

## 1.2. Biological Diversity of Tajikistan

Geographical location of Tajikistan in the southern arid zone and high mountain systems among continental deserts of Eurasia, a combination of latitude zonation and vertical belts from hot deserts and subtropics to permafrost natural complexes, and genetic merging botanical and geographical zones conditioned the rich landscape biological diversity.

The sustainable conservation of biodiversity provides a harmonic development of the society and nature, particularly in countries with transitional economy, which Tajikistan belongs to. This is associated with the formation of a considerable part of the national income due to the use of biological resources (forests, pastures, agriculture).

The mountain landscapes of Tajikistan contain 0.66% of the world animal and 1.8% - plant diversity, including wild relatives of domestic animals and cultivated plants.

Tajikistan has rich genetic resources of species which are a potential source of raising high-productive and resistant cultivated varieties, admoment plants, and medicinal, aromatic, and industrial raw material. One of the world centers of cultivated plant origin is located here. Gathering medicinal and food plants, and fruit in mountain forests, hunting and fishing promote improving the welfare of the Tajik people.

The richness of biodiversity (table 1.1) is observed at the genetic, species, population, biocoenosis, and ecosystem levels; there are many relict and endemic species. Most of the components are vulnerable to anthropogenic impacts.

The area of contemporary Tajikistan contains more than 9 thousand species of spore-bearing and flowering plants and over 13 thousand of animal species.

### Value of Biological Resources for the Population of Tajikistan

The local population traditionally uses wild nature products as raw materials in construction, utensils and dyers production, etc.

1090.7 thousand head of cattle, 2269.3 thousand sheep and goats, and 71.2 thousand horses are being raised due to the natural vegetation of pastures.

Local people gather wild berries – sea buckthorn (*Hippophae rhamnoides*), barberries (*Berberis*), currants (*Ribes*), raspberries (*Rubus odoratus*), hawthorn (*Crataegus*), etc., as well as mushrooms and dozens of medicinal plant species.

They gather nuts and stone fruits in naturally growing forests – walnut (*Juglans*), pistachio (*Pistacia*), almond (*Amygdalus*), wild apple (*Malus*), pear (*Pyrus*), plum (*Prunus*), cherry plum (*Prunus sogdiana*) etc.

Local people and specialized organizations store up medicinal plants.

Small part of the population is engaged in hunting and fishing.

The number of game mammals is estimated at 11 species, birds – 36, and fish – 20.

Fur-skins of red marmot (*Marmota caudata*), muskrat (*Ondatra zibethica*), fox (*Vulpes vulpes*), badger (*Meles meles*), wolf (*Canis lupus*), etc. are stored up.

International hunting is organized for the following animals: argali (*Ovis ammon*), Siberian ibex (*Capra sibirica*), urial (*Ovis vignei*), and Tajik markhur (*Capra falconeri*).

Game fishing in lakes and water reservoirs is inconsiderable (164 t). Most of fish and animals are caught by poachers.

Table 1.1. Main Components of Biodiversity

No.	Composition	Number
1.	Ecosystems	12 types
2.	Types of vegetation	20 types
3.	Flora	9 771 species
4.	Wild relatives of cultivated plants	1000 species
5.	Endemic plants	1132 species
6.	Plants, listed in the Red Data Book of Tajikistan	226 species
7.	Fauna	13531 species
8.	Endemic animals	800 species
9.	Animals, listed in the Red Data Book of Tajikistan	162 species
10.	Agricultural crops	500 varieties
11.	Domestic animals	30 breeds

### 1.2.1. Ecological Systems

Hard natural climatic and mountain-formation processes promoted favorable penetration of plant and animal species from neighboring botanical and geographical zones, hybridization, and appearance of new species. Numerous types of ecotopes, biocoenosis, and ecosystems, in contrast combination, were formed in this environment of a relatively small area. Later, as a result of the climate aridization, in a short period of time, the unique ecosystems appeared under the extreme conditions of development in restricted mountainous area with high anthropogenic load. Many natural ecosystems have a considerable anthropogenic impact, some are endangered to complete degradation; a threat to their ecological balance disturbance is growing.

Mountain ecosystems include: nival-glacier, high-mountain-desert, meadow-desert, forest, most of wetland, ruderal, and, sometimes, urban ecosystems.

More than 80% of natural watercourses of the country are located in high mountainous areas. The foothills contain a small part of meadow-steppe ecosystems, situated in the lower reaches of the Pyandj, Vakhsh, Kafirnigan, Zeravshan, and Syrdarya rivers. Relatively young ecosystems, with a small number of species, are formed in the artificial watercourses.

