

Factors and consequences of desertification processes in the mountains of Central Asia

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Ecological diversity of mountains and foothills of Central Asia sharply contrasting the frugal monotonous nature of the adjacent arid plains, contributed to the establishment of the most ancient Central Asia civilizations in the foothills. Vicinity of the desert-like plains imposed a continuous threat for population and economy. The pressure was both climatic (draught, dust storms, etc.) and military threat (nomadic tribes). These threats forced the citizens of foothill plains to link their existence with the mountains, especially in the first stages of population development. Vicinity of mountain areas predetermined the development of all-year round livestock with yearly cycle of migration from rangelands (remote high altitude pastures in the mountains in the summer) and agricultural production bound to the rain period. The later provided for stability of yields. Later they started to use water of mountain streams. Centers of the most ancient cultures were found namely on foothill plains in the Central Asia, showing evidence of targeted use of resources concentrated around the boundary between mountains and plains.

As a whole, mountains became a stabilizing factor of economic activity for early civilizations of Central Asia. Such cities as Almaty, Bishkek, Tashkent, Samarkand, Ashkhabad and other towns located on foothill plains have experienced long continuous active life.

It is known, that agricultural cultural centers (e.g. China, North-India, Mesopotamia, Egypt, Peru-Bolivia and others) were developed in dry and warm regions of the Earth, which required irrigation. The largest centers of agricultural cultures were located in fertile valleys of large rivers and their tributaries or in vast mountainous hollows, on plains, foothills and slopes of low mountains. Mechnikov (1924) mentioned the development of ancient civilizations is in the basins of large rivers. These civilizations with high level of state organisation were secondary, while the primary agricultural centers were originated in the mountains (Zhukovsky 1964). It is known that agri-

cultural cultures in the valleys near the rivers were established by mountain tribes. Vavilov (1926) showed that the centers of plant species diversification were located in the mountains and they also became the place of origin of the majority of cultured plants.

Sharp relief of big mountain systems lead to broad differentiation of ecological conditions and therefore it served as an arena for the development of primary agriculture.

Alongside with the slash-and-burn agriculture, forests were exploited for timber in a number of regions. In many regions, the grazing of livestock had a big impact on the natural vegetation cover, which was often carried out without taking into consideration the nature's capacity for rehabilitation of vegetation cover. In forest regions with dry climate goats and other animals were eating leaves of young trees, which in the end has lead to the devastation of forests. Overgrazing by cattle destroyed vegetation of dry steppes and savannas, which then often acquired the character of semi-deserts and deserts.

The impact of economic activity on the vegetation cover has had probably many times a damaging effect on the human society.

Centers of one of the first civilizations in the history of human kind (North-Western India) are located in regions currently covered with a desert. A suggestion was expressed that in the past these regions were steppes, in which favorable conditions existed for the development of livestock and some types of agriculture. Excessive grassing of cattle (sheep) could have lead to the destruction of vegetation cover, which had been keeping lower temperature and higher relative humidity of the lower layer of air. As the result the volume of precipitation decreased, which made recovery of vegetation cover impossible.

Another example we can draw concerns the environmental changes in the Mediterranean basin in the antique epoch. The vast forests existed in the territory of Greece and other Mediterranean countries, which were later destroyed as the result of excessive grazing. This has lead to increased erosion and complete elimination of soil cover on many mountainous slopes, further increasing the aridity of climate and significantly worsening environmental conditions for agricultural production.

The above examples are only few of a great number of cases where man induced changes have lead to such a deterioration of the natural environment that on the level of technical capacities of that time turned out to be irreversible.

Development of civilizations in Central Asia during almost 6,000 years of continuous history was accompanied by intensive exploitation of plant re-

sources, leading to the deforestation of mountainous territories. This caused deep human induced changes in the character of landscapes of mountains and plains, adjacent to mountains in Central Asia. This resulted in the formation of qualitatively new ecological situation in Central Asia. Elimination of natural vegetation cover in the mountains played an important role in this situation. The elimination of forests over large areas in arid conditions such as in Central Asia, forest landscapes are practically not renewable.

