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Mountain deforestation in Middle Asia and agroforest ameliorations

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The 6,000-year evolution of Middle Asian civilizations was accompanied by the intensive exploitation of plant resources in mountain areas that caused the profound anthropogenic transformation of mountain and pre-mountain landscapes in Middle Asia.

Nowadays, proportion of woodlands in Middle Asian mountains is very low. The forest area covers 2.5% of the whole territory. In the case of Uzbekistan mountains it is only 0.76%. Moreover, 85% of the total forest area is covered by sparse woodlands and clearings. In contrast, the numerous historical documents testify the former wide spread of mountain forests. Historian Quintus Curtius Rufus (IV c.B.C) wrote about the dense impenetrable forests in the Zeravshan basin where Alexander the Great and his soldiers were hunting. The forests that had covered the northern slopes of mountains in the Zeravshan basin are known from the works of Arrian from the VIII. century. Tabari had also mentioned forests in his description of the Arab campaign in 730 (Masson 1948).

Large-scale destruction of mountain forests began in early Middle Ages with the vigorous growth of mining because the juniper coal was mainly used for metal extraction. Archeologists ascertained that the great amount of charcoal had been burnt in Karamazar mountains and in Akhangaran. The charcoal kilns are found in those areas of Kuramin mountains where juniper is totally absent now (Masson 1948).

The emergence of new forms of metallurgy in the XVIII-XIX cc. accelerated the deforestation of mountains. By the beginning of the XIX c., the Middle Zeravshan mountain forests remained only in the upper parts of several sais (ravines). The charcoal necessary for metallurgy began to come to Samarkand and Bukhara from the upper parts of the Zeravshan basin. Nevertheless, the botanist A. Leman visiting this region in 1841 described here dense pistachio forests. At the beginning of the 20th century only isolated pistachio shrubs remained there. The destruction of mountain forests became especially intensive during the period 1860-90 due to the industrialization of metallurgy. The pistachio and almond forests of Nuratine ridge as well as the juniper and mixed forests of Zeravshan and Turkestan ridges were cleared almost completely (Stavsky 1961, Arandarenko 1889).

The pistachio forests were cleared on the mountain slopes in the Fergana valley, in South Tadjikistan and in other mountains regions. The remnants of tree stumps and the isolated trees point out the recent existence of dense juniper stands (Korovin 1962, Masson 1948).

The former continuous juniper stands in the middle mountain belt had been reduced up only 1.5 mln hectares by the beginning of this century. Destruction of these forests continued in the period from 1949 to 1974. They were cleared on the area of 711,000 hectares. Nowadays, the juniper stands cover 574,100 ha accounting for 52% of all mountain forests in Uzbekistan. However, the degradation of juniper forests is still going on.

At the present mesophyllous forests and woodlands form only isolated relict stands in the remote mountain regions; they have no environment-forming function as the former forests had.

The walnut and fruit-tree forests had been distracted on about 10 mln hectares during the last century. This has led to the transformation of woody slopes of Pamiro-Alai, Tien Shan and Kopetdug into dry steppes, to the development of erosional processes and to the alteration of organic matter migration in soils.

The lower limit of fir-tree in Tien Shan has shifted 100 to 200 m higher in the historical time. The former mountain forests are now replaced by a sedge-meadow grass formation, steppe-grass shibliak stands and tragacanth associations (of spiny pillow-like plants and mountain xerophytes). If the former had arrived from the lower piedmont adyrs the letter had come from the southern highlands. The distribution of tragacanth associations in Middle Asia was accelerated by erosion. Grazing has also become an important factor of plant cover transformation (Vtorov and Vtorova 1983).

For a long time neighboring mountains and plains were guaranteeing transhumance grazing in the form of a seasonal move of stocks from mountains to plains in winter and vice versa in summer. Uncontrolled grazing, especially when excessive, worsens greatly the moisture and physical characteristics of soils. The destruction of sod layer and the soil compression at grazing lands result in the increase of soil specific weight 1.5 to 2 times. It caused the decrease of water

permeability and 2.7 times growth of surface runoff and erosion. In light forests of Western Tien Shan, the surface runoff is also accelerated by grazing; the erosion-starting values of its velocity are reduced. As a result, the soils of grazing forests can soak 10 times less water than it falls down during a heavy rain. Consequently, the erosion processes are significantly increased on the grazed slopes. The excessive grazing on mountain slopes causes the disastrous soil erosion, worsening the grazing themselves and ,also, baring the mountain slopes.

