The Karakum Desert

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Abstract The Karakum Desert is one of the largest deserts worldwide. It locates within one Central Asian country – Turkmenistan. Covering about 80% of its territory it is vital for the economic development of the country. It holds in storage the oil, gas, and other mineral deposits. Distant-range cattle husbandry is practiced here; cotton growing, feed production, melon crop cultivation, and horticulture are developed on irrigated lands.

Keywords Climate, Desert, Economy, Relief forms, Soils, Vegetation, Water resources

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1 Introduction

Creation of the Turkmen Lake "Altyn Asyr" occupying one of the depressions in the Karakum Desert required construction here of the collector and drainage network and infrastructure that later on should support performance of this magnificent project. Accordingly, it seems appropriate to open this chapter with the description of the Karakum Desert, its components, and ecological and geographical characteristics.

Turkmenistan is one of the leading countries in Central Asia. Its territory locates in the drainless basins of the Caspian and Aral seas. It belongs to the zone of extratropical deserts of the Northern Hemisphere. The largest sandy desert Karakum covers the northern and central parts of Turkmenistan (about 80% of the country's territory) (Fig. 1).

The Karakum Desert locates in the arid zone with 80–300 mm of precipitations a year, thinned and scanty vegetation represented by perennial and annual succulents. This is the zone of nomadic cattle rising; irrigated farming is impossible here.

2 Landforms

The Karakum Desert (in Turkmen "Gara Gum" meaning black or overgrown sand) is one of the Asian deserts. It occupies the Turanian Plain east of the Caspian Sea, with the Aral Sea to the north and the Amudarya River and the Kyzyl Kum Desert to the northeast (Fig. 1). It is characterized by symmetrical location to the left of the large regional river – Amudarya, a vast flat "descend" to the seaside of the Caspian Sea (Kara-Bogaz-Gol Bay) confined in the south and southeast with a medley of low plateau (Kopetdag).

One of the most ancient deserts of the world – the Karakum is an inland natural sandy aggradation desert. It has clear-cut geographical borders. The northern border is formed by the Amudarya deltaic flatland with modern and ancient irrigated lands. The northeastern border runs over the Amudarya valley, while the eastern – over the state border with Afghanistan. In the southeast the Karakum Desert is limited by on spurs of the Barabil and Batkhyz uplands, while in the south and southwest it gradually merges with the hills and piedmonts of medium-height Kopetdag Mountains. The Sarykamysh Depression and the ancient dry bed of Western Uzboi are regarded as the northwestern and western borders of the desert. Sometimes the Precaspian Plain of Turkmenistan is also referred to the Karakum Desert calling it the Southwestern Karakums. The Karakums Desert in the above borders is about 360 thou km^2 [1].

The desert has a generally flat surface being the lowest in Central Asia. During its geological history the territory of the desert suffered more than once the sea transgressions. After the sea recess the exposed area was affected by wind and flowing waters. At the same time, the territory was subject to tectonic impacts that

Fig. 1 Map of Karakum Desert

formed plates with an area of hundreds and thousands of square kilometers limited by gentle and steep slopes and, in some places, by abrupt cliffs (chinks) to 50–100 m high.

The present-day surface of the Karakum Desert was formed in the recent 30–40 million years. During this time the mountain formation processes were underway in the territories neighboring the Karakums in the south and southeast. Intensive eolian processes destroyed the formed mountains turning them into a drift area. The Upper-Tertiary seas found on the territory of the modern Karakums were gradually shrinking in size and receding westward. From the Late Pliocene the Karakums were devoid of all seas. The pra-Amudarya River flowing down from mountains and reaching the northern part of the modern Low Karakums contributed much to the surface formation here. The flatland over which the river was meandering was filled with the material brought with its waters. About one million years ago, the pra-Amudarya affected by tectonic processes deviated westwards. The debris material brought not only with the waters of the pra-Amudarya, but also its tributaries Tedzhen, Murghab and others was deposited on the flatland of the Lower Karakums. The alluvial deposits filled the Central Karakums depression and their thickness exceeded 500 m in some places.

