THE ARAL SEA REGION ECOLOGICAL CRISIS: QUANTITY AND QUALITY OF AMU DARYA WATER RESOURCES AND PROSPECTS FOR SUSTAINABLE DEVELOPMENT

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Abstract: This article analyzes the ecological crisis in the Aral Sea region in relation to quantitative changes and quality indicators of the Amu Darya's water resources. The methodological basis of the study consists of a comparative analysis of relevant scientific literature and a synthesis of published observational data. The relationships between water withdrawal volumes, irrigation practices, collector-drainage flows, mineralization levels, and the distribution of certain heavy metals along the river are examined. The impact of ecological changes on soil fertility, aquatic ecosystems, and the living conditions of the local population is discussed. To ensure sustainable development in the Aral Sea region, the study proposes strategies such as the integrated management of water quantity and quality, the improvement of ecological monitoring, the implementation of water-saving technologies, and the strengthening of regional cooperation.

Keywords: Aral Sea region, ecological crisis, Amu Darya, water resources, water quality, mineralization, collector-drainage waters, heavy metals, ecological flow, sustainable development.

Introduction

The ecological crisis in the Aral Sea region serves as a complex example of the disruption in the balance between the utilization of natural resources and regional development. The reduction in the volume of river water flowing into the Aral Sea has led to the shrinking of the water body, increased salinity, and the

alteration of natural habitats. The consequences of these processes extend beyond aquatic ecosystems, impacting agriculture, employment, the supply of drinking water, and the ecological security of the region. Consequently, explaining the Aral Sea issue solely in terms of the decline in sea level is insufficient.

The Amu Darya plays a crucial role in the water supply of the Aral Sea region. Beyond the volume of water extracted from the river, its chemical composition is also significant for the stability of ecosystems and for economic activities. The mineralization of the water, as well as the presence of pollutants, can limit the possibilities for its use. The objective of this article is to synthesize the factors affecting the quantity and quality of the Amu Darya's water resources and to identify management approaches that contribute to the sustainable development of the Aral Sea region. The analysis compares the approaches and observational findings presented in various scientific papers. No new field experiments or independent laboratory measurements were conducted.

Main Part

The emergence of water scarcity in the Aral Sea region is intrinsically linked to water distribution across the entire river basin. When a large portion of the Amu Darya's flow is diverted for irrigation and other economic needs, the volume of water reaching natural areas in the lower reaches diminishes. Lakes, wetlands, and riparian forests (*tugai*) in the river delta develop in dependence on the seasonal influx of water. Therefore, when assessing water supply, it is essential to consider not only the total annual volume but also its distribution throughout the year. A water deficit during the biologically active period can have a more severe impact on ecosystems than deviations based on annual averages.

Water quantity and quality are not separate issues. When river flow decreases, the capacity for diluting salts and pollutants entering the water may also decline. However, attributing changes in water composition solely to reduced flow is incomplete. Other contributing factors include return flows from irrigated lands, interactions with groundwater, wastewater discharge, and natural

geochemical conditions. The relative influence of these factors varies across different sections of the river and throughout the seasons. For effective management, both water discharge rates and chemical parameters must be monitored concurrently.

In their study of the Amu Darya, Kulmatov et al. utilized a combination of archival data, field samples, and laboratory analyses. The observations covered hydrological monitoring stations at Termez, Tuyamuyun, Kipchak, Samanbay, and Kyzyljar. The authors noted that, during the years studied, water mineralization increased by a factor of 1.35–1.74 when moving from the upstream monitoring station to those downstream. This result demonstrates spatial variation in water quality along the river; it should be interpreted within the specific conditions covered by the study, rather than as an immutable rule applicable to all periods.

The increase in mineralization is also a significant factor for irrigated agriculture. Salts entering the soil via water can accumulate in the root zone if adequate drainage and proper irrigation are lacking. Consequently, it becomes difficult for plants to absorb water, the soil's reclamation status deteriorates, and the risk of reduced crop yields increases. Furthermore, determining the suitability of water for irrigation based solely on its total salt content is insufficient; factors such as ionic composition, soil characteristics, crop type, and drainage conditions must also be evaluated.

