with the surrounding arid desert landscape.

Plantation of poplar forest in the flood plains of the high mountain river areas. Gunt valley, Tajikistan (Gulniso Nekushoeva)