During this time the northern part of the desert – Zaunguz Karakums were slowly uprising. The Southwestern Karakums representing an inclined flatland were formed due to the action of ancient water streams.

The desert aridity was amplified with changing of the Amudarya (Oxa) riverbed that about 70,000 years ago went beyond the Low Karakums confines and turned northward to the Aral Sea. From this time on the Central Karakums were left without surface water recharge source. After the Amudarya River turned to the north the Tedzhen, Murghab, and other rivers flowing down from the Kopetdag stopped being tributaries although they brought waters to the southernmost part of the desert, i.e. they formed blind subaerial deltas. These deposits in the south of the Karakum sandy-clay flatland formed numerous takyrs and solonchaks. After turn of the Amudarya in the Low Karakums the eolian transformation of the upper layers of the Karakum series with the growing climate aridization became the prevailing process. In the Neogene-Quaternary Period the warm and humid phases alternating with dry cool periods was observed permanently across the Karakums territory which affected its landforms. Only in the recent 6,000 years we may identify the active deflation phases, each consisting of 15 century-wise rhythms, on the average [2].

Therefore, through its historical development and in the course of climatic variations in the Neogene-Quaternary Period three major parts of the Karakums and its modern relief were formed:

1. *Inclined flatland Zaunguz Karakums or Northern Karakums* (they are often called Zaunguz Plateau) covering the smaller northern part of the desert represent the ancient alluvial, deeply broken high flatland where alluvium is overlain with eolian sands composed largely of sands and carbonate sandstones. The relief of the flatland is mostly takyr with a mantle of eolian deposits to 30 m thick (10–20 m on the average) over marine deposits. The half-overgrown sands form long steeply sloping ridges to 40–60 m high. In the inter-ridge valleys the outcrops of clays and solonchaks are rather frequently met. The lowest point of the country (81 m below the sea level) is the Akdjakaya Depression in the Zaunguz Karakums.
2. *Low or Central Karakums* are a sandy desert on the ancient alluvial re-deflated flatland concave in its central part and gently sloping towards north and south, accumulating the detritus drifted from the nearby territories and divided by a chain of the Unguz depressions. It is composed largely of the sandy-clay deposits of the pra-Amudarya which are overlain with the deltaic sediments of the Tedzhen and Murghab rivers. Therefore, the whole territory is covered by laminated gray micaceous sands of very homogeneous composition, with thin interbeds or lenses of chocolate clays of the Tertiary and Quaternary age of water origin 500 m thick [3].
3. *Southeastern Karakums* locate in the interfluve of the Murghab and Amudarya rivers. This is an inclined flatland composed of the Quarternary alluvial-deltaic sediments from 0 m (in the south) to 100 m (in the north) thick. It includes deeply broken sands adjoining Karabilyu in the north, the sandy-loamy flatland with low sands and solonchaks of the so-called Obruchev steppe and the pre-Amudarya barkhan belt.

The mountains surrounding the desert were the source of the materials brought with rivers. The same circumstance determined the differences in the lithology of the surface. In the Karakums the deposits carried from the mountains by the pra-Amudarya and Amudarya prevail.

As concerns the relief, the Karakums are a small-hummocky, sandy, heavily rugged flatland generally sloping from east to west, with ridgy sands in the north and hummocky (small-hummocky) sands with flat clay areas, takyrs in the south.

Much of the Karakums surface is covered with eolian sandy deposits. In the Neogene-Quaternary Period of the geological history of the Karakums their territory received no less than 70 thou km^3 of sediments, out of which no less than 7 thou km^3 were subject to eolian transformation [4]. The sands are mostly fine-grained here. The fractions sizing 0.015–0.150 mm and 0.150–0.210 mm dominate. Due to remoteness of the main part of the Karakums from the areas of drifting the coarser fractions in the sand composition are quite rare.