Agricultural, ruderal-degraded, and partly urban ecosystems occur in all mountain zones, except for nival.

The main species of valuable forest and meadow communities are accumulated in mid-high and high-mountain zones. The latter contain larger mammals, reptiles, and birds.

Table 1.2. Ecosystems of Tajikistan

Types	Subtypes
Nival glacier ecosystem	<ul style="list-style-type: none"> <li>• Glaciers and snowfields</li> <li>• Rocks and taluses with rare vegetation</li> </ul>
High-mountain desert ecosystem	<ul style="list-style-type: none"> <li>• Rare vegetation</li> <li>• Wormwood-teresken, steppe</li> <li>• Dwarf-shrub-steppe</li> </ul>
High-mountain meadow-steppe ecosystem	<ul style="list-style-type: none"> <li>• Forbs meadow steppe, thymes</li> <li>• Low-grass meadow, swamp</li> </ul>
Mid mountain conifer forest ecosystem	<ul style="list-style-type: none"> <li>• Various-shrub steppe and light forest</li> <li>• Forbs meadow-forest</li> </ul>
Mid mountain mesophyllic forest ecosystem	<ul style="list-style-type: none"> <li>• Broad-leaf forest</li> <li>• Flood-plain small-leaf forest</li> <li>• Light forest, foliage tree, mesophyllic shrub</li> </ul>
Mid mountain xerophytic light forest ecosystem	<ul style="list-style-type: none"> <li>• High-grass, shrub, pistachio</li> <li>• Forbs wormwood, almond</li> </ul>
Mid-low-mountain semisavanna (savannoide) ecosystem	<ul style="list-style-type: none"> <li>• High-grass</li> <li>• Forbs and shrub</li> <li>• Low-grass semisavanna</li> </ul>
Foothill semidesert and desert ecosystem	<ul style="list-style-type: none"> <li>• Low-grass, saltwort-wormwood</li> <li>• Sand, semi-woody, shrub</li> </ul>
Wetland ecosystem	<ul style="list-style-type: none"> <li>• Tugai</li> <li>• Meadow, swamp</li> <li>• Wetland</li> </ul>
Agroecosystem	<ul style="list-style-type: none"> <li>• Gardens, forest-plantations, personal plots</li> <li>• Rain-fed pastures</li> <li>• Irrigable pastures</li> </ul>
Urban ecosystem	<ul style="list-style-type: none"> <li>• Municipal</li> <li>• Industrial</li> </ul>
Ruderal-degraded ecosystem	<ul style="list-style-type: none"> <li>• Weed, ruderal</li> </ul>



**Nival glacier ecosystems**

Geographically, the ecosystems of Tajikistan are subdivided into mountain and foothill-plain ecosystems.

**Mountain ecosystems** occupy the altitudes from 600 to 7000 masl. This zone contains over 90% of mountain communities. Water resources are formed in mountain ecosystems; over 80% of biodiversity are accumulated here. Most of the areas are highly productive summer pastures.

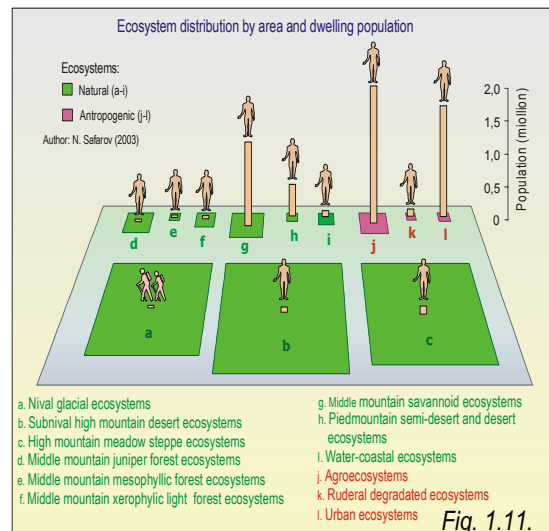
**Foothill-plain ecosystems** are located on the flat areas of mountain zones and include: foothill semidesert-desert, wetland, agricultural, urban, and ruderal-degraded ecosystems.

According to their use, ecosystems are subdivided into natural and anthropogenic (table 2.2). The interrelation of ecosystems dependent on the areas and the number of population is shown in table 1.3 and figures 1.11 and 1.12.

### Natural Ecosystems

A considerable part of the country possesses natural and relatively undisturbed ecosystems due to their isolation. Though some small fragments of ecosystems are observed at easily accessible places.

