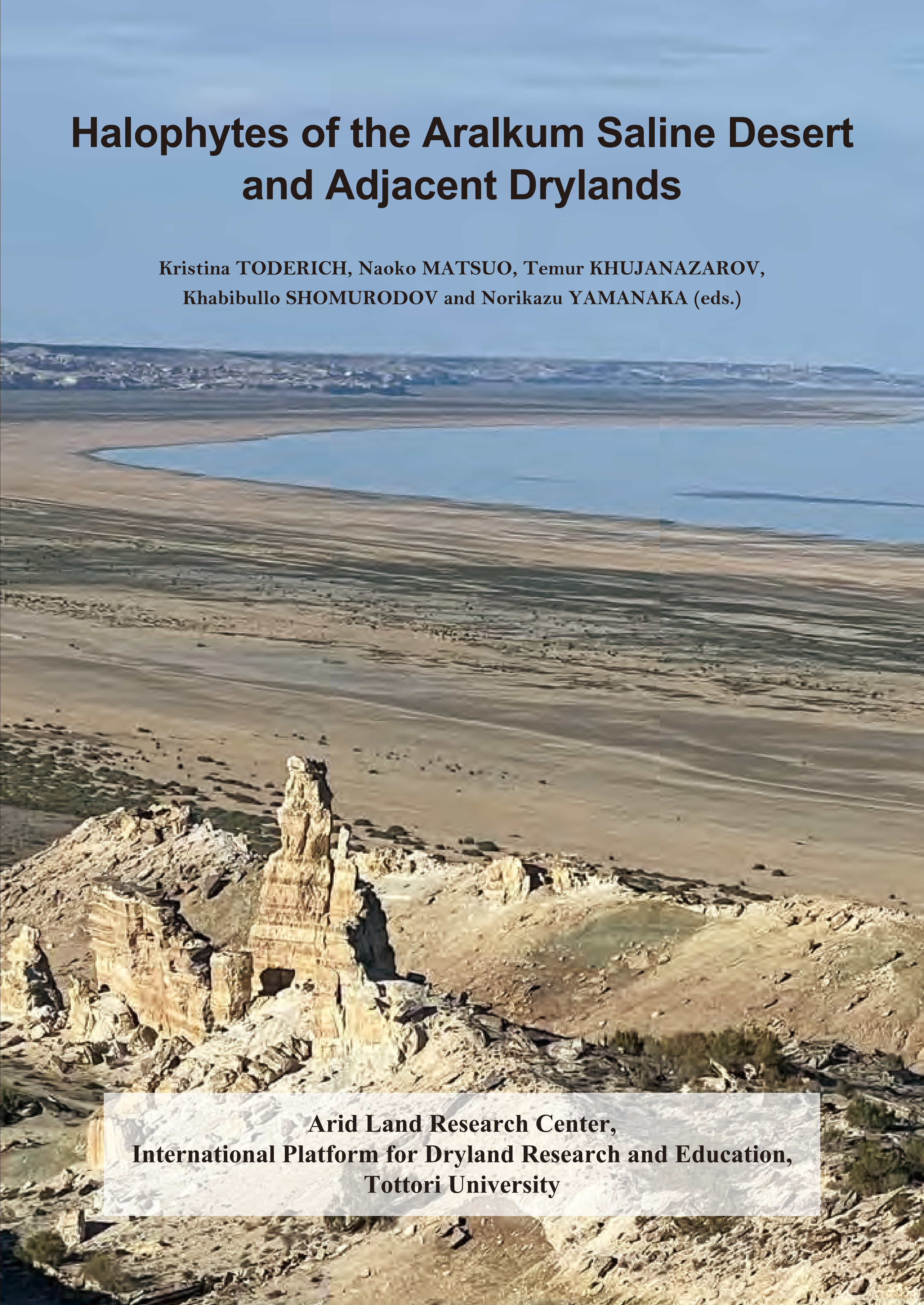
Halophytes of the Aralkum Saline Desert and Adjacent Drylands

Kristina TODERICH, Naoko MATSUO, Temur KHUJANAZAROV,
Khabibullo SHOMURODOV and Norikazu YAMANAKA (eds.)



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Cover photo: West side of the Aral Sea (NY)

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Salt pan of the Aral Sea (NY)

Preface

The near complete loss of the Aral Sea, widely considered as one of the worst human-caused ecological disasters on the planet, has created what is now referred to as the Aralkum Desert. The Central Asian Cold Desert that surrounds the Aralkum Desert is one of the world's biodiversity hotspots, providing unique habitats, breeding grounds, migratory corridors, and flyways for many rare and threatened species of flora and fauna, including wetlands in the deltas of the two main rivers (Amu Darya and Syr Darya). The Aralkum is the youngest desert in the world, and has highly unstable, salty, toxic soils with scarce plant cover. The formerly vast inland sea moderated the local climate, provided critical habitat for wildlife and abundant fish protein for humans. Combined with climate change, this loss has created a potent force in the further desertification of the region with profound negative effects to the surrounding ecosystems and the people who depend on them. It is projected that desertification will continue to expand in the region triggering further negative changes, especially those ecosystems in urgent need of conservation and protection. Many of these ecosystems are poorly understood and are in profound need of being studied and restored. This book seeks to close that gap.

The destruction of the Aral Sea has broad-reaching impacts in the regions people and environments. The lack of plant cover and moisture as well as the fine texture of the former sea bottom create the ideal conditions for severe dust storms. In the local human context, these dust storms have caused acute human health issues and have been reported to have killed herds of wild domestic ungulates. Ecologically, these dust storms pose a severe threat to ecosystem health and are pushing ecosystems in new and little-known directions with results that are negative to humanity and wildlife.

The once vast amounts of water in the Aral Sea formerly ameliorated the local climates temperatures and also provided moisture to surrounding environments. The climate is now substantially more severe and with climate change, the effects are magnified causing severe threats to biodiversity and the survival of people in the region. Humans have long interacted with the ecosystems of the greater region, and it is the center of origin for the many cultivated crops, including wheat, rye, barley, herbaceous legumes, seed-sown roots, and fruit trees. A further concern is the decline of the glaciers as well as the burgeoning human populations that further stress upstream areas of the rivers resulting in less water being transported to the Aralkum Desert region. Inappropriate agricultural techniques both local to the region upstream are triggering further habitat losses and the further salinization of soils. The ecosystems are also threatened by unsustainable firewood collection, poor grazing practices and the further converting land for agriculture. Salinization and water shortages are already putting millions of people's livelihoods at high risk, it is projected that these challenges will greatly worsen in the near future.

These factors are serving to severely disrupt the balance of these fragile ecosystems and result in the loss of wild native desert species. Such unsustainable use of biological resources has led to a sharp reduction in species populations, with some becoming endangered or going entirely extinct. One example is the fragmentarily preserved and endangered poplar forests in the Amu Darya delta. There is an urgent need for the preservation of the Central Asian cold desert with a focus on the new man-made Aralkum saline desert, one of the least protected biomes worldwide.

The Aralkum desert and its adjacent territories, as a part of the Central Asian Cold Desert are home to unique plant vegetation communities, and high botanical diversity values are undergoing transformation due to the above noted pressures. Its peculiar character is expressed in the fact that both relict and neo-vegetation formations for the Turanian lowlands are represented in this area. The native plant communities typical to mesophitic Central Asian deserts are preserved in the ecosystems surrounding the Aralkum desert, their current state is assessed as critical. Understanding these ecosystems is critical for their preservation and to support efforts to restore the Aralkum Desert with the suitable plant assemblages to create a biologically diverse novel ecosystem.

This Book describes on the phytogeography, floristic changes, current successional features of vegetation and botanical diversity of native halophytes (salt-loving plants) of the Aralkum saline desert from Uzbekistan side. More than 100 widespread and economically valuable species for key ecological groups of halophytes are described in this book including their botanic description, ecology, fodder properties, and utilization concerning other Iranian, Mediterranean, and North African arid and semiarid zones of the world.

The book also describes the scientific basis for domestication of economically valuable wild halophytes and restoration techniques (afforestation, agroforestry, alley cropping system, halophytic farming) of salt-affected biomes. Lessons learned from the conservation of transboundary desert corridors' wild vegetation would also be useful as an effective tool for streamlining agrobiodiversity conservation requirements into land-use planning and promoting biodiversity-friendly management practices in production landscapes, such as cultivated land, rangeland, and dryland forestry. This lays a concrete scientific foundation for new, more sustainable agricultural practices, which may be key for making both natural and human environments more resilient to the consequences of climate change.

It is hoped that the book will provide a valuable reference for dryland science researchers, botanists, rangeland managers, pastoralists, livestock breeders, seed collectors, farmers, householders, conservationists, forest, and extension officers, as well as national and international decision makers.

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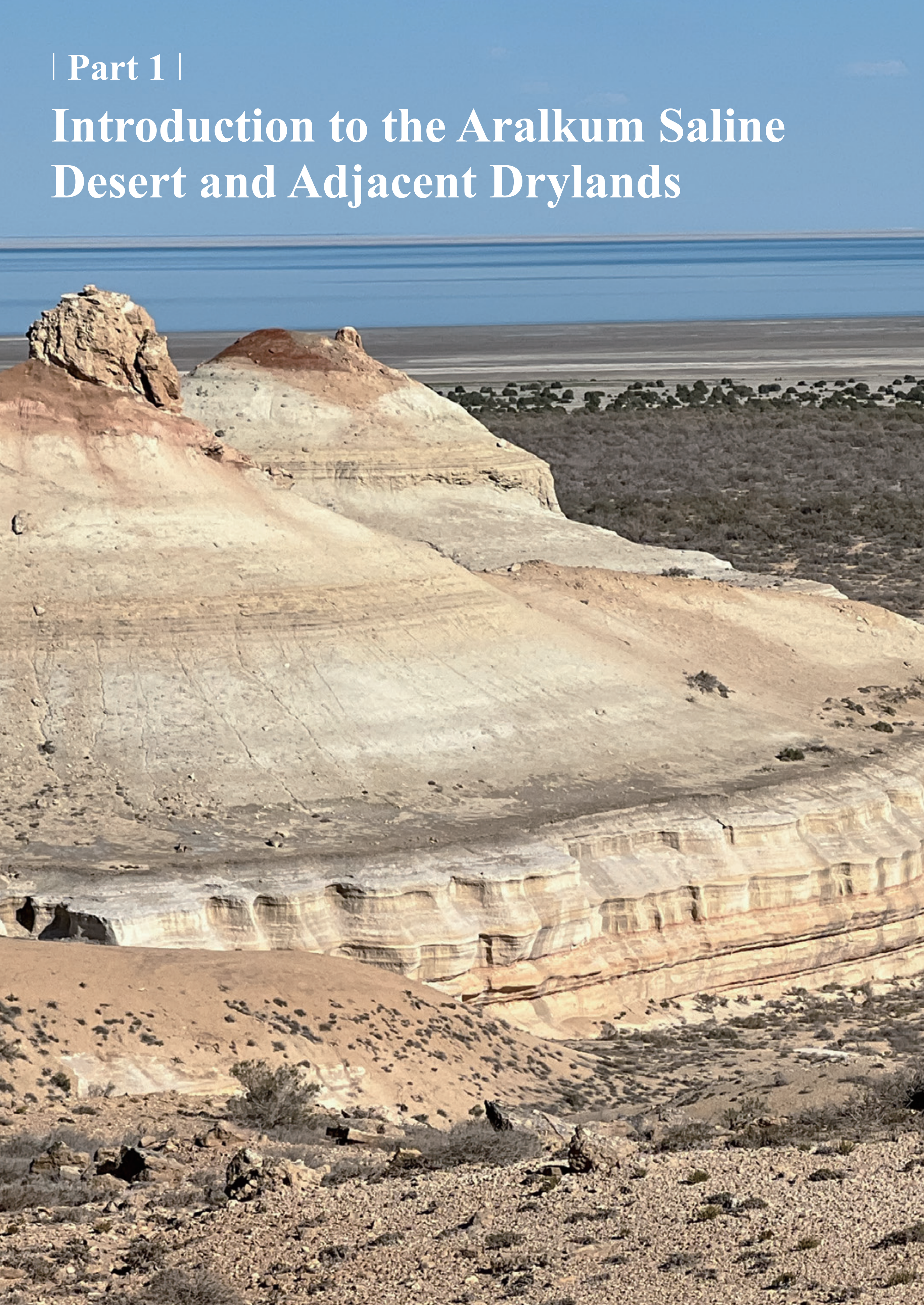
Kristina TODERICH and Norikazu YAMANAKA

| Part 1 |

Introduction to the Aralkum Saline Desert and Adjacent Drylands



Halophitic vegetation around the Aral Sea (NY)

1 History of the Aralkum Saline Desert

Kristina TODERICH

1-1. Root causes of drying up of the Aral Sea

The major part of Uzbekistan is occupied by the large Central Turanian Plain, which covers about 2/3 of the territory of Uzbekistan. It drains the waters of the Amu Darya and Syr Darya rivers into the Aral Sea depression, some 60-100 m below sea level. The Turanian Plain is open to the north, west and south and extends from the western Ustyurt Plateau to the emerging central Nurata Mountains, the foothills near Samarkand and Dzhizak. The Aral Sea Basin extends over the territories of 7 countries, namely the five Central Asian Countries (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan), partially in Afghanistan and Iran (*Fig.1-1*). Iran's part of the basin is very small. However, Afghanistan's portion is substantial and its contribution to the average annual flow of the Amu Darya is about 15%.

The Aral Sea itself, once the world's fourth-largest inland lake, has nearly disappeared. Under similar risks are the most saline desert lakes, such as Turkana (transboundary between Keniya and Ethiopia) and Lake Chad (Africa), Urmia Lake in Iran, Lake Balkhash (Kazakhstan), Lake Qinghai (China).

The shrinking of the Aral Sea was recognized' as one of the planet's worst environmental disasters' (first mentioned in 1990 in BBC News). Over the last decades the Aral Sea Basin countries have been in the top 10 list of water consumption per capita (Varis 2014). The state-controlled agriculture during the Soviet era demotivated the initiative of end users to invest in these categories of lands. The consequences of expanding irrigation lands in the basin now go far beyond the environment and has affected local economies and livelihoods of more than 40 million people.

The geological age of the Aral Sea is approximately 140 thousand years. According to the available data, the Aral Sea has suffered several transgressions during the Neogene, at least three times this water body was almost extinct. In the previous 6000 years, the amplitude of fluctuations in the water surface level was more than 20 meters (Pinkhasov 2000). In prehistoric times, these changes were associated with natural climate variations and migrations of the riverbed of the Amu Darya and Syr Darya. Since the formation of ancient civilizations in the basins of these river basins, irrigation had a significant impact on the level of the Aral Sea (Micklin 2010). The environmental situation in the region has been relatively stable before the 1950s. In the end of the 1950s, the Aral Sea had a water surface of 68 thousand km^2, maximum length of 428 km, maximum width of 284 km, water level of 53 m, and water volume of approximately 1093 km^3.

1-2. Shrinkage of the Aral Sea (chronological sequences)

Most accounts of the Aral Sea's late-20th-century shrinkage reference its 'starting' level in 1960, a crucial benchmark in its history. In the 1950s and 1960s, Soviet plans to boost cotton production in Central Asia led to a drastic increase in irrigation, causing the decline of the Aral Sea. A basic cost-benefit analysis at that time favored the economic gains from irrigated agriculture over the value of the Aral Sea, particularly its fishing industry. The ensuing decline of the Aral was anticipated and considered a positive economic outcome by the leadership in the Soviet Union. Local residents bore the cost of this

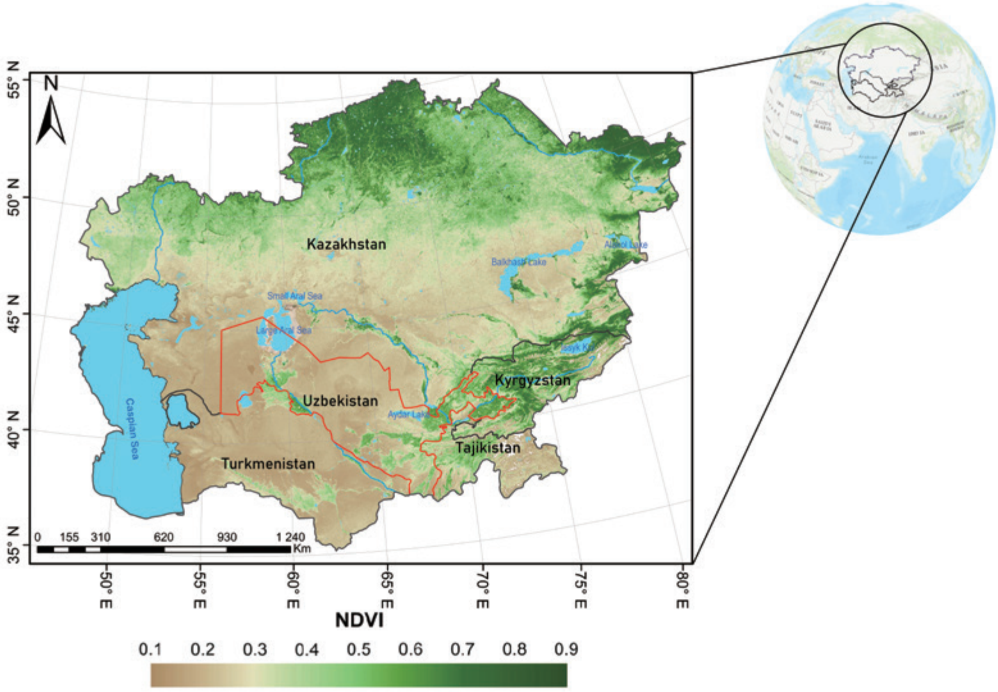


Fig.1-1 Geographical map of Central Asian countries

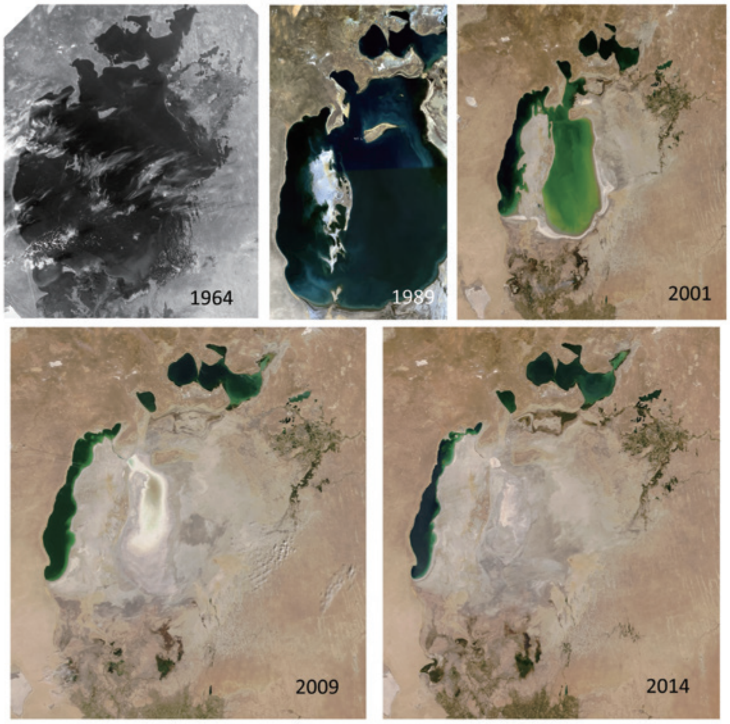


Fig.1-2 Chronological sequence of the Aral Sea shrinking (1964-2014)

(Source: MODIS Terra NASA, https://earthobservatory.nasa.gov/world-of-change/aral_sea.php, Reconnaissance Satellite NASA (https://earthobservatory.nasa.gov/images/77193/the-aral-sea-before-the-streams-ran-dry)) decision that had devastating effects on people's livelihoods and the local ecology (Micklin 1988, White 2014).

Series of images from the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite document these changes (***Fig.1-2***). In 1964 the Aral Sea was filled with water. In 1989, the water level dropped considerably. In 2001, the Aral Sea was divided into west and east, and the North Aral Sea (sometimes called the Small Aral Sea from the Kazakh side) was completely separated from the South Aral Sea. In 2014 east side of the lake completely disappeared.

The salinity of water has risen as the Aral Sea has shrunk, and around 2001 the salinity was almost three times that of the 1960s. Between 1960 and 1989, the area under cotton cultivation rose from 1.9 million hectares to 3.1 million hectares (Pomfret 2002). Such increases in sown area required more irrigation, more water diverted from the rivers, and ultimately less inflow into the Aral Sea. Irrigation canals were overwhelmingly unlined, resulting in massive seepages into the groundwater, effectively raising groundwater levels and increasing salinization.

During this period (less than for 30 years) the Aral Sea area shrank by 41 percent, its volume dropped by 67 percent, and the salinity of its water tripled (Micklin 2007). The Aral's once-thriving fishing industry was decimated, forcing the closure of processing facilities in Aralsk, Kazakhstan and Muynaq, Uzbekistan.

The large-scale irrigation infrastructure and complicated drainage systems using river water flowing into the Aral Sea have converted large territories of natural productive pastures and grasslands (Kazakh steppes) into irrigated farmlands. However, the amount of river water flowing into the Aral Sea has dropped dramatically due to intensive irrigation and monocultural cotton/wheat-based production systems. Due to river diversions the Sea water level in 1987-1989 fell enough to split it in two: the North Aral Sea and the South Aral.

The river waters of the Amu Darya and Syr Darya rivers have been used intensively for hydropower generation (in upper stream) and irrigation of agricultural lands (in the downstream). In addition, since 1985, the cycles of drought have been prolonged in the Aral Sea region, and almost no water has flowed into the lake from the two major rivers. Because of climate change, summers have become warmer, winter's cooler, spring frosts later, and fall frosts earlier (Kholmatdjanov et al. 2020). The growing season of the crops become shorter, and the humidity tends to decreased. Thus, the shrinking of the Aral Sea has progressed at a rapid pace in the last 45-50 years.

Desiccation intensity of the sea exceeds forecast rates. In 1986, the Aral Sea split into the Small Aral Sea in the north and the Great Aral Sea in the south; and in 2006, the Great Aral split into the deep narrow western part and shallow eastern part. Further diversion of water for irrigation and series of droughts drove the eastern part of the Aral Sea completely dry in 2014 for the first time in 600 years. Therefore, the Aral Sea no longer exists as a single water body. Desiccation of the Aral Sea resulted in the formation of a large salt desert covering nearly 50 thousand km², so called the Aralkum desert (***Fig.1-3***, ***Fig.1-4***).

The increased water withdrawal for irrigation reduced the inflow of water from the Amu Darya and the Sur Darya rivers to the Aral Sea by 90% compared to the middle of the 20 century levels.

Water levels fluctuated annually between 2001 and 2017 in alternately dry and wet years. The increasingly salty water was polluted with fertilizers and pesticides. The water quality of the in-flowing

Fig.1-3 A briny remnant of the Aral Sea (in the front) and saline new desert “Aralkum (back)” at about 180 km from Muynaq city (Karakalpakstan), 2017 (ES)

Fig.1-4 Puffy wet solonchaks without any vegetation (contemporary shrinkage coastal line of Aral sea from Lazerev island side, Karakalpakstan, June 2023 (NY)

Fig.1-5 Shrinkage of the Aral Sea continues. Salt marshes on the coast about 380 km from Muynaq city. (from the Ustyurt plateau side, Karakalpakstan), 2023 (NY)

water and the Aral Sea itself has drastically changed, and currently, is about the same as the Dead Sea in the Middle East.

During this period (less than for 30 years) the Aral's area shrank by 41 percent, its volume dropped by 67 percent, and the salinity of its water tripled (Micklin, 2010)(*Fig.1-5*). The Aral's once-thriving fishing industry was decimated, forcing the closure of processing facilities in Aralsk, Kazakhstan and Muynaq, Uzbekistan.

1-3. The Aralkum saline desert-a source of salts and dust storms

The Aralkum consists of sandy, saline soils and bare areas around the Aral Sea, covering an area of approximately 60000 km^2. Its area has increased from 40% in 2000 to 54% in 2008 (Low et al. 2013). The expansion of the Aral Sea desert has also contributed to local climate shifts towards hotter summer and colder winter (Gaybullaev et al. 2012). In the last few decades, the exposed dry bottom became the new "hotspot" of dust and salt storms (*Fig.1-6*). The Aral Sea contained an estimated 10 billion metric tons of salt with sodium chloride (56%), magnesium sulfate (26%), and calcium sulfate (15%). Aerosols are carried by wind over 150000 to 1500000 km^2 (Yamanaka and Toderich 2020). The frequency of dust and sand/salts storms varies in a wide range 5-146 days/year. The salty dust blows off the lakebed and settled onto fields, degrading the soil. Croplands must be flushed/leached with larger and larger volumes of fresh river water. Toxic salts and dust storms are dramatically affecting the health of animals and people there.

The altered land use and massive irrigation caused basin-wide soil and water salinization, desertification, poor quality drinking water and chronic health problems for the population. The aquatic ecosystem collapsed, destroying the fishery industry. As results the Aral Sea has turned into a vast salt-white barren land with beached boats serving as a striking image of what the future may hold. The gradual desiccation of the Aral Sea has caused the North Aral Sea (or the Small Aral Sea) to fragment into several parts. As part of Kazakhstan's efforts to save the northern parts of the Aral Sea, the Kok-Aral dike and dam were constructed in 2005, leading to a gradual replenishment. The southern part of the Aral Sea suffered the most from diminishing water inflow, with only 60 km^3 of water left.

1-4. Loss of biodiversity as consequences of shrinking of the Aral Sea

As the sea has shallowed and high salinized, biological productivity has steeply declined. By the early 1980s, 20 of 24 native fish species disappeared and the commercial catch (48000 metric tons in 1957) fell to zero in 90^{th}. Ongoing desertification processes and the shrinking of the Aral Sea have led to the drying up of a number of lakes in the delta of the rivers, especially in the delta of the Amu Darya, and the shrinking of the northern Aral Sea (*Fig.1-7*).

Wild animals and livestock raising has also suffered considerable damage because of a decline in fodder supply areas. Habitat deterioration has harmed delta fauna, which once included muskrat, wild boar, deer, jackal, many species of birds, and even a few tigers. At one time 173 animal species lived around the Aral, mainly in the deltas; 38 have survived to this day. Commercial hunting and trapping have largely disappeared.

Native plant communities of Tugai forest have degraded and disappeared; Hayfields and pastures decreased by 81% and yields fell by more than 50% ; many species of animals are endangered or extinct.

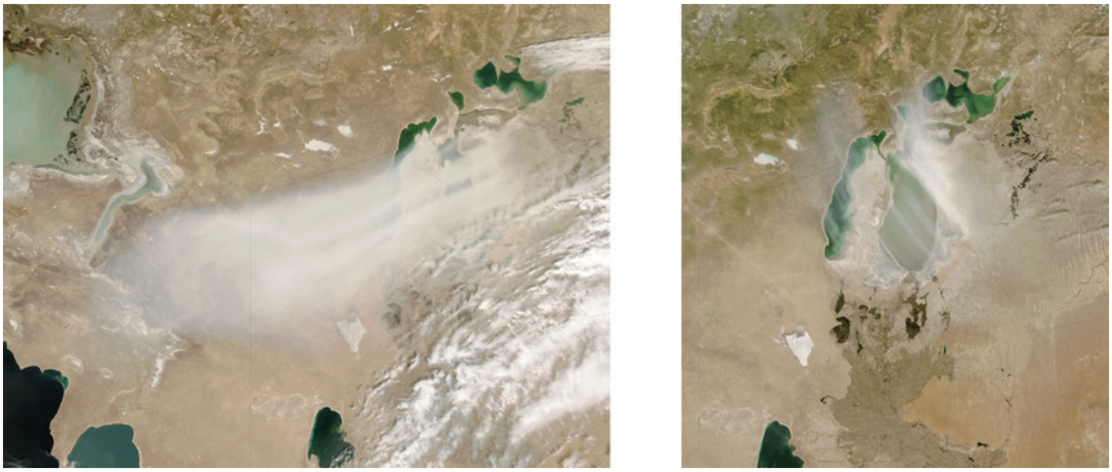


Fig.1-6 Dust and salt storms from the dry bottom of the Aral Sea (2018)

https://earthobservatory.nasa.gov/images/19853/dust-storm-over-the-aral-sea (Karakalpakstan, 2018)

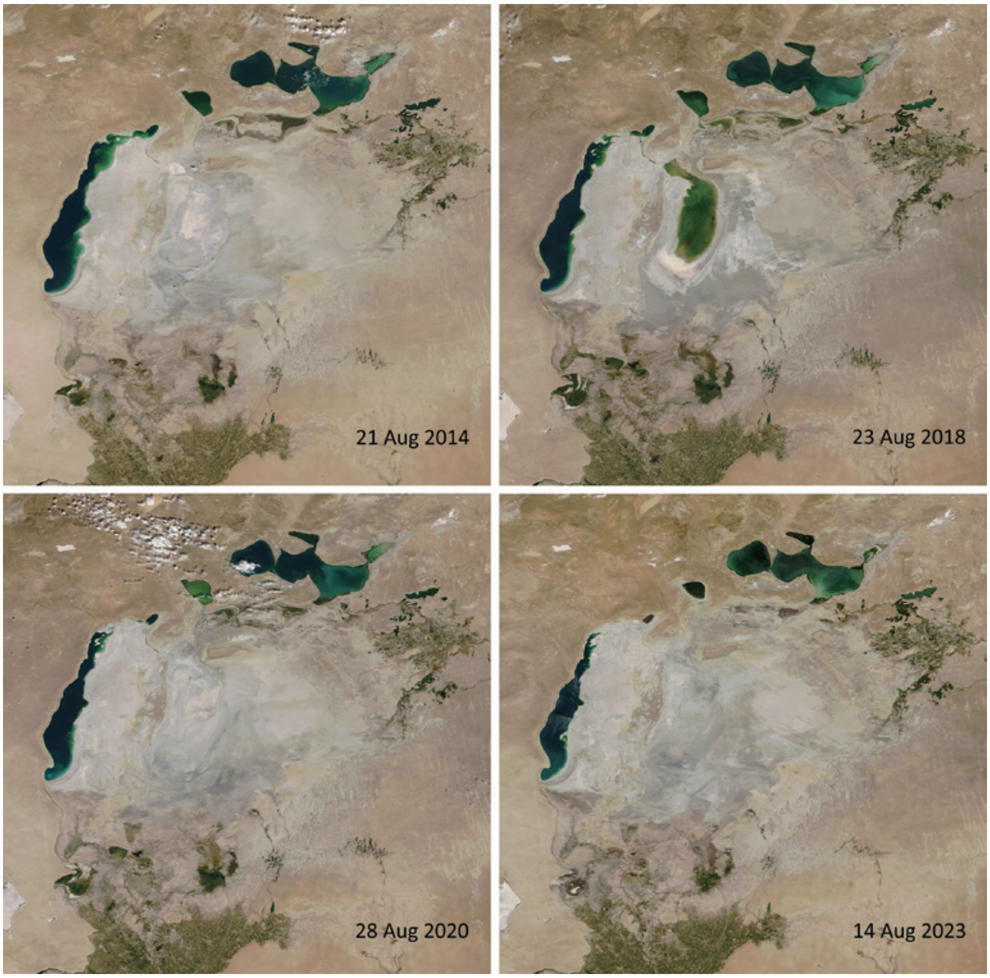


Fig.1-7 Changes of the Aralkum Saline Desert eco-landscape (2014-2023)

Source NASA, Terra MODIS (True Color)

1-5. Neo-Ecosystems of the Aralkum saline desert and landscape restoration

The uniqueness of the Aralkum saline desert and its adjacent territories is characterized primarily by the presence of relict types of vegetation here. These include a fragment of riparian forests of the Amu Darya delta - mixed shrub-turang communities (which are dominated by *Populus euphratica*, *Phragmites australis* and species of *Tamarix*), growing in the northwestern part of Lake Sarybas, Sudochie and others. The uniqueness of tugai vegetation is that the center of their origin is Central Asia, from where they moved to the desert regions of Jungaria and Kashgaria. Tugai is a special type of vegetation, which preserved the former features of tertiary flora of real savannas. The formation and development of Tugai type of vegetation and Tugai flora is associated with different cycles of development and functioning of the Tertiary Tethys Sea. Tugai forests as a relict vegetation in Uzbekistan fragmentarily preserved in small areas in the floodplains and deltas of the Amu Darya river.

Remains of old populations of *Salix turcomanica* is described only on the territory of the Lower Amu Darya State Biosphere Reserve, formerly the Baday-Tugai National Reserve.

Due to government support and conservation efforts, the North Aral Sea (from Kazakhstan side) is recovering, while the South Aral Sea, continues to decline. The flow from the Syr Darya river (in Kazakhstan) accumulates in the Small Aral; water level in the Small Aral reached 40-42 m. Water salinity reduced which allows breeding of some commercial species of fish. About 20 species of fish have been restored in the Small Aral Sea (***Fig.1-8***).

Since 1994 the International Fund for Saving Aral Sea (IFAS) - a joint committee to coordinate research and development has been established. On October 2018 with the support of 5 Central Asian countries the International Innovation Center for Aral Sea Basin (IICAS) was set up. The center is based in Nukus at the experimental station of the State Committee on Forestry in Karakalpakstan (an autonomous republic within Uzbekistan) (***Fig.1-9***).

The Multi-Partner Human Security Trust Fund for the Aral Sea Region supported by United Nation is attracting foreign investments and innovations aimed at restoring the saline dry bottom of the Aral Sea, to improve the ecosystem services and livelihoods of millions of people(***Fig.1-10***, ***Fig.1-11***, ***Fig.1-12***). Some initiatives have been taken by Uzbekistan through the establishment of the Multi-Partner Human Security Trust-Fund for the Aral Sea region (MPHSTF) in 2017 under the auspices of the United Nations to reverse the desiccation trend.

Fig.1-8 Workers of Kamystybas fish nursery reintroduced and bred multiple species of fish, Northern Small Aral Sea. Syr Darya River Basin Kazakhstan, 2018 (KS)

Fig.1-9 Preserved wetlands at Jiltarbus Lake in the delta of Amu Darya river (KT)

Fig.1-10 Salt accumulation on the dry bottom of the Aral Sea. Before planting, (NY)

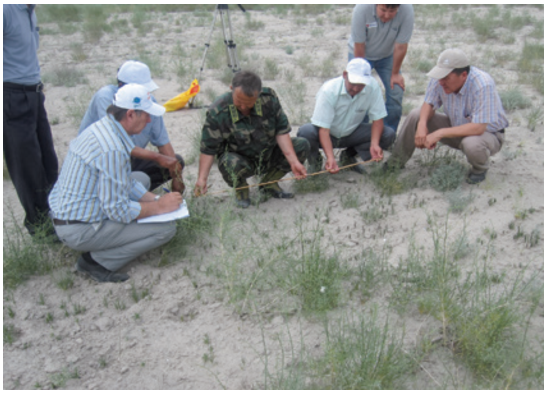


Fig.1-11 Preparation for rangelands restoration measure, (TR)

Fig.1-12. Afforestation initiative on restoring saline landscape of the dry bottom of the Aral Sea by planting black saxaul (*Haloxylon ammodendron*), as about 280 km from Muynaq, Karakalpakstan. Self-regeneration of young saxaul thanks to seeds dispersion by wind guarantees maintenance of productivity of tree plantation for 20-25 years, 2023 (NY)

2 Topography, Climate and Water Resources

Temur KHUJANAZAROV, Bakhtyar KHOLMATJANOV, Bakhriddin NISHONOV and Kenji TANAKA

2-1. Introduction

Uzbekistan with an area of 448978 km^2 (37°13′-45°36′ N, 56°00′-73°10′ E) located within the Irano-Turannian lowlands of the Central Asian region is a double landlocked country that is extremely diverse in physical and geographical conditions. It borders Kazakhstan in the north, Kyrgyzstan in the East, Tajikistan and Kyrgyzstan in the southeast, Afghanistan in the south, and Turkmenistan in the southwest. The central and north-west side of the country is arid and semi-arid plains (78.8%) with mountains (21.2%) from the south, southeast, and east (UNFCCC 1999). The climate in Uzbekistan is defined by the geographical location (the center of the Eurasian continent), topography, and the influence of various climatic systems through orography (***Fig.2-1***).

Due to its geographical features, Uzbekistan's west and northern territories are open to cold invasions, reinforcing continental features such as hot summers and cold winters, sometimes mixed with invasions of moist air from the Atlantic Ocean. The south part of the country is encircled by mountainous systems of the Himalayas, the Hindu Kush, the Pamir, and the Tien Shan, limiting access of moisture influx from the Indian Ocean, the closest moisture reservoir. Based on the geographical features of the landscapes it can be divided into western - deserted plain areas and eastern - mountainous areas, with irrigated valleys along the rivers (Sadykov et al. 1975).

The arid and semi-arid landscapes of this Central Asian country receive limited rainfall, which defines its climatic characteristics, water resources, agriculture, and overall ecosystem. With an annual average rainfall ranging from 100 to 200 mm in the plains and up to 600-900 mm in the mountain slopes, the nation experiences limited moisture influx, primarily during the winter and spring months (Kholmatjanov et al. 2020). This scarcity of natural moisture significantly impacts the country's ecosystems, agriculture, and overall water management strategies. The arid and semi-arid plains, which make up a substantial portion of the landscape, experience long, hot summers and cold winters, while the mountainous regions exhibit variations in temperature, often influenced by their elevation, relief, and slope direction.

The region's agriculture is particularly water-intensive, and the need for irrigation is substantial. Limited precipitation with high evapotranspiration rates requires large amounts of water for irrigation from its major rivers, the Amu Darya, the Syr Darya, and the Zaravshan for its water supply to sustain its critical agricultural sector. However, these rivers originate outside the country, mainly in Kyrgyzstan and Tajikistan, making Uzbekistan dependent on its upstream neighbors for water.

This reliance on transboundary water sources has brought both opportunities and challenges, central among them being the significant changes in water usage patterns that occurred following irrigation expansion in the 1950s and 1960s, which ultimately led to the ecological disaster of the Aral Sea's desiccation (Micklin 2010).

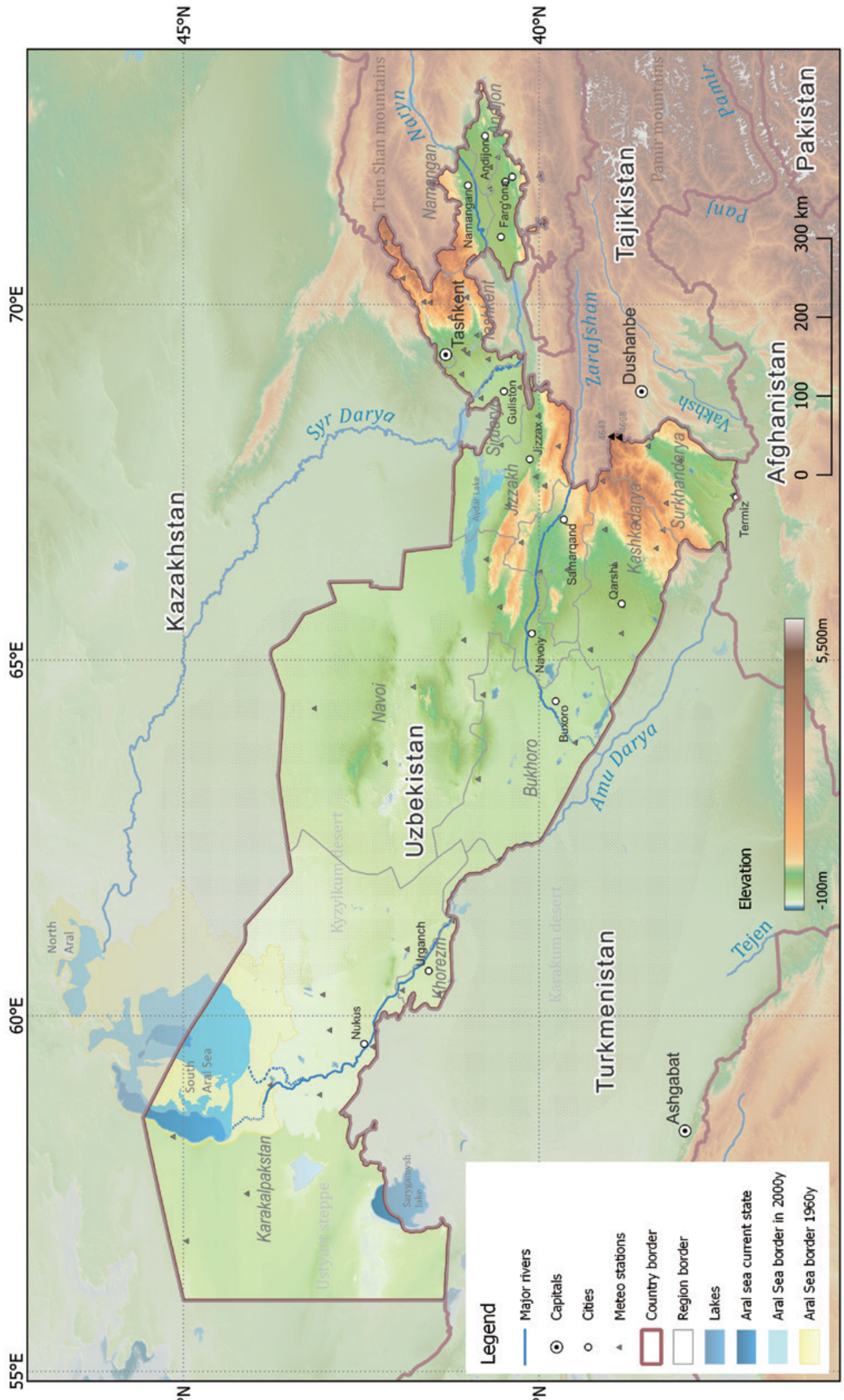


Fig.2-1 Geographical map of Uzbekistan (Natural Earth, Hydrosheds, SRTM)

2-2. Topography of the region

The topography of Uzbekistan presents a diverse landscape (*Fig.2-1, 2-2*). In the western part of the country, lies an expansive flat plains comprised of the Turanian lowlands and, depressions of the former Aral Sea. Elevation in the Kungrad city, one of biggest cities near the former Aral Sea is around 60 m above sea level. The surrounding areas, notably the Aralkum desert, which formed as a direct consequence of the gradual drying up of the Aral Sea, give rise to extensive saline sand dunes on the former bed of the sea (Orlovsky et al. 2013).

The central part of the country is predominantly flat with the renowned Kyzylkum desert stretching from the north part on the border with Kazakhstan to the south border of Turkmenistan, connecting to the Karakum desert. Elevations across this area typically do not exceed 100 to 250 meters above the sea level, creating vast arid plains that dominate the landscape.

In stark contrast, the eastern part of Uzbekistan offers a dramatic shift in topography. Here, the landscape is marked by the presence of the Tien Shan and the Gissar Ranges with individual peaks exceeding 4000 meters mixed with wide river valleys. While the official record holder is currently a peak at 4643 meters, recent explorations by researcher E. Gilbertson suggest a challenger: a neighboring location that towers at 4668 meters. It is nestled within the south-eastern sector of the country, specifically within the Gissar range of the Pamir-Alay mountain system on the border with Tajikistan.

Continuing to Tajikistan and Kyrgyzstan these mountain ranges rise to 7000 m and more, and hold the largest glaciers of the regions that play an essential role in the entire Central Asian water system. Often referred to as "water towers," (Viviroli et al. 2007) these glaciers play a critical role in the region's hydrological cycle. They are the primary sources of the major rivers, including the Amu Darya and Syr Darya rivers, which are vital for irrigation. During periods of peak discharge, these glaciers collectively contribute over 30% of the total water supply, underscoring their paramount importance (UNFCCC 1999, Lioubimtseva et al. 2005, Lioubimtseva and Henebry 2009, Sadyrov et al. 2023). As nature's reservoirs, they release water resources in hot summers, not only shaping the climate but also sustaining agriculture, ecosystems, and human livelihoods across the arid plains and fertile valleys of Central Asia. The meltwater from these glaciers during the warmer months is a lifeline for Uzbekistan and its neighboring nations, highlighting the interconnectedness of the region's topography and hydrological systems.

The river valleys form the primary centers of human habitation and agriculture in this arid landscape. These fertile oases, irrigated by the waters of the Amu Darya, the Syr Darya, and the Zeravshan rivers serve as the main living areas for the country's population. It is here that communities have thrived for thousands years, cultivating crops and orchards. The river valleys are not only the cultural and agricultural heartlands of Uzbekistan but also the epicenters of historical livelihood irrigation areas going back over 2000 years. The network of artificial canals and ditches, together with drainage system is a testament to centuries of redistribution of the precious resource, enabling a diverse range of crops to flourish and support the livelihoods of countless people. This close connection between the rivers and the inhabitants of these valleys underscores the enduring importance of water resources in shaping the country's history, culture, and economy.

The topographical diversity in these contrasting landscapes, from the vast lowlands of the west to the towering peaks of the east, underpins Uzbekistan's distinct climatic regions and ecological richness,

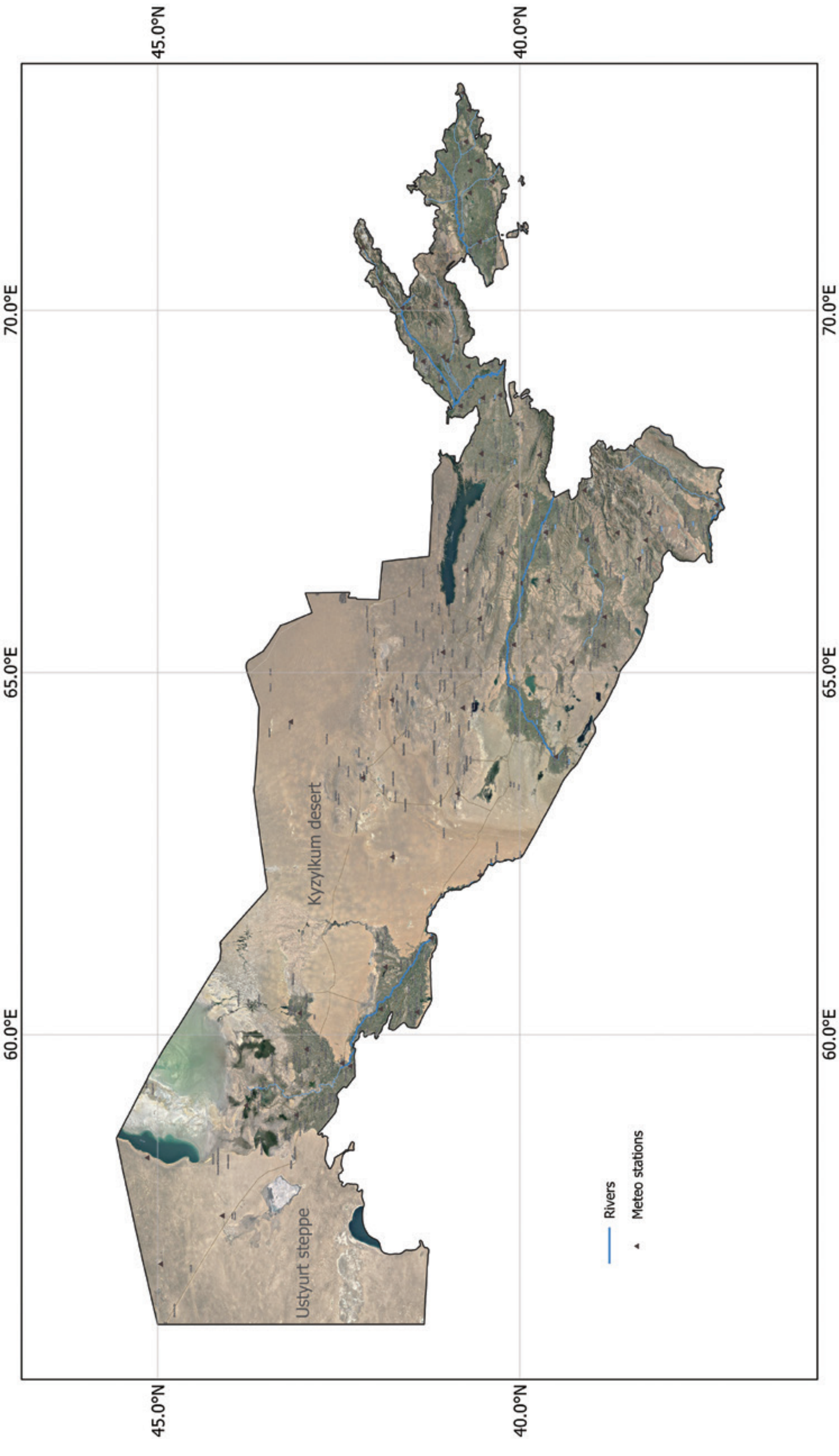


Fig.2-2 Overview of the Uzbekistan natural land cover (Google Inc.)

shaping the country's unique physical and geographical character.

2-3. Solar radiation

Solar radiation is an indispensable driver of Uzbekistan's climate, playing a pivotal role in shaping the arid continental conditions characterized by large temperature fluctuations within a single day and across the seasons. The nation's solar radiation regime is intricately tied to its geographic latitude, with summer days stretching to approximately 15 hours of daylight, while winter days contract to around 9 hours (***Fig.2-3***). Positioned within the subtropical high-pressure zone, Uzbekistan's climate is defined by its dry nature, characterized by low precipitation levels and correspondingly high evaporation rates. These climatic attributes bear a resemblance to regions such as California and the Mediterranean.

Uzbekistan experiences an impressive number of clear, cloudless days, averaging between 260 and 280 annually in the plains, and slightly fewer, around 240 to 250 days (Rakhimov et al. 2017), in the piedmont and mountainous areas, for a huge solar energy production potential. Cloudy days are most prevalent during the winter and spring months, peaking between January and March, while they are relatively scarce in August and September. The extended hours of sunlight, coupled with limited cloud cover and low precipitation, significantly elevate the amount of solar radiation received by the arid areas, intensifying the heating of the soil surface. The resultant high surface temperatures wield a profound influence on air circulation patterns, offering insight into the stability of summer temperatures.

It is this high solar radiation, combined with limited precipitation, that characterizes the majority of Uzbekistan's territory as arid or semi-arid. This is determined by the ratio of evapotranspiration to precipitation, which exhibits a stark discrepancy of up to tenfold in desert and steppe regions. This climatic interplay underscores the country's distinctive landscape, defined by its dependence on solar radiation and the challenges posed by limited water resources.

2-4. Climate zones of Uzbekistan

Uzbekistan's climate is marked by distinct seasonal variations, primarily driven by its continental features. The country experiences hot summers and relatively cool winters, resulting in pronounced fluctuations throughout the year. According to the Köppen climate classification, the majority of Uzbekistan falls into the categories of cold desert or cold steppe as indicated in Köppen's climate map (***Fig.2-4***).

In the lowland valleys and piedmont areas, Uzbekistan exhibits a mix of hot or cold semi-arid climates. These regions often feature elements reminiscent of Mediterranean and humid continental climates. In the northern part of Uzbekistan, the climate tends to be more temperate, while the southern regions, particularly those bordering Tajikistan and Kyrgyzstan, lean towards subtropical conditions.

Plains have cold winters and long hot summers, while mountainous zones depend on several parameters such as relief, elevation, slope direction and others. Temperature distribution changes from north-west to the south in the plain areas of Uzbekistan. Usually, January is the coldest month and July is the hottest.

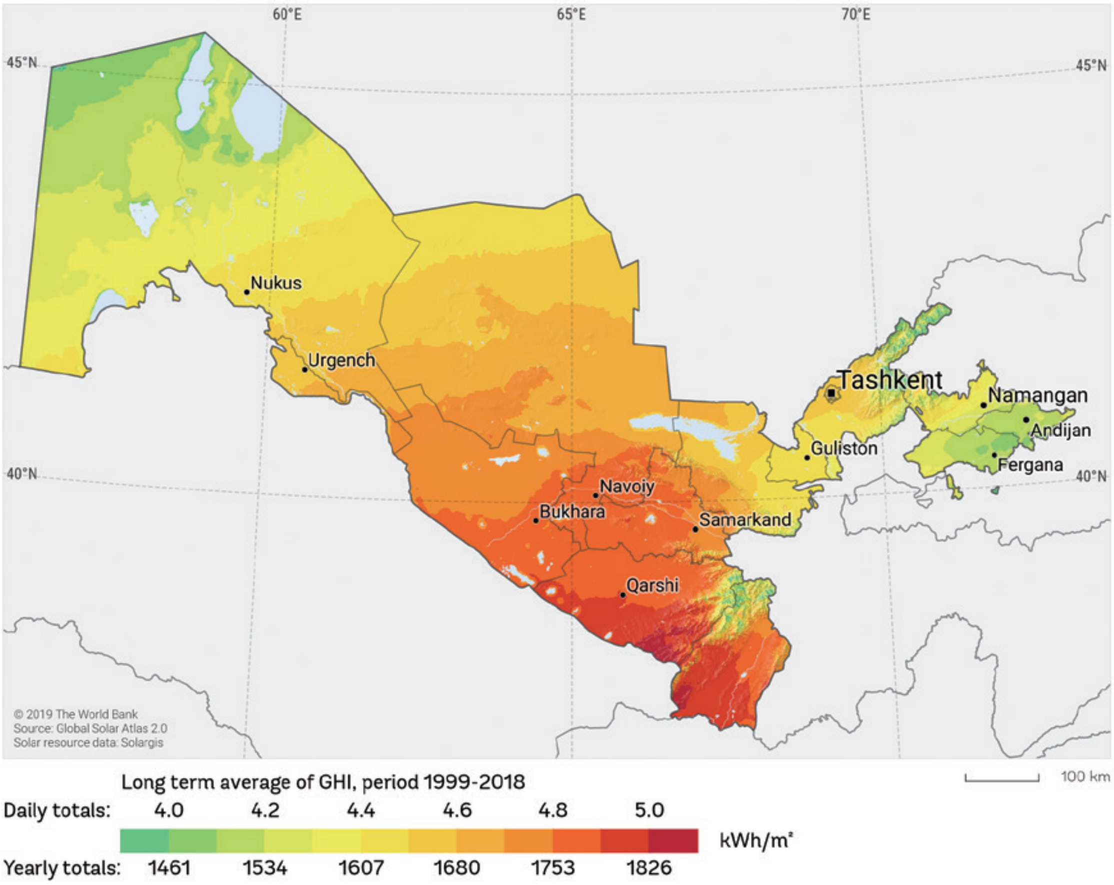


Fig.2-3 Global Horizontal Irradiation of Uzbekistan. © 2020 The World Bank, Source: Global Solar Atlas 2.0, Solar resource data: Solargis

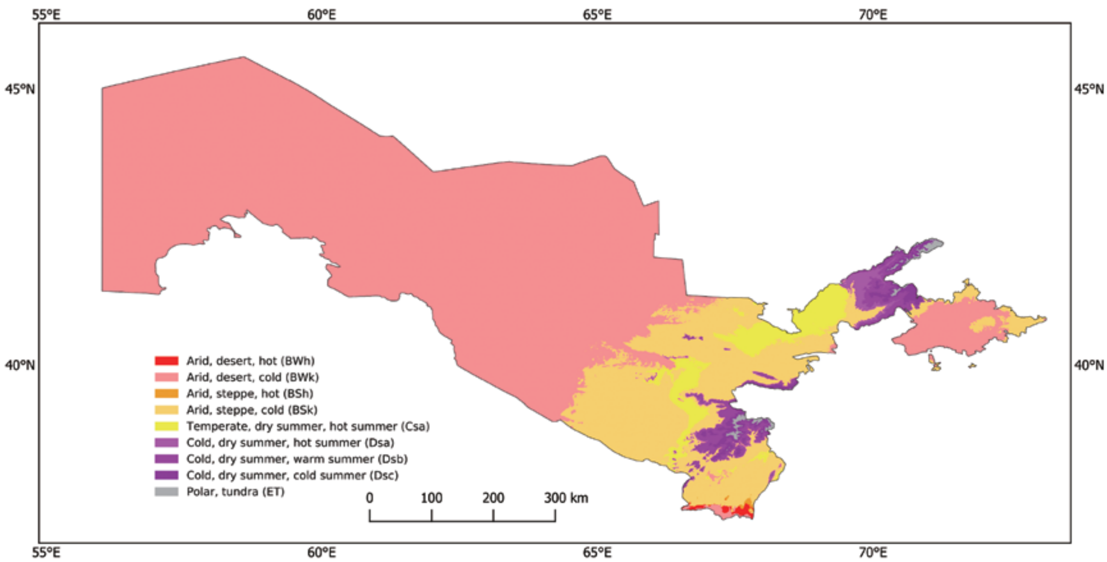


Fig.2-4 Climatic zones of Uzbekistan by Köppen-Geiger Climate Classification (Beck et al. 2018)

2-5. Temperature distribution

Temperature distribution over the territory has a zone based characteristics and can be divided into plains and mountainous areas and oasis along the rivers. Summers are very hot and dry, autumns are short with limited precipitation, Winters are cold but irregular, while Spring is the most humid season. (UNDP, https://www.adaptation-undp.org/explore/central-asia/uzbekistan). For the whole of Uzbekistan mean annual temperatures is around 15 °C, and the average summer temperatures in July around 29 °C and winters with average temperature in January is -3 °C (*Fig.2-5*). However, there are significant day-to-night air temperature fluctuations, for example summer temperature in deserts often exceed 45 °C (desert, steppe areas), while night temperature could fall to 20 °C (central-west part in *Fig.2-6*). In oasis temperature fluctuations are moderate, and in the mountains, it depend on the elevation.

The most representative meteorological stations for different part of Uzbekistan, located in mountains, plains and oasis zones were chosen for the hythergraphs shown in the *Fig.2-6*. The list of the stations, elevation, coordinates and their description is given in the *Table 2-1*.

Winters on the plains can be relatively warm, with temperatures rising up to 15-20 °C, while absolute minimum temperatures in the northern plains can plummet to below -30 °C or lower during winter (the north-west, stations Karakalpakiya and Muynaq). In the mountainous areas, for example in Kul, Baysun, and Oyganing stations (*Fig.2-6*) these figures adjust to a range of 5-10 °C, emphasizing the climate's diverse nature on higher elevations.

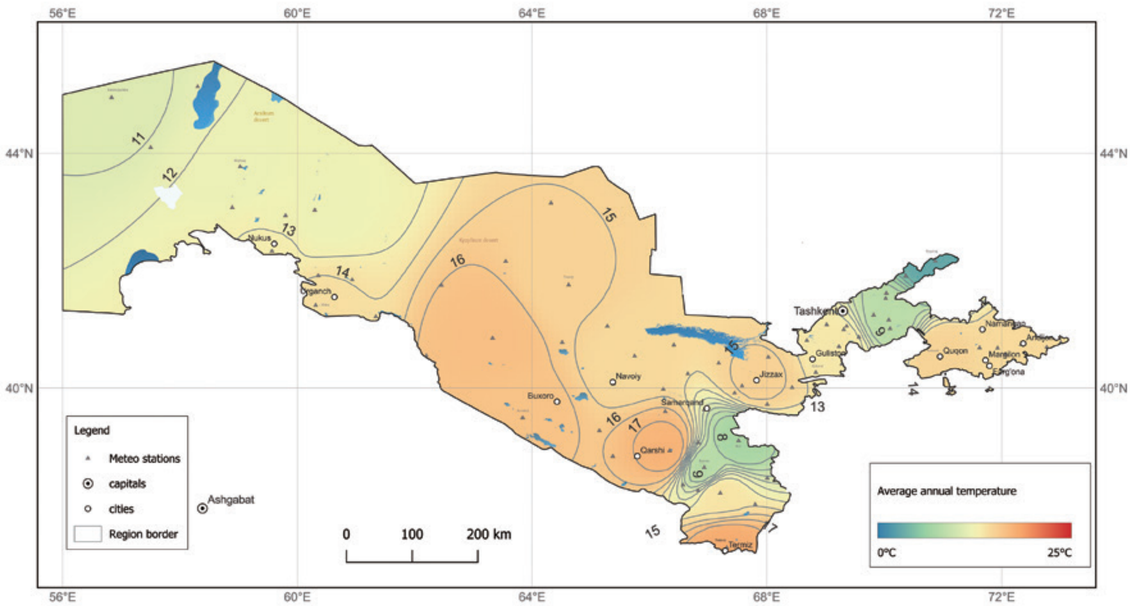


Fig.2-5 Average annual temperatures in Uzbekistan

Table 2-1 List of meteorological stations

Station name	Latitude	Longitude	Elevation, m	Description
Karakalpakiya	56°50’00”	44°57’00”	126	The north-west, Ustyurt, plains
Muynaq	59°01’26”	43°46’20”	55	The north-west, former Aral Sea border, plains
Khiva	41°24’37”	60°18’44”	101	The west central, oasis
Tamdy	41°45’30”	64°37’17”	237	The north central part of Kyzylkum desert, plains
Karakul	39°29’33”	63°50’20”	197	The south central, near Bukhara, oasis
Termez	37°16’39”	67°19’01”	313.4	The southern, oasis
Kul	39°06′00”	67°31′00”	2161	The south central, mountains
Baysun	38°12’33”	67°12’20”	1241.1	The south, mountains
Oyganing	42°09’48”	70°52’08”	2150	The northern, mountains
Kokaral	40°42’21”	69°13’39”	340.5	The east central, oasis
Kokand	40°33’00”	70°57’00”	499	The east, oasis
Andijan	40°44’26”	72°19’54”	493	The east, oasis

Spring temperatures rise fast starting from the beginning of March and in April they can exceed 20 °C. However there are often cases of spring frosts, with temperatures falling below -2 °C on the plains and down to -8 °C in the mountains. Usually, spring frosts end in the end of March in the south (Termez) and beginning of April in the other regions (Karakul, Andijan, Kokand). In most stations mean temperatures in March are usually not higher than 5 °C, especially in plains and mountains area, except south and some parts of south-west. It is only in April when minimum temperatures rise over 0 °C to provide enough warmth for vegetations growth. Pastures in deserts and mountains experience rapid vegetation growth till June (spring-bloom), when high temperatures dry leaves under scorching sun.

The hottest month is July, in the mountains July - August. Average temperature in plains and foothills are 25-30 °C and can reach 31-32 °C in the south. The period of forty days that start at the end of June and continue till the beginning of August are called “chillya” or “saraton”. Usually these are the hottest days in a year, with air temperature rising up to 40-43 °C in plains, and 43-46 °C in the south (Termez, Karakul). High temperatures in summer cause intensive snow and glacier melting in high mountains with the peak discharge of the rivers.

Although September is still considered a warm month, and can be characterized as summer, temperatures drop rapidly into October with mean temperatures of 14-18 °C in the south and 10-14 °C in the north. Night minimum temperatures rapidly fall to 0 °C and below by the end of October, although day temperatures remain high. In November the cold temperatures are stable over day and night to force plants dormancy till next spring.

2-6. Precipitation

Precipitation in Uzbekistan displays a significant spatial variation between the plains and mountainous areas. The mountains, with their own microclimates, receive the lion's share of precipitation. This phenomenon results from orographic uplift of air masses and the subsequent accumulation of precipitation on the windward slopes of the towering peaks. The amount of precipitation directly corresponds to elevation, slope direction, and moisture mass movement, with the south part of the Tashkent region receiving the highest average annual rainfall of about 900 mm, while the mountains throughout the country typically receive approximately 500-600 mm (***Fig.2-7***).

The pattern of precipitation in Uzbekistan is characterized by a distinct seasonality. Rainfall is concentrated predominantly in the winter-spring period, whereas the summers remain exceedingly dry (***Fig.2-6***) (Hu et al. 2014). The start of rains usually marks the second half of autumn and gradually intensifies into the spring months. Among these, March and April stand out with the highest share of precipitation throughout the year. Spring months typically account for 30-50% of the annual precipitation, while winter months contribute 25-40%, leaving a mere 1-6% for the summer months.

This seasonal distribution of precipitation plays a pivotal role in shaping vegetation development within the deserts and plains. In April and early May, these typically barren landscapes transform into lush scenery with vibrant greenery. However, by June, the relentless summer heat dries up most of this vegetation, leaving the terrain with dried up plants, transforming it to the yellow brown scenery.

Spring in the mountainous regions, on the other hand, often brings sudden and intense flash rains, particularly within small basins. These downpours can lead to mud floods known locally as "sel". This dangerous conditions happen suddenly and often cause significant damage to the mountain's community houses and irrigation lands sometimes drowning animals and humans.

Despite a clear trend in average temperatures, the average annual precipitation in Uzbekistan has remained relatively stable in recent decades (UN, Communication 1999). While a slight decrease was observed between 1950 and 2013, it was not statistically significant. Notably, observations from the Tien Shan and the Gissar-Alai Mountain ranges reveal some variation in precipitation between seasons. Though there is a slight increase in winter months (December to February), this is offset by slight decreases in other parts of the year. The El Niño Southern Oscillation (ENSO) wields a considerable influence over the multi-year variations in dry and wet climate patterns (Chen et al. 2022).

Limited moisture masses bring average rainfall amounts from 100 to 200 mm in the plains and up to 600-900 mm in the mountainous slopes (***Fig.2-7***), mainly in winter and spring. Small amount of precipitation in the warm period June to September significantly limits vegetation growth without irrigation (UNDP). Based on this aridity of the territory is determined.

The distribution of precipitation in Uzbekistan has a profound impact on the overall aridity of the country. In the broader context, Uzbekistan's climate is marked by an average annual precipitation of about 200 mm, while the average annual evaporation reaching approximately 2500 mm. This connection between precipitation and evaporation underscores the dynamic equilibrium of the country's water resources and the need for effective water management and resource utilization directly linked to the classification of the aridity of regions.

The majority of the nation experiences shortage of rainfall, particularly during the dry summer months when precipitation is scarce. This substantial moisture deficit significantly contributes to the arid nature

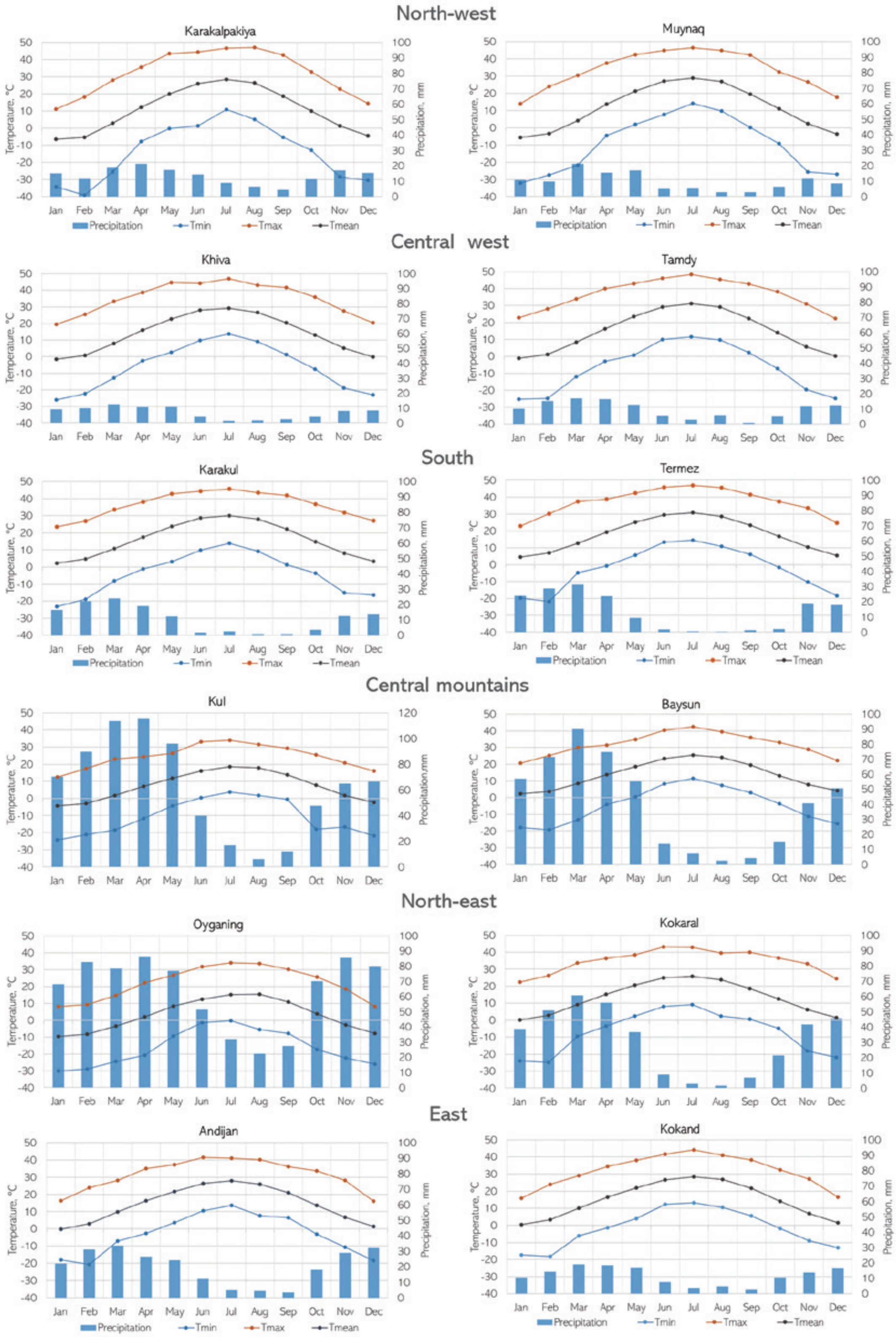


Fig.2-6 Hythergraphs in various climatic zones of Uzbekistan

of the plains and deserts. Many areas in Uzbekistan are classified as cold desert or cold steppe according to the Köppen climate classification (*Fig.2-4*) due to the shortage of rainfall, which is often below the threshold required to support vegetation.