The petrographic composition is dependent on the composition of rocks in drift source areas and on the work of water streams, eolian drift during which the less strong minerals were destroyed. The key role in the Karakums sandy deposits is given to quartz, of less significance is feldspar, debris of magmatic and carbonaceous rocks.

The sands of Zaunguz are distinguished by their light-yellow and red-yellow coloring due to abundant presence of quartz, feldspars, and granitoids. The sands of the Lower Karakums thanks to the presence in considerable amounts of magmatic rock debris (basic effusive rocks and acid gabbroids, diabases) have greenish-gray and steel-gray coloring.

Long-time development of the surface, frequent transgressions and regressions of the Caspian Sea, migration of river systems, climatic changes and other natural and anthropogenic factors combined to form specific types of the eolian relief of the Karakums.

Here we can find the following types of sand forms: hummocky, ridge, ridge-hummocky, cellular, barkhan-hummocky, barkhan, barkhan chains. The ridges occupying 60% of its territory dominate here.

In the Zaunguz Karakums the ridges are made of compact parent rocks overlain with sands. This distinguishes them from the ridge relief of the Lower Karakums. In both cases the sand ridges are extending nearly meridionally. In the Zaunguz they can be to 70 km long, 0.2–2 km wide and 5–30 m high. In the Lower Karakums their height ranges from 15 to 20 m and width 200–300 m.

The inter-ridge valleys have smaller ridges running parallel to the larger ones; they are composed of loose sands. Near the Kopetdag foothill plain the sand ridges are characterized by larger dimensions. In the inter-ridge valleys the takyr and takyr-like soils occur.

The central and southern parts of the Zaunguz Karakums abound in kyr ridges. Kyr is a long and narrow relief form composed of Zaunguz parent rocks. The width of the kyr strip may reach several dozen kilometers. Its length varies from 5 to 8 km reaching at times 20 km. Its crest width is to 1 km and the height ranges from 30–40 m to 75 m. The spacing among kyrs is 1–4 km. The kyrs tend to gradually

lowering northwards being overlain with sands and smoothly transfer into sand ridges which, in their turn, sink from 25 to 7 m near Amudarya oases. Their length is in no way inferior to the kyrs, while their crest width is no more than 200 m with spacing in inter-ridge valleys being 1.5–2 km.

Hummocky sands represent a broadly extending form of eolian relief covering 30% of the Karakums territory. They are also found in various combinations with other eolian relief forms (barkhan-hummocky, ridge-hummocky and others). The hummocky forms are usually immobile, however, in the areas transitional from the barkhan relief to the hummocky one and back they acquire some mobility. The height of these forms is 1–2 m.

The desert-specific relief features include dry beds and drainless depressions that may be rather large. Some of them have a basin-like shape (e.g., Sarykamysh), others are linear – Unguz, Western and Kelif Uzboy and some smaller ones. Unguz extends latitudinally from the Amudarua to the Ekedje and Dodur shafts for nearly 400 km. its width is 15–20 km. Separating the Zaunguz Karakums and Lower Karakums, Unguz consists of a chain of individual depressions crossed with dykes. The bottom of small depressions is composed of shors and takyrs, and in the eastern part – of sands.

The Kelif Uzboy also represents a linear chain of depressions in the Southeastern Karakums. But unlike Unguz, these depressions have the clear-cut signs of being influenced by pra-Amudarya locating on one of its meanders across the Karakums. Not very deep depressions are divided by not high sandy dykes. Some depressions of Kelif Uzboy are filled with waters of the Karakum Canal.

Dry beds are the significant phenomena in the relief, river network, and watersheds of the desert. They are often very long and remind of rivers left without water, such as Western Uzboy and Kelif Uzboy in the Karakums. The Western Uzboy was once a channel diverting Amudarya waters from Sarykamysh to the Caspian Sea. This was the river bed. Kelif Uzboy is the trace of pre-Amudarya meandering when it ran along the piedmonts of Parapamiz and Kopetdag into the Caspian.

