Araştırma Makalesi / Research Article

Socio-economic and Environmental Dimensions of the Aral Sea Disaster from the Sustainable Development Perspective*

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Abstract

The Aral Sea Basin environmental disaster has deteriorated the socio-economic and environmental circumstances of the local communities in Central Asia. The main challenges in the basin are water scarcity, food insecurity, health problems and economic contraction. Due to irresponsible use of water resources during the Soviet period and current climate change, the water body of the Aral Sea has decreased to the lowest level. This article aims to analyze the socio-economic and ecological impacts of environmental degradation in the Aral Basin from a sustainable development perspective which encompasses social, economic, and environmental dimensions. Moreover, several regional and

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international recuperation efforts were examined as examples of possible sustainable solutions. The contribution of this article to the literature is the assessment of the selected Sustainable Development Goal (SDG) performances of the basin countries located in Central Asia.

Keywords
Aral Sea, sustainable development, SDGs, environment, socio-economic impacts, cooperation.

Sürdürülebilir Kalkınma Perspektifinden Aral Denizi Felaketinin Sosyoekonomik ve Çevresel Boyutları*

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Öz

Aral Denizi havzasında yaşanan çevresel felaket, Orta Asya'daki yerel toplulukların sosyoekonomik ve çevresel koşullarını derinden etkilemiştir. Aral Denizi havzasındaki başlıca zorluklar su kıtlığı, gıda güvensizliği, sağlık sorunları ve ekonomik daralmadır. Sovyetler Birliği döneminde su kaynaklarının sorumsuzca kullanılması ve günümüzde iklim değişikliği nedeniyle Aral Denizi'nin su kütlesi dramatik bir şekilde en düşük seviyeye inmiştir. Bu makale, Aral Denizi havzasındaki çevresel bozulmanın sosyoekonomik ve ekolojik etkilerini sosyal, ekonomik ve çevresel boyutları kapsayan sürdürülebilir kalkınma perspektifinden analiz etmeyi amaçlamaktadır. Ayrıca, bazı bölgesel ve uluslararası iyileştirme çabaları, olası sürdürülebilir çözümlere örnek olarak incelenmiştir. Sonuç olarak, bu makalenin literatüre katkısı, Orta Asya'da yer alan Aral Denizi havza ülkelerinin seçilmiş Sürdürülebilir Kalkınma Amaçları (SKA) performanslarının değerlendirilmesidir.

Anahtar Kelimeler

Aral Denizi, sürdürülebilir kalkınma, SKA, çevre, sosyoekonomik etkiler, iş birliği.

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Introduction

Sustainable development approach aims to increase economic feasibility, ensure social solidarity, and establish ecological responsibility in a world of intertwined problems. It is a holistic approach considering social, economic, and environmental factors (UNDP 2015). The environmental movement gained international prominence in the 1970s, leading to the establishment of the World Commission on Environment and Development (WCED) by the United Nations. The Brundtland Report (Our Common Future) in 1987 established the relationship between environment and development, defining the concept of sustainable development. Later, it became a leading phrase in development discourse with Agenda 21 and the UN Summit on Environment and Development in Rio de Janeiro in 1992 (Adams 2-3). The Brundtland Report's definition indicates that the needs of the present should be met without compromising the ability of future generations to meet their own needs, equates needs with wants, and assumes economic growth is part of development (Brundtland Report). Hence, sustainable development has become a fundamental approach preferred by states and international organizations in dealing with environmental issues while aiming to achieve economic development.

Sustainable development is based on the idea of sustainability, which encompasses social, economic, and environmental dimensions (Pitelis 3). Social sustainability involves development that aligns with civil society evolution, promoting harmonious living among culturally and socially diverse groups. Social sustainability focuses on the collective functioning of society and individual quality of life, and the discourse on sustainable development emphasizes the importance of social equity (Bramley and Power 31). Economic sustainability develops principles and evaluates environmental impacts to create a livable future. As organizations, shareholders, employees, customers, and society depend on the environment, and the activities of producers, consumers, and governments affect the environment in significant ways (Prasad et al. 374-375), environmental sustainability emphasizes natural capital and conservation (Goodland and Daly 1005). Sustainability also addresses intergenerational equity, requiring each generation to decide how much capital to consume and save for future generations (Markulev and Long 5). In the 21st century, the sustainable development approach

