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CHANGES IN THE COAST OF THE SEFID-RUD RIVER DELTA (IRAN)

Now most of the river deltas in the world are subject to a universal process - changing their land cover and shoreline. This process is caused by regulation of river flow in the interests of hydropower, irrigation, water supply, flood control, etc., as well as economic activities in deltas. Such changes occur differentially depending on the nature of flow regulation, climatic conditions, and geomorphological features of the territory, land use, surface subsidence, sea level rise and other factors. The scale of changes in the natural environment in the deltas is very significant. Sometimes it is devastating, for example, in the deltas of the Syrdarya and the Amudarya. Since the time of such profound changes in the nature of the deltas that appeared in the first half of the last century in the Colorado Delta, and in the second half of the 20th century in the deltas of Central Asia, Europe and other regions, large scientific schools of hydrologists, soil scientists, geographers, particularly in Ukraine, were formed for their study.

The specific features of land cover change processes in the deltas of the Black Sea and Caspian Sea coasts are determined by the fact that they are caused by river runoff regulation, population growth and economic activity amplification. Another important factor in these changes is the impact of waves and sea currents that cause shore erosion or sediment accumulation. A significant factor is the fluctuation in the sea level, especially in the Caspian Sea, where, since 1996, the sea level has been decreasing at a rate of about 7 cm per year. When analyzing the changes in these deltas, much attention is paid to biodiversity problems and the conservation of wetland (so-called "Ramsar" sites) as bird habitats. This problem is especially important for the delta of the Sefid-Rud River in Iran, where the Ramsar Convention on Wetlands Protection was adopted in 1971 (The Convention on Wetlands of International Importance, especially as Waterfowl Habitat). The Sefid-Rud is a large river in northern Iran, which is formed by the confluence of the mountain rivers Kyzylozen and Shahrud at the north slope of the mountain system Elborz (Alborz). When it enters the Caspian Sea, it forms an extensive delta bordered from the south and southwest by proluvial-alluvial cones of debris (Figure 1). It was at the confluence of the main tributaries of the river that Shahbanu Farah hydroelectric power station with a dam over 100 m in height was built in 1962, and a Shabanau reservoir was created, later renamed Manjil Dam, regulating the flow of water.

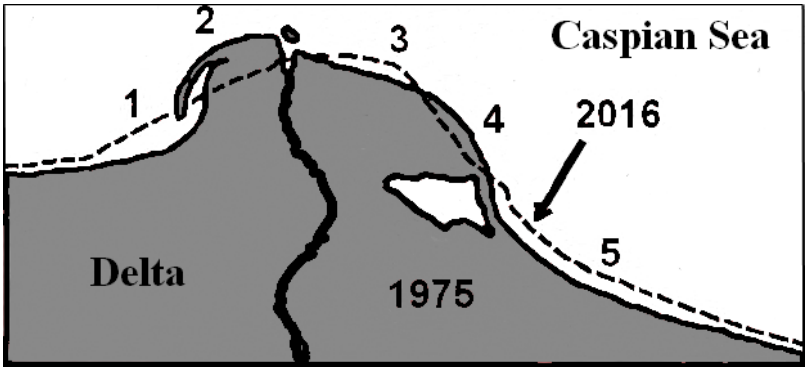
The length of the Sefid-Rud along with the largest tributary of Kyzyl-Ozen is 720 km, the catchment area is about 56.2 thousand km². The water supply of the river is mixed – by snow, glacial, rain and underground water. The average annual water flow in the channel is about 130 m³ / s, but it is subject to considerable fluctuations - from 600 m³ / s in spring during the melting of snows and in the fall during heavy rains to 70-80 m³ / s during the winter low water. The climate in the lower reaches of the river is humid, subtropical, with an average temperature of January + 11 ° and July + 26 °, precipitation of 1,000 mm and more per year in the strip between the Elborz Mountains and the Caspian Sea. In the southern part of the basin precipitation is from 200 to 400 mm.