Therefore the destruction of forests and the overgrazing have caused the intensive deforestation of mountains in Middle Asia. Meanwhile mountain forests, particularly coniferous, played an important water-protecting and conservation role. A.F. Middendorf was among the first to notice this fact. He called for the rational protection of fir and juniper mountain forests particularly if they have a closed canopy (Middendorf 1882).

The lighting or the destruction of coniferous forests and their replacement by secondary small-leaved ones have intensified the processes of snow-melting in mountain regions that has caused the acceleration of erosion and the reduction of runoff period. This has greatly increased the risk of snowmelt floods, as well as the frequency of summer floods and overflows in river basins.

Forests canopy (of conifers, in particular) considerably reduced the intensity of rains and the evaporation from the surface of soils, stimulated the condensation of water from the air masses rising along the windward slopes. When mountain slopes were covered by nearly continuous forests, the glaciers in their upper parts occupied much larger area than presently. Less condensation of atmospheric moisture and strong heating of bare slopes in summer contributed to the process of glacier melting. As a result of deforestation, the former numerous springs have shallowed and dried up; this phenomenon effected unfavorably the economic development in the adjacent plains. For instance, the considerable runoff decrease of mountain rivers in Kopetdug by XVI c. was followed by desolation on cultivated oasis in the Atrek valley and delta. During the first half of the XX c., the total flow of Kopetdug rivers was reduced by more than 50%. Currently, woody vegetation is completely absent in its lower zones. Similarly, it is seriously destroyed at high altitudes. According to V.T. Kirst, the destruction of Kopetdug forests caused the disappearance of many springs.

The floristic composition of mountain forests highly varies now. More than 120 species including many trees occur in forest habitats. The forests have considerably lighted canopy cover averaging 0.3. Therefore, primary forests have lost their water and erosion control functions. As erosional processes have fastened, floods and mud flows have become more frequent.

Due to high slope steepness in mountain regions of Middle Asia, the fine matter washing is also considerable. According to the observation at the Chatkal mountain ameliorative experimental station, nearly 90% of rainfall can sometimes run down the slopes.

The deforestation of mountains accelerates the erosional processes which affect up to 81% of the mountain soils (Khanazarov 1983). Erosion causes the maximum damage to cultivated slopes. In 1937 L.T. Zemlyanitzky stated that yearly loss of soil on the northern slope of Zeravshan ridge was equal to 2,500 m^3 per 1 ha on the 10^0 steep slopes, up to 4,000 m^3 per 1 ha on the 20^0 steep slopes, and 6,000 m^3 per 1 ha on the 30^0 steep slopes. The eroded lands in the mountains of Central Asian republics average 80% of the total territory. The area of ravines in the mountains of Uzbekistan accounts for 33,000 to 35,000 hectares. There are more than 9,000 to 11,000 ravines, mostly in piedmont zone.

Deforestation has considerably accelerated the processes of aridization and xerophytization. These processes have increased the aridity of Middle Asia, stimulated the desertification of plains and the steppization of lower and middle parts of mountains as well as the glacier reduction at high altitudes. Along with the accelerated erosion, all this intensified the matter redistruction in the "mountains - plains" system during a rather short period of time if regarded from the geological point of view.

The modern trend in the system of "mountain - plans" in Middle Asia affected by human activities is characterized by an increase of aeolian transfer of dust, salt and aerosols from plains to mountains which result from the overexploitation of plain landscapes and the misuse of irrigated lands. The considerable air pollution at plains is also caused by the cultivation of new lands, distraction of desert vegetation, overgrazing, and construction of large industrial facilities.

The new sources of dust and salts for plains of Middle Asia has been recently formed on the dried up part of the Aral sea bottom which occupies about 30,000 km^2. The Aral sea which for millenniums had been the main collector of salts in this region, thus clearing the Middle Asia, is acting in quite opposite way now. The exact calculation being rather complicated, the preliminary estimates have been made yet. According to some of them about 15 to 75 mln tons of dust pollutes the atmosphere each year. Along with the decline of the Aral sea level the amount of wind-transported dust and salts will increase (Kes 1983).