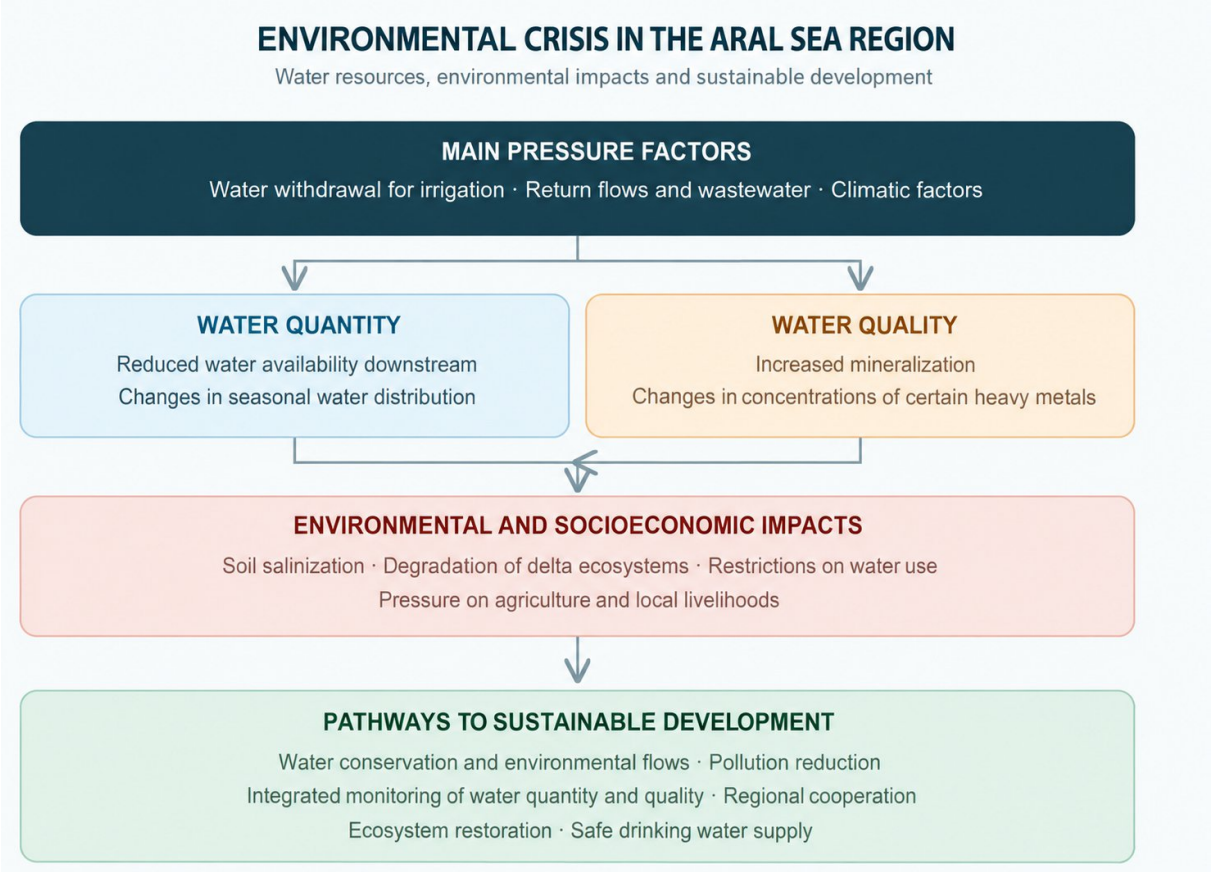
Collector-drainage waters play a distinct role in this process, serving to remove excess water and dissolved salts from irrigated lands. However, the return of such water into river systems can alter the chemical composition of the water downstream. Therefore, the task of improving drainage extends beyond merely removing water from the fields; the management plan must also address the destination, composition, and potential future use of this return water. Any reuse of such water should be based on water and soil analyses, the tolerance levels of the crops, and relevant environmental constraints.

