Study on desert agrophytocenoses on the drained bottom of the Aral Sea

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Abstract. The drained bottom of the Aral Sea encloses an area of around 6 million hectares, of which 3.2 million hectares are located on the territory of the Republic of Uzbekistan. In addition to the removal of salt, dust and sand from the dried seabed, which cause enormous damage to the environment, there is 1.5 million hectares forest-usable area on the Aral Sea, which in turn, can be seen as an opportunity to create desert shrub agrophytocenoses. The aim of this research was to develop the most effective strategies for establishing desert agrophytocenoses on the afforestationable area of bottom sediments of the drained Aral Sea and to select desert forage plants for increasing the productivity of the pastures created. Studies have shown that with the use of focal, pasture-protective and reclamation-forage methods, as well as forage plants such as chogon, teresken, boyalych, keireuk, it is possible to create pastures with a feed capacity of up to 500 feed units per 1 hectare. This will increase the number of grazed animals by 20-30%. The results can be applied to sediments from the drained Aral Sea bottom that are of the afforestationable type. In the near future, the drained bottom of the Aral Sea will serve as a reserve for animal feed, opening up new opportunities for the development of an animal husbandry industry in the Aral Sea region. At the same time, forage plants will fix the soils of the drained bottom of the Aral Sea, greatly enhancing the region's ecological situation.

1. Introduction

At the 75th UN General Assembly, a resolution was adopted according to which the Aral Sea region was granted the status of an environmental innovation and technology zone. This decision obliges the residents of the Aral Sea region to find new innovative approaches to solving the problem of the Aral Sea, to develop science-based technologies, to search for a more extended varieties of desert plants, including forage. On the drained bottom of the Aral Sea, minority of forest plantations have an impact on wind erosion development, which prevents the natural renewal of pasture plants, causes low pasture productivity and complete or partial land degradation.

According to the conclusion of two UN Secretaries-General Ban Ki-moon and Antonio Guterres, the situation around the Aral Sea is of a planetary nature. In addition to the fact that the drained bottom needs forest reclamation, there is a need to use it in economic turnover through the creation of desert agrophytocenoses, i.e. pastures [1]. This is particularly essential for Uzbekistan now in the population growth period (Uzbekistan has more than 34 million people). Uzbekistan has taken measures of self-sustainability with food and especially, livestock products. [2]. To reach these targets, increasing the number of cattle and sheep in a yearly basis is needed. But, it is not an easy task since there is a lack of feed for animal. Establishing supplementary grasslands on irrigated lands is a complex task, for the reason that other agricultural yields with strategic importance to the state are grown on them. And watering additional pastures becomes more and more difficult every year, as there is a high level of water shortage [3]. Between 2019 and 2021, in the homesteads of the local population of the Muynak district, all the crops planted were died as a result of the water scarcity for irrigation.

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Based on FAO and UNEP, 6 800 000 km^2 territory of the Earth has been degraded due to overgrazing, 1.370 00 km^2 due to cutting down trees for cooking and warming houses. It should be emphasized that as stated by the mentioned sources, 5 500 000 km^2 of the area has been degraded as a result of inappropriate farming and improper watering [4].
If until recently the improvement on the animal husbandry done by the development of still uncultivated pasture areas, now this reserve has nearly been finished. However, in Uzbekistan there is another source where pastures can be created. These are afforestationable areas of dry seabed areas of the Aral Sea. People think that the drained bottom is solid sands and salt swamps. This is not the case at all. Inappropriate sort of bottom sediments settle an area of around 35%, and the area on which desert pastures can be established is 1.5 million hectares [5]. On this area, with proper application of scientific recommendations: Novitsky Z.B. - Recommendations on methods for creating pastures on the drained bottom of the Aral Sea (Tashkent, 2014, 24c.), Recommendations for creating desert pasture agrophytocenoses on the drained bottom of the Aral Sea (Tashkent, 2017, 18c.), Recommendations for creating pastures from forage plants on the pastures with an efficiency of 400-500 fodder units per 1 ha can be created on lightly overgrown sandy sediments subject to deflationary processes on the drained bottom of the Aral Sea (Tashkent, 2020, 21c.). We are convinced that in the future this Region can become a source of feed for the Aral Sea Region, which is announced as a zone of ecological innovations and technologies [6].
The aim of the study is to establish ways and select suitable desert forage plants for creating pasture agrophytocenoses on forest–suitable types of bottom sediments of the drained bottom of the Aral Sea.