1. **Nival glacier ecosystems** occupy high-mountain landscapes of the country, considerable part of the Eastern and Western Pamirs. They are of great importance for climate formation and ecology at the regional and global level. The main water resources of Central Asian region are formed here. The cold glacial rocky landscapes of these ecosystems contain 16-17



**Fig. 1.11.**

**Table 1.3. Main Ecosystem Components**

Name of Ecosystem	Altitude above sea level	Area (m. ha)	Population (thousand)	Number	
				Animal species	Plant species
1. Nival glacier	above 4500	2.9	temporary (mountain-climbers, tourists) ca.1.9	180	16-17
2. High-mountain. desert	3500-4500	3.4	81.9	1100	650
3. High-mountain. meadow-steppe	3200-4000	3.15	150.0	2400	730
4. Mid-high mountain conifer forest	1100-3000	0.8	20.0	2900	1280
5. Mid-high mountain mesophyllic forest	1300-2400	0.2	50.0	3390	1700
6. Mid-high mountain xerophytic forest	1100-2000	0.58	20.0	5950	2400
7. Mid-low mountain semisavanna (savannoide)	600-1600	1.0	1443.0	4500	450
8. Foothill semidesert-desert	400-600	0.34	475.1	2000	520
9. Wetland	300-4200	0.50	90.0	4000	400
10. Agricultural	350-3000	0.85	2070.0	3000	900
11. Urban	400-2000	0.229	1700.0	2000	250
12. Ruderal-degraded	600-2500	0.360	100.0	2000	70
<b>Total:</b>		<b>14.31</b>	<b>6201.9</b>		

