Crimson Publishers
Wings to the Research

Review Article

Mainstreaming Agrobiodiversity Utilization and Conservation-A Key Factor for a Healthy Environment in the Aral Sea Basin

Toderich Kristina[1]*, Jianfang Qiao[2], Khujanazarov Temur[3], Qurbanov Alisher[4] and Mamutov Nizamiddin[5]

[1]International Platform for Drylands Research and Education, Tottori University, Japan

[2]Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, China

[3]Disaster Prevention Research Institute, Kyoto University, Japan

[4]Karakalpakstan Institute of Agriculture and Agrotechnology, Karakalpkstan

[5]Karakalpakstan State University, Karakalpakstan

ISSN: 2770-6745

***Corresponding author:** Kristina Toderich, International Platform for Drylands Research and Education, Tottori University, Tottori, Japan

Submission: May 12, 2023
Published: May 29, 2023

Volume 3 - Issue 4

How to cite this article: Toderich Kristina*, Jianfang Qiao, Khujanazarov Temur, Qurbanov Alisher and Mamutov Nizamiddin. Mainstreaming Agrobiodiversity Utilization and Conservation-A Key Factor for a Healthy Environment in the Aral Sea Basin. Biodiversity Online J. 3(4). BOJ. 000569. 2023.DOI: 10.31031/BOJ.2023.03.000569

Abstract

Research to date shows that salt-affected land and water resources can be effectively and sustainably used for saline agriculture and food production. It specifically taps into the potential of agrobiodiversity as just about 150 plants are cultivated around the world on a significant scale out of some 30,000 known to be edible. Our study focused on cover vegetation and botanic diversity of Central Asia Cold Desert (CACD) agro-landscapes, prone to salinization and drought. Aside from the overall appeal and appreciation of the Aral Sea Basin region as an important biodiversity hotspot, most of this extraordinarily salt-tolerant agrobiodiversity includes wild halophytes and Neglected and Underutilized Crops (NUCs). We developed an Agrobiodiversity Index (AI) and E-Database including documentation and domestication of wild halophytes species and NUCs, especially those with high potential for food and fodder production.

Keywords: Drylands; Salinity stress; Halophytic flora; Agrobiodiversity Index; Cold desert; Aral sea basin

Introduction

A tremendous and partially irreversible loss of habitats and species, among them globally threatened and endemic, became apparent. Arid lands are expected to expand in the coming decade and require serious and immediate attention from the global community, especially the ecosystem of urgently need for conservation and protection [1]. The Central Asia Cold Desert (CACD) are one of the World's 'Biodiversity Hotspot' providing unique habitats, breeding areas, migratory corridors, and flyways for many rare and threatened species of plants, animals, birds etc. These territories geographically located across "Silk Road Pathway" are the center of origin of majority of cultivated crops: wheat, rye, barley, herbaceous legumes, seed sown roots, fruit trees. CACD are threatened by degradation processes initiated through overexploitation of natural resources, e.g., firewood collection, inappropriate grazing practices and intensive agriculture development. Rapid population growth, conversion of sandy desert into farming lands and overuse of water resources, resulting in degradation of ecosystems and loss of wild native desert species. The vulnerability of this biome is still poorly understood, but ongoing land salinization processes are already putting million people's livelihoods at risk. Conservation of transboundary desert corridors wild vegetation can also be an effective tool for mainstreaming agrobiodiversity conservation requirements into land-use planning and promoting biodiversity-friendly management practices in production landscapes, such as cultivated land, pasture, and dryland forestry.