The seasonal distribution of precipitation in spring and winter, with minimal rainfall during the hot summer months, directly corresponds with the development and decline of vegetation in the deserts and plains. Spring rains breathe life into the landscape, leading to lush, green expanses. However, the subsequent intense summer heat quickly evaporates the limited moisture, causing the vegetation to wither. This connection between precipitation patterns and aridity is a defining feature of the region's climate (*Fig.2-8*). Uzbekistan's arid and semi-arid characteristics are a direct result of the limited and uneven distribution of precipitation throughout the year.

Understanding this intricate interplay between precipitation, aridity, and the distribution of water resources is essential for effective land and water management in Uzbekistan. The management of available water, often reliant on transboundary rivers, is crucial for mitigating the challenges posed by the arid climate, ensuring sustainable agriculture, and supporting the diverse ecosystems that call this unique region home.

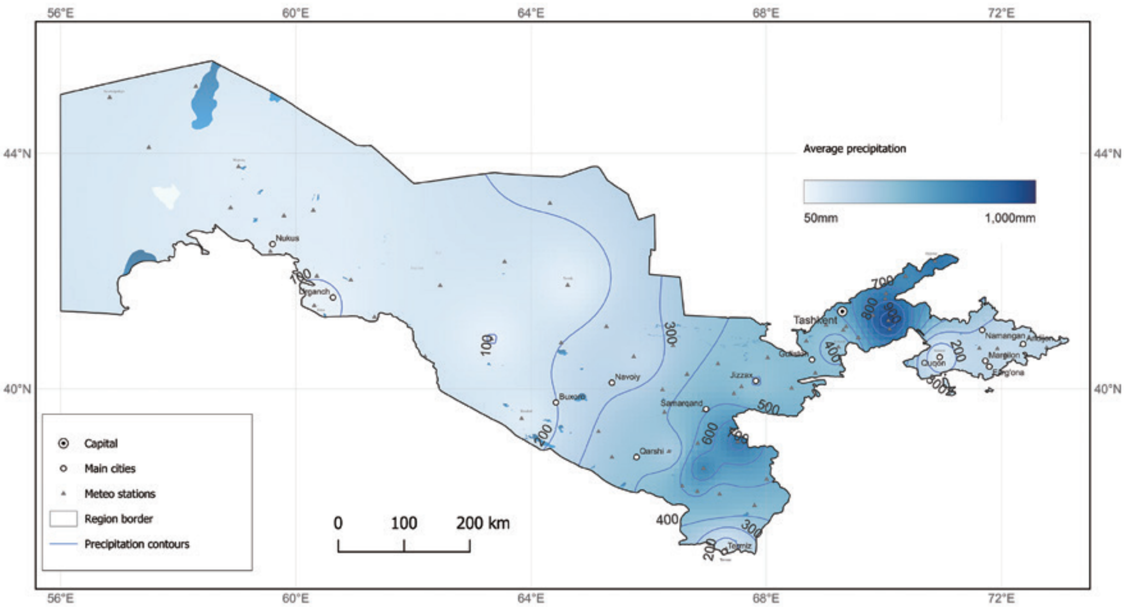


Fig.2-7 Average annual precipitation over Uzbekistan

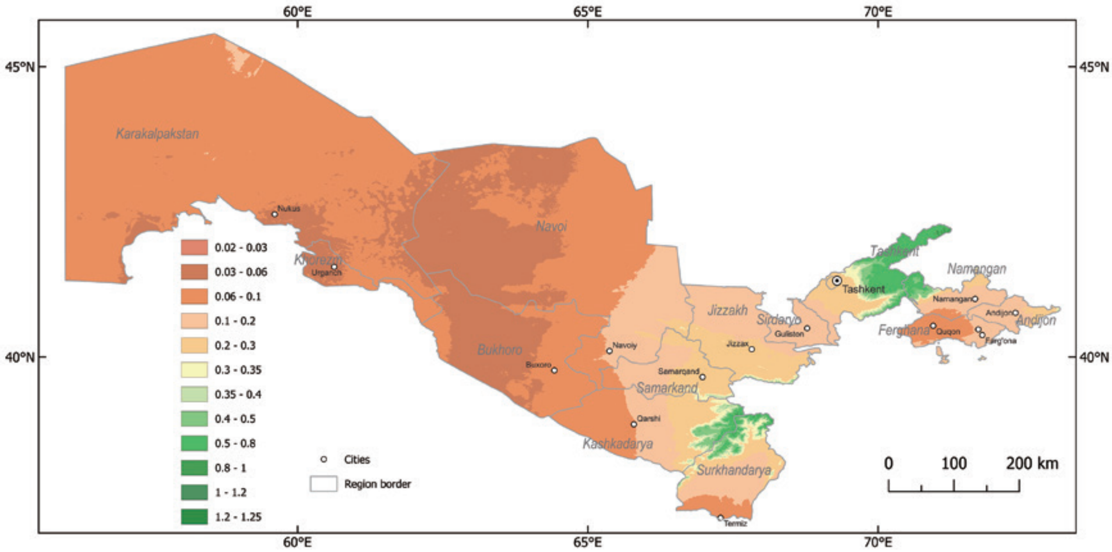


Fig.2-8 Aridity index. < 0.03 Hyper Arid, 0.03-0.2 Arid, 0.2-0.5 Semi-Arid, 0.5-0.65 Dry sub-humid, > 0.65 Humid. Source (Global Aridity Index and Potential Evapotranspiration Database - Ver 3, Zomer et. al 2022)

2-7. Water resources and the Aral Sea crisis

From a hydrological point of view one can distinguish three main zones of surface runoff in the Aral Sea Basin (*Fig.2-9*): (a) the zone of flow formation (upper watersheds in the mountain areas in the south-east part – including Afghanistan, Kyrgyzstan and Tajikistan), (b) the zone of flow transit and its dissipation (the central part-mainly Kazakhstan, Turkmenistan and Uzbekistan), and (c) delta zones (the north-west part including Kazakhstan and Uzbekistan).

The Amu Darya stands as the largest river in the region by water volume, with a length of 2540 km and a catchment area spanning 309000 km^2. Its source lies in the Pamir and Hindu Kush mountains glaciers, where Panj river, one of the Amu Darya river's tributary forms in Afghanistan and Tajikistan. In the middle section acts as a border between Afghanistan and Tajikistan. The Panj river is then joined with the Vakhsh river flowing from Kyrgyzstan and Tajikistan to form the Amu Darya river. Further downstream, it forms international borders between Turkmenistan and Uzbekistan on its way to the Aral Sea.

On the other hand, the Syr Darya, stretching 3019 km, is the longest river in Central Asia, with a catchment area of 219000 km^2. It originates in the Tian Shan Mountains of the Kyrgyz Republic, named the Naryn until it merges with the Kara Darya. Crossing international boundaries midstream, it flows through Kyrgyzstan and Uzbekistan, reaches Tajikistan, briefly returns to Uzbekistan, and eventually enters Kazakhstan (Murray-Rust et al. 2003).

Most of Central Asian rivers rely on glacier and snowmelt for water supply, with 80-90% of the annual flow occurring between April and October. Glaciers and underground sources contribute 25-50% of the yearly flow. The Pamir and the Tian Shan mountain glaciers hold a massive 845 km^3 of water, seven times more than the entire annual flow in the Aral Sea Basin. However, the rising annual temperatures and decreased precipitation since the 1930s have caused glaciers to retreat by 25%-35% (Bolch 2006, Farinotti et al. 2015, Deng and Chen 2017). While melting glaciers may temporarily increase runoff, it primarily boosts water resources during winter and early spring, with summer run-offs likely to decrease. Central Asia may also witness more floods and mudflows due to climate change, although these short-term benefits may be offset by increased precipitation variability and seasonal runoff shifts (Aizen et al. 1997, Annina et al. 2012, Chen et al. 2016). Importantly, these changes affect downstream areas more severely, intensifying water scarcity in downstream riparian states and administrative units during drought years (Dukhovny 2002, Wegerich 2007, Wegerich 2010).

In Uzbekistan, agriculture plays a significant role, contributing 34% to the national GDP, 70% of foreign currency income, and employing 55% of the workforce (AquaStat, FAO). Crops in the Aral Sea Basin countries, such as summer vegetation, silvi-viticulture, and horticulture, heavily rely on supplemental irrigation for better yields. Unfortunately, the diversion of water from the Amu Darya River Basin for irrigation has substantially reduced river flows as it approaches the Aral Sea, creating as a results series of terminal lakes storing drainage water, resulting in detrimental impacts on the sea, wetland ecosystems, and biodiversity (Micklin 2010).

Various irrigation methods are employed, with 64% relying on furrow irrigation, 31% using strip irrigation, and 5% employing basin irrigation (AquaStat, FAO) in downstream areas uplifted with powerful pump stations (***Fig.2-9***). Furrow irrigation is dominant, but in 1999, only 11.0% of canals were lined. Unlined canals lead to significant water losses, primarily due to groundwater seepage. Despite recent canal reconstruction projects, more attention from governments is needed to curb these losses. The flow rate of water also varies, controlled according to the timing of sowing and harvesting, leading to differences between the upper and lower reaches of the river.

The continued use of these outdated irrigation systems has detrimental consequences, including soil erosion, salinization, and waterlogging, particularly in Turkmenistan and Uzbekistan. This not only threatens agricultural sustainability but also long-term food security for rural communities. Waterlogging and salinization are widespread issues affecting cotton and wheat growing regions across Central Asia. These problems arise from poor irrigation water management, inadequate drainage, rising groundwater tables, and the mobilization of salts within the soil. This situation has led to the abandonment of large areas of once-productive cropland. It is estimated that around 20000 hectares of irrigated land in Uzbekistan is lost to salinity and abandonment each year (FAO 2005), reflecting the need for improved soil and water conservation practices and better management.

2-8. Soil salinity

Salt-induced soil degradation is common in arid and semi-arid areas in many parts of the world. In recent decades, it has steadily increased in large-scale irrigated agricultural systems, and found in at least 75 countries and cover more than 20% of the world's irrigated land. (Ghassemi et al. 1995, Al-Oudat et al. 2011, Toderich et al. 2022).

In Central Asian desert landscapes, the degree and chemistry of soil salinization and the distribution of salt-affected soils are more a function of the history of the areas than of their modern climatic conditions. The main factors are the presence and properties of saline rocks and the aeolian migration of salts. Another source of salts in the auto morphic soils of Central Asia is related to eolian processes. Salts

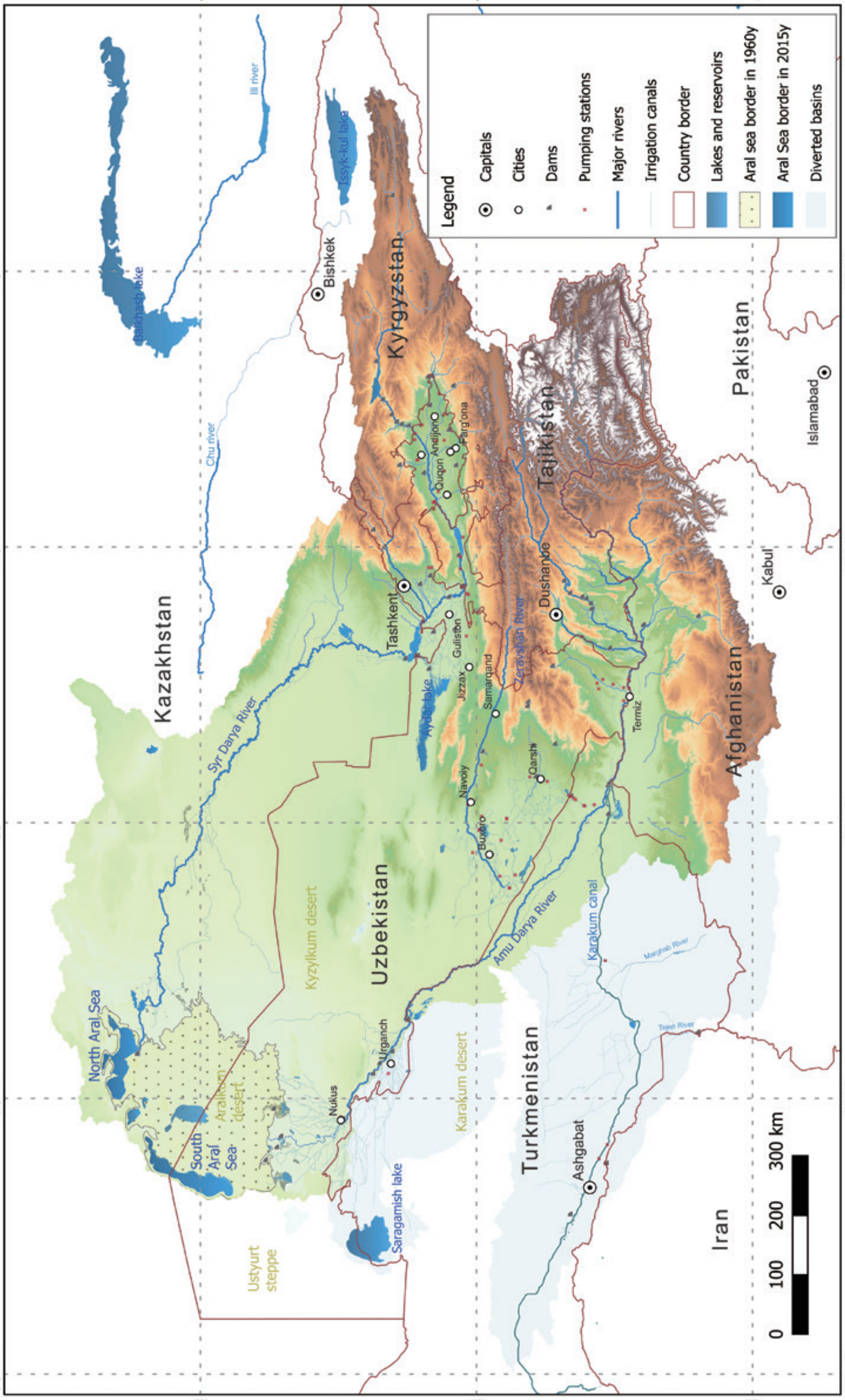


Fig.2-9 The Aral Sea Basin river and channel network

of the eolian genesis are particularly widespread on coastal plains of the Aral Sea region (Pankova and Konyushkova 2013). There is evidence that eolian input of salts may reach 500 kg/ha per year (Kovda et al. 1973) and in separate areas (particularly, in the impact zone of the Aral Sea), it may increase to 2-3 t/ha per year.

Solonchak are mostly found on the central Ustyurt plateau and its slopes, near the Aidar-Arnasay lake systems (south-west part of Navoi and north-west part of Dzhizak regions), as well as in the endorheic depressions of the Kyzylkum desert (Ayagakytma, Karakata, Mingbulak and other Aral Sea coastal areas) and the delta of the Amu Darya river.

The main characteristics of salt-affected marshland (with solonchak-alkaline soils) are the constant wetness and humidity of the top-soil profile and temporary waterlogged areas. The most common types of solonchak according to Gerasimov (in Gaevskaya and Salmanov 1975) are as follows:

- Salt marshes. i.e. hydromorphic steppe and desert soils characterized by a high concentration of water-soluble salts in the surface layer with a porous, crusted and wet solonchak. This is where the "shory" the local name for bare solonchak, is found. In summer, it has a crusty-puffy surface on which a few halophytes grow, or it is almost bare of vegetation or poor rangelands species with no pastoral value (***Fig.2-10***, ***Fig.2-11***).
- Takyr and takyr-like, loamy desert soils, are found mainly in Central Asia and southern Russia. The surface of takyr is flat. sealed. compacted and polygonal cracks appear in summer. Takyrs are formed by the accumulation of fine soil particles on periodically inundated areas of alluvial plains and desert depressions. Vascular plants are often absent but algae and lichens are active in the soil formation of takyrs.
- Salt meadows are the result of alluvial deposits on riverbanks. They have the highest content of humus and clay in the soil profile. A high salinity (1.2-3.0% soluble salt) and low productivity characterize these soils, with a dominance of carbonates, sulphates, chloride and or mixed types of salinization. The organic content ranges from 0.5% in saline sandy desert up to 0.7-1.2% in grey-brown soils on virgin and newly irrigated takyrs.

Salts accumulation in dryland soils results either from the weathering of parent saline minerals (primary salinity) or from anthropogenic activities involving unsustainable management of land and water resources (secondary salinization).

The heavily irrigated croplands are distributed mainly in the eastern and central parts of Uzbekistan, while most of the area is covered with herbaceous vegetation and limited inputs of the shrubs (***Fig.2-11***). Recurrent flooding, poor natural drainage, an old-fashioned irrigation network with a high-water table, and low drainage efficiency of the irrigation system has resulted in a rise in water level, increasing mineral composition and secondary salinization of soils. Secondary salinization is growing rapidly in this area. In these conditions, crop production under irrigation (cotton, rice, wheat, vegetables etc.) decreases quickly and becomes less sustainable each year. This secondary salinization has a direct impact on the desertification process by destroying the vegetation cover and inducing rapid deterioration of the soil structure. The emergence of large irrigation drainage terminal lakes during the last few decades in the Kyzylkum desert, especially at the Bukhara oasis has changed fundamentally the water-salt balance in the adjoining territories. In the lowest reaches of the Zerafshan, Kashkadarya and Amu Darya deltas, about 85% of lands is now suffering from various levels of secondary salinization with bare soils and

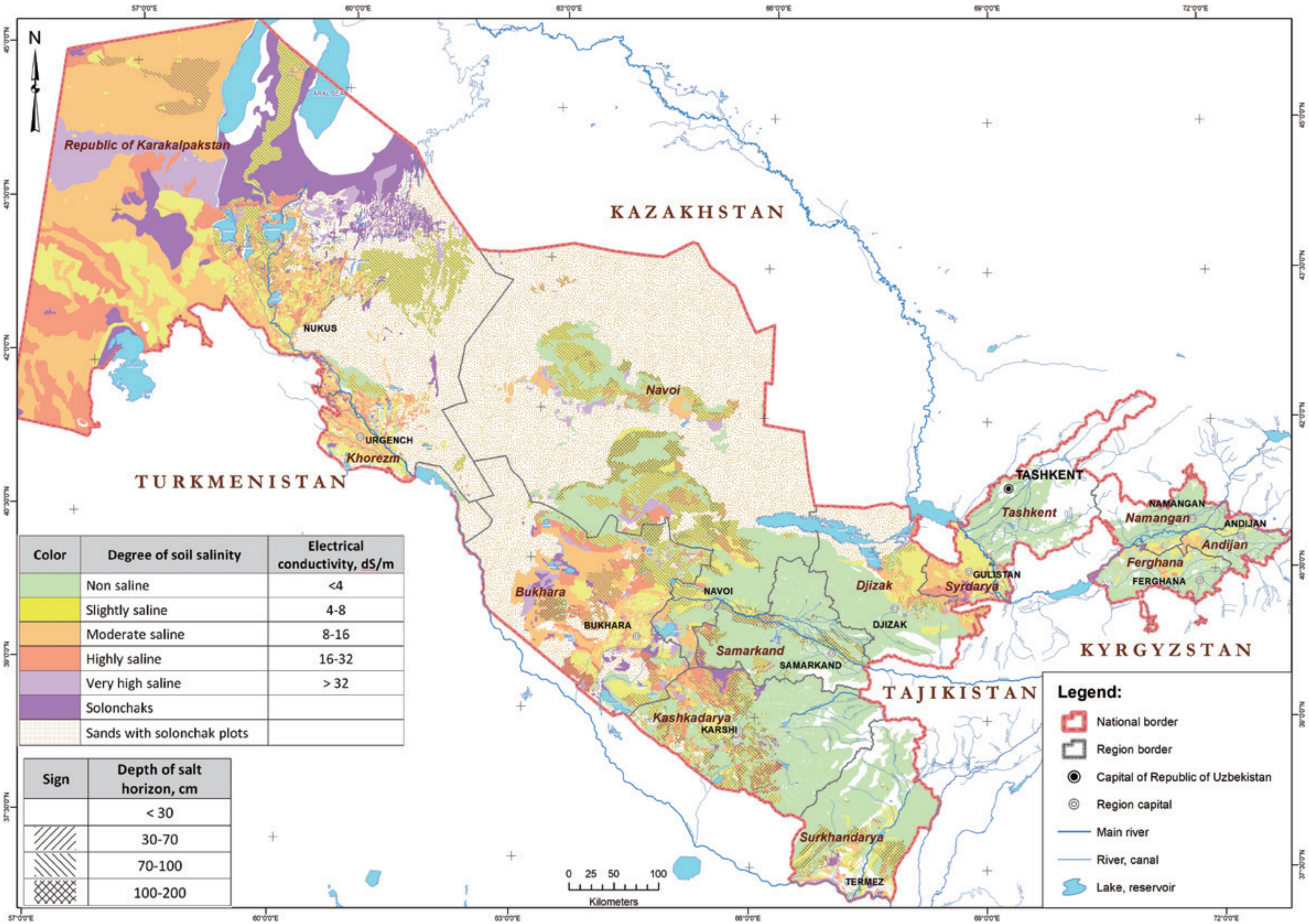


Fig.2-10 Salinization map. Based on Research of UzGIP (Ibragimov, Khasankhanova)

limited vegetations (***Fig.2-11***). The anthropogenic impact on the hydrological cycles and water regime has induced the appearance of large areas of new takyr soils (with increasing salinity).

2-9. Climate change

In the Aral Sea Basin region, significant climate change drivers are observed at a regional scale, primarily arising from two interconnected anthropogenic factors. These are comprehensive changes in land use and land cover, encompassing shifts in agriculture, urbanization, deforestation, and alterations in natural ecosystems, and the rapid degradation of the Aral Sea (Lioubimtseva and Henebry 2009, Kariyeva and van Leewuven 2011, Deng and Chen 2017). These changes play a crucial role in shaping the regional climate dynamics.

The alterations in land use and land cover across the Aral Sea Basin have been multifaceted (***Fig.2-11***). These transformations include shifts in agricultural practices, urban expansion, deforestation, and changes in natural ecosystems. Agricultural expansion, often involving the clearing of natural vegetation, affects the surface's albedo, influencing the reflection and absorption of solar radiation. Urbanization leads to increased impervious surfaces, affecting local climate patterns through alterations in temperature, evaporation, and runoff. Deforestation has wide-reaching consequences, impacting the carbon balance and influencing temperature and precipitation patterns. Changes in natural ecosystems can disrupt local and regional hydrological cycles, ultimately affecting temperature and moisture regimes. Simultaneously, the degradation of the Aral Sea introduces another layer to the climate dynamics. The substantial shrinkage of the once-massive lake has exposed vast stretches of dry, salty lakebed. This exposed lakebed absorbs more solar radiation, contributing to local and regional temperature increases. Furthermore, the desiccation of the Aral Sea has released substantial quantities of fine dust and aerosols into the atmosphere, affecting air quality and potentially influencing cloud formation and precipitation patterns in the region.

These interconnected changes in land use, land cover, and the condition of the Aral Sea collectively contribute to the complex web of climate change. Understanding and addressing these factors are essential for mitigating ongoing environmental challenges and charting a more sustainable path for the region.

In Uzbekistan, a consistent and significant upward trend in average annual air temperatures has been observed throughout the past century. Between 1950 and 2011, temperatures exhibited an average increase of 0.27 °C per decade (Hu et al. 2014). Notably, the annual temperature range in Uzbekistan has contracted over the same period, with average minimum temperatures elevating by 2.0 °C and average maximum temperatures by 1.6 °C between 1950 and 2011. Additionally, the desiccation of the Aral Sea, situated in the northwestern part of Uzbekistan, has made a minor contribution to localized climate warming. However, this warming trend is not uniform across the country, with the most pronounced temperature increases occurring in the northern regions and urban centers, ranging from 0.30 °C to 0.43 °C per decade, while mountainous areas experienced comparatively milder warming at a rate of 0.10 °C to 0.14 °C per decade. Spring and autumn witnessed the most substantial temperature rises, at 0.39 °C and 0.31 °C per decade, respectively, while the increases during winter were relatively modest, at 0.13 °C per decade (***Fig.2-12***). Notably, the most substantial increase in long-term mean temperature values (exceeding 1.0 °C) is concentrated within the colder months of the year, primarily in January, February,

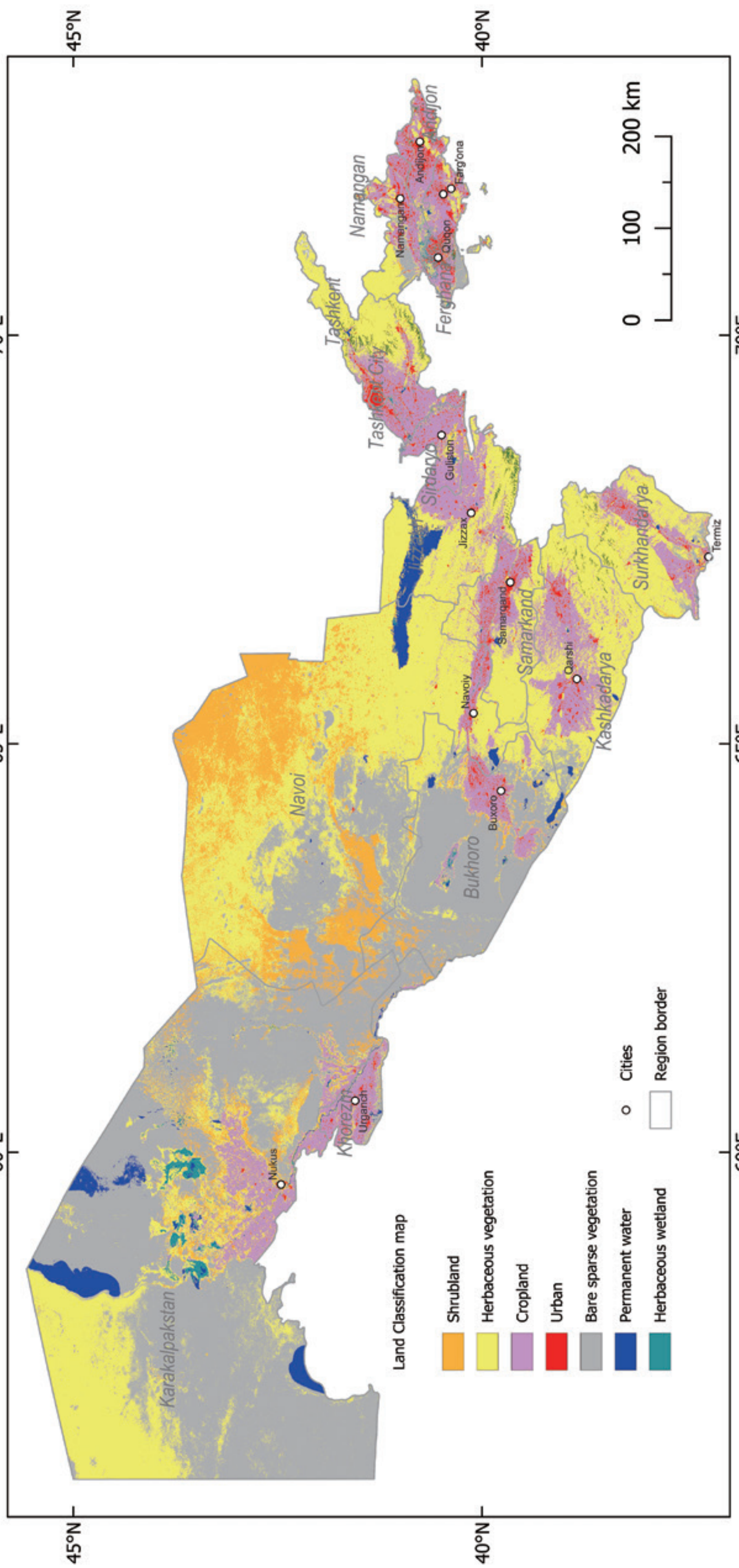


Fig.2-11 Copernicus long term vegetation cover change monitoring (Buchhorn et al. 2020)

and March, spanning the majority of Uzbekistan's territory. This warming trend characterizes winter and spring, which have become comparatively warmer by an average of 1.3 °C compared to 1960-1990 years.

Mean annual air temperatures have risen steadily and significantly in Uzbekistan over the past century, albeit with notable variation from year to year (Kholmatjanov, et al. 2020).

In the autumn season, except for October, where the average temperature increased by 1.12 °C, the rise in temperatures during other autumn months is relatively smaller, averaging at 0.58 °C. Notably, the most significant temperature increases in the summer season are observed in June and August (***Fig.2-12***).

The primary drivers of the temperature trend in Uzbekistan are linked to changes in regional circulation, and their potential future impact across the country is of significant concern. According to climate change projections presented by the Intergovernmental Panel on Climate Change (IPCC 2014), it is anticipated that temperatures in the region will rise under all scenarios. The precise direction and magnitude of changes in precipitation and river water flows, however, remain less certain. This could result in hotter summers and colder winters, with a projected median temperature increase of approximately 3.7 °C on average by the end of the century, with a substantial portion of this increase occurring during the summer months.

In terms of precipitation, general trends suggest an overall increase in the region, particularly in the northern areas, while the southern regions may experience slight decreases. Spring and fall are likely to see increased precipitation, whereas summer precipitation may decrease. This could lead to wetter winters, albeit with more frequent occurrences, and drier springs, summers, and autumns (Luo et al. 2019, Jiang et al. 2020).

Of critical importance is the reliance on river flow from the Amu Darya river for irrigated agriculture. The Amu Darya's primary source is the glaciers of the Pamir-Gissar Mountain ranges. However, over the past 50 years, the glaciers have experienced a significant reduction, shrinking by 14%. This alarming trend could potentially result in severe water shortages, posing a substantial challenge for the region's agricultural sustainability and water resource management (***Fig.2-13***).

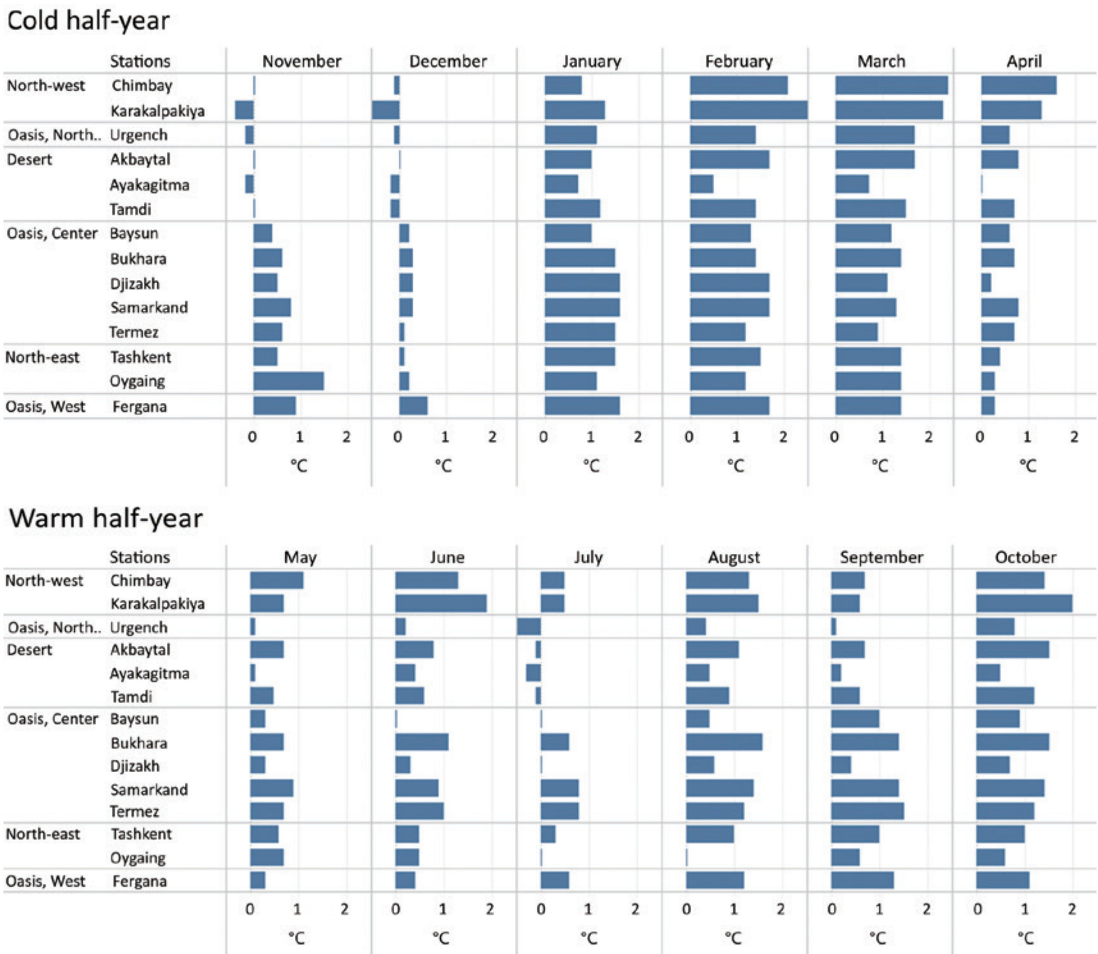


Fig.2-12 Observed climate change from 1990-2020 compared to 1960-1990 a) Cold half of the year and b) Warm half of the year (Source: Kholmatdjanov et al. 2020)

Fig.2-13 The tamarisk forest is dying (Kyzylkum desert, 2022) (NY)

3 Botanical-Geographical Zones of Uzbekistan

Kristina TODERICH and Bekhzod ADILOV

3-1. Bioclimatic and phytogeographical characteristics of arid and semiarid zones

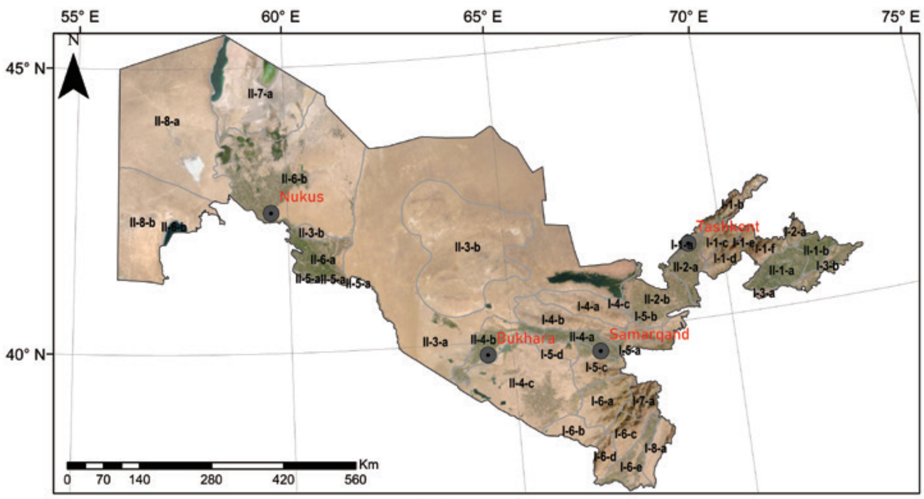
The Aral-Caspian phytogeographical sub-province, part of the Irano-Turanian province, covers the region between the Caspian and Aral seas, extending across most of Uzbekistan. The area of the former Aral Sea is now known as the Aralkum Desert. Open to the north, west and south, the Turanian lowlands stretch from the western Ustyurt plateau to the rising central Nurata mountains of Samarkand and Dzhizak foothills desert. In terms of bioclimate, the low altitude areas of the Aral-Caspian sub-province are characterized by dominant seasonal precipitation (bimodal cycle), hot dry summers and severe cold winters that prevent winter plant growth even when soil moisture is available (Gintzburger et al. 2005). The waters of the Amu Darya and Syr Darya rivers historically drained into the Aral Sea depression, some 60-100 m below sea level that is now occupied by the Aralkum Desert. From a phytogeographical point of view, the vegetation types, floristic composition of these areas have considerable similarities with those of the steppes, which extend into the mountains of northern Iran and Afghanistan. Many common species belonging to the genera *Agriophyllum, Halothamnus, Anabasis, Ammodendron, Astragalus, Artemisia, Stipagrostis, Calligonum, Corispermum, Cornulaca, Krascheninnikovia, Ephedra, Haloxylon, Halocnemum, Caragana, Halimocnemis, Salsola, Stipa, Smirnowia*, and *Tamarix*. This area also includes a number of endemics, rare and endangered species. The region has a huge diversity of *Artemisia* species (130), most of which are shrubs, the dominant species is *Artemisia terrae-albae*. The presence of a few Saharo-Arabian species (e.g., *Cutandia memphitica, Schismus arabicus, Koelpinia linearis* and several *Astragalus* spp.) in the sandy areas of the Aral Sea basin is notable.

The Aral-Caspian sub-province contains plant communities that are very similar to what is found in the steppes from north-west China to north-east Spain. The vegetation of the Aral-Caspian area is dominated by hemicryptophytes (a perennial plant having its overwintering buds located at the soil surface) and chamaephytes (a perennial plant that bears its penetrating buds just above the surface of the soil) with some rare small trees, and the desert vegetation shown similarities to that of Ibero-Maghribian province (southern part of Iberian Peninsula and Northwestern Africa). Unlike the above areas, the vegetation in the Aral Sea basin is predominated by chamaephytes, hemicryptophytes and ephemeroids (perennial herbaceous plants with a very short vegetation period, occurring at the most favorable time of the year), with some characteristic of micro-and nano-phanerophytes, such as *Haloxylon ammodendron*, *H. persicum, Calligonum* spp., *Ammodendron conolliy* and species of *Astragalus. Artemisia* species are less common in the area.

At the beginning of the last century one of the first attempts to divide the territory of the Aral Sea basin into areas of different types of vegetation was made by B. A. Fedchenko (1925). Later, using richer material, E. P. Korovin (1962) published a new classification, "Phytogeographical zoning of Central Asia" in the second volume of the fundamental publication "Vegetation of Central Asia and Southern Kazakhstan". Seven phytogeographical provinces were identified by the author: Turan desert (with 4 ecozones, such as Messerian, South Kyzylkum and Bukhara), Central Kazakhstan desert (with 7 districts: Ustyurt, Mangyshlak, Amu Darya, North Kyzylkum, Betpakdala, Muyunkum and Ishikotrau), South Turkestan mountain (with 7 districts: Karatau, Western Tien Shan, Fergana, Kukhistan, Hissar-Darvaz, Badakhshan and South Tajikistan), Turkmen-Iranian mountain (with Kopetdag and Badkhyz districts), Dzhungar-Tienshan mountain (with 6 districts: Dzhungar, Tarbagatai, Zailiysky, Kyrgyz, Chu-Ili and Talas), Central Tien Shan highland (with 5 districts: Southwestern, Northwestern, Eastern, Alai and Issyk-Kul) and the Pamir-Tibetan highland (with 2 districts: North-Eastern and South-Eastern respectively).

In the "Geographical Atlas of Uzbekistan", Mailun and Popov (2012), for the first time distinguished the Aral district, which includes the territory of salty, sandy, and rocky desert formed on the dry bottom of the Aral Sea as a part of the Lower Amu Darya district of the Aral-Caspian province. A significant contribution to the floristic zonation classification of the Aral district considering Ustyurt (including Magyshlak and Asmantai-Samsky sands and the northern cliff) was made by R. V. Kamelin (2021). His floristic classification of the Aral phytogeographical district is supported by a number of endemic species, such as *Salsola euryphylla, Gypsophila krascheninnikovii, Astragalus albescens, Euphorbia irgiscensis, Eremostachys aralensis* and *Artemisia aralensis*. At the same time, the insufficient knowledge of the flora of the Aralkum desert is recalled by R.V. Kamelin (2021).

The latest and most comprehensive classification of botanical and geographical zoning of Uzbekistan (including Aral desert region) is by Tojibaev et al. (2016 a, 2016 b). The authors proposed that the entire flatlands/plains of Uzbekistan are components of the Turan (Turano-Dzungar) province, which includes five floristic districts: Central Fergana (Kairakum-Yazyavan, East Fergana regions), Middle Syr Darya



Legend

Symbol	Floristic region	Symbol	Floristic region	Symbol	Floristic region	Symbol	Floristic region
I-1-a	Tashkent piedmont	I-4-b	Aktau	I-6-e	Surkhan-Sherabad	II-4-b	Lower Zeravschan
I-1-b	Ugam-Pskem	I-4-c	Near Nuratau relic mountains	I-7-a	Sangardak-Tupalang	II-4-c	Karshi-Karnabchul
I-1-c	Chimgan (Western Chatkal)	I-5-a	North Turkestan	I-8-a	Babatag	II-5-a	Northern Karakum
I-1-d	Kurama (Akhangaran)	I-5-b	Malguzar	II-1-a	Kayrakkum-Yazyavan	II-6-a	Khorezm
I-1-e	Arashan	I-5-c	Urgut	II-1-b	Eastern Fergana	II-6-b	Amudarya delta
I-1-f	Chorkesar	I-5-d	Zirabulak-Ziadin	II-2-a	Chinaz	II-7-a	Southern Aral
I-2-a	Southern Chatkal	I-6-a	Kashkadarya	II-2-b	Mirzachul	II-8-a	Northern Ustyurt
I-3-a	Western Alay	I-6-b	Tarkapchigay	II-3-a	Kyzylkum	II-8-b	Southern Ustyurt
I-3-b	Eastern Alay	I-6-c	Baysun	II-3-b	Kyzylkum relic mountains		
I-4-a	Nuratau	I-6-d	Kuhitang	II-4-a	Middle Zeravschan		

Fig.3-1 Phytogeographical zones of Uzbekistan, after Tojibaev et al. 2016 a

district (Chinaz, Mirzachul districts), Kyzylkum (Kyzylkum Outlier and Kyzylkum districts), Bukhara (Middle Zeravshan, Lower Zeravshan, Karshi-Karnabchul districts), Southern Priaralie (lower stream of Khoresm and Amu Darya region), Karakum, Ustyurt (northern and southern Ustyurt districts) and the Aral Sea itself (southern Priaralie district) (*Fig.3-1*).

3-2. The Aralkum desert (Dry seabed of the former Aral Sea district)

In this book, the phytogeography, floristic changes, current successional features of vegetation and botanical richness analysis of the South Priaralie (lower Khoresm and Amu Darya region), Karakum, Ustyurt (north and south Ustuyurt districts) and the Aralkum from the Uzbek side are presented. As can be seen in *Fig.3-2*, the Aralkum saline desert belongs to the southern Priaralie botanical-geographical district. The floristic composition of the dry bottom of Aral Sea is formed by the migration and resettlement of species (through seed dispersal) across southern Priaralie areas, northwest Kyzylkum and Ustyurt areas (Tojibaev et al. 2016 a). This migration is both assisted by humans through seeding and planting as well as by nature.

3-2-1. Features of soil formation and transformation in the dry seabed and shoreline of the Aral Sea

Based on data and studies from our expeditions, it is considered that the process of desertification and shrinking of the Aral Sea has led to the development of a novel ecosystem on the dry seafloor that is referred to as the Aralkum Desert. Such a long-term transformation of the newly formed landscape was reflected in the new soil genesis process, accompanied by spatial and temporal changes in the types of soil salinity and the degree of soil salinity (*Fig.3-3*). The emergence of active foci of marshlands and coastal solonchaks (wet and puffy solonchaks) depends on the texture of the sediments, the rate of drop in sea level, the salinity of the soils, and the declining levels of groundwater and level of its mineralization. Inadequate functioning of drainage and changes in hydrogeological regime in the former Aral Sea area determine the development of new types of soil salinization and formation of biotic complexes in accordance with conditions close to zonal soil-vegetation stages formation (Kurbaniyazov 2017, Novikova 2020). As a result of terrain, continuous desiccation and changes in hydrogeological conditions, various types of salt marshes are in the process of formation. In the last stages of soil genesis, the solonchak processes slow down, and with the increasing role of the arid-zonal factor, the development of the soil proceeds typically along the lines of sandy desert typology.

Table 3-1 Soil types of the dry seabed and their salinization levels

Salt formation	Area, 1000 ha.	%
Swamps	7204.9	1
Marshes	387350.6	28
Hydromorphic salt formations	760671.3	55
Automorphic salt formations	222272.9	16

Note: According to the FAO classification of soil groups, Solonchaks belong to the group of intrazonal highly saline soils, defined by high soluble salt accumulation within 30 cm. (https://www.merriam-webster.com/dictionary/solonchak). They are similar to the salinized soils in the aridisol order of the US soil taxonomy.

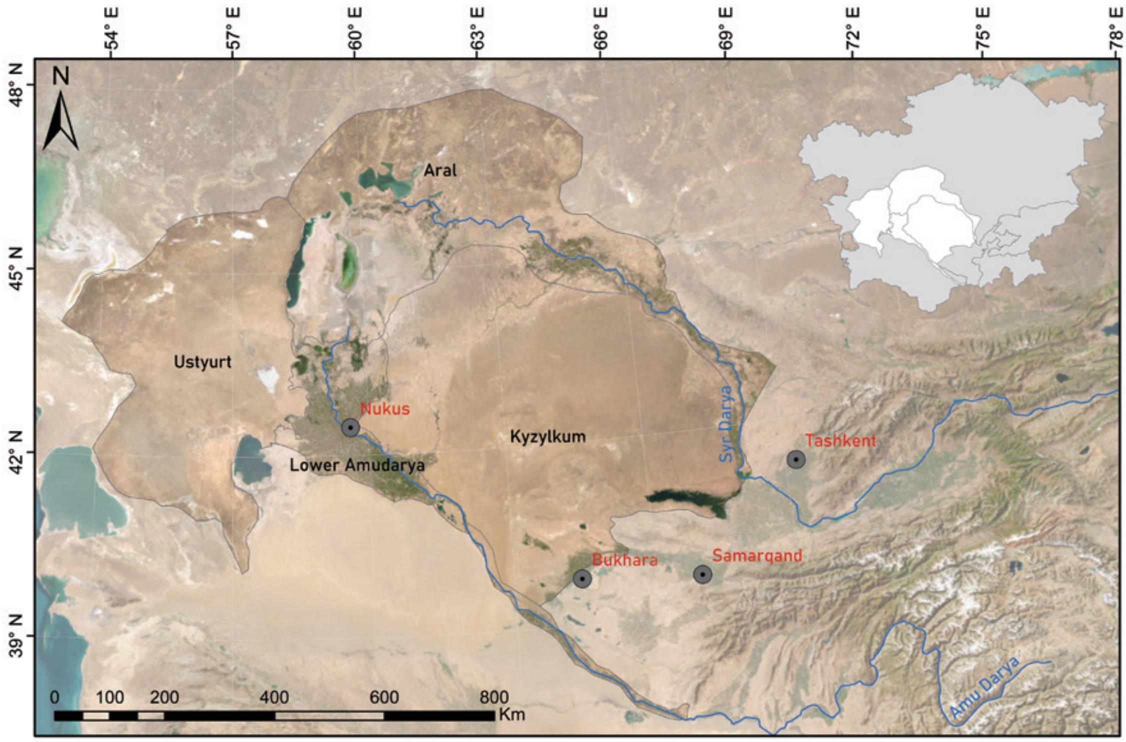


Fig.3-2 Map of phytogeographical of the Aralkum saline desert and neighboring zones (Ustyurt, Amu Darya Delta and Kyzylkum Desert), adapted by Azamat Sultanmuradov

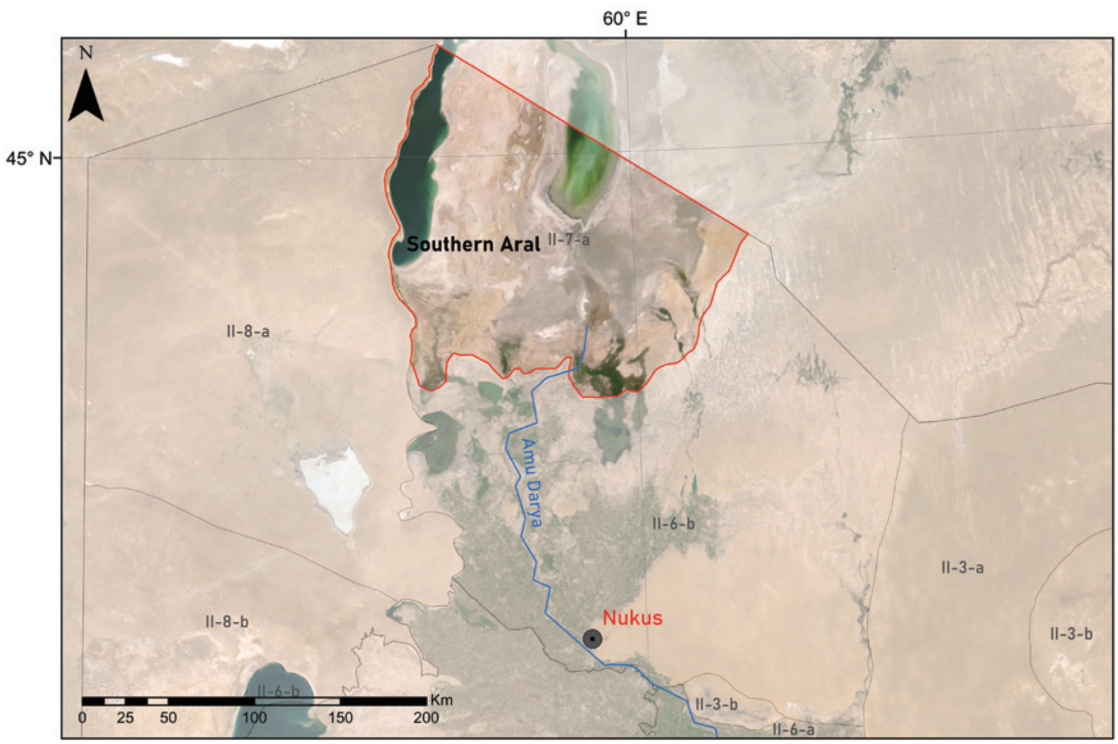


Fig.3-3 Map of phytogeographical of Aral seashore Saline Desert, adapted by Azamat Sultanmuradov

As we concluded from ***Table 3-1***, the soil-formation of the hypersaline coastal Aralkum is associated with the hydromorphic conditions of soil-forming processes, these sites occur shallow ground water (0-3 m). Hydromorphic salts formations including salt marshes represent 83% of the high saline ecosystems studied. Salt marshes are the pioneer habitats exposed to colonization by halophytes (plants that can survive in high-salinity environments). Salt marshes represent 387351 thousand hectares, i.e., 28% of the area of highly saline ecosystems (***Table 3-1***). The extent of soil salinization, abiotic and biotic interactions determine the initial establishment of salt marsh plant communities. The primary successional species are typically annuals of Amarantaceae, such as *Salicornia persica, Atriplex pratovii, Atriplex dimorphostegia, Climacoptera aralensis, C. crassa* and *Salsola nitraria*. The success of species survival in early salt marsh colonization depends on seed quality and quantity of seedbank in the soil, in addition to variables of climate and landscape. The solid residue (from surface salt crust profile) is up to 15% and is made up mostly of sodium chloride, which is considered toxic for the growth and survival of most plant species.

Hydromorphic salt formations as seen from ***Table 3-1*** occupy 55% of the dry seabed and are found in the vicinity of flooded reservoirs, saline interdune depressions, numerous residuals, and terminal (freshwater and saline) lakes of littoral of the former Aral Sea zone. These coastal areas are mainly represented by crusted, bubble and crusted-bubble saline (haplic and petrosalic solonchaks) soil varieties. Hydromorphic coastal salt formations are inhabited by halophytic vegetation (consisting mainly of species of genera *Halostachys, Halimochnemis, Kalidium, Nitraria*, and rarely by rhizomatous perennial grasses, such as *Aeluropus, Lolium, Agropyron, Aegilops, Eremopyrum* and annual herbaceous species of *Atriplex, Salicornia, Frankenia, Cressa, Climacoptera, Suaeda, Caroxylon, Limonium, Salsola* spp.). Elements of Tugai vegetation (made up predominantly by *Tamarix, Halostachys, Phragmites, Bolboschoenus maritimus* subsp. *affinis, Limonium suffruticosum, Aeluropus* spp.) are also widespread.

Automorphic soil formations are a transitional stage leading to sandy desert soils and occupy 16% of high salinity ecosystems in the area. Automorphic soil formations are developed under conditions of groundwater deeper than 5 meters and generally have a sandy texture. In undrained closed lagoons, marsh solonchaks are transformed into sor (dry) solonchaks. Automorphic saline soil formations are concentrated in the middle part of the dried seabed, as well as the eastern part of the area, adjacent to the Amu Darya delta. Changes in groundwater levels occur interconnected with soil formation and determine the dynamics of plant community successions. Complexes and combinations of mainly psammophytic + halophytic, psammophytic + tugai, halophytic + tugai vegetation types are widespread in conditions of automorphic soils.

3-2-2. Halophytic vegetation of the Aralkum saline desert and adjacent territories

Characterized by unique plants, vegetation communities and botanical diversity of the Aralkum are rapidly developing due to their young age. The peculiarity of the flora is expressed by the fact that both relict and neo-vegetation plant formations for the Turanian lowlands are represented. Moreover, the original for Central Asian deserts plant communities of mesophitic origin have been preserved on the former western shore of the Aral Sea (on the eastern elevation/cliffs of the Ustyurt Plateau). On the sands of the Aral dry seashore neohalophytic plant associations were formed, previously not observed in Uzbekistan. Notable widespread species, such as *Cutandia memphitica, Schismus arabicus, Koelpinia* *linearis*, several *Astragalus* spp. and *Artemisia* spp. were recorded.

3-2-3. Features of plant cover formation in the dry bottom and shoreline of the Aral Sea

The Aral Sea shore desert ecosystem is considered one of the most fragile under currently ongoing climate change. The dry Aral Sea seabed should be considered a new environment for colonization by halophytes, and for the conservation of halophytic vegetation (Breckle and Geldeyeva 2012). In the initial stages of the process, halophytic herbaceous and shrub species predominate, i.e., halophytes initiate the formation of primary vegetation in advance of subsequent, more stable, stages. It is characterized by reduced richness of species, especially trees and shrubs, and, thus, by low resistance to local extinctions. The vegetation cover of sandy deserts has a complicated spatial structure, which forms because of initial heterogeneity of the micro-and mesorelief landscape due to processes of soil denudation, salt accumulation and changing soil moisture content along the soil profiles. Psammophytic, halophytic, and Tugai vegetation types predominate among the plant communities here. The high level of soil salinization is dynamic and leading factor in the creation of new saline ecosystems of the Aralkum. This type of ecosystem initiates the formation of plant communities from a range of halophytic and psammophytic species. It is precisely the smooth transition of soil types in saline ecosystems that define the formation and stability of the cover vegetation. The formation of plant cover follows the desert-type plant communities formation pathway described for Central Asia, which is dominated by an integrated combination of halophytic and psammophytic desert vegetation.

As mentioned above, the colonization of bare lands of the dry seabed by vegetation is initiated by annual halophyte communities (*Salicornia, Caroxylon, Haloharis, Gamanthus, Atriplex pratovii, Climacoptera aralensis, Salsola, Suaeda* spp.). This herbaceous halophyte-dominated stage represents the synergy of three factors-groundwater depth, soil moisture and type and degree of salinization. Under such conditions, annual halophyte communities dominate for 5-10 years, producing large biomass and good quality seeds.

In particular, the annual halophyte communities established and adapted to the conditions in this biome, find themselves in completely different conditions after some years. New eco-landscapes are created by salinization and desalinization of the soil and the formation of a new lithogenic conditions for the long-term biotic colonization of the dry former seabed by different types of halophytic vegetation, dominated by halophytic shrubs (*Halocnemum strobilaceum, Halostachys caspica, Kalidium caspicum, Tamarix ramossisima, N. sibirica*). This plant formations process should be considered as a stage of the reconstruction of the primary phytocenosis of the dry Aral Sea seabed and lasts up to 40 years.

However, if we analyze the formation of individual types of vegetation in areas of the seabed that were desiccated in the early period (e.g., since 1960), we see that they are nowadays covered with stable psammophytic and psammohalophytic vegetation. Such plant cover formation is widespread in the southern and eastern part of Amu Darya delta, which represents a shallow, strongly dissected coastline with a relict archipelago of sandy islands of Kyzylkum desert. This stage is characterized by desalinization of the residual salinity of the substrate and stabilization of the lithogenic base. As a result, stable biotic zonal vegetation of the Kyzylkum psammophilous species is formed. The emergence of new phytocenosis units takes place in accordance with general phytocoenotypic regularities that have been described for similar desert areas of Central Asia, Iran and Afghanistan. Thanks to landscape interference: the combination of soil salinity and sand formation processes, new combined landscapes and vegetation types appear, the features of which are characterized by complexity and a combination of halophytes and other types of vegetation. At the same time, within the limits of the natural formation of zonal desert vegetation, halophytes usually “mix” with psammophyte and Tugai vegetation, forming other features of the phytocenosis characteristic of dried areas. Vegetation formation is a complex and lengthy process determined by plant succession, plant growth characteristics, soil salts chemistry and sand deposition patterns, which vary seasonally and annually. These have resulted in new combinations of landscapes and types of vegetation dominated by halophytic plant communities.

3-2-4. Characteristics of the main vegetation types of the dry Aral Sea seabed

The vegetation cover, which is dominated by halophytes and psammophytes, follows the desert floristic desert-type pathway described early by Akzhigitova (1982), Dimeyeva (2011) and Novikova (2020). The dry Aral Sea seabed and its adjacent territories should be considered a new environment for colonization by halophytes, and the conservation of halophytic vegetation. In the initial stages of the process, halophytic herbaceous and shrub species predominate, i.e., halophytes initiate the formation of primary vegetation in advance of subsequent, more stable, stages. The main core of vegetation of the dry Aral Sea seabed belongs to halophytic, gypsophytic, psammophytic and Tugai vegetation because of the migration and interconnection of the Ustyurt plateau, Northwestern Kyzylkum and the Amu Darya delta floras. At the current stage of vegetation formation, complexes and combinations of different species play a key role and they occupy 77% of the territory. The floristic composition of the most widespread associations of the psammophytic and halophytic vegetation combinations consists of such psammophytic species as *Haloxylon persicum, Calligonum microcarpum, Calligonum aphyllum, C. aralense, C. caput-medusae, C. eriopodum, Carex physodes, Stipagrostis pennata, Eremosparton aphyllum, Astragalus unifoliolatus, Astragalus villosissimus* and halophytic species as *Halocnemum strobilaceum, Halostachys caspica, Caroxylon scleranthum, Bassia hyssopifolia, Atriplex pratovii, Salicornia persica, Climacoptera lanata*. Most notable, as shown in ***Table 3-2*** is the combination of halophytic and Tugai vegetation (halophytic + Tugai), covering 22.7% of the total vegetation area.

Such sites are particularly common in the Karauzyak and Jiltarbus areas, where the soils are subject to constant secondary moistening by discharged water and high mineralized groundwater. The flora of these anthropogenically transformed landscapes consists of active halophytic (*Halostachys belangeriana, Halocnemum strobilaceum, Kalidium caspicum, Bassia hyssopifolia, Salicornia persica, Caroxylon scleranthum, Suaeda salsa, Suaeda crassifolia, Nitraria sibirica, Halothamnus* spp.) with Tugai elements (*Tamarix ramosissima, T. hispida, Typha angustifolia, Phragmites australis, Karelinia caspia, Alhagi pseudoalhagi, Aeluropus littoralis*) and other typical for Tugai vegetation species. Studying the Tugai vegetation of these areas is of interest for understanding the degradation of the coastal vegetation of the Aral Sea region in relation to the xerophytisation and halophytisation of adjacent territory of the Kyzylkum desert. The main dominant of The Tugai vegetation is represented by the plant formation of Tamariceta hispidae + T. ramosissimae. Due to the sharp decline in groundwater, areas with dead bushes of *Tamarix ramosissima* and *T. hispida* are often found. Plant communities of Tamarix laxae +Tamarix elongatae in combination with *Nitraria sibirica, Alhagi pseudoalhagi, Halostachys caspica, Aeluropus litoralis* and annual salsolas were recorded. Gradually, Tamarisk thickets are thinned and deep-rooted

Table 3-2 Vegetation characteristics of the southern part of the dry Aral Sea seabed

Vegetation	Formations	Associations	% Area	Stability*	
				current	future
Gypsophytic	2	4	0.8	– + +	– – +
Halophytic	5	7	5.6	– + +	– – +
Psammophytic	2	9	7.1	– + +	+ + +
Tugai	2	9	9.6	– + +	– – +
Communities and combinations:					
psammophytic+gypsophytic		7	8.9	– – +	– – –
psammophytic+halophytic		21	34.9	– + +	– – +
psammophytic + tugai		11	9.9	– + +	– – +
gypsophytic+halophytic		1	0.5	– – +	– – –
halophytic+tugai		9	22.7	– + +	– – +

*level of stability and progression: +++ satisfactory; –++ endangered; – – + critical

Alhagi species begin to dominate the herbaceous layer. In the old floodplain of the Amu Darya, black saxaul replaces *Tamarix* plant formations on takyr-like loamy soils.

The second representative of the Tugai forest vegetation is the formation of *Pragmiteta australis* and *Typheta angustifoliae*, which is located around the Sarybas, Jiltarbus and Sudoche lakes. *Phragmites* plant communities, however, are subject to constant degradation and disappearing due to the modern regulation hydraulic regime of wastewater, as well as discharged water from neighboring irrigated agricultural lands. These vegetation units are characterized by extreme dynamism. The most widespread are combinations of psammophytic and halophytic (psammophytic + halophytic) vegetation in areas where desalination occurs due to a decrease in soil chemistry and where deflation processes are active.

In this section of the book, we provide a brief description of two dominant types of vegetation in the Aralkum desert zone: gypsophyta (vegetation of the gypsum habitat) and halophyta (vegetation of the saline habitat), with the emphasis on the halophyta. We accepted the classification, widely used by Central Asian geobotanists for the description of the vegetation cover of the Aralkum desert area. Associations containing phytocenoses with a homogeneous species composition, with the same structure and restricted to similar habitats are accepted as the smallest unit of the classification. The formation included all associations characterized by a common edifice or common edifices. The formation roughly corresponds in rank to the plant union according to the Brown-Blanquet classification. The floristic characteristics of the Aralkum desert was the subject of several investigations (Breckle 2002, Breckle and Geldyeva 2012, Breckle and Wucherer 2012, Sherimbetov 2008a, b, Dimeyeva 2015, Shomuradov et al. 2021).

I. Gypsophytic vegetation type

The Vozrojdeniya island, which is a part of the Ustyurt Sarmatian plateau, reflects the gypsophytic model vegetation found in Central Asia. Representing the phytocenoses of Ustyurt and neighboring islands, such as the Barsakelmes island (Kazakhstan) only a limited number of gypsophytic species are common on these islands. Our data describe gypsophytic phytocenosis of Ustyurt as a combination of shrub, semi-shrub-perennials and annuals plant communities that are widespread on gray-brown, sandy desert, and takyr soils throughout island desert landscape. On the saline grey-brown gypsum-bearing soils of the Tertiary-Cretaceous plateau, the so-called gypsum deserts, the following species are the most common: *Artemisia terrae-alba, A. turanica*, *Caroxylon orientale, Caroylon gemmascens, Caroxylon dendroides, Anabasis salsa, Anabasis eriopoda, Anabasis brachiata, Atraphaxis spinosa, Artemisia terrae-albae, Nanophyton erinaceum, Gamanthus gamocarpus, Limonium sufruticosum, Haloharis hispida* and their plant communities. Analysis of the habitats of above listed species, where they dominate and act as components of associations, showed that in gypsum-bearing soils readily soluble salts are present in varying amounts, other than sedimentary (crystalline) gypsum. In addition, the importance of these species in the vegetation cover increases in areas where the salt content is high. These species are halophytic in their nature and show better growth, better accumulation of biomass and seed production, thus a better capacity for regeneration in saline soils. Gypsophytic vegetation, as an integral part of the landscapes of the Vozrozhdeniya Island, consists of two frequently found formations: the *Artemisieta terrae-albae* and *Anabaseta salsae* formation. The dominant species are *Artemisia terrae-albae, A. turanica, Anabasis salsa.* Plants such as *Haloxylon ammodendron, Caroxylon orientale, Caroxylon gemmascens, Caroxylon arbuscula, Caroxylon arbusculiformis* and other species are co-dominant and accompany species. Studies on *Artemisia diffusa-A. turanica-Caroxylon orientale-Caroxylon arbuscula* plant associations, common on saline gypsum soils, have shown that wormwood root systems are associated with slightly saline horizons of above-gypsum soil layer. Consequently, despite their wide distribution in such conditions, these species do not serve as indicators of gypsum soils, except for *Caroxylon orientale*, which develops a deep root system capable to penetrate deep into the gypsum layer. Another interesting feature of the gypsophytic phytocenosis of Ustyurt and the surrounding areas is the occurrence of *Haloxylon ammodendron* (Zaisan saxaul). *Haloxylon ammodendron* was described mainly in the eastern Kazakhstan and in the Dzungarian province in China, although the key habitat of this species was thought to be the Gobi Desert. Our research has broadened the known distribution of *Haloxylon ammodendron* in the Aralkum Desert, in particular at Vozrozhdeniya island (Shomurodov et al. 2021). The status of the phytocenoses of the Vozrozhdeniya island, as a single area representing the gypsophyte vegetation of the dry Aral Sea seabed, can be assessed as threatened due to active deflationary process. The formation of psammophytes (with psammophyte-shrub vegetation at late successional stages) with Tugai associations is actively growing as an indication of the rapid advance of moving sand dunes towards the island.

II. Halophytic vegetation type

The halophytic vegetation of the former dry bottom of the Aral Sea covers all landscape elements, from Tugai to gypsophytic complexes. It should be considered as a model of successional series of plant phytocenosis on saline soils, showing district patterns of changes, and reflecting the different affinities and adaptation of species and plant communities to soil salinity under the newly formed ecosystem. The halophytic vegetation is localized mainly in the central and northern parts of the dry Aral Sea seabed, and its southeastern shore. Halophytic communities capable of colonizing various saline ecotopes are replaced in a certain sequence depending on the chemistry of soil and depth of groundwater and its type and level of salinity. Four distinct stages of primary succession occurred in the Aralkum saline desert: 1) a stage of annual halo-psammophytes, represented by *Atriplex fominii, Atriplex pratovii, Salsola paulsenii, Bassia hyssopifolia*; 2) *Haloxylon ammodendron* and *Nitraria sibirica* stage on littoral saline areas with superficial sandy cover; 3) a stage of grasses (*Stipagrostis pennata*); 4) a stage of psammophylous shrubs. On slightly saline sandy areas, three stages of succession were distinguished: 1) a stage of the annual halo-psammophytes; 2) a stage of grasses; 3) a stage of psammophylous vegetation with the domination of *Haloxylon ammodendron, Calligonum caput-medusae, C. eriopodum, Xylosalsola richteri* and others. Our study showed that representatives of different life forms can appear on the initial stages of the primary succession, depending on the landform, lithology and salinity of the substrate. For example, *Tamarix hispida, T. ramossisima* and *Phragmites australis* are pioneer species on the bared sand hills along water bodies in the northern part of the Muynaq Peninsula; *Eremosparton aphyllum* is a pioneer on the aeolian sands; annual halophytes *Bassia hyssopifolia, Climacoptera aralensis, Climacoptera crassa, Atripelx pratovii* and *Atriplex fominii* appears on solonchacks on the initial stages of the primary succession (Shomurodov and Adilov 2019). Many halophytic phytocenoses are characterized by sparse vegetation cover, except for the community of annual saltworts, which often densely cover the soil surface. However, annual communities on salt marshes died up through a sharp increase in salinization of sea water and soils. This negatively affects the overall environment, leading to activation of wind deflation of unfixed bottom sands and sand-loamy soils (Shomurodov et al. 2021).

The following plant formations were distinguished at the Aralkum saline desert soils: woody-*Halodendra* (1 formation), shrubby-*Halothamna* (6 formations); dwarf shrubs-*Halothamnica* (3 formations); *Halothamnissaca* (9 formations), and herbaceous *Halopoia* (7 formations) (Breckle and Wucherer 2012, Shomurodov et al. 2021). The characteristics of the most common plant formations are listed below.