Contemporary forestation of the mountains of the Central Asia is very low. Forested areas comprise around 2.5% of the total surface area. Even then, 85% of the forest surface area is covered with rarely growing trees and clearings (spaces without trees). Many geographers, geo-botanists and other researchers identified the unlimited removal of forests for economic needs that lasted for centuries as the main cause of deforestation in the mountains of Central Asia. Several geo-botanists stated with confidence that mountains of Central Asia and adjacent piedmont areas had strong vegetation cover of tree and bush species (e.g. Zakirov 1955, Korovin 1959)

The begin of mass extermination of mountainous forests nastal during the mining business during the early medieval Age. Mostly juniper coal was used primarily for smelting metal. Archeologists uncovered large amounts of burnt coal in the Kazarman mountains and in the Ahangaran. Coal burning stoves (ovens) in the Kuraminsky mountains are found in places, where juniper is now totally absent (Mason 1948).

The process of desertification became more dramatic with the appearance of new types of metallurgic production during the 18-19th centuries. By the beginning of 19th century in the mountains of Middle Zarafshan forests were preserved only in the headstream of some rivers and charcoal required for metallurgy started to be supplied to Samarkand and Bukhara from the headstream of the river (Stavsky 1961). The decline of mountain forests accelerated particularly in 1860-1890 due to the development of metallurgical facilities on industrial scale. Almost all pistachio and almond forests were extinguished with the purpose of burning coal in Nuratau of the neighboring Pistalitau (i.e. pistachio mountains in translation from the Turkik) juniper and mixed forests of Zarafshansky and Turkestansky ranges, etc.

Only from Pendjikent across Zarafshan to Samarkand, Bukhara annually 30,000 trunks of juniper trees and 34,000 of coniferous and deciduous trees were rafted for charcoal production in 1860-1880 (Fedchenko 1950). Only Samarkand alone was consuming annually over 34,000 trees in the form of almost 10 thousand tons of coal.

Pistachio bushes on the slopes of the Fergana valley (Southern Tajikistan) and many other mountainous regions of Central Asia were cut down with the purpose of burning trees for coal production. Traces of recently growing dense juniper forests were found in the form of stump remains, individual trees and toponyms in many places of Western Tian-Shan, Kopetdag.

From the once continuous belt of dense juniper forests in the middle zone of Central Asian mountains, only 1,5 million hectares of forests remain (Shevchenko 1969). Extermination of juniper forests continued in succeeding years. Only from 1949 to 1974 juniper was cut down in the area of 711 thousand hectares.

In the Central Kopetdag only during recent 40-50 years juniper forests have been reduced by 30-40%, and the remaining forests grow 500-700m higher than their ecological optimum. The degradation of forests has not stopped til today.

The unique forests of walnut trees mixed with fruit trees, largest in the world, occupied a special place in the forest fund of Central Asia covered an area over 100 thousand hectares in 1930. The forest area decreased as the result of walnut timber production, going on in 1938-1944. At the present time the surface area of this forest type comprises around 40 thousand ha, in which over 130 types (species) of various trees and bushes grow. This is a natural botanical garden. Based on it, the stands of walnut trees mixed with fruit trees represent big value as the pool of great genetic diversity.

River valleys of Central Asia were occupied by impassable tugais in the past. At the present time only small spots have remained. For instance, the tugai valleys of river Zarafshan in the 1950's comprised around 500 thousand ha, while in 1970's not more than 50 thousand hectares, and in the 1990's - only around 500 hectares were preserved. The surface area of the forests was reduced by 200 times in forty years.

