Turkmenistan: Landscape–Geographical Features, Biodiversity, and Ecosystems

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Abstract This chapter describes in brief the geopolitical location of Turkmenistan and physiographical features of its territory, background (deserts and mountains), and intrazonal (river valleys and oases) landscapes; provides specific features of its biodiversity and basic ecosystems; focuses on susceptibility of ecosystems to the effect of anthropogenic factors, in particular in view of extensive land development, and redistribution of water resources.

Keywords Amudarya and Karakumdarya (Karakum Canal) rivers, Biodiversity, Ecosystems, Karakum Desert, Kopetdag Mountains, Landscapes, Turkmenistan, Types of deserts, Wetlands

Contents

1 General Information

Turkmenistan is one of the Central Asian republics locating in its southwestern part. The republic lies between latitudes 35°08′ and 43°48′N, and longitudes 52°27′ and 67°41′E. Its area (without the Caspian offshore area) is 491.2 thousand square

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I.S. Zonn and A.G. Kostianoy (eds.), *The Turkmen Lake Altyn Asyr and Water Resources in Turkmenistan*, Hdb Env Chem (2014) 28: 9–22, DOI 10.1007/698_2012_179,

kilometer. The territory extends for 1,100 km from west to east and for 650 km from north to south. To the east and north Turkmenistan borders Uzbekistan, to the northwest – Kazakhstan, to the west over the Caspian Sea – Azerbaijan, to the south – Iran, and to the southeast – Afghanistan.

Administratively the territory of the country is divided into 5 velajates (provinces) and 53 etraps (districts) with 21 cities (including capital – Ashgabat) and 77 settlements. The population of Turkmenistan is about six million growing annually by 5% on the average. More than half of the population (55%) lives in rural areas.

The territory of Turkmenistan covers the southwestern part of the Turan Plain extending in the arid zone of Central Asia. The nature and biodiversity of the country correspond to its southern position in the moderate climate belt. The modern natural processes are determined by open desert landscapes, generally drainless territory, climate aridity, and looseness of surface soils. At the same time, in Turkmenistan and, in fact, in the whole Central Asian region the anthropogenic factors acquire the growing significance which influences essentially the natural environment, in general, as well as the transformation and dynamics of ecosystems and their biodiversity.

The climate here is sharply continental and arid. The climate continentality is revealed in frequent and considerable fluctuations of the daily and annual meteorological characteristics, while aridity – in very low precipitations, slight cloudiness, and higher dryness of air. On the Caspian coast and in mountains the continental climate becomes somewhat milder. The average annual air temperature varies from 21°C to 34°C, however, on the plains the temperature ranges from 15°C to 18°C in the southeast to 11–13°C in the north, in mountain regions it is 10–15°C and at still higher altitudes (1.5–2.0 thousand meter) – 7–10°C.

The soil cover is rather diverse due to orographic peculiarities of the territory, hydrothermal factors, and soil-forming rocks. In the flat part of Turkmenistan the soils are extending following the latitudinal-zonal regularity, while in mountains – the vertical-belt.

By the order of decrease in their natural fertility the soils may be arranged as follows: light gray soils, meadow soils of ancient irrigation, meadow–gray, and meadow–takyr-like soils. They are all used in irrigated farming, while takyr, gray–brown, and sandy-desert soils are used as grazing lands [1,2].

2 Landscape and Environmental Peculiarities of the Territory

In physiographical and landscape–environmental terms (Fig. 1) Turkmenistan may be divided into two unequal parts: flat northern part and piedmont-mountain southern part. The flat lands account for 85% of the whole territory of the country with dominating deserts (73%) and only 12% with oases and water surfaces. The rest of the territory (15%) is covered by mountains and foothills. The lowest altitudes are recorded in the north in the Karakum Desert – 92 m below the sea