The Halocnemeta strobilacei formation: This formation is the prime colonizer of highly saline soils and is considered one of the characteristic features of the dried bottom of the Aral Sea. The dominant species *Halocnemum strobilaceum* is one of the most common and widespread species on puffy wet solonchaks in the desert. The phytocenoses dominated by *Halocnemum strobilaceum* is often found in wet and bubbly high-salinity and shallow water areas, forming large typical mounds. On the dry Aral Sea seabed, *Halocnemum strobilaceum* is a perennial succulent euhalophyte that can restore the spatial and demographic structure of its community. This indicates its high ecological and biological potential as a dominant species on wet salt marshes, salt crusted and saline sandy soils. For its normal growth and seed production requires salt in soils (NaCl >1.5-2.0%). The Halocnemetum strobilacei formation is characterized by sparse vegetation cover and extreme poor species composition, becoming at times a monodominant community. This low species richness is explained by high soil salinity, to which only a limited number of species are adapted. This explains why the association is the sole one of this type to have formed on the dry Aral Sea seabed. Among the perennial species on the wet solonchaks of the Aral Sea shores, there are species of *Kalidum capsicum*. Annual Salsolas act as obligate component and are represented by *Atriplex fominii, Climacoptera aralensis, Caroxylon scleranthum, Bassia hyssopifolia*. The average projective cover is ~15%, where *Halocnemum strobilaceum* covering ~ 8-10%. It is also distributed on gypsum sands on an area of ~1400 hectares. Species composition on this soil category is not rich, comprising of 5-6 species.

Halocnemum strobilaceum plant community is used as autumn-winter rangelands, biomass is poor

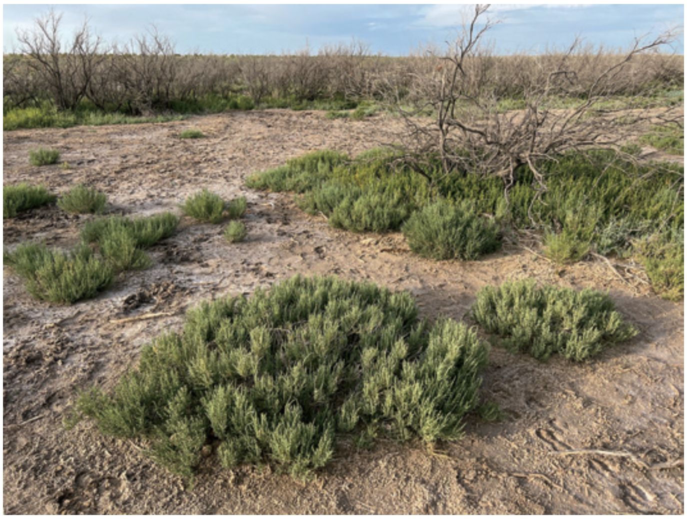


Fig.3-4 *Halocnemum strobilaceum* growing around the Aral Sea (NY)

or not eaten by small ruminants, probably because of high salt content in its succulent stems. Biomass contribution of *Halocnemum strobilaceum* plant community is about 0.15-0.25 t DM/ha.

Halostachydeta belangerianae formation: The dominant species of the formation is *Halostachys belangeriana*-an euhalophyte of the saline deserts of Central Asia. Associations of Halostachydeta belangerianae are localized only in the southern part of the dry Aral Sea seabed, those habitats where active soil moisture is preserved. In these territories, the construction of hydraulic structures is especially developed, comprising artificial lakes (Sarybas, Jiltarbus), drainage and irrigated channel systems, which contribute to the development of saline meadows soils as typical habitats for the emergence of the Halostachydeta belangerianae formation. In addition, representatives of the forming of sparse communities of the Halostachydeta belangerianae formation, are restricted to the residual coastal salt marshes in the central parts of the dry Aral Sea seabed. On the saline meadows in the southern territories, the *Halostachys belangeriana-Kalidium caspicum* association predominates. This formation often penetrates and mixes with Tugai formations because of the dynamic hydrological regime of the Tugai floodplain in recent years. The species composition is rich (up to 25 species). *Tamarix laxa* is involved as an obligate component; *Aeluropus litoralis, Karelinia caspia, Juncus articulatus, Bolboschoenus maritimus* subsp. *affinis* are facultative halophyte. Projective cover in this phytocenoses averages 40%. The formation of pure *Halostachys caspica* and *Halostachys caspica* +*Tamarix ramosissima* associations in the dry Aral Sea seabed often occurs in salt marshes of the coastal zone with a surface sand layer, as well as meadow soils with high salinity. Sand mounds of ~ 1.5 m in height can be formed by wind under *Halostachys caspica* bushes. The associations include annual salsolas, such as *Atriplex pratovii, Climacoptera aralensis, C. crassa, C. lanata*, species of *Suaeda, Haloharis hispida* and, which are characterized by their sparse growth. The productivity of these phytocenoses ranges from 0.1 to 1.5 DM/ha. They can be used as summer and autumn-winter rangelands.

***Nitrarieta sibirica* formation:** *Nitrarieta sibirica* is a representative of ancient desert flora. The formation of *Nitraria sibirica* is unique to Uzbekistan. The formation of this phytocenosis requires special conditions, such as coastal sand-clay lowlands or the shores of salt lakes, which are not so common for the landscapes of the Aral Sea basin. Representatives of this formation are found in only two geographical areas in Uzbekistan. The first is in the Assak-Audan depression of the Karakalpak Ustyurt, which in ancient times was filled with water. The second, the youngest cenoses are located on the dry Aral Sea seabed. The most interesting feature of the *Nitraria sibirica* formation is a special landscape feature called "chukolok", which are mounds ~1.5-2 m in height. The chukoloks are relics of coastal forests-Tugai, at a time when they were water-filled lakes. This formation was described on Lazerev island, where white loose silty sands derive from lake sediments. The formation of *Nitraria sibirica* stretches for 1.5-2 kilometers, occupying the entire eastern side of the island. Some unstable cenoses of *Nitraria sibirica* are found in the southwestern coastal part of the Aral Sea seabed, forming complexes with *Halostachys caspica* and *Tamarix pentandra. Nitraria sibirica* is a dominant species of this formation.

Obligate components are *Tamarix* ramosissima and black saxaul *Haloxylon ammodendron*, with annual *Salsola* spp., *Atriplex fominii*, *Climacoptera crassa*, *Salsola paulsenii* being facultative members of this formation. The area of the *Nitrarieta sibirica* formation occupies 1014.9 hectares, the average seasonal yield makes 0.13 t/ha. Seasonal fodder is used as autumn-winter rangelands and as vitamin-rich fodder for sheep and camels.

Haloxyleta ammodendrony formation: According to ecological, phytocenotic, landscape and economic criteria, the Haloxyleta ammodendrony formation is one of the most unique and characteristic of desert vegetation in Central Asia. The Haloxyleta ammodendrony formation is associated with littoral zones, from which it widely spread into clay saline and sandy deserts. The dry seabed of the Aral Sea is an arena for the disbursement of the black saxaul formation due to its wide range of tolerance to saline soil conditions. The euhalophytic (high salinity soils), hemihalopsammophytic (sandy, low-saline soils) and halopelitophytic (saline takyr soils) ecological groups of the black saxaul are widespread in the study area, demonstrating a wide penetration of this species on all landscape elements of the former dry bottom of Aral Sea. The black saxaul (*Haloxylon ammodendron*) association is found in automorphic and semi-automorphic coastal salt marshes (***Fig.3-5***). At the same time, it forms sparse cenoses on crusted-bubble, weak-crusted and crusted-high-saline chloride-sulphate soils. The solid

Fig.3-5 The black saxaul (*Haloxylon ammodendron*) association around the Aral Sea (NY)

residue ranges from 1.0 to 9%. At the same time, it forms sparse cenoses on crusted-bubble, weak-crust and crusted high-salinity chloride-sulfate soils. The species composition of the euhalophytic black saxaul formation on solonchaks and high saline soils is accompanied by typical halophytes: *Halostachys capsica*, *Kalidium capsicum*, *K. foliatum*, *Halocnemum strobilaceum*, on the solonchaks margins *Caroxylon orientale*, *Caroxylon dendroides*, *Halothamnus subaphyllus*, *Anabasis aphylla*, *A, eriopoda*, *A. brachiata*, *Limonium suffruticosum*, *Halolachna soongarica* and in small ratio *Halimocnemis longifolia*, *Nanophyton erinaceum* and annuals like *Girgensohnia oppositiflora, Ceratocarpus arenarius, Salsola paulsenii, Soda foliosa, Salsola nitraria, Caroxylon scleranthum, Climacoptera aralensis, C. lanata, C. crassa* and species of *Suaeda.* The annual and ephemeral species play an insignificant role as fodder, especially in drought years. In areas with shallow water table, *Halostachys caspica*, *Tamarix pentandra* and *T. hispid*a, rarely *Lycium* spp. participate as facultative species and are represented in the composition of euhalophytic black saxaul formation. Unfavorable abiotic conditions, however, affect the condition of the black saxaul. It reaches a height of only 1.5 meters. The process of self-propagation of the black saxaul is also significantly slowed down. According to the life forms, the distribution of species of euhalophytic Haloxyleta ammodendrony formation is as follows: trees, shrubs and semi-shrubs-11 species (16.4%), semi-shrubs and shrublets-9 species (14.2%), perennial grasses-3 species, annual grasses-42 species (21%), summer grasses-7 species (11.1%) and ephemers, which account for about 33.2% of the total number of species (Akzhigitova 1982). The euhalophytic formation of Haloxyleta ammodendrony is widespread on the fringes of the drainless depressions of Ustyurt. Massifs of this formation have been also described in Barsakelmes, Saksaulsae, Karatyuley, Kyzylstau (in Karakalpakstan). It is also restricted to the most saline interdune lowlands in the northern and western parts of the Kyzylkum Desert. Nowadays the Haloxyleta ammodendrony formation was stabilized in the transition of desert-sandy soils, which allows the reconstruction of the environment for psammophylous vegetation for the further stage of plant succession under ongoing salinization and climate change.

Kalidieta caspici formation: Pure stands of *Kalidium caspicum* (monodominant formation) have been described in the lower reaches of the Amu Darya (old delta plain on alluvial soil with a high salt content), Lazerev and Vozrozhdeniya islands and surrounding Barsakelmes on puffy solonchaks as a narrow intermittent strip (***Fig.3-6***). *Kalidium capsicum*, Halostachys caspica-*Kalidium capsicum* and *Caroxylon orientale-Artemisia terra-albae-Kalidium capsicum* associations with annual *Salsola* species are the most common composition of this formation.

On Ustyurt plateau, *Kalidium* occurs patchily in small bowl-shaped depressions with a high salt content in the upper soil horizon. A short-tall *Kalidium foliatum* with participation of singular individuals of *Limonium*, *Climacoptera*, *Psylliostachys, Haloharis hispida*, *Frankenia pulverulenta* species inhabited surroundings Again artesian well in Ustyurt. The plant communities dominated by *Kalidium* species belong to salt-accumulating plants, capable of transporting/translocating 40% mineral substances in their tissues.

Annuale salsolosa formation: In the vegetation cover of the dry Aral Sea seabed, the most common landscape formation is the annual *Salsola* formation (Annuale salsolosa). The formation is confined to hydromorphic and semi-hydromorphic coastal salt marshes. They characterize the pioneer stages of the primary growth of the dried seabed during the period of its drying out. Associations of the Annuale salsolosa formation and their sparse groups exist on the Aral seabed for no more than 1-5 years (***Fig.3-7***).

Fig.3-6 Monotypic Kalidieta caspici formation at the puffy solonchak near coastal line of the Aral Sea, June 2023 (NY)

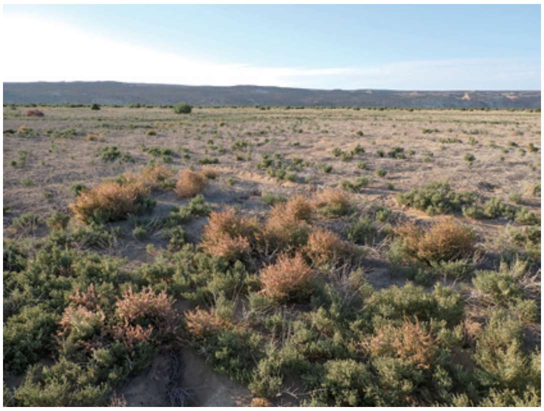


Fig.3-7 Annuale salsolosa formation is dominant in vicinity with dry seashore of the Aral Sea (View from the Ustyurt plateau, September 2023 (NY)

One of the leading elements of the Annuale salsolosa formation are mixed annual *salsola* communities made up of *Salicornia persica*, *Suaeda heterophylla*, *S.crassifolia*, *Climacoptera lanata*, *Salsora nitraria*. Depending on the dominance of a particular species, formations with a predominance of these *Salsola* spp. are distinguished. In each of them, the species are co-dominants of varying significance. In terms of species importance in the grass stand formation, *Salicornia persica* and *Suaeda crassifolia* are less present. They are unusual water-loving plants and germinate under hydromorphic soil conditions. The monocenosis of *Salicornia persica* is the most unique. In favorable years, on hydromorphic salt marshes, where soil salinity exceeds 15%, *Salicornia persica* forms a monodominant community, a landscape that is surprisingly colorful. The projective cover of the formation is low, usually ranging between 3% and 10%. However, in favorable years it reaches up to 35-40%, where *Suaeda crassifolia* and *S. paradoxa* forms continuous thickets with a height of 40-60 cm.

Among the annual halophytes, the settlements of the rare species of *Atriplex pratovii*, a neo-endemic along the shores of the dry Aral Sea seabed, are of greatest interest. Quite extensive hydromorphic communities of *Atriplex pratovii* are localized in areas near the former islands of Lazarev, Vozrozhdeniya, Konstantin, and in the Akhantai saline soils. The range of *Atriplex pratovii* as a dominant species is apparently shrinking due to the desalination of the areas. The soil under the Annuale salsolosa formation is characterized by the accumulation of salts in the root zone (TDS as of 10-20%). Chloride and chloride-sulfate are predominant type of salinization. These areas, in fact, are a dangerous source of salt and dust transfer.

3-3. Vegetation and botanic diversity of Ustyurt district

The Turanian plain consists of pre-Quaternary and Quaternary formations derived from shallow-sea sediments, covered by alluvial deposits from the eastern mountain-fed rivers. To the West are gypsyferous formations, some 150-200 meters above the Aral Sea depression form the Ustyurt plateau (*Fig.3-8*). Deeply dissected, it contains numerous salines and gypseous endorheic depressions. The plateau ends up to the east with high cliffs (“Chinks”) plunging some 100 m onto the Aral Sea shore and the Amu Darya delta. The territory of the plateau includes the borders of Uzbekistan, Turkmenistan and

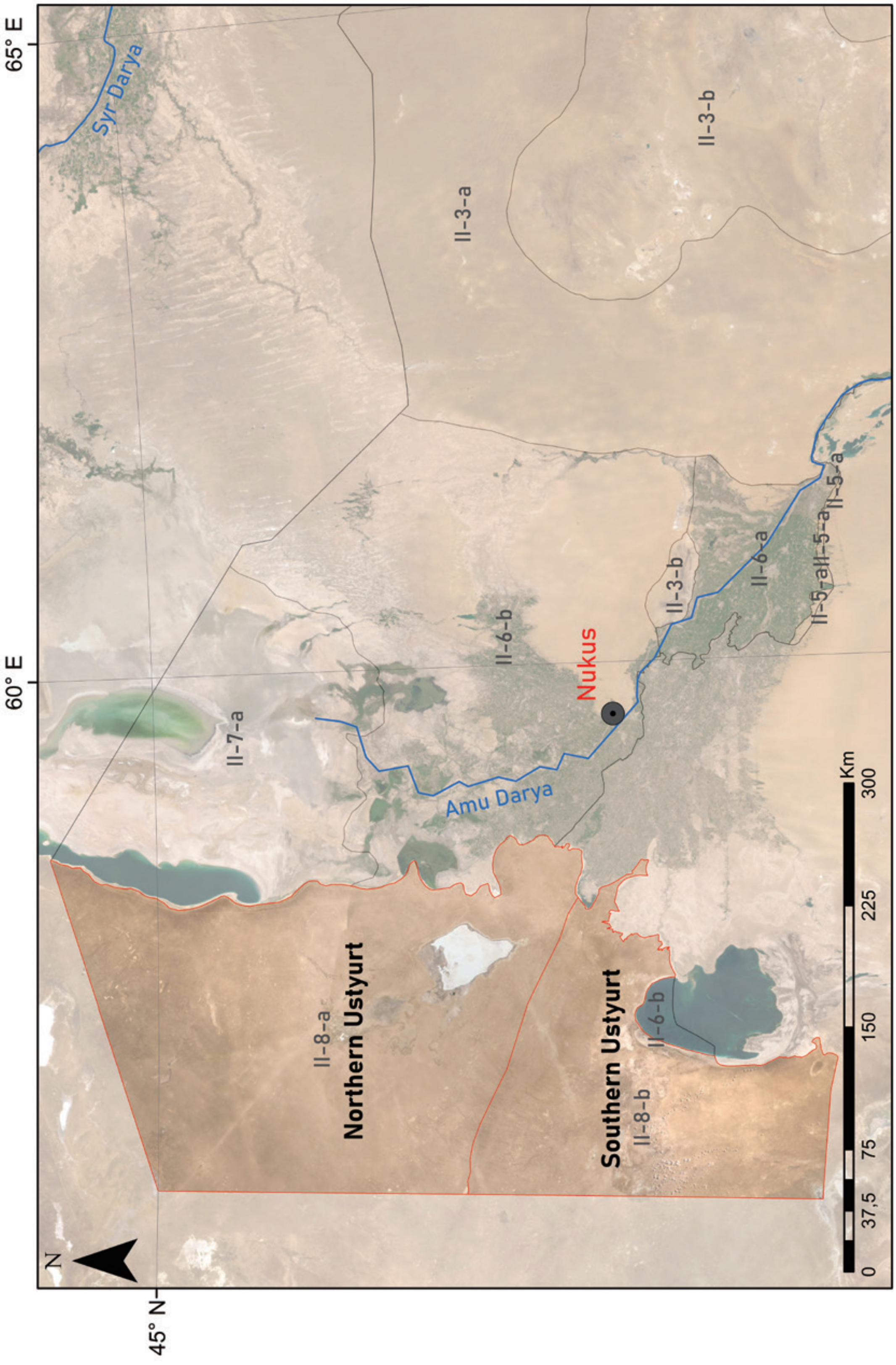


Fig.3-8 Map showing the Ustyurt

Kazakhstan, and the area is 20 million hectares, about 35% of which (7 million hectares) is located on the territory of the Republic of Uzbekistan (Karakalpak Ustyurt) (Bykova 2017).

From the Uzbek side, as mentioned by K. Tojibaev et al. (2016), two distinct regions are identified: North Ustyurt region is located to the north of the ridge Karabaur and covers most of the Karakalpak Ustyurt. South Ustyurt region covers the Uval Karabaur ridge and territory of the plateau to the south from upland, including the Assake-Audan depression and the northern part of the ridge Kaplankyr. The steep limestone cliffs change abruptly into a flat plateau. The broken line of the east cliffs delimits the east part of the plateau, the former shores of the Aral Sea that used to be much bigger (Rakhimova et al. 2018). Its geographical position and flatness reinforce its extreme climatic continentality. It is also very peculiar for Middle and Central Asia as the annual distribution of rainfall shows that about 20 % of the precipitations falls during summer. Winter temperatures are the lowest for a desert zone: the average temperature in January is –6 °C with absolute minimum of –38 °C in Karakalpakstan. Maximum temperature in summer reaches up to + 48 °C. The average annual rainfall is around 120-180 mm. The soils are the gray-brown desert and gypsiferous soils 60-70 cm deep. The plateau has no permanent streams, but there are temporary springs. By geobotanical classification, the Ustyurt plateau is a part of the northern Turan province (Rachkovskaya 2003, Tojibaev et al. 2016, Adilov et al. 2021). The Ustyurt plateau is recognized as a world-ranking ecoregion among other 200 (Global-200) of the most outstanding biological characteristics of terrestrial, freshwater, and marine ecosystems of the Earth (Olson et al. 1998). The increase in the Si-drought indexes over the last 36 years led to changes in plant community composition, vegetative cover, and species richness (Adilov et al. 2018). Basal xerophytes and halophytes like *Tamarix androssovii*, *T. hispid*a, *T. laxa*, *Halocnemum strobilaceum*, *Anabasis salsa*, *Haloxylon ammodendron*, *Caroxylon orientale*, *Nanophyton erinaceum*, *Artemisia terrae-albae* and others dominated. The invaders include *Artemisia diffusa*, *Artemisia turanica*, *Atraphaxis spinosa* and *Caroxylon arbusculiformis*, which were insignificant in the vegetation cover before the crisis in the Aral Sea. The vegetation cover of Ustyurt has evolved under extreme xerothermic environmental conditions, saline and gypsiferous soils that determined the rather uniform, but original character of the vegetation. It is a transitional area between the northern (sagebrush-saltwort) and southern (ephemeral-sagebrush) deserts. The flora of Ustyurt, according to B. Sarybaev (1994) and Tadzhetdinova (2014), included more than 724 species belonging to 295 genera and 59 families. The representatives of the ancient xerophilous family of Amaranthaceae (former Chenopodiaceae) occupy the leading position (162 species or more than 22% of the flora). Our recent studies contributed to adding new species to the flora of Ustyurt. Among them, important species are *Climacoptera crassa*, *Atriplex dimorphostegia, Kaviria gossypina, Caroxylon laricinum*, *Astragalus vulpinus*, *Centaurea apiculata*, *Jurinea schischkiniana* etc. A new endemic species of *Allium ravenii* has been described (Khassanov et al. 2011).

The more mesophytic *Artemisia terrae-albae* has declined significantly, while the more xerophytic *Artemisia diffusa* has increased in abundance. Seasonal sharply changeable climatic variables in combination with shrinkage of the Aral Sea maintained the general trend of xero-and halophyliztion of the Ustyurt environment. Mesophytic plant communities, including riparian forest, meadow, and steppe vegetation, are changed towards decreasing plant species diversity, with decreasing mesophytic plant communities. Appearance of new species combination occurs in the intermediate stages of development of these plant communities in the eastern cliffs, leading to the dominance of xerophytes and halophytes.

Anabasis salsa, *A. eriopoda*, *Caroxylon arbuscula*, *C. gemmascens*, *C. orientale*, *Halochemum strobilaceum*, *Nanophytom erinaceum*, *Halothamnus subaphyllus* with participation of annual species, such as *Climacoptera aralensis, C. lanata, Haloharis hispida, Gamanthus gamocarpus, Caroxylon scleranthum*, *Salicornia persica*, also species of genus *Halimochnemis, Suaeda* and others in association with *Artemisia* species displaying a leading presence on the Ustyurt plateau. On slightly salty areas of deserts rangelands and during the years of high rainfall, the high-quality and exceptional abundant development of ephemerals and ephemeroïds is common.

The undesirable features of gypseous desert rangelands of Ustyurt are their low grazing capacity, highly variable fodder production between years and within seasons, and deficiencies in summer animal feed. The *Artemisia* rangelands dominated by *A. terrae-albae, A. diffusa, A. halophila* in co-dominance with *Anabasis eriopoda, Caroxylon arbuscula, C. gemmascens*, *C. orientale, Halothamnus subaphyylla* and with annual species, such as *Caroxylin schleranthum, Halimochnemis, Climacoptera, Gammanthus gamocarpus* are the most valuable in terms of yield capacity, fodder value and plant palatability in the plain areas of Ustyurt. The *Artemisia* plant community produces and store satisfactory quantities of fodder supplies in all seasons of the year. *Anabasis* rangelands, despite its poor palatability, are generally used as a fodder reserve for autumn-winter period, especially for wildlife animals, camels, horses, while are less suitable for small ruminants (***Fig.3-9***).

Gypsophytes and phreatophytes (species that depend for their water supply upon ground water) are mainly observed in the cliff (at elevations), the mesophytes species, such as *Crataegus korolkowii, Rosa laxa, Clematis orientalis, Tamarix rammossima, Haloxylon ammodendron, Phragmites australis* are predominated in the bottoms of the ravines of the Ustyurt plateau. The most found sub-dominant and accompany species on these habitats are *Geranium transversale, Taraxanum bicorne, Tulipa biflora, Thalictrum isopyroides, Tragapogon marginifolius, Rosa laxa, Elymus repens, Agropyron fragile, Crataegus korolkovii, Corydalis schanginii, Galium pamiralaicum, Cressa cretica, Allium caesium, Gagea afganica, Medicago sativa, Strigosella africana, Cynoglossum viridiflorum, Convolvulus* spp., *Cynanchum sibiricum.*

Fig.3-9 *Artemisia terrae-albae –Anabasis* pasture at plateau Ustyurt eaten by camels all year round (KS)

Fig.3-10 Gypsophytic plant communities at Ustyurt cliff (NY)

Fig.3-11 *Artemisia terrae-albae* growing on the Ustyurt plateau (NY)

The floodplain woody species are patchily found also on the eastern cliff of the Ustyurt plateau. This type of vegetation is represented by fragments of the Tugai vegetation (Potamothyta according to the classification of Z.A. Mailun 1973) that occurred temporarily around natural springs and related to the water table fluctuation. The Tugai vegetation depends on the surface drainage and precipitations, with the relief interposed by small depressions surrounded by prevailing desert vegetation. Dominants of Tugai communities (*Tamarix* spp., *Crataegus korolkowii, Rosa laxa, Phragmites australis, Agropyron fragile, Rosa majalis* and *Malacocarpus crithmifolius* and others) have a northern origin and are highly resistant to excessive soil moisture and salinization.

The specificity of the floristic composition is underlined by the relatively low percentage of annuals, which is typical for Ustyurt plant communities. The endemic element of the flora of the Uzbek part of the Ustyurt is also represented by *Climacoptera ptiloptera* and *Allium ravenii*. Among the sub-endemic species, there are rare stenotopic plants that connect the flora of Ustyurt with the relic flora of Kyzylkum mountains. These include *Lepidium subcordatum, Xylosalsola chiwensis, Scorzonera bungei* and a rare endemic of the Caspian and Aral deserts *Euphorbia sclerocyanthium*. The most important species in the flora of Ustyurt are *Rhaponticum nitidum, Crambe edentula* (*from Brassicaceae*). Among others frequently occur *Anabasis ebracteolate, Artemisia kelleri, Arthrophytum lehmannianum, Climacoptera aralensis, Ferula lehmannii, Inula multicaulis, Matthiola robusta, Rhaponticum nitidum, Crambe edentula* (from Brassicaceae), *Rheum tataricum* and others.

In the southern part of the Ustyurt district on the territories of the Karabaur uval, Assake-Audan basin, and the northern part of the Kaplankyr uvala, unique phytocenosis which includes species listed in the Red Book of Uzbekistan was described. *Euphorbia sclerocyanthium, Malacocarpus crithmifolius, Xylosalsora chiwensis* are rare endemic species of the Aral-Caspian deserts. *Malacocarpus crithmifolius* is a rare relict species of monotypic Iranian-Central Asian genus of ancient xerophylous vegetation from the family Zygophyllaceae, historically associated with African savannas.

One of the unique territories of Ustyurt is the eastern cliff. The eastern cliff is a vast, morphologically rugged, arid, rocky desert. It borders the eastern part of the plateau with a broken line and serves as its natural geographical boundary. The Aral Sea, which bathes the eastern cliff, influences its climate-fogs are quite frequent here, the air is more humid, and precipitation is somewhat higher than in the plateau areas far away from the sea. The role of the terrace stretching from south to north is significant.

In this regard, the vegetation of the eastern cliff is unique in its composition of representatives of azonal and intrazonal plant types, which are not found in other desert regions of Central Asia. An example is the local distribution on the terraces of the eastern cliff of representatives of Tugai-woody (*Tamarix* spp., *Crataegus korolkowii, Rosa laxa*), Tugai-herbaceous (*Calamagrostis purpurea, Phragmites australis*) vegetation. This type of vegetation is represented by fragments of the Tugai vegetation that occurred temporarily around natural springs and related to the shallow water table level. The Tugai vegetation depends on the surface drainage and precipitations, with the relief interposed by small depressions surrounded by a predominance of desert vegetation. Dominants of Tugai communities have a northern origin and are highly resistant to excessive moisture and salinization.

The eastern cliff is presented by meadow (wild form of *Medicago sativa*), steppe (*Elymus repens, Agropyron fragile*), mountain-ephemeral (*Corydalis schanginii, Geranium transversale, Cynoglossum viridiflorum, Thalictrum isopyroides*) vegetation. Gypsophytes and phreatophytes are mainly observed in the cliffs (at high and medium elevations). *Clematis orientalis, Tamarix ramosissima, Haloxylon ammodendron* are predominant in the bottoms of the ravines of the Ustyurt plateau. The most commonly found subdominant and accompany mesophyte species on these habitats are *Taraxacum bicorne, Tulipa biflora, Tragopogon marginifolius, Galium pamiroalaicum, Cressa cretica, Allium sabulosum, Gagea afghanica, Strigosella africana, Cynanchum thesioides, Potentilla supina, Ranunculus platyspermus.*

It should be noted that in the process of climate aridization, resulting from the drying of the Aral Sea, the significance of the distinctive relief structure and hydrothermal conditions of the eastern cliff is diminished for the existence of unique vegetation in the Aral Sea region. There is a gradual disappearance of representatives of Tugai, meadow, mountain, and steppe vegetation, primarily accompanied by a decrease in the biodiversity index. In addition, due to human activity in the ecosystems of the eastern cliff, invasions of ruderal species such as *Rhaponticum repens* and *Dodartia orientalis* are observed, along with the aggression of native species such as *Echinops meyeri* and *Rosa persica* due to xerophylization.

3-4. The Kyzylkum desert district of the Turan province and neighboring areas

The Kyzylkum (the name that translates as “the red sands”) is located between two largest rivers of Middle and Central Asia, the Syr Darya to the east and the Amu Darya to the south and southwest (*Fig.3-12*). These two rivers spring from the massive mountain chains of the Tien-Shan, Pamir-Alay and the Turkestan to the west and the south-east respectively and drain into the Aral Sea to the north-west. To

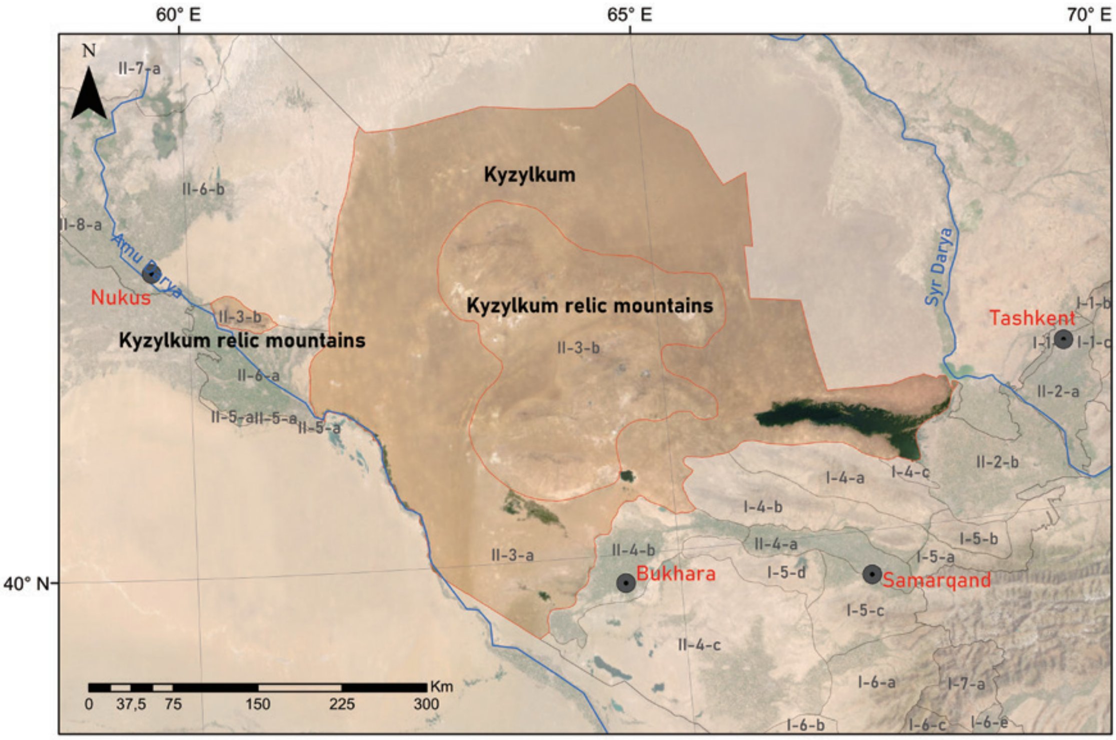


Fig.3-12 Map of Kyzylkum Phytogeographical district (from Uzbek side)

the east of the Amu Darya delta lies the Kyzylkum desert covering some 300.000 km² and extending into the Karakum desert (“the black sands”) in Turkmenistan.

The Kyzylkum is mostly covered with recent eolian and sand dunes (named locally “barkhans”, interspersed with “takyr” and “solonchack” saline depressions. A few mountains chains (Aminsatau, Bukantau, Etymtau, Kul’dzhuktau, Tamdytau, Sultan-Uweiss, etc.) to 800-900 m in height are emerging from the Kyzylkum. The eastern and the western hills of the Kyzylkum and the Nuratau range represent a link between the mountain system of Central Asia and the Ural through the Mugodzhartau mountains. The ancient Zarafshan river and its now-dry tributaries spread its quaternary alluvial deposit on the southeastern Kyzylkum. To the east and the south Kyzylkum, the clay and loess deposits are dominant in the Karnab-Mubarek steppe. Many solonchak depressions (Ayakagitma, Mingbulak, Beshbulak, Kulkuduk, Karakata, Karasugursk, Kukayaz) are located between sandy-loam/clay soil formations and large sand dunes areas. The above-mentioned geomorphological elements of the Kyzylkum desert determine the diversity of soil types: red sands, gray-brown steppe soils, gray-brown gypsiferous, takyr, saltmarsh (solonchak-alkaline soils). The Uzbek “Chul” are gently rolling lowlands with elevation between 100 to 500 m. It encloses heterogeneous environment comprising sand dunes, gypseous flats, clay and solonchaks depressions. It undergoes extreme continental arid conditions, limited and unreliable winter precipitation (MAP = 100-180 mm), a high level of evapotranspiration, extreme daily, seasonal, and annual fluctuations of air temperatures, soils with high salinity and gypsum content. The Kyzylkum desert ecosystems display a unique natural landscape of complex ecological niches where the richest desert fauna and flora biodiversity is found. In addition, in these deserts’ biotopes, there are many small lakes and ponds, where during migrations a wealth of aquatic birds can be observed.

The distinctive features of sandy desert from other desert types are due to the sand properties: a high-water infiltration rate, a mobile substrate, a significant condensation ability, and a low salinity. Moreover, the sandy substrate differs from other substrate by a more favorable water regime that provides a long period of growth for the vegetation because of easily available stored water in the soil profile. Conversely, several negative aspects affect the plant cover on sandy soils such as sand mobility which limits plant establishment, poor soil structure and low organic matter. It is easily loosened under grazing livestock and trampling by animals.

Kyzylkum district is the largest among the botanical-geographical districts of Uzbekistan; it covers the entire territory of the Kyzylkum desert. Regions of the Kyzylkum botanical-geographical district include: II-3-a Kyzylkum, II-3-b Kyzylkum relic mountains. Regions of the Bukhara district: II-4-a Middle Zeravshan, II-4-b Lower Zeravshan, II-4-C Karshi-Karnabchul. II-2-a Chinaz region of the Middle Syr Darya district. II-5-a North-East Karakum region of the Karakum district. Regions of the south Aral district: II-6-a Khorezm, II-6-b Amu Darya delta. Regions of the Nuratau district: I-4-a Nuratau, I-4-b Aktau, I-4-c Nuratau relic mountains. Regions of the Kuhistan district: I-5-a North Turkestan, I-5-b Malguzar, I-5-c Urgut, I-5-d Zirabulak-Ziadin. Flora of Kyzylkum district includes Irano-turanian, Turanian-Caucasian and/or Turanian-European elements (Tojibaev et al. 2016a, b).

According, to Khassanov et al. (2011), the flora of Kyzylkum contains no less than 1043 species with 41 endemic and 11 sub-endemic species. The dominant plant communities are perennial saltwort (*Caroxylon arbuscula, C. arbusculiformis, C. orientale*), sagebrush (*Artemisia diffusa, A. turanica*), *Convolvulus hamadae* characteristic of gypsum desert, as well as the psammophylous and halophytic communities represented by *Haloxylon persicum, calligonum* spp., *Astragalus unifoliolatus, A. villosissimus* and others; fragments of Tugai vegetation are found on the dry riverbeds. Kyzylkum botanical floristic district is characterized by the richest plant diversity and a high level of endemism. Approximately 2/3 of the endemic species of Kyzylkum grow in the relic low mountains like Kulduktau (Zakirov 1973, Khassanov et al. 2011).

Rare and endangered endemic species of the Kyzylkum are: *Stipa aktausensis, Astragalus holargureus, A. adylovii, Eremostachys eriolarynx, Bryonia melanocarpa, Silene tomentella, Lappula aktaviensis, Lepidium subcordatum, Eremurus korolkowii, Ferula kyzylkumica, Lagochilus vvedenskyi* (Sherbayev 1988, Shomurodov et al. 2015) (***Fig.3-13***-***Fig.3-15***).

The particularity of sandy soil in Kyzylkum desert induces the formation of a special ecological group of plants, named psammophytes that include all kind of plants forms, from annuals, perennials tall herbs, shrubs, shrublets to trees. The landscape physiognomy and vegetation structure are like the fixed sand dunes of the Djeiffara plain in Libya (Gintzburger et al. 2003), despite noticeable differences in climate. Vascular plants of Kyzylkum desert belong to some of 70 families and about 410 genera. Most frequent are species of Amaranthaceae, Polygonaceae, Asteraceae, Poaceae, Brassicaceae, Lamiaceae, Apiaceae, Caryophyllaceae, Liliaceae and Boraginaceae. More than 75 % of these species belong to endemic plants of Central Asia, and some 34 species among them are endemic to the Kyzylkum. Many others belong to the Irano-turanian, Turanian-Caucasian and/or Turanian-European elements.

According to their phenology and seasonal rhythm of growth (Korovin 1962, Granitov 1964, Akdzhigitova 1973, Gintzburger et al. 2003), the Kyzylkum most important species may be classified into:

- Spring-summer active (258 species, approx. 35%)
- Summer active (143 species, approx. 19 %)
- Summer-autumn active (138 species, approx. 19 %)
- Autumn-winter-spring active (103 species, approx. 14 %)
- Spring-summer-autumn active (96 species, approx. 13 %)
- All over year active (4 species; 0.5 %)

Fig.3-13 *Artemisia* pastures with *Acanthophyllum krascheninnikovii* in Central Kyzylkum Desert (KS)

Fig.3-14 Plant association of *Eremurus korolkowii* (endemic) in the southern part of Kuldjuktau (KS)

Fig.3-15 Endemic species of the Kyzylkum desert under protection (KS). a: *Astragalus centralis* b: *Astragakus kuldzhuktauense*, c: *Iris hyppolyti*, d: *Eremostachys eriolarynx*

Interesting enough, we notice many plants from this desert have some summer activity and that about 19% are specifically summer-active, very likely because of the ability to dip their roots deep (-10 to -30 m) into the soil and into high or perched water table common in the Kyzylkum and the Karakum desert as it is the case for the *Haloxylon ammodendron, H, persicum, Ammodendron conollyi*, species of genus *Calligonum* and others. This is a definite environmental advantage that few other plants have in other hot deserts of the world.

About 60 basic plants associations were described. Most dominant are the following ligneous associations making up to 30 % of the Kyzylkum flora:

◦ Micro-nanophanerophytes: *Haloxylon persicum, H. ammodendron, Ammodendron conollyi, Xylosalsola richteri, X. paletzkiana* all over sand dunes.
◦ Nano-phanerophytes: *Xylosalsola arbuscula, X. arbusculiformis*, many species of *Calligonum, Ephedra strobilacea, Astragalus unifoliolatus, A. paucijugus, A. villosissimus* on fixed dunes.
◦ Chameaphytes: *Convolvulus divaricatus, C. hamadae* (characteristic for interdune with compacted sands), *Artemisia eriocarpa, Artemisia diffusa, A. turanica, Halothamnus subaphyllus, Acantophyllum borszovii, A. elatius, Caroxylon orientale* etc.
◦ Ephemeroïds and grasses (about 10%): *Carex physodes, Poa bulbosa*, which frequently makes a continuous carpet over the sand dunes with a 2-4 cm mat of superficial densely interwoven roots. It dominates the vegetation cover. Also remarkable is a large Apiaceae: *Ferula foetida.*
◦ Perennial grasses (20%) with a dominance of *Stipagrostis pennata* and *S. karelinii*, over fairly

mobile sand. They are good sand fixing pioneer plants.

- Annual summer plants make about 40% species among sandy deserts flora: *Agriophyllum latifolium, A. minus, Corispermum lehmannianum* and *Salsola paulsenii, S. praecox, Turania aperta, Climacoptera lanata, C. crassa.*
- Ephemerals like *Eremopyrum distans, E. orientale, E. buonapartis, Senecio subdentalis, strigosella grandiflora, S. africana, Isatis violascens, I. minima, Tetracme recurvata, Streptoloma desertorum, Microcephara lamellata*, etc.

The Kyzylkum sandy desert rangelands provides the major source of fodder for Karakul sheep and other small ruminants, wild animals, camels, horses. The essential features of this sandy desert are the relative rangelands yield stability that could be grazed all year round. The rangeland of the eastern and western hills of the Kyzylkum are mostly used as autumn-winter rangelands with unreliable productivity of 0.1-0.9 DM/ha, depending on annual rainfall, vegetation cover and diversity of palatable species.

3-5. The Amu Darya delta district

The Amu Darya delta district occupies the lower reaches of the Amu Darya valley and its delta (*Fig.3-16*). The district is situated between the Karakum desert and the Ustyurt plateau in the west, the Kyzylkum desert in the east and southeast, the Tuyamuyun gorge in the south, and the dry bottom of the Aral Sea in the north. The 40000 km² of the Amu Darya delta is dissected by many dry riverbeds, salt

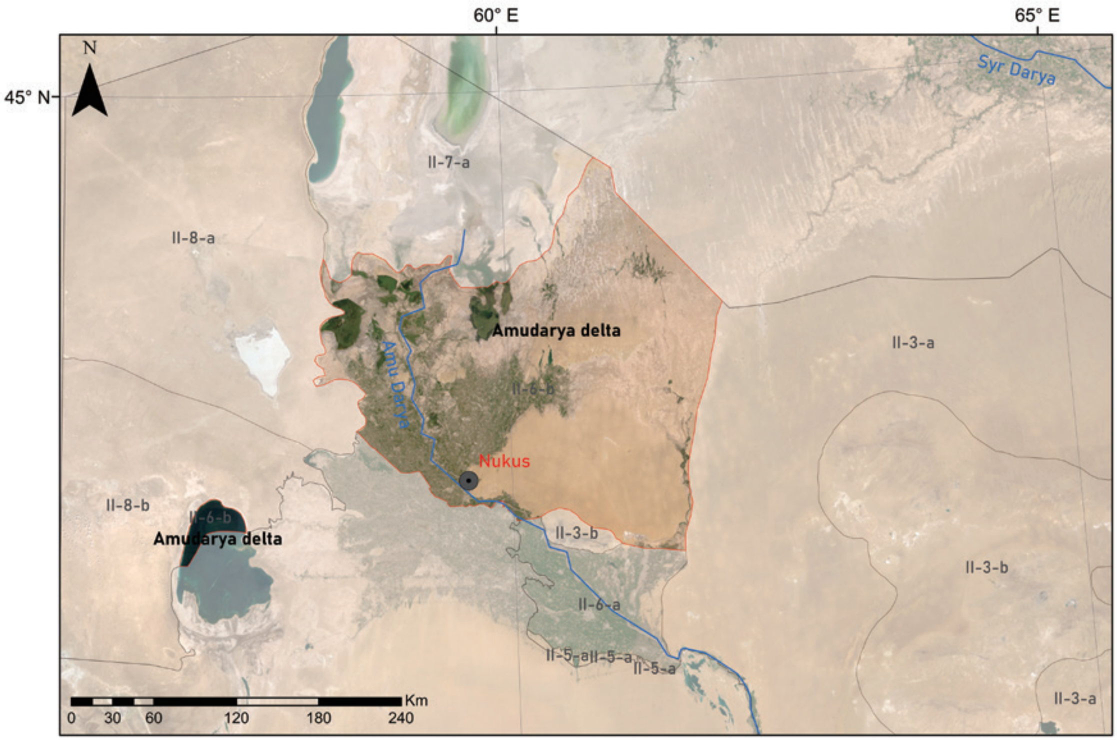


Fig.3-16 Map of the Amu Darya delta phytogeographical district

marshes and small lakes, resulting from the change of the Amu Darya river course during past geological time. It is strongly affected by actual eolian erosion feeding neogenic sand deposits of the Kyzylkum desert.

Until the 1960s the Amu Darya delta fed some 2600 lakes, while only 400 saline lakes were documented in the early 1990s. Tugai and riparian forests once covered more than 500000 ha, of which only about 10% remains today. These ecosystems have been replaced by irrigated farmland and/or have disappeared due to a lack of water and an impact of climate change. Many lakes and reservoirs have been built to restore the ecology of the surrounding deltas. Wetlands have grown and many migratory birds have found refuge there. Diversity remains low, but some species of waterfowl have expanded their breeding grounds along the Amu Darya in the southern part of the delta there is a group of lacustrine-flowing reservoirs, a group of enclosed or inside oasis reservoirs, like Jiltarbas, Sudochie, Shurkuli and others. The last group includes lakes that do not have a permanent connection with the main river channel or its branch channels. Distinctly expressed shores with halophytic vegetation and often with mixed halophytic psammophylous vegetation.

3-5-1. The floodplain forest (Tugai) ecosystem along the Amu Darya delta

Tugai ecosystem occurs on soils (marshlands) under condition of excessive water/moisture and distributed saline-water depression. The typical Tugai biome is distributed by discontinuous strips along the river streams/courses and its tributaries, where highly mineralized groundwater lies close to surface (shallow water table). Redistribution and flow of groundwater are substantially affected by river flow, channels, and drainage-collector irrigation system. On the banks of the floodplains and the delta of the Amu Darya, there grow shrubs-*Tamarix ramossissima, Tamarix hispida, T. androsovii*, which form powerful thickets and occupy large areas. The lower tier is formed by salt-tolerant grass *Aeluropus litoralis, Cynodon dactylon,* annual salsolas species. Seedlings of the *Tamarix* are permanent components of the overgrowth of naked lake and river littorals, as well as dried lodges of lakes in early spring season. Floodplain vegetation is represented mainly by reed tickets (*Phragimites australis, Phragmites*

Fig.3-17 Tugai plant community (TR)

communis accompanied by *Bolboschoenus maritimus, Juncus gerardi, Chenopodium rubrum* and others (***Fig.3-17***). However, in places, where groundwater level decline highly productive reed vegetation is replaced by shrubs, semishrublets and tall perennial and annual herbaceous species (frequently annual herbs less palatable). The species composing the floodplain Tugai communities are also represented by trees, perennial shrubs, and perennial tall herbs. The main trees are poplars species, such as *Populus euphratica, Populus pruinosa*, which form mixed as well as monodominant associations. In the arboreal tier of Tugai, *Elaeagnus turcomanica, Salix songarica, Salix wilhelmsiana* are found.

The *Tamarix* communities are very typical here. The most widespread is *Tamarix pentandra, T. ramossissima* (***Fig.3-18***), *T. androsovii* grows mainly on saline soils. Another typical shrub is

Fig.3-18 *Tamarix ramosissima* growing along river (NY)

Fig.3-19 *Populus euphratica* in the Tugai ecosystem (NY)

Caragana halodendron. Edges of *Caragana* plant communities are found on the clearings and along the edges of Tugai forests. Herbaceous vegetation is diverse. For marshland saline biotopes the most common are cattail *Calamagrostis dubia, Typha minima, Tripidium ravennae, Imperata cylindrica, Saccharum spontaneun, Elytrigia repens*, lianas *Clematis orientalis* and herbaceous-*Cinanchum sibirica, Convolvulus arvensis* and *Convolvulus sepium, Asparagus persicus*. Widespread are weeds-*Polygonum aviculare, Plantago major, P. lanceolata, Sonchus asper, Atriplex tatarica, Chenopodium album, Lactuca tatarica, Sorghum halepensis, Taraxacum* spp. and other species.

The uniqueness of the flora of the Amu Darya Delta territories is characterized primarily by the presence of relict riparian types of vegetation. These include fragments of natural riparian forests-mixed shrub-turanga communities (which are dominated by *Populus euphratica* (***Fig.3-19***), *Phragmites australis* and species of *Tamarix*), growing in the northwestern part of Lake Sarybas, lake Sudochie, lower Amu Darya (former Baday-Tugai) bioreserve and others.

3-5-2. Tugai riparian forest conservation needs

Tugai forest is a special type of vegetation, which preserved the former features of tertiary flora of true savannas. The uniqueness of Tugai vegetation is that the center of their origin is Central Asia, from where they moved to the desert regions of Jungaria and Kashgaria. Formation and development of Tugai vegetation relates to different functional cycles of the Tertiary Tethys Sea. Tugai forests as relict vegetation in Uzbekistan, fragmentarily is preserved in small areas in floodplains and deltas of the Amu Darya (from Karakalpakstan) and Syr Darya (from Kazakhstan). From the phytocoenotic point of view, these unique riparian forests of Uzbekistan are in a state of gradual disappearance. The area of these economically significant ecosystems, which in the 1960s stretched over several kilometers on either side of the rivers and lakes, has shrunk considerably. This riparian vegetation experienced permanent anthropogenic impact and needs urgent measures of protection.

Today, most examples of the Tugai plant community are in very poor condition, as it is subject of constant anthropogenic impacts of a regional and local nature. According to literature data by the end of 80-90s in northern Iran and Afghanistan, north Africa, and Middle East there were no compact integral Tugai massifs because of extreme anthropogenic disturbance of territories. At the same time, Tugai in the floodplains of the Indus, Euphrates, and Tigris rivers virtually disappeared. By now the area of one of the largest forests of the present-day Tarim river flowing on the periphery of the Takla-Makan desert in China, has been extremely reduced.

Under the impact of climate change and global warming the riparian forests of the Aral Sea region continue to be extremely vulnerable. The vulnerability of riparian forests compared to other types of vegetation is due to uncontrolled logging because of easy access to these plantations, lack of flooding, declining of water table and the expansion of saline areas. Progression of automorphic salinization on the dried bottom of the Aral Sea almost stopped the natural regeneration of riparian vegetation. In this context, the protection of fragmentary floodplain forests of the Amu Darya delta, in particular Tugai vegetation in the Lower-Amu Darya Bioreserve, Lake Sarybas as a relict plant complex, which retains the former characteristics of tertiary flora of true savannas, is of great importance (Kuzmina and Treshkin 2001).

Another argument in favor of protection of Tugai vegetation is that such monodominant reed communities as are found in Lakes Sarybas, near artificial water reservoirs of the Toguz-Tepe, Jiltabus and Sudochie Lakes system and adjoining areas of the Aralkum desert, are unique in Uzbekistan and extremely rare.

Ten associations compose phragmites plant communities was described. More than 62 species belong to these associations. Among them, 52 species have high fodder value for animals. Phragmites play a significant role in biomass accumulation in the plains of the Amu Darya delta. The average yield of above-ground biomass of Phragmites dense thickets is around 18.78 t/ha along the Amu Darya riverbank. In 1990, the total area of Phragmites ecosystems in the Amu Darya delta consisted of more than 600000 ha. Since that point, the Phragmites plant communities have declined by over 65%. This species is dominant in the lower reaches of Amu Darya wetlands areas. Phragmites stands, however, are under intense pressure due to the development of the furniture industry in Uzbekistan needing large amounts of fiber in the manufacturing of chipboard. The main raw material for particleboard production in the country are natural thickets of *Phragmites australis*. This grass has excellent agronomic properties and in many parts of the world is considered as posing a severe invasive species threat to wet ecosystems. These qualities pose interesting opportunities for the planting of reedgrass stands in degraded wet ecosystems. The creation of the Aralkum National Park will contribute to the conservation of the wild reedgrass ecosystems that provide habitats for sedentary and migratory birds, fish, and reptiles.

3-5-3. Wetlands of the Sudochie lake ecosystem

Wetlands, oases, and other water resources in drylands are frequently small areas within vast landscapes, their value to wider ecosystem function is poorly understood and often underestimated. The wetlands in the delta of the Amu Darya River have experienced an increasing trend over the last 40 years. Nowadays wetlands ecosystems as shown in ***Fig.3-21*** are only well preserved along the Lower Amu Darya Bioreserve (LABR), surrounding Sudochie, Sarygamysh, Jiltarbas, and Kerney Lakes, along the Kokcha River, Bosh Dayolik channel, and less prominent around Tuyamyun water reservoir.

Sudochie Lake system, once part of the Aral Sea, is arguably the most spectacular wetland ecosystems in the southern Priaralie, which on April 30, 2023, was included in the list of wetlands of international importance protected by the Ramsar Convention on Wetlands of International Importance.

The Sudochie lake, bordering with Ustyurt plateau, is in the Muynaq district of the Kungrad region of Karakalpakstan. It consists of many small and four large water bodies (Akushpa, Karateren, Begdulla-Aydyn and Bolshoe Sudochie) and adjoining lands. The water level of the Site is maintained by the Amu Darya River and irrigation canals. The total area of the Ramsar site is approximately 20000 hectares. It is one of the most ecologically intact zones of the Amu Darya River delta. It is a key site for the conservation and maintenance of the region's biodiversity. The lakes serve as a migratory route and habitat for West Asian birds and support many breeding waterbirds, including rare and endangered species. The Sudochie lake system is a stopover point for waterbirds from the north of Europe and Asia, western Siberia, and Kazakhstan on their migration to the wintering areas of the southern Caspian Sea on their way to African and the Indian subcontinent. Aside from of bird's species, the site is home to such IUCN Red Listed as *Gazella subgutturosa, Felis caracal* and *Saiga tatarica* of the Sudochie wetlands. There are 24 species and subspecies of fish in the wetland of Sudochie lake system. Most of them (16 species) belong to the Cyprinidae. The coastal vegetation of the Sudochian region is represented by

71 species of higher plants. The coastal vegetation of Bolshoe Sudochie lake is the richest-59 species. The vegetation cover in the modern delta almost everywhere shows traces of human activity (Novikova 1997, Dimeyeva., 2015, Kuzmina and Treshkin, 2016).

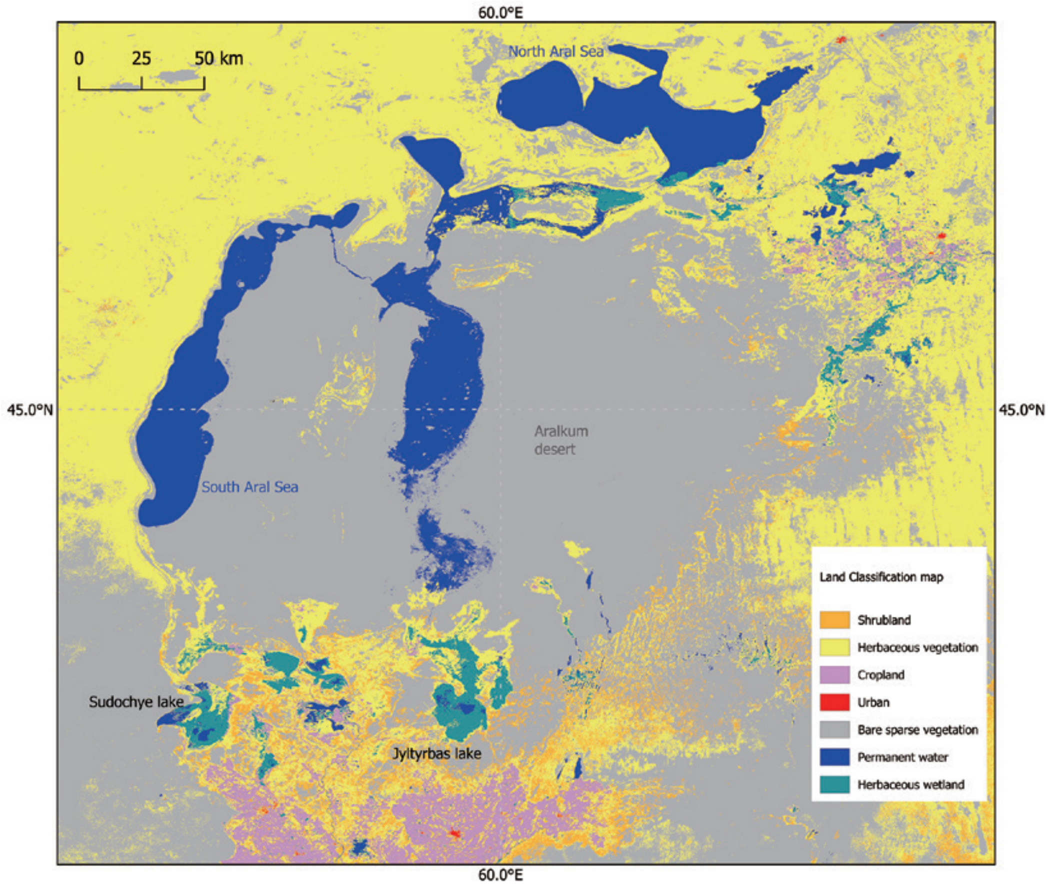


Fig.3-20 Wetland ecosystems in the Amu Darya delta (Buchhorn et al., 2020)

4 Ecology and Physiology of Halophytes

Naoko MATSUO, Kristina TODERICH and Norikazu YAMANAKA

4-1. Halophytes

In arid regions, salts often accumulate in the shallower soil layer due to natural or human-induced factors, and plants living in these regions must cope with not only drought stress but also salt stress. Most terrestrial plants wilt when they absorb water with higher osmotic pressure than their tissue water, and enzymatic reactions are inhibited when the concentration of sodium ions (Na^+) and other ions increases in the cells. However, some plants called halophytes have mechanisms to regulate salinity in their bodies, thus adapting to high-salinity environments. Flowers and Colmer (2008) define halophytes as “plants that can survive in high-salinity environments with sodium chloride (NaCl) concentrations of 200 mM or higher at all growth stages”. The relative growth rate of halophytes is greatest at high salinity, at which most terrestrial plants wilt (***Fig.4-1a***). On the other hand, among non-halophytes (glycophytes), which do not have much of a mechanism to regulate salinity in their bodies, there are some species whose relative growth rate is higher in the presence of some salts (***Fig.4-1b***) and some species that are less sensitive to salinity (***Fig.4-1c***). These non-halophyte species can grow in salt-accumulated regions if they can avoid high-salinity water in the shallower soil layer and obtain lower-salinity water.

4-2. Selective absorption of ions by roots

Plant cells are composed of a cell membrane that surrounds the cytoplasm, which consists of intracellular organelles and cytosol, and a thick cell wall that further surrounds the cytosol. Intracellular organelles include chloroplasts, vacuoles, mitochondria, and peroxisomes, many of which are surrounded by the plasma membrane.

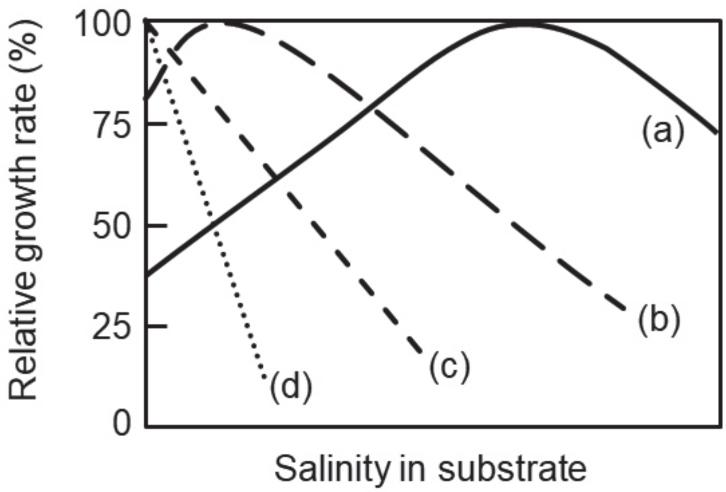


Fig.4-1 Growths of various types of plants under salt-stress (redrawn from Breckle 2002). (a) halophytes, (b) salt-tolerant glycophytes, (c) slightly salt tolerant glycophytes, and (d) non salt-tolerant glycophytes

Water molecules and other small molecules can move across the phospholipid bilayer of the membrane, but polar sugars, amino acids, and ions cannot. Water molecules diffuse through the membrane from lower to higher osmolarity, so when a plant absorbs water with higher osmolarity than that in the cell membrane, water molecules in the cell membrane are leached out, reducing the volume of the cytoplasm and decreasing the intracellular turgor pressure. As intracellular turgor pressure decreases, the stomata close, resulting in a decrease in photosynthetic rate as well as transpiration rate. Further decrease of intracellular turgor pressure causes plasmolysis. For these reasons, many terrestrial plants show a decrease in relative growth rate in high salinity environments.

Casparian strips composed of lignin and suberin in the root endocarp prevent soil water from flowing directly into the vessels (*Fig.4-2*). Thus, soil water enters the plant body through the cell membrane where transporter proteins allow only certain ions to pass through (*Fig.4-2*, dotted arrow). Na^+ accumulation is also harmful to halophytes because it inhibits enzymatic reactions. Potassium ions (K^+), on the other hand, are important for vital activities such as protein synthesis, membrane transport, turgor pressure maintenance, electrical balance, and enzymatic reaction (Rhodes, Nadolska-Orczyk & Rich 2002). The ratio of Na^+ to K^+ (Na^+/K^+) in various species of halophytes was examined and found to be smaller or nearly equal to the Na^+/K^+ in soil for all species, although values varied among species (Breckle 2002). This indicates that most halophytes selectively absorb K^+ rather than Na^+.

Maimaiti et al. (2012) examined cation concentrations of five halophyte species growing around Lake Aydin, a salt lake in the Turpan Basin, China. *Tamarix hispida* with salt glands and *Halocnemum strobilaceum* and *Karelinia capsica* with succulent leaves had higher Na^+ concentrations in the leaves than in the roots, indicating that most of the Na^+ absorbed from the roots were transported to the leaves. On the other hand, *Phragmites australis* had low Na^+ concentrations in all organs and lower Na^+/K^+ ratios than other species, suggesting *P. australis* has a high capacity for selective absorption of ions by the roots.

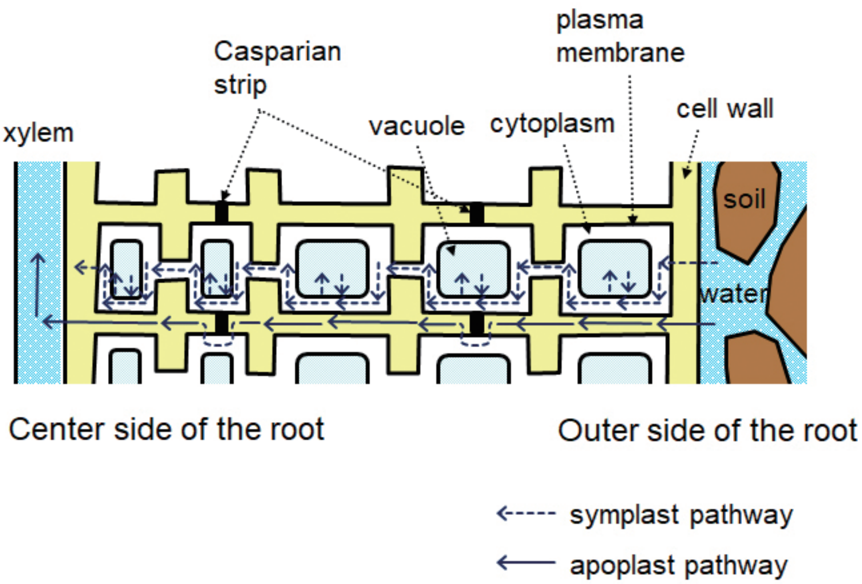


Fig.4-2 Root water absorption pathway (modified from Lambers, Chapin and Pons 1998)

4-3. Salt secretory organs

Some species of halophytes have organs that expel excess salts from the body. For example, *Tamarix* species expel salt-containing fluids from the body through salt glands on their leaves. The water in the salt-containing fluid quickly evaporates, leaving dry salts on the leaf surface (*Fig.4-3*). Note that these dry salts either fall off directly or together with the litter, resulting in salt accumulation on the soil surface. Several studies of halophytes grown under different NaCl concentration conditions have shown that the rate of salt secretion from salt glands increases with increasing environmental NaCl concentration, that the rate of salt secretion is greater in young leaves than in older leaves, and that Na^+ is selectively expeled rather than K^+ (Breckle 2002).

Salt hairs are one of the salt-secreting organs. Excess salt accumulates in the epidermal bladder cells of the salt hairs, and when salinity increases, the salt hairs rupture or drop, thereby regulating the salinity in the plant body. Salt hairs are found on the genus *Atriplex*.

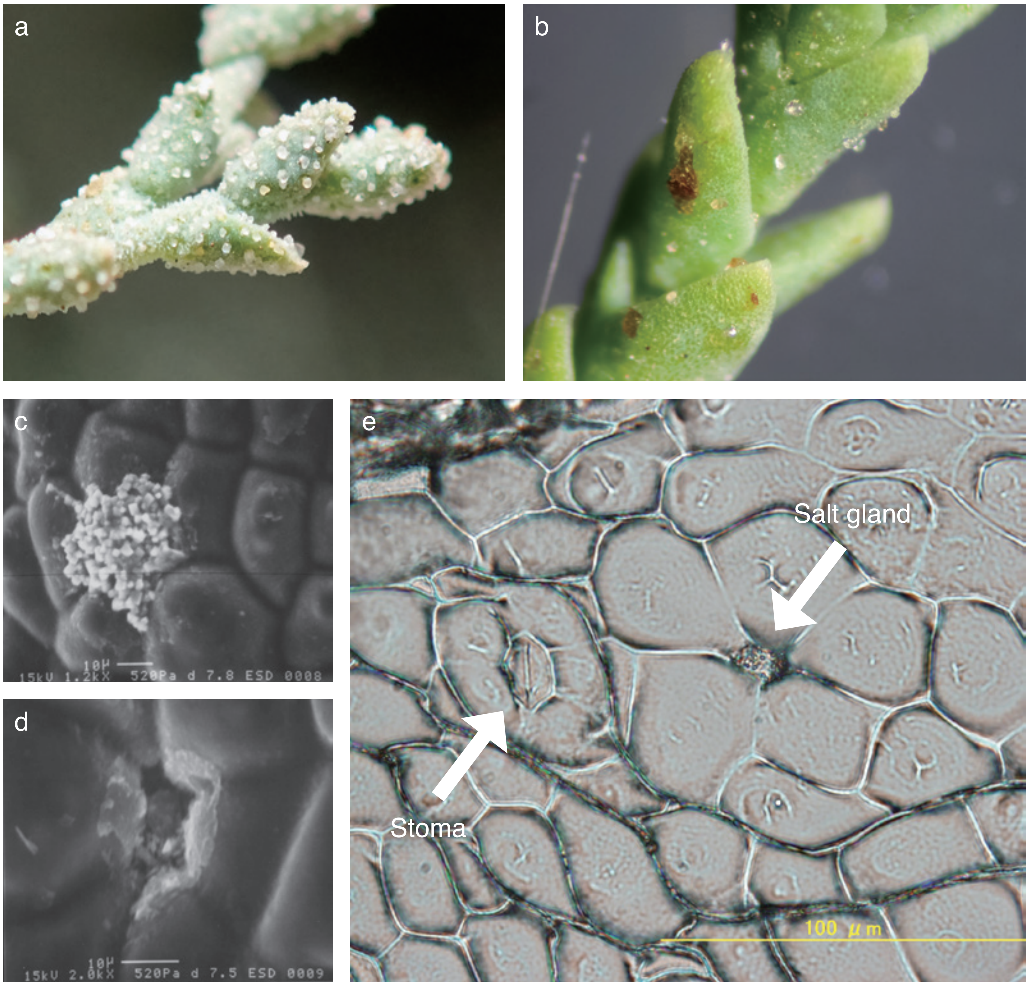


Fig.4-3 Salt secretion by *Tamarix* (NY). Salts on leaves of *Tamarix hispida* (a), and *T. austromongolica* (b: Inner Mongolia, China). Salts (c) and salt gland (d: Salt gland appear when salt crystals are removed.) on leaf of *T. austromongolica*. Salt gland and stoma on leaf of *T. austromongolica* (e)

4-4. Sequestration of salt in vacuoles

The vacuole is an intracellular organelle surrounded by a membrane (tonoplast) containing many transporter proteins and filled with a fluid containing dissolved sugars and metabolites. It occupies most of the cell volume and maintains the intracellular turgor pressure. Another important function of the vacuole is to store and break down toxic by-products, waste products, and proteins produced within the cell.