Unsustainable use of natural resources such as overexploitation of biological resources has led to a sharp reduction in species populations, with some becoming endangered or extinct. For example, the population size of tree-like species of genera Haloxylon, a dominant species to most desert ecosystems in Central Asia, has reduced by 60% [2]. Central Asian countries have a major responsibility for the preservation of cold winter deserts, one of the least protected biomes worldwide. The cold winter deserts are a major migration area for wild ungulates as well as migratory birds and deliver a broad range of ecosystem services, providing the most important pastures in the arid and semi-arid drylands of the region, fixing sand and dust and sequestering carbon. Evident anthropogenic transformation of vegetation occurs in the deltas of rivers due to irrational utilization of water, deterioration of Tugai forest, extensive irrigated agriculture and overgrazing on pasturelands. Powerful factor in the dynamics of vegetation plays contamination of soils, which derives frequently from irrigated agriculture practices (old traditional practices; monoculture, overuse of fertilizers and water for irrigation). The aridity of the climate combine with the absence of outflow in these areas further induces progressive soil salinization. At these areas significant differences in plant communities composition and species richness are reflected in their taxonomic level. The most noticeable is the richness of *Amaranthaceae*, *Plumbaginaceae*, *Asteraceae*, *Poaceae* followed by *Tamaricaceae*, *Nitrariaceae*, *Elaeagnaceae*, *Rosaceae* and *Boraginaceae*. Abundant occurrence of these taxonomic families is considered as phytoindicators of soil salinity. Soil salinization (secondary or human caused salinization) is in progress and is accompanied by decreasing of botanic diversity richness, convergence of plant communities and simplification of the spatial structure of vegetation cover. Vegetation dynamics in these areas goes towards halophylization, i.e predominance of different life forms of halophytes species with high salt tolerance ability [3,4].

Floodplains with Tugai Vegetation

The floodplain forest (Tugai) ecosystem along the Central Asian Deltas rivers 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. Floodplain vegetation are represented mainly by reed tickets (*Phragimites australis* Cav. Trin. Ex Stend, *Phragmites communis* accompanied by *Bolboschoenus maritimus* (L.) Palla, Juncus geraldii Loisel, *Chenopodium rubrum L*. and others. However, in places, where groundwater level decline highly productive red vegetation is replaced by shrubs, semishrublets and herb 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 tree are poplars species, such as *Populus ariana* (Turanga), *Populus pruinosa* (Petta), which form mixed as well as monodominant associations. In the arboreal tier of tugai, *Elaeagnus turcomanica*, *Salix songarica*, *Salix wilhelmsiana* are participate. The *Tamarix* communities are very typical here. The most widespread is *Tamarix pentandra* (Kiziljingil) grows mainly on saline soils. Another typical shrub is *Halimodendron halodendron*. The curtains of Halimodendron 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*, *Erianthus 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 sp and other species.

Agrobiodiversity of Terraces with Meadow Alluvial Soils

Due to the high salinity of soils the natural vegetation is very poorly developed. Fragments of the secondary plant associations are grown on small rivers and channels beds. Licorice (*Glycyrrhiza glabra*, *G. uralensis*) and *Karelinia caspica* communities are frequently common for these meadow alluvial soils. Sometimes together with them grow *Eguisetum ramosissium* and *Sphaerophysa salsula*. In dry habitats, *Alhagi pseudalhagi* and *Zygophillum oxianum* are common, occasionally in combination with *Rhaponticum* repens and *Capparis spinosa*. The composition of the communities includes different species, where the most commonly are species of genera *Alhagi*, *Aeluropus litoralis*, *Astragalus*, *Artemisia*, *Agropyron* with a small abundance of salt-tolerant and halophytic plant species: *Aeluropus littoralis*, *Sphaerophysa salsula*, *Glyzyrthiza glabra*, *Leymus multicualis*, *Suaeda salsa*, *Karelinia caspica*). The productivity of *Alhagi* plant communities (represented mostly by *Alhagi kirgizorum* and *A. pseudoalhagi*) is low, as the vegetation cover is very disperse. *Alhagi* plant associations sometimes forms pure thickets, but more often is accompanied by species that do not have fodder value: *Karelinia caspica, Tournefortia sibirica, Frankenia hirsuta, Bassia hyssopifolia, Tournefortia sibirica*. The productivity of thickets of *Alhagi* on salted soils, which are contaminated by plants that are not eaten-*Karelinia caspica*, *Halostachys caspica* and the poorly eaten *Salsola dendroides*. Steppic serosems with a high content of carbonate and gypsum are occupied by grasslands and Artemisia ephemeral vegetation type with various plant communities. The dominant is representatives of genera *Artemisia* (*Artmesia terrae-albae*, *A. diffusa*, *A. dracunculus*, *A. longipetalus*, *A. eximius*), *Carex pachystylis*, *Poa bulbosa*, annual chenopods, *Bromus tectorum*, *Elytrygia repens*, *Ceratocarpus utriculosus*, *Petrosimonia acuminata* and others. Halophytic steppic-meadows soils with ground water close to the soil surface or by salinization of other meadow types. They cover only small areas. The dominating plants are the grasses *Aeluropus littoralis*, *Puccinellia tenuissima*, *P. dolicholepis*, and *P. diffusa*. Spare stands of reed (*Phragmites australis var. acanthophylla*) with participation of annual saltwort species (*Salicornia europaea*, *Suaeda prostrata*), *Limonium otolepis*, *Bolboschoenus*, *Juncus, Xanthium* and Crypsis are also grown.

