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The Aral Sea Crisis and Environmental Reforms in Uzbekistan

Utemuratova Gulnarakhan Khodzhaniyazovna
Head of the Department of "Fundamentals of Management and Economics" of Berdakh Karakalpak State University, Doctor of Economic Sciences (DSc), Professor, Uzbekistan

Abstract: The Aral Sea, once the fourth-largest inland water body in the world, has contracted to 90% of its original volume, becoming one of the greatest ecological catastrophes of the twentieth century. Over the past decade, the Government of Uzbekistan under President Shavkat Mirziyoyev has undertaken unprecedented measures to mitigate the environmental consequences of the crisis. The paper analyzes the history of the catastrophe, its ecological and social consequences, as well as the complex of governmental initiatives, including the "Yashil Makon" program, water management reforms, energy transformation, and international cooperation.

Keywords: Aral Sea, environmental crisis, afforestation, water management, renewable energy, sustainable development, Uzbekistan, Central Asia, climate change, "Yashil Makon" program.

1. Introduction

The critical situation in the Aral region directly affects the destinies of millions of people in Uzbekistan, Kazakhstan, and Turkmenistan, and the experience of restoring this ecosystem has become an important lesson for the global community [1].

The Government of Uzbekistan under President Shavkat Mirziyoyev has undertaken unprecedented steps to mitigate the environmental consequences of the crisis. These measures encompass large-scale afforestation programs, water management reforms, development of sustainable agricultural practices, energy transformation, and active international cooperation [2].

The objective of this paper is to provide a comprehensive analysis of the history of the catastrophe, its ecological, social, and health consequences, as well as detailed examination of governmental initiatives and international programs aimed at restoration and stabilization of the Aral region. Particular attention is devoted to the "Yashil Makon" (Green Land) program, water management reforms, development of renewable energy sources, international financing, and development prospects through 2030.

2. History and Causes of the Crisis

- Historical Development of the Catastrophe the Aral Sea represented a unique ecosystem with an area of approximately 68,000 km² and a water volume of 1,083 km³. Prior to the 1960s, this endorheic lake was an important center of the fishing industry and a habitat for numerous species of flora and fauna. However, the intensive Soviet program of agricultural industrialization fundamentally changed the situation.

Beginning in the 1960s, enormous volumes of water from the two main feeding rivers - the Amu Darya and Syr Darya - were redirected to irrigation projects for cotton cultivation. By historical standards, this occurred with unprecedented speed: within 40 years (by the 2000s), the water body contracted to 10% of its original area [3].

Period	Water Volume (km³)	Area (km²)	% of Original
1960	1,083	68,000	100%
1980	~400	~42,000	37%
2000	~85	~7,000	8%
2005 (Karakara dam)	69.31	N/A	6.4%
2020 (North Aral)	27.5	3,400	2.5%
2024	27.5	3,400	2.5%

Table 1: Dynamics of Aral Sea Degradation, 1960–2024

Causes of the Crisis Large-scale irrigation projects**.** The Soviet government implemented an ambitious program to increase the area of irrigated land in Central Asia. To support cotton production, numerous dams, canals, and water reservoirs were constructed. These structures intercepted 80–90% of the flow of the Amu Darya and Syr Darya, leaving minimal water to feed the Aral Sea.

Inefficient water use. Deteriorated irrigation infrastructure led to water losses. Water losses from open canals due to evaporation and filtration reached 30–50%. Extensive irrigation methods were applied in agriculture, requiring excessive amounts of water.

Climatic factors. In addition to anthropogenic impacts, the region experienced periods of increased drought and reduced precipitation, which further lowered the water flow of the rivers [4].

3. Ecological, Social, and Health Consequences

Ecological Consequences

Ecosystem degradation. The desiccation of the Aral Sea led to the complete destruction of its unique ecosystem. Of the 24 fish species that inhabited the water body, 11 species disappeared. Commercial fisheries completely ceased operations between 1979 and 1984.

Formation of the Aralykum Desert. On the dried bed of the Aral Sea, a new desert formed, covering an area of 5 million hectares, covered with a toxic mixture of salt, sand, and pesticide residues. This "wound of the earth" became a source of dangerous dust storms [5].