materialized through the UN's Millennium Goals in 2000 and then through the Sustainable Development Goals (SDGs) which were adopted in 2015 to foster global peace and prosperity for people and the planet. Through achieving the targets set by the 17 SDGs, countries aim to end poverty and other deprivations, improve health and education, reduce inequalities, promote economic growth while conserving ecosystems, and tackle climate change (UN Department of Economic and Social Affairs). Therefore, the SDGs provide a very comprehensive framework for countries to deal with their socio-economic and environmental issues. The nexus of these issues is especially critical for developing countries that have been trying to deal with environmental disasters that were the results of their economic policies.

One of the examples of such environmental crises in Central Asia is the desiccation of the Aral Sea, which has continued since the 1960s and has created economic and social challenges for the countries and their populations. The complexity of the Aral Sea disaster requires a close examination of the socio-economic conditions from a sustainable development perspective. For this purpose, we take the selected SDGs (SDG3: Good health and well-being, SDG6: Clean water and sanitation, SDG7: Affordable and clean energy, SDG15: Life on land, SDG17: Partnerships for the goals) which are directly related to the Aral Sea disaster and performances of the basin countries located in Central Asia, Kazakhstan, Uzbekistan, Turkmenistan, Kyrgyz Republic, Tajikistan by indicators for guidance and define their connection to policies and the conditions that led to the desertification of the Aral Sea. Therefore, this article focuses on the Aral Sea disaster as a case study to display the interconnectedness of socio-economic and environmental well-being with a perspective of sustainable development.

The method of this article is question-oriented research. For this purpose, the article seeks to answer the following research question: How do the intertwined environmental and socio-economic outcomes of the Aral Sea disaster affect the sustainable development of the basin countries according to their relevant SDG performances? Thus, determining the relationship between the environmental crisis in the Aral Sea and socio-economic well-being provides the basis for the sustainable development approach, which brings suggestions for adaptation efforts defines and evaluates initiatives by international agencies and regional actors.

A comprehensive approach is necessary to investigate the ecological and socio-economic crises that ecosystems and people in the Aral Sea Basin have encountered, despite the abundance of literature on environmental challenges and recuperation efforts. This article claims that regional and international cooperation based on sustainable development could solve the Aral Sea Basin's socio-economic and environmental problems while basin countries work to meet their SDG targets. Since Philip Micklin's extensive research on the Aral Sea disaster, many studies have examined its consequences on the region's socio-economic structure and ecosystems, proposing partial answers. The literature fails to emphasize the sustainable development viewpoint and the SDGs, which the UN expects all actors at local, regional, national, and international levels to adopt and implement since 2015. This article examines the interaction between environmental, health, and socio-economic aspects in the Aral Sea Basin from a sustainable development perspective by analyzing the SDGs, making it original.

Environmental Crisis in the Aral Sea

The Aral Sea is situated in Central Asia and surrounded by Uzbekistan and Kazakhstan with nearly an equal length of shoreline, while Turkmenistan, Tajikistan, Kyrgyz Republic, Afghanistan, and Iran share the total drainage basin of 1.8 million km^2. As seen in Figure 1, Uzbekistan's coastline is in the country's Karakalpakstan Republic (Micklin, *The Aral Sea Disaster* 48). The Amu Darya and Syr Darya Rivers' waters accumulated in a closed basin in Karakalpakstan with no outflow to form the Aral Sea, which in 1942 had a surface area of 66,458 km2 and 2345 km2 of islands (Ökmen 25). The Aral Sea, with its water surface of 67,499 km^2 and a volume of 1,089 km^3, was listed as "the world's fourth biggest lake in 1960" (Aladin et al. 74). As well as supporting biodiversity, the vast deltas of the Amu Darya and Syr Darya Rivers make a significant contribution to economic activities such as agriculture, hunting, fishing, and the harvest of reeds used as building materials and livestock feed (Micklin et al. 111). Moreover, before environmental degradation, the Aral Sea had an abundant fish life, feeding a large part of the population of Karakalpakstan (Altan 36; Ökmen 25). Thus, it has been crucially important in terms of fisheries as well as regional transportation (Micklin et al. 111).