Increased Na^+ concentrations in the cytoplasm inhibit enzymatic reactions, whereas K^+ also inhibits protein synthesis at concentrations above 180-200 mM (Brady et al. 1984). Therefore, many salt-tolerant plants maintain Na^+ and K^+ concentrations in the cytosol in the range of 100-150 mM by storing Na^+ and K^+ in the vacuole (Wyn Johns & Gorham 2002). Vacuoles have been reported to have higher concentrations of Na^+ and K^+ (Wyn Johns & Gorham 2002) and higher Na^+/K^+ than cytoplasm (Flowers & Colmer 2008).

4-5. Osmotic adjustment by accumulating compatible solutes in cytosol

When Na^+ and K^+ accumulate in the vacuole, the osmotic pressure of the fluid in the vacuole increases relatively. In order to maintain osmotic equilibrium between the vacuole and the cytoplasm, water-soluble low-molecular-weight substances such as amino acids, betaine, and sugars are induced and accumulated in the cytoplasm. These substances are called “compatible solutes” because they do not inhibit enzyme activity like Na^+ does. This regulation of osmotic pressure by storage and degradation of compatible solutes is called osmotic adjustment, and is found in many plants not only in response to salinity stress, but also in response to drought stress and low-temperature stress.

There are a variety of compatible solutes (Chen & Murata 2002, Boscaiu et al. 2009). Among them, the betaines (quaternary ammonia compounds with carboxyl groups) such as glycine betaine and the amino acid such as proline are found in a wide range of higher plant families (Rhodes & Hanson 1993). There is a trade-off between glycine betaine and proline, in that species with high concentrations of one have low concentrations of the other (Tipirdamaz et al. 2006). Among the sugar alcohols, inositol and pinitol are present in many families of higher plants, while sorbitol and manitol are present in only a limited number of families (Flowers & Colmer 2008). Other sugars such as sucrose, trehalose and fructan also play a role as compatible solutes. It has been reported in many halophytes that when the environmental NaCl concentration increases, the intracellular concentration of compatible solutes also increases (Sanada et al. 1995), but there are also species in which the concentration of compatible solutes does not change (Khan et al. 1998). It should be noted, however, that if rearrangement of compatible solutes occurs between intracellular compartments due to an increase in external NaCl concentration, the overall compatible solute concentration in the tissue of the cell may not change even if the cytoplasmic compatible solute concentration increases (Flowers & Colmer 2008).

4-6. Succulent leaves and stems

Thickening of cell is a morphological change in which the parenchyma (non-woody tissue), such as leaves and stems, store large amounts of water and cells become larger. This dilutes the intracellular salinity. *Salicornia, Kalidium* and *Suaeda* species found in solonchak and along shores of salt lakes have typical succulent leaves and stems (***Fig.4-4***).

Fig.4-4 Succulent leaves and stems of *Salicornia percica* (a,b), *Kalidium capsicum* (c, d) and *Suaeda salsa* (e, f) along shores of salt lake (NY)

4-7. Water use strategies and salt tolerance of halophytes in the Kyzylkum desert assessed by stable isotope analysis

Isotopes are nuclides with the same number of protons (or electrons) but different numbers of neutrons, of which those that do not decay radioactively are called stable isotopes. Stable isotopes of carbon are ^{12}C and ^{13}C, and stable isotopes of oxygen are ^{16}O, ^{17}O, and ^{18}O. The ^{12}C and ^{13}C are naturally occurring at 98.89% and 1.11%, respectively, while the ^{16}O, ^{17}O, and ^{18}O are naturally occurring at 99.759, 0.037 and 0.204%, respectively. Due to the bias in the natural abundance ratios, the stable isotope composition in the sample is expressed as a thousand-fold deviation from the stable isotope composition in the international standard (δ value). The stable carbon isotope ratio ($\delta^{13}C$) and oxygen isotope ratio ($\delta^{18}O$) are given by,

$\delta^{13}C = (^{13}R_{sample} / {}^{13}R_{standard} - 1) \times 1000$ (‰), and

$\delta^{18}O = (^{18}R_{sample} / {}^{18}R_{standard} - 1) \times 1000$ (‰),

where $^{13}R_{sample}$ and $^{13}R_{standard}$ are $^{13}C/^{12}C$ of the sample and the international standard (Vienna Peedee Belemnite, VPDB), respectively, and $^{18}R_{sample}$ and $^{18}R_{standard}$ are $^{18}O/^{16}O$ of the sample and the international standard (Vienna Standard Mean Ocean Water, VSMOW), respectively.

Since isotope discrimination occurs against ^{13}C during C_3 photosynthesis due to the faster diffusion rate of $^{12}CO_2$ than $^{13}CO_2$ and the faster reaction rate of $^{12}CO_2$ than $^{13}CO_2$ with Rubisco, the $\delta^{13}C$ of leaf organic matter ($\delta^{13}C_{om}$) in C_3 plants is lower than that of CO_2 in air ($\delta^{13}C_{air}$), i.e., the percentage of lighter isotopes in leaf organic matter is higher than CO_2 in air (*Fig.4-5*). The isotope discrimination during C_3 photosynthesis ($\Delta^{13}C_{om}$) has the following relationship to the ratio of intercellular CO_2 concentration (C_i) to air CO_2 concentration (C_a) (Farquhar et al. 1989).

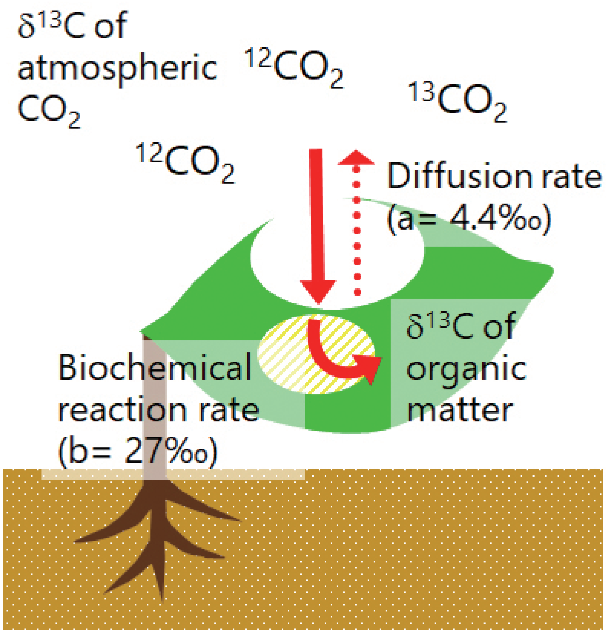


Fig.4-5 Carbon isotope discrimination during C_3 photosynthesis

$\Delta^{13}C_{om} \approx \delta^{13}C_{air} - \delta^{13}C_{om} = a + (b - a)\ C_i/C_a$

where a is the discrimination factor due to the faster diffusion rate of $^{12}CO_2$ than $^{13}CO_2$ (4.4‰), and b is the discrimination factor due to the faster reaction rate of $^{12}CO_2$ than $^{13}CO_2$ with Rubisco (27‰), respectively. The intrinsic water use efficiency (iWUE) at a leaf scale is defined as the ratio of photosynthesis rate (A) to stomatal conductance related to H_2O (g_s),

$iWUE = A/g_s = g_s\ (C_a - C_i)/1.6g_s = C_a\ (1 - C_i/C_a)/1.6$

Therefore, C_3 plants with lower $\Delta^{13}C_{om}$ have lower C_i/C_a and higher intrinsic water use efficiency

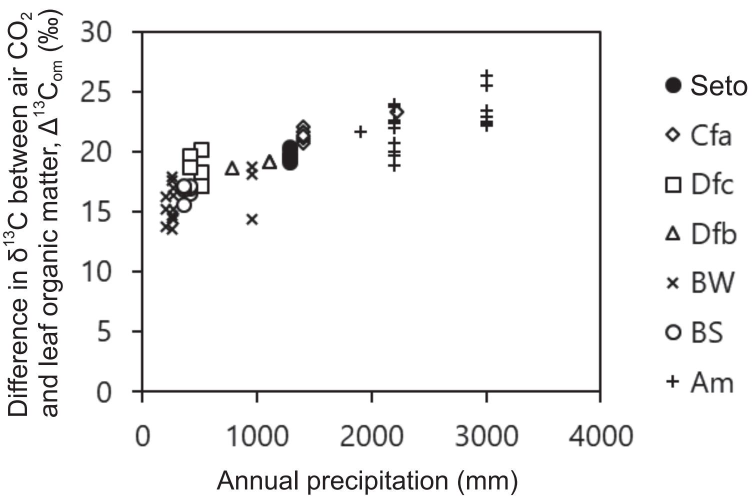


Fig.4-6 Relationship between annual precipitation and the difference in carbon isotope ratio between air CO_2 and leaf organic matter ($\Delta^{13}C_{om}$) of tree species in different climates (modified from Matsuo 2020)

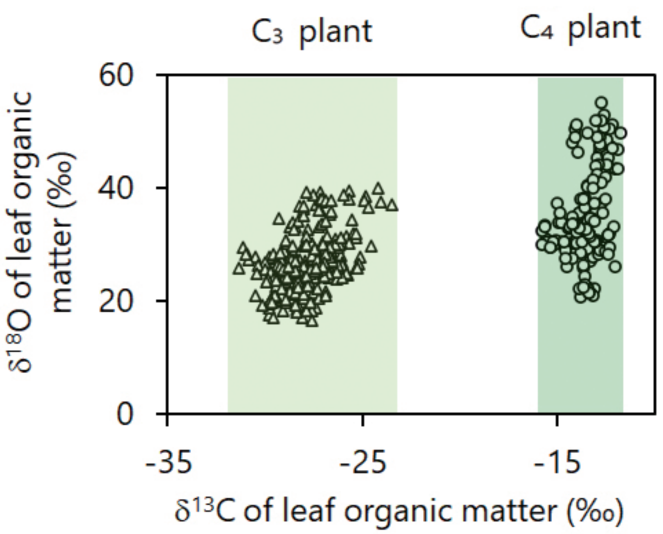


Fig.4-7 Carbon isotope ratio ($\delta^{13}C$) and oxygen isotope ratio ($\delta^{18}O$) of lear organic matter of 56 species of halophytes growing in three sites with different precipitation in Uzbekistan (Matsuo et al. unpublished data)

(*Fig.4-6*). Assuming that the $\delta^{13}C_{air}$ is uniform, C_3 plants with higher $\delta^{13}C_{om}$ have lower C_i/C_a and higher intrinsic water use efficiency. On the other hand, the $\delta^{13}C_{om}$ in C_4 plants is lower than $\delta^{13}C_{air}$ but higher than $\delta^{13}C_{om}$ in C_3 plants, which is due to the smaller isotope discrimination during C_4 photosynthesis (*Fig.4-7*). Thus, the $\delta^{13}C_{om}$ has been used to distinguish between photosynthetic types such as C_3, C_4, and C_3-C_4 intermediates and to assess intrinsic water use efficiency in C_3 plants (Farquhar et al. 1989).

Since isotope discrimination of water does not occur when plants absorb water with their roots, the stable oxygen isotope ratio ($\delta^{18}O$) of water in the stem reflects that of the water absorption source (*Fig.4-8*) (Yakir 1992). Therefore, by comparing the $\delta^{18}O$ of stem water ($\delta^{18}O_{sw}$) to that of groundwater or soil water at different depths, the water absorption source for the plant can be estimated. The $\delta^{18}O$ of leaf water ($\delta^{18}O_{lw}$) is then higher than $\delta^{18}O_{sw}$, because transpiration from stomata causes isotope enrichment of the water in leaves due to the higher saturated vapor pressure of $H_2{}^{16}O$ than $H_2{}^{18}O$ and the faster diffusion rate of $H_2{}^{16}O$ than $H_2{}^{18}O$ (*Fig.4-8*). Theory and experiments show that this isotope enrichment is related to relative humidity, leaf temperature, stomatal conductance (g_s) and leaf boundary layer conductance. Since ^{18}O in carbonyl oxygen of triose phosphates exchanges with ^{18}O of leaf water (*Fig.4-8*), the $\delta^{18}O$ of leaf organic matter ($\delta^{18}O_{om}$) reflects both the isotope enrichment during transpiration and the $\delta^{18}O$ of plant water absorption sources, regardless of photosynthetic type (Farquhar et al. 2007).

Barbour et al. (2000) demonstrate the negative relationship between stomatal conductance (g_s) and oxygen isotope enrichment of leaf organic matter relative to source water ($\Delta^{18}O_{om} \approx \delta^{18}O_{om} - \delta^{18}O_{sw}$) in wheat grown under different humidity conditions. However, it should be noted that the positive and

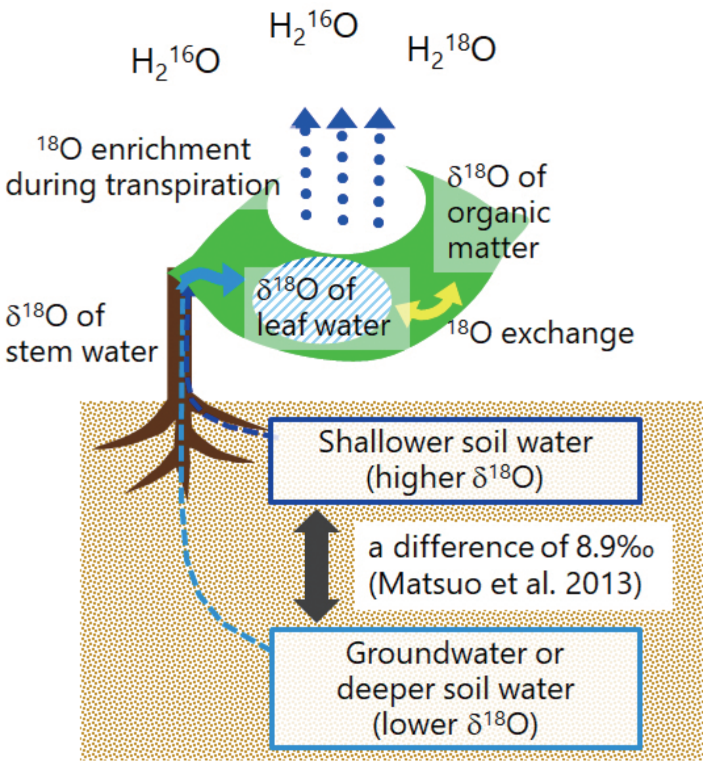


Fig.4-8 Isotopic enrichment of leaf water and organic matter relative to stem water by transpiration

negative relationship between g_s and $\Delta^{18}O_{om}$ changes when the difference in transpiration rate is due to differences in the humidity of the growing environment and when it is due to differences in stomatal conductance (Farquhar et al. 2007). It should also be noted that the $\delta^{18}O_{om}$ reflects not only isotope enrichment during transpiration, but also $\delta^{18}O_{sw}$, which varies widely among plants in arid regions. Therefore, attention should be paid when comparing the $\delta^{18}O_{om}$ among plants in different growing environments in arid regions.

Here is a case study in which these isotope parameters to assess the water use strategies and salt tolerance for halophytes in the Central Asian desert. Matsuo et al. (2013) examined the isotope parameters in two C_3 species, *Artemisia diffusa* and *Tamarix hispida*, and a C_4 species, *Haloxylon aphyllum*, growing or planted at seven plots with different soil salinities in Kyzylkesek (41º05'N, 64º52'E) of the Kyzylkum desert. The $\delta^{18}O_{sw}$ of *T. hispida* and *H. aphyllum* distributed in high-salinity plots were similar to the $\delta^{18}O$ of artesian water and different from the $\delta^{18}O_{sw}$ of *A. diffusa* distributed in lower salinity plots (***Fig.4-9***). This suggests that *T. hispida* and *H. aphyllum* depend on water with low salinity in the deeper soil layers, whereas *A. diffusa* depends on water in the shallow soil layers, which are more affected by salt accumulation. The $\delta^{13}C_{om}$ and $\Delta^{18}O_{om}$ were lower in *A. diffusa* than in the other species (***Figs.4-10*** and ***4-11***). This indicates that *A. diffusa* growing only during periods of relatively high water content in the shallow soil layers have lower intrinsic water use efficiency and higher transpiration rates. The highest $\delta^{13}C_{om}$ and $\Delta^{18}O_{om}$ in *H. aphyllum* (***Fig.4-11***) suggest that it may reduce salt uptake by decreasing transpiration even though they can access low-salinity water in the deeper soil layer. The responses of $\delta^{13}C_{om}$ and $\Delta^{18}O_{om}$ to soil salinity observed in *T. hispida* (***Figs.4-10*** and ***4-11***) suggests that *T. hispida* may maintain low transpiration rates and increase intrinsic water-use efficiency in response to increasing soil salinity. Thus, the distribution of halophytes in salt-accumulated areas is related to their water use strategies such as salinity of the water-absorbing source, intrinsic water use efficiency, and stomatal control of transpiration.

Fig.4-9 Oxygen isotope ratios ($\delta^{18}O$) in stem water of *Artemisia diffusa* (black open circles), *Tamarix hispisa* (black triangles) and *Halophylon aphyllum* (black open diamonds) and $\delta^{18}O$ of artesian water (blue open circles and blue squares) at seven plots with different soil salinities in the Kyzylkum Desert (redrawn from Matsuo *et al*. 2013)

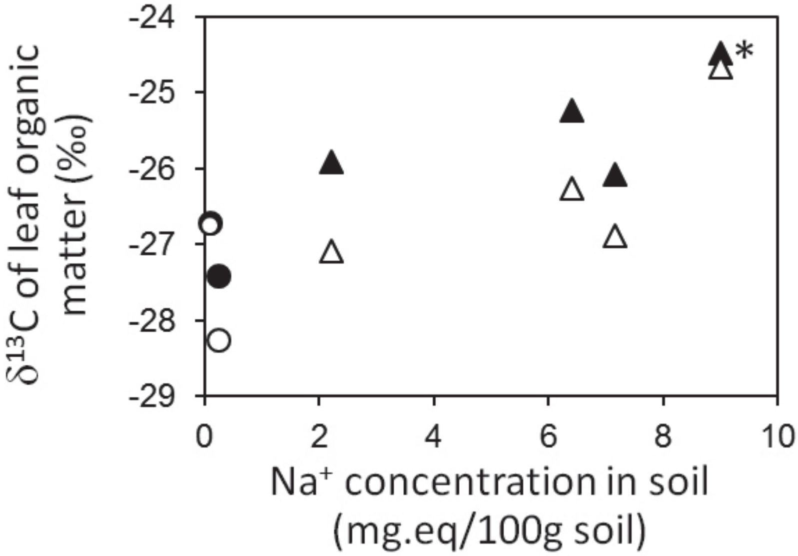


Fig.4-10 Carbon isotope ratio ($\delta^{13}C$) of leaf organic matter in *Artemisia diffusa* (circles) and *Tamarix hispida* (triangles) plotted against mean sodium (Na^+) concentration in soil at 0-120 cm deep (redrawn from Matsuo et al. 2013). White and black symbols refer to the 2007 and 2008 data, respectively

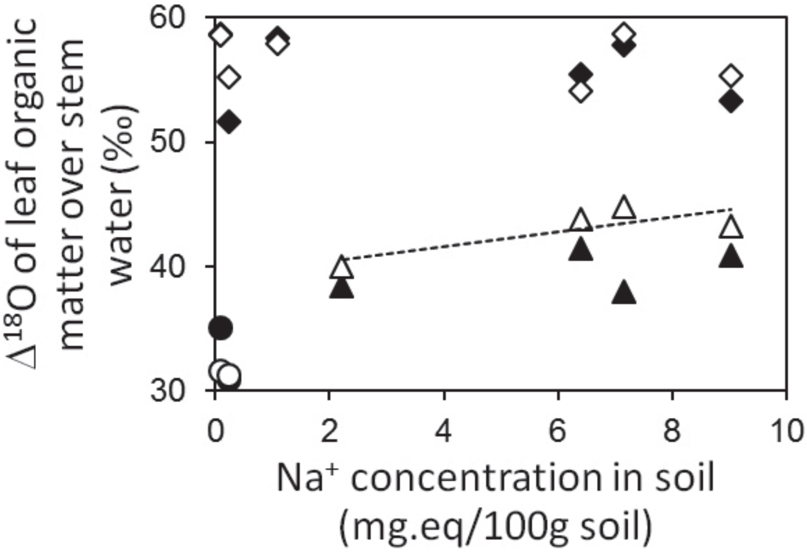


Fig.4-11 Oxygen isotope enrichment ($\Delta^{18}O$) of leaf organic matter above that of stem water in *Artemisia diffusa* (circles), *Tamarix hispida* (triangles), and *Haloxylon aphyllum* (diamonds) plotted against mean sodium (Na^+) concentration in soil at 0-120 cm deep (redrawn from Matsuo et al. 2013). White and black symbols refer to the 2007 and 2008 data, respectively

5 Ecological Groups of Halophytes of the Aralkum Saline Desert

Kristina TODERICH

5-1. Characteristics of salt-affected (anthropogenically transformed) lands

With climate change, the frequency of droughts is expected to increase, this will further increase the pressure on already limited water resources, further exacerbate the Aral Sea crisis and to reduce productivity of agricultural crops triggering feed shortages for livestock and other such effects (Xenarios at al. 2021, Nishonov et al. 2023). Along with climate change, land degradation from salinization and overgrazing are reducing vegetation cover, botanical diversity, and palatability of key species in the regions extensive grasslands are posing a further threat to livestock (Shaumarov et al. 2012, Shuyskaya et al. 2022).

The process of salinization in the Aralkum desert is due to the following factors: the degradation of Tugai forest, overuse use of water and the extensive irrigated area in agriculture. Soil contamination through salinization is a major factor in the dynamics and changes of halophytic vegetation. It is frequently caused by ineffective and water consumptive flood irrigation practices combined with a poorly functioning drainage system. Anthropogenic soil salinization is predominant. The effects of salinisation are dependent on soil types as well as water levels. Permanent topsoil moisture and the temporary waterlogging are characterized as salt affected marshes (with solonchak-alkaline soils). The most common types of solonchaks are those where halophytes and salt tolerant non-conventional crops can grow and produce good quality seeds. Categories of easily restored solonchaks and marginal lands are given below:

1. Salt-marshes (hydromorphic soil of steppe and desert zones characterized by high concentration of water-soluble salts in surface layer; porous, crust and damp solonchaks are distinguished. A certain place among them has "shory"-local name of bare (crusty-puffy) solonchaks (***Fig.5-1***) that have a surface almost without vegetation or is rarely species of halophytes. Such kind concern to a category of infertile pastoral lands.

2. Takyr and takyr-like (primitive thin desert soils, mainly loamy in Central Asian and Southern Russia. Surface of takyrs is flat, condensed with polygonal cracks. Takyrs are mainly formed on periodically inundated areas of alluvial plains. Vascular plants are often absent (algae and lichens are active in soil formation).

3. Salt- meadow (with highest content of humus and clayely features in the soils profile). A rare fraction of vegetation is characterized to these lands.

4. Abandoned salt-affected farming lands (so called marginal low productive lands). Fluvisol, gleyic, cambisol, calcaric and fluvisol, gleyic, calcaric, sodic with a heavy texture within topsoil (0-30 cm) of chloride-sulfate type moderate-high salinity (EC 6-12 dS/m) characterized these soils. The nutrient content in the 0-100 cm soil layer varies 0.6-0.8% of humus, 1.2-2.1 mg/kg of $N\text{-}NO_3$, 25.2-28.5 mg/kg of P_2O_5, 122-157 mg/kg of K_2O. The organic content ranges from 0.5 % in saline sandy desert and up to 0.7-1.2% gray-brown soils on virgin and newly irrigated takyrs.

A low productivity and high salinity (1.2-2.0 and rarely more than 3.0% of soluble salts) characterize these soils, with a dominance of carbonates, sulfate, chloride and/or mixed types of salinisation. The organic content ranges from 0.5 % in saline sandy desert and up to 0.7-1.2% gray-brown soils on virgin and newly irrigated takyr. The wet and salty marshlands, frequently turned into sterile bare land, are commonly distributed on sea and salted lakeshore, in drying deltas of the Desert Rivers and on margins of irrigated lands. Only on swamps with temporary spring and artesian wells, the overgrowth of *Salicornia* is frequent. All these types of land patch the Ustyurt plateau, the Aral region, and the lower reaches of the Amu Darya River and Bukhara oasis. The pastoral and fodder value of this vegetation type are difficult to evaluate.

The Aral dried seashore, surrounding lakes, numerous water ponds, and extensive deltas, along with the ancient alluvial plains in the basins of the Amu Darya and Syr Darya rivers, house the majority of salt-affected rangelands and abandoned farming lands. Many of the above areas remain largely abandoned by farmers (Suska-Malawska et al. 2022). Degraded and affected by salinity rangelands are found in the Kyzylkum desert (in saline depressions, on swamps with temporary spring and artesian wells) and *Artemisia terrae-albae* overgrazed rangelands along Ustyurt plateau. Soil salinization on these land categories in the Aralkum saline desert and neighboring territories is accompanied by a decrease in the richness of botanical diversity, convergence of plant communities and simplification of the spatial structure of vegetation cover. The vegetation changes are undergoing towards the predominance of different life forms of halophytes species with high salt tolerance thresholds. This shift represents a serious shift in biodiversity and ecosystem functions and poses a severe threat.

Fig.5-1 Typical halophitic plant community with dominance of *Climacoptera* spp. plant communities on the puffy solonchak in the dry bottom of the Aral Sea (NY)

5-2. Halophytic flora and characteristics of main ecological groups

Halophytes represent approximately 2% of the global flora, which inhabit a multitude of saline biotopes, usually coastal ecosystems like beaches, rocky shores, salt marshes, estuaries, and lagoons, but also the saline depressions in inland deserts (Toderich et al. 2009, 2022, Hasanuzzaman et al. 2014, Caparros et al. 2022).

Most conventional crops are known as glycophytes (*glyco* = sweet + *phyte* = plant; "sweet water" plants) or plants that are sensitive to salts stress, i.e genetically they are not salt tolerant (Glenn et al. 1999). Therefore, the accumulating salts can reduced their crop yields, and in some cases, cause a complete loss of production (Yamaguchi et al. 2005, Andre Noble ed. 2009, Shabbir Shahid 2013).

The US geologist Oscar E. Meinzer (1876-1948) coined the term halophyte. The term halophylous ("salt-loving"), describing organisms that grow or live in salty conditions such as salt marshes, was first used in 1888 by F.A. Lees in a phrase "Certain halophylous".

Aral-Caspian phytogenetic resources of wild halophytes and its cultivation technology packages are not precisely known, which makes it difficult to adapt to saline farming (Toderich et al. 2018). Halophytes of Central Asian flora occupying various types of saline habitats comprise about 700 species of halophytes belonging to 34 families (Akzhigitova 1982). Approximately one third of them refers to typical halophytes, 26% of them are endemic species of Central Asia and 4% are specific endemic of Uzbekistan. There were significant differences between the plant community composition and species diversity at the family level. Most noticeable for the Aralkum saline flora is the relative richness of the Amaranthaceae with nearly 33%, equivalent only with Australian chenopods. It is also quite rich in Asteraceae (20%), Poaceae (11%), Fabaceae, Brassicaceae (about 11%) and less Boraginaceae, Plumbaginaceae, Polygonaceae and others. Among them there are native and exotic halophytes both C_3 and C_4 plants suitable for reclamation of arid and semi-arid, salt/affected, and waterlogged lands that have been proven very useful in demonstration trials (Toderich et al. 2013, 2023). These plants have naturally evolved to have morphological, physiological, and anatomical traits that allow them to persist in and even benefit from saline soils and mineralized irrigation water. Furthermore, because halophytic plants can accumulate salts from the soils, they may delay further salinization or even remediate specific ions from salt-affected soils, eventually enabling agricultural production of conventional crops like alfalfa, wheat, rice and others (Glenn et al. 1999, Shuyskaya et al. 2017).

There are numerous definitions and classifications of halophytes based on habitat, mechanisms of their salt tolerance (Akzhigitova 1982, Toderich et al. 2009, Grigore and Toma 2017, Acosta-Motos et al. 2017, Shuyskaya et al. 2017). Halophytes are often divided into (1) facultative, which can grow both in the absence of salt and low salt concentrations, and (2) obligate or "true," which requires a certain salt concentration for optimal growth. Halophytes can also be divided into two large groups according to habitat (Toderich et al. 2009). Halophytes of the Aralkum desert can thrive and reproduce in environments with high saline concentrations (≥ 200 mM NaCl). The predominant ecological halophytic groups in the Aralkum saline desert flora are as follows (***Fig.5-2***).

Hyperhalophytes or succulent euhalophytes (salt accumulating): This group of plants is characterized by the presence of highly saline water (full-strength seawater; up to 100 dS m1). The water table varies from 0.5 to 15 m depth, with solonchak-alkaline and solonetz soils. Plants are succulent and have both C_3 and C_4 types of photosynthesis. The main species of C_4 group includes species of genus *Haloxylon, Caroxylon, Calligonum, Phragimes, Anabasis eriopoda*, as well as annual chenopods such as *Climacoptera longistylosa, Climacoptera kasakaroum, Climacoptera bucharica, Climacoptera crassa, Climacoptera subcrassa, Salsola transoxana, Climacoptera ferganica, Climacoptera aralensis, Climacoptera turcomanica, Climacoptera turgaica, Climacoptera itricata, Climacoptera turkestanica. Plantago coronopus* (C_3 photosynthesis), *Frankenia hirsuta, Limonium* species, *Salicornia* species (C_3 photosynthesis), *Halostachys belangerana*, *Halocnemum strobilaceum* (C_3 photosynthesis), *Petrosimonia crassifolia, Petrosimonia litwinowi, Halocnemis varia, Halogeton glomeratus* belong to the ecological group of halophytes.

Xerohalophyte: This group of plants is a good indicator of superficial distribution (1-2 m) of underground water; and mainly consists of salt-accumulator and salt-excluder plants. Such species occur in wet sandy areas at the edge of salt flats, marshes and salt deserts; wet marshes salted soils on the margin of lakes, tugai, salted desert depression and takyrs. The botanical diversity comprises of *Suaeda*, annual *Salsola* species, *Aeluropus repens, Aeluropus littoralis, Aeluropus villosus, Poa littoralis, Tamarix hispida, Tamarix androsovii, Tamarix ramossisima, Kochia scoparia* which tolerates full-strength seawater. Mostly C_4 photosynthesis, except *Tamarix* species.

Haloxerophytes: The water table is at >4 m depth having different types of soils (from sandy to clayey), grey with gypsum content, alkaline meadow salt marshes, and sandy desert soils. *Haloxylon ammodendron*, perennial *Salsola* spp.; *Ephedra strobilaceae, Halothamnus subaphylla, Campharosma lessingii, Kochia scoparia, Zygophyllum* sp., *Alhagi pseudoalhagi, Lycium turcomanicum, Lycium ruthenicum*, some *Calligonum* sp., *Ceratoides ewersmanniana, Anabasis annua, Anabasis salsa, Anabasis aphylla, Anabasis eriopoda, Anabasis ferganica* are the major contributors of this group.

Halogemimezophytes: Widespread in steppes, semi-desert and desert zones mostly on solonetz-alkaline soils, lake shores and riverbanks, where the water table varies between 1.5 and 25 m deep. *Cynadon dactylon, Limonium gmelinii, Salsola arbuscula, Karelinia caspia, Zygophyllum fabago, Caragana halimodedron, Agropyron desertorum, Eremopyrum orientalis, Psylliostachys suvorovii, Atriplex tatarica, Bassia hyssopifolia, Glycyrrhiza glabra, Limonium otolepis* are the major dominants of the group. It includes both C_3 and C_4 plants.

Halophreatophyte: The water table varies between 20 and 80 m where the plants grow on stony skeletal saline substrate. It is a small group of plants mostly shrubs, semi-shrubs and semi-shrublets: *Haloxylon ammodendron, Salsola arbusculiformis* (as a C_3-C_4 intermediate species) and some species of *Atraphaxis, Nanophyton, Anabasis*.

Halohydrophytes: These are species that require aquatic conditions or wet soils. Flooding in inland salt marshes affects the microhabitat of this group of halophytes. This group includes the following species: *Tripidium ravennae*, *Phragmites australis, Phragmites communis, Arundo* spp., *Typha* spp., *Hippophae ramnoides, Populus euphratica, Elaeagnus angustifolia*.

In recent years, due to the development and use of modern physicochemical and biochemical methods, new information was obtained on salinity adaptation in different types of halophytes based on proline and K^+ accumulation and function (Shuyskaya et al. 2020). Two distinct groups of halophytes were identified by the nature of osmolytes (proline accumulation patterns):

i.). Salt-tolerant glycophytes (excluders): these species prevent ion influx into the plant, and the main osmolytes are organic osmolytes, such as (glycine betaine), and amino acids (proline and glutamate)

ii.). Salt-loving halophytes: these plants the main osmolytes are the inorganic ions Na^+ and Cl^-

Furthermore, based on their cellular mechanisms of salinity tolerance, halophytes can be divided into 2 main groups:

a) Salt-accumulating plants (euhalophytes), which can accumulate significant amounts of Na^+ and Cl, which are largely compartmentalized into the cell vacuoles of aboveground organs. In the cytoplasm, K^+ ions and some nontoxic organic osmolytes, such as proline, betaines, or polyhydric alcohols, can be accumulated to balance the osmotic potential of ions between the cytoplasm and vacuoles. As is shown on ***Fig.5-2***. halophytes of this group are characterized by succulent and non-succulent species depending on the water content of leaves. Among them are species of genus *Climacoptera, Halostachys, Salicornia, Suaeda* and others.

b) Recretohalophytes (chrinohalophytes), which can excrete inorganic ions, primarily Na^+ and Cl^-, through the salt glands or salt hairs on the leaf surface (vesicular hairs, vesiculated hairs, salt bladders, bladder hairs, or, simply, bladders), thereby reducing their inorganic ion content via the leaves. In recretohalophytes, such as *Tamarix ramosissima* and *Limonium linifolium*, the increase in soil salinity also increases the efficiency of salt glands, which leads to decreased Na^+ and K^+ contents in shoots, accompanied by decreased proline content (Shuyskaya et al. 2017). It was also found that chemical composition of salts excreted by *Tamarix* and the composition of the soil salts differ between *Tamarix* grows in soils with different salt content and chemical composition of salts (soda, chloride, sulfate-chloride or chloride-sulfate). The content of salts excreted by *Tamarix* is higher than that accumulated inside the plant; sodium chloride (halite) is predominant (Lebedeva et al. 2020).

There are several species that combine various mechanisms. For example, there are species that can accumulate a certain amount of sodium in leaves (as euhalophytes) under saline conditions while also excreting excess ions through their salt glands or salt hairs (Al Hassan et al. 2017, Bueno et al. 2020).

5-3. Seed characteristics and seed germination ecology of halophytes

The seeds of halophytes differ significantly in their morphological characteristics (color, form, size) and anatomical characteristics (seed coat texture and size, rate of differentiation and position of embryo; level of endosperm development, fruit morphology, seed quality, seed viability and germination; content of various inhibitors, secondary metabolites and other substances, which may negatively influence seed quality and germination conditions). For example, berries with a soft pericarp like those of *Anabasis* have a deep dormant period determined by the presence of flavonoid pigments. The germination of many Amaranthaceae like *Atriplex, Salicornia, Suaeda* and *Salsola* is delayed by the presence of a considerable amount of salts (mostly chloride), located in the bracts/bracteoles or perianth segments. The presence of polyphenols and tannins in the upper layers of the fruit pericarp of many species of Amaranthaceae maybe an adaptation to post harvest fruit storage (Butnik et al. 2016).

Fruits of some species of *Atriplex* and *Suaeda* differ in seed germination and seed vigor features due to prominent polymorphism. The small dark seeds of Suaeda with thick-walled small cell sperpoderma have low germination rate in comparison with yellow seeds, produced from the same plant. The fruits of *Atriplex* spp. contain a high percentage of chlorides that accumulate moisture, and significantly inhibit the seed germination rate. Removing the fruit wings usually stimulate seed germination.

In the case of halophytes (*Halostachys caspica, Salicornia europaea* and others) seeds remain viable for a long period due to high contents of tannins in the spermoderma cells and low metabolic process in the chlorophyll-free embryo. The germination of seeds of different groups of halophytes varied according to type of soil salinity, the concentration of salts in the water and soil and salts chemical composition. Seed germination in mixed salt solutions was higher than in sodium chloride alone, possibly due to the influence of Ca^{2+} and Mg^{2+} (Khaitov et al. 2020). Seeds of *Calligonum* species (Polygonaceae) apparently retain the moisture stimulating seed viability due to the presence of cell layer containing salt crystals and the protective spermoderma.

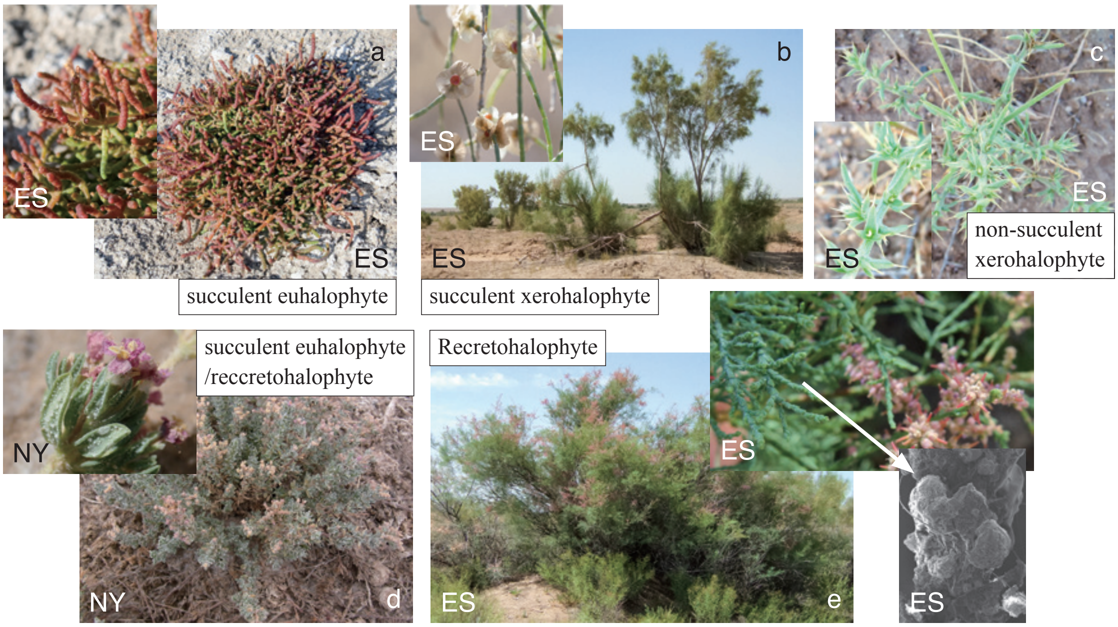


Fig.5-2 Plant species of different types of halophytes: succulent euhalophytes (a: *Salicornia* sp.), succulent xerohalophyte (b: *Haloxylon ammodendron*), non-succulent xerohalophyte (c: *Salsola paulsenii*), succulent euhalophyte/partly recretohalophyte (d: *Frankenia hirsuta*), recretohalophyte (e: *Tamarix ramosissima*)

6 Domestication of Wild Halophytes into a Halophytic Farming

Kristina TODERICH and Norikazu YAMANAKA

6-1. Prospects for cultivation of halophytic plants

Interest in using wild halophytes as cultivated plants has increased due to the increasing prevalence of stresses such as drought, salinity and high temperatures. Known for their salt tolerance, these crops have proven to be a valuable alternative for human nutrition and various biotechnology applications (Toderich et al. 2013, Correa et al. 2021). Salinity impacts on biodiversity include a relative increase for salt tolerant and for salt loving (halophyte) and a decrease for glycophytes (plants that prefer low sodium ecosystems). In rangelands, this can severely compromise quality and palatability of rangeland fodder plants. In croplands, increasing salinity limits the diversity of habitat types that restricts the range/extent of crops that may grow and reproduce in a saline environment. Threats to genetic diversity and habitats of wild halophytes and indigenous species (including crops, trees, livestock, fish and pollinators) are also associated with desertification, deforestation and degradation of rangelands. During the last decades, about 76% of the saxaul forest in Central Asia has been lost or degraded due uprooting or as result of poor self-regeneration of native trees populations (Zhang et al. 2023). Large parts of the Kyzylkum deserts, wetlands (Sudochie; Jiltarbas, Shurkuli, Ayagakitma and other lake ecosystems in the downstream of the Amu Darya river) are heavily degraded and habitats for many endemic, rare and endangered animal and plant species are threatened. Inadequate management has caused a loss of biodiversity, and those areas are now incapable of fulfilling important ecosystem functions (Toderich et al. 2023). Globally there are more than 1500 species of vascular halophytes (salt-loving plants) distributed in over 500 genera with a great economic potential. These plants can be progressively domesticated (cultivated in a saline farming system) to increase the amount of fodder available by utilizing of abandoned saline lands and providing a low-cost technologies and approaches to support ecosystem resilience (Toderich et al. 2018, Ozturk 2018). Wild halophytes species of the Aralkum saline desert and its neighboring dryland areas represent a salt-tolerant gene pool with a considerable potential economic value as food, fodder, medicine, oil, industrial and other materials. They could be the basis for genetic improvement of salt tolerance in conventional crops. But there is a lack of awareness of halophytic farming production. We need to know the potential production capacity of halophytes in the soils under varying saline conditions and/or irrigation with slightly mineralized water; and to investigate the availability of suitable markets for large-scale production of technical, medicinal and aromatic halophytes on saline soils. The domestication of such plants with high economic potential requires intensive research efforts (Hirich et al. 2020, Abidi et al. 2022).

Halophytic cropping system is a relatively new approach to managing with salinity in dryland agriculture. It involves the development cropping systems for saline environments by exploring the capacity of halophytes and salt tolerant non-conventional crops. It is also aims to learn how to produce high quality seeds in saline conditions by improving soil fertility and increasing the resilience of the agricultural ecosystem.

6-2. Range improvement and regeneration techniques

The range improvement and rehabilitation of degraded saline rangelands, inclusive the dry bottom of the Aralkum has been done by direct seeding (including aerial seeding and manual seed broadcasting), in contrast to most other range improvement operations which transplant nursery-grown seedlings, for example, in the arid and semi-arid areas of the West Asia and North Africa (*Fig.6-1* - *Fig.6-3*).

The best time for seed sowing is in the late autumn and winter season, when snow covered the soil, conditions that greatly facilitate direct seeding and are favorable for seed germination when temperatures reach a suitable lower limit. Sheep then trample the sown area to pit the seeds into the soil; this is an effective and cheap way of obtaining proper germination and minimizing loss of valuable seeds. A natural stratification of seeds occurred under low winter temperatures. A mixture of seeds of fodder species with various life forms may be seeded to improve rangelands productivity. Minimal land preparation is required prior seed sowing (*Fig.6-4*). Rough tillage ensures that sufficient moisture is

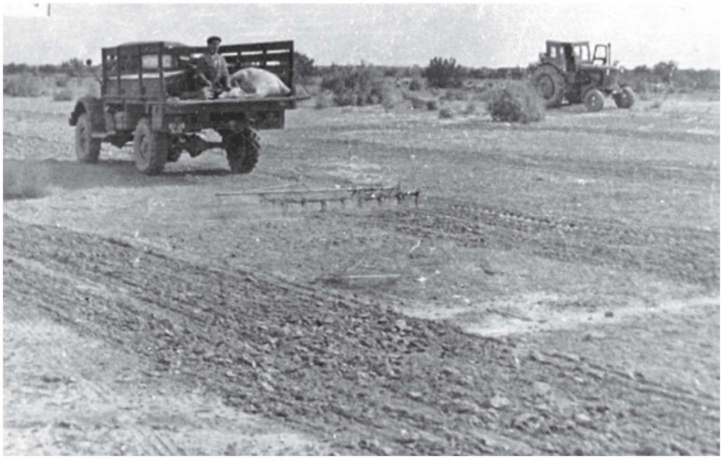


Fig.6-1 Old reseeding techniques practiced widely since 19th century is still used to create a vegetation cover at the dry bed of the Aral Sea (GG)

Fig.6-2 Saline affected ranges on the dry bed of the Arala Sea improved with *Haloxylon ammodendron* (BK)

Fig.6-3 Adult tree of *Haloxylon ammodendron* in fruit maturation stage (about 8-12 years old) (IA)

available and competition from undesirable plants is eliminated. The growth of *Haloxylon* and dwarf shrub seedlings can be accelerated using such a technical approach.

Haloxylon ammodendron, H. persicum, Calligonum species., Xylosaxola paletzkiana, X. richteri, Caroxylon orientale, C. gemmascens, Halothamnus subaphylla, Bassia prostrata, Camphorosma lessingii, Artemisia turanica, A. halophyla, A. diffusa, Eurotia ewersmanniana, Astragalus species, Cousinia recinosa, Poa bulbosa, A. desertorum, Agropyron fragile with participation of annual *Salsola* species (*S. schlerantha, S. pestifer*), *Gamanthus gamocarpus, Halimocnemis* and *Haloharis* species proved to be of most value for restoration of salt-affected rangelands.

The characteristics of seeding rate for basic arid zone forage plants chosen for the creation of artificial pasture phytocoenosis (*Fig.6-5*) depending on species, type of pastures and sowing qualities of seeds. Pastoralists needs to test seed germination value or to procure seeds from specialized seed growers' companies. Reseeding techniques with using of black saxaul (*Haloxylon ammodendron)* is used extensively for the creation of pastoral shelter, windbreaks and tree belts on the saline dry seabed of the Aral Sea, as well as throughout Kyzylkum desert and deltas of the rivers both in Uzbekistan, Kazakhstan and Turkmenistan.

The improved ranges can be grazed with appropriate management after 2-3 years. The life span of such improved range can be as long as 20-30 years if managed well and as long as 40-50 years if self-regeneration of black saxauls plantations occurred. Forestation initiatives on saline soils not only improved the productivity of rangelands but contribute to fixing moving sand dunes and protecting oases, settlements, towns and industrial sites from sand encroachment, sands and salts storms.

6-3. Afforestation and agroforestry technique

It has long been recognized that introducing of agroforestry systems can provide a range of environmental benefits, including those related to dryland salinity control, biodiversity enrichment, carbon sequestration, renewable energy, and flood mitigation. One of the most important motivations for the government to develop and promote agroforestry is that these benefits can be in addition to

Fig.6-4 Fuelwood collection on desert and semidesert region in Uzbeksitan (KT)

Fig.6-5 Artificial agrophytocenoesis with *Bassia prostrata* and annuals. Improved ranges can be grazed with appropriate management after 2-3 years (KT)

the financial benefits from the sale of commercial products. In an agroforestry system multipurpose tree species with high adaptive potential, salt, drought, frost tolerance, and high utility value are used. The leading tree species in terms of survival rate, growth characteristics, and adaptability to high-saline environment proved to be *Haloxylon ammodendron, Xylosalsola paletzkiana, Halothamnus subaphyllus, Caroxylon orientale, Artemisia difusa, X. richteri* at the saline sandy sites, followed by *E. angustifolia, Populus euphratica, P. nigra* var. *pyramidalis, Robinia pseudoacacia, Morus alba*, and *M. nigra* and some of salt tolerant fruit species, such as *Cynadon oblonga, Armeniaca vulgare, Diospyros kaki*, *Prunus armeniaca*, and wild species of genera *Malus* for salt-affected agricultural lands. Re-introduction of desert and riparian trees, shrubs and perennial tall grass are recommended for the restoration of saline wetlands. The overall ranking of the trees, weighing all parameters concurrently shows that species of genus *Tamarix* and *Elaeagnus angustifolia, Populus* and *Morus* trees have the highest potential for growing on both loamy and sandy soils, which represent the dominant soil textures in the region. As results, at marginal sites where a shallow, slightly-to-moderately saline groundwater is available throughout the growing season, *Elaeagnus angustifolia, Robinia pseudoacacia* and species of *Populus* showed the fastest growth and highest water use. This indicates the suitability for planting on low fertility saline lands. Preliminary outcomes of our studies on salt-affected soils have also indicated that tree plantations with *E. angustifolia, Populus nigra* var. *pyramiodalis, Morus nigra* have potential for increasing the soil organic matter due to the relatively rapid leaf litter decomposition. *Morus nigra*, *Diospylos kaki*, and *Cydonia oblonga* showed reasonable DM production on degraded land, with high biomass allocation towards the root fraction followed by a high fruit yield. Among tree species, Poplar (*Populus alba, P. nigra* var. *pyramidalis* and *P. euphratica*) showed the best growth and performance of physiological and agronomic parameters, followed by *Morus nigra. Populus diversifoilia*, which displayed high rates of leaf and wood production appeared to be the most sensitive to the saline sandy-soil type. Trees/shrub/plantations were deeply planted (sticks tap into the water table) through seedlings transplanting in early spring and/or in late autumn seasons. Irrigation with low-quality water should be applied during the initial stage of growth before sole reliance on available drainage water (EC 4.5-12.3 dS m^{-1}) resource becomes possible. Trees/shrubs plantations act also as a biological drainage, greatly increasing land productivity and improving the health of soils through rapid decomposition of leaf litter. An example of optimal integrated agroforestry system comprises of 12% tree cover, 30% lucerne and 38% annual forage crops in pastures with traditional agriculture practice. It provides satisfactory drainage control in saline environments and prevents salt accumulation at the root zone. C_3 halophyte species can colonize nutrient rich microsites and C_4 species can occupy nutrient poor microsites (***Fig.6-6***).

6-4. Phytoremediation techniques

Phytoremediation is defined as the cultivation of plants to reduce soil and water contamination from organic and inorganic pollutants. When dealing with large areas and low budgets it is the most cost effective and realistic means of obtaining the objectives of reducing salts (Caparrós et al. 2022). Phytoremediation with halophytes is often used for the removal of toxic salts from agricultural lands affected by salinity (Yamanaka and Toderich 2020).

The cultivation of licorice (*Glycyrrhiza glabra*) is a viable alternative in soils restoration technique by improving soil fertility and lowering groundwater levels (Andre Noble 2009, Khaitov et al. 2022).

Fig.6-6 Agroforestry demo trials (mixed multi-purpose fast growing trees with crops (IA) Salt-and drought tolerant trees/shrubs with annual cash crops between rows) on salt-affected farmers lands in the Delta of the Amu Darya river (Samanbay in 2019). a: land preparation and tree planting by of one year old trees seedlings, b: the same lands after one year, c.:the same lands after 3 years. Soil fertility and yield productivity increased by 2.0-2.5 times. Safflower (*Carthamus tinctorius L.*) being cultivated between trees rows represents a valuable food, dye and for vegetable oil. A good forage for all livestock. A potential plant for silage or winter concentrate.

Licorice is a perennial tall herb with a deep root system. It can reach depths up to 17 m. This halophyte can be propagated by seed, rootstocks and/or cuttings. It is easy to establish dense and long-lasting plantations on salt contaminated lands. Cultivation is recommended in early spring when the soil temperature reaches 10-12 ºC. At a plant density of 25800/ha, a total yield of 11400 kg ha^{-1} can be achieved with the shoot to root ratio being similar with 5460 kg ha^{-1} of above ground biomass and rhizome biomass at (5940 kg ha^{-1}). The total yield may be pushed up to 15420 kg ha^{-1} on good sites by increasing the plant density, this is not understood to have negative results on glycyrrhizin content (Marzi et al.1993).

Licorice root has a high commercial value because of sweet-tasting glycyrrhizin, sugars, flavonoids, sterols, amino acids, resins, starch, essential oil and saponins. Root powder and extracts are widely used in the food industry, pharmacology, cosmetics, and traditional medicine. In addition to improving social and economic benefits of farmers, licorice cultivation is one of the best technologies to convert saline soils into productive lands in the 5-7 years following the harvesting of licorice roots for commercial use (***Fig.6-7***). Following such phytoremediation we recommend the following crops: semi-dwarf early maturing variety of *Helianthus annuus, Sesamum indicum, Vigna radiat*a, sweet sorghum (*Sorghum bicolor*) in a mixed farming with native halophytes (***Fig.6-8***).

6-5. Food, fodder, medicinal and oil containing underutilized crops

Quinoa *(Chenopodium quinoa)* is an annual cash crop from Amaranthaceae family. This plant species is one of the oldest crops cultivated in the Andes (Latin America) for about 5000 years. Compared to common cereals Quinoa grains are very nutritious. Quinoa is known to be gluten-free, high in protein and one of the few plant foods that contain enough of all nine essential amino acids. It is also high in fiber, magnesium, B vitamins, iron, potassium, calcium, phosphorus, vitamin E and various beneficial antioxidants. Quinoa is one of the world's most popular healthy foods. Its seeds may be consumed as human food in flour, baked products, soups, drinks, salads and breakfast cereals. Leaves and stems are used as animal feedstock for their higher nutritive value.

Hibiscus cannabis as an annual fast-growing and salt tolerant crop is recommended to cultivate for production of durable hygroscopic fiber (up to 21% in dry stems), used for the manufacture of technical and packaging materials (***Fig.6-9***); Industrial oil is extracted from the seeds, and the cake is used to feed livestock. Hemp branches contain 16-20% fiber, of which 35% is primary fiber and 65% is secondary fiber. Secondary fiber is much softer and has high elasticity.

Jerusalem artichoke *(Helianthus tuberosus)* is an herbaceous perennial plant. It is also cultivated widely across the temperate zone for its tuber, which is used as a root vegetable.

Peganum harmala is a perennial herb or small shrub (Height: 30-50 cm) of Nitrariaceae commonly called "wild rue" or "harmel", and it grows on degraded and overgrazed desert and semidesert pasturelands with various levels of salinity. This species is widely distributed in desert areas from Mongolia, China, Central Asian desert, Iran to Mediterranean region. This plant, including its seeds contains alkaloids, which for centuries have been widely used in traditional medicine. Extract of harmala is effective in treatment of resistant depressions and they are also used in the treatment of Parkinson's disease and several other disorders. Likely, it has been used as an indigenous medicinal plant since ancient times. The Zaroastrian Persian and Muslims communities commonly use its extract in ritual purification ceremonies; its dried leaves and fruits has also been sold to people in local markets (*Fig.6-10*).

Fig.6-7 Licorice planted on saline farmer lands through cuttings. Artificial plantation of licorice in the 4th year of cultivarion (KT)

Fig.6-8 Switching to draft sunflower salt tolerant local variety after 5th years of licorice cultivation will convert saline soils into agricultural fertile lands (KT)

Fig.6-9 *Hibiscus cannabis*-a promising textile technical cash crops cultivated on alkaline saline soils in Karakalpakstan (NA)

Fig.6-10 *Peganum harmala* at fruit maturity stage sold in local market and used as medicine (GG)

Many species, with or without forage value, could be exploited for food, industrial dyes, and medicinal purposes (*Fig.6-11*, *Fig.6-12*).

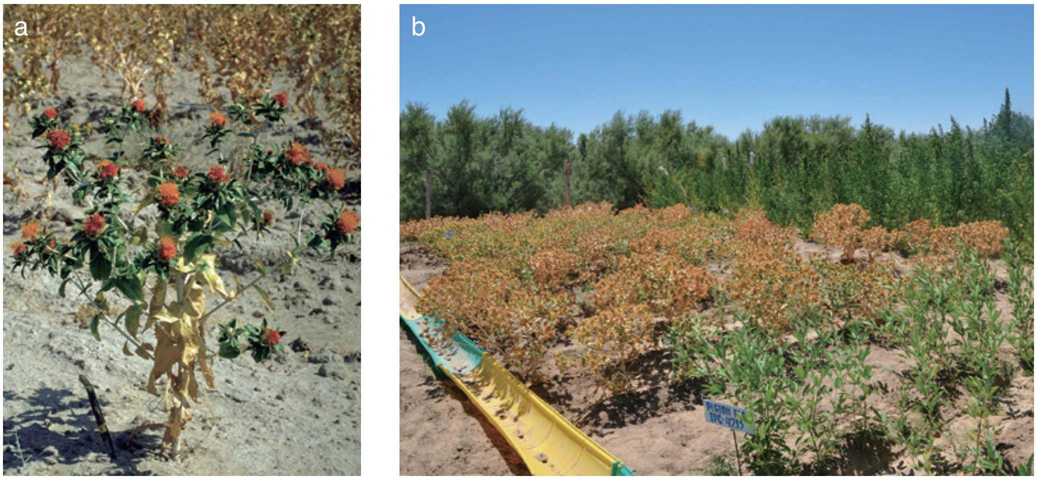
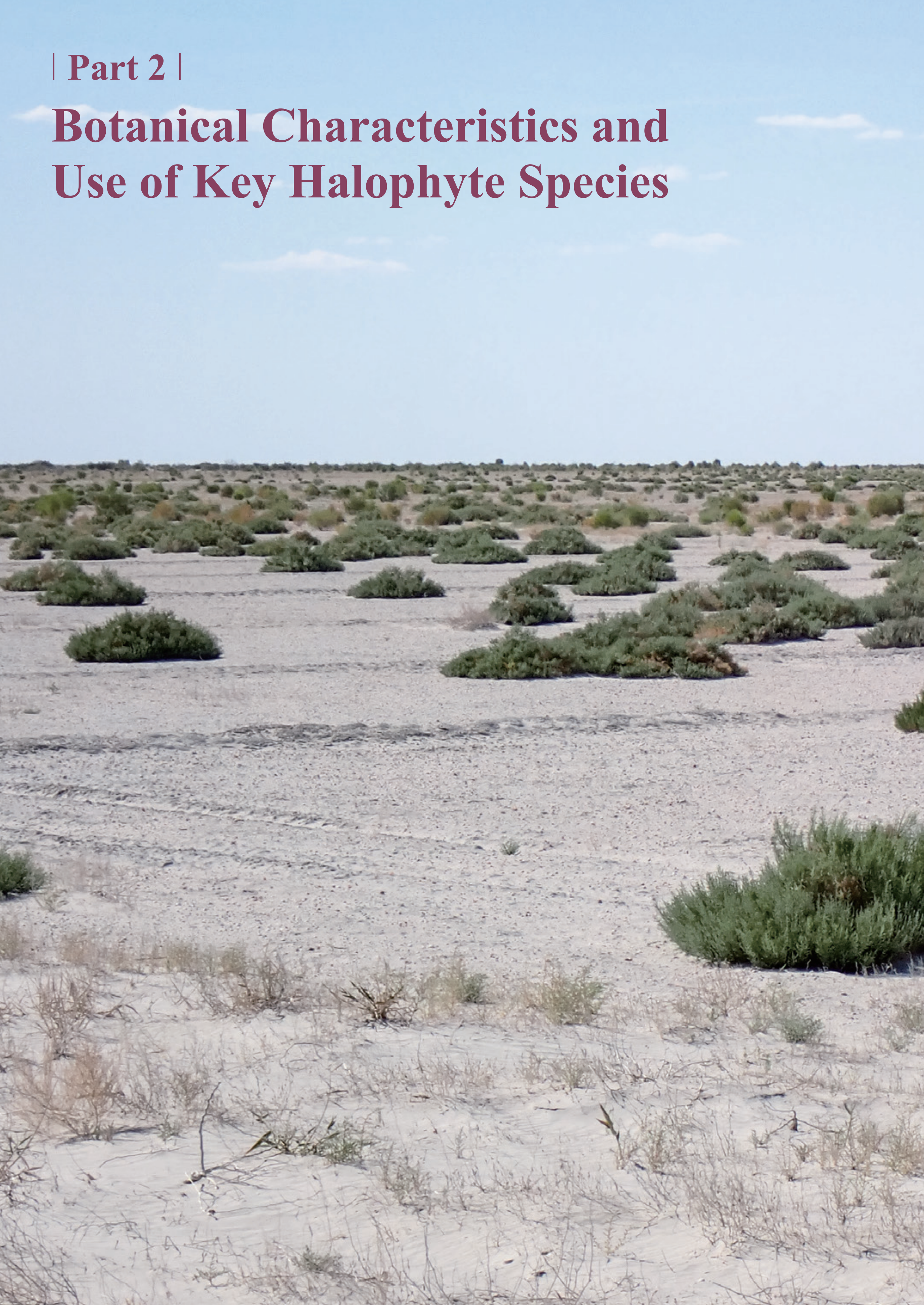


Fig.6-11 *Charthamus tinctorius* L. is a valuable fodder for all livestock (open grazing, silage, and winter concentrate). Seeds of *Carthamus* are of high economic value as food, dye, and vegetable oil. a: *Charthamus tinctorius* in flower. b: Cultivation of *Charthamus* tinctorius (TK)

Fig.6-12 Villages used dye from wild halophytes in the process of naturally dying carpets (GG)

| Part 2 |

Botanical Characteristics and Use of Key Halophyte Species



Amaranthaceae Juss.
Amaranthus retroflexus L. (black seeds)

Synonym: *Amaranthus retroflexus var. genuinus* Thell. ex Probst, *Galliaria retroflexa* (L.) Nieuwl., *Pyxidium retroflexum* (L.) Montandon
Local name: Qaytarma machin (Uzb), ширица отогнутая (Ru.).

Botanic characteristics and life form: C_4-non-succulent, annual pseudocereal, mostly pale green, sometimes reddish-tinged, 20-80 cm high.
Stem: Stem erect, simple or branched, grayish by dense short hairs, slightly angled.
Leaves: Large, ovate-rhombic, obtuse or slightly notched at apex, terminating in a short mucro, smooth above, shortly hairy beneath on the margin. Leaves turned red during fruit maturation stage.
Flowers: Bisexual in glomerules crowded in a green dense and very compact paniculate inflorescence, disposed mainly at the summit of the stem, branched in lower part, oblong-cylindric or ovoid-pyramidal; tepals 5, surpassing the fruit, in staminate flowers lanceolate, in pistillate oblong-linear, spatulate enlarged toward apex.
Fruit: Utricle ovoid to sub-globose, 1.5-2.5 mm, 1-seeded, indehiscent, rupturing irregularly or with circumscissile lid.
Phenology: Flowering and fruit maturation: June - August.
Seed germination: Small (less than 1.5 mm in diameter), black or blackish-brown, very shining, sharp-margined. 1000 seeds weight is about 1 g. One plant can produce up to 500 thousand seeds. In the soil, the seeds remain viable for 68 months. Seeds germinate in spring at a soil temperature of 22-26 °C. Due to abundant fruiting, it causes a huge clogging of the soil, giving up to 800-900 seedlings per 1 m^2.
Economic importance: There were few alkaloids in the aboveground biomass. Pigs willingly eat green biomass of *Amaranthus*, preferring it to other pasture species. The seeds may be used as food for birds (in the form of groats). Young boiled leaves are used for food. Young plants (including roots), in mixture with and consentrate foods. bran, are greedily eaten by animals. Livestock also graze readily on mature plants. Suitable for ensilage and concentrate feeds.
Habitat: Inhabitant in vegetable and ornamental gardens, weed-infested places, and field borders. It can be found on abandoned marginal lands in the vicinity of human and livestock settlements as well as seasonally flooded sandy flats.
Distribution: Introduced and naturalized nearly worldwide-European countries from West to East, Caucasus: Siberia, Central Asia: Aral-Caspian regions, Syr Darya and Amu Darya river basin, Western Asia, North African and Latin American countries.
Note: It is cultivated as a leaf vegetable, pseudo grain and ornamental plant. Used also in folk medicine for centuries. As an excellent source of protein, but also for ceremonial purposes, indigenous people have cultivated amaranth for centuries. For over 4000 years ago along with potatoes and maize, it was one of the staple foods of indigenous peoples. Amaranth can be used as a foodstuff by adding amaranth flour to biscuits and breads.


KT


KT


KT


KT

Amaranthaceae Juss.
Amaranthus viridis L.

Local name: Ko'k amarant (Uzb), щирица зеленая (Ru.).

Botanic characteristics and life form: C_4-pseudohalophyte, short-lived perennial herb (up to 1.0-1.8 m) commonly known as green amaranth.

Stem: Straight, sparsely to densely branched, with numerous erect or occasionally ascending branches (40-1.20 cm in height), ribbed, and red dyed.

Leaves: Triangular-ovate to narrowly rhombic, 3-7 cm long, 1.5-5.5 cm wide, glabrous, the tip usually narrow and with a small, narrow notch, stalks 1-10 cm long.

Flowers: Small green flowers with 3 stamens. Flowers assembled in a slender panicles in leaf axils or at branch ends. Female flowers are more numerous, bracts and bracteoles whitish, triangularly ovate to broadly lanceolate, membranous, with a short, bright or reddish awn. Sepals 3. Staminate flowers ovate to elliptic, 1.5 mm long, with a pointed tip, mucronate, stygmas 2-3.

Fruit: Small brown capsule (1.2-2 mm in diameter), wrinkled, indehiscent.

Phenology: Active growth: March - April, fruit maturation: June - August, sometimes until September.

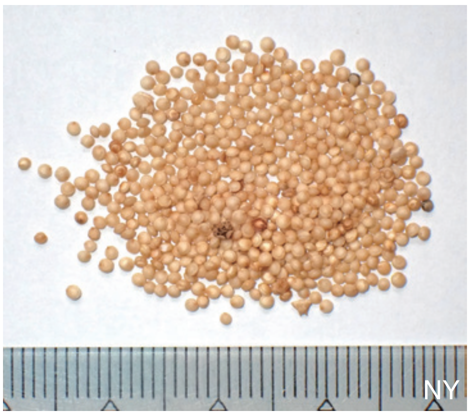
Seed germination: Small numerous yellowish-white, ovoid, glossy, slightly compressed, reticulated and with shallow projections on the reticulum. It reproduces mostly from seed. Unlike other amaranths, the seeds are easily harvested by scraping ripe spikes between fingers. Seed germinate well (up to 90%) at the alternating day/night temperature of 15/5 °C.

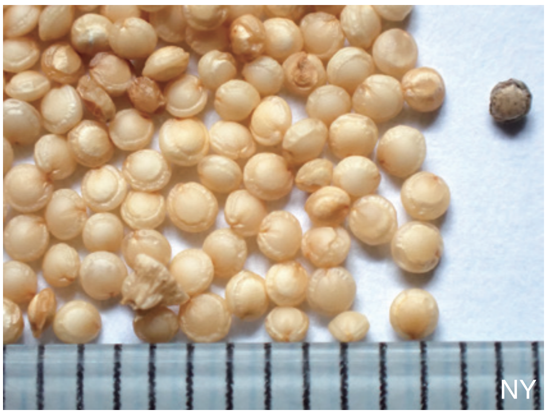
Economic importance: Green amaranth contains up to 38% protein. The leaves and seeds contain lysine, an essential amino acid. Due to its resistance to salinity, heat, drought, low soil nutrients, diseases and pests, Amaranthus is recommended for cultivation as a food and fodder crop.

Habitat: Abandoned salt-affected lands, railroads, lawns, gardens, waste areas, other disturbed habitats.

Distribution: Cosmopolitan.

Note: It is used as a boiled vegetable. The seeds can be eaten as a nutty snack. The high content of chemical substances (minerals, protein, amino acids, lipids) and bioactive metabolites (unsaturated fatty acids, tocopherols, tocotrienols, phytosterols and squalene) give amaranth a high nutritional and medicinal values.



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Amaranthaceae Juss.
Anabasis eriopoda (Schrenk) Paulsen

Synonym: *Brachylepis eriopoda* Schrenk
Local name: Qirqbuyurg'un (Uzb.), кемпир муштум (Kr.), ежовник шерстистоногий (Ru.).

Botanic characteristics and life form: C_4-stem succulent euhalophyte, undershrub, 10-30 cm high, glaucous, almost bluish, glabrous, usually hemispherical. Root straight, cylindric, long, blackish, 1-2 cm in diameter. Caudex white woody, capitate, woolly-tomentose at the base.
Stem: Cylindrical, very numerous prostrate-ramified, 2-5 mm in diameter at the subterete base, in upper part obtusely 4-angled like the branches, wrinkled on drying, profusely divaricately branched from the lower third, consisting of 10-15 internodes woolly-tufted at base.
Leaves: Horizontal or slightly recurved, all leaves terminating in a colorless bristle 2-5 mm long, arched-recurved to pendulous, only the uppermost ascending.
Flowers: Solitary in leaf axils, bisexual; bracteoles lateral, herbaceous, obtusely keeled, prickly, shorter than the flowers; perianth segments scarious, obtuse, oval or the inner oblong, obsoletely and irregularly toothed at apex, unchanged in fruit; stigmas subulate, short, thickish.
Phenology: Flowering: at the beginning of June, fruit maturation: at the end of August - September.
Seed germination: Seeds small, vertical, glabrous, lenticular or orbicular, light brown with thin hulled fruiting body, spirally intorted embryo and traces of endosperm. Laboratory seed germination is low. De-hulled and de-bracted fruits or pre-treated (light/dark) sequences, long-term stratification (5/25 °C, night/day) in 12-hour cycle, significantly increase seed germination. Seed viability 7-12 months.
Economic importance: Fodder for sheep, goats and camels. Contains a large amount of ash. It is not eaten or eaten very badly in fall and winter. Ash contains potash and soda, used in soap making. It was widely used as an insecticide. A special extract named ánabasin is applied to relieve inflammation, heal ulcers, restore respiratory centers, and reduce blood pressure, hot pressing and nervous function.
Habitat: Takyrs; also chalks, solonchak, especially gypsum, sandy-clay and gravelly-solonchak deserts with wormwood-dominated (*Artemisia terra-albae-Caroxylon orientale-Haloxylon* spp) plant communities.
Distribution: Central Asia: Aral-Caspian, Balkhash, Ustyurt plateau, Kyzylkum, Amu Darya river, Tajikistan, rarely in Issyk-kul in Kyrgyzstan, sometimes Iran, China (Inner Mongolia), Afghanistan, Mongolia (Gobi desert).
Note: The chemical composition of DM at fruiting stage contains (%) : hygroscopic water 5.31, ash 35.26-37.24, cellulose 4.96-5.23, crude protein 5.97-6.31, crude fat 2.46-2.60, nitrogen-free extract 46.09-48.62, starch equivalent 32.27-34.05. Aboveground biomass of *A. eriopoda* serves as a source of potash for home production of soap. In addition to potassium, the ash contains a large amount of sodium. Chemical composition: organic acids (in %) 13.6: oxalic acid 9.04. Alkaloids 0.06-2.45%. Roots: alkaloids 0.63%. Leaves are rich in saponins, alkaloids, flavonoids (>0.45%). Fruits contain saponins and alkaloids up to 1.08%.