The Western Uzboy is the largest of other dry beds. It may be clearly tracked from the southern bank of Sarykamysh to the Kelkor solonchak and along the dry bed of Aktam as far as the Caspian Sea. The total length of Western Uzboy is 500 km, the maximum width of its valley is 3 km, its greatest depth is −40 m. In its riverbed one can see many strip-like “dry” salt lakes extending in the riverbed for 1–5 km. Their width is usually no more than 50–100 m. In the southern part there are several freshwater lakes as well as shors, takyrs, and salt ridges. Uzboy diverts excessive water from Sarykamysh.

3 Climate

The climate of the Karakums may be classified as the climate of deserts of temperate latitudes. It is sharply continental and very arid which may result from specific atmospheric circulation, location of the Karakums deep in the huge

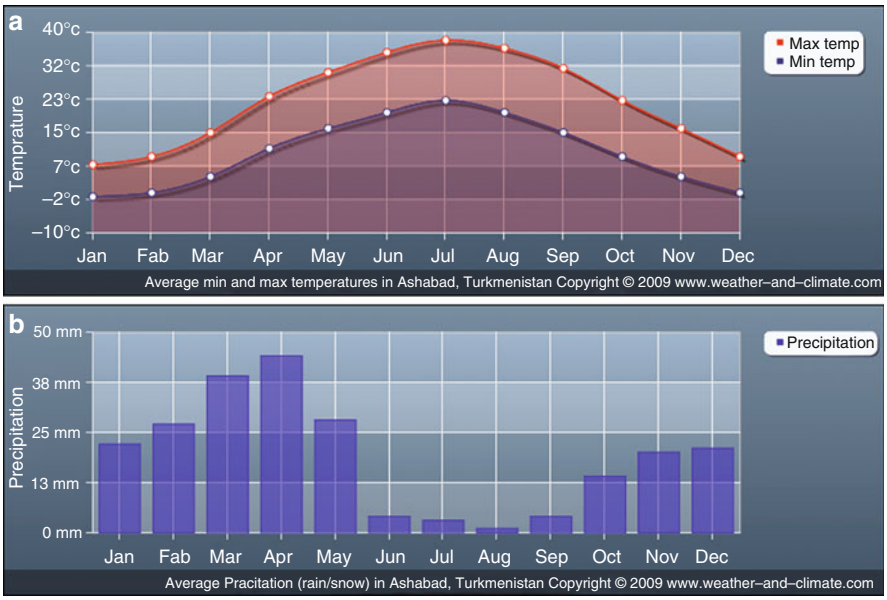

Fig. 2 The monthly mean minimum and maximum daily temperature in Ashkhabad (**a**). The monthly mean precipitation, including rain, snow, hail in Ashkhabad (**b**)

continent, its southern location, the nature of underlying surface and mountain systems in the southeast and south. The climate here is characterized by very hot cloudless and long summer, soft rainy spring, warm dry autumn, and frosty winter with frequent thawing periods.

The average annual air temperatures across the desert are positive varying from 11°C to 13°C in the north to 15–18°C in the southeast.

Winter is mild with low snow. The coldest month is January with the average temperature varying from −6°C in the northeast of the country to +3°C to +5°C in the south (Fig. 2). In some years, invaded by Siberian anticyclone the winters became very severe. Frosts with temperatures from −30°C to −35°C may last for long. The frost-free period is 230–250 days. Summer is very hot and dry. The maximum air temperature in July may rise above +30°C. The absolute maximum of +48°C to +50°C is registered in the Central and Southeastern Karakums. The daily amplitudes of air temperatures are very high reaching 50°, while on the ground surface they may be even 80°.

The distinguishing feature of the climate in Karakums is not only high air temperatures, but also a long sunshine period that may reach 2,800–3,100 h a year, on the average. The number of sunshine days in a year varies from 120 to 185 decreasing from south to north.

