Solutions of desertification in the current Amudarya delta

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Abstract. This article presents several factors contributing to the desertification processes in the current delta of the Amu Darya River. It also examines how the gradual process of desertification, along with the acceleration of soil salinization and the expansion of saline areas, is occurring due to the lowering of the groundwater levels in the current delta of the Amu Darya. The northern part of the present delta of the Amu Darya is divided into small deltas of varying ages: the highlands of the Amu Darya channel, the Kazakdarya, Raushan, Kipchakdarya, Oqboshli, and Erkindarya, while the southern part is separated into the highlands of the Amu Darya channel, the Uldarya, Kiyatjargan, Shurtomboy, and Kizketken-Chimboy. Due to the high and very high salinization of the soils in the inter-channel depressions in the eastern part of the Kizketken-Chimboy small delta, their use for agricultural purposes is inefficient, and their use as pastures for livestock is suggested. A comparison was made between the desertification processes in the Kazakdarya branch and the Kohnadarya branch. In the lower part of the Kohnadarya branch, salinization occurs due to salts brought from the Aral Sea in the geochemical composition of the eluvial elementary landscape. In the upper parts of the small deltas, desertification is slow due to the influence of the Amu Darya, while in the lower parts of the deltas, desertification is progressing more intensively. In general, the importance of relief features such as channel heights, their slopes, and inter-channel depressions related to surface water flow has been highlighted in the deterioration of the geoecological condition in deltas.

1 Introduction

In the conditions of global climate change, the growth of the population in the world leads to an increase in the need for the use of natural resources and, at the same time, the emergence of desertification and degradation. Paragraph 15 of the UN program for sustainable development until 2030 defines tasks aimed at "protecting, restoring and rationally using terrestrial ecosystems, combating desertification, stopping land degradation, and preventing the loss of biological diversity". These tasks require the research of desertification processes occurring under the influence of anthropogenic and

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natural factors in arid climatic regions and the development of measures to prevent it. Land desertification leads to the extinction of biospecies and exacerbates climate change. Global warming and changes in how land is used, especially deforestation, are among the biggest factors responsible for humanity's breach of this planetary boundary.

Desertification is currently one of the global problems facing humanity and causes enormous economic, social and environmental damage to nature and society. Almost one-third of the land is arid lands, and one-sixth of the Earth's population lives in these lands. Desertification is spreading from densely populated plains to relatively sparsely populated areas, as well as to high-altitude plains and sparsely populated mountainous areas. The main reason for this is an increase in the population and anthropogenic pressure on nature. Desertification processes are associated with such problems as climate change, reduction of biological diversity, desiccation of soils and increased degradation. On the territory of our Republic there are arid and semi-arid territories exposed to natural salinization, sand dunes and dust storms. It is noted that such changes cause soil degradation, deterioration of reclamation conditions of soils and arable lands, increased erosion processes, acceleration of such negative natural and geographical processes as soil and plant degradation. In addition, the current Amudarya delta also leads to changes in ecological ecosystems due to desertification process, reduction of fertile land productivity, climate degradation and desiccation. At present, the desertification process in the current Amudarya delta in a very short period of time leads to changes in all types of geosystems, including natural and anthropogenic landscape complexes.

Study Area. The current delta of the Amudarya begins from the city of Nukus and continues to the border of the Aral Sea in 1961.It is the most impressive area with 19,000 km^2 where the desertification process is accelerating. (Figure 1). G.V. Lopatin, who studied the geology of the modern Amudarya Delta, divides the delta into two parts: 1. The southern part in automorphic and hydromorphic modes: the small deltas of Kizkentgen - Chimboy, Shortanboy, Erkindarya are on the right bank of the modern delta of the Amudarya. The small deltas of Uldarya and Kiyatjargan are located on the left bank of the modern Amudarya delta.

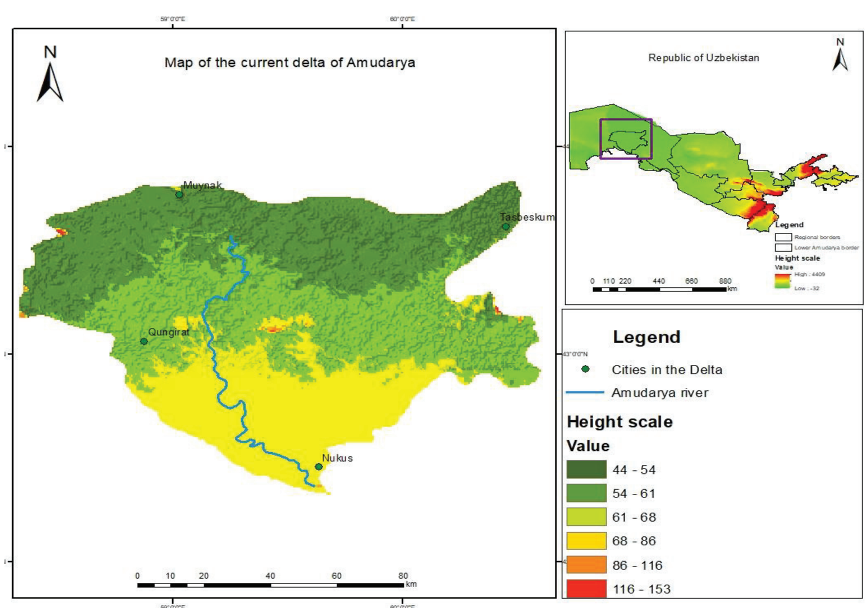

Fig. 1. Study area: Map of the Amudarya delta.