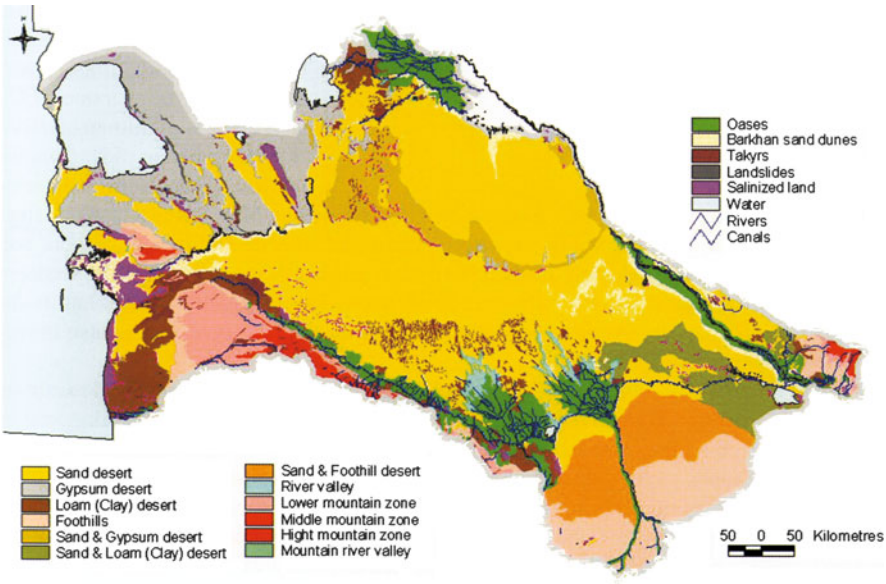

Fig. 1 Landscape and ecosystem division of Turkmenistan territory

level (Akcha-gaya Depression), the highest areas are found in the south in Kopetdag (Chopan Mountain – 2,889 m, Shakhshakh Mountain – 2,912 m) and in the far east in Koitendag (Airy-baba Mountains – 3,139 m).

The plains are generally inclined to the west – to the Caspian Sea and to the north – to Sarykamysh. They are subdivided into lowland and highland plains.

Lowland plains of Turkmenistan include the Karakum Desert (Central, Zaunguz, and Southeastern), Sarykamysh Depression, seaside lowland and river valleys of Amudarya, Karakumdarya (Karakum Canal), Murgab, and Tedjen dissected by a dense network of artificial irrigation canals. The Central (or lowland) Karakums stretch from west to east from the ancient bed of Western Uzboy to Kelif Uzboy (occupied at present by the Karakumdarya River valley in its upper reaches), while from north to south from the Unguz Depression to the midstream of Karakumdarya. The Zaunguz Karakums are limited in the west and south by a narrow chain of small Unguz depressions, in the east – by the Amudarya River and in the north – by the Sarykamysh Depression. This is an extensive area covered with overgrown large sand ridges, narrow kyr, and crushed stone ridges. The Southwestern Karakums stretch southward from the Middle Karakumdarya smoothly passing into the hills of Badkhyz and Karabil. Some researchers identify the Eastern Karakums as an independent area.

The Sarykamysh Depression has smooth slopes and a flat bottom; at present as well as in the quaternary period it was occupied by a vast lake with the same name (3.47 thousand square kilometer) surrounded by clay-solonchak areas. The maritime lowland is located among the western spurs of the Kopetdag Mountains,

southern margins of the Krasnovodsk Plateau, Caspian Sea and in the south – the valley of the Atrek River (in its lower reaches). The surface is mostly covered with clays, while in the marginal area solonchaks and sands prevail. The river valleys in plains have a few mildly revealed terraces (to three of them). The Amudarya delta is composed of old alluvial and modern sandy and sandy-clay sediments. The deltaic plain of the river is sloping smoothly northward (to the Aral) and also westward (to Sarykamysh). Quite recently it was developed for agricultural use.

High plains of Turkmenistan were formed from Tertiary plateaus that adjoin in the north and northwest the lowland plains of Turkmenistan. These include Krasnovodsk Plateau, Southern Usturt Plateau, and related smaller residual uplands – Butentau, Duzgur, Tarimgaya, Kangakyr, Zengibaba, and Eshchekankrenkyr (Akchagai). The Krasnovodsk Plateau covers the peninsula bearing the same name and extends to the northwest to the Oktumkum sands, to the north to Kara-Bogaz-Gol Depression (with the bay of the same name), and to the southeast to Chilmamedkum. In the northeast it passes into Tuarkyr folded area with the "mountains" Ersarybaba and Babashi and chinks Begendjalykyr, Tyuverkyr, Akkyr, Tekedjik, and Koimatdag stretching for considerable distances. The Southern Usturt Plateau locates in the central part of Northern Turkmenistan and includes broken uplands (Chelyungkyr, Kaplankyr) alternating with depressions filled with the sands of Uchtagankum and Kumsebshen and solochaks of Kazakhlyshor and Karashor (for the project – the cup of Turkmen Lake Altyn Asyr).

3 Deserts and Their Biodiversity

In Turkmenistan the sandy, clay, crushed-stone, and solonchak deserts can be found. They have different soils, vegetation, and wildlife. All desert areas are characterized by a long dry summer and poor vegetation not forming the closed canopy that may develop only during a short spring.