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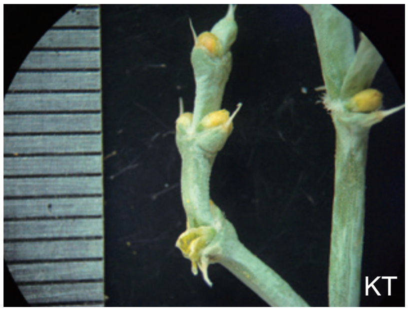
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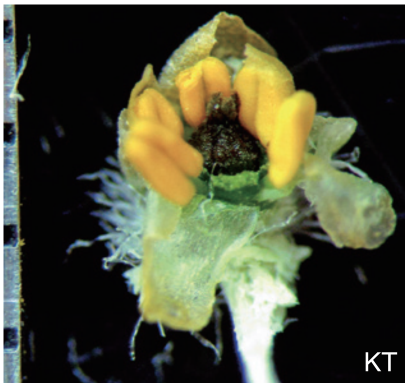
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Amaranthaceae Juss.
Anabasis salsa (Ledeb.) Benth. ex Volkens

Synonym: *Brachylepis salsa* Ledeb., *Anabasis ramosissima* Minkw.
Local Name: Sho'r buyurg'un (Uzb), сортаң бұйыргғын (Kaz), boyurgun (Trk), ежовник солончаковатый (Ru.).

Botanic characteristics and life form: C_4-succulent euhalophytes. Perennial almost spherical small shrub (10-60 cm) with strong woody ramified branches at the base. Root system is distributed in the upper superficial layers of soils (on 0.5-1 m).
Stem: Naked, white-green, glabrous, and cylindrical, articulate (5-20 internodes).
Leaves: Opposite, fleshy, prolonged (2-5 mm) slightly pointed at the end, amplexicaul or reduced to scales. Bracts: reduced to scale-like leaves, egged-triangular form. Bracteoles: grassed, wide-egged, and hulled.
Flowers: Bisexual, small, subtended by 2 bracteoles, axillary, usually solitary in spike or assembled in a panicle inflorescence.
Fruit: Monospermous, wide-egged, fleshy utricle. Pericarp: glabrous, fleshy, red, perianth leaflets-pentamerous with slightly sclerified coatings at maturity.
Phenology: Flowers: May - June, fruit maturation: August - September.
Seed germination: Small, vertical, glabrous, lenticular or orbicular, light - brown with thin hulled fruiting body, spirally intorted embryo and traces of endosperm. De-hulled and de-bracted fruits or pre-treated (light/dark) sequences; long-term stratification with 5/25 °C night/day on 12 hours cycles significantly stimulate germination rate.
Economic importance: *Anabasis salsa*, like other species of this genera, is considered the most preferable fodder for camels on autumn-winter pastures in the southern chink of Ustyurt. Valuable source for sheep, goat and horse in early spring. Occurs together with *Caroxylon orientale, Artemisia terrae-albae, A. kemrudica, C. fruticosus, Lycium ruthenicum, Anabasis brachiata, A. eriopoda, A. aphylla, Nanphyton erinaceum, Nitraria schoberi, Malacocarpus crithmifolius* plant species.
Habitat: On grey-brown soil, loamy alkaline soils, salt marshes, takyr-like and gravelly stony with high content of gypsum, rare on bedrocks scattered over considerable areas.
Distribution: Widespread in Central Asia (main component of *Artemisia terra-albae* pasture at plateau Ustuyurt, Karakum, Muyunkum deserts). Frequent in Mongolia, Southeast European part of Russia, Southern Siberia and Caucasus.
Note: Forage contains (% DM): crude protein from 7.1- up to 14.8; ash 18.2-31.0 cellulose 11.7-26.4; fat 1.5-3.2. Digestibility of protein (%) 70.2, fibber 69.1, fat 56.6, cellulose 44.9. Fresh forage of *Anabasis* contains also highly quantity of mineral salts (45% of soluble salts) and secondary metabolites such as alkaloids, oxalate, glycosides, tannins, phytosterol. In winter, provide about 41 fodder units and 6.5 kg of digestible protein/100 kg D.M.


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Amaranthaceae Juss.
Atriplex dimorphostegia Kar. et Kir.

Synonym: *Obione dimorphostegia* (Kar. & Kir.) G.L.Chu
Local name: Dimorfli olabuta (Uzb.), лебеда диморфная (Ru.).

Botanic characteristics and life form: C_4-non-succulent salt excreting euhalophyte. Spring-summer annual plant 5-40 cm tall (average 15-20 cm), gray-green, spread-branched, with whitish bare stems, cherry-colored leaves from below.
Stem: Grayish-green, divaricately branched; stem whitish, glabrous when mature.
Leaves: Ovate (egg-shaped) wrapped around its flowers and fruits; alternate except the lowermost 1-3 pairs, petiolate, only the upper ones sessile; mostly obtuse, entire. Abaxial leaf lobes densely covered with flaky scales.
Flowers: Solitary or 2-3 in glomeruli, sitting in the axils of the leaves. The perianth is spherical, its lobes are free, with fruits not changing.
Fruit: Dimorphous. Utricle with membranous pericarp. Two distinct types: i.) fruit (1.2-2 mm) bracts are flat, brownish-red, convex, lustrous. Flat fruit type appears first and is distributed in the proximal portion of the plant. ii.) fruits carry a wrinkled hump in the center (humped type of 2-2.5 mm).
Phenology: Active growth: February - early March, flowering: April - May, fruit maturation: June - July. It remains in a dry state until the end of August-beginning of September.
Seed germination: Small 1.5 mm in diameter; Germination on two-layers of filter-paper in Petri dishes at alternating (daily/nigh 22 °C/10-15 °C). Seed germination varies-68-89%.
Economic importance: It refers to fodder plants with good digestibility, eaten well by camels and satisfactorily by sheep and goats (it is readily eaten in a dry state after the autumn rains). Forage biomass in flowering stage contains high protein (22.7%) and low fibre (17.9%). Because of the abundance of grazing land, it is also suitable for haymaking.
Habitat: Saline sands, often sandhills, margins of takyrs, chalk, gravelly soil. Tolerate saline and very alkaline soils.
Distribution: Central Asia (Aral-Caspian, Kyzylkum, Karakum, Amu Darya and Syr Darya River basins), Afghanistan, Morrocco, Western Sakhara, Gulf countries, Xinjiang province (China).
Note: Locals use leaves in their diets due to high contents of vitamins and minerals. It is recognized as a good phytoremediator (clean up of contaminated soils by heavy metals). It can concentrate harmful levels of nitrates in its leaves. Artificial plantings can be made by sowing in mid to late spring. The genus consists of about 250 species. The name saltbush is derived from the Latin and refers to plants that store salts in their aboveground biomass (leaves and stems). It tolerates the highly saline soils of the Aral Sea coast.


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Amaranthaceae Juss.
Atriplex nitens Schkuhr

Synonym: *Atriplex sagittata* Borkh, *Atriplex hortensis* subsp. *nitens* (Schkuhr) Pon.
Local name: Jiloli olabuta (Uzb.), лебеда стреловидная (Ru.).

Botanic characteristics and life form: C_4-euhalophyte. Non-succulent salt accumlator. Annual herb (80-170 cm tall) with a powerful tap root system.
Stem: Erect, sparsely branched, cylindrical, green-striped, base colour yellowish or sometimes reddish.
Leaves: Deciduous, sessile or on a short petiole, alternate along branches, rarely in opposite pairs. Blade of variable shape, may be entire, toothed or lobed. The surface of the leaves is covered with bladder-like hairs, which later collapse to form a silvery, scurfy, or mealy surface, rarely with elongated trichomes.
Flowers: Borne in leaf axils or at the ends of branches, in spikes or spike-like panicles. After flowering, the bracts sometimes enlarge, thicken or become appendage-like, surrounding the fruit but not attaching to it.
Fruit: Large greenish lenticular achenes with shiny smooth testa, enclosed in a 5-lobed perianth. Fruit bracts enlarged during full maturation stage. Fruits heteromorphic, varying in shape and size. Pericarp free, tightly enclosed by fruiting bracts. Seeds flattened, mainly vertical, radicle inferior, lateral, or superior. Seeds viability: 2-3 years.
Phenology: Flowering: April - May, fruit maturation: July - September.
Seed germination: Seeds are dormant due to inhibitors in fruit bracts. Dormancy breaking treatments: (1). storage at laboratory temperature for four weeks (2). Stratification in the dark at 3-5 °C on filter paper moistened with distilled water (or treating solution) for four weeks and (3). Scarification by mechanical removal of testa. Field germination is high at low temperatures on clayey loam (heavy texture), low organic matter, slightly alkaline, low phosphorus and high potassium soils. Shows good self-regeneration if seeds remain in the soil after post-harvesting.
Economic importance: Nutritional fodder for animals, especially in growth active stage; in fruiting period recommended for producing fodder concentrates and pellets. Depending on the sowing and harvesting periods, the plant can grow very rapidly and produce above-ground biomass (31463-99898 kg/ha) in desired quantities from a unit area without fertilizers and irrigation. *Atriplex* biomass and fruits are sometimes eaten well by camels, large-cattle and used as food plants by larvae.
Habitat: Fixed sands, miscellaneous inland habitats with sparse or no vegetation. Tolerate high dries solonchaks and alkaline soils. Form large plantations on abandoned and salt-affected farmers lands.
Distribution: Central Asia and Caucasus, Afghanistan, China and Eurasia.
Note: *A. nitens* shows promising results in saline reclamation and in promoting halophytic farming. Cultivation of *A. nitens* is preferable in cold seasons after snow and rains. It can be used as an ornamental and landscaping plant to prevent soil erosion in arid areas. Genus Atriplex encompasses ca. 260 species distributed worldwide.


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Amaranthaceae Juss.
Atriplex pratovii Sukhor.

Local name: Pratov olabutasi (Uzb.), лебеда Пратова (Ru.).

Botanic characteristics and life form: C_4 non-succulent euhalophyte (secreting excessive salt out through salt bladders on the leaves). Annual herb with a spreading-branched stem from the very base 10-80 cm tall, silver-grey with powdery mildew from the base.

Stem: Straight, herbaceous, silver - gray from powdery plaque.

Leaves: Numerous, regular, elongated-triangular, expanded at the bottom.

Flowers: Unisexual, with 5 stamens, pistillate without a perianth, collected in dense glomerules (clusters). Inflorescence is a spike-shape of an ear, in which rhombic bracts are distinguished.

Fruit: Indehiscent single-seeded utricle, enclosed in 2 bracts (bracteolar veil), on a short stalk with tuberculate appendages on the back and a spear-shaped middle lobe. The seeds are relatively large, up to 4 mm long, colored in various shades of brown and light brown.

Phenology: Flowering: July - August, fruit maturation: September - October.

Seed germination: Dimorphic seeds: light seeds are flat, 1.5-2 mm in diameter; and dark seeds are round, 1-1.5 mm in diameter. The germination rate of light seeds is high 76-92%, germination lasts 6-10 days. Temperature optimum +10-15 °C. Light-colored seeds do not have a dormant period. Self-regeneration is good along the Aral Sea coast, where the soil seed bank is adequate.

Economic importance: Restoration of saline landscape; fodder for all kind of animals.

Habitat: It grows on seaside saline soils and sands, as well as sandy loam and loamy soils of various salinity degrees.

Distribution: Narrowly local endemic of the Aral Sea coast within Kazakhstan and Uzbekistan.

Note: First colonizer of the salt marches of coast area of Aral sea.


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Amaranthaceae Juss.
Atriplex tatarica L.

Synonym: *Chenopodium tataricum* (L.) E.H.L.Krause, *Schizotheca tatarica* (L.) Čelak., *Teutliopsis tatarica* (L.) Čelak.

Local name: Tatar olabutasi (Uzb.), татар коөкпегі (Kr.), лебеда татарская (Ru.).

Botanic characteristics and life form: C_4-non-succulent salt accumulator, annual herb 10-100 cm tall.

Stem: Erect or ascending, branched from the base.

Leaves: Leaves alternate, petiolate, triangular-ovate to oblong-ovate, rarely narrower, sinuate-toothed or lobed, often hairy on the margins and silvery-farinose on both sides.

Flowers: Flowers in terminal spiciform inflorescences, staminate flowers 5-merous; pistillate in glomerules of 3-20, enclosed by a pair of bracteoles.

Fruit: Indehiscent utricle. Fruiting bracteoles united in lower half, rhombic-sagittate or often 3-lobed, prominently nerved, minutely stipitate.

Phenology: Flowers: June - July, fruit maturation: July - September.

Seed germination: Seeds round, 2.5-3 mm in diameter, lustrous, glabrous, brown. Seed germination is high 96-98%, germination takes 6-12 days. Optimum field temperature for seed germination is +10 °C, but seeds germinate faster at 20-22 °C. Field germination 80-85%. Salt accumulation (chloride ions) in perianth and fruit (intact utricles) inhibits germination. Removal of fruit covers and bracteoles improves seed germination. Seedlings of Atriplex are reported to tolerate extremely high salinities (2500-5000 ppm). Germination decreases with age. It is low after 2 years of storage.

Economic importance: Young stems, leaves and fruits are readily consumed by sheep, goats, cattle, and camels especially in early spring to later summer. Environmental factors, cultural practices, sowing and harvesting times all have a significant impact on the nutritional value and digestibility of *A. tatarica* forage. In budding stage, dry matter content (%): ash 12.32, crude protein 8.07, albumin 6.99, crude fat 2.62, crude cellulose 24.17, extract free of nitrogen 32.29. Flowering stage foliage contain (%): ash 22.42 to 24.37, cellulose 11.07 to 12.03, crude protein 10.89 to 11.84, crude fat 1.84-2, nitrogen-free extract 45.78 to 49.76. The nutritive value of green forage is equivalent to that of medium-quality oat straw.

Habitat: On salt marshes, along the banks of rivers, channels, ditches, on brackish meadows, rocky slopes, abandoned salt-affected lands. Recommended for reclamation of salt affected lands.

Distribution: Central Asia and Caucasus, Afghanistan, China and Eurasia.

Note: Seeds contain alkaloids, coumarins, flavonoids (0.48-0.5%), and saponins. The leaves are suitable for marinades, spices, vegetable meals, and pickles. The plant can also be used as a source of potassium and calcium. The plant extract is used in traditional medicine.


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Amaranthaceae Juss.
Bassia prostrata (L.) Beck

Synonym: *Kochia prostrata* (L.) Schrad.
Local name: Yerbag'ir izen (Uzb), бассия распростёртая, изень стелющийся (Ru.).

Botanic characteristics and life form: C_4-non-succulent euhalophyte. A semi-shrub (60-1290 cm tall) with prostrate woody shoots, from which straight or ascending herbaceous branches come out at the base. Woody root system thick, penetrating up to 3-3.5 m - gypsum; 4.5-5.2 m in foothills and up to 6.5 m deep in sandy desert soils.
Stem: Woody stem usually less than 10 cm; annual branches simple or branched, not striate, slightly ribbed, densely light yellow-brown, light reddish, or gray-white pilose, densely white crisped pilose or subglabrous.
Leaves: Sub-sessile, small (0.5-0.3 cm long; 0.5-2.0 mm wide), compressed, thinly hairy, thread-linear or semi cylindrical, acuminate with dentate margins.
Flowers: Bisexual and female, usually 2 or 3 per glomerule, arranged in spikes on upper part of annual branches, assembled in panicles. Perianth globose, densely sericeous; segments ovate or oblong, incurved, apex obtuse; winglike appendages with purple-red or black-brown veins, flabellate or obovate, membranous, margin irregularly crenate. Filaments filiform, slightly exserted. Stigmas 2, purple-brown, filiform.
Fruit: Monospermous (1.5-7.3 mm), indehiscent utricle, depressed globose; pericarp gray-brown, thickly membranous. Fruiting perianth segments slender cartilaginous, connate at the indurate base to form a yellowish 5-armed stellate structure; wings 5-horizontal spreading (1.5-2.2 mm), unaccreted, pale-green, triangular towards base, deeply lobed, faintly radial veined.
Phenology: Flowering: May - August, fruit maturation: July - end September.
Seed germination: Small black-brown, subglobose, ca. 1.5 mm in diameter. Maximal germination: 88% (30 °C). Seed viability 8-12 months. Germination improved in 12 hours (dark/light) cycles (15/25 °C, night/day). Bassia species can also be propagated vegetatively.
Economic importance: The young stems, leaves and fruits are good forage for all types of livestock and wildlife animals all year round. Considered a high caloric fodder by shepherds. Highly productive, drought-resistant and salt-tolerant, much promoted for the improvement of rangelands and/or the creation of long-term pastures in desert and semi-arid areas, and to produce hay and concentrate feed for winter season. Excellent regrowth ability. Expected yield in semi-desert 1.2-2.6 t/ha.
Habitat: In mixed shrub and grasslands communities on grey-brown, loessic deposit, loamy-clay soil, steppes, stony slopes very rarely, salt-alkaline soils, on salt-marsh margin (ref: *Bassia*-clay ecotype), sandy soil, desert wadis (*Bassia*-sandy ecotype) and stony, calcareous, skeletal slopes (*Bassia*-stony ecotype).
Distribution: Central Asia and China, Morocco, North Caucasus, Pakistan, South European Russia, Spain, Switzerland, West Himalaya, West Siberia.
Note: *Bassia* ecotypes prefer a sunny location with a medium level of soil moisture. estimated to 45.1-67.5 Fodder Units and 9.68 kg digestible protein/100 kg DM. Green forage contains (% DM): crude protein 14-15; fat 3.3-4.3; ash 9.7-13.8; nitrogen free extract substances - 28.7-43.5; cellulose 26.5-30.8. Leaves of *Bassia* contain 14.7 protein, 4.7-39.6 mg/kg of carotin, and 10.7-18.5% lignin.


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Amaranthaceae Juss.
Bassia scoparia (L.) A.J.Scott

Synonym: *Kochia scoparia* (L.) Schrad., *Atriplex scoparia* (L.) Crantz, *Bushiola scoparia* (L.) Nieuwl., *Chenopodium scoparia* L., *Salsola scoparia* (L.) M.Bieb.
Local name: Supurgi izen (Uzb.), бассия веничная (Ru.).

Botanic characteristics and life form: Non-succulent C_4 euhalophyte. An annual plant 30-150 cm tall.
Stem: Green or reddening toward fall, strongly branched, stem and branches upright, covered in upper part with thin crisp hairs.
Leaves: Alternate, lanceolate to linear-lanceolate, flat, acute, narrowed at base into a petiole, prominently veined with short appressed hairs sometimes confined to the underside, the margin long-ciliate.
Flowers: Small in compact clusters of 1 or 2 (up to 5) in the axils of bracts; female flowers mostly without a keel. Inflorescence in spikelike or paniculate arrangement.
Fruit: Winged utricle, monospermous, indehiscent.
Phenology: Flowering and fruit maturation: July - October.
Seed germination: Seeds dark to blackish-brown, small mostly ovate. Field seed germination at 15-20 °C varies 78-92%.
Economic importance: In culture (garden form) yields a large harvest, therefore, it is necessary to carefully study it for the purposes of silage and, if the results of silage are positive, it should be further tested on abandoned agrifields. Good fodder crop for animal feeding as fresh and concentrates. (DM %): ash 10.3, protein 9.4, fat 0.8, fiber 28.5, nitrogen-free extract 51.0. The seeds contain saponins. Compared to most grasses and forage plants, it contains higher levels of protein and oxalate. Its use should therefore be limited by its toxicity when eaten in large quantities. Grown as an ornamental, evergreen foliage for landscaping. It is used in the reclamation of salt-affected land, useful in preventing soil erosion. Recommended as a phytoremediator for the removal of traces of heavy metals such as chrome, lead, selenium and uranium.

Habitat: Grows well in grasslands, deserts, ruderal areas, roadsides, abandoned agricultural lands and very alkaline saltmarshes. Withstands drought and salinity.
Distribution: Almost cosmopolitan species.
Note: Used in folk medicine for rheumatism and dropsy, it has diuretic, laxative, and diaphoretic properties. It was originally introduced as an ornamental bedding plant for its yellow-reddish stalks and dense leafage. The locals use it to produce of brooms for household cleaning.


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Amaranthaceae Juss.
Camphorosma monspeliaca L.

Synonym: *Camphorosma Lessingii* Litv.
Local name: Marsel kamforosmasi, Lyessing qoramatov (Uzb.), камфоросма монпелийская (Ru.).

Botanic characteristics and life form: C_4-non succulent euhalophyte. Perennial, small shrub (height 25-80 cm) with a grayish, heath-like appearance. Woody and slightly ramified short shoots form a turf arising from the base. Pivotal root system reaching to depth 2-8 m.
Stem: Annual shoots borne on the woody branches whitish or white-tomentose with short crisp hairs, mostly ramified only in the upper part.
Leaves: Narrow, sharply pointed, rigid, densely covered with scale-like hairs, silvery appearance. subulate, 3-10 mm long.
Flowers: Bisexual; regular, single axillary arranged in a compound panicle; 4 stamens with elongate un-appendiculate anthers. Perianth 5-Iobed (1.0-1.5 mm long), orbicular, flattened, hairy.
Fruit: Small, lyzicarpous, monospermous.
Phenology: Flowering : June-end of August, fruit maturation: September - end of October.
Seed germination: Vertical, orbicular, flat 1.5-1.75 (2) mm long, brown or brownish-black. Embryo small, curved chlorophytic with a large starched perisperm. Seed vigour 88-92%. Light sensitive. Germination (%): 38-42 at the field; laboratory 79-84. Short-term stratification increase seed germination rate. Seed longevity 8-12 months.
Economic importance: Highly nutritional forage for small ruminants and camels. Well consumed during fall and winter period after leaching of mineral substances. Expected yield in *Artemisia* steppe varies 0.06 to 1.2 t DM/ha. During early stage of vegetation considerable amount of mineral salt, volatile oil, microelements and amino acids available. At fruiting stage in Western Kazakhstan (% DM): crude protein 14.4; nitrogen 10.1; fat 2.2; cellulose 35.2; nitrogen free extract 39.3. Fodder value estimated to 48 fodder units and 2.4 kg digestible protein/100 kg DM.
Camphorosma as a drought, salt, frost and grazing resistant plant is recommended for improvement and/ or creation of long-term, mainly autumn-winter pastures.
Habitat: On salt-marshes (solonchak-alkaline soil), especially along riverbanks and lakes shores, as well on nearby stony slopes in solitary stands in *Artemisia-Haloxylon ammodendron* plant communities.
Distribution: Central Asia and Afghanistan, North Caucasus, Mongolia, Morocco, South European Russia, Tunisia, Turkey, Xinjiang province in China.
Note: The plant emits the odor of camphor and in the past, it had medicinal applications as a stimulant, diuretic, and diaphoretic. It still finds use in popular medicine in some localities. The plant contains about 0.2% of volatile oil.


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Amaranthaceae Juss.
Caroxylon dendroides (Pall.) Tzvelev

Synonym: *Salsola dendroides* Pall.
Local name: Draxtsimon sho'rak (Uzb.), даpактай баялыш (Kr.), солянка древовидная (Ru.).

Botanic characteristics and life form: C_4-succulent euhalophyte. A semi-shrub 0.7-1.5 m tall, profusely and densely branched.
Stem: Woody stem is short at the base, mostly no more than 5-8 cm tall and thick, producing straight long annual shoots, branched only in the upper half and grayish from thick, curly hairs. The branchlet-systems often pyramidal in outline.
Leaves: Small, fleshy, shortly linear to boat-shaped or scale-like, about 1-4 (-8) mm long and about 1.0-1.5 mm wide, glabrous or pubescent.
Flowers: Flowers sessile, 2-6 perianth subglobular or broadly ovoid, flattened from the top especially in lateral flowers; solitary in upper axils, about 2-2.75 mm. long, sessile, or rarely more in axillary clusters, both perfect and pistillate; and seeming spicate. Sepals 5, glabrous to pubescent.
Fruit: An utricle, globose; pericarp membranous of about 6-10 mm in diameter (including wings); wings encircling the fruit, each wing reniform to transversely elliptic or deltoid-obovate, 2-4 mm. long, 1.5-7 mm. wide, scarious with a sheeny surface, very closely veined, erose on outer edge.
Phenology: Active vegetation in April, flowering: June - August, fruit maturation: end of August - October.
Seed germination: Small brown, horizontal about 1.5 mm wide. Field germination is low (8-12%), because of sclerified fruiting body. Viable seeds: 78-82%. Stratification (3 °C) for 0.5-1 month increase the germination up to 56%. Seed viability more than one year.
Propagated exclusively by seeds.
Economic importance: Annual shoots contain a lot of ash (over 30%), the amount of which is quite significant even in winter. In the annual shoots during the growing season there is a lot of sugar (over 10%) and little fiber (about 20%). Camels eat all year round; in summer it is satisfactory, while in fall and winter during fruiting stage it is consumed by all types of animals. The leaves and young branches of the plant are willingly eaten by sheep, especially in January, after frosts and snow.
Used as material for potash extraction. Chemical composition of volatile organic acids 1.49%, alkaloids 0.05%. Stems, fruits, seeds contain saponins. For fixing slopes for artisanal production of lye and soap making. On winter pastures in clean and mixed thickets, the gross yield is 0.1-1.2 t/ha of dry weight. The yield of green mass is 0.01-0.5 t/ha.
Habitat: Common on slightly to moderately saline, preferably deep clayey or silty semi-desert soils of plains and gentle slopes and solonchaks in downstream of Amu Darya rivers basin; occurs also on the chinks of Ustuyurt.
Distribution: Afghanistan, Iran, Iraq, Kazakhstan, Kyrgyzstan, North Caucasus, South European Russia, Tajikistan, Transcaucasus, Turkey, Turkmenistan, Uzbekistan.
Note: Artificial plantations of *C. dendroides* are used for the rehabilitation of degraded and salt affected drylands. Local people used the extract for medicinal purposes as a diuretic, laxative and anthelmintic. It is considered a good biofuel plant.


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Amaranthaceae Juss.
Caroxylon gemmascens (Pall.)Tzvelev

Synonym: *Salsola gemmascens* Pall.
Local name: Titir, kurtakchali sho'rak (Uzb.), Jertezek (Trk.), Tytr (Kzk.), Солянка почечконосная, тетыр, джертезек (Ru.).

Botanic characteristics and life form: C_4-gypsohalophyte. Perennial almost spherical-shaped low-shrub (15-45 cm) slender, woody at the base.
Stems: Heavily ramified, covered with many transparent scale-like mounds; there are many salt glands along the stem as well as on the leaf surfaces.
Leaves: Alternate, small 3-angular with a hump from below, and large extended at the base and attached closely to stem.
Flowers: Bisexual, Anthers divided almost to the end with oblong-ovate or lanceolate-acuminate appendage. Stigmas compacted, glabrous, reddish colour.
Fruit: Monospermous, nut-like, winged red-bright yellow, pinkies (7-10 mm). Perianth during fruiting stage with short, thin faintly veined kidney-like shape or inverse ovate wings; upper perianth: wide, thick -walled with convex, friable tube.
Phenology: Flowering: August - September, fruit maturation: September - October.
Seed germination: Horizontal, rarely vertical or sidelong one.
Economic importance: From autumn until spring, well grazed by camel and small ruminants. In autumn and beginning of winter considered as high calorific feed for sheep and camels, but later in spring and summer poorly consumed except by camels. Not grazed by horses and cattle. Expected yield 0.01-0.5 t DM/ha that contains 71 fodder units and 9.7 kg digestible protein/100 kg DM. Fodder value much higher during winter period. Green forage (%): protein 8.8-13.8, fat 1.6-3.5, cellulose-17.5-26.0, ash 22.2-28.6.
Habitat: Prime colonizer (edificator) on takyr-like or on compacted sandy, gypsiferous more friable soils, takyr soils advanced on ancient alluvial deposits of part of flood plain near riverbed of Central Asia, residual salt-marshes (solonchak-alkaline soils) and heavy clay or loamy gypsiferous soils in South-West of Kyzylkum, Minbulak depression, Aral Sea bottom, Kazakhstan.
Distribution: The native range of this species is Caucasus to Central Asia and Afghanistan, rare in Mongolia.
Note: Considered as a valuable plant for range improvement and/or creation of permanent pastures on salty and solonchak, takyr-like soils, also used for rehabilitation of degraded saline desert areas.


BA


KT


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Amaranthaceae Juss.
Caroxylon incanescens (C.A.Mey.) Akhani & Roalson

Synonym: *Nitrosalsola incanescens* (C.A.Mey.) Theodorova, *Salsola incanescens* C.A.Mey.
Local name: Kulrang sho'rak (Uzb.), Солянка сероватая (Ru.).

Botanic characteristics and life form: Annual herbaceous semi-succulent euhalophyte, up to 60 cm tall, greyish from dense, spurred hairs that do not shed.
Stems: Semi-succulent with upwardly slanting branches.
Leaves: Regularly lobed, short, sessile, blunt, and fall early fruit maturation stage.
Flowers: Bisexual, solitary. Involucral bracts longer than subtending bracts, equal to or shorter than perianth. Perianth-lobes (5) ovate or lanceolate, filmy-veined, appressed-hairy, gathered in a rounded arch at the apex, pubescent with appressed straight simple smooth hairs. Inflorescence paniculate or spicate.
Fruit: One-seeded lysicarp in a perigynous covering of 5 perianth leaflets, which are pubescent with smooth, straight hairs, the apex of which forms a cone. The wings are horizontal, located in the middle part of the leaflets, 2 kidney-shaped, 3 narrow, pink, brown when ripe. When fully ripping, the lower wings are glabrous or ciliate at the margins.
Phenology: Flowering: May - June, fruit maturation: June - end of September.
Seeds: Horizontal, the embryo is spiral. After 12 months of dry storage at +18-25 °C, germination at the same temperature was 91%. The seed dormancy is shallow or absent. Seeds dispersal by wind.
Economic importance: Fodder species are readily eaten by animals (camels, horses, small ruminants). They can be grazed freely or mixed with other desert fodder plants as hay for winter feeding. Used for restoration of degraded rangelands.
Habitat: Grows on salty, loamy, sandy-clayey soils. Frequently occurs along the desert roads, abandoned overgrazed pastures.
Distribution: Central Asia, Iran, Iraq, Pakistan.
Note: Indigenous shepherds use a substance called shaghar, derived from *C. incanescens*. It is used to make raisins. This plant has medicinal and industrial properties.


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Amaranthaceae Juss.
Caroxylon orientale (S.G.Gmel.) Tzvelev

Synonym: *Nitrosalsola orientalis* (S.G.Gmel.) Theodorova, *Salsola orientalis* S.G.Gmel.
Local name: Sharq sho'ragi (Uzb.), күйреуік (Kaz.), kevryk (Trk.), солянка восточная, солянка корявая (Ru.).

Botanic characteristics and life form: C_4-semi-succulent euhalophyte, salt, frost and drought resistant due to a powerful taproot system (down to 7.0 m that reach underground water). Perennial, polymorphic, friable sub-shrub (25-60 cm). Life span: 12-25 years.
Stem: Branching from the base; woody branches greyish brown, stiff, woody, crooked, covered with short, crisp hairs. Annual twigs herbaceous, densely short, pilose.
Leaves: Small 25-30.8 mm, alternate, linear, almost semi-terete, obtuse, slightly dilated and adpressed, hairy at the base.
Flowers: Bisexual, single, sepaloid, dark yellow with 2 bracteoles. Anthers: lengthening-oblong, appendiculate or with small orbicular appendage. Inflorescence: wide panicle. Bracts much thicker and less rigid. Bracteoles broad, obtusely keeled, scarious margined. Perianth segments: ovate, hulled-margined, lanceolate, hairy, rarely becoming glabrate during fruit maturation.
Fruit: Winged, indehiscent nuciform, monospermous. Perianth (including wings) 7-10 mm in diameter in fruit; segments narrowly ovate, abaxially somewhat fleshy and winged from the middle, densely pubescent, margin membranous; part of segment above wing fused with others, forming a short cone; 3 wings purple or roseate or possibly yellowish, turning brown when ripe, reniform, with numerous veins; other 2 wings smaller.
Phenology: Flowering: May - August, fruit maturation: August - end of September.
Seed germination: Seeds orbicular, yellow-dark/brown (2.0 to 2.5 mm) closely accreted with thin fruiting body. Embryo large (20-28 mm), spirally intorted with perisperm. Germination in the field 18-52%. Stratification of seeds (3 °C/0.5-1 month) or treatment with phytohormones and washing of fruits (distilled water 2-3 changes) increase germination. Freshly harvested seed viability 85-92%, declining sharply after 12 months in aerial. storage. Seeds anemochorous (disperse by wind).
Economic importance: Excellent fodder; eagerly eaten by all livestock, of high feed value in autumn and winter for camels, sheep and goats. It can be harvested as a hay crop and as a concentrated feed for winter season. It is known to be an alkaloid plant.
Habitat: On gravelly, gypsiferous, clay-saline soils, takyrs, less often on salt marshes, sandy loam areas from plains to highlands. Growth in large stands at the plateau Ustuyurt in *Artemisia tera-albae - Anabasis salsa - Caroxylon gemmascens-Nanopyton erinaceus* plant communities.
Distribution: Middle and Central Asia, Caspian region, Caucasus, Iran, Afghanistan, China.
Note: Drought and salt tolerant used for range improvement and/or creation of permanent autumn-winter pastures. Expected yield on adyrs MAP 200-350 mm rangeland reaches 0.85-1.26 t DM/ha. It is widely used for pastures restoration program. Yield productivity of improved pastures varies 1.59-3.28 t DM/ha. Pastoralists uprooted to consume as fuel.


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Amaranthaceae Juss.
Caroxylon scleranthum (C.A.Mey.) Akhani & Roalson

Synonym: *Salsora sclerantha* C.A.Mey.
Local name: Tog'oyakrangli sho'rak (Uzb.), shora "peshmek" (Trk.), солянка жестkoцветковая (Ru.).

Botanic characteristics and life form: C_4-non-succulent euhalophyte. Annual (10-45 cm), profusely branched from base, at least in upper part farinose with slim bladdery hairs, in lower part densely covered with long willowy tangled and largely fugacious hairs.
Leaves: Alternate terete, dilated at the base, hairy, deciduous when fruiting.
Flowers: Bisexual, solitary remote 3-5 mm long at anthesis. Perianth much longer than bracteoles, heavily clothed with bladdery scales and usually with some simple hairs; scarious-margined winged in fruit below the middle; wings membrananous, often stiff, rounded-obovate or oblong-spatulate, yellow or pinkish or purple turning yellowish; fruiting perianth including wings 7-12 mm across, the lobes pyramidal connivent, the inflexed margins forming slits. Anthers divergent well beyond the middle.
Fruit: Single-seeded monospermous utricle in a 5-lobed perigonal cover. Wings horizontal, transparent with prominent midvein, assembled in a cone-shaped column narrowed at base; pink or purple, turning yellowish when ripe. Fruit 7-12 mm in diameter including wings, with pyramidal lobes, the inflexible margins forming slits.
Phenology: Flowering: July - August, fruit maturation: August - October.
Seed germination: Small, orbicular brown with spiral embryo without perisperm. Freshly harvested seeds have low germination. Seeds stored for one month at room temperature germinated on day 8 at +20 °C and lasted up to 15 days with 50% germination. Seed viability is 12-14 months.
Economic importance: Good palatability and nutritious value. Green biomass 0.15-0.43, rarely to 0.6 t/ha. In summer, rich in vitamins for sheep, lambs, goats and cattle. Palatability in autumn is greatly improved. Highest contents of ash than other annual salsolas (up to 34.8% in summer; and decreases up to 9.8% in winter). Forage biomass (% DM): cellulose 14, rises to 44 when dry; protein 8-14%. Carotin content varies from 8.4 at bud stage up to 2.79 mg/kg in fruit.
Habitat: Compacted and grey-brown sand, weakly salted, loamy clay or seldom on stony areas. Occurs both individuals or in patches of many individuals in Artemisia-terrae albae desert plant communities.
Distribution: Middle and Central Asia, Iran, Afghanistan, China.
Note: Natural regeneration of *C. scleranthum* occurs in both spring and fall, but plants germinated in late fall and winter seasons are more drought resistant and more likely to establish. Used to restore degraded/salt affected pastures and for open grazing cattle, sheep, goats, and camels. Rainwater harvesting using contour furrows that prevent run-off increases the successful establishment of artificial agrophytocenoses with *C. scleranthum*. It is harvested for hay by local pastoralists. It is also mixed with other fodder crops and used as a winter bio-feed for livestock.


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Amaranthaceae Juss.
Ceratocarpus arenarius L.

Synonym: *Ceratocarpus utriculosus* Bluket ex Krylov., *Ceratocarpus caput-medusae* Bluket ex Krylov, *Ceratocarpus turkestanicus* Sav.-Rycz., *Ceratocarpus arenarius* subsp. *utriculosus* (Bluket ex Krylov) Takht.

Local name: Qum ebalagi (Uzb.), қум эбелек (Kaz.), кум эбелек (Kr.), рогач песчаный (Ru.).

Botanic characteristics and life form: C_4-non-succulent euhalophyte. Annual (12-15 cm high), almost spherical plant (5-30 cm), greyish, pubescent and strongly ramified at the base. The bracts end in short awns, so that when the plant matures, it becomes prickly. Pivotal root system (30-55 cm) is superficial.

Stems: Long (5-30 cm), grayish by stellate hairs and strongly branched from base, slender crooked, bifurcated, ascending from woody root.

Leaves: Rigid, alternate, opposite less often by 3 in group, linear or threading-linearly, 1-4 cm long and 0.5-2 mm broad with stellate hairs. Bracts (1.0-1.4 cm in long, 0.5-2.0 mm wide) highly pubescent, spiniform at the end.

Flowers: Monoecious, unisexual in small axillary clusters in terminal inflorescence; male flower: inconspicuous, short petioled with two-lobed perianth and 1 stamen arranged axillary by small glomerule (2-5); female: singular without perianth with superior highly pubescent ovary and 2 threading or filamentous stigmas, surrounded by 2 accreted bracts.

Fruit: Utricle 5-10 × 2-5 mm, lyzicarpous, monospermous, indehiscent with thin hulled fruiting body. Fruit dimorphism: at the base of the plant, fruits flattened, inverse-egged shape almost without horns structures; the fruits at the upper part: oblong-inverse wedged, faint venation on the margins and at the end with 2 width horns-like structures.

Phenology: Flowering: May - June, fruit maturation: July - August.

Seed germination: Small, vertical with differentiated embryo and a trace of endosperm. Anemochory seed dispersal. After dry storage (fresh harvested seeds) at room temperature for 12 months germination varies 60-85% in both light and darkness over the range of temperature regimes at 5 °C/25 °C.

Economic importance: Valuable feed for camels, horses, sheep all round year, preferably in early spring. Serves fattening feed for camels and horses, improves the amount and quality of milk. In favourable wet years could be used for hay production. Rejected by all livestock in summer because of spines, but well eaten by camels, horse and small ruminants in late autumn after rains.

Habitat: Prefers wastelands and slightly saline sands. Occurs also on brown or grey-brown soil and semidesert belts. Frequently grows singularly and only most often forms a small groups. Arenarius means sand in Latin, so it takes its scientific name from its preferred habitat.

Distribution: Central Asia, south European part of Russia, Caucasus, West Siberia, China (Xinjiang), Mongolia, Pakistan.

Note: At fruit maturation the forage of *C. arenarius* contains (%): crude protein 11.7; fat 1.6; ash 17.0-19.7 cellulose 26.5; soluble carbohydrates -1.2-11.6; Na-0.57-1.12; P-0.17-0.35; Ca-0.61-1.47; K-2.92%. Fodder value about 38 FU and 9.1 kg digestible protein/100kg DM. It contains alkaloids, saponins and other secondary metabolites.


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Amaranthaceae Juss.
Climacoptera aralensis (Iljin) Botsch.

Synonym: *Salsola aralensis* Iljin
Local name: Orol baliqko'zi (Uzb.), климакоптера аральская (Ru.).

Botanic characteristics and life form: C_4-succulent euhalophyte. Annual, herbaceous plant (30-65 cm high) with a basal rosette of leaves, erect and obliquely branches.
Stem: Glaucescent-purple, covered with rather short spreading often fugacious hairs entangled below.
Leaves: Alternative, obtuse, decurrent, less fleshy and hairy, compared with *C. lanata*.
Flowers: Single, bisexual, sepaloïd (five-lobed perianth), yellow-coloured with white centers, assembled in a spike inflorescence.
Fruit: Utricle monospermous, lysicarpous in a perigonial cover of 5 narrow keeled micro-wings. Wings are greenish and light brown, fused with dark pink spots at the base. The ring closely covers the wings, which are different in size from each other. Small sunken fruits, sparse indument, wing shape and pattern distinguish *C. aralensis*.
Phenology: Flowering and fruit maturation: July - November.
Seed germination: Horizontal with a spiral embryo (2.0-2.5 mm) and traces of endosperm. Dry storage within 6 months and stratification (3 °C/0.5-1 months) raises germination. Propagation is usually by division or by seed. Seeds should be sown in spring and kept moist until germination takes place.
Economic importance: Grazed by all kind of animals on open pastures. Fruits and dry stems consumed by cattle in autumn-winter, when alkaline salts been leached away. Fruits used to fatten wildlife, small ruminants, camels. Used for hay making production.
Habitat: Dry bottom of Aral sea, at the margins of lakes, water reservoirs, tugai forest and wet solonchaks. Endemic.
Distribution: Native to Aral Sea shores, deltas of the rivers in Uzbekistan, Kazakhstan and Turkmenistan.
Note: It has high tolerance (up to 700 mM) to different cloride/sulphate or mixed salts.
Could be distinguished by small sunken fruit and dimensions, sparse indumentum, wing shapes patterns.


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Amaranthaceae Juss.
Climacoptera lannata (Pall.) Botsch.

Synonym: *Salsola lanata* Pall.
Local name: Syertuk baliqko'z (Uzb.), kush-gezy (Trk.), климакоптера шерстистая (Ru.).

Botanic characteristics and life form: C_4-succulent euhalophyte. Annual, dove-coloured herbaceous plant (10-60 cm), covered with long-woolen hairs. Tap root system penetrate on 50-80 cm into the soils.
Stem: Herbaceous with erect branching from the basis sprouts covered with long-woollen dense hairs.
Leaves: Alternate, except for lowermost, fleshy, semiterete, very slightly decurrent at base high pubescent.
Flowers: Solitary, bisexual, sepaloid (five-lobed perianth), violet-coloured, assembled in a spikelike inflorescence. Anthers: pink/violet, tetrathecas, elongated with inflated short appendage; stigmas thick, short, papilliform. Bracts of perianth lanceolate, pointed, hairiness.
Fruit: Lyzicarpous, nuciform, indehiscent, monospermous, wing-shape, with thin hulled fruiting body. Fruiting perianth: lanceolate, pointed, pubescent, assembled in a friable cone-shaped column. Wings overlapping against each other, red: 3-orbicular, remiform, 2-narrow, almost linear (10-17 mm); wings horizontal, fine linear veined.
Phenology: Flowering: July - August, fruit maturation: September - October.
Seed germination: Seeds horizontal, orbicular, flattened, pile-brown (2.9-3.8 mm), spirally intorteded embryo (2.0-2.5 mm) with traces endosperm. Viability: 85-95%. Germination: light-sensitive at 25 °C varies from 78 up to 91%. Longevity of germination 10-12 months.
Economic importance: Valuable pastoral food for sheep, goats, and camels. In mixture with other shrubs and ephemeral desert species is used for range improvement and rehabilitation of sandy highly saline and waterlogged soils. Not touched during summer due to the presence of woolliness when dry, and/or sometimes due to essential oils and other substances that give a strong smell. Better grazed by wildlife animals, small ruminants and cattle in late fall and early winter after rains, when alkaline salts been leached away. Fruits fatten animals, especially during lambing and lactation. Expected yield in artificial plantation 2.3-3.1 t/ha.
Habitat: Saltmarshes, clay and gypsiferous deserts, on takyr-like, sandy salted soils with shallow water table, on margins of salt-marshes (solonchak-alkaline and solonetz soils).
Distribution: On the territory of Central Asia, it is widespread in Aral-Caspian regions (Amu Darya and Syr Darya valeys, Kyzylkum, Karakum), very rare in Tian-Shan and Pamiro-Alai. It is frequently occurring in Afganistan, Iran, China and Mongolia, and not frequently in European part.
Note: *C. lanata*, a hyperhalophyte and drought resistant plants in mixture with other shrubs and ephemeras desert species, is recommended for improvement productivity of saline/or waterloging arid rangelands, as well as for creation of pure halophytic pastures.


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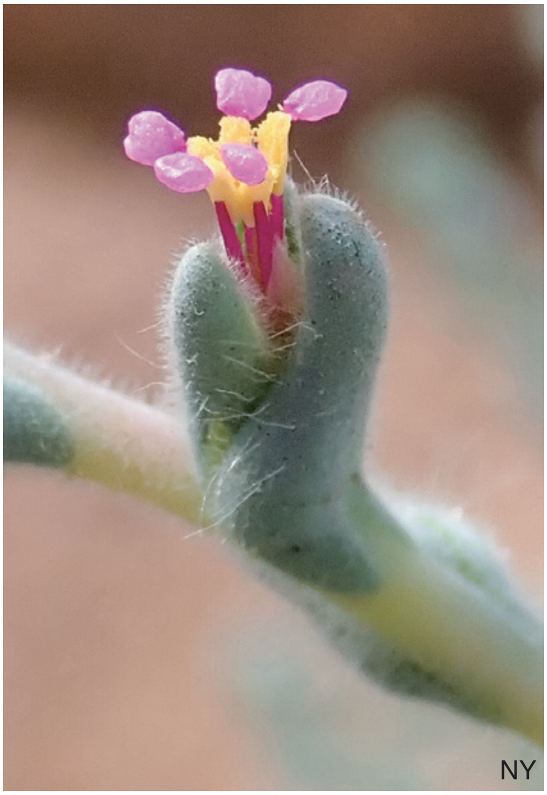
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Amaranthaceae Juss.
Halimocnemis macrantha Bunge

Synonym: *Halimocnemis macranthera* Bunge
Local name: Yirikchangdonli buzovbosh (Uzb.), галимокнемис крупнопыльниковый (Ru.).

Botanic characteristics and life form: Succulent-euhalophyte. Annual long- vegetating plant, bluish, 5-15 cm tall, branched from the base, densely pubescent with short and very sparse long terminal hairs protruding from the margins of leaves.

Leaves: Narrow, linear fleshy, apex obtuse or easily deciduous spinose mucronate.

Flowers: Solitary in bract axils, bisexual, light yellow with 2 bractlets. Perianth segments 5, lanceolate, membranous, proximally hardened and usually connate into an urceolate tube, without an appendage, hairy or rarely glabrous. Disk entire. Stamens 5 or 4, inserted on disk; filaments filiform, compressed; anthers oblong, base free, apex with a vesicular appendage. Ovary ovoid, laterally compressed; ovule pendulous on long funicle; style slender; stigmas 2.

Fruit: Utricle broadly ovoid to globose; pericarp membranous, free from seed. Perianth pubescent with simple unicellular and glandular hairs. Fruit length 5.7 mm, fruit base width 4.1 mm, column length 6.9 mm.

Phenology: Flowering and fruit maturation: June - July.

Seed germination: Seeds vertical, globose, laterally compressed; testa slightly fleshy, embryo planospiral; perisperm absent. Seeds are difficult to separate from the perianth and pericarp. Weight of 1000 seeds is 46.78 g. Freshly collected seeds do not germinate. Moist, stratification in snow slightly increased germination to 0.8-1%. Scarification with concentrated sulphuric acid for 22 hours, followed by washing with water, resulted in a germination rate up to 37%. Seed dormancy deep combined (exogenous and endogenous). Removal of fruiting cover and long stratification by alternate temperatures increases germination.

Economic importance: It is a good autumn-winter fodder plant for camels and sheep. Before fruiting (June) it is almost not eaten, but later during November - February and even in March it is well eaten by camels, much better than by sheep. Good for open grazing by wildlife.

Habitat: Grows on sandy-pebbly places between sands. Well adapted to takyr-like saline soils, rocky and gypseous habitats.

Distribution: Central Asia. Endem.

Note: When in flower, local people collect it as a sedative tea.


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Amaranthaceae Juss.
Halocharis hispida (Schrenk) Bunge

Synonym: *Halimocnemis hispida* Schrenk
Local name: Dag'altukli quyonjun (Uzb.), Қоянжуүн (Kaz.), галохарис щетинистоволосый (Ru.).

Botanic characteristics and life form: C_4-succulent euhalophyte. Annual herb (5-50 cm tall), bushy-branched from the basis.
Stem: Densely covered with rigid, thin, silky hairs.
Leaves: Small alternate, covered on both sides with short hairs.
Flowers: Bisexual, perianth (five-lobed); stamens-5; anthers with small, lancet, yellowish appendage; stigmas filiform, almost equal with style.
Fruit: Lysicarpous utricle monospermous in a perigonous capsule of 4 tepals, separated at the apex, forming a column, and fused at the base. Fruit length 3.5 mm, width 2.3 mm, column height 5.5 mm.
Phenology: Active growth: April - May, flowering and fruit maturation: June-beginning of August.
Seed germination: Small, vertical, rigid and flattened with a spiral embryo. Weight of 1000 seeds 19.54 g. After 60 days of wet stratification (in snow at 0-3 °C), germination at +15-25 °C was 25%. Germination increases to 56-70% after 1 year of dry storage and decreases to 22% after 3 years of dry storage. In nature, mass seedlings appear every 3-4 years, when the greatest amount of precipitation is observed, washing out inhibitors from fruits and softening sclerified fruiting covers. The dormancy is deep, combined (endogenous and exogenous) due to lignification of perianth tepals and the presence of inhibiting substances inside of the tepals.
Economic importance: Due to high pubescence of the plant and rigid fruits it is grazed by all kind of animals only in autumn after rains. Eaten in excess may induce digestive diseases for animals. In natural dense stand may produce up to 0.3-0.5 t. DM/ha. In fruit stage forage of *H. hispida* contains (%): mineral salts up to 30; protein 15.9; cellulose-18.0. *H. hispida* it is a perspective plant for restoration of salt-affected lands.
Habitat: Occurs frequently on fixed and saline sands, takyr-like soils, both salted sierozem and salt-marshes (solonchak-alkaline soils).
Distribution: Native to Central Asia, Iran and western Pakistan.
Note: Suitable for restoration of saline soils; used to create mixed halophytic pastures. Concentrate feed for small ruminants when mixed with other desert halophytes for winter feeding.


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Amaranthaceae Juss.
Halocnemum strobilaceum (Pall.) M.Bieb.

Synonym: *Salicornia strobilacea* Pall., *Halopeplis strobilacea* (Pall.) Ces.
Local name: Qubbachasimon sho'rso'zan (Uzb.), тобурчактай сарсазан (Kr.), Сарсазан шишковатый (Ru.).

Botanic characteristics and life form: C_4-stem succulent euhalophyte. Perennial, glabrous semi-shrub or small shrub with creeping succulent jointed annual stems, leaves in the form of scales. At the dry bottom of the Aral Sea *H. strobilaceum* often forming rounded hummocks up to 2 m in diameter.
Root system: Central tap poorly developed; lateral superficial (10-35 cm deep). The roots reach the ground water. In the presence of a compacted horizon, especially gypsum, the main root develops only up to this horizon, the subordinate roots go deeper, which develop a much larger mass compared to the main root. The main root percists for 3-4 years and develops in favorable conditions only to a depth of 1-1.5 m.
Stem: Old stems woody, intertwined with brownish bark; young stems jointed, succulent, much branched, erect to ascending with opposite orbicular buds. Annual shoots terete, succulent, jointed, with short cylindric to sub clavate joints and opposite sterile globular buds, these remaining long undeveloped or giving rise to abbreviated opposite flowering branchlets.
Leaves: Obovate (1 mm), strongly reduced to fleshy cups, connate at the base with scarious margins.
Flowers: Bisexual without bracts in clusters of 2-3, on short lateral and terminal branches and completely sunken into fleshy stems. Inflorescence: opposite, short fleshy cone-like spikes.
Fruit: Non-winged, monospermous compressed-ovoid (1.25 mm). Pentamerous perianth-segments at fruit stage three-lobed, unequal, drop-form, broadly oblong, hyaline, apex truncate.
Phenology: Flowering: July - end of August, fruit maturation: September - end of October.
Seed germination: Vertical, oval or ovoid, compressed, 0.5-0.75 mm long with a pimpled edge. Light sensitive. Seed stratification with alternating temperatures stimulates germination. A seed priming treatment based on prior exposure to high concentrations of salt (500-800 mM NaCl) maximize the percentage of germination. Propagated by seeds, by rooting stems and by longitudinal division of roots.
Economic importance: Medium fodder quality. At the end of flowering the fodder green mass of *Halocnemum* contains (%): crude protein 15.9; fat 4.0; cellulose 13.3; Ash 46.2; nitrogen 35.9, major elements, insignificant amount of alkaloids and other. Excellent prime colonizer of highly saline site. Capable to accumulate more than 25% of salt in tissue. Frequently used in rehabilitation and establishment of halophytic pastures. Biomass contribution 0.15-0.25 t DM/ha. The plant is used as a source of potash and soap making production.
Habitat: Narrow ecological amplitude in wet salt-marshes, salt-crusted and/saline sandy soils. Requiring presence of salts salt in soil (NaCl >1.5-2%) for normal development.
Distribution: Central and East Asia, South part of Russia, Iran, Afghanistan, Caucasus, Mongolia, China, West Siberia. In all arid areas of North Africa.
Note: Nomadic tribes used it for fuel and as insecticide. It contains substances toxic to plant pests, especially when applied in solution with soft soap. Recommended for restoration of highly saline soils, and as an ornamental plant.


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Amaranthaceae Juss.
Halopeplis pygmaea (Pall.) Bunge ex Ung.-Sternb.

Synonym: *Salicornia pygmaea* Pall.
Local name: Pakana sho'rgiyox (Uzb.), соровник низкорослый (Ru.).

Botanic characteristics and life form: Succulent salt accumulating euhalophyte, annual prostrate (creeping), glabrous, dark green in flower, becoming purplish in fruit, up to 30 (-45) cm tall, up to 15-25 cm in canopy diam. Woody rootstock up to 2 cm in diameter strongly ramified.
Stem: Procumbent/prostrate in open habitats, erect in dense ones; lower and older branches with tubercles of salt-accumulated crystals; lower median internodes of main stem 2-3 cm long. Stem branches succulent, glabrous and articulate. Old stems are slightly woody at base.
Leaves: Opposite, strongly reduced to small fleshy scales with narrow dry margin, glabrous, unstalked and united at base, enclosing and forming succulent sheath around stem.
Flowers: Bisexual, aggregated in a dense terminal, spike-like thyrses (10-15) mm. Central flower rounded-rhombic to almost circular.
Fruit: Dimorphic. A fertile segment produces a maximum of 6 seeds (2 cymes with 3 flowers each). Mucilaginous and hooked hairs, which aid seed dispersal, cover the testa/surface of the seeds. Seeds are shed from September to the end of November.
Phenology: Flowering: late July - August, fruit maturation: end of August - beginning of October.
Seed germination: Small (1.0-1.7 mm). Newly harvested seeds are dormant. Field germination increases after winter snow and spring rains, which leach excess salts from the soil. Some seeds (soil seed bank) remain in situ for germination the following spring. Seed viability more than one year after dry storage at room temperature. Stratification (temperature regimes between 5/15 and 20/30 °C seem to have little effect on the overall germination rate, but the germination rate is faster at higher temperatures.
Economic importance: DM (at flowering stage) contains 47.4% ash, 10.4% crude fibre, 4.16% protein and 0.45% lipids. Among the most important minerals (mg/g dry matter) are sodium 159, magnesium 9.01, potassium 7.22 and calcium 2.99. Owing to its high fibre and mineral content, *H. pygmaea* showed remarkable potential as a functional ingredient feedstuff and for producing bioethanol.
Habitat: Occurs in inland salt flats, along salt marshes, saline lake shores, riverbeds, salt margins, saltmarshes as a component of the *Tamarix-Halostachys-Halimochenemis-Kallidium* halophytic plant communities.
Distribution: Caspian desert, Betpakdala. In Central Asia: Karakata, Ayagakitma saline depression in western Kyzylkum desert, Muyunkum, Fergana valley, Badkhyz.
Note: At the beginning of its life cycle, it has a dark green color, becoming progressively greenish yellow, and finally purple at fruiting maturation end.


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Amaranthaceae Juss.
Halostachys caspica (M.Bieb.) C.A.Mey.

Synonym:*Halostachys belangeriana* (Moq.) Botsch., *Arthrocnemum caspicum* (M.Bieb.) Moq., *Halocnemum caspicum* M.Bieb., *Salicornia caspica* Pall.

Local name: Kaspiy qorabaragi (Uzb.), shorak (Trk.), солянколосник каспийский (Ru.).

Botanic characteristics and life form: C_4-stem succulent and salt accumulating euhalophyte. Perennial small bush with articulate and strongly ramified annual branches, up to 3.5 m tall.

Stem: Pale green-coloured, juicy, glabrous, articulate, smooth, but often rough with short barb.

Leaves: Opposite, in a form of small, fleshy, triangular acuminate scale. Perianth: fleshy, three-lobed accreted almost to its upper side.

Flowers: Inconspicuous, bisexual without bracteoles and assembled into spike in groups (3). Inflorescence: opposite, fleshy, ovoid-oblong, spike-shaped.

Fruit: Utricle, monospermous, indehiscent with thin-membranous fruiting body. Perianth at fruit maturity slightly inflated, three-edged.

Phenology: Flowering: July - August, fruit maturation: August - September.

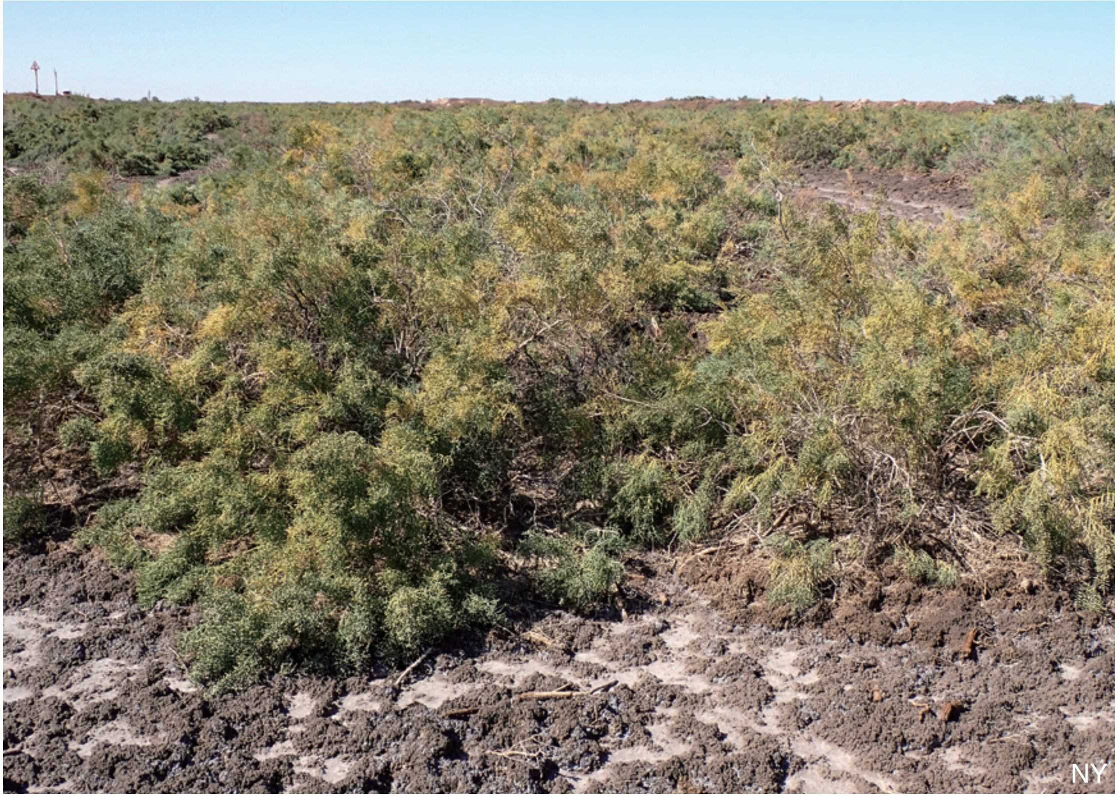
Seed germination: Small (about 0.75 mm), vertical, compressed, ovate - oblong, glabrous with a small embryo spirally intorted without endosperm. Germination is low and stimulated by stratification with 3 °C during 0.5-1 month or processing stimulators.

Economic importance: Poor nutrition value. Little grazed by wildlife, small ruminants and cattle on the pastures. Camels consumed it in fall and winter after rains. Prospective shrub for reseeding on salty soils, where other wood plants cannot grow. Expected green biomass in the autumn on shore of Aral Sea reach 1.4-2.6 DM t/ha. May be poisonous, due to a presence of alkaloids.

Habitat: Narrow ecological range: grows vigorously, individually and in patches, on wet-compact and muddy salt-marsh with solonchak-alkaline soil. Sometimes, unique plant able to grow on salt-marsh (solonchak-alkali) soils. It forms dense plant associations on saline sands with shallow water table (1.3-2.5 m) with the participation of *Halocnemum strobilaceum, Kalidium caspicum, Aeluropus litoralis, Haloxylon ammodendron* and *Salsola dendroides* (at 3.5 - 5.0 m water table).

Distribution: It is distributed along the Aral Sea coast, in the saline depressions of the Kyzylkum and Karakum deserts, and in the southern part of Balkhash region. Lower part of Volga valley, Caucasus to plain of Central Asia, Iran, Mongolia and China.

Note: Fuel wood when dry, medicinal, decorative, industrial (source of potassium). Extract from plants has a strong insecticides properties.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Amaranthaceae Juss.
Halothamnus subaphyllus (C.A. Mey.) Botsch.

Synonym: *Aellenia subaphylla* (C. A. Mey.) Aellen, *Caroxylon subaphyllum* (C.A.Mey.) Moq. *Salsola subaphylla* C.A.Mey.,
Local name: Kambargli cho'g'on (Uzb.), галотамнус малолистный (Ru.).

Botanic characteristics and life form: C_4-succulent euhalophyte. A perennial woody, greenish, glabrous, strong branched shrub (50- up to 250 cm) with a pivotal root system 5-12 m deep. Life length: 7-25 years.
Leaves: Linear, alternate, juicy, leathery, pointed. Buds drop-like, arranged spirally. Perianth: simple, pentamerous, naked, bracts oblong-ovoid.
Flowers: Bisexual, occasionally unisexual, solitary, alternate in spikes assembled in a panicle. The bracteoles are scale-like, transverse-oval, with membranaceous margin all around, adjacent to the flowers, together with the bract forming a low cup. The flowers are 3.2-5.0 mm long with oval tepals, the stigmas are truncate at their tip.
Fruit: Single-seeded indehiscent utricle. The winged fruit is 11-17 mm in diameter, their wings inserted in or a bit below the middle. The tube of the fruit is dish-like, narrowed to its base, with prominent ridges, at its bottom with flat, oval to round pits.
Phenology: Flowering: May - August (80-90 days), fruit maturation: end of October - November.
Seed germination: Small, orbicular, dark-brown with large (2.0-2.3 mm) spirally intorted embryo surrounding perisperm. Seed coat- thin double celled with intermediate cuticle. Field germination low: 9-35%; seed germination stimulated by stratification for 1-2.5 months (2-4 °C) and then alternating 15-28 °C (night/day) increases germination up to 2.0-2.5 times. Removing of sclerified fruiting body and sprout of seeds with temperature 24-26 °C increase the germination. Soaking fruits in distilled water for 2-3 hours significantly increased germination. Seed viability: 10-12 months. Propagated also vegetatively.
Economic importance: Young stems, leaves and fruits are readily consumed by sheep, goats, cattle, and camels especially late spring and autumn. In winter, hardened and sclerified yearly growth is well eaten by all livestock. *Halothamnus* is widely use as sand-fixing, for range improvement and/or creation of high productive multi-and-mono component summer-autumn rangelands. Extract from aboveground biomass is used to treat cold, cough, diarrhea, fever, swellings, wounds and against parasitic worms. Broth-water from green leaves is used for lowering blood pressure. Extract from fruits is applied in dermatology treatment. Contains alkloids (subaphyllin and salsoline). Leaves accumulate boron.
Habitat: Growth frequently in mixed shrub and woodlands plant communities on sandy, grey-brown, clay soils, rarely skeletal salted slopes and on saltmarshes margin, often on salty or gypsum soils, and rarely on calcareous soils, and on the skirts of salt marshes.
Distribution: Uzbekistan, Kazakhstan, Turkmenistan, Tajikistan, Iran, Afghanistan, Pakistan and Baluchistan. It is found in the Aral-Caspian depression, extending to China and Mongolia, in the western Balkhash region, and in Southern part of Eurasian steppe.
Note: The species has been first described in 1833 by Carl Anton von Meyer as *Salsola subaphylla* (In: Karl Eduard Eichwald). Since ancient time villagers used dye (brown and yellow, red) from the plant in the process of naturally dyed carpet production. About six species were described in the genus *Halothamnus*. *Halothamnus glaucus* Botschantzev frequently occurs in Alal Sea basin deserts and semideserts, also patchily at the Ustyurt plateau.


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Amaranthaceae Juss.
Haloxylon ammodendron (C.A.Mey.) Bunge ex Fenzl

Synonym: *Haloxylon aphyllum* (Minkw.) Iljin, *Anabasis ammodendron* C.A.Mey., *Arthrophytum ammodendron* (C.A.Mey.) Litv.

Local name: Zaysan saksovuli (Uzb.), kora-sasak (Trk.), саксаул зайсанский (Ru.).

Botanic characteristics and life form: C_4-succulent stem, xerohalophyte-phreatophyte. Aphyllous tree-like reaching more than 12 m high. Trunk: thick, rough, with dark-gray bark. Root system of a universal type deeply penetrating 9-16 m on the 5 years. Longevity of life is 50-90 years.

Stem: Articulate, dark -green, succulent, strongly ramified, trailing down.

Leaves: Opposite, reduced up to scales and even hillock. Bracteoles is larger than leaflets of perianth, hulled, slightly toothed on the margin.

Flowers: Small, inconspicuous, bisexual, antipetalous, singular in the axills of scale-like leaves. Stamens 5, accreted on the basis, anthers oblong-elongated without appendage. Ovary superior, stigma in 2.5-3 times are longer than column.

Fruit: Utricle, monospermous, indehiscent, with five wings. Tepal lobes orbicular form an appreciable pressed column. Wings with orbicular or wedge-sharped by the basis, horizontal (7-12 mm) with rough edges on perimeter with fine venation.

Phenology: Flowering: April - May, fruit maturation: October - beginning of November.

Seed germination: Horizontal, orbicular, light brown, smooth, with a thin fruiting body, large spiral embryo (15-20 mm) spirally intorted, with poor developed endosperm. Germination rate 40-88% with temperature 20-25 °C; % of valuable seeds: 76-92. Longevity of germination 8-10 months. Seed's stratification (+ 2-4 °C) within 1-2 months is effective.

Economic importance: For open grazing due to high fodder value for all kind of animals. Assimilative stems and fruits are a valuable calorific food for sheep, camels and goats. In Central Asian desert thanks to good phytoameliorative properties *H. ammoderdron* is used for long-term rangelands creation and radical improvement. It is also used for regeneration of tugai communities on sandy beds or hillocks of dunes, takyrs, saltmarshes (solonchak-alkali soils), and for creation of sand-fixing and wind-protective belts. Used for afforestation program and rehabilitation of hypersaline dry bottom of Aral Sea.

Wood-durable, heavy (it sinks in water), brittle but it does not splinter. The wood has enormous value as a fuel in its native range plants, it burns well and gives a good heat and coal-making (up to 40%). From wood local people extracts acetone, alcohol, vinegar acid. Ash of green younger branches (ichkara) is widely used for dying wool. *Haloxylon* wood is used as timber and serve also as an ornamental plants.