The Karakums refer to the zone of insufficient wetting. The average annual precipitations here vary from 80 to 300 mm (Fig. 2) and their quantity is growing from north to south. About 50–60% of precipitations fall in February and April.

High summer temperatures, insufficiency of atmospheric precipitations, and lack of surface flow contribute to formation of the air humidity regime. The relative humidity reaches its maximum in January making 70–78% and in June through September, the most arid period, it drops to 22–25%.

Low air humidity results in intensive evaporation from the water surface. The annual evaporation varies from 1,400 to 2,300 mm which is 15–20-fold more than annual atmospheric precipitations [5].

The permanent feature of deserts is winds. Slight winds (2–3 m/s) are blowing every day. At a speed of 4 m/s they form the wind-sand flow that triggers movement of unfixed sands and formation or rearrangement of sand relief. In the Central Karakums strong winds blow for 10 days a year, on the average, while in the Southeastern Karakums – to 50 days. Mists are usually observed in the southeastern areas from November through March for 10–20 days a year near water bodies. Thunderstorms occur ten times a year, in May, in the Zaunguz and Central Karakums.

4 Water Resources

As the book has a special chapter devoted to the water resources of Turkmenistan, we will provide here only a brief description of water resources in the Karakum Desert.

Location of Turkmenistan inside Eurasia, far from oceans, in the zone of deserts of temperate belt explains its low water supply. This situation is aggravated by the relief conditions. The greater part of the country has no surface waters. In the deserts the surface flow is formed only on small takyr and takyr-like watersheds composed of clay deposits. After rainfalls over 5 mm the surface flow is formed as very short-term floods. The size of the surface flow is dependent on the quantity of precipitations, their intensity and, to a great extent, on the size of a watershed and wetting before rainfall. The flow is accumulated in lower parts of takyrs and is quickly lost to evaporation and distributed seepage. The average many-year surface flow from 1 km^2 of takyrs varied from 5 to 20 km^3 a year. This flow and also limited groundwater reserves some of which are fed with mountain waters represent, in fact, the water resources of the Karakums. Their total volume is insignificant, hundred times smaller than the flow of Amudarya, Murghab, and Tedzhen rivers heading to the desert.

Ground waters occur nearly across the whole territory of Karakums. Closer to the recharge areas (waters of Amudarya, Murghab and Tedzhen rivers, and Kopetdag rivers seeping and being lost in sands) the ground waters become slightly saline. In the central part of the deserts their salinity is high. More than 10,000 dug pits are dispersed over the Karakums. Many desert regions have no freshwaters at all, but they have hundreds of pits (chirle) collecting rain waters from takyrs and directing them into deeper sandy horizons where they form lenses “on top of saline ground waters.”

Table 1 Water resources and natural wetting of the Karakum Desert [6]

Description	Amount (km^3)
Amudarya River flow	12.3–13.6
Murghab River flow	1.46
Tedzhen River flow	0.730
Flow from takyrs	0.225
Flow from takyr-like watersheds	0.016
Static reserves of large fresh-water lenses	80
Sub-takyr fresh-water lenses on saline ground waters	0.0003[a]
Water of atmospheric precipitations without adjustments	42.4
The same with adjustments for wetting of the precipitation metering cylinder and inadequate account of winds	51.4

[a]Provided their reserves are replenished regularly.

Therefore, by rough estimates the water resources of the Karakums formed by the local surface flow (potential water resources) make presently 244 mln m^3, including flow from takyrs 225 mln m^3 and flow from takyr-like watersheds 15.7 mln m^3. Regardless of their insignificant amounts these water resources are important for watering of pasturelands although only a small part of them are used.

The summed up characteristics of water resources and natural wetting of the Karakums are presented in Table 1 below.

5 Soils

Low precipitations and very high temperatures in the vegetation period interfere with the development of biological and soil processes making them specific. Thus, the Karakums soils feature low thickness, meager humus content, poor structure, and nearly overall salinity.

The main types of soils developed here are sandy desert, gray-brown, takyr-like, takyrs, solonchaks, residual meadow and cultural irrigated soils of oases [1].