Treetops can catch a significant part of precipitation. Observations show that dense coniferous forest catches (retains) 43.3% of annual volume of precipitation, juniper forest -25,5%, walnut trees forest - 24%. Besides this, forest cover dramatically reduces rain intensity. Depending on the intensity of rain and age of trees, from 60% to 90% of the volume of precipitation received by soil in the open space get under the cover of deciduous forest (Botman 1986). In walnut trees forest up to 192 center/he of the forest bedding (spreading), possessing high water retaining capacity is accumulated. For instance, at the present time regulated flow from mountainous forests, running down to the Fergana valley for irrigation contains 400 million m³ (Mamytov 1982). Snow melting is much slower in the forests in comparison with deforested areas. The melting takes about 15-18 days while in the Southern slopes in the shade of trees - around 40. Penetration of surface water flow into the soil of mountain forests was improving water-physical properties of soils, replenishing the stocks of ground water, due to rivers running down from the mountains. This is why quite recently before the massive decline of forests in Central Asia, a stripe of land surrounding the mountains was moistened. This created favorable conditions for a rich development of trees and bushes in piedmont plains and at the same time it was improving local climate (Zakirov 1955).

It is known that the role of forest vegetation in forming the environment is not restricted to the immediately forested areas, but also extends further across the boundaries of mountain territories, because water sources, which originate here, are running into irrigation channels, which serve as water supply to towns and settlements, irrigation of cottons plantations and other agricultural crops in the valleys.

Anthropogenic thinning is a specific feature of contemporary mountainous forests Central Asia: density of forest on average is 0.3. Mesophilic forests and sparse growth of trees are preserved only in the form of selected relic islands in hardly accessible areas in the mountains that have not suffered such

an impact, creating environment, which was a characteristic feature of former forest stands. This is why presently natural mountain forests in Central Asia can not perform their water retaining function. That results in erosion in the mountains, leading to floods and mud-slides that now appear more frequently.

First of all the supply of nutritional substances with sediments to flood lands and on the fields is attributed to negative secondary effects. Weighted sediments of the majority of rivers contain from 10 to 15% organic substances, while in the river Kyzylsuu, Fandaryi, Garma, Isfary and other rivers the proportion reaches 20%. It was found out that in the 1950's in the downstream of Amudaria river in the section where the river enters the valley, about 1.3 million tons of humus, 12 million tons of nitrogen, 1,16 tons of phosphorus and 2.4 million tons of potassium were accumulated as sediments before the upper delta per year. Approximately a half of this quantity went to irrigated fields. Currently the greater part of weighted sediments (up to 75% dredges) started to accumulate as sediments in the water reservoirs (there are over 60 of them). This leads to the degradation of soil. For instance, only at the bottom of the Nurek water reservoir 5 million tons annually accumulate as sediments.

Destruction of coniferous forests or at least their substitution with secondary small leaved plants accelerated the process of snow melting snow in the mountains and the period of water flow was shortened. The latter significantly increased the threat of spring floods, frequency of summer floods, floods in the basins of rivers, where forests were extinguished.

Rauner (1901) said, that in order to sustain the expansion of irrigated land areas and increasing needs of stable water supply in the summer, it is necessary to care about forest vegetation. Decline of forests and human induced fragmentation of forests will lead to the degradation of irrigation systems. As an example the author indicated the existence of 860 thousands acres of land, which were previously irrigated and later affected by desertification.

As the result of the deforestation, the intensity of river flow on the northern slopes of the Turkestan and Nuratinsky ranges decreased to 40%. The Southwestern Kopetdag also shows a bright example of the impact of deforestation on mountain watersheds and the reduction of water flow in the mountain rivers. As the result of its strong deforestation in the 16th Century, the flow intensity in the mountain rivers decreased dramatically, including the river Atrek, which has led to the devastation of the agricultural oasis in the valley and in the delta of this river. During the first a half of the 20th Century, aggregated flow intensity in rivers, running down from the slopes of the Kopetdag reduced additionally by 50% on the background of significant inter-annual and intra-annual variability in precipitation and intensification of summer droughts (Kirsta 1976). At the present time tress were completely destroyed in the lower zone of Kopetdag. Forests were also destroyed to a significant extent also at higher altitudes. According to the opinion of Kirsta (1976), extinguishing of forests in the Kopetdag area became one of the main reasons of water flow decline and disappearance of numerous water sources.

The removal of walnut and fruit forests during

the past century from an area of approximately 10 million hectares has led to the transformation of slopes in the Pamir-Alay, Tien-Shan and Kopertdag mountains. Formerly covered with dense forests, these slopes turned into dry steppes, threatened by erosion and leeching of organic matter from the soil.