Sandy deserts occupy both the lowland and highland plains and the largest of them is the Karakum Desert (350 thousand square kilometer). Quite naturally, the deserts leave their "imprint" on the natural environment of the country, in general, determining its soil conditions and biodiversity. Deserts are characterized by environmentally specific combination of contrasting factors, some of which are in excess (abundance of heat), while others in deficit (water insufficiency). Deserts represent a life domain with highly specific biodiversity having deep and century-old genealogical links with the arid conditions. In the course of evolution its components, such as plants and animals, managed to develop and acquire a sum of morphophysiological and ecological–ethologic adaptations enabling them to survive in such extreme environment. The conditions for existence of biodiversity in sandy deserts (not on drifting barkhans, but in hummocky-ridge deserts) are more favorable than in clay and other types of deserts. Sand is capable to keep water at great depths. And water gives life to plants, while availability of rather rich vegetation with its fodder potential and protective properties creates, in its turn, the favorable conditions for animals [3].

Flora of deserts, in particular of the Karakums, comprises some 700 varieties. On barkhans the vegetation is scattered widely or is completely absent. Quite seldom one can find here *Stipogrostis* sp., some varieties of *Calligonum* sp., Saltwarts (*Salsola* sp.), *Ammodendron conollyi*, and some others. The vegetation on the hummocky and ridge-hummocky sands is represented largely by the groups of White Saxaul (*Haloxylon persicum*) with a grass cover of *Carex physodes*, rarely Bulbous Meadow Grass (*Poa bulbosa*) and other grasses. Several varieties of *Calligonum*, saltwarts (*Salsola* sp.) are also met here, in particular *Salsola richteri*, Milk-vetch (*Astragalus* sp.), and *A. conollyi*. Perennial grasses are also growing here, such as Wild Onions (*Allium* sp.), Bindweeds (*Convolvulus* sp.), Iris (*Iris* sp.), Desert Candle (*Eremurus* sp.), and others. The groups of Black Saxaul (*Haloxylon aphyllum*) including several dozens of plant varieties are usually growing in lowlands. The Black Saxaul (*H. aphyllum*), unlike White Saxaul (*H. persicum*), may form thickets that comprise also *Calligonum*, Milk-vetchs (*Astragalus* sp.), Saltwarts (*Salsola* sp.), Jointfir (*Ephedra* sp.) with the grass cover made largely of annual grasses. Vast areas overgrown with well-preserved Black Saxaul (*H. aphyllum*) forming in some places "desert forests" are not so extensive as it was in the past century [4].

Fauna of the Karakums comprises 2 species of amphibian, 40 species of reptiles, 238 of birds, and 50 species of mammals [5,6], while the invertebrates living here are not adequately studied and comprise about five to six thousands of species [7]. Out of reptiles the stenotopic species in the sandy areas are Common Wonder (*Teratoscincus scincus*) and Comb-toed (*Crossobamon eversmanni*) Geckos, Lichtenstein's Toadhead (*Phrynocephalus interscapularis*) and Secret Toadhead (*Phrynocephalus mystaceus*) Agamas, Reticulate Racerunner (*Eremias grammica*), and Rapid Racerunner (*Eremias scripta*). In areas with compacted substrate the Even-fingered (*Alsophylax pipiens*) and Southern Even-fingered (*Alsophylax laevis*) Geckos, Sunwatcher Toadhead Agama (*Phrynocephalus helioscopus*) and *Phrynocephalus raddei*, *Eremias intermedia*, and *Eremias lineolata* occur. Out of the eurytopic reptile species you can meet Horsfield's Tortoise (*Agrionemys horsfieldii*), Steppe Agama (*Trapelus sanguinolentus*), Grey Monitor (*Varanus griseus*), Iranian Saw-scaled Viper (*Echis multisquamatus*), and Steppe Ribbon Racer (*Psammophis lineolatus*). They can live both in sands and on clay and crushed-stone surfaces. The areas composed of compact soils may become the habitat for such birds as Black-bellied Sandgrouse (*Pterocles orientalis*), Eurasian Stone-curlew (*Burhinus oedicnemus*), Houbara Bustard (*Chlamydotis undulata*), and Greater Short-toed Lark (*Calandrella brachydactyla*). Shrubs growing in sandy areas become the nestling places for Turkestan Ground-Jay (*Podoces panderi*), Great Grey Shrike (*Lanius pallidirostris*), and some Old World warblers (*Sylviidae*). Among the eurytopic birds we can name Little Owl (*Athene noctua*), Eurasian Eagle-Owl (*Bubo bubo*), Crested Lark (*Galerida cristata*), Isabelline Wheatear (*Oenanthe isabellina*), and Desert Finch (*Rhodospiza obsoleta*). Among the mammals the most typical stenotopic species connected with sand substrate are Piebald shrew (*Diplomesodon pulchellum*), Long-clawed Ground Squirrel (*Spermophilopsis leptodactylus*), several species of jerboa (Northern Three-toed