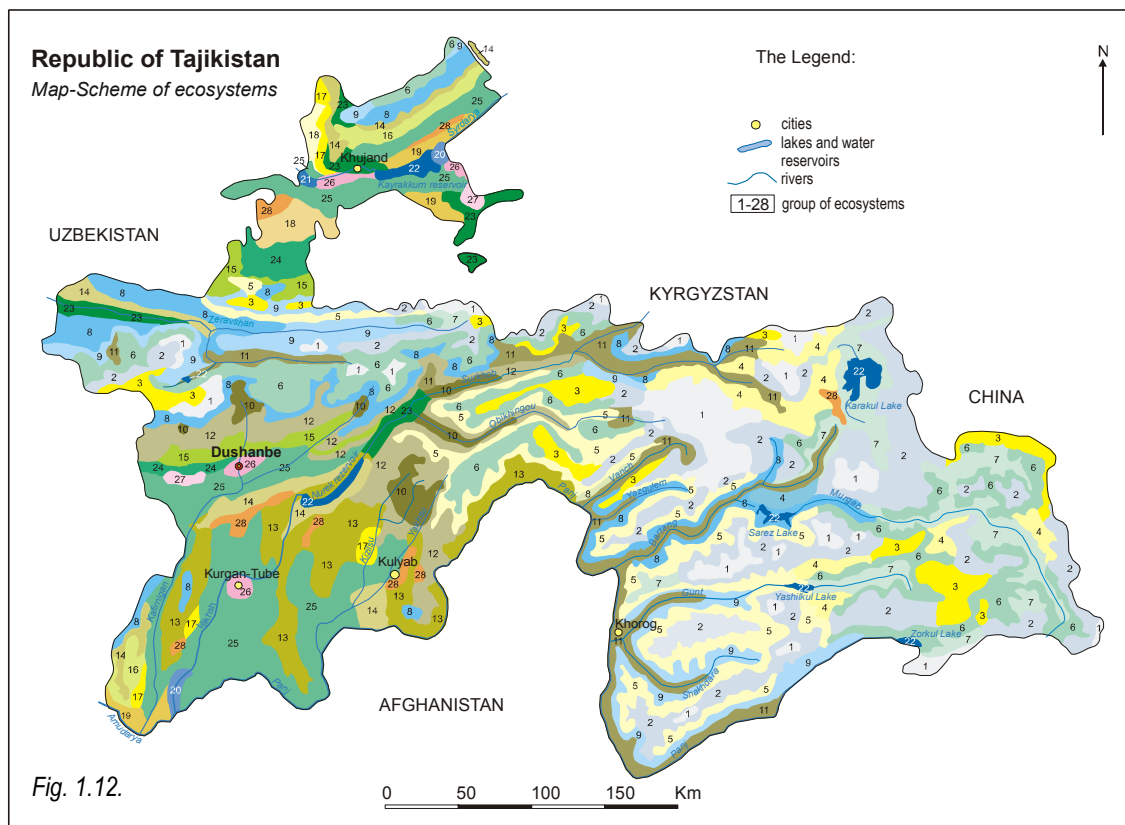


Fig. 1.12. Legend to Map-Scheme of ecosystems

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| <p><b>Nival Glacier Ecosystems</b></p> <ul style="list-style-type: none"> <li>1 Glaciers and snowfields</li> <li>2 Rocks and taluses with rare vegetation</li> </ul> <p><b>High Mountain Desert Ecosystems</b></p> <ul style="list-style-type: none"> <li>3 Rare vegetation</li> <li>4 Wormwood-teresken, steppe</li> <li>5 Dwarf-shrub-steppe</li> </ul> <p><b>High Mountain Meadow and Steppe Ecosystems</b></p> <ul style="list-style-type: none"> <li>6 Forbs meadow steppe, thymes</li> <li>7 Low-grass meadow, swamp</li> </ul> <p><b>Mid-Mountain Conifer Forest Ecosystems</b></p> <ul style="list-style-type: none"> <li>8 Various-shrub steppe and light forest</li> <li>9 Forbs meadow-forest</li> </ul> <p><b>Mid-Mountain Mesophyllic Forest Ecosystems</b></p> <ul style="list-style-type: none"> <li>10 Broad-leaf forest</li> <li>11 Flood-plain small-leaf forest</li> <li>12 Light forest, foliage tree, mesophyllic shrub</li> </ul> <p><b>Mid-Mountain Xerophytic Light Forest Ecosystems</b></p> <ul style="list-style-type: none"> <li>13 High-grass, shrub, pistachio</li> <li>14 Forbs wormwood, almond</li> </ul> | <p><b>Mid-Low-mountain Semisavanna (savannoide) Ecosystems</b></p> <ul style="list-style-type: none"> <li>15 High-grass</li> <li>16 Forbs and shrub</li> <li>17 Low-grass semisavanna</li> </ul> <p><b>Foothill Semidesert and Desert Ecosystems</b></p> <ul style="list-style-type: none"> <li>18 Low-grass, saltwort-wormwood</li> <li>19 Sand, semi-woody, shrub</li> </ul> <p><b>Wetland Ecosystems</b></p> <ul style="list-style-type: none"> <li>20 Tugai</li> <li>21 Meadow, swamp</li> <li>22 Wetland</li> </ul> <p><b>Agroecosystems</b></p> <ul style="list-style-type: none"> <li>23 Gardens, forest-plantations, personal plots</li> <li>24 Rain-fed pastures</li> <li>25 Irrigable pastures</li> </ul> <p><b>Urban Ecosystems</b></p> <ul style="list-style-type: none"> <li>26 Municipal</li> <li>27 Industrial</li> </ul> <p><b>Ruderal-degraded Ecosystems</b></p> <ul style="list-style-type: none"> <li>28 Weed, ruderal</li> </ul> |
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species of flowering plants: ragged robin (*Melandrium apetalum*), whitlow grass (*Draba altaica*), milk vetch (*Astragalus nivalis*), *Saussurea glacialis*, etc. Rare and endangered large mammals listed in the Red Data Book – argali (*Ovis ammon polii*), snow leopard (*Uncia uncia*), and Siberian ibex (*Capra sibirica*) – are found at the lower boundaries of these ecosystems.

These are areas of world mountain-climbing, tourism and international hunting. The long-term tourist and mountain-climbing activity resulted in the area pollution with garbage producing a negative effect on the quality of water in the below rivers.

**2. High mountain desert ecosystems** occupy the vast areas of the Eastern and Western Pamirs; fragmentarily, they occur in the Zervashan River Valley. They are used for summer pasturing, tourism, and international hunting. Vegetation consists mostly of teresken (*Ceratoides Krascheninnikovia*), wormwoods (*Artemisia pamirica*, *A. Korshinskyi*), *Ajania tibetica*, feather-grasses (*Stipa glareosa*), *Oxytropis immerge*, *Acantholimon diaspenioides*, *A. pamiricum*. They sustain the ecological balance and are used as forage areas. The most valuable communities are wormwood-teresken and meadow-steppe. They include some endemic, rare, and endangered plants – Badakhshan dandelion (*Taraxacum badachschanicum*), Pamir desederia (*Desideria pamirica*), etc.

The main background animals are: argali (*Ovis ammon*), snow leopard (*Uncia uncia*), Siberian ibex (*Capra sibirica*), red marmot (*Marmota caudata*), and *Syrrhaptis tibetana*, as well as some nature embellishing butterflies: machaon (*Papilio machaon*), apollo (*Parnassius apollo*), and alexanor (*Papilio alexanor*).

As the anthropogenic impact on the vegetation and animal worlds is increasing, pastures are degrading, causing reduction of the areas



**High mountain desert ecosystems**



**High-mountain meadow-steppe ecosystems**

and populations of wild animals. In recent ten years, poaching alone caused a drop in numbers of argali and Siberian ibex by 50%.