Sandy desert soils occur everywhere across sandy territories, in particular on the surfaces fixed with grass vegetation. They are not saline, but poor in nutritive substances and low-productive without application of respective organic and mineral fertilizers. These soils are used very effectively for cattle grazing (Fig. 3).

Gray-brown soils spread over the vast territory of Western and Northern Karakums in Zaunguzie. They develop on saline parent rocks. At the same time their long washing with atmospheric precipitations decreases the level of water soluble salts in the top soil layer. This is also facilitated by a relatively light texture of deposits making up these soils. Gray-brown soils as well as other soils of deserts are poor in humus which is explained by intensive mineralization of organic matter in soils in conditions of the arid desert climate. In some regions the gray-brown soils by their agrochemical properties are suitable for development of irrigated farming here.

Fig. 3 Sands in the Karakum Desert

These soils develop in automorphic conditions of ancient deltas, upper river terraces, and piedmont inclined plains composed of alluvial and proluvial deposits. In the regions of ancient farming the sediments generated by irrigated farming make their contribution into their formation.

Takyr-like soils, mostly of the transitional desert-oasis strip of Karakums, are a part of the arable land stock. Irrigation increases their humus content, improves structure and microaggregation permitting to receive high yields of various crops, including cotton.

Takyrs are developed broadly over the ancient deltaic and piedmont plains often combining with takyr-like soils and also in the inter-ridge depressions. They are formed in layered, mostly clay and loamy, alluvial and proalluvial deposits (Fig. 4).

Takyrs formed on outcrops of saline clay lenses and also on clay deluvium in inter-ridge depressions may be found quite often in the Karakums.

Residual meadow soils may be found on alluvial plains of the Amudarya, in the northwestern margins of the Murghab and Tedzhen deltas, in the Sarykamysh Depression, in the Western Uzboy valley, and in Southwestern Turkmenistan. They occur spot-like alternating with various sandy surfaces. These soils are generally slightly and medium saline, but non-saline ones are also found. These are highly fertile lands of the desert plain.

Solonchaks (shors) are developed among parent rocks forming deep (hundreds of meters) vast depressions mostly of the tectonic origin over eluvium of parent rocks. But more often shors appear among sands and in this case the depth of depressions may reach 20–40 m, the length – several kilometers and the width – hundreds of meters.

Extensive areas of solonchaks (shors) may be found on ancient deltaic plains of the Amudarya. They are formed on alluvial saline deposits at shallow groundwater occurrence (1–3 m).

Fig. 4 Takyr in the Karakum Desert

Depending on the salt composition and depth of groundwater occurrence all solochaks are divided into puffed, crust, crust-puffed, wet, and others. In many cases their whole profile is wetted in various degree as ground waters occur at a depth of 1–2 m. Takyrs often have spots of takyr solonchaks. Solonchaks are largely of the secondary origin and they are widely met as individual spots in oasis where ground waters are stagnant and occur close to the surface.

The cultivated-irrigated or irrigated soils are spreading within ancient and modern oasis. As a result of long irrigation a kind of cultured soils appeared here. They have a zonal nature and, at the same time, the anthropogenic origin.

6 Vegetation

About 700 varieties of higher plants may be found in the Karakums. The desert-specific climate, heavily saline ground waters, prevailing sandy substrate – all these factors, all together and individually – affect the plants obliging them to be heat-, cold-, salt-resistant, adapted to drifting sands, strong winds and dust storms.

Many plants of the desert refer to xerophytes, succulents, halophytes and demonstrate high adaptation to local conditions thanks to their morphological and physiological features. Desert plants manage to find sufficient water even in waterless and low-water areas. They possess special mechanisms protecting them from excessive heating and desiccation. Their evaporation is minimal. This becomes possible due to their deep root system (in saxaul it reaches 14 m) or development of horizontal roots satisfying their “thirst” with ground waters of the topsoil. Some plants have small leaves and no leaves at all. They assimilate with the

Fig. 5 Saxaul in the Karakum Desert

help of green offshoots (white and black saxaul) many of which fall off in summer (Fig. 5). Others have woolly leaves, waxy or glossy leaves (e.g., sandhill wattle) [1].