Jerboa *Dipus sagitta*, Comb-toed Jerboa *Paradipus ctenodactylus*, and others), Sand Cat (*Felis margarita*). You can also meet such stenotypes as Asiatic Wild Ass (*Equus hemionus*), jerboa (Thick-tailed Three-toed Jerboa *Stylodipus telum* and Blanford's Jerboa *Jaculus blanfordi*), and some other mammals, but their habitat is usually clay plains. Wolves (*Canis lupus*), foxes (*Vulpes vulpes*), Long-eared Hedgehogs (*Hemiechinus auritus*), and Desert Hares (*Lepus capensis*) are widespread and eurytopic in the Turkmen desert, they may also be found beyond its borders. In solonchak and stony deserts the composition of animal species is much poorer as their existence in such tough living conditions compared to sandy and clay areas is very hard. Therefore, in the deserts the overgrown sands may boast of the richer biodiversity. Somewhat inferior in this respect are clay deserts. And barkhan sands, stony and, in particular, solonchak sandy areas are most poor in organic life [3,4].

4 Mountains and Their Biodiversity

The mountains in Turkmenistan include ranges referring to the Turkmen–Khorasan system in the southwest of the country, piedmonts Parapamiz (Badhyz and Karabil) in the south and Koytendag or Kugitangtau Mountains, the outspurs of the Hissar Mountains in the far east. The mountains in Turkmenistan are low and medium height. All have no snow caps. They are affected by the desert landscape, thus, they do not have enormous water reserves. The maximum height of the Great Balkhan Mountains is 1,880 m (Mount Aplan), Badhyz – 1,267 m, Karabil – 984 m, Koytendag – 3,139 m, Kopetdag – 2,889 m (Mount Chopan in Turkmenistan), and 2,942 m (Mount Rizeh in Iran).

The main range in the Turkmen–Khorasan Mountains is Kopetdag making their northern part and ending in the northwest as small Kurendag Range and further on as Small and Great Balkhan Ranges separated from Kurendag with a sandy-clay plain. The Kopetdag Range is not high, but it is rather elongated stretching from northwest to southeast for 500 km and further beyond Turkmenistan, but near the borders of Iran and Afghanistan it passes into Parapamiz Range. Its piedmonts are made of two systems of smoothly rolling uplands: Badkhyz in the south of the Tedjen–Murghab interfluve and Karabil eastward of the Murghab River valley.

Kopetdag includes some parallel running ranges and plateaus (Garaul-Nokhur, Desht-Tuman plateaus, and others). It is intersected by numerous rocky gorges and deep valleys over which rivers, not so water abundant as plain rivers, flow. In the north Kopetdag neighbors on the piedmont plain (to 20 m and in some places to 40 m wide) sloping northward some areas of which are used for growing agricultural crops.

The Great Balkhans are the isolated mountains stretching from west to east for 35 km. In the west the Great Blakhans border on the Krasnovodsk Plateau, in the north and northeast – the Chilmammetkum sands, in the east – the western margins of the Karakums, and in the south they are separated with the solonchak-clay strip

Kelkor from not high Small Balkhan Ranges (779 m) belonging already to the Kopetdag Mountains. The Koytendag Ranges are rising quite apart from others on the Tukmen–Uzbek border; they are a part of the Pamir-Alay Mountains. The Koytendag is heavily cut with canyon-like gorges and has rather smooth slopes.

Vegetation cover in mountains of Turkmenistan varies from belt to belt, but there is no clear-cut difference between the belts. Above the altitude of 1,000 m Turkmen juniper (*Juniperus turcomanica* – in Kopetdag and Balkhans, *Juniperus zeravschanica* – in Koytendag) is widespread. The northern slopes of Kopetdag have no coniferous forests. The shrubs and trees are mostly found in moist mountain gorges. For the Badkhyz most typical are pistachio thin forests (*Pistacia vera*) and giant Ferula Badrakema (*Ferula badrakema*).