Serosems and meadow solonchaks are expanding in low places of relief, to the waste lands of irrigated massifs, to the outskirts of oases, wastewater bodies (places of discharge of channel and drainage water). Due to the increased mineralization of irrigation river waters, in connection with the return of highly mineralized ground and collector waters to the river channel the processes of formation of solonchaks increase, and mainly here forms alluvial-meadow irrigated saline, meadow-marsh, irrigated saline, meadow solonchaks and crust-plump solonchaks. Marsh soils of landscapes of inter-riverbeds depressions during agricultural development become meadow-marshy irrigated, rice-swamp irrigated, and meadow solonchaks in fallow lands. There is an increase in the level of highly mineralized groundwater, which causes secondary salinization of soils in landscapes of inter-riverbeds depressions due to intensive evaporation of soil moisture. Highly saline habitats of these areas are dominated by *Aeluropus litoralis* and *Karelinia caspica*, there are some species of annual saltworts, e.g., *Climacoptera ferganica*, *Climacoptera turcomanica*. (Litv.) *Botsch, Climacoptera turgaica* (Iljin) *Botsch, Climacoptera subcrassa* (Popov) *Botsch, Salsola dendroides*, *Salsola* rigida, S. incanescens, *S. sclerantha*. On the saline gypsum-containing and alkaline soils the hyper-halophytic species represented by *Halocnemum strobilaceum*, Halostachys belangeriana, *Suaeda* corniculata, S.acuminata, *S. prostrata*, S. *salsa, Salicornia europaea L.*, Halimochnemis vilosa, Petrosimonia glauca (Pall.) Bunge, P. oppositifolia, *Atriplex verrucifera* M. Bieb occur.

Agroecosystems of Oases

This zone is dominated saline/sodic is represented by a strongly transformed-large agro landscapes. The natural landscape is transformed at a rapid pace, and with it, new biocenoses are formed. Irrigation and tillage determine the nature of vegetation, create a peculiar microclimate. The basis of the vegetation cover of the cultivated areas of oases is occupied by agricultural crops (cotton, rice, maize, alfalfa, garden and rainfed crops), orchards and forest park plantings, unprocessed-types of wild vegetation close to natural formations. Abandoned farms due to secondary salinization (human-induced salinization) loss their potential agricultural productivity. On the abandoned fields there are thickets of *Elaeagnus*, *Morus*, *Tamarix* accompanied by numerous perennial annual herbs. The abandoned lands on the outskirts of the fields, banks of irrigation canals, unsuitable areas with moist soil, usually densely overgrow with bushes and halfshrubs. In the agricultural landscape, the following groups of wild vegetation are encountered: tugai, solonchak, psammophilous-shrubby, halophytes and hydrophytes (reed, cattail, *Carex*, *Agropyron*, *Bromus*, *Aeluropus litporalis*). In the bed lands, temporarily out of cultural use, formations of *Alhagi* and licorice are developed. Unused moistened areas turn into swamps and swampy meadows. The floristic composition is relatively poor. Our studies concentrated on the analysis of halophytes flora, which is widely recognized to produce fodder stocks for cattle and small ruminants. Three key ecological groups of halophytes have the potential for reclamation of salt-affected soils: Euhalophytes-can dilute and accumulate salts within their succulent leaves and/or stems and thus have the highest salt tolerance among other eco-groups of halophytes, species of genera *Salicornia*, Climacoptera, *Halimocnemis*, Halostachys and other belong to it. The large numbers of halophytes belong to recretohalophyte- species that possess typical salt excretory structures (salt glands; salt hairs, trichomes, etc.) and through exclude surplus of salts out of the plant, such as *Karelinia caspia* (Pall.) Less, species of genera *Tamarix*, *Limonium otolepis*, and other species can accumulate and translocate salts ions (salt-excretion), which exude out the excess salts) in aboveground biomass belong to crinohalophytes. The prominent chrinohalophytes are described among species of genus *Salsola*, *Atriplex*, *Bassia*, *Halimodendron halimodenrn*, *Aeluropus litoralis*, *Glycyrrhiza glabra* [4]. Our Investigation proved that succulent euhalophytes and chrinohalophytes accumulate salts in their cells and/or secrete the substances through their inherent organs/salt glands/trichomes.

