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On the Relationship between the Drying out of the Aral Sea and the Salinization of Irrigated Lands

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ABSTRACT
In this article, it is emphasized that the drying of the Aral Sea is the main reason for geoecological problems such as salinization and desertification in the Central Asian region, especially in Uzbekistan. Suggestions and recommendations are given to reduce the negative consequences of these problems.

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Introduction

As part of the USSR, the Central Asian republics, with their dry climate, were turned into a monoculture region of moisture- and sun-loving cotton to supply raw materials for the Russian textile industry and became salinized in more than half of the irrigated lands. High pollution of the atmosphere with salt and dust particles, soils with various types of pesticides, an acute lack of drinking water in most of the territory, not only in the desert part but also in some valleys, etc., and most importantly, the drying out of the Aral Sea, which has turned into a global environmental problem.

The Main Part

The history of human civilization knows many instructive examples of how unsustainable economic activity causes inevitable destructive processes in nature. The now-infamous region of what is now the Sahara was once an intensive agricultural zone. This is evidenced by the remains of settlements covered with sand. People who earned their daily bread apparently acted contrary to natural laws, for which they paid dearly. All this was familiar to the most ancient farmers on the banks of the Tigris and Euphrates, in the Indus, Yellow River deltas, and in the Lake Lob Nor basin. Sooner or later, salinization occurred, and although they tried to restore their fertility through drainage and huge expenditures of fresh water to wash the saline lands, it was to no avail. This does not lead to success even in our time. As a result, "nomadic" agriculture appeared. This is confirmed by the fact that, according to archaeological data, on the flat part of the Amu Darya and Syr Darya basins, the area of ancient irrigation is 4.5–6 million hectares, i.e., significantly larger than the modern one, which can only be the result of nomadic agriculture due to salinity [1].

As you know, the Aral Sea used to serve as a large salt reservoir, receiving more than 25 million tons of salt annually. This figure was calculated based on data from the Chatly hydrostation in the lower reaches of the Amu Darya, where the average long-term annual flow before 1970 was 1410 m^3/s, taking the salinity to be 400 mg/^{l} (400 g/m^3), which gives 17.6 million tons of dissolved substances. If we add the contribution of the Syr Darya, this figure will far exceed 25 million tons per year. Now the Aral itself has turned into a huge global source of salts, with a volume of more than 10 billion tons, for wind transport over long distances, increasing salinization to distant irrigated lands.

Is there a way out of this situation in the near future, since the environmental situation does not allow much time for this? The work completed to date and continuing today to consolidate the sands and salt fields gives us some optimism in solving the problem. 40 artesian wells were drilled [8, p. 178]. In 2018–2019, protective forest plantations were created on an area of 461 thousand hectares. To carry out this activity, sand-accumulating furrows were cut over an area of 1126 thousand hectares, mechanical protection was installed from reeds 93 km away, and seeds of saxaul (Haloxylon ammodendron) and other desert plants were prepared in the amount of 1500 tons. More than 500 units of equipment and two AN-aircraft-2 were involved in this work, over 2000 workers and employees. Initial results are encouraging. 50–80% of seedlings have taken root [8, p. 194]. However, covering the entire bottom with them presents certain difficulties.

At the same time, according to Uzhydromet, in the average long-term section, the flow of the Amu Darya River near Kerki city until 1970 inclusive is 2010 m^3/s, and the mineralization is 300–500 mg/^{l}, the average is 400 mg/^{l}. As a result, the total amount of salts flowing through this gauging station during the year was 2010 m^3/s • 400 g/m^3 • 31.536 million seconds per year = 25 354 944 tons, i.e. 25,3 million tons. Above, in the same way, the average annual flow of dissolved substances at the Chatly hydrostation was determined to be equal to 17 786 304 tons. The difference in readings between the two posts is 7 568 640 tons. On average, this amount of dissolved substances per year in the composition of the water taken for irrigation between these posts ended up in agricultural fields. The irrigated areas in Karakalpakstan are 432.8 thousand hectares, in Bukhara region – 249.9, in Kashkadarya region – 426.7, in Navoi region – 115.6, in Khorezm region – 236.8, in Turkmenistan Republic are 1200 thousand hectares, a total of 2.4618 million hectares. Dividing the volume of dissolved substances by the irrigated area we get 3075 kg/ha. This amount of dissolved substances with irrigation water annually entered each irrigated hectare, increasing its salinity.