The current measures on animal and plant conservation are low-efficient. Even the creation of the National Park, comprising nearly 40% of these ecosystems, cannot improve their condition.

**3. High-mountain meadow and steppe ecosystems** occur fragmentarily, sometimes as wide belts, in all mountain ranges of Tajikistan and are of great ecological importance. The great part of the ecosystems includes habitats of rare endemic mammals, birds, insects, and valuable vegetation communities. Grass productivity of meadow and meadow-steppe ecosystems is 5-6 times higher as compared to others. They make over 90% of summer pastures.

The main coenosis-forming species of this type of ecosystem are: fescue (*Festuca altaica*, *F. pamirica*), feather grass (*Stipa kirghisorum*), meadow grass (*Poa alpina*), sedge (*Carex melanantha*, *C. stenocarpa*), cobresia (*Cobresia stenocarpa*), *Oxytropis savellanica*, thyme (*Thymus seravshanicus*), etc. The most valuable communities include forbs meadow and steppe, and thyme swamp, most common in the high mountains of the Eastern and Western Pamirs. The forbs meadow-steppe and thyme ecosystems are typical for Central and Northwestern Tajikistan. In overgrazing areas, the ecosystems are strongly degraded (over 30% of the total area), the grass productivity being reduced from 20-25 to 10-12 centners per ha. Periodically, the communities lose the most valuable species, including at least 150 rare and endangered species. The animal world of these ecosystems includes: snow leopard (*Uncia uncia*), argali (*Ovis ammon polii*), red marmot (*Marmota caudata*),

*Syrrhaptes tibetana*, Siberian ibex (*Capra sibirica*), Tibetan snow partridge (*Tetrogallus tibetanus*), etc.

This type of ecosystems is an intermediate link between forest (low borders), subnival and nival ecosystems (top borders). Many communities of this type become secondary due to the anthropogenic impact.

**4. Mid-mountain conifer forest ecosystems** compose nearly 50% of the total forested areas of the country. They are common in northern Tajikistan, within the Kuramin, Turkestan, and Zeravshan ranges. In small fragments, they occur in Central, Southwestern Tajikistan, and in the Western Pamirs mountains. Juniper and light forests are important for regulating and conserving water resources, protecting slope soils, fortifying river banks, and preventing mudflows.

Juniper forests and light forests are represented by 4 species: *Juniperus seravschanica*, *J.turkestanica*, *J.semiglobosa* and *J.sibirica*, among which Zeravshan juniper (*J.seravschanica*), Turkestan j. (*J.turkestanica*), and semicircular j. (*J.semiglobosa*) are forest-forming species.

There are some rare and endangered animal species in the juniper forests: Tien Shanian brown bear (*Ursus arctos*), urial (*Ovis vignei bochariensis*), Tajik markhur (*Capra falconeri*), *Vipera lebetina*, and ring dove (*Columba palumbus*).

The most valuable communities are motley-shrub-steppe and forbs-meadow juniper forests.

The main juniper and light forest areas are annually reduced by 2-3%. Nearly 30% of their specific diversity is endangered.

The main reasons for worsening the state of juniper forests are:

- Intensive cuttings for a number of centuries;



Mid-mountain conifer forest ecosystems



Mid mountain mesophyllic forest ecosystems

- Complete absence of biotechnical measures;
- Lack of forest monitoring and treatment;
- Intensive uncontrolled cattle grazing;
- Slow growth of juniper forests;
- Lack of juniper nurseries.

**5. Mid-mountain mesophyllic forest ecosystems** are represented by maple-walnut and willow-poplar-birch forests with light forest mesophyllic shrubs. They are important for the socio-economic activity (gathering fruit and berries) and sustain the ecological balance. These forests contain a considerable number of rare endemic species of animals and plants. They are suitable for an optimal life and recreation zones. They are common all over the country, except for northern and southern Tajikistan.

The most valuable communities of these ecosystems – broad-leaf mesophyllic relict forests: walnut (*Juglans regia*) and maple (*Acer turkestanicum*) – are widespread in Central Tajikistan. Great areas of small-leaf forests – birch (*Betula tianschanica*) – occur in the Zeravshan River Valley, within the Karateghin Range, and in the Western Pamirs; mesophyllic shrubs are mainly observed in Central Tajikistan.