Results obtained on salinity management showed that with appropriate plant genotypes, productive agriculture is possible across a wide range of salt-affected lands. Integration of wild halophytes into saline agriculture showed promising results in agroforestry and in mixed farming system with Non-Conventional Crops (NCC), such as pearl millet, quinoa, sudan grass, *sorghum*, indigofera, *amaranthus*, sweet clover, safflower, sesame, mungbean, artichokes, which are characterized as glycohalophytes and pseudohalophytes. Quinoa and Amaranthus are promising protein-rich halophytic pseudocereals with potential to enhance livelihoods food and nutrition [5]. A desktop review has been initiated to look at the halophytic forages widely recognized as a means for forage using saline land and water; factors affecting the utilization of this biomass by ruminants such as sheep, cattle, and goats. This review has focused on three factors that affect livestock production using these plants-biomass production, Nutritive Value (NV) of the biomass and Voluntary Feed Intake (VFI). Use of non-conventional water for establishment of artificial agro-phytocenosis and tree plantation is the key advantage for domestication of economic-valuable native tree, shrubs, and perennial halophytes. An agro-silvicultural model of trees intercropped with complementary crops, especially deep-rooted, early maturing, and frost tolerant legumes and graminous crops were documented [6]. Herbaceous fodder crops planted within the inter-spaces of salt-tolerant trees/shrubs plantations improve productivity of saline prone soils, solve the animal feed gaps in the lands degraded both by overgrazing and salinity, and increase the profits for smallholders. Special emphasis was given to non-conventional cultivation techniques; especially root zone salinity management, irrigation regime, and pest control, agroforestry: deep-rooted planting of poplars, apple, apricot, mulberry, Russian olive trees and different kinds of berry semi-shrubs intercropped with salt-tolerant non-traditional forage crops on saline lands for multi-purpose use.

Conclusion

Using the Central Asia Cold Desert (CACD) underutilized agrobiodiversity that produces diverse, nutritious foods will contribute to the conservation of these precious dryland resources; conserving biodiversity resources will make them available for future climate scenarios and food and nutrient needs for local communities. For this reason, the creation of an Agrobiodiversity

Index (AI) including documentation and domestication of wild halophytes species and NCC can bring production and consumption together, raise awareness about the multiple links between agrobiodiversity, healthy nutrition, and sustainable food production in desert areas, mostly those affected by soil salinity. The Agrobiodiversity Index will help policymakers and the private sector to assess dimensions of agrobiodiversity to guide interventions and investments for a wide variety of nutritious foods while having minimal impact on the environment. Since the climate is changing then agriculture and food must too.

Acknowledgement

This research was supported by the Science and Technology Research Partnership for Sustainable Development (SATREPS), in collaboration with the Japan Science and Technology Agency (JST, JPMJSA2001).

References

1. Spinoni J, Barbosa P, Cherlet M, Forzier G, Cormick N, et al. (2021) How will the progressive global increase of arid areas affect population and land-use in the 21st century? Global and Planetary Change 205: 103597.
2. Yuanming Z, Akash T, Alice CH, Kristina T, Deyuan H, et al. (2023) Challenges and solutions to biodiversity conservation in arid lands. Review. Science of the Total Environment 857(3): 159695.
3. Gus G, Kristina T, Bakhtyor M, Muhiddin M (2003) Rangelands of the arid and semiarid zones of uzbekistan. France.
4. Shuyskaya E, Toderich K, Kolesnikov A, Prokofieva M, Lebedeva M (2023) Effects of vertically heterogeneous soil salinity on genetic polymorphism and productivity of the widespread halophyte *Bassia prostrata*. Life 13(1):56.
5. Toderich KN, Mamadrahimov AA, Khaitov BB, Karimov AA, Soliev AA, et al. (2020) Differential impact of salinity stress on seeds minerals, storage proteins, fatty acids, and squalene composition of new quinoa genotype, grown in hyper-arid desert environments. Frontiers in Plant Science 11: 607102.
6. Toderich KN, Khujanazarov T, Ibraeva M, Toreshev P, Bozaeva ZH, et al. (2022) Manual Innovative approaches and technologies for salinity management of marginal lands in Central Asia.