Desert vegetation is very sparse not forming closed canopy. Due to this fact and lack of leaves in large shrubs the deserts have no forests and, as a result, no shadow, underbrush and grass peculiar of forests.

In spring the whole territory of the Karakums, except barkhan sands, gets covered with a green carpet of ephemers and ephemeroids that scorch out in late April – early May. They mostly consist of sandy sedge grass (ilek) making good feed for cattle throughout a year. Out of shrubs the white and black saxaul prevail. Moving southwards the shrubs disappear giving place to grasses.

In the Karakums apart from higher plants the mosses and lichens (karakharsang) suppressing grass vegetation, in particular in Zaunguzie, are widespread. Barkhan sands are overgrown with selin and sparsely occurring shrubs – sandhill wattle and one-two varieties of kalligonums (kandym). The vegetation on barkhan sands is very sparse.

The desert vegetation consists of the following varieties: desert-woody thickets (white and black saxaul in combination with cherkez, kandym, sandhill wattle, and others); psammophytic shrubs (tamarisk, kandym, singren, sandhill wattle, and others); slightly overgrown bare sands – barkhans (wormwood varieties, exrophyte semishrubs – keurek, tansy and others); succulent thistle vegetation (sarsazan, glasswort, saltwort, and others) on solonetz soils and solonchaks; blue-green algae and lichens on takyrs; tugai (Asiatic poplar, oleaster, willow varieties, tamarisk, liana, cane, and others). In the river floodplains apart from background plants the perennial and annual grasses are growing on sands.

Availability of large shrubs, small shrubs and grassy vegetation creates a multi-layered pattern. It is most clearly visible in the sandy desert. It determines the possibility to use pastures in different seasons of a year. Grass pastures should be used for cattle grazing preferably in spring, summer, and autumn, while the multi-layered pastures may be used the year round.

7 Animals

The fauna of the Karakums is very specific. It is distinguished by high assimilation to the desert conditions, protective coloring of animals, rather poor species composition compared to other zones, and prevailing nocturnal animals.

The very important factor for animals is the desert climate, in particular the long warm period of a year, a short, usually warm, winter and availability of fodder in all seasons of a year (but not equally abundant in all seasons). The fauna of the Central Asian deserts is typical of the Turan Depression, and it has many common species with Middle Asia, North and Central Africa. The quantity and composition of species in different parts of the desert depend on difference of natural environment. Very specific is the fauna of river valleys where apart from the desert species you can find animals peculiar of dense tugai thickets and water bodies. There is also the fauna of oasis and settlements. Thus, the Amudarya valley numbers 211 bird species, while the Western Karakums – 118 species. The river valleys are the habitat for over hundreds of nestling birds, the desert – 20–30 species [1].

The animal world has two main complexes: fauna of sandy areas and fauna of areas with compact soils – clays and crushed stone. The animal world of sandy shrub deserts is most rich. The takyrs and, in particular, solonchaks are nearly lifeless.

The most typical mammals found here are: roofed – gazelle (everywhere); predatory – corsac, fox, wolf, dune cat (endemic), steppe cat, caracal; rodents – sand eel (greater sand eel, midday gerbil, Libyna jird, in particular the first one), thin-toed ground squirrel (in sandy areas), yellow gopher (in clay deserts), numerous jerboa – smaller, hairy-footed, comb-toed (endemic) and others; insectivorous – sand shrew and long-eared hedgehog; bats are distributed sporadically. The reptile population is rich and quite specific: steppe tortoise; snakes – carpet viper (poisonous), arrow snake, sand boa and many others; lizards – toad agama (long-eared, sand, takyr). Among the insects the most extensively represented are the

colepterous (darkling bettle, leaf-horned and others), flies, ants, termites (several species). Quite frequently met are solifugae and scorpions. The fauna of ticks is quite diverse.