A special attention should be deserved to the glaciers of Middle Asia. Their surface is considerably polluted by dust particles which are carried here with from arid plains in the quantities amounting to dozens of tons per km^2. Natural pollution of snow cover in the mountain regions of Middle Asia is reported from all altitudes including the highest peaks. Even at the elevation of 7,000 m above sea level, V.K. Nozdryukhin (1970) observed the spots of "yellow snow".

The glaciers are polluted not only in summer

but all the year around. Investigating dust fall on the surface of glaciers at the northern slopes of Terskey Ala Tau ridge, A.N. Dikikh concluded that "the present natural pollution of glaciers by fine aeolian matter is extremely high and it accounts for 152 to 1,114 g/m^2. The dust pollutions of less than 200 g/m^2 are rather rare phenomena". Total ice pollution analysis performed by Yu.A. Anokhin showed that the amount of dust on the Abramov glaciers at the altitude of 4,440 m above sea level averages 28 g/m^2/year in the last 50 years. According to his data the glaciers pollution by fine aeolian matter has being increased recently (Dikikh 1975, Anokhin 1978).

The amount of aeolian matter carried to the glacier surface depends upon altitude. According to L.F. Kamalov's estimates the aeolian transport of dust in western Tien Shan varies from 62.3 t/km^2 (1,500 m above sea level) to 148.2 t/km^2 (3,000 m above sea level). According to Glazovsky and Glazovsky (1982), the average dust fall below the altitude of 2,000 m was 7 t/km^2/year, while it was 50 t/km^2/year in the altitude above 3,000 m in Zailiysky Ala Tau. Our observations show that the amount of dust also depends on orographic features. For instance, the Nuratin basin receives approximately 1.4 times less dust than the windward slopes of the northern Nuratin ridge. The data on the intensity of air-transported dust falls and salts in Middle Asia is the evidence of wide spread of this pollution on large scale. Majority of scientists agree that the area of glaciers in Middle Asia is reducing (Anokhin 1978, Dikikh 1975, Dolgushin 1972, Shchetinnikov 1984).

The surface pollution by fine aeolian matter growing from year to year will stimulate ice melting. It is the aeolian pollution that increases the intensity of glacier melting by 20%. Analyzing the aero and space images for different years (1952-78), A.S. Shchetinnikov obtained the qualitative and quantitative characteristics of glacier degradation in Pamiro-Alai. In fact, the individual glaciers of the area less than 0.1 km^2 disappeared, while the majority of others were divided into two or three parts. The Zeravshan glacier was formerly reducing 1 m/year, whereas now it is 1 m/month. It has become nearly 80 km shorter during 100 years of observations (Dikikh 1975, Shchetinnikov 1984).

The human activity in Middle Asia affects the processes in large natural complexes and proves the existence of the "mountains-plains" systems. However, for a long time physical geography has divided landscapes of mountains and plains into separate classes and analyzed them individually. As a result the scientific field remained behind the practical needs.

Let us analyze the main nature management tendencies that seem the most reliable and effective and which affect the whole system of "mountains-plains" either directly or through intercomplex and interterritorial relationships. Let's concentrate on the leading element of this system – the mountains, especially on their watershed areas which are in their way centers of a landscape (Shchetinnikov 1984).

The most effective measure is forest amelioration in the basins of small rivers and seasonal watercourses. Physiografically the amelioration of river basins means the complication of their landscape structure by the creation of small anthropogenic complexes. These complexes are formed by: (1) man-made forms of relief such as terraces and dams and (2) results of cultural vegetation planting. The task of today is to spread different types of terracing all over the watershed. At the sai beds and floodplains, it is suitable to construct dams which would reduce the velocity of stream flow and oppose the erosion processes.

According to A.A. Khanazarov's observations the afforestation of watersheds contributes to a significant increase (by several times) of the annual specific discharge, to the equalization of discharges for various periods (from long term to daily). Due to the afforestation the intensity of erosion can be reduced by 100 times and even more (Khanazarov 1983).

It should be expected that wide spread of agroforest amelioration practices may cause the future changes of the atmospheric regime above plains and mountains (Vinogradov 1980).

Principally, the continuous afforestation of Middle Asia can transform in several decades the cycle of matter between desert plains and mountains, particularly the dust transport. The agroforest amelioration appears to be the most efficient controlling approach for the further increase of the potential resource base of both plains and mountains.

According to my opinion it is as soon as possible necessary to elaborate and start conducting a special program "Forest Amelioration" for Middle Asia (through redistribution of means predestined for nature conservation measures).

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