2. Methods

The investigations were carried out on afforestationable kinds of bottom sediments of the drained bottom of the Aral Sea from 2012 to 2020. The method of forming desert pastures was studied, the representatives of fodder plants was selected, the efficiency of the created agrophytocenoses was also considered. The work was accomplished on the basis of a State programs on research projects: KHI - 5 - 012 - 2016; KHA - 7 - 026 - 2015; KX - A - KX - 2018 – 110; I-BV-KX-2019-4.
The focus of research were the types of bottom sediments with a chlorine salinity of below 0.04% and granulometric composition related to sandy loam and loamy soils [7].
The techniques of forming desert shrubbery pastures were pasture-protective, reclamation-forage and focal forest plantations.
The variety of forage plants were composed of the following breeds: teresken gray - Ceratoides latens J.F.Gmel., chogon -Aellenia subaphylla (C.A.Mey.) Aellen.), keireuk – Salsola orientalis S.G. Gmel., boyalych – Salsola arbuscula Pall., izen - Kochia prostrata (L.) Schrad., In addition the main forest-forming breed is the black saxaul - Haloxylon aphyllum (Minkw.) lljin. The soil was treated with chisel aggregated on a T-150K tractor, followed by sowing seeds or planting yearly seedlings. The above-mentioned desert forage plants, which make the basis of the pastures being created, were tested. All the works were conducted by laying experiments in the field in 10-12 multiple repetitions.

3. Results and Discussion

Let's explore the long-term research findings about the development of pasture agrophytocenoses using a diverse variety of desert fodder plants. Nobody has looked at the possibility of cultivating a wide variety of fodder plants on the Aral Sea's dried-out bottom in order to establish a desert pasture agrophytocenosis. As a result, this work was carried out for the first time, and in the spring of 2015, a series of studies to create desert pasture agrophytocenoses were started, in which two or more forage plant species were included. The experiment's foundation was a statistical technique involving the seeding of fodder plant seeds. During the growing season, soil humidity was examined and biometric measurements of growing plant seedlings were carried out. It is known that the growth and development of plants, especially in the first year, is greatly influenced by soil moisture. The still weak-developed root system of plants are located in the horizon up to 15 cm, so this is where the moisture plays an especially important role. Under the sprinkling of seeds, the soil was treated with chisel, and the humidity was studied by months by the thermostatic-weight method, both on the control and on the soil treated with chisel.
May 2015 saw precipitation totals of 70.9 mm, or almost the mean annual average, which permitted a humidity of 3.60-8.38% in the 0-20 cm horizon (Table 1). In the 0-5 cm layer, soil humidity ranged from 6.80% in April to only 1.12% at the end of the growing season in September. 2015 was a good year for forage plant shoots to appear in the agrophytocenosis and for seeds to thrive.. But, in June and July there was a strong hot weather, the air temperature increased up to 500 C, and on the Earth's surface it was exceeding 600 C, which caused the burning of the leaves of teresken and other types of forage plants that had not yet grown strong. Nevertheless, the leaves were burned, the root system of the seedlings of plants is alive.
In September, based on the autumn calculations results of the number of plants left after the hot weather in summer, the root systems of Chogon and teresken were excavated. The condition of root systems in 22 sample plants were

investigated. It became clear that the roots from sown seeds in depth spread on average by 15-17 cm and horizontally by 10-12 cm. The hot temperature in summer did not have a harmful effect on the condition of the roots. They were they were active and growing and when received extra moisture reserves because of winter-spring precipitation, the roots began their biological progress.