The lower boundary of pine growths in Tien-Shan moved 100-120m to higher altitudes during the historic time (Vtorov and Vtorov 1983). Areas covered with mountain forests in the past are currently occupied with range (sedge and *Poa trivialis* (fowl-grass)) formation, steppe-adjusted bushes of shibliak and tragakant associations. While the first moved from the hypsometrically lower adyrs of foothills, the latter came from more southern mountains of the Front Asia. The erosion has promoted the dissemination of the tragakant associations in Central Asia (Korovin 1959).

The second most important factor leading to human-induced desertification in the mountains of the Central Asia is grazing and overgrazing. Grazing is one of the most significant factors shaping the character of Central Asian nature. Vicinity of mountains and valleys in such arid climate has allowed for wide spreading of grazing.

Unorganized excessive grazing dramatically worsens the water retaining capacity of soil and ground. As the result of the compression of turf and soil horizons, its volumetric weight in grazed areas decreases by 1.5-2 times (Kosmin 1983). The permeability and filtration capacity of soil and surface flow and flushing off decreases by 2.7 times respectively. In thin forests of the Western Tien-Shan cattle grazing leads to the enhancement of surface flow and decrease of the flush-off velocity threshold.

The cattle (sheep), and especially goats eat young crops and sprouts in the juniper forests, dramatically decreasing the juniper's capability of rehabilitation. Soil compression caused by grazing also impairs the rehabilitation of juniper. Thus, due to cattle grazing, young sprouts occupy only 7.1% of total forest area in Kyrgyzstan, whereas in forests older than 100 years old - more than 50% of the total forest cover (Shevchenko 1969).

At the present time around 70% of the area of middle zone and over 80% of surface area of low mountain zones in Central Asia are under intensive grazing. As the result pastures deteriorate practically in all mountain regions of Central Asia. It was found that during recent 50 years a sharp decrease of total productivity in all types of fodder land was observed. For instance, yields of tipchak steppes in the 1930's varied from 5 to 12 centers/he, and 50 years later it was from 2 to 7 centers/he. Within 50 years the productivity dropped by 30%.

In the mountains of Central Asia, runoff from the slopes and subsequent flushing off of fine soil particles are wide spread. Observations at the Chatkal Mountain - melioration station showed that up to 90% of precipitation flows down from the slopes.

As much as 81% of the surface area of soils in the mountain areas is prone to erosion. Especially ploughed slopes in the mountains are strongly suffering from erosion. For example, it was observed that on the northern slope of the Zarafshansky range only slopes of 10° lost up to 2,500 m³ of fine soil particles per hectare, while slopes of 20° lost up to 4,000 m³ and slopes of 30° lost up to 6,000 m³ of fine soil particles. The erosion has damaged on average over 80% of mountainous areas

across the republics of Central Asia.

Frequent draughts due to general desiccation, partially due to deforestation of mountains, promote the development of erosion. Areas of rain fed (non-irrigated) lands, which had once been covering piedmont plains also started to shrink due to the desertification of mountains.

It is not difficult to prove that the extermination of trees and bushes and development of grass vegetation in the mountains was induced by human activity. This is why ecological conditions in the mountain areas of Central Asia are now characterized by wide distribution of steep, stony and rocky slopes, often naked slopes with severe erosion. Scarce vegetative cover or its absolute absence leaves the slopes vulnerable to erosion.

problem of soft humus layer degradation in the soil, which leads to irreversible degradation (desertification) of biotope conditions. Soil is mostly not available or only as a rough-skeleton. Due to this problem, upper zones of the mountains in this region often comprise areas which are vulnerable to mudslides.

Thus, deforestation and overgrazing in the mountains of Central Asia enhances the processes of aridification, manifested in the desertification of plains, foothills, and substitution of with the steppe vegetation in the mountains, reduction of the surface area of glaciers and other numerous natural and human-induced chain events that can be observed at the present time. The author illustrates the causal chain of events and consequences of deforestation in the mountains and its manifestation in the adjacent plains using the example of Central Asian region. (see Fig. 1).