In the mountains the most widespread fauna is as follows: reptiles – Himalayan Agama (*Laudakia chernovi*), Turkestan Rock Agama (*Laudakia lehmanni*), Caucasian Agama (*Laudakia caucasia*), and Khorasan agama (*Laudakia erythrogastra*) as well as several species of *Eremias*; snakes – Eurasian Worm Snake (*Typhlops vermicularis*), Dahl's Whip Snake (*Coluber najadum*), and Striped Dwarf Racer (*Eirenis medus*). The Caucasian (*L. caucasia*) and Turkestan (*L. lehmanni*) agamas are stenotopic and live in the rocky and stony areas. Such species as Central Asian Cobra (*Naja oxiana*), Horsfield's Tortoise (*A. horsfieldii*), and Grey Monitor (*V. griseus*) are eurytopic and are met not only in mountains, but on plains, too. The most typical mountain birds are Lammergeier (*Gypaetus barbatus*), Caspian Snowcock (*Tetraogallus caspius*), Red-billed Chough (*Pyrrhocorax pyrrhocorax*), White-winged Grosbeak (*Mycerobas carnipes*), Eastern Rock Nuthatch (*Sitta tephronota*), Wallcreeper (*Tichodroma muraria*), Song Thrush (*Turdus philomelos*), Ring Ouzel (*Turdus torquatus*), and Rock Thrush (*Monticola saxatilis*). These species do not leave mountains. Thus, White-winged Grosbeak (*M. carnipes*) prefer living in juniper stands, while Wallcreeper (*T. muraria*) – on bare rocks and cliffs. In the mountains some other bird species may be found, for example, Eurasian Magpie (*Pica pica*), Golden Eagle (*Aquila chrysaetos*), Little Owl (*A. noctua*), Rock Dove (*Columba livia*), Chukar (*Alectoris chukar*), Common Quail (*Coturnix coturnix*), but they are eurytopic and may migrate deep into the plain. Out of mountain mammals there are Wild Goat (*Capra aegagrus*) and Markhor (*Capra falconeri*), Urial (*Ovis vignei*), Afghan pika (*Ochotona rufescens*) Treecreeper, Meadow vole (*Microtus* sp.), and rare Ural Field Mouse (*Sylvaemus uralensis*). Night bats prefer, in fact, living in mountains, but some species when the conditions are suitable live on the plains [3].

5 Oases and Their Biodiversity

Turkmenistan, like whole Central Asia, is a closed drainless area with very poor river network. Not high mountains are dry compared to other Central Asian mountain systems. Precipitations are greater in the mountains, than on the plains, but they are mostly absorbed by soft soils and lost to evaporation. Their smaller

amount flows down the mountain slopes or appears in the form of springs over the ground surface. Oases are connected with the river valleys where agriculture is developed.

All large rivers take their origin beyond the borders of the country. These are such transborder rivers as Amudarya, Murghab with tributaries Kushka and Kashan, Tedjen, Atrek with tributaries Chendyr, and Sumbar as well as small rivers flowing down the Kopetdag slopes and also the Koytendarya River in Koytendag. The Amudarya River 1,409 km long with only 799 km within Turkmenistan borders accounts for 90% of all surface water resources in the country. At the same time, the network of artificial canals and headers is well-developed, in particular in the zone of Karakum Canal (or Karakumdarya River, 1,380 km long) and Turkmendarya River (180 km) that take their feeding from the Amudarya River basin. The total length of irrigation canals is over 40 thousand kilometer, while of the collecting and drainage network – over 35 thousand kilometer. The surface waters of flat Turkmenistan, apart from rivers and canals, include artificial reservoirs (16 in total) and lakes. The Karakumdarya River valley and the dense network of artificial canals in the flat part of the country appeared in the past century as a result of irrigation construction.

The Murghab and Tedjen rivers formed blind deltas that at present are included into the collecting and drainage system of the Turkmen Lake of Altyn Asyr.

The rivers, except Karakumdarya, are not overgrown due to high water turbidity. But the lakes forming oxbows in river floodplains are overgrown heavily. The coastal aqueous vegetation in lakes is represented by Common Reed (*Phragmites australis*), some varieties of Cattail (*Typha* sp.) and Club-rush (*Scirpus* sp.) River valleys are characterized by quite specific wildlife. In fresh waters, mostly in Amudarya and Karakumdarya rivers, many fish species may be found, such as Catfish (*Silurus glanis*), Bream (*Abramis brama*), Common Carp (*Cyprinus carpio*), Turkestan barbel (*Barbus conocephalus*), Snakehead (*Channa argus*) (invader), Asp (*Aspius aspius taeiniatus*), as well as Bighead Carp (*Aristichthys nobilis*) and Grass Carp (*Ctenopharyngodon idella*) that were acclimatized here still 50 years ago; out of amphibian – Lake Frog (*Rana ridibunda*) and European Green Toad (*Bufo viridis*); out of reptiles – Caspian Turtle (*Mauremys caspica*) and Europeanpond Turtle (*Emys orbicularis*), Grass Snake (*Natrix natrix*), and Tessellated Water Snake (*Natrix tessellata*). The birds living in riparian tugai include Common Pheasant (*Phasianus colchicus*), Shikra (*Accipiter badius*), Stock Dove (*Columba oenas*), Turtle Dove (*Streptopelia turtur*), Common Cuckoo (*Cuculus canorus*), Pallid Scops Owl (*Otus brucei*), Common Nightingale (*Luscinia megarhynchos*), and some other small sparrow species. Water basins are the habitat for dubbling ducks, Common Coot (*Fulica atra*), Black-winged Stilt (*Himantopus himantopus*), Pratincoles (*Glareolidae*), *Stemidae*, and others. Among mammals there are found otters living in Tedjen, Murghab, Sumbara, and Etrek water areas. In the floodplains of the same rivers Wild Boars (*Sus scrofa*) may be met, while in sea waters – rare Caspian Seal (*Pusa caspica*).