Environmental degradation in the Aral Sea Basin is best defined as a "creeping environmental problem," which Glantz (1999) uses to categorize a "long-term, low-grade, and slow-onset cumulative process." In the early 1980s, environmental experts like Philip Micklin (*The Water*; *The Aral Sea Problem*) started to pay attention to this disaster, but until Mikhail Gorbachev finally made it public in 1985, decision-makers largely ignored the environmental degradation in the basin.

Figure 1. Map of the Aral Sea (World Atlas)

The region has a prolonged history of environmental mismanagement. In the early 1920s, the introduction of several fish and invertebrate species to the Aral Sea adversely affected native species. Large irrigation projects were first launched in the 1930s to irrigate the steppes of Uzbekistan, Kazakhstan, and Turkmenistan, especially to grow cotton. Projects such as the Fergana Valley Canal, the Kyzylorda Region water catchment complex in Kazakhstan for rice production, the irrigation of the south of Kerki and the opening of the Karakum Canal in Turkmenistan have disrupted continuous water supply from Amu Darya and Syr Darya, thus disturbing the natural balance of the Aral Sea (Altan 36-37; Ökmen 25). Therefore, the hydrological cycle of the Aral Sea has been disturbed as the countries used outdated irrigation techniques to increase agricultural production, notably cotton planting (Loodin 2495). As Ökmen (23) argues, the Soviet Union's ideological structuring, in parallel with its geographical width and large population, made itself felt predominantly in environmental issues. For instance, the Karakum Canal, which was constructed in 1954, was a result of that era and was designed for the irrigation of the arid area around the Aral Sea to promote agricultural production instead of supplying for the larger basin (Duzdaban 53). The Soviet Union's monoculture cotton cultivation policy made it more difficult to access water in the Central Asian republics. The water balance of the Amu Darya River Basin was adversely affected when water was diverted into irrigation canals for cotton fields (Loodin 2502). Regulations of the Soviet era mandated that the downstream republics, for their irrigation-based agricultural economies, would receive the spring and summer water from the upstream states (Duzdaban 53).

Since the 1960s, the unsustainable upstream irrigation withdrawals from Amu Darya and Syr Darya Rivers eventually caused the desiccation of the Aral Sea, which became shallower and was split into separate water bodies (Aladin et al. 73). In the 2000s, the problem became so severe that some parts of the Aral Sea totally dried up and turned into a desert, which was called Aral-Kum (Atvur 223). As Yalçınkaya and Mehmetcik (154) explain, one of the most important outcomes of the desiccation process was that it caused a water scarcity in the region. The Aral Sea disaster poses significant threats, including water scarcity, food insecurity due to soil degradation, health complications from contaminated water and the environment, and an economic downturn (Loodin 2495). The reduced fresh water supply from

rivers and the spread of sand and salt from drying parts caused increased salinity, leading to health issues, and destroying agricultural production (Altan 37, 40; Ökmen 26). Moreover, decades of monoculture practices for cotton production during the Soviet era and a heavy use of pesticides and chemicals polluted the Aral Sea, thus bringing it to the brink of disaster (Ökmen 26; Altan 40).

The Aral Sea first split into two water bodies between 1987 and 1989: the Small Aral in the north, where Syr Darya flows, and the Large Aral in the south, with Amu Darya discharging its waters. As examined by Micklin (*The Aral Sea Disaster* 52), the water level of the Small Aral dropped by 13 m and the Large Aral dropped by 23 m between 1960 and 2006. In 2007, the surface of the Aral Sea shrank to 13,958 km^2 (21% of 1960) with a volume of 102 km^3 (9% of 1960) while the surface of the Large Aral was 10,700 km^2 (17% of 1960) with a volume of 75 km^3 (8% of 1960), and the figures for the Small Aral were 3,258 km^2 (53% of 1960) and 27 km^3 (33% of 1960), respectively (Aladin et al. 79).