After the collapse of the USSR supply of coal from Russia and Kazakhstan to Uzbekistan reduced dramatically. People, living in the vicinity of mountains started ruthlessly to cut trees and bushes, growing in the mountains, for stove fuel. Only during recent 10 years, the same volume of forests and bushes were destroyed as during previous 40-50 years. If no specific measures are undertaken to provide population of kishlaks (villages) with fuels for heating, then in the nearest 15-20 years mountains will completely lose trees and bushes. At the current dynamics of population growth, cattle population will double proportionally to it in 20-30 years. Naturally, the burden on pastures will also increase by 2 times.

All this in the end will let the mountainous territories of Central Asia fall behind in economic development. This will be reflected in unfavorable development in the social sphere, depopulation, and further worsening of economic and social situation, etc.

Mountainous regions of Central Asia are remarkable for their unique character and occupy over 20% of the total territory of the region. The economic production of these mountain areas is comprised of 10% industrial production, 8-9% agricultural production, and a significant part of recreational capacity.

The sustainable development of mountainous regions of Central Asia involves two main groups of issues. The first group consists of socio-economic problems: lagging of mountainous territories behind in economic development, resulting in unfavorable tendencies in social sphere, depopulation, hence further worsening of economic situation, etc.

The second group is ecological problems of

mountains, relating to both global negative tendencies and regional "overloads". Acceleration of erosion, pollution, general degradation of natural complexes are among the main problems. Productivity of medicinal herbs is reduced.

Then, former approach to the economic development of mountains in the soviet time, using methods, suitable for plains, ignoring natural conditions of mountain regions, which has lead to the appearance of numerous nature-economic conflicts and objectively allowed to let the ecological situation become more acute not only in mountainous regions, but also in the frameworks of broader territories (for instance, the Aral crises).

Construction of electric stations and water reservoirs, mining, organization of tourism, recreation and health treatment in the mountains acquired a wide scope and perspectives of their further development are really colossal. At the same time man-made burdens on nature of mountainous countries in general are increasing, while in selected habitats concentration of impacts achieves great extent. Issues of nature conservation in the mountains become extremely relevant.

On the basis of comprehensive analysis of collected materials we have identified the problems (social, economic, ecological, etc.) of mountain regions of Central Asia and also the problems of the adjacent plains in a broad scope, in contrast to isolated studies that have been published in the past. Presently the expanding diverse interactions between mountain regions and plains are the characteristic feature of economic and social development of the Central Asian region in general. This interaction must be accounted for in the efforts for an efficient geographic division of labor on different geographical scales – within large economic regions and in the frameworks of individual farms. Growing complimentary nature of mountainous and valley parts of the region and of many farms leads to significant shifts in territorial organization of economics, distribution of population and lifestyle of people.

Population migration also belongs to relevant socio-economic problems of mountain regions and has to be addressed in order to achieve economic integrity of the mountains and adjacent plains.

Prospective economic rise of the mountain regions will not be possible without solving the problem of migration from mountains to plains. Active social and economic policy on prevention of depopulation of mountainous rayons of Central Asia must be based on new approaches, in particular on the experience accumulated in CIS and foreign countries about economic development planning in the mountains. Industrialization of mountain territories with establishment of large mining industrial and hydro energy complexes will require a significant inflow of population for labor. For the establishment of normal sex and age structure, as well as with the proposed raising economic effectiveness of territories under intensive forms of their development, it is necessary to establish developed resort-tourism economy.

Necessity of the development of tourist resorts in the mountains is dictated by the problems of