Describing environmental conditions of biodiversity in oases we should mention such habitats as tugai in river valleys, cane thickets near lakes and reservoirs, and

anthropogenic landscapes. Tugai forests are represented by rather original and specialty tree and shrub communities. They include, first of all, two varieties of poplars – *Populus euphratica* and *Populus pruinosa* combined with Eastern Oleaster (*Elaeagnus orientalis*) and different varieties of Tamarisk (*Tamarix* sp.) interweaved with lianas. By now the tugai have been destroyed in many places and are used for growing agricultural crops. Some tugai areas survived only near the Amudarya and small areas near Murghab and Tedjen rivers [4].

Agricultural lands are used for cultivation of cotton, grain and fodder crops, vegetables, and melon crops. They are also occupied by orchards, vines, etc. The total area of agricultural lands in Turkmenistan is over 402 thousand square kilometer of which 385 thousand square kilometer are grazing lands, while 17 thousand square kilometer are irrigated lands. At the same time, the areas suitable for irrigation and drainage development in the future make about 177 thousand square kilometer [8]. The productivity of arid grazing lands used for free-range animal husbandry is low and depends greatly on the seasonal climatic conditions of a particular year or several years. Moreover, arid grazing lands are affected by deflation processes, in particular, in the technogenic zones during construction of roads and gas pipelines. In the agrarian sector the priority crops are wheat and cotton accounting for 49% and 42% of the sown areas, respectively.

The anthropogenic complex of species is being formed in the river valleys and oases with agricultural lands, residential buildings, and other structures needed by a man, in orchards and parks of settlements and cities, in field and road protective shelterbelts. Habitats appearing as a result of human activities in Turkmenistan tend to broaden. The classical example here may be the changes in the desert landscapes and habitats in the zone of the Karakumdarya that were observed after construction of this artificial waterway in the mid-twentieth century that led to formation of the intrazonal anthropogenic landscape along its route. We can name here the most typical representatives of the fauna found here: mammals – Common Pipistrelle (*Pipestrellus pipistrellus*), Short-tailed Bandicoot Rat (*Nesokia indica*), Gray Dwarf Hamster (*Cricetulus migratorius*), House Mouse (*Mus musculus*), Common jackal (*Canis aureus*); birds – Laughing Dove (*Streptopelia senegalensis*), Common Swift (*Apus apus*), Eurasian Hoopoe (*Upupa epops*), Common Myna (*Acridotheres tristis*), Common Blackbird (*Turdus merula*), Eurasian Tree Sparrow (*Passer montanus*), and others; reptiles – several species of gecko (*Gekkonidae*); amphibian – Lake Frog (*R. ridibunda*) and European Green Toad (*B. viridis*).

6 Ecosystems

On the territory of Turkmenistan the specific ecosystems were developed and exist corresponding to its division into the plain and mountain parts. On the plains the desert ecosystems mostly prevail, while in the mountains with the clear-cut altitudinal belts some specific ecosystems are found. Wetland and anthropogenic ecosystems occur mostly on plains and much less in mountains. Desert ecosystems presently cover 79% of the country's territory (without the Caspian offshore zone)

of which 73% are flat-desert ecosystems and 6% are piedmont-desert. Other ecosystems account for 2–9% of the territory. They are developed quite unevenly (Fig. 1) and their contours are usually not clear-cut; they have smooth transitional zones among them called ecotones.

Desert ecosystems. For the plains the most typical are sandy desert (overgrown and half-overgrown) ecosystems that compared to others possess more diverse plant and animal life, both as concerns the range of available species and their quantity. In this respect, the ecosystems of clay deserts take the second place, and there is an ecotone existing between these two types – sandy-clay deserts. The most poor are crushed-stone and solonchak ecosystems as well as the ecosystem of drifting barkhans. In addition to what was said above, we should stress their low productivity. The main limiting factors here are moisture deficit and high air temperatures. Due to water shortage the plants (main producers) grow sparsely and do not form closed stands. Their small leaves are adapted to save water, while thorns protect them from being eaten by animals as a source of moisture. As is known, the photosynthesis, breathing, and growth processes in life organisms go on quicker at temperatures from 20°C to 40°C, while the shade air temperatures in Turkmen deserts rise higher than 40°C, and soil may be heated to 70°C and more. Accordingly, the high temperatures do not only cause intensive evaporation, but also slow down the vital life processes.

From the mid-twentieth century, as a result of unceasing development of the plain and desert ecosystems their transformation has become practically irreversible. Disposal of great quantities of highly saline drainage waters into the depressions in desert led to waterlogging of arid lands, including grazing lands.