Table 1. Soil moisture (%) based on the variants of experience in creating pasture agrophytocenoses (2015)

Horizon depth, cm	Months of research				
	April	May	June	July	September
Option with the treatment of the soil with chisel					
0 - 5	6.80	3.60	2.56	1.98	1.12
6 - 10	7.34	5.06	3.45	2.21	1.75
11 - 20	10.08	8.38	6.12	3.24	2.22
21 - 40	21.77	22.40	17.65	15.46	12.41
41 - 60	26.60	28.93	26.71	23.45	22.34
Drained bottom not subject to soil treatment (control)					
0 - 5	5.43	2.77	2.21	1.78	1.12
6 - 10	6.10	4.10	3.42	2.36	1.76
11 - 20	8.75	7.31	5.41	3.42	2.23
21 - 40	20.95	21.45	17.64	15.41	12.54
41 - 60	26.10	27.98	23.45	21.29	17.68

Table 2. Calculating the forage plant seedling density (pcs/m2) in the newly formed desert agrophytocenoses on the Aral Sea's dried-up bottom in 2015

Plant type	Time of accounting for the number of seedlings by month			
	13 may number of shoots	6 june number of shoots	30 july number of shoots	15 september number of shoots
Chogon-teresken agrophytocenosis				
Aellenia subaphylla	21.1±0.73	23.2±0.82	23.7±0.70	18.4±0.48
Ceratoides latens	29.0±0.72	31.3±0.62	32.3±0.51	27.6±0.60
Total:	50.1±0.73	54.5±0.70	56.0±0.60	45.0±1.08
Boyalychevo-keireukovy agrophytocenosis				
Salsola arbuscula	2.6±0.37	3.9±0.34	2.3±0.27	1.0±0.17
Salsola orientalis	3.0±0.33	4.0±0.45	2.3±0.26	1.0±0.15
Total:	5.6±0.35	7.9±0.40	4.6±0.27	2.0±0.32
Saxaul-Circassian agrophytocenosis				
Haloxylon aphyllum	9.2±0.69	11.0±0.64	9.9±0.68	6.6±0.59
Salsola Richteri	2.9±0.38	5.0±0.44	3.0±0.37	1.5±0.20
Total:	12.1±0.53	16.0±0.54	12.7±0.52	8.1±0.79
Chogonno-keireukovo-boyalychovo-teresken agrophytocenosis				
Aellenia subaphylla	24.8±1.05	26.5±1.18	24.6±1.0	20.1±0.93
Salsola orientalis	1.8±0.29	3.5±0.34	1.9±0.18	0.7±0.13
Ceratoides latens	28.5±0.96	30.0±0.89	27.5±0.90	23.1±0.96
Salsola arbuscula	1.4±0.25	2.6±0.42	1.5±0.25	0.7±0.15
Total:	46.5±0.63	62.6±0.70	55.5±0.58	44.6±2.17

As this experimental studies have shown, the most favorable conditions for the growth of forage plants on the sandy loam plain of the drained bottom of the Aral Sea are in teresken and Chogon, less favorable in boyalych and keireuk. In the chogonno-tereskene agrophytocenosis there are 45 ±1.08 plants per meter square, and in the Boyalychevo-Keireuk agrophytocenosis there are only 2 plants (Table 2). For establish desert shrub pastures, creating multi-species agrophytocenoses is recommended, as for example chogonno-keireukovo-boyalychevo-teresken agrophytocenoses wherein there have 44.6 ± 2.17 pieces of plants per 1 m2, which will enable 4-5 years of growing period in order to get fertile pastures with an opportunity of up to 500 fodder units per 1 ha.

Identifying the stock of fodder weight in the air-dry state on the above-mentioned experimental options in September 2017 revealed that the volume of pastures in the chogonno–teresken agrophytocenosis was 562±12.4 kg/ha, boyalychevo-keireuk agrophytocenosis - 118±4.7 c/ha, Saxaulovo-Cherkezov agrophytocenosis – 285±7.9 c/ha and in chogonno-keireukovo-boyalychevo-tereskene agrophytocenosis, respectively, 522±12.7 c/ha. According to the experimental data, even though the ground mass was negatively impacted by the first year's intense heat, the protected root systems of the plants allowed them to recover due to the buildup of moisture in the winter and spring. As a result, by the third year of their growth, the plants had formed pastures with a plentiful supply of fodder weight.