Dust storms and pollution. Annually, 700 million tons of salt and toxic dust are raised from the dried bed into the atmosphere. These particles disperse across distances exceeding 2 million km², contaminating soil, water, and air in neighboring regions. The concentration of toxic substances, including pesticides and salts, creates a serious threat to the health of the population.

Soil salinization and land degradation. In certain districts of Moynak, soil salinity levels reach 80–96%, making the land unsuitable for agricultural use. Approximately 2 million hectares of land have been degraded:

1. Soil deflation: 2 million hectares
2. Irrigation-induced erosion: 619 thousand hectares
3. Gully erosion: 40 thousand hectares

Consequences for Agriculture

Despite initial increases in irrigated areas, the long-term consequences of degradation were catastrophic:

Crop	Yield Decline	Note
Corn	-3×	Three-fold decline
Rice	-2×	Two-fold decline
Cotton	-1.6×	Base crop of the region

Table 2: Yield Decline of Major Crops in the Aral Region

Soil salinization led to reduced soil fertility. Salinized soils require additional irrigation, creating a vicious cycle of degradation [6].

- Social and Economic Consequences Prior to 1960, fisheries provided employment for more than 60,000 people and made a significant contribution to the regional economy. By the early 1980s, fishing completely ceased, leaving thousands of families without means of subsistence.

The inability to earn income from fisheries and degraded agriculture led to mass migration. The population of Moynak decreased from 40,000 people in 1980 to fewer than 5,000 at present.

- Health Consequences the Aral Sea crisis had a devastating impact on the health of the region's population.

Respiratory diseases. Toxic dust from Aralykum contains pesticides, heavy metals, and salts:

1. Chronic bronchitis
2. Bronchial asthma
3. Pneumoconiosis

Oncological diseases. The concentration of carcinogenic substances has led to increased cancer incidence in the region.

Disease	Increase (since 1960s)	Region
Respiratory diseases	5×	Karakalpakstan, Khorezm
Anemia	4×	Children under 5
Stomach and liver cancer	3×	All age groups
Diarrheal diseases	7×	Children under 5

Table 3: Increase in Morbidity in the Aral Region

4. Governmental Reforms and Initiatives of Uzbekistan

President Shavkat Mirziyoyev, who came to power in 2016, declared environmental protection a priority of the state. In 2019, the Ministry of Ecology, Environmental Protection and Climate Change (MEPCC) was established with expanded authority and a budget equivalent to 2.1% of state environmental expenditures.

UN Resolutions and International Recognition. On the initiative of Uzbekistan, in 2021 the UN General Assembly adopted the historic resolution A/RES/75/202, declaring the Aral region a

"Zone of Environmental Innovation and Technologies" (ZENIT). This provided international recognition and access to financing mechanisms and cooperation frameworks.

In December 2023, the UN General Assembly unanimously adopted the resolution "Central Asia Facing Environmental Challenges" (A/RES/78/196).

International Programs and Financing

International Fund for Saving the Aral Sea (IFAS)

Established in 1993 by five countries: Uzbekistan, Kazakhstan, Turkmenistan, Tajikistan, and Kyrgyzstan. As of 2024, IFAS coordinates the activities of 42 active environmental projects in the region. **Scale and targets.** The program, launched in 2019, became a flagship restoration project. The goal is to plant 1 billion trees and shrubs, increasing green cover in the republic from 8% to 30% by 2030.

Financing of the "Yashil Makon" program:

For the period 2019–2030, 28.7 billion sum (USD 2.28 million) was allocated from the state budget, plus financing:

1. International grants: USD 3.4 million (GEF, GGGI, UN)
2. Private sector and volunteer contributions: USD 1.8 million
3. Total investments: USD 7.48 million

Results in the Aral region:

Period	Area (million hectares)	% of Target Plan
2018–2023	1.7	42.5
2024 (plan)	0.175	10.3
2025 (plan)	0.286	16.8
2026–2030 (forecast)	1.4–2.0	29.4+
Total by 2030 (forecast)	**4.1–4.7**	**104+**

Table 4: Progress of the "Yashil Makon" Program in Target Indicators

Plant species used:

Species	Latin Name	% of Plantings	Function
White saxaul	Haloxylon ammodendron	45%	Sand stabilization
Black saxaul	Haloxylon persicum	15%	Ecosystem species
Desert salt-wort	Salsola spp.	18%	Soil improvement
Four-stamen tamarisk	Tamarix tetrandra	12%	Moisture bioindicator
Ephedra (Joint-fir)	Ephedra strobilacea	8%	Medicinal plant

Table 5: Biological Composition of Afforestation in the Aral Region

Planting technologies:

1. **Aerial seeding (drones and helicopters):** covers 45,000 hectares annually, cost USD 12–18 per hectare (30% savings compared to manual methods)
2. **Mechanized planting:** fleet of 360 tractors with productivity of 800–1,200 seedlings per day
3. **Seedling preparation:** 12 state nurseries with productivity of 4.2 million seedlings annually

Energy Transformation

Development of renewable energy sources (RES):

Type of RES	2020 (MW)	2023 (MW)	Target 2030 (GW)
Solar energy	0.89	1.68	3.8
Wind energy	0.45	0.92	2.5
Total RES	**1.34**	**2.60**	**6.3**
% of generating capacity	2.1%	4.8%	18%

Table 6: Development of Renewable Energy Sources in Uzbekistan

Solar power plants in the Aral region:

1. **Nukus Solar Station:** 100 MW (commissioned April 2024)
2. **Karakalpakstan Solar Station:** 150 MW (under construction, commissioning 2025)
3. **Khorezm Solar Station:** 85 MW (design phase)
4. **Small modules:** 340 installations (18 MW)

Total: 335+ MW of solar capacity in the region.

Nationally Determined Contribution (NDC) under the Paris Agreement:

1. Reduction of greenhouse gas emissions by 35% by 2030 from 2010 levels
2. 2023 emissions: 178.3 million tons CO_2-equivalent (6.1% reduction achieved)
3. 2030 target: 123.4 million tons CO_2-equivalent

Climate commitment financing:

1. Green Climate Fund (GCF): USD 34.7 million
2. Global Environment Facility (GEF): USD 28.4 million
3. World Bank (climate credits): USD 156.8 million
4. ADB Development Credit: USD 89.3 million
5. **Total international financing:** USD 309.2 million

5. Results and Challenges

✓ Stabilization of the North Aral Sea:

1. Water volume stabilized at 27.5 km^3
2. Salinity decreased from 18 to 10–11 g/L
3. 22 fish species recovered
4. Annual catch: 8,000 tons

Afforestation: Planting of 1.7 million hectares of forests has contributed to reduced dust storms, improvement of local microclimate, and restoration of biota[11].

Recovery instability:

1. During 2021–2024, water levels decreased by 1.8 meters
2. The system may return to critical conditions under unfavorable scenarios

Forest survival problems: Survival rates vary from 30–70% depending on precipitation.

Continuing desertification: 6.8 million hectares of the dried bed remain largely unforested.

Climate change: Average annual temperature is rising, extreme droughts are increasing, and glacial resources in the river headwaters are declining.

The Government of Uzbekistan during 2016–2024 has demonstrated political will and the capacity to implement large-scale environmental reforms:

1. **Afforestation:** 42.5% implementation by 2024, creation of 78,000+ jobs
2. **Water management reform:** Saving of 10.2 billion m³ of water during 2022–2024
3. **Energy transformation:** RES from 1.34 GW (2020) to 2.60 GW (2023)
4. **International financing:** USD 309.2 million attracted

The Aral Sea crisis remains one of the greatest ecological catastrophes in history. However, Uzbekistan's experience during 2016–2024 demonstrates that with political will, multilevel cooperation, and innovative approaches, significant improvements in environmental conditions can be achieved [13].

Development prospects through 2030:

On the basis of the current pace of program implementation, it is expected to afforest 4.1–4.7 million hectares, install 6.3 GW of RES capacity, reduce GHG emissions by 35%, increase access to clean water to 85%, and create 280,000+ new jobs.

The global community can draw an important lesson: care for the environment and balanced management of natural resources are necessary conditions for long-term development. The Aral region can become a leading zone of innovation for solving the environmental challenges of the twenty-first century.

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