Mountain ecosystems. These ecosystems cover the south of the country and contribute to climate formation there, although they themselves are affected by the nearby desert plains. The main specific feature with these ecosystems is their high biodiversity compared to plains which may be attributed to their vertical zoning and varying environmental conditions on slopes of different exposure. The wildlife here comprises many endemics characterized by small areas of extension. For example, in Kopetdag possessing 1,700 plant varieties the endemics account for 19.5% (332 varieties), and this is the highest percentage for mountain regions of Central Asia. Mountain ecosystems of Turkmenistan, in particular in Southwestern Kopetdag, reveal low stability to the economic use regime, including recreation. Thus, overgrazing may lead to soil erosion and formation of landslides. The soil cover may also degrade as a result of plowing of slopes, destruction of the tree and shrub vegetation. The mountain ecosystems in Turkmenistan are believed to be the depository of biodiversity and, to some extent, of fresh water. However, they are not connected, in fact, with the wetland ecosystems of plains. Mountain ecosystems (in Southwestern Kopetdag) belong to one of the centers of cultural plant origin. These ecosystems require milder regime of use, in particular in the zones of their use for recreation purposes, as development of tourism may bring irreversible changes in them [8]. The living conditions for wild animals in mountains are more diverse, therefore, these ecosystems are more abundant than in deserts. The life in mountain ecosystems dictates certain requirements to components of biodiversity, but they are less tough than in desert ecosystems [3].

Wetland ecosystems. Wetlands ecosystems of Turkmenistan are divided [9] into coastal–marine and valley–oasis ones which, in their turn, are broken down into lacustrine, river, tugai, and oasis ecosystems, i.e., the excessively wetted territories of the natural and anthropogenic origin. At the same time, a rather unique "mosaic" of wetland ecosystems may be found on plains of Turkmenistan.

In the offshore zone with depths to 200 m in the Turkmen sector of the Caspian Sea we can identify the coastal–marine ecosystem making an integral part of the single ecosystem of the Caspian Sea. This synergism is supported by active horizontal and vertical water circulation and migration of fish and seals over the whole water area of the sea. The most vivid example of synergism of this ecosystem is its reaction to invasion of Sea Walnut (*Mnemiopsis leidyi*). This species hibernates in the south, near the Iranian coast, while in summer with the currents it has enough time to expand over the whole water area as far as the offshore area. The ecosystem of the Caspian Sea, regardless of its integral nature, consists of several subordinated ecosystems. One of the main dividing factors is the bottom relief, the so-called sills, controlling the rate of water exchange: inside each part of the sea it is greater than among nearby parts. The top level in the ecological hierarchy is taken by the sea ecosystem in general, that is followed by the ecosystems of the Northern, Middle, and Southern Caspian, still lower levels are taken by the subordinated ecosystems. The greatest diversity can be found in the offshore ecosystems among which the upwelling ecosystem may be distinguished near the eastern coast of Middle Caspian [10] to which the Turkmen sector of the sea belongs.

Disturbance and development of the coastal–marine ecosystem in disregard of environmental requirements and expertise lead to pollution of water and coastal ecosystems, reduction of biodiversity, and deterioration of the social and economic conditions. At the same time, the Turkmen sector of the Caspian Sea is considered to be the purest, and this is the result of the targeted efforts on protection of the natural environment.

Out of all components of biodiversity in the coastal–marine ecosystem the wetland birds are directly linked with the mainland water bodies and in the future with Turkmen Lake of Altyn Asyr because the river and, in particular, large lake ecosystems are the places of concentration of water fowl on their transcontinental migration routes (Afro-Eurasian and Central Asian), while the Turkmen Caspian and inland water bodies being wetland ecosystems are the environmentally favorable places for passage and hibernation of these birds.

River and lake ecosystems (including reservoirs as artificial lakes). The whole diversity of river ecosystems may be grouped into three main types of habitat: open shallow water areas, cane thickets and, in particular, tugai.

Tugai (fringe woodlands) is a specialty relict type of the ecosystem – the floodplain tree-shrub and grass communities developed in floodplains of rivers in Central and Western Asia. The tugai ecosystem includes two types of vegetation – tugai and cane where hygrophytes (*P. australis*, *Typha* sp., *Scirpus* sp., and *Carex* sp.) are growing on meadow and meadow-alluvial soils. Perennial thickets of cane form plavni in some places. The critical condition of the tugai ecosystems in river valleys in Turkmenistan (except the Amudarya nature reserve) as in the whole Central Asian region requires their comprehensive and transboundary monitoring and

protection [11]. The fertilizers applied amply and washed from fields, animal husbandry wastes and sewage waters produce their negative effect on river ecosystems of Turkmenistan.