2. The northern, i.e. the "living part" of the hydromorphic regime of the Small Kunadarya-Kazakdarya Delta was located on the right bank of the current Raushan, Amudarya delta, and the small Akbashli Kipchakdarya delta on the left bank of the current Amudarya delta. The main reason why the northern part is considered a "living part" was that the development of hydromorphic soils continued here. Indeed, in this northern "living part" of the delta, the soils of the hydromorphic regime prevailed until 1961, that is, on the one hand, in the Amudarya and its tributaries Kazakhdarya, Akbashli, Kipchakdarya, etc. there was almost no water, and on the other hand, the influence of the Aral Sea on the "living part" of the delta is estimated to be very strong.

Formed deltas appear simultaneously, without dying off, they differ from each other in their age. In the lower reaches of the Amudarya, the earliest delta of the Sarikamish was formed, the age of which is 17-18 thousand years, and the delta of the Akchadarya is 10-12 thousand years old. The age of the current delta of the Amu Darya is 5,000,000 years, and the younger deltas in the northern part (Kazakhdarya, Akbashli, Kipchakdarya) are 2,500 years old. If we look at the history of the formation of small deltas of the modern Amudarya delta, we can see a certain pattern. Along with the formation of the small deltas of Shurtamboy, Kizketken-Chimboy on the right bank of the current delta of the Amudarya, the small delta of the Uldarya is also being formed on the left bank. After the formation of these small deltas, the river moves north. Due to the large flow of water in the river, several networks are separated, as a result of which a small delta of the Erkindarya is formed on the right bank, and a small delta of the Raushan is formed on the left bank.

If we pay attention to the small deltas of Raushan, Akboshli, Kipchakdarya, located on the non-irrigated areas of the left bank of the current Amudarya delta, then this is the last small delta. Since 1961, due to the limited water consumption of the Amudarya, after which there were no small deltas on the left bank, each branch separating from the Amudarya has its own small section of the delta. If we analyze the relief map of the region, the watershed with the largest area is located to the west of the highlands along the Amudarya bed and to the east of the small delta of the Kipchakdarya. Due to the fact that the relief on one side is very low, and on the other side is the end of surface water flows, salinization always prevails in the soils.

2 Materials and methods

Natural geographical processes occurring in Amudarya deltas are also related to the "woody" landscape structure of the deltas, the desertification process in these areas is slow due to the influence of the Amudarya on the upper parts of small deltas, while in the lower parts of the deltas the desertification process continues intensively.

Soil salinization, which is one of the main causes of desertification, depends on the groundwater level. In the Republic of Karakalpakstan, where the current Amudarya delta is located, if we analyze the division of infiltration waters into sections by the depth of the infiltration water level on irrigated lands, in 2020, filtration waters were located up to 0-1 meter make up 3%, filtration waters located at a depth of 1-1.5 meters make up 12%, the largest area of the region, i.e. 50 percent, falls at a depth of 1.5-2 meters. 35 percent of the total area is occupied by seepage water located at a depth of up to 2 meters (Figure 2). Soil salinization, which is one of the main causes of desertification, depends on the groundwater table (Tab.1). In 65% of irrigated areas of the region, the depth of groundwater does not exceed 2 meters. This situation will definitely affect soil salinization and, accordingly, the acceleration of desertification in the region.

Table 1. Results of some physico-mechanical indicators of soils in the Kungirat collector system.