The most valuable walnut-maple forests are located in the Sarikhosor, Childukhtaron, and Dashti-Jum zakazniks. These forests include a



considerable number of rare and endangered species of flora and fauna. Among plants, there are: Victor's ungernia (*Ungernia Victoris*), magnificent ostrowskia (*Ostrowskia magnifica*), cousinia darvasica (*Cousinia darwasica*, *Cousinia leptocampyla*), Hissar iskandera (*Iskandera hissarica*), Yagnob feather grass (*Stipa jagnobica*); mammals: weasel (*Mustela pallida*, *M.n. heptneri*), Turkestan lynx (*Felis lynx*), snow leopard (*Uncia uncia*), urial (*Ovis vignei bochariensis*), Tien Shan brown bear (*Ursus arctos*), yellow porcupine (*Hystrix leucura*); birds: ring dove (*Columba palumbus*), pheasant (*Phasianus colchicus*), golden eagle (*Aquila chrysaetus*), and Egyptian vulture (*Neophron percnopterus*), etc..

The forest vegetation communities have a considerable number of wild relatives of fruits: apple (*Malus*), pear (*Pyrus*), cherry plum (*Prunus*), hawthorn (*Crataegus*), barberries (*Berberis*), and other species, which form a favorable environmental niche for large mammals, including rare and endangered species.

Forested areas are annually reduced, while no restoring work is carried out. Nearly 50% of flora and fauna species are endangered.

**6. Mid-mountain xerophytic light forest ecosystems** occupy vast areas of southern and western Tajikistan; small fragments occur in northern Tajikistan. They include: pistachio, forbs wormwood, almond. In dry hot regions, pistachio forest's function is to regulate water resources; they also are an optimal habitat for wild animals from arid zones. No natural restoration of pistachio forests occurs due to their intensive use as pastures and haylands. Vast areas (80%), earlier occupied by pistachio communities, are now overgrown with shrubs.

The animal world of this ecosystem type is much richer than that of others. Of large mammals, there are: Persian gazelle (*Gazella subgutturosa*), urial (*Ovis vignei bochariensis*), wolf (*Canis lupus*), fox (*Vulpes vulpes*); reptiles: Central Asian cobra (*Naja oxiana*), and steppe tortoise (*Testudo horsfieldi*).



**Mid-mountain xerophytic light forest ecosystems**



**Low-mountain savannoid ecosystems**

turosa), urial (*Ovis vignei bochariensis*), wolf (*Canis lupus*), fox (*Vulpes vulpes*); reptiles: Central Asian cobra (*Naja oxiana*), and steppe tortoise (*Testudo horsfieldi*).

This type of ecosystems contains wild relatives of barley (*Hordeum spontaneum*), vetch (*Vicia tenuifolia*), almond (*Amygdalus bucharica*), persimmon (*Diospyros lotus*), jujube (*Zizyphus jujuba*), pomegranate (*Punica granatum*), grapes (*Vitis vinifera*), etc. They become secondary communities due to intensive cuttings. Large areas of winter pastures, non-irrigable crops, and settlements, situated in these ecosystems, cause a reduction of xerophytic light forest areas.

In order to preserve and sustainably manage this type of ecosystems, cattle grazing in young pistachio forests has to be completely stopped, protected area should be created to preserve the unique high-altitude communities and rare endemic animals (urial, Tajik markhur, Persian gazelle, etc.).

**7. Mid-low mountain semisavanna (savannoid) ecosystems** are widespread in southern and northern Tajikistan. They develop under hot climatic conditions.

Here, a considerable part of animals and insects with summer aestivation period dwell. High-productive winter pastures and leguminous crops are common. Vast areas of these ecosystems (40-50%) have degraded pastures, thus became low-productive.

The main valuable communities of this type are high-grass and forbs-shrub communities. The dominant species are: barley (*Hordeum bulbosum*), meadow grass-sedge (*Poa bulbosa*, *Carex pachystylis*), ferule (*Ferula kokanica*, *F.kuhistanica*), Jerusalem sage (*Phlomis bucharica*), etc.

The animal world, except for insects, is presented by a small number of species with summer and winter aestivation periods. Background amphibians are: steppe tortoise (*Testudo horsfieldi*) and *Ophisaurus apodus*. Rare and endemic species are also found here : seese partridge (*Ammoperdix griseogularis*), white bustard (*Otis tarda*), skink (*Eumeces schneideri*), Persian gazelle (*Gazella subgutturosa*), Turkestan saker falcon (*Falco cherrug*), and golden eagle (*Aquila chrysaetus*).

Vast areas of these ecosystems (70%) are strongly degraded. The main reasons of the degradation are:

- Cutting trees and shrubs;
- Intensive ploughing of steep-slope areas;
- Frequent fires;
- Complete absence of crop and pasture rotation;
- Violation of the haymaking technology;
- Unregulated cattle grazing in fall and spring period.