Observations regarding heavy metals are also significant when assessing the water quality of the Amu Darya. The article under review illustrates how the concentrations of copper, zinc, and hexavalent chromium vary along the course of the river. However, an increase in concentration from upstream to downstream does not necessarily imply that sanitary standards have been violated at every point. Drawing such a conclusion requires consideration of the specific concentration levels, the chemical form of the substance, the duration of exposure, and the intended use of the water. Furthermore, identifying the source of pollutants necessitates a dedicated investigation; attributing these increases to a particular enterprise or activity based solely on the observed rise is scientifically insufficient.

Climatic factors can exacerbate existing pressures on water resource utilization. Rising temperatures affect evaporation rates and the water requirements of crops, while shifts in precipitation patterns and snow or glacial reserves can alter the seasonal flow regime. Nevertheless, a statistical correlation between temperature and mineralization does not, in itself, prove a direct causal link. Factors such as the volume of irrigation, the operational regime of reservoirs, and return flows must be analyzed in conjunction with one another. This approach helps to avoid an oversimplification of the causes behind environmental issues. Examining the Aral Sea crisis from the perspective of sustainable development requires addressing ecological restoration and human well-being in tandem. Water quality, the provision of safe drinking water, agricultural income, and natural habitats are all interconnected. Therefore, when evaluating environmental projects, it is essential to measure not only the volume of work completed but also the practical outcomes achieved. For instance, the survival of vegetation in restored areas, improvements in water quality, and the extent to which the local population can access these services can serve as criteria for effectiveness.

Future management strategies must integrate water conservation, pollution reduction, and the maintenance of ecological flows. When irrigation technologies

are upgraded, the fate of the saved water must be monitored at the basin level; if it is simply used to expand agricultural land, no additional water may reach the downstream areas. Practical avenues for regional cooperation include sharing monitoring data, standardizing measurement methodologies, and coordinating seasonal water allocation. Furthermore, in the Aral Sea region, linking water quality monitoring with the tracking of dust and salt storms—alongside systems for public awareness—will strengthen preparedness against environmental risks.



Conclusion

Mitigating the ecological crisis in the Aral Sea region depends on the joint management of both the quantity and quality of the Amu Darya's water resources. The studies reviewed indicate that, in addition to addressing water supply in the lower reaches, it is essential to focus on issues related to mineralization and pollutants. Furthermore, the results of any monitoring cannot be interpreted in isolation from their temporal scope, geographical coverage, and the analytical methods employed.

For sustainable development, key priorities include increasing irrigation efficiency, managing return flows, accounting for the water requirements of delta ecosystems, and improving the supply of safe drinking water. The actual impact of water-saving measures must be evaluated at the basin scale and linked to the water that reaches ecological systems. Collaboration among scientific institutions, water management organizations, and local authorities ensures that decisions are evidence-based. Consequently, ecological restoration efforts become integrated with improving the living conditions of the local population, protecting natural resources, and adapting to future risks. Such an approach serves to strengthen the long-term development prospects of the Aral Sea region.

References

1. Kulmatov R., Gapporov K., Alimov A., Opp C. Assessment of quantitative and qualitative indicators of water resources in the Amu Darya Basin, Uzbekistan. Environmental Research & Technology. 2026. 9(3). pp. 502–512.

2. Ergashev A., Ergashev T. Ecology, Biosphere, and Nature Conservation. Tashkent: Yangi Asr Avlodi, 2005.

3. Uysal Oğuz C., Özkan A., Özer S. Socio-economic and Environmental Dimensions of the Aral Sea Disaster from the Sustainable Development Perspective. bilig. 2026. Issue 116. pp. 29–58.

4. To‘xtayev A. S. Ecology. Tashkent: O‘qituvchi, 1998.

5. Yormatova D. Ecology. Tashkent, 2009.