Soil type	Depth (cm)	pH	Dry residue (%)	on a mg-equivalent basis						Salinity level	Mechanical composition
				HCO_3^-	CL^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	$Na+K^+$		
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Grass-barren soil (Upper part of Ravshan delta)	0-0.5	7.7	0.32	2.10	0.90	0.48	1.02	0.16	2.30	Weakly salted	Sand
	0.5-14	7.9	0.43	1.17	0.41	3.48	2.50	0.16	2.40		light sand
	14-28	7.8	0.86	0.50	5.94	4.31	3.77	1.48	5.50		medium sand
	28-50	7.8	0.24	0.47	2.12	0.56	1.17	0.82	1.16		Sand
	50-62	8.1	0.08	0.45	0.74	0.21	0.66	0.26	0.48		Sand
	82-106	8.2	0.31	0.57	2.49	1.02	1.58	1.43	2.07		light sand
	106-133	8.2	0.14	0.55	0.64	1.18	0.87	0.92	0.58		Sand
Grassland-desert soil (middle part of Ravshan delta)	0-3	7.8	0.75	0.87	0.96	6.94	6.48	0.72	1.57	Medium salted	light sand
	3-10	8.0	0.81	0.80	2.49	6.33	4.95	2.70	1.77		medium sand
	10-16	8.0	0.30	0.62	1.44	1.61	0.94	1.53	1.20		light sand
	16-57	7.8	0.12	0.47	0.43	0.68	0.45	0.85	0.28		Sand
	57-65	8.3	0.08	0.50	0.19	0.43	0.22	0.58	0.42		Sand
	65-76	8.3	0.24	0.57	0.67	2.20	1.08	1.26	1.10		light sand
	95-125	8.4	1.41	0.75	1.82	18.8	3.37	4.50	13.5		medium sand
	125-150	8.0	0.33	0.62	1.29	2.62	1.17	1.08	2.26		Sand
	150-205	8.2	0.52	0.57	1.92	3.09	1.98	2.07	1.53		light sand
Meadow-salary soil (lower part of Ravshan delta)	0-2	8.2	3.46	1.92	18.86	22.69	16.20	12.15	15.12	Very strongly salted	light sand
	2-5	8.1	3.31	0.65	18.86	24.36	15.93	7.83	20.11		Sand
	5-18	8.0	0.85	0.55	6.44	5.62	2.70	2.16	7.75		light sand
	18-42	8.3	1.06	0.65	6.73	6.52	3.35	2.48	10.07		light sand
	42-59	8.3	1.40	0.65	6.40	14.16	7.67	3.13	10.41		medium sand
	59-80	8.5	1.21	0.62	6.15	12.16	5.72	3.02	10.19		light sand

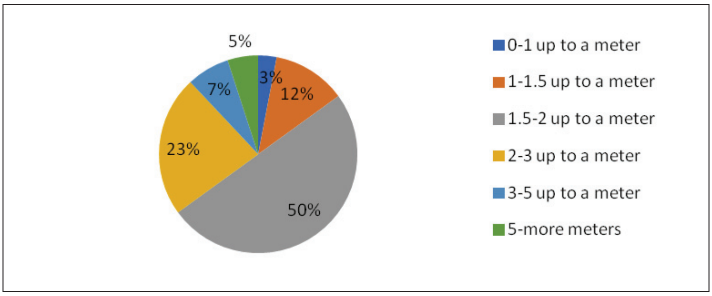

Fig. 2. Division of areas by depth of infiltration water on irrigated lands in the Republic of Karakalpakstan in 2020.

3 Results and Discussion

In the irrigated areas of the modern Amudarya delta, changes in landscape types and deterioration of melioration conditions are observed. Because the collectors in this area poorly drain groundwater due to the different slopes of some sections of the delta. As a result, salt accumulates in low-lying areas, causing swamping.

A.K. Urazbaev divides the modern Amudarya delta into small deltas of different ages, including the uplands of the Amudarya valley - Kazakdarya, Raushan, Kipchakdarya, Akboshli and the Erkindarya delta in the northern part, as well as the uplands of the Amudarya valley - Uldarya, Kiyatjargan, Shurtomboy and Kizketken-Chimboy Delta in the southern part.

Three relief groups of the modern Amudarya delta (uplands, mountain slopes, interdelta depressions) directly affect the geo-ecological situation in the delta and acceleration of desertification process. The soil cover of the highlands differs from the lowland soil cover in terms of salinity and groundwater level. In short, it is reasonable to consider the magnitude of the role of valley uplands, valley upland slopes, and interdrainage depressions associated with surface water flow in degrading the geo-environmental conditions in deltas. The emergence of delta landscapes is connected with the process of surface water runoff, this process forms soils in the delta, their lithologic composition and microrelief forms. Because of this river flow and relief are related to the water level in the delta, hydromorphic group landscapes were formed first. Semi-hydromorphic, automorphic group landscapes began to form as a result of decreasing water consumption of the Amudarya, drying up of some of its networks, formation of small lakes, and changes in the hydrothermal regime of soils in the delta.

4 Conclusion

If we analyze the topography of the modern Amudarya delta, the largest depressions are around Sudochye Lake, between the Kukhnadarya upland and the Amudarya upland, between the Akboshli upland and the Amudarya upland, as well as between the lower part of the small delta of the Erkindarya and the Amudarya, the elevation of the Kizketken-Chimboy small delta in the area adjacent to Lake Karateren and other lands; - in the organization of artificial reservoirs, a special role is played, first of all, by the water consumption of the Amudarya, as well as the height of the surrounding riverbed with the height of the lowest place, i.e. the greater the differences between the lowest and highest territory, the greater the capacity and area of the artificial reservoir formed there; the development of economical ways of using water resources, the introduction of the issue of payment for the use of water in the transition to market relations; - after harvesting grain crops, nothing is planted on empty land, while land unprotected from summer heat heats up and causes severe salinization due to excessive evaporation; - when designing crops, take into account the mechanical composition of soil, delta elevations, slopes of uplands and depressions between deltas.

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