Habitat: Occurs in fixed sands on depressions of sandy beds and hillocks with a various contents of salts, as well as on valley and bed of oldest rivers with relatively superficial distributed underground waters (more than 4.0 m); on layers of the clay salted horizons; and also grows on gray-brown, the margins of takyrs and takyrs-like soils. The decline of saxaul forests in the arid regions of Mongolia and Aral Sea Basin caused serious deflation of salts and dust storms.

Distribution: Southwest and Central Asia, Afghanistan, from Egypt to Mongolia and China.

Note: Pastoralists from centuries collect and use wild plants for food, medicine, shelter, dyes, firewood, and they are also considered an important part of their culture and arts. Roots host Cistanche flava - a parasitic plant used in traditional medicine from ancient time. Cistanche is sometimes known as the "ginseng of the desert".


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Amaranthaceae Juss.
Haloxylon persicum Bunge

Synonym: *Arthrophytum persicum* (Bunge) Sav.-Rycz.
Local name: Oq saksovul (Uzb.), ак суксеул (Kaz.), саксаул персидский (Ru.).

Botanic characteristics and life form: C_4-psammo phreatophyte (a ground water dependent tree like species), large ramified from the base bush, less often trees, 2.5-5 in height, with curved trunk and light gray bark. Tap root system deeply penetrating (up to 20-35 m). Stems articulate, fleshy, light green, annually partially fall down, wood fragile. Leaves in compare with *H. ammodendron* are small, lemma-like with sharp ears. The botanical characteristic and passage of all phases of ontogenesis is identical with *H. ammodendron*, except that the vegetation cycle of *H. persicum* begins on 10-20 of days earlier than *H.ammodendron*.
Economic importance: Young vegetative stems, leaves and fruits represent a most valuable feed for all livestock nearly all year round: In autumn and winter best value, especially fruits and annual shoots; during fruiting stage, considered by the shepherd as a high calorific forage. Forage yield 0.8-1.2 t/ha. Palatability of *H. persicum* by animals is identical with *H. ammodendron*, however much better grazing for camels. Much harvested as fuel wood. Fodder value: about 52 Fodder Units and 5.3-7.6 kg digestible protein/100 kg DM; Lower ash content than *H. ammodendron*. New shoots of *H. persicum* contains (%): crude protein 2.7-9.8; cellulose 12-26; nitrogen free extract 6-40.5; citric acid 1.2-1.7, vitamins (mg/kg) C 1378-4374; carotin 56-87; K10.8-36.3 g/kg; Ca 25.0-47.7 and Mg 13.8-22.0 g/kg.
Habitat: Occurs mostly on moving dunes, at the chinks of plateau Ustuyurt in combination with *Atraphaxis spinosa, Ephedra dystachia, Xylosalsola arbuscula* and others.
Distribution: It occurs in the Irano-Turanian desert across Central Asia, China, Palestine, Israel, Afghanistan and Iran.
Note: A harvest of forage weight of *H. persicum* pastures is varied from 0.8 to 1.2 t/hà. Assimilative stems and fruits are a valuable calorific food for sheep, camels and goats. Palatability of *H. persicum* by animals is identical with *H. ammodendron.* Used in combination with *Calligonum* species and others in afforestation programs for sand fixation. Wood is very precious. In remote areas pastoralists used as fuel.


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Amaranthaceae Juss.
Kalidium caspicum (L.) Ung. Sternb.

Synonyms: *Halocnemum caspicum* (L.) Tausch, *Salicornia caspica* L.
Local name: Kaspiy shoxilagi (Uzb.), поташник каспийский (Ru.).

Botanic characteristics and life form: C_4 succulent salt accumulator euhalophyte. Perennial, strong branched succulent low-shrub (15-75 cm) with deep penetrated root (up to 3-4 m in depth). Numerous adventitious roots are formed when branches are covered by sands.
Stem: Woody, whitish, friable.
Leaves: Stem-clasping and decurrent, nearly orbicular to semiterete small, alternate sharp acuminate, succulent.
Flowers: Bisexual without bracteoles, assembled in groups by 3 in dense in linear-cylindrical, fleshy sessile spike-like inflorescence with alternate scale-like free bracts. Perianth lobes 4-5- nodulous with an outgrowth in the central part. One to three flowers appearing sunken into fleshy axis.
Fruit: Monospermous, orbicular-ovoid (1.25-1.5 mm wide.), reddish-brown, covered by papillae.
Phenology: Flowering: July - August, fruit maturation: August - beginning of October.
Seed germination: Vertical smoothly, glabrous seed is disc-shaped with tuberculate to papillose surface. It contains a semi-annular embryo and copious perisperm. Field germination 14-29%. Seed viability 8-10 months. In wet arid/semiarid conditions on salt-marshes (solonchak-alkaline soils) seeds germinate in May - April. Well propagates vegetatively.
Economic importance: Not grazed, not touched by all livestock due to significant number of poisonous substances in the vegetative organs. Considered an excellent plant for restoration of salt/affected desert lands. Yield of *K. caspicum* plant community with participation of annual salsolas and ephemerals varies (0.59-0.95 t DM/ha).
Habitat: Grows on sandy to loamy soils in brackish and saline flats, on wet and plump salt-marshes (solonchak-alkaline soils), on coastal areas of salty lakes. It is considered a principal colonizer on the dry bottom of Aral Sea.
Distribution: Dry bottom of the Aralkum, Kyzylkum and Karakum Deserts, Aralo-Caspian and Balkhash regions, as well as in Southern-East Europe, Russia Iran. The native range of this species is Eeastern Turkey to Xinjiang and northern Afghanistan.
Note: Rich in mineral salt (NaCl up to 40%). Chemical composition (% DM): crude protein 8.3-15.9; fat 3.3-4.0; nitrogen free extract - 27.9-40.7; ash 30.5-42.6; cellulose 11.8-15.2. For ancient time used as source of potash for soap making, dying and silicate industries.
There are four species in the flora of the Aralkum: *K. foliatum, K. caspicum* and the recently described *K. juniperinum*. Populations of species of the genus *Kalidium* in the saline desert of Lazerev island occupy large areas, often forming monodominant communities. *K. capsicum* in the Irano-Turanian floristic region (Central Asia and West Asiatic areas) is considered as a threatened woody species.


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Amaranthaceae Juss.
Nanophyton erinaceum (Pall.) Bunge

Synonym: *Polycnemum erinaceum* Pall.
Local name: Kipritikansimon toshbuyurg'un (Uzb.), нанофитон ежовый (Ru.).

Botanic characteristics and life form: Leaf succulent-halogypsophyte. Semi-shrub (5-15 cm tall and 20-25 cm width) forms dense pillow-shaped sod. Tap root (up to 180 cm depth) with bare root neck (trunk), several (up to 10) skeletal branches living up to 50 years.
Stem: Rigidly cespitose, repeatedly short-branched, compactly pulvinate in outline, stems woody, often very stout. Often after being eaten by livestock as a small pad on a short trunk.
Leaves: Alternate, closely approximate, completely covering up the stems, short, fleshy, subulate, mostly prickle-pointed, rarely obtuse, strongly dilated and hyaline-margined at base, glabrous or scarcely roughened with minute tubercles, with an axillary tuft of long hairs.
Flowers: Bisexual, solitary in the axils of upper leaves, 5-membranous with boat-shaped, exceeding bracts. Leaflets of perianth filmy ovate, free, glabrous with a short mucro at some distance from the margin, strongly bladdery-inflated in fruit and elongating to 10 mm.
Fruit: Berry-shaped lysicarpous capsule, in perigonial covering, crimson-red before ripening, brown fleshy at maturity, 2.9 mm long, 2.6 mm wide, with elongated column up to 2.8 mm, remaining in perianth of 5 separate yellow filmy leaflets.
Phenology: It begins to grow in May. Flowering and fruit maturation: July - end of August. Annual twigs grow no more than 1-4 cm in summer.
Seed germination: Small and vertical seeds with large spirally intorted embryo. Light-sensitive. Seed viability 10-12 months. Ground germination is extremely low. Without stratification and scarification seeds do not germinate. Germination of freshly harvested seeds at +18-25 °C was 7%, germination started on day 8 and lasted 15 days. The pericarp contains flavonoids that inhibit germination.
Economic importance: It produces negligible yields of fodder mass, at best not exceeding 0.5 t/ha of green biomass. In active growth stage it is eaten by camels, horse, and less by small ruminants. (% DM): crude protein 12-14; fat 2.5-2.9; ash 17-20; nitrogen-free extract 37; cellulose 15-23; carbohydrate 19-24. Fodder (fattening) and medicinal plant. *Nanophyton erinaceum* forms stable associations with *Caroxylon gemmascens* on compacted takyrs and gypsum soils.
Habitat: Grows on chalky, cartilaginous-rubbly, gypsiferous, solonetz-solonchak, grey-brown soils, often forming monodominant associations.
Distribution: Central Asia: Aral-Caspian, Kyzylkum, Amu Darya, Syr Darya and Tian-Shan (Karatau). East and southern European Russia, Mongolia, and Xinjiang (China).
Note: Vegetative organs and fruits contain flavonoids saponins and alkaloid nanophyton, which significantly reduces blood pressure.


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Amaranthaceae Juss.
Salicornia perennans Willd.

Synonym: *Salicornia acetaria* Pall., *Salicornia prostrata* Pall.
Local name: Sho'ran (Uzb.), солерос солончаковый (Ru.).

Botanic characteristics and life form: C_3 stem succulent and salt accumulating euhalophyte, annual prostrate (creeping), glabrous, dark green in flower, becoming purplish in fruit, up to 30 (-45) cm tall, up to 15-25 cm in canopy diam. Woody rootstock up to 2 cm in diameter strongly ramified.
Stem: Procumbent/prostrate in open habitats, erect in dense ones; lower and older branches with tubercles of salt-accumulated crystals; lower median internodes of main stem 2-3 cm long. Stem branches succulent, glabrous and articulate. Old stems are slightly woody at base.
Leaves: Opposite, strongly reduced to small fleshy scales with narrow dry margin, glabrous, unstalked and united at base, enclosing and forming succulent sheath around stem.
Flowers: Bisexual, aggregated in a dense terminal, spike-like thyrses (10-15) mm. Central flower rounded-rhombic to almost circular.
Fruit: Dimorphic. A fertile segment produces a maximum of 6 seeds (2 cymes with 3 flowers each). Mucilaginous and hooked hairs, which aid seed dispersal, cover the testa/surface of the seeds. Seeds are shed from September to the end of November.
Phenology: Flowering in late July - August, fluit maturation: September - November.
Seed germination: Small (1.0-1.7 mm). Newly harvested seeds are dormant. Field germination increases after winter snow and spring rains, which leach excess salts from the soil. Some seeds (soil seed bank) remain in situ for germination the following spring. Seed viability more than one year after dry storage at room temperature. Stratification (temperature regimes between 5/15 and 20/30 °C shown insignificant effect on the overall germination rate, but seeds germinate faster at higher temperatures.
Economic importance: DM (at flowering stage) contains 47.4% ash, 10.4% crude fibre, 4.16% protein and 0.45% lipids. Among the most important minerals (mg/g dry matter) are sodium 159, magnesium 9.01, potassium 7.22 and calcium 2.99. Owing to its high fibre and mineral content, *S. perennans* showed remarkable potential as a functional ingredient for concentrated feed. Aboveground biomass is a good source for bioethand production.
Habitat: Occurs along wet salt marshes, saline lake shores, riverbeds, salt margins, saltmarshes as a sub-component of the *Tamarix- Halostachys-Halimochenemis-Kallidium* halophytic plant communities.
Distribution: In saline desert depressions of the Kyzylkum desert in Uzbekistan, such as Ayakagitma, Mingbulak, Karakata Mulali, Lavlyakan, rarely grows on the wet solonchaks on Aral Sea shore.
Note: At the beginning of its life cycle, it has a dark green color, becoming progressively greenish yellow, and finally purple at fruiting maturation end.


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Amaranthaceae Juss.
Salicornia persica Akhani

Local name: Eron sho'rani (Uzb.), солерос персидский (Ru.).

Botanic characteristics and life form: C_3 stem succulent and salt accumulating euhalophyte. Annual herb 5-30 cm with superficial tap root system.
Stem: Erect, much branched; branches green, fleshy and glabrous. Older stems somewhat woody basally.
Leaves: Opposite, strongly reduced to small fleshy scales (up to 1.5 mm) with a narrow dry margin, hairless, unstalked and united at the base, thus enclosing and forming a succulent sheath around the stem.
Flowers: Dimorphic in dichasias of 3, the central one (median) larger than the lateral ones, embedded in the fleshy bark of the stem. The perianth indivisible, obtuse-angled at the edge, and looks from above like a rhombic shield with a hole in the center.
Fruit: Utricle, indehiscent, monospermous. the fruit wall/pericarp is membranous. The perianth is a persistent part of the fruit. Fruits are of 2 types: median large and lateral small. The median fruits are 1.4 mm in height, 0.9 mm in width, off-white in colour, elongated, horseshoe-shaped, and laterally compressed. Lateral fruits are 0.8 mm high, 0.6 mm wide, elongated oval, pubescent with hooked hairs.
Phenology: Flowering in May, fruit maturation: June - August.
Seed germination: Seeds vertical, oviform, small (1.5 mm long), black-brown, covered on a top by bundle of hooked hairs. Embryo: curved and small. Laboratory germination: 12-18%. Stratification at 3 °C/0.5-2 months or chemical significantly increases the germination. Seeds germination of median fruits was 80% at +4-6 °C and 95% at +10-15 °C after 2 years of storage.
Economic importance: The aerial parts of the plant are consumed in salads or processed into pickles, beverages, or vinegar. Most frequent desert forage plants on salty flats. Well grazed by cattle, camel, occasionally by sheep and goats in early autumn and in winter. Limited consumption due to high salt contents of alkaloids in vegetative tissues. Green vegetative part (%): more than 90% water (more than 92.5).Ash 36, crude protein 9.0; small amount of cellulose 20.5; and nitrogen free extracts 31.8% DM: NaCl 44, Na_2SO_4 0.27, Na_2CO_3 4.5. It contains a lot of oxalates acid and alkaline salts. In folk medicine, it is used as an anti-scurvy and diuretic. Used for production of potasha due to high content of minerals (Na 43.87%), and for glass and soap making that has been a common practice for several centuries. Industrial plantation of *Salicornia* is highly effective in remediation of polluted lands by removing selenium, zink, copper and other trace elements from soil.
Habitat: Wet solonchaks and seacoasts forming large thickets, salty sands, alkaline and saline soils, salt-lake shores, beaches in deserts areas.
Distribution: Central Asia, China, Caucasus, Scandinavian countries, Europe and Mediterranean region.
Note: Salicornia's name comes from Latin, meaning 'salt'. It is one of the most salt-tolerant plant species in the world, tolerating up to 1000 mM NaCl or more.
Among species of genus *Salicornia, S. bigelovii* Torr is recognized as one of promising cash crop. The commercial cultivars of *S. bigelovii* has demonstrated seed yields of 2-3 t/ha; biomass production is around 20 t/ha. It is cultivated for production of high-quality oil reach in protein and fatty acids. It can be consumed as green vegetable. Dried *Salicornia* leaves are used to feed fish. *S. bigelovii* were domesticated at the commercial scale for livestock feeding, and for salt and oil extraction.


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Amaranthaceae Juss.
Salsola praecox (Litv.) Litv.

Synonyms: *Kali praecos* (litv.) Sukhor.; *Salsola paulsenii* subsp. *praecox* (Litv.) Rilke
Local name: Ertagi sho'rak (Uzb.), солянка ранняя (Ru.).

Botanic characteristics and life form: C_4 non-succulent euhalophyte, annual (5-25 cm), densely papillose, rarely glabrous and short-lived plant.
Stem: Branching from the base; few elongated lower branches ascending. Branches light green or yellowish when young and then turning black when drying.
Leaves: Alternate, filiform, stiffish, almost semiterete, very slightly and gradually dilated toward base, spreading almost horizontally, spiny-tipped, usually somewhat reflexed in upper part, persistent and not wilting at fruiting.
Flowers: Solitary or in spikelike inflorescence, inconspicuous, bisexual with spiny bracteoles; bracts longer than bracteoles, often thickened at base. perianth glabrous or rough. Stigma filiform, as much as to 2-4 times as long as style. Anthers without appendix.
Fruit: Winged, indehiscent monosepermous utricle. Segments of fruiting perianth winged below the middle, together with wings 6-8 (rarely 9) mm in diameter; wings hyaline, colorless, markedly nerved, overlapping, 3 of them subreniform, the other 2 very narrow; segments above the wings long-acuminate from a very broad base, rising into a long central beak.
Phenology: Flowering: April - June, fruit maturation: May - July.
Seed germination: Seeds small (0.21-0.83 cm), horizontal. Laboratory germination (25-28 °C) 67-78%.
Economic importance: Well grazed at the early stages of vegetation.
Habitat: Growing mostly in open inland salt marshes, marshy-steppe, sandy-clay areas, more rarely blown sands and sandhills desert plant communities.
Distribution: Aralo-Caspian regions, Kyzylkum, Karakum, Balkhash, Amu-darya and Syr-darya valleys. Endemic.
Note: *S. praecox* has similarities to other Asian annuals like *S. pestifer, S. paulsenii, S. aperta, S. soda, S. androssowii, S. sogdiana, S. acutifolia, S. tamaricina*. All these species of section Kali are evolutionary young and taxonomically remains very contradictory. The Asiatic group shows some affinities in floral characters, structural specificity and pollen morphology with European species such as *S. kali* and *S. ruthenica*.


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Amaranthaceae Juss.
Suaeda altissima (L.) Pall.

Synonym: *Chenopodina altissima* (L.) Moq., *Chenopodium altissimum* L., *Dondia altissima* (L.) Druce, *Salsola altissima* (L.) L.
Local name: Bo'ychan qorasho'ra (Uzb.), бийик сведа (Kr.), сведа высочайшая (Ru.).

Botanic characteristics and life form: Highly resistant to salinity and drought. Succulent euhalophyte. Annual bare branching plant, 25 to 200 cm tall.
Stem: Erect, obliquely spreading, terete, slightly ribbed, light green, sometimes reddish, turning black when drying out glabrous. At the tips young stems are covered with short fugacious scarious hairs.
Leaves: Alternate, thicky succulent (flashy) filamentous blunt bluntly straight, upwardly curved, glabrous 15-25 mm long, 1-1.5 mm wide.
Flowers: Bisexual, perfect and pistillate, glomerate; clusters compact and apparently sessile, inflorescence a pyramidal panicle. Perianth narrowed, swollen at fruit. Perianth leaflets somewhat attenuate at base, divided to the middle. Leaflets of (5) divided up to half into rounded keeled lobes, closed at fruits.
Fruit: Single-seeded dry utricle enclosed in the persistent ovary shell (pericarp) that easily separates from the seed.
Phenology: Flowering and fruit maturation: July - September.
Seed germination: Dimorphic seeds: small (1-2 mm) vertical, black, orbicular smooth obscurely and finely reticulate; large vertical developed in heteromorphic flowers mixed with small horizontal from pistilate flowers. Embryo spiral. After 3 months of dry storage at variable temperature (+6-40 °C), germination of large seeds occurred on day 2 and continued for 20 days, giving a germination rate of 83.4%. The germination of the small seeds was observed on the 23rd day, the germination lasted for 33 days, and the germination rate was 24%.
Economic importance: It is an oleaginous plant containing flavonoids that can be used in the manufacture of soda. It is consumed as fuel by the local people. After frost it is eaten by camels. It is recommended for restoration of salt affected grey-brown soils. Occasionally applied for soda extraction.
Habitat: On weedy places, in riparian areas, on irrigated lands, saline soils, occasionally forming large plantations.
Distribution: Central Asia, southern part of European Russia, Caucasus, Siberia, Mediterranean, Afghanistan, Iran, Mongolia and China.
Note: *Suaeda* biomass is considered as a renewable source of energy, food and edible oil. Extracts from this plant meet folk and alternative medicines' needs.


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Amaranthaceae Juss.
Suaeda paradoxa (Bunge) Bunge

Synonym: *Belowia paradoxa* Bunge, *Borsczowia paradoxa* (Bunge) G.L.Chu
Local name: G'alati qorasho'ra (Uzb.), Qara sora (Kar.), сведа странная (Ru.).

Botanic characteristics and life form: Succulent euhalophyte. Annual blue-green plant 50-120 cm tall, with linear, harsh leaves.

Stem: Erect, much or little branched, terete, slightly ribbed, glabrous, base to 7 mm in diam; branches obliquely spreading.

Leaves: Leaves linear, flat, stiffish, acute to obtusish, narrowing toward base, closely approximate on the branches, upright, arranged in a vertical plane, the floral leaves much reduced, oblong-ovate to ovate, usually 1-3 cm × 1.5-2.5 mm, base attenuate into short petiole, apex acute.

Flowers: Mostly in many-flowered clusters on the flowering branchlets; flower bisexual, yellowish-white in color, forming a paniculate inflorescence; perianth subglobular, dorsally flattened; segments in perfect flowers united only at base, in the pistillate united to between one-half and two-thirds.

Fruit: Fruiting perianth obovoid, with somewhat elongating perianth segments.

Phenology: Flowering and fruit maturation: July - September.

Seed germination: Dimorphic: horizontal small (1.0-1.5 mm in size), black, strongly convex. sublustrous. coarsely and prominently granular. Large seeds (more than 2.0 mm) vertical, strongly flattened, tawny, smooth and soft.

Economic importance: Low fodder quality. Camels eaten it willingly when dry. Biomass is a renewable source of energy. *Suaeda paradoxa* is recommended as an ornamental plant in gardens. It is also used in traditional medicine to treat fever and malaria.

Habitat: Tugai forest and wetlands, commonly as weed in cotton fields and generally in irrigated fields and wasteland, salt-affected farmer lands, solitary or in groups.

Distribution: Central Asian countries, especially in the deltas of the rivers, Afghanistan, and China (Xinjiang).

Note: *Suaeda* was harvested and burned, and the ashes were processed as a source of sodium carbonate for glassmaking in the Middle Ages and early post-medieval centuries.


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Amaranthaceae Juss.
Suaeda salsa (L.) Pall.

Synonim: *Chenopodina salsa* (L.) Moq., *Chenopodium salsum* L., *Cochliospermum salsum* (L.) Lag., *Schoberia salsa* (L.) C.A.Mey., *Suaeda maritima* subsp. *salsa* (L.) Soó
Local name: Sho'rxoq qorasho'rasi (Uzb.), сведа солончаковая (Ru.).

Botanic characteristics and life form: Leaf succulent and salt accumulating euhalophyte. High salt tolerant during germination and seedling stages. Annual herbaceous (25-100 cm), with tap shallow root system.
Stem: Terete to slightly angled, reddish-violet, erect to ascending, glabrous or tomentose with gland-headed hairs, much branched from base.
Leaves: Alternate, sub-acute, fleshy, sub-globose, oblong or inverse-narrowly lanceolate (1-1.25 cm long, 0.05-0.1 cm wide). Perianth segments (1 mm), deltoid, almost spherical, strongly convex, narrow and fused at base.
Flowers: Small bisexual, rarely female, inconspicuous, sessile in axillary 2 to 5 flowered clusters, each cluster subtended by bract forming leaf spikes or lax panicles. Anthers (0.25 mm). Anemophilous.
Fruit: Monospermous, horizontally compressed utricle, pericarp thin-walled, membranous, free from seed when dry.
Phenology: Flowering and fruit maturation: August - September.
Seed germination: Small (1.2-1.5 mm), strongly compressed with sharp edge, lenticular or orbicular-ovoid, black or black-brown, smooth glossy, with mesh figure. Sometimes dimorphic: early formed seed with corky testa; late-dimorphic seeds with scarious testa. Embryo in a flat coil (flat spiral) perisperm absent. Seed viability: 24-32%. Long-term stratification with day/night cycle under alternate temperatures stimulates germination; maximal in fresh water and decreased by high concentrations of sodium chloride. Black seeds germinated sporadically at +10-15 °C (0.6-1.5%). High temperatures activate germination: maximum germination (9%) was observed on day 5 after placing in growth chamber, total germination is low.
Economic importance: Fodder plant of medium-poor quality. Grazed by camels and small ruminants mostly in autumn -winter. Recommended for silage making for winter feed. Expected yield in wetlands and Tugai forest varies 0.55-1.16 t/ha.
Eaten (after boiling); used as medicine because of laxative properties. In past it was applied for potash production.
Habitat: Saline and alkaline soils on beaches, lake shores, puffy solonchaks; salinas; scattered, but frequently in considerable numbers.
Distribution: Widely occurs in Central Asia, Caspian saline shores, Iran, Mongolia and China (Xinjian province).
Note: Species of *Suaeda* are considered as a model for promotion of halophytic mixed farming (saline agriculture) as a source of food, medicine, forage, and bioenergy. *Suaeda* species have great potential as oilseed crops. The seed yield of *S. salsa* is about 2000kg ha^{-1} in saline soils where the soil salt content is about 5 g kg^{-1} dry soil.


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Amaranthaceae Juss.
Xylosalsola arbuscula (Pall.) Tzvelev

Synonym: *Salsola arbuscula* Pall.
Local name: Daraxtchasimon sho'rak (Uzb.), aq boyalish (Kar.), баялыш соран (Kaz.), сведа солончаковая (Ru.).

Botanic characteristics and life form: C_4 non-succulent salt accumulating euhalophyte. Shrub from 20 to 150 cm tall (average 80-100 cm), strongly spread-branched, with milky (young) twigs and narrowly linear thick, stiff leaves. Life span approximately 7-12 years.
Stem: Stem branched from base, up to 2 cm diam., grey, with fissured bark; annual shoots rigid, soon turning milky white, simple or with shorter ascending laterals, terminating in loose or modestly condensed spikes.
Leaves: Leaves alternate, narrowly linear, 5-35 mm long, thickish, pale green, constricted just above the base, obsoletely gibbous at the dilated white base.
Flowers: Bisexual, solitary, perianth segments membranous, obtuse, winged in fruit below the middle, wings semiorbicular or narrower, scarious, slightly yellowish with a faint rosy flush, often slightly hairy.
Fruit: Utricle 2-3 mm diam, with hardened cap, horizontal. Fruiting perianth (8)10-13 mm diam, wings subequal, straw-coloured, coriaceous; tepals above the wings first incurved and forming a broad, indurated circular.
Phenology: Flowering: end of May - September. Anemophilous, occasionally entomophilous plant. Fruit maturation : September - October.
Seed germination: 78-82% Stratification (3 °C) for 0.5-1 month and processing with phytohormones are effective and increase germination to 54%. Storage under dry conditions (20-22 °C) is also effective. Seed viability 14 months.
Economic importance: Considered a good summer-autumn forage for sheep, goats mostly grazing annual growth, leaves and fruits and woody thinner stems too. It provides winter fodder for sheep and wild animals. Camels eat *X. arbuscula* throughout the year. Expected DM yield 0.2-0.25 t/ha. Widely recommended for rangelands improvement and/or creation of long-term rangelands in combination with *Haloxylon ammodendron, Caroxylon orientale* and ephemers.
Habitat: Desert plant communities on sands and solonetz soils, shallow hummocky sends, gravelly and chalky slopes and more rarely gypsonous rocks; scattered over considerable areas.
Distribution: Central Asia, especially in South-West part of Kyzylkum, Ustyurt, Aralo-Caspian, Muyunkum, Karakum; occures also in the South-East part of Russia, Iran, Afghanistan, China, Mongolia.
Note: Large bushes annually produce green shoots and leaves up to 1000 g of raw mass (dry 500 g). Forage contains (%): 3.6-19.8 crude protein, fat 2.16-3.4; about 19.8% of microelements and mineral salts.
Suaeda plant communities, pure and mixed stands (in combination with *Haloxylon ammodendron, Calligonum* species, *Artemisia diffusa, Caroxylon sclerantha, C. orientale* and ephemerals), play an effective role in fodder production, in soil conservation, and in the prevention of wind erosion. It is used by the local people for firewood and for the tanning of hides.


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Amaranthaceae Juss.
Xylosalsola paletzkiana (Litv.) Akhani & Roalson

Synonym: *Salsola paletzkiana* Litv.
Local name: Palyetskiy sho'ragi (Uzb.), qara sherkez (Kar.), қора черкез (Trk.), солянка Палецкого (Ru.).

Botanic characteristics and life form: C_4-non-succulent halopsammopyte. Perennial drought and salt tolerant strongly branched up to 3-4 m tall, black tree.
Stem: Many-stemmed, profusely branched; ultimate branches very slender and long, milky-white, glabrous, smooth; bark of older branches light brownish-gray; wood black.
Leaves: Alternate, linear, slender, (30-80 mm long), glabrous, acuminate with a short-pointed tip.
Flowers: Bisexual, solitary 5-merous. Leaflets of perianth are dark acuminate, glabrous, filmy along the margin, forming large light-colored, almost transparent wings at fruit. perianth segments. *X. paletzkiana* differs from *S. richteri*: subtending bracts are often restored. Involucral bracts with a subulate subtending vein, terminated in the upper part by a mucro about 0.5 mm long and broad at the base. Tepals 4.5-5.0 mm long, apiculate, with a short, prominent central vein. Anthers 3.0-3.5 mm long, divided for 1/2-2/5; appendage 0.8-1.0 mm long, acute. Stigmas 0.2-0.3 mm wide.
Fruit: Dry lyzicarpous indehiscent utricle. Fruit diameter 13-15 mm, with 5 horizontal (2 narrow and 3 broad) wings. The tops of the perianth leaflets form a prominent column.
Phenology: Flowering and fruit maturation: June up to October.
Seed germination: Horizontal, large (3.0 mm in diameter). The embryo is spiral. Freshly harvested seeds germinated at +18-25 °C was 8.5%, germination started on day 2 and lasted 9 days. After stratification for 20 days (at low temperatures) the germination capacity significantly increased up to 40%. Seeds viability up to 1.5 years.
Economic importance: Valuable fodder plant, especially well grazed by sheep and goats in the autumn and winter. Camels consume around all year. Green biomass and fruits contain (%): crude protein 16.5-22.9; fat 2.4-2.0; nitrogen free extract 38.3-43.1; cellulose 17.8-21.0. Fodder value (FU) of Green matter in spring 25, summer 45 autumn 38; winter 33 fodder units/100 kg green matter.
Recommended for afforestation program of degraded sandy desert. A good sand fixing and ornamental plant.
Habitat: Grows preferably on fixed sand and barkhanes, and on grey-brown sandy soil.
Distribution: Native for sandy desert of Central Asia and Afghanistan.
Note: All plant organs contain the alkaloid salsolidine, which raises blood pressure and stimulates cardiac activity. It is possible to make a durable black dye from wood and fresh leaves.


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Amaranthaceae Juss.
Xylosalsola richteri (Moq.) Kar. & Litv.

Synonym: *Salsola arborescens* var. *richteri* Moq., *Salsola richteri* (Moq.) Karel ex Litv.
Local name: Rixter sho'ragi (Uzb.), Sherkez (Kar.), солянка Рихтера (Ru.).

Botanic characteristics and life form: C_4-halopsammophyte. Strongly branched tree, up to 3-4 m tall, black tree.
Stem: Many-stemmed, profusely branched; ultimate branches very slender and long, milky-white, glabrous, smooth; bark of older branches light brownish-gray; wood black.
Leaves: Alternate, linear, slender, (30-80 mm long), glabrous, acuminate.
Flowers: Perianth segments lanceolate, acuminate, dark, narrowly scarious-margined, glabrous in fruit clustered at center and winged below the middle; wings large, light-colored, subpellucid. silky-lustrous, stigmas flat and glabrous, two-thirds as long as to equaling the thick style.
Fruit: Nut-like, monocarpous (9.8-18 mm). Upper perianth flat, grey, rigid; constricted in middle in friable column. Wings horizontal colourless, seldom pink or grey; 10-15 mm, membranaceous linear or inverse oval-shaped fine venation.
Phenology: Flowering: July - September, fruit maturation: September - October.
Seed germination: Germination rate: 56-68%. Light dark sequence with alternative (15-28 °C) or low temperature stimulate germination. Treatment with gibberellic acid is effective too. Seed viability 16-24 months.
Economic importance: Valuable fodder plant, especially well grazed by sheep and goats in the autumn and winter. Camels consume around all year. It is also a medicinal, alkaloid, tannic and poisonous plant. Extract from green twigs stains cotton fabrics in sandy and black colors. Recommended for afforestation and agroforestry programs on saline sands.
Habitat: Grows on moderately saline fixed sand and sandy dunes barkhans, as well as on grey-brown sandy soil. Resistant to chloride salinity.
Distribution: Native in Central Asia and Afghanistan.
Note: Fruits and flowers contain the alkaloid salsolin (0.7-3.1%), which is used to lower blood pressure and to strengthen the nervous system. Among the flavonoids coumarins have been detected. Extracting the above-ground biomass is used as a dye, giving a brown color.


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Amaryllidaceae J.St.-Hil.
Allium caspium (Pall.) M.Bieb.

Synonym: *Amaryllis caspia* (Pall.) Willd., *Crinum caspium* Pall.
Local name: Kaspiy piyozi (Uzb.), арам жуа (Kaz.), taw piyazi (Kar.), лук каспийский (Rus.).

Botanic characteristics and life form: C_4-psammohalophyte, perennial herb, one of the green-white onion or dark brown, height of the plant is approximately 10-30 cm. with massive umbels of greenish-white variety, on short stems.
Stem: Bulbose stem is globose (2-4.5 mm in diameter), a papery outer covering is nearly black, flowering scape (stem) is stumpy, 10-30 cm tall, 1 cm thick.
Leaves: Large 1-3, ranging from linear or linear-lanceolate to broadly lanceolate, 5-25 mm broad, not exceeding the escape, the edge of the leaf scabrous or smooth.
Flowers: Funnel-shaped star-like, pink or rarely whitish (5-11 mm). Frequently borne in umbels of many-flowered clusters. Umbel fasciculate, often hemispherical or spherical, rather loosely; stalk of the flowers 2-4 or more times the length of the sterile parts of the flower segments. Bract one-third as long as the umbel. Within umbel outside flowers bloom first and flowering progresses to inside.
Fruit: Dry capsule that open longitudinally along the capsule wall between the partitions of the locule.
Phenology: Vegetates from March to half of May; after drying, it quickly vanishes from pasture grass, flowering: April - May, fruit maturation: June - July.
Seed germination: Heteromorphic seeds are small. black irregular, and angular; length ranged between 1.74-4.47 mm and width ranged between 1.06-3.44 mm. The seeds germinate reliably under warm, moist conditions. It takes 7-10 days they take to emerge at room temperature as 90%. Seed priming with nutrients (e.g. gibberellic acid) improve germination and seedling vigor. Seeds has ability to maintain germination for up to 3 years. *A. caspium* propagates by seeds and vegetatively through bulbs.
Economic importance: Refers to poisonous plants. Even with insignificant eating by cattle, the taste and smell of milk and oil are strong. *Allium capsicum* may also be used as ornamental plants or as a source of extracts for use in various pharmaceutical or cosmetic products.
Habitat: Inhabits on sandy deserts and sands in areas of mottled outcrops, on sands at an altitude of 100-500 m. It can be found in sandy deserts (from western Kyzylkum desert towards Caspian Sea shore), in areas of exits of variegated rocky strata, on riverine sands.
Distribution: Endemic for deserts adjacent to the Caspian, Central Asia (mostly in Aral-Caspian region), Pamir-Alay mountain system (from South to West). It is considered native to southern parts of European Russia.
Note: In ancient, especially in medieval times, onion was prized for its medicinal properties and was carried as a charm against and other evils. The plant is used in traditional and folk medicine in many places, and there is some evidence that it may help prevent heart disease. Bulb contains about 0.1 percent essential oil, alkaloids, saponins.


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Apiaceae Lindl.
Ferula foetida (Bunge) Regel

Synonym: *Ferula scorodosma* Bentley & Trimen,
Scorodosma foetidum Bunge
Local name: Sassiq kovrak (Uzb.), сассық қурай (Kaz.), chomych (Trk.), ферула вонючая (Ru.).

Botanic characteristics and life form: Xero-halophyte. Perennial, monocarpic (fruit once in 7-9 years), ephemeroïd plant (about 1.0 up to 1.6 m) tall with a thick, juicy, cylindrical, and deeply penetrating massive tap root.
Stem: Single, strong ramified at the top, fleshy, thick with rosette-like leaves (from 40 up to 100 cm diameter) arising from the base.
Leaves: Alternate, 80 cm long, soft, much divided on large lobes with sheathing stalks at the base.
Flowers: Borne in many-radial terminal umbels compound in a large spheroid one. Perianth with tiny calyx of 5 teeth and 5 free, egged-form often notched and sometimes unequal in size, pale colour petals. Stamens 5 alternating with the petals; inferior ovary of 2 fused carpels, ripen into 2 separating, but indehiscent parts, suspended from the tip of the axis.
Fruit: Large, flattened, ovate-elliptic achene divided into 5-ribbed with wing-like margins mericarp. Oil-ducts 2-3 per furrow.
Phenology: Flowering: March - April, fruit maturation: April - May.
Seed germination: Seeds small white brown, flatly compressed, 3-20 per inflorescence. Seed with small erect embryo (1/2 seed size), surrounded by endosperm and with a thin seed coat. Pericarp contains a big quantity of inhibitors. Field and laboratory seed's germination is low. Long-term stratification (0-10 °C). 1-1.5 or several months treatment of seeds with sand or peat greatly increase the germination. Washing and/or removal of fruit body positively influence germination rate. Reproduce by seeds and vegetatively from living rhizomes and rootstocks.
Economic importance: Forage, medicinal, resinogenic, volatile oil, food and fibrous plants. It is also used for perfume and soap industries. Used both as pasture and concentrate-ensilaged mixed with *Artemisia*. Before flowering, green leaves are well eaten by camels and horses. Fruits and seeds are consumed by sheep, goats, gazelles in spring-summer periods. After soaking the fruit in boiled water for 24 hours, local people use the seeds for winter fattening of livestock. As a spice, *Ferula foetida* is known for its strong, pungent smell. This is due to its high concentration of sulphur compounds. It is commonly mixed with wheat or rice flour.
Habitat: All over plant communities of pastures on foothills, semi-desert and sandy desert. Often as individuals but may form dense communities (100-1500 plants/ha) on clay-loamy foothill plains, in sandy deserts, grey-gypsum soils.
Distribution: Middle, Minor and East Asia, Kazakhstan.
Note: Mature fruit contains (%): fat 9.5, ash 10.9; crude protein 22.8-30.0, cellulose 29.0; nitrogen-free extract 34.0; in leaves (%): fat 6.8; ash 10.9; crude protein 24.5; cellulose 10.3; root of vegetative plants (%): Soluble sugar 18.4-25.8, starch 17.6-29.7, cellulose 3.3-18.2, protein 6.2-9.5; during vegetation contains 31.5 mg/kg carotene, aromatic resin (pitch) (31.3-65.1%) and volatile oil (6.9-17%). The dried aromatic gum resin is exuded from the living rhizome, rootstock or tap root. *Ferula foetida* has a long history of spiritual uses. Known as 'devil's dung' (because of its funky smell), it was used to ward off evil, break curses and for protection in the African American tradition of ancient tribes.


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Apiaceae Lindl.
Ferula kyzylkumica Korovin

Local name: Qizilqum kovragi (Uzb.), ферула кызылкумская (Ru.).

Botanic characteristics and life form: Xero-halophyte. Ephermeroid, perennial plant (height about 30-50 cm), polycarpic, root is cylindrical, thickened at the neck.

Stem: Single, wrapped at the base with fibers of dead basal leaves, branching into a narrow panicle in the middle part, later colored reddish. The branches are regular.

Leaves: Leaves on both sides are pubescent, sometimes almost naked, basal on short and thick petioles, expanded into the vagina; their plate is broadly rhombic in outline, triplet dissected, segments in turn twice pinnately dissected into oval, 5-10 mm long pinnately incised sections, stem leaves with a greatly reduced plate, upper the same are reduced to vaginas, the vaginas are oval, swollen, enclosing the stem.

Flowers: The inflorescence is a compound umbrella. The shorter central spikelets contain bisexual flowers, while the long lateral spikelets contain both male and female flowers. In dry years only bisexual are produced, while wet year inconspicuous male flowers are dominated. Bisexual flowers are 5-membered, with a reduced calyx, 5 yellow petals, 5 stamens on long staminate filaments and inferior ovary.

Fruit: Achene (immature) splitting into 2 oblong-oval mericarpy, brown, 7-8 mm long, 4-5 mm wide, with narrow filiform dorsal and marginal ribs and especially secretory glands at the base.

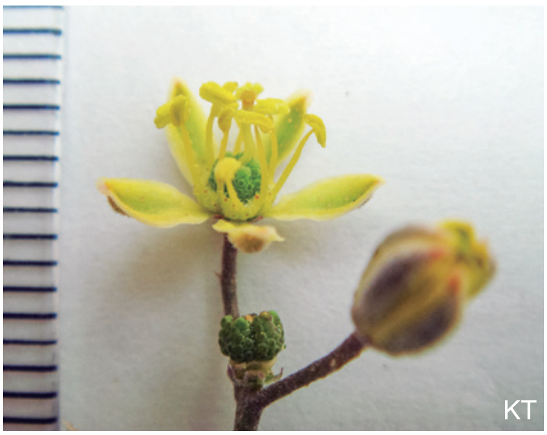
Seed germination: Seed numerous, endosperm occupies most of the seed. The embryo is small, green and morphologically well differentiated. Field germination is very low. Seed germination (after two months of storage) was 53% at +6-8 ºC. Germination took 43 days.

Economic importance: Landscaping plant at saline gypseous soils. Not eaten by animals.

Habitat: Occurs on the rocky slopes of the remnant hills.

Distribution: Endemic in the flora of Uzbekistan.

Note: Essential oil and medicinal plant, widely used in pharmacology and cosmetics. Five ester complex substances were detected in *F. kyzylkumica* roots. The maximum accumulation of these compounds was observed during the flowering stage.

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Apocynaceae Juss.
Apocynum venetum subsp. *scabrum* (Russanov) ined.

Synonym: *Apocynum scabrum* Rusanov, *Poacynum venetum* (L.) Mavrodiev, Laktionov & Yu. E. Alexeev, *Trachomitum scabrum* (Russanov) Pobed., *Trachomitum venetum* (L.) Woodson
Local name: Kendir (Uzb.), кендырь венецианский (Ru.).

Botanic characteristics and life form: C_3-halo-phreatophyte with wide range of distribution. A semi-shrub with erect stems 1.0-2.8 m tall, with opposite leaves and small purple or purple flowers collected at the ends of branches in half-cones.
Stem: Except for the inflorescences, the stems are glabrous; the branches and branchlets are white-gray, terete, and slightly striate.
Leaves: Petiole 3-6 mm; leaf blade elliptic to narrowly ovate, 0.5-2.2 cm, base rounded or cuneate, border denticulate, apex acute or obtuse, mucronate.
Flowers: Bisexual, assembled in a few to many flowered corymb-like cymes, carried on flower-cluster-stalk 2-4 cm, hairless. Sepals are 1.5 mm long and narrowly elliptic or oval. Corolla is purplish red or pink; tube is campanulate, 6-8 mm long, and granulose; lobes are 3-4 mm long. The disc is fleshy and 5-lobed, with rounded lobes and a base adnate to the ovary.
Fruit: Follicles slender, 8-20 cm long and 2-3 mm wide.
Phenology: Flowering: April - September, fruit maturation: October - beginning of December.
Seed germination: Seeds ovoid or ellipsoid, 2 to 3 mm in diameter, with a coma (a tuft of hairs on the seed) of 1.5 to 2.5 cm that facilitates wind dispersal. Field germination at the soil depth at 20 cm varies 72-78%. High germination was observed at 15-35 ºC. Insignificant percentage germinated after 3 months of stratification. Seedling establishment is most vigorous on wet sites. Apocynum reproduces by rhizomes or suckers from the root crown. Adventitious rhizome buds produce aerial shoots.
Economic importance: Because it contains the glucoside cymarin, it is not eaten fresh by cattle. There have been cases of fatal poisoning in cattle, sheep, and camels. Livestock eat starchy rhizomes. The juice of the sap contains gums, resins, and tannins. The bark and root are used for tanning hides by Turkmen and Iranian. It is recommended for restoration of salt-affected and baren lands.
Habitat: Along river valleys on sandy, pebble deposits, on rocky slopes, on brackish meadows. It colonizes disturbed sites, abandoned fields, and wetlands in rivers delta.
Distribution: Central Asia and Afghanistan, North Caucasus, Iran, Iraq, Pakistan Mediterranean and northeastern China, European Russia, Inner Mongolia, Mongolia, Altay, West Siberia and Japan.
Note: The stems and roots contain the cardiac poison apocinin and tannins in an amount of 6 to 11%. *A. venetum* fiber known as 'king of wild fibers' is suitable for textile industry, manufacture of higher grades of paper, overalls and explosives. The leaves contain rubber and resins. Extract of plants shown an anti-inflammatory, antioxidant, cardiotonic and hepatoprotective effects. Folk medicine uses fatty oil from seeds. Luobuma tea, made from the flowers of the *Apocynum*, is becoming increasingly popular in the East Asian health food markets.
Other similar species: *Apocynum venetum* subsp. *lancifolium* (Russanov) ined. is common in Central Asian areas.


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Asteraceae Dumort.
Artemisia diffusa Krasch. ex Poljakov

Synonym: *Seriphidium diffusum* (Krasch. ex Poljakov) Y. R. Ling
Local name: Chochiq shuvoq (Uzb.), акқ жусан (Kaz.), evshan (Trk.), полынь раскидистая (Ru.).

Botanic characteristics and life form: C_3-xerohalopyte. Perennial, polymorphic, low shrub (30-50 cm), pubescent, grey-green, ramified and slender lignified stems with a short and strong branches at the basis "= caudex" (4-12 cm in length). Shrub' s longevity: 7-25 years. Pivotal, powerful, root penetrates to 1.1-2.5 m deep.
Stem: Reproductive stems: erect or arch-curved (15-30 cm in height and up to 3 cm wide) and ramified at the upper part.
Leaves: Sessile (1.5-2.0 cm long; up to 1.0 cm wide), twice - three times pinnatipartite pointed at the end. Leaves surface is densely covered with silky hairs of various structures giving them a silvery appearance.
Flowers: Inconspicuous, bisexual, protandrous, pentamerous, pale yellow gathered in groups (3-7) in oviform, sessile capitulum (3-4 mm long), assembled in a wide panicle inflorescence.
Fruit: Dark-brown indehiscent, monospermous achene with membranous pericarp.
Phenology: Vegetative growth of above ground organs from end of February - beginning of June; Long summer rest when spring leaves may fall. Longevity of cycle of vegetation 230-237 days. Flowering: September - October, fruit maturation: October - November.
Seed germination: Seed is small, with erect, large, chlorophytic embryo without endosperm. Seed coats 3-5 cells' layers. Light sensitive, germinate with temperature 15-20 °C on coarse river sand substrate. Laboratory seed's germination range from 46 to 94%, while field germination is lower 5-20%. Special temperature sequences (13/31 °C) after 14 months of seed storage significantly stimulate germination.
Economic importance: Provide a most valuable fodder bank during the autumn-winter feed gap for all kind of animals. In the early spring due to the presence of highly contents of carotin (about 100 mg/kg) in young sprouts, Artemisia is well eaten by cattle, but care must be exercised with small ruminants (possibility of abortion). Ripe fruits readily eaten due to the decrease of strong smell and bitter taste). In Uzbekistan, *A. diffusa* is collected for winter as animal feedstocks (as hay, silage and concentrate food blocks). Woody parts are systematically used by local people as fuel wood.
Fodder value: Green leaves and twigs during spring contains (%): crude protein 16.9; fibber 15.8; fat 4.49; ash 12.7 and up to 39.7 carotin; at fruiting stage, (%): crude protein 8.0; fat 5.54; ash 6.72; cellulose 45.4. Fodder value is estimated to 18-66 fodder units (FU) and 2.2-7.8 kg digestible protein/100 kg D.M.
Habitat: Typical plants of the Southern Turanian deserts; inter-dunes, depressions and on northern slopes of sandy ridges; most abundant on loamy-saline sands, stony and grey - brown soils of plains, foothills.
Distribution: Endemic of Central Asian desert and foothills.
Note: Consider as a phytoremediator. *A. diffusa* can accumulate and translocate toxic heavy metals from contaminated habitats. Valuable species for rehabilitation of degraded rangelands in clay and gypsum desert.


TR


TR

Asteraceae Dumort.
Artemisia terrae-albae Krasch.

Synonym: *Seriphidium terrae-albae* (Krasch.) Poljakov
Local name: Oqyer shuvoq'i (Uzb.), жусан (Kaz.), полынь белоземельная (Ru.).

Botanic characteristics and life form: Perennial low-shrubs, 35-60 cm tall, with thick woody roots.
Stem: Is usually straight. The whole plant has dense whitish pubescence, often silvery appearance.
Leaves: Most often lobed or pinnately divided, alternate, dissected, less often entire and entire-edged, the lobes are small and thin. Lower leaves are larger, often on long petioles, middle and upper leaves are smaller, less dissected, and usually sessile.
Flowers: Bisexual small, more often yellow, sometimes reddish, collected in small inflorescences-heads-ovoid, cup-shaped or almost globular baskets 1-10 mm in diameter with shingled wrapper leaves. Inflorescences consist of slender tubular flowers, with marginal filamentous and unisexual pistillate flowers; the whole inflorescence is surrounded by a shingled veil. The flower heads are gathered in long brushes panicles.
Fruit: Achene smooth obovoid or ovoid.
Phenology: Budding stage in April - May, flowering and fruit maturation: September - October.
Seed germination: Small seeds without tuft. Light sensitive, germination at 15-20 °C on coarse river sand. Germination rate varies: 65-89%. *A. terrae-albae* is easily propagated vegetatively.
Economic importance: *A. terrae-albae* is a landscape feature of sagebrush pastures used as fodder (open grazing) for sheep, goats, horses and camels, especially in early spring, autumn and winter. Pastoralists collect (uproot) *Artemisia* and store it for winter fodder. It is also suitable for haymaking, better feed and used after exposure to frost and rains in winter when volatile oil and other chemical compounds have been leached. It is also often used as fuel for cooking and heating.
Habitat: On saline drained bottom of the Aral Sea, on wide gypsophytic plain of Ustyurt, shallow hilly areas (weakly sandy fixed) with sparse communities of small shrubs and desert xero halophytic and psamophytic grasses. Sometimes occurs on sandy-gravelly alluvial deposits and stony slopes of foothills.
Distribution: This species' range extends from Central Asia (Pre-Caspian Ustyurt and Northern Priaralie) to Mongolia and China (northern Xinjiang). Other similar areas of *Artemisia terrae-albae* can be found in Morocco, Spain and in some areas of North Africa.
Note: Used mainly in stomachic remedies. In earlier times, wormwood tinctures were used as an anthelmintic. Wormwood is applied as an appetite stimulant in tinctures, infusions and extracts made from the leaves and flowering tops of the shoots. The essential oil of *A. terrae-albae* has antifungal property and is concerned in perfumery and cosmetics.


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Asteraceae Dumort.
Artemisia turanica Krasch.

Synonym: *Seriphidium turanicum* (Krasch.) Poljakov
Local name: Turon shuvog'i (Uzb.), қара жусан (Kaz.), полынь туранская (Ru.).

Botanic characteristics and life form: C_3-Xero-halophytic salt accumulator. Small shrub (height 20-50 cm). Woody, thick root strongly in old specimens vertical split into several parts, with very numerous, prostrate or ascending, strongly condensed. It is ground water dependent and also tolerant to frost.
Stem: Flowering shoots numerous, slender, nonflowering shoots covered with grayish cracking bark, whitish arachnoid-hairy, later completely glabrous, intensely violet-brown or almost black, lustrous, branched above with almost horizontal branches.
Leaves: Leaves withering early, green; lower leaves petiolate, up to 1.5-2.0 cm long, their laminas oval, twice or thrice pinnately cut, terminal lobes linear, 3-5 mm long; middle cauline leaves sessile, less compound with pinnate auricles; uppermost leaves undivided, linear, sometimes with 2 lateral lobes at base.
Flowers: Bisexual, inconspicuous (2.0-2.8 mm), in small axillary clusters (3-5) with yellow corolla. Inflorescence: small, spherical, bright brown. Florets 3-5, corolla yellow; anthers linear, apical appendages subulate, basal appendages much short, round; stigma lobes short, linear-oblong, truncate, short-ciliate, after anthesis weakly divergent.
Fruit: Fruit indehiscent, monospermous achene with membranous pericarp.
Phenology: Vegetation begins in February - March, maximum growth in April - May. Flowering and fruit maturation: September - October.
Seed germination: Small, with erect, large, chlorophytic embryo without endosperm. Seed coats thin (3-5 cells' layers). Viability: 85-92%. Light sensitive, germinate with temperature 15-20 °C on coarse river sand substrate. Laboratory seed's germination range from 46 to 94%, while field germination is lower 5-20%. Special temperature sequences (13/31 °C) after 14 months of seed storage significantly stimulate germination. Seeds viability: 2 years. Reproduced by seeds and by particulation (by small parts). Anemophilous but entomophily also admitted.
Economic importance: Valuable feed for all livestock mainly in autumn and winter. Younger sprouts, heads and leaves are well consumed by cattle. Green forage production varies from 0.15-0.3 t/ha; on improved rangelands, may reach 1.5 t/ha when cultivated with young dense stand. A valuable plant for range rehabilitation and improvement of autumn-winter pastures.
Habitat: Often mixed with *A. diffusa*, pure stand rare. Well adapted to clay/sandy loamy soils; prefers heavy soils; Sometimes on sandy-gravely alluvial deposits or stony slopes of foothills.
Distribution: Compared to *A. diffusa*, this species widely present on all part of desert of Central Asia, Kazakhstan, south Russia, South and Northern part of Turanian lowlands to Balutchistan.
Note: Green forage of *A. turanica* contains (% DM): crude protin 10.1-19.3; cellulose 12.6-28.1; carbohydrates up to 27.0; fat 4.3-6.4; various mineral salts (% DM): Na 2.3; Si 1.0; Ca 0.8; K 0.7; Mg 0.7. Fresh biomass contains volatile oil used in traditional medicine (tincture from dry leaves is used to induce appetite and for the treatment of gastric complaints). It is good for phytoremediation of arsenic-contaminated soils.


TR


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Asteraceae Dumort.
Cousinia resinosa Juz.

Local name: Qatronli karrak (Uzb.), кузиния смолистая (Ru.).

Botanic characteristics and life form: Non-succulent xerohalophyte (excrets salts through salt glands). Monocarpic. Biennial herb (up to 75 cm). Root vertical, woody, blackish fibrous, with a globular, resinous, sticky, slightly arachnoid-hairy collar.
Stem: Solitary, 15-60 cm tall, hairy, erect, upper part erect, densely white-tomentose, upper half or sometimes almost from base branched.
Leaves: Large, white-green, simple, stalked, elliptic to lanceolate, finely striped, sharply serrate, with spiny margins. All plant organs densely covered with sharp spines. Basal leaves stalked, elliptic-lanceolate, coriaceous, greyish-green, densely white-tomentose; lower cauline leaves like basal leaves but sessile, decurrent; middle and upper leaves ovate or broadly ovate, sessile, broadly long-decurrent, large and spiny-crenate-toothed, pubescent.
Flowers: Regular, bisexual, pentamerous, stamens 5 attached to the corolla tube. Anther fused to stamen. Inflorescence a terminal oviform, numerous capitula (18.0-23.0 mm long; 7.0-8.0 mm wide), with lobed bracts and flat, bare receptacles; disc florets pale pink.
Fruit: Achene (4.5 mm long, 2.0 mm wide), dry, non-hesitating, monospermous, finely perforated, inverted ovoid, with pointed tip. The pericarp is membranous, flat and smooth. Pappus short, with bristly hairs.
Phenology: Flowering: June - July, fruit maturation: July - August.
Seed germination: Large with an erect embryo without endosperm. Light-sensitive. Germination in the laboratory: 72-84%; up to 90% germination at 20 °C (16 hours) or 30 °C (8 hours). Seed dispersed by wind and animals.
Economic importance: *C. resinosa* is a co-dominant of *Artemisia*-ephemerals rangelands. It is rarely directly grazed, except by camels and cattle, and is usually harvested as silage and winter fodder. Average forage biomass yield is 0.6-1.7 t/ha. Hay and silage are harvested at the budding stage (end of May - June). Harvested dry, it is stored on the roofs of barns or sheepfolds, then chopped and fed to livestock as a winter concentrate. A good melliferous plant for beekeeping.
Habitat: Dry plains, loamy foothill and low mountain slopes with high gypsum and limestone content.
Distribution: Uzbekistan, Kyrgystan, Tajikistan, Turkmenistan, Southern Kazakhstan, Afghanistan, Iran.
Note: In vegetative green growth, contains (% DM): crude protein 5.8; fat 3.4; cellulose 45; ash 6.9; nitrogen-free extract 30. Dry matter contains (% DM): protein 6.8; fat 4.9; cellulose 49; ash 6.5; nitrogen-free matter 15.8.
Cousinia species richness in Uzbek flora accounts for about 22% of total Asteraceae diversity, making it the second largest genus of flowering plants after *Astragalus* L. (Tojibaev et al. 2014, Usmonov 2017). Other xerohalophytic *Cousinia* spp: *Cousinia minuta* Boiss. (Kyzylkum and Karakum), Iran and Kashmir; *Cousinia dichotoma* Bge. (Endemic. Kyzylkum desert and Amu Darya River basin); *Cousinia affinis* Schrenk Turanian-Dzungarian floristic zone; *C. waldheimiana* Bornm-a new species in the Flora of Uzbekistan. A sign of severe rangeland degradation is its occurrence in dense thickets around animal camps, settlements and watering points.


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Asteraceae Dumort.
Karelinia caspia (Pall.) Less.

Synonym: *Pluchea caspia* (Pall.) G. Nicholson, *Serratula caspia* Pall.
Local name: Kaspiy oqboshi (Uzb.), kamak (Trk.), Каспий карелиниясы (Kr.), карелиния каспийская (Ru.).

Botanic characteristics and life form: C_3-Recretohalophyte (excretion of Na+ by salt glands distributed on leaves surface). Has broad-spectrum resistance to salts and pests. Perennial, large (1-1.3 m) herb and tap root system. The root penetrates up to 5-9 m depth reaching mineralized underground water (phreatophytic feature).
Stem: Strait, rigid and strong branched from base.
Leaves: Large, fleshy sessile with entire margin.
Flowers: Inflorescence: singular, terminal, oblong-elongated, capitulum straight brown at maturity. Flowers: Numerous, bisexual, pink, violet.
Fruit: Dry indehiscent achene. The achene is narrow and wedge-shaped. The pubescence is soft-felt with long, filiform hairs, uniform. Pappus uniseriate with dense, obliquely upward directed setae bearing thin, long, shiny hairs.
Phenology: Vegetative period begins at the first half of April, flowering in June, dries off in July - August.
Seed germination: Seed germinates 85-90% in a 2:1 peat/sand mixture under ambient conditions [temperature: 25 °C/18 °C (day/night), photoperiod: 16 h/8 h (day/night), relative humidity: 60%]. Rapid multiplication occurs from tuberous roots.
Economic importance: Poor forage. Not grazed by cattle, little consumed by sheep, goats and camels in winter. Could be used as raw material in silage in mixture with *Alhagi pseudoalhagi* and *Cousinia decurrens*.
Habitat: Typical of damp-salty vegetation. Grows on alluvial deposits, barren lands and saline margins of lakes and shores. Semi desert foothill and plains, alluvial deposits; fallow field, usually on calcareous loamy and/or gravely soils.
Distribution: Mostly in Central Asia, Tarim river, Caspian areas.
Note: *Karelinia* is a promising phytoremediator of saline-alkaline soils. It is a pioneer species for the improvement of saline, alkaline and desertified soils. Wild associations of this halophyte can be used as renewable source of alternative energy, and it can be planted in abandoned saline arid lands for improving and increasing their productivity. The only drawback for this halophyte in terms of biogas production is the high sodium and sulfate content in biomass which can reduce the capacity of anaerobic digesters.


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Boraginaceae Juss.
Heliotropium arguzioides Kar. et Kir.

Synonyms: *Heliotropium leucocladum* Rech.f.& Riedl, *Heliotropium radula* Fisch. & C.A.Mey. Ex Ledeb., *Helotropium xinjiangense* Y.L.Liu

Local name: Arguziyasimon g'ijmalos (Uzb.), гелиотроп аргузиевый (Ru.).

Botanic characteristics and life form: Non-succulent C_3 salt exclusion psammohalophyte. Shrubby perennial with numerous suckers and roots spreading horizontally up to 50 cm into the soil.

Stem: Woody, erect or ascending at base with ribs and flaking white bark. Branches crowded and covered with dense stiff hairs.

Leaves: Spirally arranged, oblong to lanceolate or oblong to elliptic (1-3 cm long) on long peduncles with cordate base. Leaf surface with slightly rolled margins, heavily pubescent with greenish-grey to white-grey simple hairs.

Flowers: Bisexual, small, four- or pentamerous, assembled in unilateral terminal scorpioid cymes (1.0-2.5 cm wide), pubescent, ebracteate. Sepals free, highly pubescent, less often fused, dismembered on oblong pointed lobes; corolla: white or yellow 2-4 mm long, bases of petals accreted in column with the well-expressed nectarium. Stamens: 5, fused with free filaments; ovary: 2-4(5) loculars with a false partition between them, often encircled by a basal disc. Stigmas short with one small terminal conic style.

Fruit: Dry (2.0-5 mm long), ellipsoid, divided at maturity into 2-4 one-seeded mericarps; mericarps linear-elongated or ovate, densely villous.

Phenology: Flowering and fruit maturation: April - August.

Seed germination: Small straight or curved, with large, erect embryo and fine endosperm. Seed coat thin, dense. Dark - sensitive. Cold stratification (3 months), followed by germination at 10/35 °C; washing, scarifying and/or treating with chemical stimulators increases germination. Seeds viability: up to 2 years. For propagation, it is recommended to use seeds of 8-9 months of age, when the viability is highest.

Economic importance: On the pastures it is mainly grazed by sheep, goats and camels. It is considered an alkaloid plant. Valuable plant for its ability to develop underground runners to hold sand in place where the *Carex* cover is destroyed.

Habitat: Sandy deserts and the outskirts of takyrs, saline abandoned pasturelands. Common on loose sands near wells, degraded areas, calcareous and rocky hills (frequently on Ustuyurt plateau), together with Tournefotria sogdiana.

Distribution: Uzbekistan, Tajikistan, Turkmenistan Afghanistan, Iran, Kazakhstan, South European Russia, and the province of Xinjiang in China.

Note: Contributes to fixing of shifting sands due to numerous sucking roots.

Other species in the desert flora of Uzbekistan: *Heliotropium biannulatiforme* M. Pop; *Heliotropium ellipticum* Ledeb.


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Capparridaceae
Capparis spinosa L.

Local name: O'tsimon kovul (Uzb.), gewl (Kar.), чөөп сымал коңуз баш (Kr.), каперсы колючие (Ru.).

Botanic characteristics and life form: C_3-salt exclusion xerophreatophyte. Perennial, drought-and salt tolerant an evergreen, climbing, spreading, thorny shrub, typically 35-50 cm tall, but spreading to 2-5 m by semi-deciduous branching. Its roots can be 6 to 10 m long.
Stem: Branches thin are usually 2-3 m long. Pale yellow spines are often hooked and divaricate, sometimes weakly developed.
Leaves: Round, fleshy, alternate, thick, 2-5 cm long, simple, ovate to elliptic, thick and shiny, with a rounded base and a mucronate, blunt-tipped or emarginate tip.
Flowers: Bisexual large 5-7 cm in diameter, axillary and solitary, with purple sepals and white petals. Stamens are numerous, violet-filamented.
Fruit: Caperberry, ellipsoid, ovoid or obovoid with a thin pericarp. The fruit bursts when ripe, exposing many seeds embedded in a pale crimson flesh. A thousand seeds weigh 6-8 g.
Phenology: Flowering: May - June, fruit maturation: July - September.
Seed germination: Seeds are 3-4 mm, greyish brown and reniform. The embryo is spirally curved. Seeds mixed 1:4 with well-wet river sand in sealed bags and buried 25-30 cm deep in the ground from December to February (90 days) enhanced germination up to 2.5-fold. Stratification (15/25 °C alternating temperature; and light/dark cycles) for 3 months stimulates sprouting. Asexual propagation (from wood and stem cuttings) is common. Rooting takes 6-8 weeks or more.
Economic importance: Practically not eaten by livestock because of the sharp thorns along the entire length of the sprouts. The dry leaves of the plant are readily eaten by almost all species of farm animals. It is applied for landscaping and reducing erosion along highways, steep rocky slopes, sand dunes or fragile semi-arid ecosystems. *C. spinosa* is recommended to combat soil salinisation and desertification, as it covers a large area of the soil surface and produces one of the deepest root systems. It is also regarded as an effective phytoremediator.
Habitat: Rocky-gravely soils to slopes, in foothills, on alluvial deposit, channels and rivers banks. Growth in the walls of ancient city walls as well as on rocky, coastal cliff faces.
Distribution: Widely in arid zones of Uzbekistan, along the chink of the plateau Ustyurt, west and central Asia, Caucasus, Mediterranean region, Africa, Iran, Afghanistan, Pakistan, India and in drylands of Africa.
Note: There is evidence to suggest that the caper was introduced to Mallorca by the Muslims during the 300 years of their rule at the beginning of the second millennium. Its Arabic name is al-Kabara (alcaparra in Castellano). Its young flower buds, known as capers, are widely used to flavor food, and different parts of the plant are used in the manufacture of medicines and cosmetics. Capers used to be grown for their flower buds and unripe fruit. They were eaten after being pickled in brine. Becoming very popular in Mediterranean cuisine.
Other species: *Capparis rosanowiana* B. Fedtsch. occurs in Ustyurt.


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Caryophyllaceae Juss.
Acanthophyllum pungens (Bunge) Boiss.

Synonym: *Acanthophyllum brevicalycale* Soskov, *Acanthophyllum ruptile* Vved., *Acanthophyllum tenuifolium* Schischk, *Saponaria pungens* Bunge
Local name: Tikanli bolishtikan (Uzb.), тикендїї кой тикен (Kr.), qozitken (Kar.), тікенді бозтікен (Kaz.), колючелистник колючий (Ru.).

Botanic characteristics and life form: Psammophreatophyte, withstand salinity and severe drought. A polymorphic, perennial, cushion-forming sub-shrub (15 to 35 cm tall), armed with spiny leaves. Main root thick. The species is densely branched from the centre (with few branches at the base) and covered with dense, simple to multi-cellular hairs.
Stem: Brownish globose caespitose; internodes subequal (9.5-12.1) mm long, branched at the base, tomentose.
Leaves: Horizontal or toothed, subulate-needled, 2-4 cm × 1-1.5 mm, sparsely tomentose; axils with dwarf, spinose, sterile shoots.
Flowers: Sessile in capitate dichasias of 9. Bisexual, actinomorphic, pentamerous, spiny on 2-3, sessile, pink-violet or pink-reddish, with strongly spinulose bracts. Petals: 5. Stamens 20. Inflorescence: A terminal, compact, three-branched corymb (2-6 cm wide). Ovary: Single, with 4-8 ovules.
Fruit: Capsule ovate, dehiscent by teeth or by 4 valves. Fruit contain anthocyanin pigments.
Phenology: Flowering: April - May, fruit maturation: June - August.
Seed germination: Glabrous, light brown, with perisperm, 1.7-1.9 mm long, 0.9-1.3 mm wide, oblong or oblong ellipsoid in outline. Seed set and viability are low. Laboratory germination of seeds at +18-23 ºC was 56%, germination began on the 4th day. Field germination 18.1%.
Economic importance: Livestock, except camels, do not graze. Firewood for cooking. Provides a source of protein and minerals for ruminants, especially in the dry season when vegetation on natural grazing land is scarce.
Habitat: On rocky shores. gravel outcrops, often on limestone slopes and fixed sands; gravel desert, sandy saline plains.
Distribution: Uzbekistan (western Kyzylkum desert and Ustuyurt), Kazakhstan, Kyrgyzstan, Mongolia, North Caucasus, Tajikistan, Transcaucasus, China (Xinjiang), seldom Mongolia.
Note: It is an endemic to the Uzbek flora. It grows in *Artemisia diffusa and Artemisia terrae-albae* plant formations on gypsum-rich soils (less sandy sediments). Valuable saponin-bearing plant. Source of triterpene glycosides. In traditional medicine to treat fever, headache, and skin diseases. Recommended as ornamental plant for cultivation. It is propagated by seeds and cuttings. Seeds should be sown in spring or fall in well-drained soil. Cuttings should be planted in moist, sandy soil in full sun or partial shade place.
Genus *Acanthophyllum* consists of about 75 species that are widely distributed in the Irano-Turanian lowlands. Other species in the flora of Aral Sea region are *Acanthophyllum cyrtostegium* Vved., *Acanthophyllum subglabrum* Schischk., *Acanthophyllum korolkowii* Regel & Schmalh., *Acanthophyllum korshinskyi* Schischk.