**8. Foothill semidesert-desert ecosystems** occupy high terraces of the plains in the lower reaches of large rivers: Pyandj, Vakhsh, Kafirnigan, Syrdarya, and Zeravshan.

The major communities of this type are: saxaul, black saxaul, calligonums, and perennial saltwort thickets. They play an important role in protecting soils, preventing erosion, and providing winter pasturing. These ecosystems include 30-40% of the total winter pasture areas, most of which are degraded and cultivated for irrigable agricultural crops. One can find here endemic animal species of regional and global value, many of which are endangered.

The vegetation dominants are: saxaul (*Haloxylon persicum*), calligonum (*Calligonum litvinovii*), saltwort (*Salsola richteri*), wormwood



**Semidesert-desert ecosystems**



**Wetland ecosystems**

(*Artemisia tenuisecta*), harmel (*Hammada leptoclada*), sedge (*Carex physodes*), halostachys (*Halostachys belangeriana*), halocharis (*Halocharis hispida*).

The animal world of the ecosystems is represented by unique species which are adapted solely to open areas, with rare vegetation and hot and dry climate. Mammals are represented mainly by: Persian gazelle (*Gazella subgutturosa*), jakal (*Canis aureus*), big-eared hedgehog (*Paraechinus hynomelus*), and steppe cat (*Felis libyca*). Of reptiles, there are: steppe agama (*Agama sanguinolenta*), gray monitor lizard (*Varanus griseus*), shaft-snake (*Taphrometopon lineolatum*), and sand echis (*Echis carinatus*); of insects the xerophyllous species prevail.

In southern Tajikistan, nearly 30 thousand hectares of this ecosystem type are near-protected areas of the Tigrovaya Balka Reserve. Considerable areas of the sand-desert ecosystems are cultivated for cotton growing.

**9. Wetland ecosystems** include tugai (sometimes tugai forests), meadow-swamp (the river lower reaches), and wetland ecosystems.

They are very important for the preservation of the global ecological balance, particularly for regulating the numbers of waterfowls of Eurasia, as some waterfowls of the continent hibernate here. Due to the worsening state of the Aral Sea, numerous waterfowls (from the Amudarya River lower reaches), among which there are rare and relict species, have found "shelter" and new habitats in the tugai of the Tigrovaya Balka Reserve.

The watercourses of the southern landscapes of Tajikistan are the base of water game species development and provide sustainable reproduction of fish, fur-bearing animals, and birds.





**Tugai ecosystem**

In the presence of biomass, tugai ecosystems equal subtropical forests of South Asia.

The world intact tugai ecosystems have been preserved only in the Tigrovaya Balka Reserve. 645 plant species, over 70% of which are assigned solely to tugai, and nearly 30% are common of meadow-swamp and sand-desert ecosystems, are defined here.

The main vegetation dominants are: *Populus pruinosa*, elaeagnus (*Elaeagnus angustifolia*), desert thorn (*Lycium dasystemum*), macereed (*Typha angustifolia*), alang grass (*Imperata cylindrica*), bur reed (*Phragmites communis*), sugarcane (*Saccharum spontaneum*), Kashgar tamarisk (*Tamarix hispida*), black grass (*Juncus articulatus*), etc.

The animal world of the tugai is much richer than that of the sand-desert ecosystems. Many of the animals find shelter in the tugai, where the following bird species hibernate: white and gray herons (*Egretta alba*, *Ardea cinerea*), bittern (*Botaurus stellaris*), garganey teal (*Anas querquedula*), European teal (*A. crecea*), marsh harrier (*Circus aeruginosus*), mud hen (*Rallus aquaticus*), moor hen (*Gallinula chloropus*), pheasant (*Phasianus colchicus*), pygmy cormorant (*Phalacrocorax pugmeus*), great cormorant (*Ph. carbo*), serpent eagle (*Circaetus ferox*), etc. The background species of the tugai mammals are: jungle cat (*Felis cnaus*), jakal (*Canis aureus*), Bukhara Red deer (*Cervus elaphus*), etc.

The biodiversity specific composition of watercourses is usually variable. Mountain and high-mountain water reservoirs mainly contain the Arcto-alpine species of sedge (*Carex diandra*, *C. oliveri*, *C. stenocarpa*, *C. parva*), cobresia (*Cobresia pamiroalaica*, *C. capillifolia*, *C. persica*, *C. stenocarpa*), meadow grass (*Ranunculus songoricus*), primrose species (*Primula capitel-*

*lata*, *P. Kaufmanniana*, *P. algida*, *P. farinose*, etc.). The low-mountain and plain reservoirs are characterized by the presence of common horsetail (*Equisetum arvense*), macereed (*Typha angustifolia*), potamogeton (*Potamogeton crispus*), anagalis (*Anagalis arvensis*), sedge (*Carex orbicularis*), bur reed (*Phragmites communis*), and many others.