Currently, the average annual flow of the Amudarya near Kerki has not changed, and the Amudarya water does not flow into the Aral Sea, i.e., it is completely spent on irrigation. Dividing the average annual ion flow of the Amu Darya near Kerki in the amount of 25 354 944 tons by the irrigation area of 2,4618 million hectares, we obtain 10,299 kg/ha. And this is done every year. If this continues, these lands may soon go out of agricultural production.

Secondly, the complete withdrawal of water from the Amu Darya and Syr Darya led to a widespread rise in groundwater levels. For example, in the early 1960s in the Mirzachul, the groundwater level was at a depth of 16–18 m, and currently it is almost on the surface of the earth. The volume of accumulated groundwater here amounts to tens of billions of m^3. Even in the Fergana region, on 46% of irrigated lands, the groundwater level is from 0 to 2 meters above the ground surface. GWL even in wells at the foot of the mountains at an altitude of 700–936 m above sea level. located at a depth of 1–2.68 m from the surface of the earth. A rise in the groundwater level above 2.5–3 m from the surface of the earth serves as a signal of a violation of the environmental situation and the need to take urgent measures to regulate it. As of 2008, such lands accounted for more than 50% of irrigated lands. They also pose a seismic hazard. Back in the eighties, there were reports of groundwater being pumped out from under the city of Ashgabat by a large number of vertical wells, as is currently being done in the city of Gulistan where located Syr Darya region.

At present, In Uzbekistan saline lands amounted to 2.1707 million hectares or 50.7% of the irrigated area. Of these, 31.3% are slightly saline, 15.5% are moderately saline and 3.8% are highly saline. The worst situation in this regard is observed in the Khorezm, Jizzakh and Fergana regions, where compared to 1990-1992. the area of saline lands increased by 1.5–2 times [2].

In the Khorezm region at the beginning of the 1990s, 35.6% of irrigated lands were not salinized. Now, there were no non-saline lands left, and the area of highly saline lands during this period increased 3.8 times. Particularly alarming is the sharp increase in saline lands in the Fergana region – 2.2 times, despite its location close to the sources of the rivers.

In some regions, the situation has now become even worse. For example, in Karakalpakstan, according to UNDP, the area of saline lands has reached 95% of the total cultivated area. According to the assessment measurements of the "O'zdavyerloyiha" Institute, carried out in 2017 in the Chust, Pap, and Mingbulak districts of the Namangan region, 7461.4, 19896.0, and 26543.0 thousand hectares were salinized, respectively, which is 26.8, 59.0, and 76.3% of the total irrigated area, which is several times more than it was. As you can see, the process of land salinization is progressing alarmingly quickly.

Salinization of irrigated lands annually requires large amounts of money to improve the reclamation condition of irrigated lands. However, they do not give good results. For example, according to V.A.Dukhovniy et al., in Uzbekistan for the period 1971–1980, 973.9 thousand hectares were ameliorated, and the area of ameliorative lands during this period decreased only from 1374.7 thousand hectares to 1101 thousand hectares, or 273 thousand hectares [3].

In 1985, they gave a high assessment to the lands of the Jizzakh region, where by 2007, the area of saline lands had increased 1.7 times compared to 1992, i.e., in 15 years. Work to improve the reclamation state of irrigated lands in 2008–2017 reduced saline lands by only 160 thousand hectares.

Currently, more than 2 million hectares, i.e., more than half of the irrigated land, are salinized to varying degrees in Uzbekistan. As a result, we have seen a progressive decrease in agricultural yields. Rising groundwater levels lead to flooding of the foundations of buildings and structures, which contributes to the deformation of engineering structures and their destruction. This is currently observed in the cities of Nukus, Kokand, Namangan, Gulistan, Jizzakh, Bukhara, Navoi, etc. And the Aral Sea remains a powerful supplier of salt and dust on a global scale, sharply worsening living conditions in the region and intensifying the process of desertification not only on the flat part but also in the foothills, despite climate warming.