According to Micklin et. al (123), the situation of the Aral Sea worsened after the collapse of the Soviet Union in 1991, when Kazakhstan and Uzbekistan became two new riparian countries. Due to the lack of effective and comprehensive restoration initiatives, desiccation continued, and the Aral Sea was divided into four water bodies by September 2009, with the water level falling by 26 m, the surface area declining by 88%, and the water volume reducing by 92% (Micklin, *The Past* 193). According to the satellite observations carried out by scientists, the Large Aral consisted of three water bodies in September 2009, a deep western sea and a shallow eastern sea with a channel connecting them; and an entirely separate Tshchebas Bay (Micklin, *The Past* 202). By 2010, there were 8.2 million ha of irrigated land, up from about 5 million ha in 1960. Such growth in the irrigated area was beyond the point of sustainability, resulting in a significant decrease in river discharge to the Aral (Micklin et al. 123). Unfortunately, by September 2011, as Micklin (*Efforts* 362) noted, the Aral Sea had become only a small remnant of what it was in 1960. Especially due to excessive water withdrawal for Uzbekistan's irrigation program, the Aral Sea's water level has decreased (Loodin 2495). In addition to the irrigation problems, the water flow of the Amu Darya in Karakalpakstan has significantly decreased

due to dramatic climate change since the late 1980's (Loodin 2502). As can be seen in Figures 2, 3 and 4, the Aral Sea has lost most of its water due to changes in water volume.

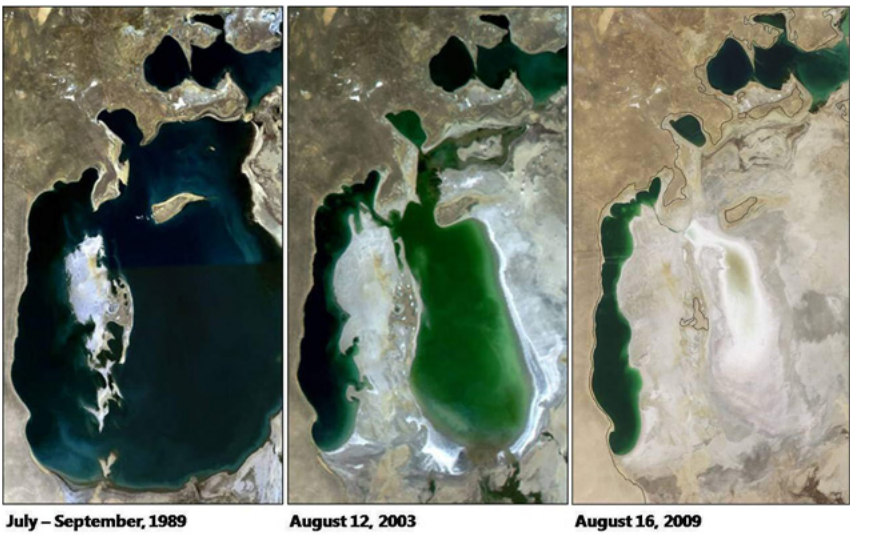

Figure 2. Desertification of the Aral Sea from 1989 to 2009 (NASA)

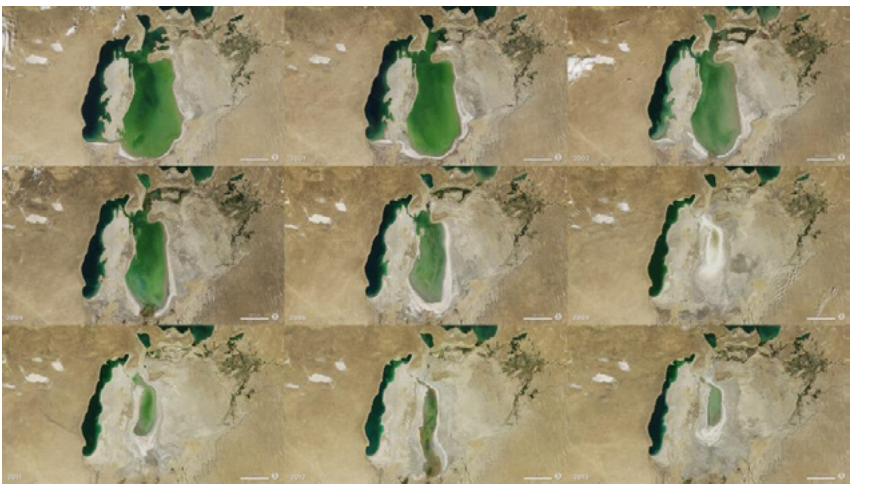

Figure 3. Satellite Images Showing Changes in the Aral Sea from 2000 to 2013 (NASA)

Figure 4. Satellite Image of the Aral Sea in 2018 (NASA)

Micklin et al. (125) highlight the impact of the Aral Sea's desiccation on Vozrozhdeniya Island, a remote island used for secret bioweapons testing. After the Soviet Union's collapse in 1991, the Aral Sea's shrinkage led to the island expanding and joining the mainland. Concerns arose about weaponized organisms escaping Russian decontamination efforts, leading to a 2000 US-Uzbek collaboration to eradicate pathogens used as weapons (Micklin et al. 125).