The delta of the Sefid-Rud is projected into the sea for about 20-25 km and merges along the edges with deltas and cones of small rivers and temporary watercourses along (along the sea edge) 70-75 km. Actually, the delta of the Sefid-Rud extends from the Anzeli estuary to (roughly) the village of Rudsar. Previously, the delta of the river was actively being pushed into the Caspian Sea, but after the construction of the Manjil dam, the pace of its extension decreased noticeably. The construction of the Manjil dam with a reservoir of 1.86 km^3 made it possible to reduce the threat of severe flooding in the delta, where more than 238 thousand hectares of land are irrigated for rice, wheat, orchards, and vineyards. But it also had a negative impact on fisheries due to reduced water runoff, increasing its temperature, reducing nutrients, especially for sturgeon and Caspian trout. Now in the Sefid-Rud basin (mainly in the mountainous part) no less than 14 dams are being built for water supply, hydropower, and irrigation. In general, a typical conflict in the use of water resources in the upper and middle parts of the basin and, on the other hand, in the lower reaches is observed in the Sefid-Rud basin. Consumption of water in the upper and middle parts of the basin without any restrictions can lead to a reduction of water resources consumed from the Manjil reservoir for irrigation of rice and other crops in the delta.

The method of investigation is based on the use of time series of Landsat space images for analysis of changes in the shoreline under regulation of river flow by dams and reservoirs. On a space image for 2016, a shapefile was made that limited the field of study (delta of the river) and overlapped the imagery of previous

years (1975 and 1985). Changes in the shoreline were showed graphically, and the approximate quantitative parameters of the erosion or sediment accumulation areas were determined taking into account the resolution of space images (Landsat 2 - 60 m, and Landsat 5 and 8 - 30 m).

Fig. 1. Displacement of the shoreline in the modern mouth of the Sefid-Rud River for 1975-2016. Numbers



1-5 - areas where the changes in the shoreline were estimated due to erosion or accumulation of sediments.

The formation of the Sefid-Rud delta shoreline was determined as a whole by the inflow of sediments (about 40 million m^3 per year) and the impact of the longshore streams of seawater carrying sediments mainly from west to east, as well as strong storms that destroy the shores. Of great importance was the migration of the main riverbed from the north-west to the present western one. Historically, fluctuations in the level of the Caspian Sea had a significant impact on the shift of the shoreline as well. In recent decades, the regulation of the river flow by reservoirs, which led to a sharp decrease in the inflow of sediments into the delta, became the most important factor.

A comparison of the satellite images for the year 2016 and for 1975 showed that in the area of the present mouth of the Sefid-Rud River, there is an intensive transfer of sediments along the coast by currents from west to east. In this case, the configuration of the delta shoreline changes due to the erosion of the shores (Fig., Sections 2 and 4) or sediment accumulation (Fig., Sections 1, 3, 5). As a result, the entire estuary part of the delta shifted to the east, changing the landscapes of the most valuable protected area "Bandar Kiashahr Ramsar Site" and the game reserve "Bujagh Non Hunting Area". Approximate distances to which the shoreline of the delta has shifted were estimated approximately taking into account the resolution of space images (Landsat 2 - 60 m, and Landsat 5 and 8 - 30 m). These parameters are shown in the table.

Table.

Changes in the shoreline of the delta under the impact of erosion and accumulation processes, m

Номера участков	Смещение береговой линии за периоды		Процессы
	1975-2016 гг.	1985-2016 гг.	
1	+480	+240	аккумуляция
2	-600	-300	эрозия
3	+300	+540	аккумуляция
4	-300	0	эрозия
5	+360	+180	аккумуляция

Conclusion. The regulation of the Sefid-Rud river flow by the large Manzhil reservoir determined the accumulation of river sediments in this reservoir and significantly changed the ratio of erosion and accumulation processes to the delta coast. For the period 1975-2016 maximum manifestations of erosion of coastal sediments penetrated to a distance of up to 600 m deep into the territory, and the accumulation processes in some areas created a new land with a length of up to 540 m in the direction of the sea water area. This process was most active in the 1970s and 1980s. The creation of new reservoirs in the basin will lead to a reduction in solid and water runoff. And this will lead to further degradation of the unique "Ramsar" lands of the southern coast of the Caspian Sea.