Warming should have led to an increase in precipitation, since an increase in air temperature leads to an increase in its moisture capacity and, accordingly, an increase in precipitation. This is confirmed by the fact that during the Holocene warming, the humidity in Central Asia was 1.5–2 times higher than today. The area of the Aral Sea was two times larger than in 1960. An increase in precipitation was also observed during the current warming. Until 2000, out of 35 meteorological stations in Uzbekistan, 13 noted an increase in precipitation in both the warm and cold periods of the year, 6 in the cold period, 7 in the warm period, and 7 noted a decrease in precipitation. The maximum increase in precipitation was 20%, and the decrease was 15%. However, since the late nineties, when drying out affected most of the Aral Sea, the amount of precipitation began to decrease, and this could be the result of a sharp increase in the concentration of hygroscopic and crystallizing particles in the atmosphere due to the Aral salt and dust [4]. The same phenomenon was one of the main reasons for the intensification of desertification in Northern Africa. The huge Sahara Desert in 1980 had an area of 8.633 million km^2. By 1990, its southern border had shifted south by 130 km, and its area reached 9 million 269 thousand km^2, although in 1985, 1986, and 1988, shifts to the north were observed [5].

In the conditions of the Aral basin, we have seen an increase in the area of the focus of salt and dust due to the drying out of the Aral Sea by more than 60 thousand square kilometers. This may increase the expansion of the desert in all directions and even the spread of desertification to the foothills. Every year, hundreds of millions of tons of salt are carried by the wind to the surrounding areas, expanding the areas of salt deserts, creating vast salt marshes, and increasing the salinization of already saline lands. Judging by the directions of dust storms, the removal of salts occurs in more than 75% of cases in the territory of Karakalpakstan, the Khorezm region, and Turkmenistan [6].

Perhaps, considering the above, the Small Aral is being revived in Kazakhstan, reducing the irrigated area in the Kazakhstan part of the Syr Darya basin by two times, carrying out extensive work to regulate the river bed, and improving the collector and drainage network with the calculation of the discharge of drainage water directly into the Small Aral. Currently, the surface area of the Small Aral is more than 3.3 thousand km^2, the water level is at an altitude of 42 m above sea level, and the water salinity has dropped to 8–9 ppm. The fishery industry is being restored. The annual catch is around 11 thousand tons.

In order to get out of the crisis situation in Uzbekistan as quickly as possible, it is necessary to free the cultivated areas from the large, excessive load of irrigation water in order to protect them from further salinization. This opportunity is created by the widespread implementation of President Sh.M.Mirziyoyev's proposals to reorient part of crop production to orchards and vineyards, as well as accelerated transfer to drip irrigation. This will reduce water consumption per hectare to 3.5–4 thousand m^3/ha. For an irrigated area of 4 million hectares, 16 km^3 of water will be sufficient. If we consider the same amount of loss to the fields, the total water consumption will be 32 km^3.

The water resources of the flat part of the Aral basin are according to 103.3 km^3/year [7]. This means that with the widespread use of drip irrigation, it will always be possible to send more than 50 km^3/year to the Aral Sea. If water supply to the Aral Sea begins now, as calculations show, by 2045, the surface area of the Aral Sea could rise to 45 thousand km^2. This is quite enough to reduce salt and dust emissions to a minimum. These calculations were carried out on the basis of table 6.3 of the appendices of the book by Prof. V.A. Rafikov [8].

Speaking about the need to switch to drip irrigation, the President especially emphasized that drip irrigation saves irrigated lands from salinization, sharply reduces costs for improving their reclamation condition, negates the need for a collector-drainage network, and makes it possible to expand the cultivated area due to the territory it occupies. Drip irrigation is widely used in many countries around the world, especially in Israel, where great success has been achieved; from 1 hectare, a cotton yield of up to 100 c/ha is obtained. This is possible with us too. For example, we often see cotton bushes with 20 or more open bolls. If you count their weight at 4 g, you get 80 grams of cotton from one bush. If there are 100 cotton bushes per hectare, the result will be 80 c/ha.

Conclusion

To introduce drip irrigation, the government of the country has provided subsidies in the amount of 8 million soums per ha. However, the adoption rate is very low. The main reason, as surveys show, is that farmers do not have confidence in spending it strictly for its intended purpose. Therefore, it is necessary to entrust the transfer of agriculture to drip irrigation to the Ministry of Water Resources and carry out this work at the expense of expenses for the construction of water management facilities and improvement of the land reclamation condition. Financial support from international organizations and donor countries for the Aral Sea should also be directed to these purposes. In conclusion, I would like to especially note that in order to preserve irrigated lands fertile for descendants, it is necessary to completely transfer crop production to drip irrigation and at least 50–60 km^3 of water per year, send it to the Aral Sea for its revival, and, most importantly, protect the lands from salinization [9].

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