Lake ecosystems are confined mostly to river floodplains. But such lakes (and their floodplains) may be also formed as a result of water discharge from irrigation systems and their existence depends on the scale and condition of land irrigation. In the past century artificial lakes – reservoirs were constructed in Turkmenistan for seasonal flow regulation. We should also mention here that the waterlogged areas in the river valleys and near-oasis zone as due to drainage of irrigated lands and disposal of wastewaters beyond the borders of oases some desert ecosystems got transformed into the lakes. Small water basins filled with brackish waters in which salinity grows with every passing year have appeared. Unfortunately, this leads to soil salinization and formation of small solonchaks. Diversion of saline waters beyond irrigated zones is the fact as well as the actions on wastewater desalination and its utilization. The water levels in Turkmen lakes are subject to significant seasonal and annual variations and this depends on climatic conditions in a particular year and the rate of silt deposition, in particular, in reservoirs. Water level fluctuations in lakes change the water salinity in them. On desert plains some small lakes and their floodplains exist only intermittently: in spring during rainfalls they get filled with water and in summer they dry out turning into solonchaks with the surface salt crust.

We should stress here the great significance of the wetland ecosystems for a man. They accumulate and store fresh water that is cleaned of pollutants there. The wetlands are the habitat of many plants and animals, including those put on the Red Book of Turkmenistan (2011). These ecosystems are required for the life of local communities and provide possibilities for tourism development. However, excessive pollution affects the ecological equilibrium and is able to interfere with the capacity of water bodies for self-purification.

Among the natural valley–oasis ecosystems that suffered from intense anthropogenic transformation there is the Amudarya delta the southwestern part of which is located in Turkmenistan. As is known, in the past 50 years due to uncontrolled use of water resources for irrigation of agricultural lands, the average river flow into the Aral Sea (initially 56 cubic kilometer a year) was reduced to more than tenfold. And the grave disturbance of ecosystems and the major ecological disaster in the Central Asian region led to drying out of the Aral Sea with all consequences for the natural environment.

Against the deficit of water resources, climate aridization, drop of the water level in the Aral Sea, and significant water level fluctuations in the Caspian Sea the wetland ecosystems in Turkmenistan face also potential anthropogenic threats, both direct and indirect. The direct threats include actions resulting in the reduction of biodiversity and, in general, degradation of ecosystems, such as destruction of tugai, overgrazing, poaching. The indirect threats produce their negative effects through pollution from drainage waters, industrial (the Caspian is also polluted with oil and oil products) and municipal and domestic wastewaters. As a result, we have salinization, deflation, and desertification of the wetland ecosystems being combined with ineffective systems of irrigation and land use and transborder “misuse”

of river flows. This gives rise to reduction of areas, still greater degradation of wetland ecosystems leading to loss of biological diversity [12].

Anthropogenic ecosystems. Anthropogenic ecosystems are believed to be secondary towards the natural ones. They have appeared on agricultural and urbanized territories. Their share accounts for over 9% of the Turkmenistan area. Beginning from the second half of the past century the irrigated lands in the country has increased multiply. On the virgin lands the new anthropogenic ecosystems – oases, such as Khauzkhan, Akhal, Shasenem, and others of smaller size were formed. These ecosystems are distinguished by their intrazonality and mosaic nature. In the oases one can find the attending and "interacting" elements of wild and cultural plants. Of course, the endeavor to maximize agricultural production reduces sharply the biodiversity, the animals and, in particular, plants are subject to artificial selection. In this context, the weed vegetation also plays an important role as concerns preservation of biodiversity and integrity of phytocenosis in the anthropogenic ecosystem. In the arid environment the existence of various components of biodiversity is impeded, thus, many species get adapted to the conditions of the anthropogenic ecosystem as they find them more optimal. Therefore, the fauna in such ecosystem represents an assembly, and the diversity, say, of birds, and their number here are higher than in nearby natural, in particular, desert ecosystems. This is most well visible in arid plains as irrigation and any other man's activities lead to complication of the structure of the ecosystem which, in its turn, attracts here the respective species of wild fauna, thus, increasing their population.

In conclusion it should be stressed that the structure and dynamics of biodiversity are dependent intimately on the condition of ecosystems and ecological, geographic, and climatic peculiarities. The ecosystems of Turkmenistan are strongly affected by negative anthropogenic factors, including transborder. The greatest changes are observed in the desert and wetland ecosystems that were affected by wide-scale development of lands with accompanying redistribution of water resources. This in full measure may be referred to the whole Central Asian region. This is why the project "Turkmen Lake Altyn Asyr" was included into the regional program of action on improving the ecological, social, and economic situation in the Aral Sea area for 2002–2010 [13]. The natural ecosystems have the invaluable importance to support the life of the growing population of the country. In view of restricted possibilities for extending the cultivated lands and water shortage and in view of fragility of desert and mountain ecosystems, the greater attention should be focused on their study and monitoring until the well-balanced evaluation of their economic use is obtained.

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