Nearly 330 species of higher plants inhabit water reservoirs of Tajikistan; 145 of these are typical solely of the mountain and high-mountain areas, others are water and wetland in the low-mountain and plain areas of the country.

The biodiversity of wetland ecosystems is very important for keeping the natural balance and improving the socio-economic situation in the country. The vegetation and animal organisms inhabiting the reservoirs form organic and mineral complexes. They promote water purification, regulate the mountain water regime, enrich both water and air with oxygen. Many wetland plants are used as haylands, pastures and forage for cattle, though the overgrowing of plain water areas with thick grass is harmful for some fish species raising.

Currently, the biodiversity of foothill wetland ecosystems is in the most critical state, as they are contaminated with a great volume of water flowing from irrigated lands.

### Anthropogenic Ecosystems

These ecosystems include agricultural, urban, and ruderal-degraded areas. Over 30% of the country area has been transformed into anthropogenic systems which meet the general needs of the population. Increasing the anthropogenic impact on the environment, without considering its capacity, is dangerous for the socio-economic development. It is particularly well observed in the mountain agricultural areas.

**10. Agroecosystems (agricultural ecosystems)** are located in all natural zones, from hot foothills (300 masl) to high-altitude deserts of the Eastern Pamirs (3000-3500 masl). The main varieties of agricultural crops, local species of wild relatives of cereals, leguminous, industrial, vegetation and melon, and forage plants (genetic resources) grow on unprotected areas.

In recent decade, the area of the agricultural ecosystems has been considerably increased, particularly due to the development



**Agroecosystems**

of rain-fed and irrigable lands, which, together with pastures, are estimated at slightly over 4 m. ha. 1550 varieties of fruits and berries, 463 – vegetable and melon, 46 – cereal, 39 – leguminous, 25 – industrial, 39 – forage, and about 1850 decorative crops are raised and adapted to local environment within wide range of soil and climatic conditions. Nearly 50% of the cultivated crops are local varieties. There are about 30 breeds of domestic animals.

Most vivacious example of conservation of the animals genetic pool is the extension of yaks habitats within mountainous Tajikistan.

Violation of the regulations of agricultural irrigational technologies and crop rotation results in annual destruction of soil fertile layer, salinization and swamping of some areas; this is primarily due to the destruction of soil-forming fauna and flora. Steep-sloped lands are prone to landslides.

**11. Urban ecosystems** comprise the cities of Dushanbe, Khudjand, Isfara, Kanibadam, Istravshan, Kulyab, Kurgan-Tybe, Tursunzade, large settlements, and industrial enterprises. They are located in the most vulnerable environ-



**Yaks herd in the Pamirs**

mental areas (forests, river banks, lakes, ponds, etc.). Here, the main structure of natural ecosystems is completely destroyed, the process being irreversible. The urban zone around the cities is being increased, new system of water supply, central heating, sanitary-purifying zones, and green plantations, which is to be maintained artificially, being created. The ecological load on the area unit is increasing annually, while measures on stabilization get more complicated. The majority of introduced species are found in urban ecosystems including cities (table 1.4).

**12. Ruderal-degraded ecosystems** occur in all zones of human activity, being particularly well observed in cattle breeding areas. Stable communities adapted to external impacts are formed locally in high-mountain pastures and in low-mountain areas.

On the pastures and sown areas, the most dangerous plants for people and animals are: colchicum (*Colchicum luteum*), *Thermopsis dolichocarpa*, *Trichodesma incanum*, heliotrope (*Heliotropium dasicarpum*), and some wormwood species (*Artemisia*). The main dominant communities of ruderal ecosystems are the representatives of compositae (*Compositae*), cereals (*Gramineae*), buckwheats (*Polygonaceae*), meadow grasses (*Ranunculaceae*), St. John's-worts (*Guttiferae*), and often labiates (*Labiatae*).

**Table 1.4. General Flora Composition in Urban Ecosystems**

Name	Total area (thousand ha)	Green zone (thousand ha)	Number of plant species		
			Total	Including introduced	Including local
Dushanbe	12.5	3.60	800	150	70
Khudjand	3.0	0.82	900	120	50
Kurgan-Tyube	3.4	0.96	500	40	35
Khorog	0.23	0.07	1200	50	20
Kulyab	0.27	0.77	600	70	40
Tursunzade	11.75	3.2	300	80	25
Istravshan	0.75	0.03	900	55	25
Isfara	8.35	2.8	1000	60	30