The targeted approach, as well as the development of pasture-protective forest and reclamation-feeding strips, were the primary ones that we evaluated while conducting scientific study on the drained bottom of the Aral Sea (project KX-A-KX-2018-110).

The development of pasture-protective forest strips from black saxaul is of utmost importance to forest reclamation research, which is creating strategies that allow for the construction of pastures on the drained bottom [8, 9]. The importance of these bands in enhancing the microclimate when establishing pastures cannot be overstated. Forest plantations, a biophysical body and a dynamic component of desert environments, control the drainage of moisture from the soil and the growth of vegetation, prevent the formation of deflationary processes, and considerably improve the wind regime of interbond gaps [10].

Foresters have a crucial job to do: gather moisture, conserve it, and use it wisely. In the summer, when the exposed area of the drained bottom feels extreme heat, minimizing evaporation beneath the protection of the strips is essential for the survival of plants. The experiment demonstrated that the daily moisture saving under the protection of forest strips is 11.3 mm. With the protection of forest strips, evaporation reduced by 31.3% during the day in April, by 46.4% at night, by 25.3 and 30.6% in May, and by 26.0 and 48.7% in June-July. Forest strips not only bind the soils on the drained bottom, but by reducing evaporation, they create additional moisture reserves in the soil for the growth of forage plants, which is especially important for the drained bottom, where the annual precipitation rate does not exceed 90 mm per year [11]. As our research has shown, forest strips from saxaul contribute not only to better growth and development of forage plants, but also significantly increase its nutritional value. In addition to binding the soils on the drained bottom, forest strips also increase soil moisture reserves for the establishment of forage plants by reducing evaporation, which is crucial for the drained bottom where the annual precipitation rate is less than 90 mm per year [11]. According to our research, saxaul's forest strips considerably boost the nutritional value of forage plants while also promoting their better growth and development. According to our zootechnical investigation, forage plants protected by forest strips contain 1.0-2.7% more protein and protein than open pastures on the drained bottom, but the amount of water is also higher by 2.4-17.0% and the amount of fiber is lower by 0.32-5.16%. Because of the higher humidity in the areas protected by forest strips, the feed is thus more nutrient-dense and easier for animals to consume [12].

The location of the protecting forest strips is determined by the area where the wind is active. The distance between the lanes can increase with a weaker wind condition (90-120m). The separation between the bands is 30–50 m in locations where there is intense wind activity. Three rows are used to form the stripes. In the interstitial areas, seeds of forage plants such chogon, teresken, boyalych, keireuk, and izen are sown [13].

Reclamation and feeding strips, which can be found both in open areas and on the interbond spaces between protected forest strips, have developed on the drained bottom of the Aral Sea. In open sections of the drained bottom, reclamation and feed strips are set 10 m apart from one another. These strips, which are primarily made of forage plants, are planted in interstitial spaces with a distance of 20 m between them. Within two to three years, forage plants reach the fruiting stage, and under the influence of the wind, the seeds disperse throughout the entire interbond space, resulting in the formation of enriched desert pastureland [14According to studies, there were 6-8 plants per square metres in the third year following the establishment of reclamation and forage strips in the interstitial areas as a result of self-seeding.

The soil is treated with strips 1.5 meters wide using a chisel or disc harrow in order to create reclamation and feed strips. Along the loosened sections, shrub and semi-shrub seeds are sowed. Chogon, keireuk, and teresken produced the best results in the accumulation of phytomass of the analyzed variety of plants. After gathering and assessing the purity of the seed pile and laboratory germination, the aforementioned breeds' seeds are sown in the autumn, winter, and spring. Rolling is done after seed sealing with tooth harrows. Chogon seeds should be placed in neat rows, and keireuk and teresken seeds can be mixed together and sown at the same time [15].