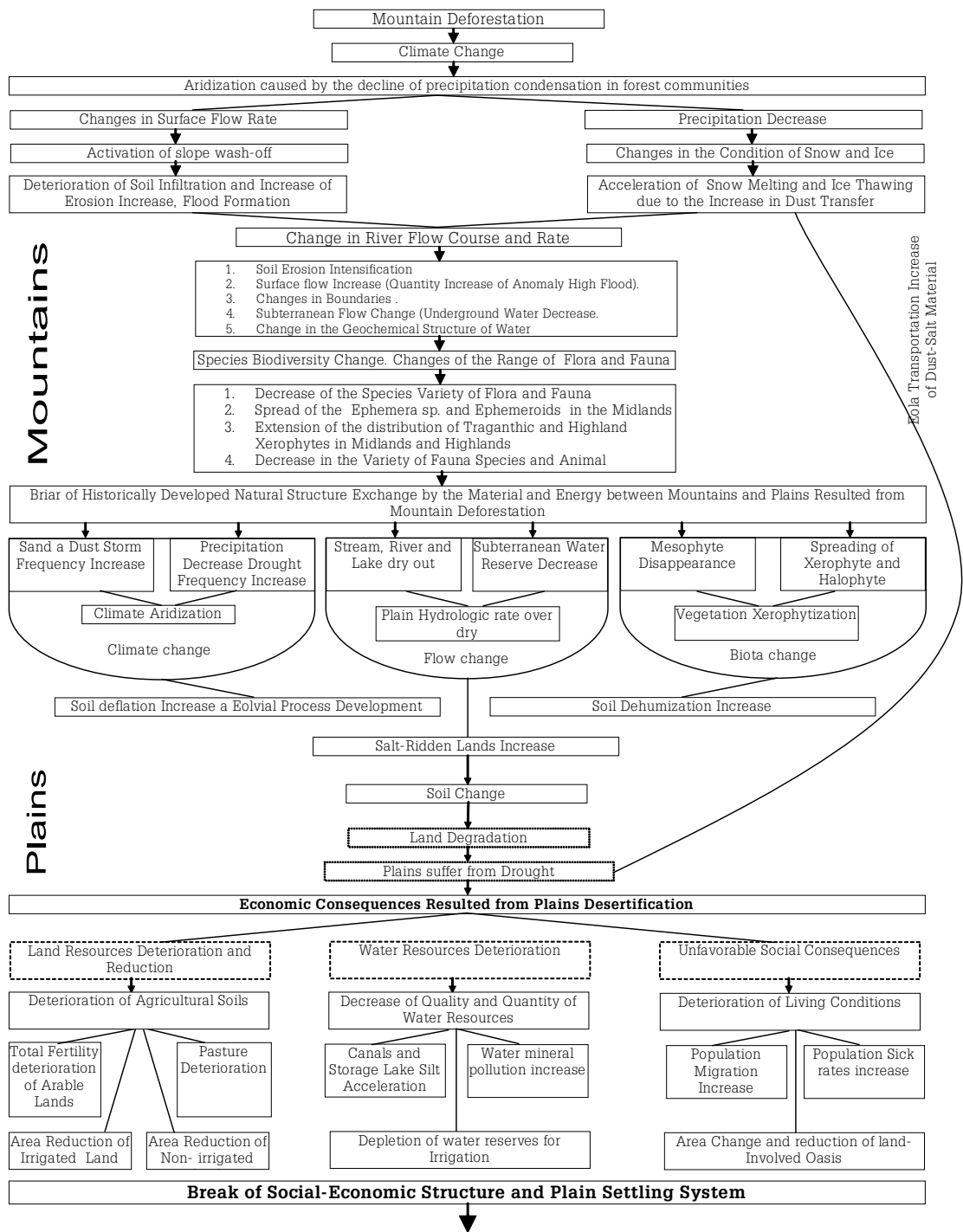


Fig. 1. The chain of natural economic mountain deforestation consequences developed in adjoining plains.

environmental conditions in plains, environmental pollution in large cities. In the Central Asian regions these problems are aggravated by the very hot summers on plains and respectively limited possibilities for recreation. As the result already now a spontaneous flow of population to the mountains on weekends has become a tradition. Its non-organized nature brings significant damage to environment. Meanwhile, establishment of a large recreational base of international importance can become an alternative to spontaneous development of mountains. Work in the sphere of maintaining cultural and tourist resorts could significantly expand the possibilities for recreational activities of the of the fast growing population of the Central Asian republics.

In the future, mountain recreation resorts in Central Asia could acquire international importance. Great combination of ancient monuments of Samarkand, Bukhara, Merv, Kokand and of charming mountain landscapes has the potential to attract significant numbers of foreign tourists.

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