8 Economy

The Karakum Desert possesses significant and diverse natural resource potential: fuel-power (oil, gas, solar and wind energy), chemical raw materials (potassium and table salt, mirabilite, sulfur, and others), construction materials, agro-climatic resources (the longest vegetation frost-free period permits cultivation of warmth-loving crops), curative, fresh and saline ground waters, fertile (when irrigated) lands, pastures that, due to their forage and climatic conditions, offer the year-round grazing for cattle.

At present the surface and outlook of the Karakum Desert is formed by anthropogenic activities, although the exogenous factors should not be neglected.

Different volumes and conditions of water use led to appearance of different types of farms, different modes of local resource management. Depending on the supply of water, its quality either irrigated farming or cattle grazing farming, small or large irrigated areas, cultivation of selected crops appeared in the desert. Availability of water also controls the concentration of population, sizes of settlements, comfort of living, and life conditions.

Large oil and gas deposits were discovered in the Karakum Desert on the basis of which the oil and gas processing (Turkmenbashi) and chemical industries were developed. Gas and oil are transported via large main pipelines within the country and abroad: Korpedhe (Turkmenistan) – Kurt Kui (Iran) 200 km long; Dovletabad (Turkmenistan) – Serakhs – Khangeran (Iran) and others. Gas is used at large gas-turbine power plants in Turkmenbashi, Marakh, and Balkanabad.

Chemical industry uses the raw materials extracted in the Kara Bogaz Gol Bay in the west of the Karakum Desert. In Gaurdak the sulfur deposits are developed that provide raw materials to the chemical plant in Turkmenabat producing fertilizers for agriculture out of Gaurdak sulfur and Karatau phosphorites.

Very important is also the development of the transport-communication system in the desert where the railroads are of key significance. In the recent years the railroads Tedzhen – Serakhs – Meshkhed (300 km long), Ashkhabad – Karakumy – Dashoguz, Turkmenabat – Atamyrat (230 km long) were constructed with the further exit abroad. The internal automobile roads Turkmenbashi-Ashkhabad-Mary (980 km long), Ashkhabad-Mary-Turkmenabad (600 km long), Ashkhabad-Karakumy-Dashoguz (along the railroad), and others ensuring internal cargo transportation are improved to satisfy international standards.

Historically two types of irrigated farming have been established in the desert, they are small oasis and large oasis farming. The first type developed on piedmont plains near small water sources and on a border with the desert in flooded areas, in areas of ground water discharge on temporary water streams. The large oasis

farming appeared in deltas and valleys of large and medium rivers and also near large artificial canals for inter-basin and inner-basin water transfers, first of all, the Karakum Canal.

The farming in Turkmenistan is completely dependent on artificial irrigation. Out of the total consumption of water resources 90% of water is used annually for irrigation purposes. As the water resources are limited only 2 mln ha of land may be put under irrigation annually. The key agricultural crops are cotton and wheat.

The main use of the Karakum Desert territory is for animal husbandry based on desert pasturelands. And their watering plays a key role in their development. The animal products produced in the desert are less costly than in the steppe zone. Sheep and camel rearing is practiced most extensively, and recently the horse breeding was added here.

Breeding of Karakul sheep distinguished by high adaption to the specific water-fodder situation in the desert has acquired great importance. The share of Karakul sheep in Turkmenistan makes 70% of the total flock. The greatest sheep stock is found in the Central and Southeastern Karakums. In the southwest and north of the desert, their quantity is much less due to scanty pastures.

For agriculture development the construction of the Turkmen lake Altyn Asyr in the center of the Karakums is in the focus of attention. Its construction will permit to use more wisely the collector-drainage waters presently disposed into the desert, the Sarykamysh Lake and partially into the Amudarya River as well as to improve the condition of irrigated lands and to increase the water resources of the country.

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