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Convolvulaceae Juss.
Convolvulus divaricatus Regel & Schmalh.

Synonyms: *Convolvulus afanassievii* Luferov; *Convolvulus desaerticulus* Podlech
Local name: Tarvaqay pechak (Uzb.), qoypashek (Kar.), шырмауык (Kaz.), чырмоок (Kr.), вьюнок растопыренный (Ru.).

Botanic characteristics and life form: Psammophreatophyte, salt tolerant. Greyish, woolly, small, hemispherical, perennial shrub (30-90 cm tall). Pivotal woody root (to a depth of 2-8 m or more).
Stem: Strongly branched, prostrate from base, decumbent or ascending, densely haired.
Leaves: Alternate, small, tall, glandular-haired, linear to elliptic; middle and upper leaves ovate or sub-ovate, rarely ovate-lanceolate, sessile, usually tapering, always rounded at base.
Flowers: Single, rarely 2-3 on short lateral branches; sepal (4)5-6 mm long, elliptic or ovate-lanceolate, usually quite long and pointed, rarely broad, densely villous; corolla (10)11-15 mm long, yellowish or pinkish-white; spike 4-5 mm long, hairless, only the tip lightly hairy. Stamens 5 at base of corolla, with well-demarcated nectaries.
Fruit: Capsule, sometimes opening with a false crack.
Phenology: Budding and active growth in March, flowering: May - June, fruit maturation: July - lasts to October. In fall period after rains new shoots and leaves regenerate. Plants remains in pasture vegetation all winter.
Seed germination: Seed has incurvate embryo with folding cotyledons, surrounded by hard cartilaginous layer of endosperm. Seed coat water impermeable. Germination low. Scarification and long-term stratification (5 °C and 29-30 °C) for 1.5-2.0 months or longer result in 55-85% germination. Treatment with concentrated sulphuric acid and/or soaking in boiling water significantly increase germination.
Economic importance: Well grazed. In spring and early summer, it is satisfactorily eaten by camels, sheep and goats, not consumed in hot midsummer and early autumn, and grazed by all kinds of animals after late autumn and winter rains. Store as winter fodder.
Habitat: On sandy flats, desert gypseous soil.
Distribution: Kyzylkum, Ustyurt, South part of Central Asia and Afghanistan, rarely Iran, Mongolia.
Note: Vegetative growth (% DM): ash 10; protein 14; fat 2.9; cellulose 40; nitrogen-free extract 33. Green parts contain alkaloids. Local people harvest it for silkworm feed. It is a medicinal plant (against constipation, kidney disease).
Other species in Flora of Karakalpkstan: *Convolvulus fruticosus* that occurs in the pasture vegetation of Ustuyurt plateau along with *Artemisia terra-albae, A. kemrudica; Anabasis salsa* and *Caroxylon orientale. Convolvulus hamadae* contains alkaloids (garmin and gigrin) present in the root.


NB


NB

Convolvulaceae Juss.
Convolvulus erinaceus Ledeb.

Synonyms: *Convolvulus denudatus* Petrov, *Convolvulus exelsus* R.R.Mill
Local name: Qattiqshoxli pechak (Uzb.), qoypashek (Kar.), шырмауык (Kaz.), чырмоок (Kr.), вьюнок ежевидный (Ru.).

Botanic characteristics and life form: C_3-non succulent halopsammophyte. Excrete salts through salt gland. Perennial semi-shrub 25-50 cm high with woody stems at the base, abundantly spread-branched stems.
Stem: Profusely and splayed-branched, often knee-sinuous, stiff, woody at the base; branches and twigs depart at right angles.
Leaves: Narrow, linear, rigid, covered with short, tightly pressed hairs.
Flowers: Bisexual. 1-3(5) flowers per short lateral branches; sepals 3-4 mm long, back-ovate or oblong-back-ovate, rounded at the top, densely, pressed silky-hairy, densely ciliated at the edges; corolla 5-8(9) mm long, white, rather deeply five-lobed, with wide lobes, with five densely hairy stripes on the outside.
Fruit: Single-seeded capsule, ovoid 4-5 mm long, hairy at the top.
Phenology: Flowering: June - August, fruit maturation: August - September.
Seed germination: Seeds 2-3 mm long, ovate, indistinctly granular, dark brown. Incurvate embryo with folding cotyledons, surrounded by hard cartilaginous layer of endosperm. Seed-coat water impermeable. Germination low. Scarification and long-term stratification (1.5-2.0 or more month at 5 °C) + 29-30 °C result in 55-85% germination. Treatments with concentrated sulphuric acid (30 minutes) and/or soaking in boiling water significantly increase germination. Field germination varies 28-74%. Seed viability up to 6 years.
Economic importance: The aboveground part of the plant contains a significant amount of alkaloids, nevertheless, it belongs to fodder. In its green form, it is almost not eaten, but in autumn and winter it is considered one of the best feeds for camels, sheep and goats. It has a large stock of feed biomass. It is well known as a source of a fragrant oil that is obtained from the distillation of its roots and stems.
Habitat: Hilly sands, sandy plains and stony and rocky soils.
Distribution: Uzbekistan, Kazakhstan, Kyrgyzstan, Turkmenistan, less in Tajikistan. Occurs also in Afghanistan, Iran, Pakistan, North Caucasus, Transcaucasus and Saudi Arabia.
Note: Chemical composition: ash 5.4; protein 12.6; fat 3.2; fiber 43.6; nitrogen-free. Extract substances: 35.2. The aboveground part contains a significant amount of alkaloids. In summer it is almost not eaten, in autumn and winter it is eaten by sheep and camels satisfactorily. It is used by local people as medicinal application for liver disease, epileptic disease. The use of the name *Convolvulus* predates that of Linnaeus by well over a century.
Other *Convolvulus* spp.: *Convolvulus hamadae* V. Petr on sandy desert soils; *Convolvulus fruticosus* Pall. and *Convolvulus erinaceus* Ledeb. are predominant on the calcareous low desert mountainous slopes (e.g. on Ustyurt plateau).


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Convolvulaceae Juss.
Cressa cretica L.

Synonym: *Cressa monosperma* Stokes
Local name: Krit sho'rpechagi (Uzb.), сортаңқара (Kaz.), кресса критская (Ru.).

Botanic characteristics and life form: Thermocosmopolitan, recretohalophyte (highly salt-tolerant, excretes salts through salt glands). Perennial undergrowth (30-35 cm).
Stem: Woody at base, with many branches above, branches pilose.
Leaves: Densely packed, sessile, ovate-elliptic to lanceolate, length of the leaves 2.5-9.0 mm and 1.0-6.0 mm width, apex acute, basally cuneate, rounded or sub-lanceolate, pubescent in silky hairs. Sepals ovate, sharply pointed, silky hairs.
Flowers: White, grow in clusters in the axils of the upper leaves. Corolla 5-6 mm long, tube and elliptic lobes about equal in length. Stamens and styles 2-4 mm long. Ovary 2-cell, with 4 ovules.
Fruit: Mericarp ovoid, 3-4 mm long. Seed usually 1, with a shiny surface.
Phenology: Flowering and fruit maturation are from the end of June to September.
Seed germination: Seeds are dormant. Germination of unscarified seed was significantly lower (0 to 23%) at alternating day/night temperatures of 10 °C/20 °C. Mostly propagated vegetatively by means of woody perennial rootstock. Seed viability several years.
Economic importance: Seldomly grazed by camels and wild animals. Indigenous people collect the plant and apply the extract to treat diabetes, ulcers, asthma, bronchitis, dyspepsia, flatulence, colic, anorexia, anemia, diabetes and skin. It has some potential as an antibacterial, antifungal agent. In combination with *Tridax procumbens* and *Euphorbia thymifolia* extract, it possesses anticancer effect.
Habitat: Sandy seashores; saline lakes beds, salt marshes, wet solonchaks, rarely on abandoned saline lands.
Distribution: Native to Mediterranean saline soils, frequently occurs in Greece, Africa in western and Central Asia (salt marshes in Kyzylkum desert and Aral Sea areas) to India.
Note: The plant has a sour, unpleasant taste. It contains terpenic compounds used widely in traditional medicine. In Indian Sanskrit mythology, *C. cretica* is commonly known as Sanjeevani because of its life prolonging and age prevention properties.


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Cyperaceae Juss.
Bolboschoenus maritimus subsp. *affinis* (Roth) T. Koyama

Synonym: *Bolboschoenus affinis* (Roth) Drobow, *Bolboschoenus popovii* T.V. Egorova, *Scirpus affinis* Roth

Local name: Dengizbo'yi ko'lqamishi (Uzb.), klubnekamısh (Kar.), деӯиз тїймек камыш (Kr.), клубнекамыш морской (Ru.).

Botanic characteristics and life form: C_4-non-succulent euhalophyte, perennial, 30-55 cm tall. Creeping rhizomes, 1-3 mm in diameter with spherical or ellipsoidal reddish-brown tubers.
Stem: Upright, sharply triangular with leaves arranged in a spiral in three lines.
Leaves: 6-10 cm long, yellow to brown, with straight margins on scarred side; blades 2.0-7.5 mm wide, flat or sometimes folded, serrated, grey-green or green, with smooth or slightly hairy margins above.
Flowers: Head-like inflorescence formed by sessile spikelets with short, broadly rounded, yellowish-white spikelets and broadly ovate to oval, plano-convex fruits. The colour of the floral scales is yellowish-white, neither violet-striped nor slightly violet-striped; the stigmas are 2; the anthers are long (1.5-3.5 mm); the styles are bifid, sometimes trifid styles can be found on the same inflorescence.
Fruit: (Nuts) rusty brown to dark brown, broadly obovate in outline 2.5-3.0 mm long and 2 mm wide; flattened to slightly convex (rarely slightly concave) on abaxial side, plano-convex or slightly biconvex with round edges. Pericarp (in cross-section) with well-developed exocarp, sclerenchymatous mesocarp and endocarp.
Phenology: The flower stalks rise above the leaves in summer. Fruiting lasts from October to March.
Seed germination: Seeds germinate well in saline habitats with fluctuating salinity. (Induced secondary dormancy allows seeds to germinate when salinity decreases). Tubers are easily propagated vegetatively.
Economic importance: Used intensively for grazing livestock, particularly camels and horses, and less intensively for small ruminants and wildlife. It is recommended for reclamation of wet solonchaks and alkaline saline soils. It is suitable for planting around ponds and for establishing wet gardens.
Habitat: *B. maritimus* inhabits saline lakeshores and riversides; salt marshes, desert sands with mineralized shallow water table; inland saline habitats with nutrient-poor, acid grounds. Occurs also in wet places around roads and grasslands along streams; habitats are frequently saline muddy brackish places. The vegetative parts are also highly salt-resistant in summer- hot season.
Distribution: Occurs from south-west European Russia through Afghanistan to Central Asia, India, Southeast Asia and China. The native range of *B. maritimus* is from Iran to Central Asia and the west of Pakistan.
Note: Survival in hot environments with high soil salinity is made possible by the dormancy of seeds and tubers.


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Elaeagnaceae Juss.
Elaeagnus angustifolia L.

Synonym: *Elaeagnus angustifolia* var. *normalis* Kuntze, *Elaeagnus turcomanica* Kozlowsk.
Local name: Ingichkabargli jiyda (Uzb.), jigildik (Kar.), жіңішкежапырақты жиде (Kaz.), ичке жалбырактуу жийде (Kr.), лох узколистный (Ru.).

Botanic characteristics and life form: C_4-phreatohalophyte nitrogen-fixing, salt tolerant plant. Perennial thorny tree, 3-11 m high, with reddish-brown bark.
Stem: Unarmed or with sharp spines, 0.7-3 cm long; young branches and both leaf surfaces silvery-white, densely covered with stellate scales, upper leaf surface grayish-green or green and almost without scales.
Leaves: Large, alternate, lanceolate, oblong-linear, linear-lanceolate, sometimes elliptical-lanceolate, oval or oblong (4.5-8.0 cm long; 1.5-2.0 wide), entire, covered with a silvery white indumentum.
Flowers: Bisexual, four-lobed creamy yellow calyx in 1-3 in leaf axils, on pedicels 2 mm long; perianth campanulate or broadly campanulate, silvery-white, densely covered with white scales and sparse, small yellowish glands; perianth tube 5-6 mm long, 2.5-3 mm broad; lobes lanceolate, ovate or triangular-lanceolate, acutish, yellow and glabrous inside. Flowers appear in early summer and are followed by clusters of fruit, a small cherry-like drupe 1-1.7 cm long, orange-red covered in silvery scales.
Fruit: False, drupiform, soft, dark brown or yellowish, oblong (1.7-3.0 cm long, 1.3 cm wide), with numerous small furrows. Fruit are sweet with a dryish, mealy texture, therefore readily eaten and the seeds disseminated by many species of birds, small wild animals.
Phenology: Flowering: May - August, fruit maturation: September - November.
Seed germination: Seed coat thin, membranous. Long-term (more than 3 months) stratification (1-10 °C) and treatment with sulphuric acid increase germination. Removing the soft fruiting body and stone stimulates germination. Well propagated by sprouting.
Economic importance: None grazed on open rangeland. Only interest is as wind break on irrigated and cultivated areas. Poor quality fuel wood. Fruits are consumed as delicacies. Rich in sugar. Also used as feed for domestic birds. Used in local medicine for respiratory and digestive problems. Good for bee-keeping and honey production. It is widely used as a landscaping and ornamental tree for its resistance to salinity, drought and frost, fragrant flowers, edible fruit, attractive yellow foliage and black bark. Widely used in agroforestry program. Roots posses symbiosis with nitrogen fixing bacteria.
Habitat: Sea coast, shores of rivers and lakes, desert riverbeds, floodplain. Russian olive-poplar Tugais forms a monospecific stand in wetlands Tugai forest in combination with various species of *Populus, Salix alba, Salix songarica*. Tolerate mineralized ground water.
Distribution: Native Central and western Asia, Iran, southern Russia, Kazakhstan, Turkey, parts of Pakistan and India.
Note: Its common name is due to its similarity in appearance to the olive tree (*Olea europaea*), so locals called it the "Russian olive tree". Russian olive thrives on poor soils, has a high seedling survival rate, matures in a few years and outcompetes native vegetation. In many parts of the world is considered invasive. Known locally as senjed, the dried fruit is one of seven served in its own syrup in a fruit salad called haft mēwa, which is eaten during Nowruz (muslim spring ceremony) in Central Asian countries and Afghanistan.


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Elaeagnaceae Juss.
Elaeagnus turcomanica Kozlowsk.

Synonym: This species is considering as a synonym of *E. angustifolia* L.
Local name: Turkman jiydasi (Uzb.), jigildik (Kar.), лох туркменский (Ru.).

Botanic characteristics and life form: C_4-phreatohalophyte, deciduous perennial tree species (up to 4.4 m tall).
Stem: Densely branched, narrow, hairless, brown or yellowish, less spiny than E. angustifolia.
Leaves: Alternate, short-petiolate, silvery from the scales or tomentose from the stellate hairs.
Flowers: Bisexual or polygamous axillary, solitary or in clusters, petal-less, with tubular-campanulate four-lobed calyx. Stamens 4.
Fruit: A drupe with elliptical stone and sweet mealy pulp.
Phenology: Flowering: June - August, fruit maturation: September - October.
Seed germination: Well propagated by seeds, suckers and cuttings.
Economic importance: Foliage and fruits are food for birds and animals. The local people used the fruits for their diet especially in winter and spring when there is a lack of vitamins and minerals. It is recommended as landscaping ornamental, honey plant and to prevent soil and water erosion along the river-and channels bank. Wood is used occasionally for construction and wickerwork, shelterbelt.
Habitat: Main edificator of Tugai forest in the downstream areas of Aral Sea Basin (native to Lower Amu Darya Bioreserve). It tolerates severe frost in winter, drought in hot summer and highly mineralized underground water. It is an edificator of Tugai forest in the Aral Sea Basin along with *Populus ariana; Populus diversifolia; Populus pruinosa; Salix wilchelmsiana.*
Distribution: Native to Central Asia, Iran and Afghanistan.
Note: Foliage and fruits are food for birds and animals. In Bukhara oasis (eastern part of Kyzylkum desert and middle stream of Amu Darya river) there is a domesticated hybrid form - Bukhara jida. It is a shrub or small tree. It is cultivated for its large fruits with a sour-sweet taste. The stones of the fruits have decorative stripes. Children make beads. The fruit of the jida tree is an indispensable part of the oriental bazaar. Powdered stones have a pharmaceutical purpose.


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Elaeagnaceae Juss.
Hippophae rhamnoides L.

Synonym: *Argussiera rhamnoides* (L.) Bubani, *Elaeagnus rhamnoides* (L.) A.Nelson, *Hippophae rhamnoides* subsp *turkestanica* Rousi, *Rhamnoides hippophae* Moench

Local name: chikanda, chakanda (Uzb.), Sarkonak, Sarkonazh, Jumrutnamo (Tdj.), Облепиха крушиновидная (Ru.).

Botanic characteristics and life form: Thorny, deciduous, perennial small tree or shrub (up to 3.5 m tall) with dense branching. Drought and salt tolerant (able to withstand salty coastal soils and waterlogging).

Stem: Brownish-green, yellowish- brown or black bark with numerous spiny branches, 2-7 cm long.

Leaves: Linear or linear-lanceolate, 2-8 cm long, 0.2-0.8 cm broad, sub obtuse, narrowed at base; with silvery-green at the abaxial surface.

Flowers: Dioecious plant: male flowers 2.5 mm long, borne in clusters at the base of the shoots; calyx lobes sub-orbicular. Stamens 4. Female flowers yellowish, borne in dense clusters of 2-9, axillary from the spines.

Fruit: Fleshy drupes, 5-6 mm in diameter, subglobose, slightly roundish, compact, pale yellow to dark orange.

Phenology: Flowering: April - May, fruit maturation: September - October.

Seed germination: Small with an upright large embryo and remnants of the endosperm. Seeds of wild varieties need to be stratified (2-5/10 °C, 16 hours/30 °C, 8 hours) for 1-3 moths. Treatment with $KMnO_4$ (0.05%) significantly stimulates germination.

Economic importance: No grazing by animals. Sometimes used as fencing; also applied to fix sand in certain states (high water table). Fruits eaten by birds. Leaves used as tanning material, containing more than 10% tannin. Local people use the fruits for eating, making jam and wine, as well as for extracting paint. Wood used for handicrafts. Due to its ability to bind sand, it is used in reforestation programmes in mountain and coastal areas. Also used as live fencing due to its beautiful foliage, strong branching and thorny nature. Used in traditional medicine to treat respiratory, digestive and dermatological problems. Honey making plant.

Habitat: Coasts, lake shores, mountain streams and brooks; riverbank pebbles, riverbank gravel, tugai, willow and poplar woods on sand, gullies, slopes, rocks and cliffs.

Distribution: Southern Europe, European part of Russia, Ural, Caucasus, Asia Minor, Central Asia, Pamir-Alay, Tyan-Shan, Mongolia, Iran, Afghanistan.

Note: Plants have a highly developed and extensive root system, living in symbiosis with nitrogen-fixing bacteria. The roots are also responsible for transforming the insoluble organic and mineral matter in the soil into a more soluble form. Due to its ability to fix nitrogen, it is an excellent fertilizer for poor and degraded soils. Vegetative propagation occurs rapidly by using suckering roots.


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Ephedraceae Dumort.
Ephedra distachya L.

Synonym: *Chaetocladus distachys* (L.) J. Nelson, *Ephedra distachya* subvar. *linnaei* Stapf
Local name: Qo'shboshoqli zag'oza (Uzb.), итшомырт шырғанак (Kaz.), чычырканак (Kr.), облепиха крушиновидная (Ru.).

Botanic characteristics and life form: C_4-non-succulent salt excluder gypsophytic plant. A strong-branched evergreen shrub 10-20 (up to 50) cm in height with creeping rootstock. Its roots are thick, long and ramified.

Stem: Short, branched from base, woody, with dark grey bark. Shoots greyish-green, rarely yellowish-green, greyish-brown in fall and winter, finely ribbed, straight or more often arching above, twig-like, jointed; internodes 1.5-7 cm long.

Leaves: Opposite, reduced, 1.5-2 mm long, one-third to one-half fused; brownish yellow on young branchlets. Free parts cut into triangular blades; ends blunt or rounded.

Flowers: Dioecious. Male cones (microstrobiles) are collected in clusters of three at the ends of short branches or peduncles; they consist of an axil with four pairs of bracts; the filaments in the axils of the bracts are about 2 mm long, with seven or eight anthers.

Female cones (megalobes) ovate, on short branches or at top, solitary or in clusters, with 3 to 4 bracts; lower ones semi-elliptic, obtuse, with narrow membranous margins; inner ones semi-elliptic.

Fruit: Succulent berrylike, globose, 6-7 mm long, red.

Phenology: Flowering: May - June, fruit maturation: July - August.

Seed germination: Seeds are usually two, oval or oblong, 4-5 mm long, 2-3 mm wide, smooth, convex, dark brown. It propagates vegetatively by root suckers, forming large runners from parent plant.

Economic importance: *E. distachya* called "Kuzmicheva grass" is considered as food and medicinal plant. The dry herbage is recommended for treatment of bronchial asthma, arterial hypotension, pharyngitis and other diseases. Active ingredients are ephedrine and pseudoephedrine. The succulent, cone-shaped berries are edible. Due to the high content of biologically active substances, the vegetative parts of the plant can cause poisoning in domestic sheep, birds.

Habitat: Chink/cliffs of Ustuyurt plateau, semidesert and desert regions, in the plains or outcrops of parent rock, and on gritty slopes in mountainous locations. It can spread over large areas, when growing in loose soil.

Distribution: Central Asia and northern Caucasus, Mediterranean and southern European countries, South European Russia and western Siberia, Inner Mongolia and Xinjiang province in China. Endangered and rare species are protected in many countries. The over-exploitation of wildlife for medicinal purposes is prohibited.

Note: The green, non-lignified shoots are used as a raw material for medicinal purposes - Latin Herbae Ephedrae. The content of ephedrine and pseudoephedrine in green twigs varies 0.25-1.7%, ephedrine in total is up to 65%. The whole plant contains tannins, pyrocatechin, flobufen, etc. Juicy berries contain up to 160 mg% ascorbic acid.

Ephedra distachya subsp. *helvetica* is commonly used for landscaping and erosion control.

Other species: *Ephedra intermedia* Schrenk & C. A. Mey. occurs in the Aralkum saline desert.


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Ephedraceae Dumort.
Ephedra strobilacea Bunge

Local name: qo'shboshoqli zag'oza (Uzb.), kizlsha (Kar.), космасакшалы кылша (Kaz.), чекенде (Kr.), хвойник двухколосковый (Ru.).

Botanic characteristics and life form: C_4-non succulent xero-gypsophyte. Evergreen, dioecious, erect or hanging, shrub (1-2 m) with deeply penetrating and spreading (about 10-15 m) root system. Life span 50-70 years.

Stem: Bark: woody, grey with whip-like, slender green, fleshy and articulate stems.

Leaves: Opposite or in whorls of 3-4 (about 2 mm), scale-like fused at the base.

Flowers: In small cones: male at tips of branches subtended by ciliate bracts; perianth 2-lipped, staminal column with 3-4 sessile or short stipitate anthers; female cones 1-3 seeded, solitary or groups of 2-3, subtended by 2-4 pairs of bracts; Ovule with scarious or fleshy bracts becoming woody at maturity of seed.

Fruit: Dry, winged (6-7 mm), papery, fleshy yellow-reddish with scale bracteoles.

Phenology: Flowering: May, fruit maturation: June - July

Seed germination: Surrounded by fleshy coat, with woody tegument; endosperm and embryo well developed. Dark-sensitive. Germination 20-40% at 20 ºC. Scarification or long-term stratification of seed is recommended. Seeds are strongly damage by insects.

Economic importance: Energy-rich fodder for all livestock, including young animals (especially lambs); in summer, when all ephemerals have dried out, well consumed by goats, sheep and camels. Main food source in autumn and winter, after snow. If Haloxylon and Salsola species dominate the pastures, the palatability of Ephedra tends to be reduced. The production of green fodder is 0.08-0.5 t/ha. Under natural wild growth, the plant has potential as a sand fixer and for restoration of saline desert pastures. Used to improve rangeland, however, is not always successful due to severe insect damage to seeds.

Habitat: On fixed and mobile sand with high chalk and limestone concentration. Single or mixed with *Haloxylon, X. Richteri* and some perennials and annuals. Will grow and persist even in partially buried sand, interdunes with moderately saline soil.

Distribution: Mostly in central Asia, occasionally in eastern Mediterranean, north-eastern Africa, Syria to northern Arabia.

Note: Medicinal plant due to the high content of alkaloids ephedrine groups used as a regulator of the nervous system, to raise the blood pressure, against rheumatism and gastric problems, as well as treatment of bronchial asthma, cardiological and vascular system.

The best time to harvest is at the flowering stage when the plant is in flower. Ephedra is a high protein feed with 14-16% crude protein and a digestibility of about 77. Other chemical constituents (%): fat 1.6-3.0%; ash 8.4-9.0%; nitrogen-free extract 46.1-47.2%; carotene 50.5-81.5%; vitamin C 785-8656 mg/kg; and significant amounts of amino acids. Microelements (g/kg): Ca 19.3-25.8; K 10.1-16.1; Na 0.1-1.4; P 0.1-0.8.


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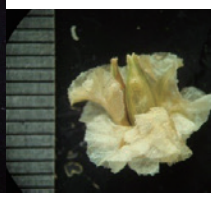

Fabaceae Lindl.
Alhagi pseudalhagi (Bieb.) Fisch.

Synonym: *Hedysarum pseudalhagi* M.Bieb.
Local name: Soxta yantoq (Uzb.), jantaq (Kar.), Кәдімгі жантақ түйетікенек (Kaz), жалган жантагы (Krg), Ýandak (Tkm), Верблюжья колючка обыкновенная (Рус).

Botanic characteristics and life form: C_3-high halotolerant, phreatophyte. Perennial herbaceous plant (50-100 cm) with numerous thorny branches and an extensive pivotal root system. Life span 7-25 years. Root more than 2 m deep and extending 8-15 m in all directions.
Stem: Stems glabrous, greenish, longitudinally ridged and highly branched, with the leaf axil of nearly every node supporting an ascending leafless branchlet, 2-5 cm long, tipped with a thorn (about 5 mm long).
Leaves: Alternate, petiolate, sparse, simple thick, leathery, elliptic or obovate, oblong-lanceolate, unpaired parted with stipules about 1 mm long. Upper leaf surface glabrous (sometimes sparsely hairy) and covered with minute red dots. Lower leaf surfaces sparsely covered with hairs.
Flowers: Bisexual, pentamerous, short-stalked, arranged alternately along each thorn branchlet axis, pea-like, pink or purple to crimson; sepals persistent, fused and cup-like, with small sub-equal teeth. Inflorescence: few-flowered (1-3, rarely to 6) assembled in lax axillary racemes. Stamens: 10 with bases of 9 filaments fused into a tube around style and one free. Ovary: apocarpous, subsessile, many-ovulate; style filiform, up-curved, glabrous; stigmas head-like, long papillous.
Fruit: Indehiscent lomentum, woody, polyspermous legume (pod 2.5-3.8 long; 0.3 cm wide), reddish brown constricted between seeds, slender, often curved and tipped with a small spine.
Phenology: Flowering: May - July, fruit maturation: August - September.
Seed germination: 5-8, (about 3 mm long; 2.5 mm wide) yellowish or greenish-brown with dark mottling, reniform, ovate-orbicular, smooth textured with large, erect embryo, surrounded with endosperm. Seed coats; firm, brilliant, multi-cellular with retiform sculpture. Soft-and hard-coated (about 86 %) seeds are produced. Dark-sensitive. Field germination 9-12%; laboratory 34-38%. Optimal temperatures and soil depth for germination is near 27 ºC and 1 cm respectively. Scarification, or sulphuric acid treatment (1-1.3 h)/28-30 ºC significantly increase the germination. Passing through an herbivore digestive tract appears to stimulate germination. Seed viability: 2 to several years.
Plants spread rapidly by vegetative reproduction from vigorous rhizomes. Rhizomes at depths to 1.5 m produce new shoots and deep vertical roots at about 1.0-1.5 m intervals.
Economic importance: One of the most valuable forage plants in the desert and semidesert pastures of Central Asia, southern part of Russia and eastern Mediterranean. Young stems, leaves fruits and seeds are considered as a fattening feed. Eaten by goats and camels and stored in the winter as a fodder/hay. Young stems, leaves fruits and seeds are considered as a fattening feed. Fruits are eaten by large herbivores, especially cattle and horses. Collected intensively by farmers and livestock owners for hay making (winter feed) and silage at flowering time; Used as part or pure concentrate granular feed. purposes.
The whole plant is used for medicinal purpose (as regulation digestive problems, against respiratory illness) hay and honey making (50-60 kg honey), sugary (up to 55-sacharous), bearing-oaken substances, good sand-fixation and windbreak plant. Collected also as fuel and as construction materials. Roots contains rubber, sugar, tannins, resins and wax. *Alhagi* spp. are widely used in is in the management and rehabilitation of grasslands, especially those overgrazed by animals and affected by soil salinization.
Habitat: It grows on alkaline soil with salinity > 16 dSm-1 and is widely distributed at the peripheries of salt marshes, saline desert depressions, at the Aral seashore and along salt belts of small rivers, artificial lakes and water bodies. Found mostly in pastures, abandoned and neglected lands.
Distribution: Central and East Asia, South part of Russia, Iran. East Mediterranean region.
Note: Other species in the Aralkum desert area: *Alhagi canescence* (Regel) Shap. and *Alhagi persarum* Boiss. & Buhse.


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Fabaceae Lindl.
Ammodendron conollyi Bunge ex Boiss.

Synonym: *Ammodendron karelinii* var. *conollyi* (Bunge ex Boiss.) Yakovlev
Local name: Konolli quyonsuyagi (Uzb.), qoyansuyek (Kar.), коноллы қоянсүйек (Kaz.), песчаная акация Конолли (Ru.).

Botanic characteristics and life form: C_3-drought and salt tolerant psammohalophyte. Shrubs or small trees reaching 3-6 m high. Tap root (down to 4 m deep) and adventitious horizontal roots (12-15 m). Life span 25-30 years.
Stem: Crown poorly ramified and often trails down, flexuous. Trunk: wood red, 6-30 cm in diameter with 2-4 skeletal axis on which twisted, glabrous branches form.
Leaves: Compound-pinnate, silvery- pubescent. Inflorescence: dark purple, in dense spikes or raceme borne in leaf axils.
Flowers: Bisexual; irregular, pentamerous with 10 (9 accreted and 1 free) stamens. Ovary superior with numerous ovules.
Fruit: Large, linear, curved or twisted, light brown, polyspermous, dry dehiscent pod. Beans are bare, compressed from the sides.
Phenology: Flowering in April, fruit maturation: June - July.
Seed germination: Seeds reniform, oblong-orbicular, dark brown with large, erect embryo without endosperm. Hardiness about 78%. Fresh harvested germination rate: 8-12%. Scarification, treatment with sulphuric acid for 0.5-1 hour in solution of $KMnO_4$ and boiling water, then 12 hours (dark/light) cycles (20/30 °C, night/day) improve germination. Seed viability 9-12 years.
Economic importance: Leaves and annual growth grazed by small ruminants and camels, especially in winter during forage shortage when alkaloid content is lowest. Fruits consumed by all livestock even in summer and later. In plant communities where *A. conollyi* dominates (about 75 shrub-tree/ha), expected biomass productivity is 0.5-0.7 t DM/ha; on sand dunes with dense grass cover may produce 0.05-0.15 t DM/ha. The roots and stems contain dye substances that color the wool and cotton in a bright yellow color. Leaves and thin twigs contain alkaloids. It is considered medicinal. Powder from a dry plant has strong insecticidal properties. The stems and roots contain a coloring substance. Excellent honey-making plant. It has solid and durable wood used for various household needs.
Distribution: Uzbekistan (on sands of Kyzylkum desert; dry bottom of Aral Sea), Iran, Kazakhstan, Turkmenistan.
Note: *A. conollyi* has a medicinal value as leaves, fruits and roots contain a large quantity of alkaloids: ammodendrin and pahicarpin, recommended as respiratory stimulant and diuretic; a heart poison when used in large quantities.
Other : *Ammodendron karelinii* Fish. et Mey. has the same ecology as *A. conollyi*, but the branches are more erect and rigid and prickly at the ends. Both species has ornamental value and recommended for reclamation of shifting sands.


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Fabaceae Lindl.
Astragalus amarus Pall.

Synonym: *Picraena amara* (Pall.) Steven, *Tragacantha amara* (Pall.) Kuntze
Local name: Achchiq astragal (Uzb.), singren (Kar.), астрагал (Kr.), астрагал горький (Ru.).

Botanic characteristics and life form: C_3-halophreatophyte, perennial shrub, (20) 45-65 cm tall, from a strong short buried woody divided caudex. *A. amarus* is characterized by almost complete hairlessness, stemlessness, reduced number of leaf pairs.
Stem: Stems (10) 19-37 cm long, simple, firm, terete, clothed at base in scalelike hyaline stipules; foliar stipules not adnate to petiole, connate at base, lunate, acutes, (4) 6-12 mm long, thickish.
Leaves: (6) 10-15 (17) cm long, the petioles firm, rigid, terete, much shorter than the rachis; leaflets 3-4 (7) pairs, orbicular to rounded-oval, rarely oval, short-acuminate, 5-11 mm long, thickish.
Flowers: Bisexual, zygomorphous. Stalks 2-4 cm long, with 10-12 (17) flower heads. Involucral bracts lanceolate, white-haired, calyx 9-10 mm long, tubular, toothed, with hairs. Corolla 13 mm long, lilac-pink with lighter boat.
Fruit: Pods red, 10-13 mm long, gently arcuate, divergent, 4-5 mm broad, 3-4 mm thick, pointed and terminating in a straight attenuate rigid beak 2 mm long, few-seeded.
Phenology: Flowering: May - June, fruit maturation: June - July.
Seed germination: Orbicular, shiny with large erect embryo and impermeable seed coat. Hardness up to 65%. Germination of untreated seeds 4-9%; scarified up to 89%. High germination recorded after treatment by immersing in solution of sulfuric acid. Alternate temperature (night/day cycle (20/30 °C) significantly increased germination. Seed viability 3-4 years.
Economic importance: Eaten mainly by sheep, goats and camels. Due to its glycoside compounds it has a medicinal value.
Habitat: Grows on sands, gravelly and rocky soil, rarely on clayey slopes and gypseous soil; frequently occurs on variegated rocks in Kyzylkum desert.
Distribution: Native to Central Asia and Southern European Russia.
Note: *A. amarus* is the only species of the Picrophaceae section that is characteristic of the colourful outcrops (and their analogues) of North Turan - an exclusively isolated type.
The name *Astragalus* is derived from the ancient Greek name ‘astragulos’, meaning ‘ankle-bearing’, which refers to the shape of the fruit pod. *Astragalus* in English means ‘milkvetch’, close to the ancient belief that a goat’s milk supply increased after grazing these plants.


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Fabaceae Lindl.
Astragalus orbiculatus Ledeb.

Synonym: *Alopecias orbiculatus* (Ledeb.) Steven, *Tragacantha orbiculata* (Ledeb.) Kuntze
Local name: Yumoloqbargli astragal (Uzb.), астрагал округлолисточковый (Ru.).

Botanic characteristics and life form: Non-succulent salt exclusion xerohalophyte. Perennial, grows up to 20-60 cm, white hairy (hairs up to 2.5 mm).
Stem: Solitary or several, densely covered with spreading long hairs up to 2.5 mm; at the maturity becoming lignified at the base.
Leaves: Ovate, sessile or with very short petiole; stipules green, 6-15 mm, very shortly adnate to petiole, densely spreading hairy; rachis loosely to densely covered with long spreading hairs; leaflets in 9-14 pairs, apex rounded or more rarely slightly emarginate.
Flowers: Inflorescence a yellow cluster in a raceme, 2-3 cm long, loosely 3-7-flowered, peduncles slender, 2-4 cm long, nodding; racemes 2-3 cm long, loosely 4-7-flowered; bracts linear, 8-12 mm long, pointed, often hairy.
Fruit: Legumes with a stipe 1-3 mm, 14-17 mm, 5-7 mm high and 5-6 mm wide, with a very short beak, 2-locular; valves thin, hairy.
Phenology: Flowering: April - May, fruit maturation: May - July.
Seeds: Seeds compressed, reniform, 2.5 mm long, smooth, reddish.
Economic importance: Refers to plants used as fodder. Occasionally eaten by almost all animals including wildlife. Due to the insignificant amount of herbage, it has no economic importance.
Habitat: Salt marshes, fallow lands, wastelands, affected by salinity pastural lands.
Distribution: Native to Central Asia and Northern Pakistan, Afghanistan, Iran, Xinjiang desert province.
Note: *A. orbiculatus* is a promising species for in vitro cultivation (biotechnology) due to its therapeutical properties. Flavonoid production is one of the targets for biotechnological optimization.


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Fabaceae Lindl.

Caragana halodendron (Pall.) Dum. Cours.

Synonym: *Halimodendron halodendron* (Pall.) Voss.
Local name: Kumushrang qizilchangal (Uzb.), ак шенгел (Kaz.), shengel (Kar.), тіктії кеңерчек (Kr.), чингиль серебристый (Ru.).

Botanic characteristics and life form: C_3-non-succulent xerohalophyte, perennial, large shrub up to 2.5 m tall with spiny stems. The crown is round and spreading up to a width of 3 meters.
Leaves: Paripinnate with oblanceolate, entire, rounded at the end almost sessile 1-5 leaflets (12-40 mm long). Stipules small, triangular, thorny.
Flowers: Bisexual, zygomorphic (up to 2 cm long), long-stalked (2 to 5 mm), alternating along each spine axis, purple-pink or rarely whitish; calyx (4 to 5 mm long) persisting, fused and bluish (campanulate). Ovary apocarpous, stalked.
Fruit: Polyspermous legume, strongly swollen, bivalve, leathery, hard, yellowish-brown. (pod 1.5-2.5 cm in length; 0.2 cm wide) on long stalked (4-6 mm long) often curved and tipped with a short spine.
Phenology: Flowering and fruit maturation: April - September.
Seed germination: Free seeds inside pods, noisy when pods waving in the wind or shaken. Pre-soak the seed for 12 hours in warm water before sowing. Reproduce also by cutting.
Economic importance: Good-honey making and decorative plant. Used to erect live fence. Roots are used as a yellow dye. In the desert areas, used as fuel.
There is little information of its chemical composition and bioactivity pharmaceutical value.
Habitat: A common plant in Tugai vegetation; frequent on saline wet soils, rivers and aryks banks; abandoned irrigated fields together with Tugai forest trees (such as *Populus* spp., *Elaeagnus* spp., *Salix* spp.) and perennial herbs (such as *Glycyrrhiza glabra, Cynodon dactylon, Aeluropus litoralis*). Usually forms dense, hardly passable thickets. Moderately salt tolerant, drought and frost tolerant (up to -35 ºC).
Distribution: Ustyurt plateau, flood plains of the Amu Darya, Zerafshan, lowlands of Central Asia, Caucasus, Mongolia, Iran.
Note: Not touch by all livestock when green, occasionally leaves and fruits in late autumn or winter eaten by sheep, camels, goats. A bad weed in cultivated agricultural lands as form dense spiny thicket. Indigenous people eat its young leaves and flowers.


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Fabaceae Lindl.
Eremosparton aphyllum (Pall.) Fisch. & C.A.Mey.

Synonym: *Lugaion aphyllum* (Pall.) Raf., *Spartium aphyllum* Pall.
Local name: Bargsiz qulonquyruq (Uzb.), siyirquyriq (Kar.), жапыраксыз құланқұйрық (Kaz.), Эремоспартон безлистный (Ru.).

Botanic characteristics and life form: Psamohalophyte. Extremely drought, and less salt tolerant. Semi-shrub up to 1 m high, with underdeveloped leaves, purple flowers, with swollen beans.
Stem: Up to 1 m long, branched from base; branches numerous, long, virgate, erect; branchlets slender, glabrate or hairy. The older parts of the stem are covered with yellowish-reddish bark, the younger ones are grayish-brown, peeling and, finally, the younger parts are grayish.
Leaves: Leafless or reduced to small lanceolate membranous scales, appressed to stem.
Flowers: Subtended by 2 bracteoles and a large bract, disposed of singly in long loose racemes, violet; calyx pubescent, the teeth usually one-quarter to one-third as long as the tube; corolla 6-7 mm long; standard suborbicular, retuse; wings with a small lateral tooth at base.
Fruit: One-seeded pod (legume), full maturation pod is inflated, short-ovaloid or subovoid, light-colored, short-hairy, 7-9(10) mm long and 5-7 mm broad, terminating in curved beak, the stipe 3 mm long, covered with short adjacent hairs.
Phenology: Flowering and fruit maturation: May - July.
Seed germination: Deeply dormant seeds. Asexual propagated by underground rhizomes and sexual is reproduced by seed. *E. aphyllum* has a high-water requirement for germination. Seeds will not germinate under severe drought stress.
Economic importance: It belongs to poisonous plants. The roots also contain a significant amount of toxic alkaloids. Used for sand stabilisation and desert landscaping. Locals uprooted as fuel. It is considered a medicinal and fibrous plant.
Habitat: It is a component of xeropsamophytic vegetation in the hot sandy desert, often with the participation of desert tree-like species, such as *Haloxyon ammodendron, H. persicum, Tamarix ramossisima, Nitraria sibirica*, species of *Calligonum* and others. Prefers sands and loam gray-brown soils.
Distribution: Uzbekistan (former bottom of Aral Sea, especially at Lazarev and Vozrojdeniya islands), Kazakhstan, Kyrgyzstan, Northern Caucasus, occasionally at Arabian peninsula.


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Fabaceae Lindl.
Glycyrrhiza glabra L.

Local name: Tuksiz shirinmiya (Uzb.), boyan (Kar.), жалан мия (Kaz.), түксүз кызыл мыя (Kr.), солодка голая (Ru.).

Botanic characteristics and life form: C_3-non-succulent salt excluding haloxerophyte. Perennial herb (30-150 cm) with a deep penetrated pivotal root system (2-4 m) extending laterally (4 m) in all directions.

Stem: Erect to ascending, multi-branched from the base and covered with pointed glands or glandular spines. Stipules small, lanceolate awn-shaped, falling down at flowering stage.

Leaves: Large (5-20 cm) on short hairy pedicels, imparipinnate (3-9 pairs). Leaflets oblong-ovate, elliptic to lanceolate with numerous point glands.

Flowers: Small (0.8-1.0 cm long) blue-lilac, blue-violet, or white-pink, bisexual, gathered in loose spikes (5-12.0 cm long); calyx: tubular (6-8 mm long), teeth lanceolate equalling or shorter than tube, dense covered with short, glandular hairs. Stamens 10 (9+1). Entomophilous.

Fruit: Pods (1.5-3.0 cm long; 4.0-6.0 mm wide) with friable pericarp. Erect or slightly curved, indehiscent, polyspermous (3-9 seeds).

Phenology: Flowering: May - July, fruit maturation: July - September.

Seed germination: Small (2-3 mm long; 3-4 mm wide), dark-brown, ovate-reniform, smooth with large embryo, surrounded by traces of endosperm; Field germination 12-48%. Hardn 60%. Stratification and scarification as well as chemical processing with sulphuric acid (15-30 minutes) increase germination. The germination of non-scarified seeds increased to 71% with prolonged treatment with succinic acid (up to 48 hours). Soil germination of non-scarified seeds was 12.2% (8-15%). The germination of succinic acid treated seeds was 91.2%. Seed viability 3-4 years. Sexual (by seeds) and vegetative (creeping rhizomes).

Economic importance: Well, grazed up to fructification by camel and sheep; valuable for hay and silage making. On 3 years stand of cultivated plants, expected yield: dry roots 2.50 t/ha, hay 1.26 t/ha; and on 6 years old crop: 7.5 and 3.2 t/ha respectively. Seed harvested yield 46 kg/ha. Stand salinity. Potential plant for rangelands improvement, restoration of salt-affected agricultural lands. It is a good melliferous plant. *Glycyrrhiza* is frequently utilized for biomass, bioenergy, and pulp production.

Habitat: In desert/adyr, semi desert more often in the steppe areas, on riverbanks, old deposits, post-agricultural, abandoned lands; field margins; Tugai forest.

Distribution: Central Asian rivers delta, European part of Russia, Caucasus, West Europe, Asia Minor, Iran, Afghanistan, China, Northern of Africa.

Note: One of the most popular medicinal plants for respiratory, gastric, skin, stomach ulcer diseases. In the food industry, cosmetics, skin tanning and technical purposes (dyeing of wool), powder and extract from the roots are widely consumed. It contains alkaloids, flavonoids, coumarins, glycyrrhizic acid and other organic acids, tannins, vitamins. It is included in the pharmacopoeias of many countries. Liquorice extracts are used in the confectionery industry, in breweries, in the production of liqueurs and spirits, and in the tobacco industry. In the countries of origin, the root is often already processed into liquorice candy. The genus name *Glycyrrhiza* derives from the Greek glykys, meaning ‘sweet’, and rhiza, meaning ‘root’. In late antiquity, the word was Latinised. The resulting “liquiritia” found its way into the English “liquorice”.


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Fabaceae Lindl.
Sphaerophysa salsula (Pall.) DC.

Local name: Sho'rxoq bo'yani (Uzb.), partildauk (Kar.), айбатмия (Kaz.), шорчул сферофиза (Kr.), сферофиза солонцовая (Ru.).

Botanic characteristics and life form: Non-succulent euhalophyte. Perennial long-lived herb growing 30-80 cm, rarely up to 1.5 meters tall with vigorously creeping root system.
Stem: Erect, strongly branched and covered with short appressed white hairs.
Leaves: Unpaired, 4-10 cm long, with six to ten pairs of elliptic leaflets. The leaflets are acute, lanceolate, 2 mm long.
Flowers: The inflorescence is a raceme of several pea-like flowers each just over a centimeter wide. They may be brick-red to deep pink to brownish or red-orange in color. The calyx is bell-shaped, 5-toothed. Corolla brick-red, 1.3-1.5 cm long and 1 cm wide, flag rounded, slightly emarginate, wings sickle-shaped, long, curved, almost equal in length to the boat.
Fruit: Legume (pod) up to 3.5 cm long. It is inflated and bladderlike, hairless, translucent, shiny, and papery when dry. It is mottled greenish or reddish. It contains several seeds each about 2 mm long.
Phenology: Flowering: May - August, fruit maturation: June - September.
Seed germination: Seeds numerous brown, reniform to nearly semicircular, ca. 2.5 mm; funicle 1-3 mm; hilum rounded and sunken. It has low germination rate.
Economic importance: In natural habitats is a year-round fodder for wildlife, small ruminants, cattle and camels.
Habitat: Plains, wastelands, sands, oases, ditch sides, around salt ponds.
Distribution: Frequently occurs on the dry bottom of the Aralkum saline desert. Widespread in Central Asia, Afghanistan, Iran, Azerbaijan, north-west China, Mongolia, in Russia (Dagestan, Western and Eastern Siberia).
Note: Several types of bacterium, such as *Rhizobium, Agrobacterium* and *Mesorhizobium* and other rhizobia were recently isolated from the roots of this species. The medicinal properties of *S. spherophyza* are due to the content in all parts of the plant of the alkaloid spherophysine.


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Frankeniaceae Desv.
Frankenia hirsuta L.

Synonym: *Frankenia laevis* subsp. *hirsuta* (L.) Fiori, *Frankenia laevis* var. *hirsuta* (L.) Batt. & Trab.
Local name: Dag'altukli ittovon (Uzb.), сайгак шоп иттабан (Kaz.), тіктїї франкения (Kr.), франкения жёстковолосистая (Ru.).

Botanic characteristics and life form: Succulent salt-excreting recretohalophyte that can tolerate salinity > 20 dS/m. Low strongly branched semi-shrub 35-40 cm tall. Covered with dense long usually straight or slightly curved hairs.
Stem: Branches procumbent or ascending or erect, knotty, rarely glabrous, nearly always sparsely or densely covered with short white 1-celled stiff straight hairs.
Leaves: Linear to oblong-linear, 3-8 mm long, 0.5-4 mm broad, subacute, revolute-margined, sparsely or densely covered beneath with short white hairs, ciliate petiole 0.5-1 mm long. Prominent salt excretion glands on leaf surfaces.
Flowers: Restricted to conspicuous, dense, corymb-like tufts terminal to main stems and branches. Calyx 3.5-5 mm, sparsely to densely pubescent, with hairs up to 0.5 mm long. e. Corolla pale purple or white, purplish or pink; petals 4-6 mm, obovate, long- clawed, finely denticulate above. Stamens 6.
Fruit: Capsule 2.5-3 mm, 3-valved, ovoid or oblong-ovoid.
Phenology: Flowering and fruit maturation: June - July.
Seed germination: Seeds numerous (0.3-0.5 mm), light brown, oblong - ellipsoidal pointed below.
Frankenia hirsuta large seeds germinated faster and to a higher percentage than small seeds at 23 and 29ºC. Plants could be reproduced vegetatively.
Economic importance: It is considered a forage plant. In autumn, only the vegetative parts are eaten. It is also popularly called saiga grass. It is considered medicinal and alkaloid plants.
Habitat: On solonchaks and solonetzes, wet and swollen solonchaks, solonchak deserts, and stony steppes. It prefers coastal and intercontinental habitats, growing on sandy and gravelly ground because of its high tolerance to salts.
Distribution: Its native range is from the Mediterranean to West Siberia, Middle Asia, the Aral Sea's salt flats, Afghanistan and Iran.
Note: Suitable for rural areas with saline soils as an ornamental, melliferous and landscaping plant.
Frankenia consists of about 70 to 80 species of shrubs, sub-shrubs and herbaceous plants that are adapted to saline and dryland environments. It is a good for remediation of contaminated by heavy metals soils.


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Moraceae Gaudich.
Morus alba L.

Local name: Oq tut (Uzb.), ак тут (Kaz.), шелковица белая (Ru.).

Botanic characteristics and life form: Xerohalophyte. Tree up to 12 m tall with compact rounded crown.
Stem: Annual branches almost erect, grey or grayish-brown, pubescent. Buds: widely-oviform (about 6 mm long; 2.0 mm wide), acute or bluntly at the top. Leaves: long-pedicelate (3cm long); reniform-ovate, rarely oblong-oviform, entire or 2-5 pinnate-lobed, cordate towards the base and subacute at the top; unequal dentate on the margins.
Leaves: Rigid, glabrous above and sparsely pubescent from bellow.
Flowers: Unisexual, sessile, inconspicuous; perianth segments elliptical-oviform, outside pubescent. Female catkins oviform or oblong. Ovary: superior or half-inferior, monospermous with one amphitropous, upwards developed micropyle and 2-woolen stigmas; Male catkins cylindrical, friable or dense flowered: cylindrical rolled (2.0-4.0 cm long). Stamens 4. Pollen grain: widely-ellipsoidal or spheroidal, 2-rarely 3-porous.
Fruit: Large (2-2.5 cm long) aggregate, fleshy, false, almost sessile, oviform, white, light pink, juicy, fragrant oblong mulberries (infructescence).
Phenology: Flowering: April, fruit maturation: May - June.
Seed germination: Seeds have a deep dormancy. The best way to increase germination is to soak the seeds in tap water for 24 hours and bed them in wet sand. 50/50 mixture of compost and coarse sand can be used. To achieve high seed germination, long-term conditioning (at 5-8 ºC for 7-8 months) is required. Two to three years old seedlings are recommended to establish industrial orchards.
Economic importance: *M. alba* with twisted golden branches, locally known as the 'ilan-tut' ecoform, is most used for decorative and ornamental purposes. *M. alba* is mainly cultivated for its tasty white fruits ("balhi-tut" ecoform). All kind of animals willingly eat leaves. The fruits are eaten both fresh and dried ("qoq tut"), making various syrups and drinks. Its bark and leaves can be used to make yellow and black dyes. The fibre of the branches is suitable for making coarse spinning yarn. Branch powder is a good raw material to produce high quality paper. Wood of all kinds and in all ecological forms is used for traditional construction.
Habitat: Occurs on stony gravels soils, sloppy hills. Widely cultivated in drylands, foothills, and on field agricultural margins.
Distribution: Native to floodplain of Central Asia and Caucasus. Tolerant to strong drought, early frosts and moderate soil salinity.
Note: In Uzbekistan, the leaves of *M. alba* ("hasak tut" ecoform) are used to feed silkworms since ancient times. In addition to *M. alba, M. bombycis, M. kagayamae* and *M. multicaulis* are also used in the sericulture industry in Central Asia, Japan and other countries. All these hybrids have large leaves, high biomass and are frost tolerant. Traditional construction uses wood of all species and ecoforms. Precious woods for the manufacture of artistic handicrafts.


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Nitrariaceae Bercht. & O.Presl.
Nitraria sibirica Pall.

Synonym: *Nitraria schoberi* var. *sibirica* (Pall.) DC.
Local name: Sibir oqtikani (Uzb.), сібір актікен (Kaz.), сибирь боз кенерчегї (Kr.), селитрянка сибирская (Ru.).

Botanic characteristics and life form: C_3-succulent, salt accumulating halopsammophyte, 0.5-1.5 m tall shrubs, prostrate, arching or rarely erect.
Stem: Young twigs white, sterile twigs spiny at top.
Leaves: In fascicles of 4-6 on current year's twigs; blade elliptic, 6-15 × 2-5 mm, glabrous or pubescent when young, base cuneate, tip blunt to blunt-tipped.
Flowers: White, cymes 1-3 cm long, hairy. Sepals 5, green. Petals yellowish green to almost white, elliptic, 2-3 mm.
Fruit: Dark red fleshy drupe, ellipsoid to globose, 6-8 mm in diameter, both ends obtuse; mesocarp dark blue to purplish. Stone egg-shaped, 4-5 mm, with a pointed tip. Fruits poorly edible for animals and human consumption.
Phenology: Flowering: May - June, fruit maturation: July - August.
Seed germination: Reproduction: Predominantly vegetative, also sexual. Sensitive to light; 62% of seeds germinated after 24 days. Special temperature pre-treatment on demand.
Economic importance: Landscaping in the restoration of saline lands; preventing sands shifting. Fruit considered inedible for human and animal consumption. Camels, horses and sheep occasionally eat its leaves and twigs. Nitraria uprooted for fuel by local people.
Habitat: Growth in dense populations at saline desert sandy soils, oasis sand, salt sand, lake shore sands; gypseous soils.
Distribution: Native for flora of China, occurs in the psammo-halophytic shrub communities on dry bottom Aral Sea near Akpetki and other remnant mountains in the Kyzylkum desert, Mongolia. Rarely occurs in eastern part of Russia, Australia and Europe.
Note: In the folk medicine of Northwest China, the fruit of *N. sibirica* is widely used to treat hypertension, blood disorders and gastroenteritis.
Other species: Widely distributed in Aral Sea shore: *Nitraria* is one of the few fruit-berry plants able to grow on solonchaks. Tolerate soil salinity up to 31% water-soluble salts. Grows in saline habitats forming huge phytogenic mounds. 6 months after harvest and stratified at +5 ºC for 40 days, germination at +25 ºC was 44%. Suitable for reclamation of saline soils, fixing of shifting sands, has significant medicinal value to treat digestive disorders, fever, and inflammation.
Propagation is done by seed and by rootstock.


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Nitrariaceae Bercht. &O.Presl.

Peganum harmala L.

Synonym: *Harmala peganum* Crantz, *Peganon harmalum* (L.) St.-Lag.
Local name: Oddiy isiriq (Uzb.), adraspan (Kar.), кәадімгі адыраспан (Kaz.), кадимки адырашман (Kr.), гармала обыкновенная (Ru.).

Botanic characteristics and life form: Phreatohalophyte, perennial hemispherical herbaceous plant with tap root and woody underground rootstock, usually growing in saline soils.
Stem: Numerous twisting or erect, glabrous much-branched from the base slightly sulcate.
Leaves: Stipules of lower leaves more distinct, small, lanceolate, sometimes incised. Leaves (3-8 cm), numerous, sessile, opposite, glabrous, fleshy, blade irregularly pinnatisected; lobes linear, entire, acute.
Flowers: Large (2-4 cm), bisexual, white-yellow, regular, pedicelled, solitary or paired in terminal cymose inflorescence. Sepals 1-1.5 cm, narrowly linear, sometimes with two small lateral lobes. Stamens: 12-15 dilated at the base, inserted in whorls (3-5) in three rows at base of cup-shaped disc. Stigmas: lobed on short style.
Fruit: Dry loculicidal or dehiscent capsule (5-8 mm), spherical, slightly flattened from above, pale brown, subglobose 3-valved, with membranous or slightly sclerified fruiting body.
Phenology: Flowering: May - July, fruit maturation: August - September.
Seed germination: Numerous (more than 30), small (1.5-4.4 mm), flattened, triangular, tuberculate, dark-brown with direct or slightly bend down embryo, surrounded with endosperm. Seed coat: thin, lustreless, tuberculate.
Economic importance: Toxic and unpalatable. Animals will only graze it if they are starving or have severe mineral deficiencies. Seeds and fruits are the most toxic; a lethal dose is 0.15% of the animal's body weight. It contains such alkaloids as harmine, harmel and harmalol. As a ruderal weed it also occurs among field crops. The seeds yield a red dye that is used in dyeing wool. Organs used: seeds used to produce harmine; roots are used less often. Extract from seeds is also used as an anthelmintic (to expel parasitic worms).
Habitat: On clay to sandy loam flats, steppe areas and sandy soils. Individuals or large monospecific plant communities on overgrazed sites. *P. harmala* prefers loamy soils and can grow in very alkaline and saline soils. It reproduces either by seed or root. Sometimes it is the only plant visible, especially around settlements and watering places for animals. It serves a phytoindicator of overgrazing and severe vegetation degradation.
Distribution: Irano-turanian and Saharo-Arabian; arid and semi-arid Mediterranean areas South Euro-Siberian; Middle Asia, Southern Kazakhstan, Caucasus, South Russia, Siberia, Indo-Himalayas, West Mongolia.
Note: One of the most famous medicinal plants used in traditional, mostly Tibetian medicine. *P. harmala* was known to Dioscorides (ca. AD 40-90), Galen (ca. AD 129-217), and Avicenna (ca. AD 980-1037) as a psychoactive drug. The ancient Greeks used powdered seeds to treat recurring fevers as well as tapeworm. In Turkey and Central Asian countries, the dried capsules have been used as a talisman against "evil-eye," and smoke from burning the dried seeds has been used to treat mental illnesses. I was also used as a hallucinogen in indigenous ceremonies.


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Orobanchaceae Vent.
Cistanche salsa (C.A.Mey.) Beck

Synonym: *Orobanche salsa* (C.A.Mey.) Kuntze, *Phelypaea salsa* C.A.Mey.
Local name: Sho'rxoq iloncho'pi (Uzb.), сортан цистанхе (Kaz.), цистанхе солончаковая (Ru.).

Botanic characteristics and life form: Psammoholophyte, perennial plant 20-45 cm tall with thick and fleshy stems and large whitish purple flowers at the top.
Stem: Long, underground, vertical thick (5-20 cm), distinctly thickened at the base, covered with elliptic-lanceolate, alternate scales attached to the roots of the host plant.
Leaves: Ovate-elliptic or ovate-lanceolate, 0.6 to 1.6 cm long.
Flowers: Yellowish, inconspicuous, on a short peduncle, grouped in a long, pyramidal, spiked inflorescence rising from the sand on a sturdy stalk. Calyx 5-lobed. Sepals, bracts and calyx segments glabrous. Corolla 30-40 mm long, yellow with blue back. Ovary: glabrous, incurved.
Fruit: Capsule with two, rarely three, valves, ovoid, equal to or much longer than the calyx, naked.
Phenology: Flowering: April - May, fruit maturation: June - September.
Seed germination: One of the most effective methods of establishing commercial industrial plantations is vegetative propagation.
Economic importance: Extract from roots and flowers has high pharmacological effects, including neuroprotective, immunomodulatory, antioxidant, anticancer and hepatoprotective properties.
Habitat: More common in north-west Kyzylkum and north-east Karakum on sandy dunes. It is also found on alkaline soils and in salt marshes, and rarely on calcareous soils and in limestone.
Distribution: Central Asia, China (Inner Mongolia, Xinjiang, Ningxia, Gansu and Qinghai) Desert.
Note: *Cistanche* is a rare root parasitic traditional Chinese medicinal herb under *Haloxylon, Calligonum, Anabasis salsa,* and *Tamarix* trees. Currently 6 species of *Cistanche* are known and widely used as raw material in herbal medicine. They are *Cistanche deserticola*, *Cistanche lanzhouensis*, *Cistanche mongolica, Cistanche salsa*, *Cistanche sinensis*, *Citanche tubulosa*.

Plumbaginaceae Juss.
Limonium otolepis (Schrenk) Kuntze

Synonym: *Statice otolepis* Schrenk
Local name: Quloqbargli kermak (Uzb.), itsygek (Kar.), кермек (Kaz.), кермек ушколистный (Ru.).

Botanic characteristics and life form: C_3 remarkable non-succulent recretohalophyte with excretive salt glands and salt bladders on leaves and stems surface. Perennial small shrub (30-80 cm high). Tap thick root dark-brown (1.5 m deep).
Stem: Woody, glabrous, erect to ascending, with many branches on top. Stem leaves mostly on lower nodes, sessile, circular (10-30 mm wide), gradually withering and falling after flowering.
Leaves: Arranged in basal rosette, large (15-40 cm long and 5-10 cm wide), simple, sessile, twisted, elliptic-lanceolate, leathery, dark or light-green above, silvery lower surface; faintly veined with wavy margins.
Flowers: Infinitely bluish, bisexual, regular, 5-metamerous, blue-violet-whitish, solitary, sessile, arranged in 3-bracted spikelets together forming a branched, unilateral panicle or corymb. Involucral bracts hairy. Calyx narrowly tubular, persistent, forming a dispersal unit with the fruit. Sepals often with lobed margins at the base. Corolla with fused petals. Stamens-5, intimately united with corolla.
Fruit: One-seeded capsule partly enclosed by the persistent calyx.
Phenology: Flowering: May - July (non-synchronous flowering phenology is observed among individuals in the same population), fruit maturation: August - September.
Seed germination: Small with large embryo, thin layer of endosperm and without perisperm. Optimum germination is observed in distilled water and low salt content (100 mM NaCl) at 20/10 ºC under 14/10 hours light/dark cycles). In wild habitats, the seeds germinate well after the rains in the spring. It is also propagated vegetatively by rhizomes (rootstalks).
Economic importance: Occasionally grazed by small ruminants and camels. Not touched by cattle. Recommended for remediation of acidic and contaminated soils.
Habitat: Widespread in semi-desert and desert areas. It grows in saline, alkaline and gypsum soils. Commonly found along the shores of lakes and on the banks of rivers, salt marshes and cliffs (Ustyurt plateau). Mostly isolated plants, sometimes in dense stands.
Distribution: Typical halophyte of the Iran-Turanian flora. Native in Central Asia: ranging from Turkmenistan, through Kazakhstan, Kyrgyzstan and Tajikistan, to northern China in Gansu and northern Xinjiang, and Trans-Caucasus.
Note: At flowering stage contains (%DM): protein 12; fat 1.5; ash 15; water 10. Rich in tannins, especially in roots. Roots extracts (black and dark green) are used as a source of dye. It has a promising potential to be cultivated for its ornamental and medicinal values.
Other species in the Aralkum desert areas: *Limonium suffruticosum; Limonium caspium, Limonium gmelinii*. The Na^+ excretion rate of a single salt gland in *Limonium* species increased with increasing NaCl concentrations in the soil.


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Poaceae Barnhart
Aeluropus littoralis (Gouan) Parl.

Synonym: *Calotheca littoralis* (Gouan) Spreng., *Poa littoralis* Gouan
Local name: Sohil sho'rajrig'i (Uzb.), сортан ажырыгы (Kaz.), шорчулезенчїл (Kr.), прибрежница солончаковая (Ru.).

Botanic characteristics and life form: C_4-non-succulent chrinohalophyte/recretohalophyte, grass, perennial (20-60 cm) with laying stalks.
Leaves: Two-row distributed, flat, rough with pricles plants growing on higher salinated soils and soft and blunt (plants which grow on slightly salinated soils).On a surface of stalks and leaves crystallizing salts occurred.
Flowers: In globose clusters, dioecious although monoecious populations occur. Inflorescence spikes assembled in panicle. Spikelet naked, 5-10 flower clusters. Anthers: ovate-oblong form. Ovule-anatropous, crassinucellate, bitegmic.
Fruit: Indehiscent, monosporous ovoid-lanceolate caryopsis, three-edged (1.2-1.4 mm), light brown with hulled fruiting body assembled in flower and spikes scales.
Seed: Small with a differentiated, direct embryo and endosperm.
Phenology: Flowering: April - July, fruit maturation: July - August.
Seed germination: Light-sensitive and germinate well under variable temperatures ranges - 38-62%. Short-term stratification with variable temperatures 5-10 ºC/28 is much effective. Seed viability: 8-9 years. Reproduced both by seed and vegetatively by rootstocks.
Economic importance: Limited use as a forage due to the "stiff" character of the leaf blades. Potential exists to develop softer palatable cultivars. Is readily eaten by large horned cattle and horses during a year, camels eaten it satisfactory, for sheep and goats. It is better in the early autumn-winter periods. Harvest of pastoral grass, on crust solonetz-alkaline soils - 0.2 t/hà of dry weight. On the salted meadows and wet salt-marshes (solonchak-alkali soils) 0.10-0.12 t/hà, and per favorable years 0.4 t/hà. Aeluropus plant communities used for hay harvesting may yield up to 2-4 t DM/ha); during favourable years under cultivation 0.4 t DM/ha. Well consumed by camel, cattle, horse all year round; for sheep and goats, better used early autumn-winter period.
Habitat: Tolerates full-strength sea water and salinities up to 56 dS/m and has been grown on Mediterranean Sea water at Ashqelon, Israel. (N.P. Yensen per. obs.). Occurs in wet sandy areas at the edge of salt flats, marshes and salt deserts. saltmarshes (solonchak-alkali) and crust solonetz-alkaline soils in all deserted and semi-deserted areas. *Aeluropus* as salt-tolerant plant is often occurs wet marshes salted soils on the margin of lakes, tugai, salted desert depression, takyrs side by side with *Halostachys Suaeda, Climacoptera, Tamarix, Phragmites* and *Salsola*, as also as weeds in enriched cultivated or waste ground. Sometimes it forms a separate micro-association at several meters. It is a good indicator of superficial distribution less than one meter of underground water.
Distribution: It occurs in Eurasia: scattered through the Mediterranean Sea coast, France (type specimen from Maguelone), northern Italy; the Saharo-Arabian region; northern Africa; Algeria west through Egypt, Palestine, and Israel to Saudi Arabia; Iraq; India, Iran; Pakistan; Central Asia; northern China and Mongolia.
Note: Salt excretion *Aeluropus lagopoides* (L.) Trin. var. *lagopoides* has widely spaced leaves that are neither strongly distichous nor rigid. This latter quality may provide an opportunity to develop a forage variety. *Aeluropus lagopoides* (L.) Trin. var. *mesopotamica* (Nab.) Bor in Rech. (1964) has closely spaced leaves that are strongly rigid, nerved and distichous.


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Poaceae Barnhart

Phragmites australis (Cav.) Trin. ex Steud.

Synonym: *Arundo australis* Cav.

Local name: Janub qamishi (Uzb.), qamis (Kar.), кадімгі камыс (Kaz.), түуштүк камышы (Kr.), тростник южный (Ru.).

Botanic characteristics and life form: C_4-xerohydrohalophyte (tolerate high saline habitats), perennial tall herb up to 6 m, as time fast rate is 3 m. mostly grows 1.5-3 m. Root: powerful, filamentous. Phragmites has a dense network of roots and rhizomes which penetrate up to two meters in depth reaching ground water.

Stem: Upright; rigid and hollow; persisting in winter nodes glabrous or pubescent. leafy up to the top.

Leaves: Green to grayish-green in color, flat, smooth leaf blades; 25-50 cm (10-20 in) long, 1-3.5 cm (0.4-1.4 in) wide, hairy ligules.

Flowers: Bisexual, small, without perianth. Panicle large (20-30 cm in length) usually purple or golden in color, less often loose, hairy. Spikelets 10-18 mm, florets 2-5; glumes acute, lower glume up to 1/2 length of lowest lemma, 3-5 mm, upper glume 6-9 mm; lowest lemma linear-lanceolate, 8-15 mm; floret callus with hairs equal to lemma; lemmas very narrowly lanceolate, 9-16 mm, apex long attenuate.

Fruit: A caryopsis with an adherent pericarp: light carried away by wind (anemochories seed dispersal). Seeds numerous with white short hairs below.

Phenology: Flowering: June - August, fruit maturation July - November.