Different types of bottom sediments, ranging from light granulometric composition soils to heavy, and to varying degrees saline, up to malevolent salt marshes, represent the drained bottom of the Aral Sea [16]. We investigated the focal method, which basically consists of placing 7–10 sites (foci) with a dimension of 2 x 2 meters on 1 hectare of the drained bottom. This method is one of the most promising ones for establishing pastures. These locations are used to sow the seeds of forage plants, which take 2-3 years to reach the fruiting stage before their seeds are dispersed by the wind to cover the entire area (pastures). Studies have revealed that by the fifth year, the whole area where the forage plant foci were laid was covered with forage plants. These plants then produced seeds, and their expansion was exponential. 5060 kg, or 2176 fodder units, of air-dry fodder were present on one hectare of these pastures (kg).

On the drained bottom of the Aral Sea, where vegetation only rarely grows, the forest and fodder plantations established play a crucial function [17]. This is particularly significant right now because there has been a significant increase in carbon dioxide emissions, which has led to a fall in oxygen levels and warmed Earth's climate. Uzbekistan signed the Kyoto Protocol in 1997, and it came into effect in 2005. Without vegetation, it is impossible to comply with the Kyoto Protocol's key requirements. The planet as a whole benefit from forests' resistance to the greenhouse effect [18]. Forest plantations and pastures made from fodder plants on the drained bottom are significant in this regard. They are a biological factor that can restore the Aral Sea region's population to health, address the issue of feeding animals, and reduce the incidence of deflationary processes, which improves air quality by lowering carbon dioxide and boosting oxygen [19].

Ecological, economic, and social implications are associated with the development of desert shrub pastures on the drained bottom of the Aral Sea [20].

environmental. Forage plants have roots that hold the soil in place and prevent it from being eroded, which reduces the frequency of deflationary processes. As a result, less salt and dust are removed, which reduces the fertility of irrigated lands and stabilizes crop yields. Additionally, cleaner air that people may breathe would improve the local population's gene pool.

- *economic.* The drained bottom's forest-friendly types of bottom sediments serve as a reserve for the creation of a base for animal husbandry in the region. There are existing techniques for developing desert agrophytocenoses on the drained bottom employing a variety of fodder plants. When establishing desert agrophytocenoses, a properly chosen variety of fodder plants will enable an increase in pasture capacity of 500 fodder units per hectare. In comparison to natural pastures, the number of grazed animals can be raised by 20–30%, and as a result, the people of the region can be supplied with livestock products.

- *social.* The scientists at the Forestry Research Institute also see their mission as helping the local populace develop animal husbandry since they will have access to feed by creating multi-component pastures. According to our instructions, forestry organizations are already establishing pastures on the drained bottom of the Aral Sea, where people will congregate and graze their livestock. The local population will be heavily involved in animal husbandry if these groups of people (communities), who will graze 40–50 cows, are given access to mini dairy processing plants, which the machine will pick up once a week for sale through the retail network, and which the following week bring money for the delivered dairy products. People will begin breeding pets if they start to feel that their labor is valued and that they can support their families comfortably with the money they make. The outcomes of the study on the development of pasture agrophytocenoses will make it possible to put together a movement for the growth of animal husbandry on the drained Aral Sea bottom. It will begin as a Start and transition into Motion later on. By establishing grazing agrophytocenoses on the Aral Sea's drained bottom, we will be able to consolidate the bottom and address social difficulties affecting the local population [21].

4. Conclusions

Based on the research findings, it can be suggested that a variety of fodder plants can be used to develop desert pasture agrophytocenoses on afforestationable types of bottom sediments of the drained bottom of the Aral Sea. It is advised to use the focal method of establishing pastures, as well as pasture-protective and reclamation-forage afforestation techniques, to accomplish this goal. These techniques will fix the drained bottom and protect it from blowing soil particles, as well as increase the forage productivity of the area and increase the number of grazed animals by 20–30%.

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