Seed germination: More than 95% seed germination was achieved within an alternate temperature regime (range 10-30 °C). Seed not germinate under low temperatures. Plants are extensively spreading by rhizomes that can live for 3-6 years.

Economic importance: Considered as good fodder plant for horses as grazing or hay when green before flowering. Hay making at 8-9 leaves stage. Expected yield 0.8-1.0 t DM/ha. Has rapid regrowth after trampling and overgrazing. Suitable for silage making if mixed with other forage crops. Fodder value harvested before flowering contains 30% cellulose and protein 8.2%. and at fruiting cellulose over 40%. Rich in sugar content in young shoots.

Habitat: Early colonizer (edificator) of plants communities in saline lakes depressions and wetlands Tugai vegetation. Grows well on salt-marshes (solonchak-alkali soils) even covered white salt crust. Occurs in pure stand on high water table or flooded areas; brackish or salt marshes and flats, fens, fresh tidal marshes or flats, marshes, river or lake sides.

Distribution: It is considered a cosmopolitan plant.

Note: Local people use for different hand-made articles. Common building material, raw material for paper and chemical industry (sugar and starch production). Fresh harvested seed-crude or cooked can be ground into a powder and utilized as a flour. Indigenous communities recommended for medicinal purpose. Root rhizomes and runners - crude or cooked like potatoes. It contains up to 5% sugar.


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Poaceae Barnhart

Stipagrostis karelinii (Trin. & Rupr.) H.Scholz

Synonym: *Aristida karelinii* (Trin. & Rupr.) Roshev., *Arthratherum karelinii* (Trin. & Rupr.) Tzvelev
Local name: Karelin selini (Uzb.), narseleu (Kar.), селин Карелина (Ru.).

Botanic characteristics and life form: C_4-psammorecretohalophyte. Perennial, loose bunchgrass (height 80-150 cm, diameter up to 100 cm). Tough, filamentous, shallow root structure capable of absorbing all surface moisture from sand dunes. Horizontal roots extend 15 m from the bunch, with subterranean stems (suckers). Persistent roots hairs allow plants to survive on moving sands.
Stem: Densely branched from bunch base, glabrous with numerous axillary buds. Subterranean horizontal stems develops basal sequential tillers named 'leafy rhizomes'. Vertical aerial shoots remains alive for a period of 1.5 years.
Leaves: Narrowly linear, broad at the base, becoming curled and spiky at the tip; thick spiny hairy coating on the top.
Flowers: Small bisexual without perianth. Inflorescence: open loose spike; at the basis covered by sheath of the top leaf.
Fruit: Relatively light caryopsis subtended by glabrous palea and lemma, attached to a short pointed hairy pedicel. The fruiting body is firmly linked to the seed coat.
Phenology: Vegetation starts in April, flowering: June - July, fruit maturation: end of July - August.
Seeds: Large with papus-like awn and well differentiated embryo, at the base of seed with abundant starchy endosperm.
Economic importance: Considered as a poor fodder plant (roughage). Hardly grazed even green, but better use late in autumn and winter. Well consumed by all livestock when collected as hay before flowering or with collected after being softened by rain and snow late in autumn or beginning of winter. Average dry weight by bush 1-2 kg DM up to 5 kg DM. Expected yield on good stand 1.7 t/ha DM. At the blooming stage (% DM), cellulose 35-37; crude protein is 7. Typically used as roughage. Hay has a value of around 30 FU and 1.4 kg digestible protein/100 kg DM.
Habitat: Edificator of moving sandy dunes; inter-dunes depression in *Haloxylon persicum, Ammodendron, Calligonum* psammophytic plant communities.
Distribution: Native to Central Asia and Southern European Russia. Southern sandy dunes and desert of Kyzylkum.
Note: The desert pioneer plant *Stipagrostis pennata* plays an important role in sand fixation, wind prevention, and desert ecosystem recovery, nitrogen-fixing microorganisms of rhizosheath etc.


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Poaceae Barnhart
Stipagrostis pennata (Trin.) De Winter

Synonym: *Aristida pennata* Trin., *Arthratherum pennatum* (Trin.) Tzvelev
Local name: Patli selin (Uzb.), urgashi selu (Kar.), селин перистый (Ru.).

Botanic characteristics and life form: C_4-psammorecretohalophyte (tolerate saline sands and severe droughts). Perennial large, loose bunchgrass (80-150 cm tall). Powerful, filamentous, superficial root system, able to catch all surface moisture on sand dunes. Horizontal roots, with underground stems (=suckers) extending to 15 m from bunch. Specific ability to convert above ground stems (1 and 2 years old) into suckers that play essential role in fixing moving sands. Secretory hairs are developed on the surface or roots.
Stem: Densely branched from bunch basis, glabrous.
Leaves: Rough, narrowly-linear, wide at base, becoming rolled and spiky at end; face by dense spiny hairy layer.
Flowers: Small bisexual without perianth. Inflorescence: open loose spike; Base covered by sheath of the top leaf; flower scales are twice as short as spikelets, with a three-part awn, awn branches about 15 mm long, all pinnately pubescent hairs up to 3 mm long.
Fruit: Indehiscent, dry, hard kernel, pale yellow, with a fruiting body closely attached to seed coat.
Phenology: It begins to vegetate in April, flowering in May, fruit maturation: end June, July - August. Secondary flowering and fruiting are often observed in autumn, in September - October.
Seed germination: Light-sensitive. Fresh harvested seed has low germination rate. Dry storage (under 30 °C for 6 months) stimulate germination. Scarification (removal fruit cover). Seed life span 7-9 years. Extensively reproduce vegetatively by rootstock.
Economic importance: A most valuable forage (better than *Stipagrostis karelinii*) well consumed by all animals both in spring and winter either direct grazing or as hay. Green forage harvested at early vegetation stage contains (%): protein 9.49; fat 1.57; fiber 35.3; N-free extract 34.4; moisture 12.4.
Habitat: Inhabits shifting sands; thrive saline sandy soils in inter-dunes depression.
Distribution: Occurs across Irano-Turanian lowlands from Aralo-Caspian areas, Afghanistan. Caucasus, Western Siberia, Iran and China. In Kyzylkum and on the drybottom of Aral Sea grows mainly in associations with *Calligonum, Haloxylon, Ammodendron, Astragalus, Artemisia*. It is considered an excellent sand-fixing plant.
Note: It is one of the main winter fodder for all kind of animals. The leaves give fibers used for the manufacture of gold-mining mats. They are superior in quality to imported ones. The roots are suitable to produce brushes, and the whole plant is used in the paper and pulp industry. It is known as a medicinal plant.


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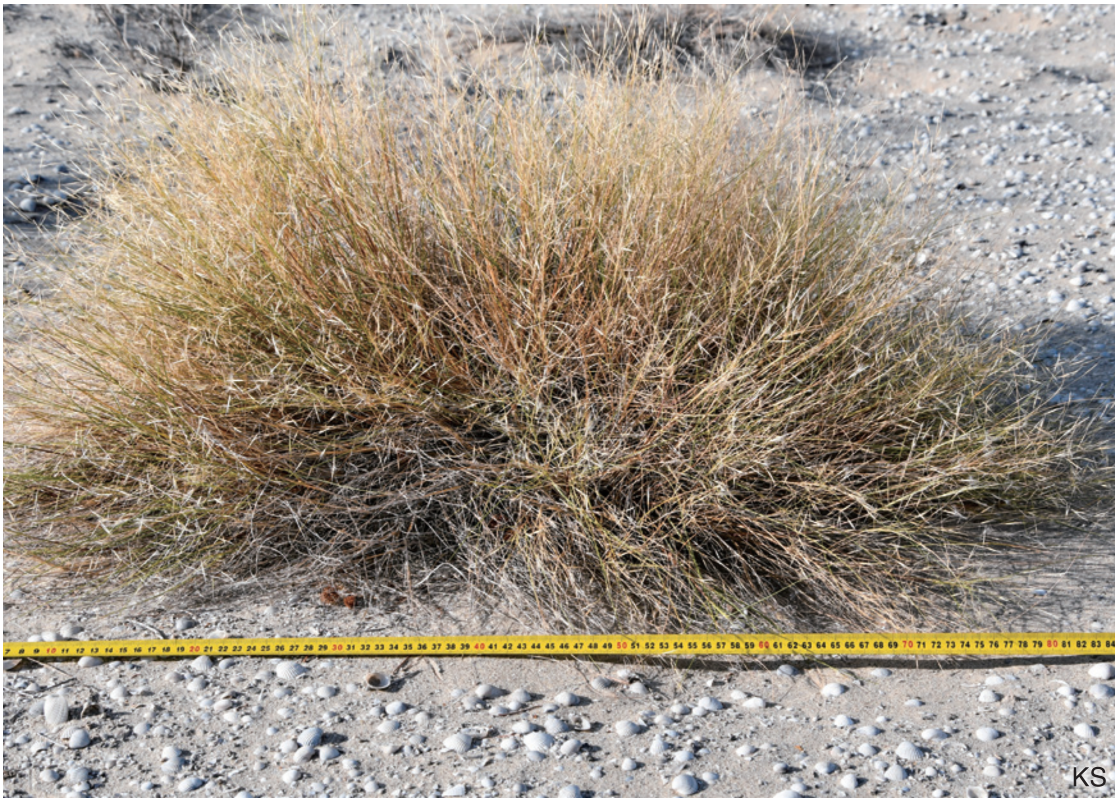
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Poaceae Barnhart
Tripidium ravennae (L.) H.Scholz

Synonym: *Erianthus ravennae* (L.) P.Beauv, *Erianthus purpurascens* Andersson, *Saccharum ravennae* (L.) L.
Local name: Raven savacho'bi (Uzb.), miska (Kar.), равеннтин эриантусу (Kr.), эриантус равеннский (Ru.).

Botanic characteristics and life form: C_4-hydrorecretohalophyte. Perennial large (4-6 m tall) grass with a powerful turf (spreading up to 1 meter in diameter). It is an aggressive, rapidly spreading, and persistent species with dense and diffuse root system.
Stems: Arise from creeping rhizomes and stolons. Pale, silvery, feathery, multiplied feathers on the tips of bamboo-like stems up to 1.0 m tall, appearing in late summer to early autumn. In autumn the stems may have a purplish-bronze coloring.
Leaves: Large narrow-linear (up to 1m long; 1.5 cm wide), sharp-rough on a margins Densely covered with long, fuzzy, tawny hairs at base of the leaf.
Flowers: Bisexual, feathery, fan-shaped, green with reduced perianth. Inflorescence large in a compose spike or paniculate. Panicles are 25-70 cm long, the axis markedly angular (usually 6-angled). Individual racemes are 1.5-3 cm long, much shorter than the supporting branches. The internodes and flower-stalks are hairy with hairs 3-6 mm long. Spikelets are slightly heteromorphous, 3-6 mm long, the callus bearded with whitish, greyish or sometimes yellowish hairs up to about 4 mm long. Glumes are equal, membranous, those of the sessile spikelet glabrous, the lower scabrid on the keels, or sometimes with a few hairs at the base, those of the pedicelled spikelet sparsely to moderately hairy on the back.
Fruit: Caryopsis. Purplish spikelets are 0.12-0.24 mm wide and 3-6 mm long.
Phenology: Flowers and fruit maturation: June - October.
Seed germination: Each plume produces thousands of tiny seeds that are dispersed by wind and water. Reproduced both by seed and vegetatively by rootstocks. Seed viability less than one year.
Economic importance: Poor quality roughage. Almost not eaten, except green in early vegetation. Hay consumed by camels, horse, more rarely sheep. Potential for silage making.
Habitat: Component of Tugai forest, riverains, wetlands. Inhabits loamy and alluvial soils.
Distribution: Riparian forest, salt marshes, on riverbanks and Tugai ecosystems in Central Asia
Note: Used as construction material and fuel. It is a good shelter for migratory birds; wildlife. Has potential as an energy crop.


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Polygonaceae Juss.
Atraphaxis spinosa L.

Synonym: *Atraphaxis spinosa* var. *linnaeana* Meisn.
Local name: Sertikan tuyasingren (Uzb.), тікенді түйесінір (Kaz.), тикендїї боз караган (Kr.), курчавка колючая (Ru.).

Botanic characteristics and life form: Succulent leaves xerohalophyte and phreatophyte. Prickly, much-branched, deciduous shrub (30-110 cm tall) with long, slender, spreading stems. Young wood glabrous and whitish; bark loose.
Branches: Linear, slender, twisting, spiny on the end.
Leaves: Grey (3-5x3-4 mm) orbicular, elliptic or egg-shape, on a top blunt or with a short edge, entire, glabrous from both sides.
Flowers: Bisexual, white, rosy-tinted, on short, spine-tipped, lateral twigs; assembled in small axillary clusters by 2-6 or in racemiform inflorescence.
Fruit: Wingless achene (flat nut), ovate, from above narrowed, bright-brown or yellowish-green, smooth, brilliant.
Phenology: Flowering: June - July, fruit maturation: August. Occasionally secondary flowering occurs in September - October.
Seed germination: Fresh seeds of *A. spinosa* shown a highly germination rate at 30 °C/20 °C. Propagation: seeds and vegetatively; germination 1-3 months at 16-18 °C; nursery-cuttings in late summer; layering in spring. Prefer: sunny site with a deep drained soil.
Economic importance: Not easily grazed as strong woody spines prevent livestock from approaching short new shoots. Leaves and young emerging stems before flowering eaten by all kinds of cattle, especially by camels.
Recommended for cultivation on degraded saline gypsum soils. Any pruning should be restricted to the removal of branch tips every second or third year during the spring to maintain a neat compact habit.
Habitat: Small isolated on clayey gravelly steppes, sandhills and stony barren slopes, alluvial and colluvial deposits on dry riverbed on saline gypsonous soils.
Distribution: Central Asia: Ustuyurt cliffs in vicinity with Aral Sea, Pre-Balkhash regions, Kyzylkum, Karakum, Pamir-Alay and Tyan-Shan complex, Kopetdag, Southern east European part of Russia, Western Siberia, West Asia and Iran.
Note: Ornamental. Landscaping. The plant is a source of a yellowish-white manna-like substance that is eaten as a food or used in making sweetmeats.
Ethnoveterinary medicine used to treat animals. It has been cultivated in some countries since the beginning of the eighteenth century.


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Polygonaceae Juss.
Calligonum caput-medusae Schrenk

Local name: Dag'altukli qandim (Uzb.), qandim (Kar.), жузгун щетинистый (Рус.).

Botanic characteristics and life form: C_4-psammophytic and phreatohalophyte. Shrub growing up to 2 m, rarely growing until 3-4 m as small tree, microphylous, strongly branched, with light grey or pink-green bark. Life span 25-30 years. Strong root system extending to depth 2 m, superficial lateral roots stretching 10-30 m.

Stem: Bark of mature branches light grayish or pinkish-yellow.

Leaves: Small, to 2 mm long, subulate, recurved, membranous-margined at the base.

Flowers: Perianth segments ovate, purple, 3 mm long, broadly white-margined, reflexed in fruit; anthers purple.

Fruit: Ovoid or non-form, covered by long branched and flexible bristle (10-15 mm diameter), yellow or bright red, hard impermeable indehiscent that delays germination.

Phenology: Flowering and fruit maturation: between May - June.

Seed germination: Seeds require stratification (1-2 ºC) for 30-50 days. Chemical treatment of fruits with concentrated sulfuric acid for 4-8 hours increases germination rate to 60%.

Economic importance: Sand-fixing, fuel-producing, and decorative plant. One of the most suitable plants for sand dunes. Green branches and fruits are devoured by all animals in the spring and early summer; fruits and old green stems are favoured in the fall and winter. Plant that can be used to enhance rangeland productivity and to create long-term pastures in sandy deserts. Can be grazed the same year it was planted. The yield is expected to be about 1.5 t DM/ha in the first year and up to 2.1 t DM/ha in the second year.

Habitat: Desert sandhills, sandy steppes and gravelly soils. Widely distribution on shifting and fixed sands of deserts and semi-deserts.

Distribution: Turanian desert (Kyzylkum and Karakum), Vozrojdeniya and Lazarev isles at the former dry bottom of Aral Sea, Inner Mongolia, Iran, Iraq and Xinjiang province in China.

Note: New spring shoots are high in protein and sugar. Tannins are found in 10-13% of plant organs. The forage value is around 72 FU/100 kg DM.


VS


VS

Polygonaceae Juss.
Calligonum eriopodum Bunge

Synonym: *Calligonum eriopodum* subsp. *turkmenorum* Soskov & Astanovan.
Local name: Junoyoq qandim (Uzb.), qandim (Kar.), жузгун шерстистоногий (Ru.).

Botanic characteristics and life form: C_4-psammophreatophyte with a high salt tolerance. An arborescent shrub to 5 m high; loses leaves early.

Stem: Bark of mature branches whitish-gray, rarely reddish.

Leaves: Branchlets of the current year and leaves often covered with short papillose hairs.

Flowers: Bisexual; small, arranged in pairs, rarely solitary in the axils of membranous ochreas. Perianth pentafid, segments (up to 1 mm long), pink with green middle vein, pendulous during fruit maturation. Pedicel covered by dense short hairs; 10-16 stamens connate at base, red anthers. Styles 4.

Fruit: Rectangular nutlets (25-50 mm long, 20-40 mm broad) with soft spines like tufts of hair.

Phenology: Flowering: May, fruit maturation: May - June.

Seed germination: Seeds small, black and oval-shaped. The best way to propagate it is from seed, which should be sown in the spring or early summer. It can also be reproduced from cuttings taken in late summer or early autumn.

Economic importance: Forage plant. Well grazed on winter-spring rangelands. Biannual branches contain (% DM): protein 11; ash 8.5; fat 1.2; cellulose 41; nitrogen-free extract 27; water 10.

Habitat: Desert sandhills, sandy steppes, rocky and gravelly habitats. Occurs on shifting sand, and sand dunes in *Haloxylon, Ammodendron* plant communities.

Distribution: Native to Uzbekistan Kazakhstan, Turkmenistan and Iran.

Note: Young leaves, flowers and fruits are good sources of bioactive chemicals with medicinal properties.


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Polygonaceae Juss.
Calligonum junceum (Fisch. & C.A.Mey.) Litv.

Synonym: *Calligonum calliphysa* Bunge, *Calliphysa juncea* Fisch. & C.A.Mey.
Local name: Yakansimon qandim (Uzb.), qandim (Kar.), жузгун ситниковый (Ru.).

Botanic characteristics and life form: C_4-long fruiting psamophreatophyte and tolerant to soil salinity. The base of this low shrub (height 35-80 cm, less frequently 110 cm) is formed by spreading and vigorous branching. Bush with tiny leaves and a prominent caudex.

Stem: Bark of mature branches gray or brownish; herbaceous branchlets in clusters of 5-10 from nodes of annotinous branches, green, slender, branched, jointed; joints 0.5-3 cm long, terminating in a short truncate white or brownish membranous ocrea.

Leaves: Linear to linear-oblong, 3-8 mm long, readily deciduous.

Flowers: Bisexual, pedicels slender, 3-4 mm long, thickened toward apex, jointed below the middle; perianth segments glabrous, ovate, unequal, the outer 3 mm long, green on the back, with a broad white scarious margins.

Fruit: Roundish, rarely somewhat elongated, 8-9 mm in diameter, membranous-hairy; achene unrolled, elliptic, long-tapered at apex, 4-ribbed, broad ribs obscurely keeled; bristles numerous, in 12 rows on ribs, capillary, soft, slightly enlarged at tips, supporting a thin utricular membrane.

Phenology: Flowering and fruit maturation: May - June.

Seed germination: Significantly improved germination of dormant seeds with abrasion (mechanical breaking of seed coat), sulfuric acid and cold stratification treatments.

Economic importance: Fodder plant. Excellent plant for all cattle as feed, provide different products and services, such as forage, traditional medicine, halting desert encroachment and stabilizing sand dune (using different afforestation program).

Habitat: Desert sandhills; clayey and sandy steppes.

Distribution: Uzbekistan, Iran, Kazakhstan, Kyrgyzstan, Mongolia, Turkmenistan and China (Inner Mongolia and Xinjiang).

Note: Introduced into Saharan North Africa. A distinctive characteristics of *C. junceum* is dark-wine colored bark of old stems.


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Polygonaceae Juss.
Calligonum leucocladum subsp. *leucocladum* (Schrenk) Bunge

Synonym: *Pterococcus leucocladus* Schrenk
Local name: Oqpo'st qandim (Uzb.), qandim (Kar.), жузгун белокорый (Ru.).

Botanic characteristics and life form: C_4-psammophreatophyte, salt and frost tolerant, tree-like shrub up to 7 m tall.
Stem: Bark of mature branches white; branches strict, long, straight or prostrate, strongly flexuous, angularly refracted, nodose, herbaceous branchlets slender, striate-sulcate with loosely disposed flowers at the ends, jointed; joints to 3-4 cm long, terminating in a short sheathing brownish ocrea.
Leaves: Filiform, 2-5 mm long, not united with ocreae, readily deciduous.
Flowers: Small at 1-2 in axils of branches. Perianth segments unequal oviform, green above, white on margins. Anthers bright red.
Fruit: Nutlet slightly twisted (8-22 mm long), pale yellow when young, pale brown when mature. Wings 2-lobed, soft, broadly elliptic on very short (0.5-1.5 mm) ribs or elongated elliptic on long (1.5-3 mm) ribs, glabrous, less often near the margin with simple, (1-4 mm long) laminate appendages. Wings straight, less often with revolute or convolute margins, transversely wavy surface and with doubly toothed margins. Wing halves not fused at the ends. The fruit is therefore triangular or short-cylindrical in shape.
Phenology: Flowering and fruit maturation: May - June.
Seed germination: Deeply dormant seeds. Mechanical and chemical seed treatments stimulate seed germination.

Economic importance: Excellent plant for all cattle as feed. Locals used as wood fuel, and construction materials.
Habitat: Occurs in psammophytic *Haloxylon* communities, takyr-like arenaceous and typical sand deserts, edges of Tugai vegetation, fine sands near outcrops or beds of grey sandstone, limestone and other rocks, ancient riverbeds, cliff slopes.
Distribution: Central Asia, Iran and northwestern China.
Note: Recommended for use in afforestation programmes to improve the productivity of degraded pasturelands.


KT


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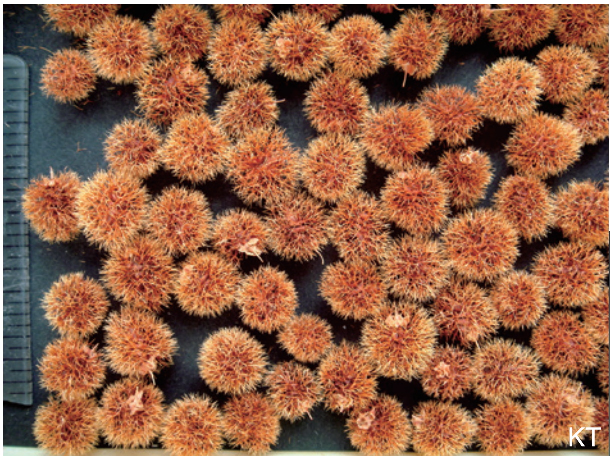
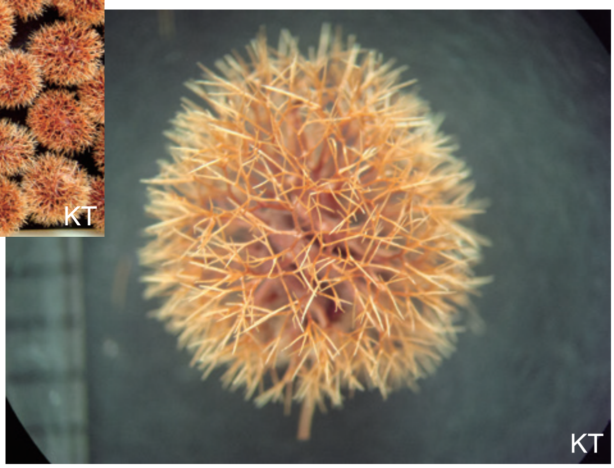
Polygonaceae Juss.
Calligonum microcarpum I.G. Borshch.

Synonym: *Calligonum minimum* Lipsky, *Calligonum elatum* Litv.
Local name: Maydamevali qandim (Uzb.), qandim (Kar.), жузгун мелкоплодный (Ru.).

Botanic characteristics and life form: C_4-psammophreatohalophyte. A low shrub, 0.5 m in height, rarely up to 3 m.
Stem: Bark of mature branches grayish or reddish, herbaceous branchlets slender, densely covered with flowers.
Leaves: Small, to 2 mm long, subulate, recurved, membranous-margined at the base as other species of *Calligonum*.
Flowers: Flowers axillary, mostly in groups of 5; pedicels jointed below the middle, glabrous, as long as or 1.5 times as long as the perianth; perianth segments subequal, broadly obovate, whitish-green, to 2 mm long; anthers pink.
Fruit: Ovaloid to subspherical, 7-9 mm in diameter, rather densely setose or rarely loosely setose with achene showing through the bristles; achene spirally coiled clockwise or anticlockwise, linear-elliptic, enlarged at the middle, cylindrically tapering toward both ends, the rounded bluntish ribs keeled.
Phenology: Flowering: April - May, fruit maturation: May - June.
Seed germination: Small, black, oval seed with low seed germination rate. Seed dispersal by winds.
Economic importance: Young stems and fruits well grazed by all livestock in spring and winter. Potential for range improvement of sandy deserts. Beekeeping and landscaping plant.
Habitat: Desert sandhills, sandy steppes, rocky soils and open grasslands.
Distribution: Native to Central Asia, Caucasus and northern Iran.



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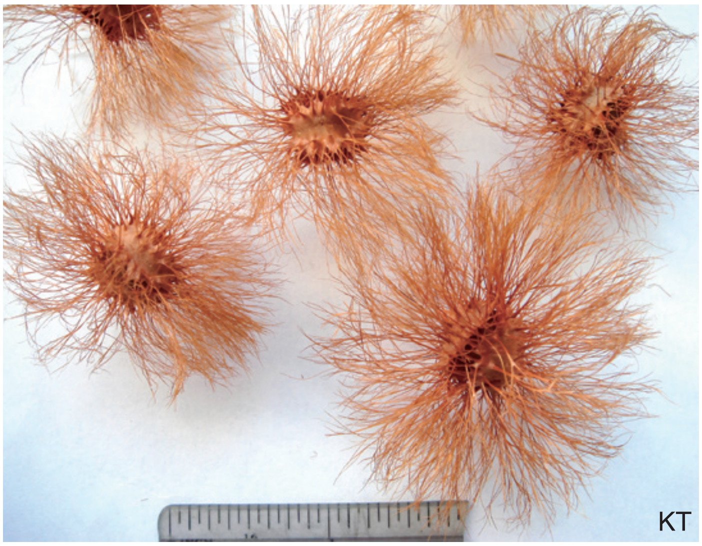
Polygonaceae Juss.
Calligonum setosum (Litv.) Litv.

Synonym: *Calligonum acanthopterum* var. *setosum* Litv.
Local name: Dag'altukli qandim (Uzb.), qandim (Kar.), жузгун щетинистый (Ru.).

Botanic characteristics and life form: C_4-psammophreatohalophyte. A rather low shrub, barely reaching 1 m in height, spherically branching; bark of mature branches whitish. Strong pivotal root system with superficial roots to depths of 12-14 m.
Stem: Branches nodose, refracted-flexuous, with internodes to 3 cm long; branchlets of the current year numerous, some floriferous, finally all deciduous.
Leaves: Small, inconspicuous, filiform, to 5 mm long, promptly deciduous.
Flowers: Flowers whitish-green, remote, in 1 or 2 fascicles per branchlet; pedicels of upper flowers to 5 mm long, jointed below the middle; fascicles mostly particolored; perianth segments unequal; the inner broad, obovate, white with a green dorsal stripe, 3 mm long; the outer smaller, ovate; all reflexed in fruit; anthers rounded-ovate, yellow.
Fruit: Excluding bristles, oval in outline, 15-20 mm long and 12-17 mm wide; achene coiled, sharply ribbed; wings not united with base of style, stiff, slightly exceeding achene, conspicuously transversely veined, the margin studded on all sides with long, stiff, subulate, often doubly forked bristles equal to or exceeding the width of the achene; surface bristles in 1 or 2 (rarely 3) rows, equal to or more often exceeding the marginal bristles, always forked.
Phenology: Flowering: May, fruit maturation: May - June.
Seed germination: Small, black, shiny. Germination rate in the laboratory: 40-65%. Seed viability is seven years. Long-term (1.5-2.5 months) treatment under low temperature (0-4 ºC) and treatment with low concentration of sulfuric acid (for 4-8 hours) considerably enhances germination. Can be propagated by seed and cuttings.
Economic importance: Good forage for sheep and camels in spring and summer. Fruits and young stems are consumed all year round by all livestock. An early colonizer of sandy rangeland and sand shifting dunes. Valuable in May and beginning of June during grazing season as provides forage rich in vitamins. Recommended for controlling soil erosion, creating windbreaks and stabilising shifting sands in combination with *Haloxylon ammodendron*, perennial and annual salsolas and perennial grasses. Locals used old dry branches as fuel.
Habitat: Desert sandhills, sandy steppes and rocky habitats.
Distribution: Central Asia, Caucasus and northern Iran.

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Polygonaceae Juss.
Rheum tataricum L.f.

Synonyms: *Rheum caspicum* Pall., *Rheum songaricum* Schrenk
Local name: Tatar ravochi (Uzb.), tuyejapraq (Kar.), татар рауғаш (Kaz.), ревень татарский (Ru.).

Botanic characteristics and life form: Salt accumulating xerohalophyte. Perennial with high tolerance to drought, salinity and nutrient deficiency, thick hollow stems 40-70 cm tall, up to 50 cm in diameter, rounded basal leaves, rhizome is 5-6 cm thick, vertical, branched, abundantly covered with black-brown scaly sheaths.
Stem: Stems 2 or 3, robust, hollow, sulcate, glabrous, branched from the middle at an angle of about 40°, the terminal branches drooping in maturity and thus forming an almost spherical inflorescence.
Leaves: Leaves to 35 cm long and 50 cm broad, rounded, cordate at base, with 3 prominent principal veins, the lower surface and the very short petioles minutely papillose, the upper surface glabrous.
Flowers: Small yellow-white, perianth segments 5, equal, 3 mm long, yellowish, with 3-5 brown nerves, stamens slightly shorter than perianth, anthers oblong.
Fruit: Ovate, 9-12 mm long and 8-10 mm wide, on short pedicels 2-3 mm long, articulated in the upper half. The nuts are obovate, finely wrinkled, dark brown, almost black, dull; the wings are narrow 1-1.5 mm wide, dark red-brown, heart-shaped from below, narrowed to the top and here with a barely noticeable shallow notch; the vein runs along the very edge of the wing.
Phenology: Flowering: April - May, fruit maturation: June - July.
Seed germination: Seed should be planted in a sheltered cold frame in fall. The seed can also be planted in a cold frame in the spring. Prick the seedlings out into individual pots when they are large enough to handle and grow them on in the greenhouse or cold frame for their first winter before transplanting in the open field trails in spring. Divide the rootstock with a sharp spade or knife, ensuring sure that each division has at least one growing bud. Larger divisions can be directly planted into their permanent places. We've discovered that it's best to pot up the smaller divisions and grow them on in a cold frame in light shade until they're well rooted before planting.
Economic importance: On rangelands the juicy leaves of the plant are readily eaten by all animals, especially camels, sheep and goats. The leaves contain 90-95% water before flowering, so when eating them, animals may not drink for 4-5 days. The plant is also a feeding food, especially for camels. In addition, rhubarb is a promising tanning plant. Its relatively powerful roots contain 15-17% tannins, 7-13% in the peel of fruits, 18-20% in seeds, and 12-14% in rhizomes. The average weight of underground organs of one plant is about 500 g. The content of tannins in them is 7-17%, in fruits 6-11.5%. In addition, coloring substances and carbohydrates. Young leaves and especially thick, juicy, soft petioles are eaten. The juice from the petiole replaces water under desert conditions.
Habitat: Steppes; on gravel, clay, grassy and dry slopes, and hillocks, grasslands, deserts, plains. Endemic for the Transvolga regions.
Distribution: East European Russia, Kazakhstan, Tajikistan, Afghanistan, South European Russia, Ukraine, Uzbekistan, China (Xinjiang).


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Rosaceae Juss.
Crataegus korolkowii L. Henry

Synonym: *Crataegus pinnatifida* Bunge var. *major* N. E. Br., *Crataegus pontica* K. Koch.
Local name: Korolkov do'lonasi (Uzb.), боярышник Королькова (Ru.).

Botanic characteristics and life form: C_3-xerophreatophyte. Tree up to 1.6-5 m high, with a wide crown.
Stem: The branches are dark gray, annual branches and shoots have tomentose pubescence. There are no spines.
Leaves: Dense, bluish-green; the lower ones are obovate-wedge-shaped, often oblong, with a base descending onto the petiole, at the apex coarsely incised-toothed or three-lobed; the upper ones are 4.5-6.5 cm long and wide, rhombic or broadly obovate in outline with a broadly wedge-shaped base, deeply five-parted, often with a three-incised middle lobe or seven-parted. The lobes are usually oblong, their length is, for the most part, 3 times greater than their width, partly entire, partly with 1-4 large teeth at the apex.
Flowers: Bisexual, clusters of white flowers occure in spring; flower 1.5-2 cm in diameter; sepals broadly triangular, sharp or pointed, reflexed when fruiting; stamens 20, with white anthers. The inflorescences are compact, 3-5 cm in diameter, 8-14 flowered, with hairy or tomentose axes and pedicels 3-7 long.
Fruit: 1-2 of strongly flattened at the poles berries of 15-28 mm in diameter, bright red, green-rusty to orange-yellow, often with a reddish side.
Phenology: Flowering: May - July, fruit maturation: September.
Seed germination: Seeds are a small, dark brown. Propagation is usually done by seeds, but it can also be done by cuttings or layering.
Economic importance: Fruits of the Korolkov hawthorn contain carbohydrates 9.9%, sucrose up to 0.3%; pectin 4.6%, vitamins C, tannins, catechins, epicatechin. It is an excellent melliferous plant and is recommended for landscaping, restoration of degraded pastures, windbreaks and shelterbelts to prevent soil erosion.
Habitat: It grows on dry, usually rocky, rarely on fine-earth slopes (mostly on Ustyurt cliffs), with single scattered trees, sometimes forming small groves.
Distribution: In nature, the range covers the eastern regions of Transcaucasia, Central Asia, Turkey and the northern regions of Iran.
Note: *C. korolkowii* is used as an ornamental in gardens and parks. Its fruits are edible and can be used in the production of jams and jellies. It is also used for medicinal purposes.


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Rosaceae Juss.
Rosa laxa Retz.

Synonym: *Rosa majalis* J. Herrm.
Local name: Siyrak itburun (Uzb.), котыр раушан (Kaz.), шиповник рыхлый (Ru.).

Botanic characteristics and life form: C_3-xerophreatophyte (deep-rooted wild species using derived water from the phreatic zone), non succulent halophyte excrete salt (through glandular trichomes). Shrubs 0.8-2 m tall with large foliage crown. The small size of the leaves and the presence of red pigmentation in the immature leaves and stems distinguish this rose from cultivated hybrids. Almost leathery leaves distinguish *R.laxa variety kaschgarica* from Chinese wild rose species.

Stem: Woody, often arching and hanging stems. Branchlets terete, straight or slightly curved, glabrous; prickles in pairs below leaves or scattered.

Leaves: Surface of old leaves covered with white waxy powder, leaves small of 4.5-10 cm including size of petiole; leaflets 7-9, elliptic, oblong, or ovate, rarely obovate, 1.5-4 cm long, 1-3 cm wide, glabrous or pubescent. Leaflets small, sublanceolate or obovate, with few small and scattered spines. Petioles glandular or pubescent. Spines numerous, recurved, broad or widened at the base.

Flowers: Bisexual, pale rose-pink, moderately double, with deformed pistils and stamens, often 3-6 in corymb, sometimes solitary, 1.5-3 cm in diameter; pedicel 1-1.8 (-3) cm, glandular; bracts ovate, pubescent, glandular hispid, apex acuminate. Sepals 5, ovate-lanceolate, leaflike, abaxially sparsely pubescent and glandular hispid, adaxially densely pubescent, margin entire. Petals 5, white or pink, obovate, apex erose. Stamens in a cluster with a single central stigma. Later season flowers are borne on secondary laterals from June flowering stems.

Fruit: Hip red, oblong or ovoid, 1-1.8 cm in diameter, glabrous, often shiny, apex with a short neck and persistent, erect sepals.

Phenology: Flowering: May - June, fruit maturation: June - late December.

Seed germination: The seeds are small and have a prominent layer of hairs under the flesh of the fruit.

Economic importance: The fruit is a rich source of vitamins and minerals, especially in vitamins A, C and E, flavanoids and other bioactive compounds. It is also a fairly good source of essential fatty acids. Excellent melliferous plant.

Habitat: Described from an isolated population living on the rocky outcrops of the western part of the Ustyurt plateau, close to the salty shores of the Aral Sea. Occasionally occurs on sandy or rocky areas, north-slope shrub, dry riverbeds, stream rocky sides. It is an ancestral species with high drought and salt tolerance (gypsum and limestone soils) and superior winter hardiness (can persist low temperature up to -50 ºC in winter).

Distribution: As reported in *Rosa* in Flora Xinjiangensis (Han 1995) and in Xinjiang flora (Le Luo et al. 2018), the botanical variety *Rosa laxa* was found only in the Tarim Basin. It was also found in arid plains (e.g. the Gobi, arid slopes, seasonal river valleys, gravel and salt-alkaline lands, especially in the Kashgar area) in southern Xinjiang. It is also reported to grow in Central Asia, Siberia, and Mongolia (Han 1995, Le Luo et al. 2018).

Note: Relict. *R. laxa* Retz. var. *Kaschgarica* is one of the ancestors of a large number of varieties of rose. Effective conservation measures should be put in place to preserve this indigenous and geographically isolated species of wildlife.


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Salicaceae Mirb.
Populus euphratica Olivier

Synonym: *Populus diversifolia* Schrenk.
Local name: Evfrat teragi, turang'il (Uzb.), torangil (Kar.), тополь евфратский (Ru.).

Botanic characteristics and life form: C_3-xerophreatophyte. A tree of medium size (approximately 15-20 m), with a spreading head.
Stem: Branches terete, with sparse pubescence visible with the aid of a magnifier.
Leaves: Leaves of short shoots rounded-ovate. 2.4-4 cm long, cordate or truncate at base, often cuspidate, the cusp with 4 diverging teeth on each side, the 2 glands at the base of the blade very small and concave, petiole long, compressed laterally, at first very sparsely pubescent.
Flowers: Nectariferous, pendulous (catkin) appearing early before leaves.
Fruit: Young fruits clothed with dense velvety pubescence; stalk about half as long as the capsule, to 6 mm long, rugose, glabrous. Seed are numerous, small, ovoid, with silky hair emerging from funicle.
Phenology: Flowering and fruit maturation: April - May.
Economic importance: The plant is used as a building material for various household needs. Leaves and branches serve as excellent food for all animals. It is considered a tanning and dyeing plant. This beautiful, shady, very salt-tolerant and drought-resistant tree is recommended in agroforestry to provide fodder for livestock, timber, fiber for making paper. It is widely used for landscaping cities.
Habitat: Riverbanks, solitary or forming groves. It is a prominent component of Tugai flood plain ecosystem.
Distribution: Central Asia Afghanistan, Pakistan, Iran, Iraq, China , Mongolia, Turkey, Mediterranian and Northern African Countries and Algeria.
Introduced into: Egypt and Spain.
Note: Fast growing tree, resin of bank and volatile oils (up to 0.3%) from buds are used in traditional medicine as a tincture and ointment to treat rheumatism, burns and haemorrhoids. Also used in the cosmetic industry.


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Salicaceae Mirb.
Populus pruinosa Schrenk

Synonym: *Balsamiflua euphratica* f. *pruinosa* (Schrenk) *N.Chao* & J.Liu, *Balsamiflua pruinosa* (Schrenk) Kimura, *Turanga pruinosa* (Schrenk) Kimura
Local name: Ko'kbargli terak, turang'il (Uzb.), торангыл терек (Kaz.), torangil (Kar.), тополь сизый (Ru).

Botanic characteristics and life form: C_3-xerophreatphyte tolerant to salinity and frost. Deciduous tree (height up to 15-20 m) with erect or slightly twisting trunk (up to 50 cm in diameter). Crown wide spreading with brownish-grey bark.
Stem: With a whitish uneven trunk.
Leaves: Short shoots coriaceous, reniform, emarginate or minutely apiculate, with entire or wavy or slightly sinuate margins, heavily pruinose on both sides, often pubescent at first, at length somewhat velvety.
Flowers: Mostly dioecious, rarely monoecious, appear in early spring befor leaves open. Male flowers (up to 2 mm long), long-pedicelled in compact (dense) catkins; 12-14 stamens anthers ovate, dark-brown with free filaments. Female catkins (5-6 cm long), dense, woolly with single ovary.
Fruit: Large, ovoid-oblong capsule, narrow at top (6-10 mm long), opening by 2 slits.
Phenology: Flowering and fruit maturation: March - May.
Economic importance: Only its decorative value is indicated in the literature. In autumn and winter, young twigs, bark, and especially leaves and fruits are perfectly eaten by all animals in green and dry form. Turangyl wood is used for the manufacture of furniture. It is durable, well polished, in appearance is not inferior to walnut wood. Hedges are made of branches, canopies and houses are covered with them. It is considered a tanning and dyeing plant. It does not react at all to an increase in the level of subsurface waters.
Habitat: Riverside sands and pebbles in desert areas, solitary or in groves, often together with other species of the subgenus Turanga; rarely near springs or wells.
Distribution: Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan and Xinjiang province in China.


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Salicaceae Mirb.
Salix songarica Andersson

Synonyms: *Salix hypericifolia* Golosk.
Local name: Jung'or toli (Uzb.), tal (Kar.), ива джунгарская (Ru).

Botanic characteristics and life form: Xerohalophyte. A drought and salt tolerant tree to 8-10 m high, reaching ages of up to 75 years.
Stem: With trunk to 35-40 cm in diameter and a dense round top, annotinous branches slender, pale brown, the young sometimes pendulous; buds small, appressed, oblong, tawny.
Leaves: Stipules lanceolate, rarely ovate, sometimes with large lobes at base, glandular, soon caducous, mostly absent; petioles glandular, 0.4-1 cm long; leaf blades narrowly lanceolate, 3-7.5 cm long and 0.6 cm broad, broadest at or below the middle, broadly cuneate at base, acuminate at apex, glandular-serrulate or entire on the margin, glabrous, lustrous, on both sides concolor green, slightly silky when young; midrib and lateral veins prominent beneath, riblike; lateral veins 12-16 pairs, at an angle of 40-45 °C.
Flowers: Catkins subcoaetaneous or somewhat serotinous, to 5-7 cm long, stalked, with 2 or 3 bracts, commonly terminating in short lateral shoots, slender, long, curved, the pistillate loose; rachis puberulous or glabrate. Scales caducous; pistillate spatulate or narrowly ovate; staminate broadly obovate, truncate, monochromatic pale yellow, white-woolly at base, puberulous or glabrate toward apex; stamens 3 (rarely 4), villous at base; filaments short; anthers small, yellow, round; glands 2, posterior (or sometimes 1 anterior), one-third as long as the ovary; ovary ca. 4 mm long, ovoid-conical, obtuse, glabrous, green, becoming brownish; style very short; stigma thickish, entire or 2-parted, with short broad lobes; stipe ca. 1.5 mm long.
Fruit: Capsule to 5-5.5 mm long.
Phenology: Flowering: May, fruit maturation June.
Seed germination: Seeds are small and light with low viability. Light sensitive. Germination capacity is 83% in 4 days. It is easily propagated by cutting.
Economic importance: In Central Asia's countries, it is used as a building material and fuel. Branches and leaves are excellent food for all animals, especially in winter. It is considered a good melliferous plant. It is a tannic plant. The bark contains from 5.61 to 7.81% tannins. The species is fast-growing. In order to consolidate the banks of the Amu Darya and its tributaries, planting of this and other types of willow is practiced. In Uzbekistan, it is used to prevent the banks of canals and ditches from crumbling, water and wind erosion.
Habitat: The most widespread willow in a Tugai forest and river floodland woods of Center Asia.
Distribution: Afghanistan, Iran, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan and Xinjiang.
Note: The bark, twigs, leaves and flowers contain phenolic glycosides, especially salicin and salicortin with high pharmaceutical properties.


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Solanaceae Juss.
Lycium ruthenicum Murray

Synonym: *Lycium vulgare* var. *ruthenicum* (Murray) Terraciano
Local name: Rus oqching'ili (Uzb.), aq tiken (Kar.), орыс тікенбұута (Kaz.), дереза русская (Ru.).

Botanic characteristics and life form: A non-succulent xerohalophyte, perennial, very thorny and multi-branched shrub, 60 cm to 2 m tall. Tap root system 1.5-2.0 m in depth.
Stem: Yellowish-grey twigs and arching shoots with spiny, purplish twigs and branches; white-grey bark densely covered with short subulate spines, 3-20 mm long (developing on all nodes). Branches divaricate, nodose, yellowish or greyish, old one's ashen grey.
Leaves: Sessile, glaucous, fleshy, faintly veined, usually blunt, highly variable in shape, from narrowly linear (most commonly), subcylindrical to narrowly oblanceolate, 0.5-3.5 cm long, 0.75-3 mm wide.
Flowers: Bisexual; pentamerous, white-light purple, in axillary clusters of 1-6 in a cyme inflorescence.
Fruit: Black berries 4-8 mm in diameter.
Phenology: Flowering from second half of April to July, fruit maturation: June - October.
Seed germination: Seeds are brown, kidney-shaped, numerous, reniform and angular, up to 2 mm large. Germinates without special preparation, but stratification (5 °C) for 2-4 months improves germination. It usually germinates when treated at 20 °C for 18 hours or at 30 °C for 6 hours. Vegetative propagation by cuttings is recommended. Planting *Lycium* adapted to saline soils improves productivity of saline soils and increases local farmers' incomes. Industrial plantation by cuttings is better carried out in late autumn or early spring under low air and soil temperatures.
Economic importance: It contains the alkaloid betaine and traces of atropine and choline in the stem and leaves, making it a more noxious and poisonous plant than black nightshade. Blackberries have laxative properties. The red pigment physolien is found in fresh berries. In the early stages of vegetation, it is readily eaten by sheep, goats and camels with no harmful consequences. *L. ruthenicum* is a plant that can be harmful to domestic animals because of its thorns. Dry branches/thorns often become tangled in the wool of animals, causing illness.
Habitat: Widespread, on the edges of cultivated fields, along riverbanks, in dry riverbeds, on takyr flats, on saline, alkaline soils with low nutrient content. Often found on the dry bottom of the Aral Sea, growing in dense, impenetrable thickets on shallow, saline soils. It is also common in Tugai floodplain plant ecosystem.
Distribution: Central Asia across Irano-Turanian; other species from North Africa to China (occasionally found in association with *Lycium barbatum* L, which is cultivated for its valuable red berries, used as sweets and in traditional dishes).
Note: Good honey producer due to long flowering; suitable for living impenetrable fences. Burns fairly well, but the prickliness makes it extremely awkward to use. Because of their nutritional properties, *Lycium* fruits, also known as goji or wolfberry, have become increasingly popular in the western world.


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Tamaricaceae Link
Tamarix hispida Willd.

Local name: Dag'altukli yulg'un (Uzb.), ermanijingil (Kar.), тікентүкті жыңғыл (Kaz.), катуу тіктїїжылгын (Kr.), гребенщик щетинистоволосый (Ru.).

Botanic characteristics and life form: C_3-recretohalophyte (salt exluder), tree (4-6 m) or large shrub, microphylous, polymorphic with reddish bark. Deep root system (up to 6-8 m) with rhizomes and suckers.
Stem: The aerial branches are highly branched, greyish brown and densely covered with hairs.
Leaves: Filamentous, small, scale-like, alternate, without hairy stipules, with a thin layer and spots of salt on the surface.
Flowers: Small, actinomorphic, bisexual, with compound perianth, often in bright purple spikes. Petals with well-developed nectar disc at base. Stamens variable, from 4 to 10, attached at their bases. Anthers ovate to elliptic with a pointed stigma.
Fruit: Capsule multi-seeded, conical, loculicidal dehiscent.
Phenology: Flowering: June - September, fruit maturation: August - October.
Seed germination: Small, rod-shaped. On the top of the seed are clusters of seed hairs. The length of the seed hair is about 2 to 4 times the length of the seed. The seeds are wind-dispersed. A high percentage (>85%) of seed germination is observed in early spring after snowmelt. *Tamarix* can tolerate very salty water, but seeds will only germinate in fresh water.
Economic importance: Limited and occasional grazing by small ruminants and gazelles, better accepted by camels and cattle. Useful firewood in saline environments, easily established from cuttings for revegetation of arid and semi-arid saline environments. Could be used as a stabiliser for shifting sand dunes. Excellent melliferous plant.
Habitat: Sandy to loamy saline soils (on solonchak); important leaf litter containing salt causes soil sterilisation and stabilisation under tree or shrub. Common on riverbanks, terraces, saline flats and takyr, on sand dunes on high saline water table. Wind and salt resistant.
Distribution: Southwest Europe to Central Asia, North Africa, Middle East. Native in many semi-arid and arid countries with Mediterranean climate.
Note: Reforestation and dune stabilisation (on saline ground), carpentry and building. Fuelwood. Source of tannins (up to 40% in galls). Promising for afforestation and restoration of wetlands and marshlands due to quick rooting of stems and woody cuttings.


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Tamaricaceae Link
Tamarix laxa Willd.

Synonym: *Tamarix laxa* var. *occidentali-caspica* Bunge, *Tamarix laxa* var. *polystachya* (Ledeb.) Bunge, *Tamarix laxa* var. *racemosa* Ehrenb

Local name: Yulg'un (Uzb.), jingil (Kar.), борык жыңғыл (Kaz.), чачырандыжылгын (Kr.), гребенщик рыхлый (Ru.).

Botanic characteristics and life form: C_3-recretohalophyte. Perennial, slow growing shrub 50-75 cm tall (rarely 1.5 m), with a taproot system reaching groundwater (mineralized up to 25 g/l). It produces adventitious roots from submerged stems. Littering and salt accumulation fixed the surface of the sand mound under the crown.

Stem: Slender, smooth reddish-brown. Branchlets straight, short, fragile. The bark of old branches is gray.

Leaves: Small (scales) overlap each other along the stem, yellow-green, lanceolate or ovate-oblong to rhombic, ca. 0.5 mm, base attenuate and slightly decurrent, margin narrowly membranous, apex acuminate or acute, mucronate. Leaves surface encrusted with salt secretions through numerous salt glands, papillae and epidermal hairs.

Flowers: Flowers congested apically and umbel-like, with sparse, brown, oblong scales; bracts brownish or greenish, ovate, or narrowly elliptic, margin membranous, cartilaginous in upper half. *T. laxa* is distinguished by 4-merous flowers. Calyx ca. 1 mm; sepals 4, ovate, margin broadly membranous, apex obtuse or acuminate, recurved at fruiting stage, outer 2 carinate. Petals 4, strongly spreading and reflexed, pink, rarely whitish pink, oblong-elliptic to oblong-obovate, ca. 2 mm. Disk dark red, fleshy, 4-lobed. Stamens 4, equaling or slightly exceeding petals.

Fruit: Capsule 3-4 mm, slender, with a tuft of hairs to aid wind dispersal, also by water.

Phenology: Flowering in April - May, occasionally second bloom occurs in autumn on current year's branches. Flowers blooming in autumn are 5-merous.

Seed germination: On surface of fresh water (floating germinated seeds) is rapid and high (>90%). 1000-seed weight was approximately 48 mg. Seed germination occurs under a wide range of temperatures (5-30 °C), after long periods of storage (at least 12 months on dispersal), under high concentrations of salts (700-900 mmol·L-1). The seed pappus and hypocotyl hairs played an important role in seed dispersal and seedling establishment. Seedlings require extended periods of soil moisture saturation for growth. Can be propagated vegetatively by submerged adventitious rooting and cuttings. Wildlife with *T. laxa* seems to favour the establishment of riverine trees, such as *Populus, Salix* and others.

Economic importance: It is considered medicinal, honey-bearing, dyeing, decorative. Used for carpentry and firewood. Serves as a fodder plant for camels, horse and sheep.

Habitat: Grows in disturbed streams, watercourses, banks and drainage washes of natural or artificial water bodies, sand inter- dunes depression and wet grazing pasturelands. It is salt-alkali-tolerant plant and Cd^{2+} toxic resistance excretohalophyte.

Distribution: Native to Afghanistan, Central Asia and northern Caucasus, north Central China, Inner Mongolia, Iran, Southern European Russia and western Siberia.

Note: Chemical composition (% DM): protein 11.5, fat 2.3, fiber 20.3, nitrogen-free extract 35.3, ashes 30.6. The plant contains a significant amount of tannins (in leaves 11-12%, in bark 16-18%). The wood was used by the Saka people hundreds of years ago (in combination with wood and ibex horn) to make bows of enormous strength.


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Tamaricaceae Link
Tamarix ramosissima Ledeb.

Synonym: *Tamarix pallasii* var. *ramosissima* (Ledeb.) Kar.
Local name: Sershox yulg'un (Uzb.), qizil jingil (Kar.), кызыл жыңғыл (Kaz.), көп бутактуужылгын (Kr.), гребенщик ветвистый (Ru.).

Botanic characteristics and life form: Typical C_3-recretohalophyte with numerous salt-excreting glands on the leaf surface. 1-3(-6) m tall shrubs or small trees.
Stem: Old branches are dark gray; current year ascending branches are reddish or orange-yellow and lengthy.
Leaves: Ovate or deltoid-cordate, 2-5 mm long, 1-2 mm broad, acute, semiamplexicaul.
Flowers: Flowers with five petals. Calyx 0.5-1 mm; sepals broadly elliptic-ovate or ovate, apex acuminate or obtuse; inner 3 (0.5-0.7 or 0.3-0.5 mm), border narrowly membranous, irregularly dentate, not carinate. Petals pink or purple, (1-1.7 0.7-1 mm), approx. 1/3 longer than calyx, apex emarginate, rising, touching each other and creating a cup-shaped corolla, persistent in fruit. The disk is 5-lobed, with emarginate lobes at the tip. Stamens 5 to 1.5 times the length of the corolla; filaments not dilated at base, inserted between disk lobes; anthers obtuse or with obtuse protrusions at apex. Ovary conic, triqueter; styles 3, clavate, 1/4-1/3 the length of the ovary. Capsule triqueter, conic, (3-5 mm), 3-4 times the length of the calyx.
Fruit: Capsule trigonous-pyramidal 3-4 mm long, 0.7-1 mm broad at base, 3-4 times as long as calyx.
Phenology: Flowering and fruit maturation: May - September.
Seed germination: Freshly harvested seeds from the spring and summer flowering seasons can both germinate rapidly under the thermoperiods of 5/15 °C, 5/25 °C, 15/25 °C or 25/35 °C.
Economic importance: Young; twigs, flowers and bark of adult stems contain a large amount of tannins, up to 35-50%, which are concentrated in galls. The species has medicinal value: Bark and young branches with leaves can be used as an astringent. Galls are recommended as raw materials for the production of medical tannin. The leaves also contain coumarin compounds. Thin long twigs are used for weaving various baskets, fishing gear, making brooms. Stems are applied for hedges, covering roofs of premises, for fuel. Melliferous plant. It is of great importance as a forage plant. Very promising for landscaping.
Habitat: Sandy and clayey solonetzic steppes, chalky mountains, solonetzes, solonchaks, banks of rives and streams, lake shore and seacoast, hummocky sands, also growing in parks and gardens.
Distribution: Afghanistan, Bulgaria, China North-Central, East Aegean Is., East European Russia, Greece, Inner Mongolia, Iran, Iraq, Kazakhstan, Kyrgyzstan, Krym, Lebanon-Syria, Mongolia, North Caucasus, Pakistan, Qinghai, South European Russia, Tajikistan, Tibet, Transcaucasus, Turkmenistan, Ukraine, Uzbekistan, West Himalaya and Xinjiang.
Introduced into: Argentina Northeast, Argentina Northwest, Argentina South, Arizona, Arkansas, California, Cape Provinces, Colorado, Hungary, Idaho, Kansas, Louisiana, Maryland, Mexico Northeast, Mexico Northwest, Montana, Namibia, Nebraska, Nevada, New Mexico, North Carolina, North Dakota, Oklahoma, Oregon, South Dakota, Spain, Texas, Utah, Vietnam, Washington and Wyoming.
Note: *Tamarix* species have a number of benefits for wildlife.


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Typhaceae Juss.
Typha angustifolia L.

Synonym: *Typha minor* Curtis
Local name: Ingichkabargli qo'g'a (Uzb.), jeken (Kar.), аил кога (Kaz.), жекен (Kr.), рогоз узколистный (Ru.).

Botanic characteristics and life form: Aquatic perennial halophyte with thick cylindrical stems 100-200 cm tall and rigurous creeping rhizomes. Growing to 1.8 m sometimes up to 4-4.5 m high.
Stem: Approaching inflorescence, 2-3 mm thick stems.
Leaves: Leaves flat or often slightly convex on the back, 4-6 mm or rarely up to 10 mm broad; inflorescence long-cylindric, the interval between the staminate and pistillate parts 3-8 cm long.
Flowers: Unisexual, very small, with a perianth of fine hairs. Inflorescence compact, thin, cylindrical, 2-stalked. Male flowers on upper part of inflorescence, female flowers below; flowers clearly separated. Female flowers cinnamon-brown, 8-20 cm long, 1.5-2.5 cm wide. Tepals hairy and with scaly hairs. Stamens 1-8, stigmas filiform.
Fruit: Dehiscent, follicle or achene of about 5-8 mm long with persistent style and long hairs derived from the perianth. Pericarp is transparent and splits longitudinally in water releasing tiny seeds.
Phenology: Flowering and fruit maturation: June - August.
Seed germination: Seeds ellipsoid, ovoid, linear, or fusiform, terete in transection, 0.7-1.5 mm long. Seed coat brown, thin, membranous, punctate or reticulate. Seeds on the stem sometimes persist for up to six months. Germination requires light and alternating temperatures (optimum results are obtained with a 20/30 °C 12/12 h photothermic period). Germination began after three days and reached 22-40% in seven days. It is mostly propagated vegetatively.
Economic importance: Rhizomes are eaten whole or ground into flour. Shoots, seeds, flowers, pollen, and stems are also eaten if collected in active growth vegetation stage. The long, thick leaves are used to weave carpets and durable, waterproof bedding. They are used in the refrigeration industry because of their low wettability. Their high buoyancy is used to fill swim belts, lifejackets and vests. Recommended for aquatic ecosystem restoration and waste water treatment.
Habitat: Shores of rivers and lakes, wetlands, backwaters, ditches, and clay pits in brickyards.
Distribution: Almost cosmopolite plant.
Note: Raw rhizomes contain up to 15% starch. It is recommended to be used together with reed as a promising raw material for the paper industry. It has medicinal properties due to the presence of alkaloids and other chemical substances. Dense stands of typha provide nesting place and shelter for wetland animals and birds.


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Ulmaceae Mirb.
Ulmus minor subsp. *minor*

Synonym: *Ulmus densa* Litv.
Local name: Ko'kqayinbargli qayrag'och (Uzb.), Sada (Tj.), карагаш (Kaz.), каражыгач (Kr.), вяз малый (Ru.).

Botanic characteristics and life form: Xerophreatophyte, extremely resistant to drought. Tree (5-15 m, taller in favourable locations) with dense pyramidal crown, sometimes in large bushes (suckers). Dark bark, splitting. Slightly hairy shoots.
Leaves: Asymmetrical, unequal at base, rigid, simple, alternate, elliptic-ovate, rounded, underside usually hairy; margins doubly, occasionally tribally, toothed or serrate; lobes sharply pointed. Petioles short, pubescent. Stipules decussate, elliptic-lanceolate, with inconspicuous upper furrows. Perianth segments: Perianth segments 4-8, with not fused, imbricate lobes.
Flowers: In fascicles, on short pedicels, appearing before leaves, small, usually hermaphroditic assembled in dense clusters on branches. Stamens 4-8 opposite the perianth lobes.
Fruit: Compressed samara, small nutlet with broad, oval wing (wind dispersal), notched at tip.
Phenology: Flowering and fruit maturation: March - April.
Seed germination: Seed with a large embryo without endosperm. Seed coat thin. Seed dormancy induced by inhibitor in pericarp. Long stratification (at 5 °C/2-3 months) stimulates the germination. It can reproduce by root suckers.
Economic importance: Highly durable and slow-growing, it is used for construction (carved columns for mosques and homes), joinery (traditional carved doors for old mosques, private homes, etc.) and caskets. Hollow trunk wood is of high quality and is recommended for furniture and boat shipbuilding. Large branches are traditionally used for water pipes. Used for roadside tree planting. Fuelwood.
Habitat: Drought- and salt-tolerant, growing in semi-desert plains, mountain valleys; sometimes isolated in the Adyr near houses, farms and "mazar" (cemetery).
Distribution: Central Asia (Pamiro-Alay, Tian-Shan).
Note: Withstands alkaline soils and high mineralized water; has a special value as a shade tree in interior valleys during hot summer season.


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Zygophyllaceae R.Br.
Zygophyllum atriplicoides Fisch. & C.A.Mey.

Synonym: *Halimiphyllum atriplicoides* (Fisch. & C.A.Mey.) Boriss.
Local name: Olabutasimon tuyatovon (Uzb.), парнолистник лебедовый (Ru.).

Botanic characteristics and life form: Xerohalophyte, salt accumulator. Shrub with dense crown up to 50-120 cm tall.
Stem: Strongly branching, with angular trunk 1-1.5(2.5) cm wide, branches thick, whitish, the older flexuose, with pale cinereous bark, wood yellowish; stipules very short, broader than long, acute, sometimes obtuse.
Leaves: Covered with stellate opposite hairs when young, spatulate-oblong, obovate or ovate, 1.5-3(4) cm long, 8-12 mm wide, gradually tapering to petiole one-third as long as blade, in young opposite, clustered when old, hardly acute at apex. Pedicels 1 cm long, nearly as long as or slightly longer than calyx.
Flowers: Sepals obovate or suborbicular, obtuse, broadly membranous at margin, dorsally grayish, 5-6 mm long; petals 1.5-2 times as long as sepals, obovate, obtuse; stamens exserted; staminal scales small, oblong, serrate-dentate at margin and apex.
Fruit: Capsule elliptic-cylindrical, 1.5-2(-2.5) cm long, 1.5-2.5 cm wide, 5-lobed, each lobule with 1 or 2 seeds, reticulate at base and apex.
Phenology: Flowering: April - May, fruit maturation: May - June.
Seed germination: Seeds 6-7 mm long, 1-2 in each cell, brown, covered with numerous gray papillae. Deep dormant seeds with extremely low germination rate. Sensitive to salinity at the seed germination stage. Priming treatments with various chemical substances (gibberellic acid and ascorbic acid at 100, 200, and 300 mg/L) stimulates germination up to 75%. Seed viability more than 14 years.
Economic importance: The leaves contain a large amount of alkaloids. The leaves are well eaten throughout the year by sheep and especially goats. Other animals do not eat this plant. A dye is obtained from the fruit, which turns the skin yellow.
Habitat: Grows well on sandy hills and dunes, foothills, clayey stony, pebbly soils. It forms an extensive vertical and horizontal root system, sometimes with a radius of up to 15 m.
Distribution: Central Asia, Kope-Dagh Range, Afghanistan, Iran, Iraq, Lebanon-Syria, Pakistan.
Note: Genus *Zygophylum* with about 100 species; found in deserts and steppes from the Mediterranean region to Central Asia, South Africa and Australia. Recommended for sands stabilization, for restration of saline lands and for prevention of wind erosion.


KS


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Zygophyllaceae R.Br.
Zygophyllum eichwaldii C.A.Mey.

Synonym: *Zygophyllum coccineum* Lepech.
Local name: Eyxvald tuyatovoni (Uzb.), tuyetaban (Kar.), туйетабан (Kaz.), жуп жалбыракчан (Kr.), парнолистник Эйхвальда (Ru.).

Botanic characteristics and life form: Salt accumulating xerohalophyte. Shrub (height 30-75 cm). Deep pivotal root system.
Stem: With elongate whitish branches; stipules short-triangular, obtuse.
Leaves: Simple, 2-3.5 cm long, 7-20 mm wide, oblong or ovate, with 5-7(10) mm long petioles. Pedicels ca. 15 mm long, declinate or erect; sepals and petals 4, obtuse.
Flowers: Solitary or paired, terminal, pale yellow and white with red or purple spot at base of petal. Calyx with 5 overlapping sepals and clawed; 8-10 stamens; held in whorls. Pollen grain 2-celled, 3-colporate. Ovary superior with 5 fused carpels often winged. Ovule 2 or rarely numerous, amphitropous, bitegmic, carssi-nucellate. Short style and lobed stigmas.
Fruit: Dehiscent drupe or 4-5 lobed berry-like capsule, angled along the locule partition or winged.
Phenology: Flowering: March - April, fruit maturation: April - June.
Seed germination: Seed coat thin, shining, smooth. Germination at 28 ºC/dark was 77-83%. Chemical treatment with kinetin or thio-urea increases germination. Seeds were germinated well under different salinities.
Economic importance: Fodder, honey production, medicinal (antiseptic), colorant (local people extract yellow from fruits to dye wool). Leaves and fruits used to treat rheumatism and skin diseases.
Habitat: Mountain slopes, stony, pebbly, sometimes saline desert soil.
Distribution: Endangered species in desert areas of Uzbekistan and Turkmenistan.
Note: At flowering (% DM): ash 12; crude protein 10; cellulose 17; nitrogen-free extract 53. Leaves rich in vitamins. Aerial parts contains alkaloids and volatile oil.


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Zygophyllaceae R.Br.
Zygophyllum oxianum Boriss.

Local name: Amudaryo tuyatovoni (Uzb.), tuyetaban (Kar.), туйетабан (Kaz.), жуп жалбыракчан (Kr.), парнолистник амударьински (Ru.).

Botanic characteristics and life form: Xerohalophyte, salt accumulator, perennial (height 20-60 em), semishrub, glaucous, glabrous woody at base, root robust, vertical, woody.
Stem: Few, 1-3(5), erect, herbaceous, branching mostly above, densely striate; branches more or less appressed to stem, slightly curved, internodes 5-6 cm long; stipules large, (4)5-7 mm long, herbaceous, ovate, obtuse.
Leaves: Lower leaves large, with petioles shorter than blade and terminating in short soft filiform mucro; leaflets of lower leaves large, asymmetrical, obliquely ovate or orbicular, 2.5-4 cm long, 1.5-3.5 cm wide, obtuse, usually remote, leaflets of upper leaves much smaller. Pedicels 10-12 mm long.
Flowers: Bisexual; solitary, axillary; pedicel (5-8 mm), elongate in fruit; sepals oblong-ovate (5-7 mm), margins scarious; petals (6-8 mm) orange-red, whitish tip, emarginate; 10 stamens, anthers (about 2 mm long), oblong-linear; filaments (1-2 cm), basal scales oblong, ciliate. Ovary 5-locular, oblong.
Fruit: Fruits many, cylindrical, slightly tapering at base, 1.5-(2.5) cm long, 5-7 mm wide, 5-locular, with 5 acute ribs and 5 concave grooves.
Phenology: Flowering: March - April, fruit maturation: May - August.
Seed germination: Seeds numerous, ca. 2.5 mm long, 2 mm wide, orbicular-ovate, smooth, gray. Due to deep dormancy, seed germination is low. Stratification at low temperature increases seed germination rate. Seed viability more than 12 years.
Economic importance: Medicinal plant. Fresh leaves and fruits are used to treat boils, and a decoction of roots for rheumatism. For the treatment of wounds, an ointment made of root powder, cooked on mutton fat, is also used. It contains the alkaloids zygofabagin and possibly harminh, and there are also vitamins C and K in the leaves and fruits. Ointments of leaf powder with vaseline and essential extract of leaves with peach oil are effective in the treatment of lichens, furunculosis, carbuncles and chronic eczema. The leaves contain coumarin compounds. It is well eaten by camels, and in dry form – leaves and thin twigs - by sheep and goats. It plays an essential role in the forage balance of pastures. During the fruiting period, the leaves and unripe fruits are strongly washed in water. A good honey plant. In winter it is used as fuel.
Habitat: Clayey, solonetzic and solonchak soils, sometimes on sands. General distribution areas: Central Asia's country: Aral-Caspian, Syr Darya, Karakum, Pamir-Alay.
Distribution: Afghanistan, Iran, Kazakhstan, Tajikistan, Turkmenistan and Uzbekistan.
Note: It is traditionally used for diabetes, eczema, liver and stomach disturbances, and for its haemostatic properties. Dried flower heads are used in a refreshing drink or tea.
The generic name is derived from the Greek words (zygon), meaning 'double', and phyllon, meaning 'leaf'. It refers to the leaves, each with two leaflets.


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