As a result of the water level decline, the Aral Sea's divided into two parts, the Small Aral Sea in Kazakhstan and the Large Aral Sea primarily in Uzbekistan, causing ecological crisis, societal disruption, health problems and economic losses (Strickman and Porkka 110). The decreasing water level and hyper-salinization in the lake created harmful implications for the ecosystems as well as for the socio-economic structures in the region.

The Nexus of Environmental Degradation and Socio-Economic Well-being in the Aral Sea Basin

The environmental crisis in the Aral Sea Basin has eventually become a humanitarian crisis causing economic, social, and medical problems. The impact of the desiccation was acute on the whole ecosystem and deteriorated the economy and the social conditions of the people.

Ecosystems and Humans

The Aral Sea Basin's environmental degradation has led to both green and brown environmental issues such as ozone layer, greenhouse gases, climate change, waste removal, safe water provision, urban health problems, inadequate sanitation, and local air pollution (Vogel 233). Ecological disasters often go unnoticed until they significantly impact large populations' health. A 1991 study in the Aral Sea coastal area revealed that intestinal infections, non-infectious diseases like cancer, heart disease, digestion, hemogenesis, and respiratory system problems were causing significant illness (Elpiner 129-135). Wæhler and Dietrichs also relate that poverty, poor hygiene, and malnutrition are blamed for the high rate of sickness, particularly tuberculosis. Multi-drug-resistant tuberculosis (TB) is a major issue in this region. Thus, environmental degradation threatens human health on the one hand and people's livelihoods and well-being on the other. Additionally, the population in Karakalpakstan displays somatic symptoms such as emotional stress due to environmental problems (Crighton et al.), which proves how human health is integrated with ecological health. The Aral Sea coastal region experienced high infant morbidity and mortality rates, with genetic problems more common. Infections like typhoid fever, viral hepatitis, and paratyphoid increased, and anaemia was prevalent. The population with registered parasitic diseases also increased. Maternal mortality tripled between 1985 and 1990, which indicates the acuteness of social problems (Elpiner).

Groundwater level changes and soil salinization impact regional public health, with poor water sources reducing surface water dilution and self-purification. Polluted Amu Darya and Syr Darya lead to water pollution: canals, and aryks, and agricultural produce are contaminated by pesticides and fertilizers. Pesticides are found everywhere, from drinking water to the

air and even in mother's milk. The dried bottom of the Aral Sea releases dust containing large amounts of salt and chemical pollutants through large-scale dust storms. The World Health Organization (WHO 2022) states that outdoor air pollution causes 89% of the 4.2 million premature deaths in low – and middle-income nations. According to the 2022 World Air Quality Report, Uzbekistan is the 20th most polluted country, and the Kyrgyz Republic is the 24th most polluted country (IQAir). The average concentration of fine particulate matter (PM 2.5) in Uzbekistan was 6.7 times the WHO annual air quality guideline value, while it was 6.2 times in the Kyrgyz Republic; 4.6 times in Kazakhstan; and 4.3 times in Turkmenistan (IQAir). The deteriorating quality of the air is closely connected to the pollution of soil and water, which eventually threatens human health.

Van der Meer et al. (177) state that environmental refugees in the Aral Sea face complex issues. Individuals who fled had the chance, skills, and means to leave and adapt. Kazakhstan and Uzbekistan, as riparian states, have different economic development levels. Kazakhstan has the largest economy in Central Asia, abundant natural resources, and political stability. It attracts economic migrants from Uzbekistan, which has a weaker economy and lower average income. According to Erdinger (138), the Aral Sea's desiccation has diverse effects on Karakalpakstan, the poorest region in Uzbekistan. Old reed marshes, woods, and oases in the delta of the Syr Darya dry up, too, because of climate change. Hence, the future of the Karakalpaks is at risk. The remaining local population living around the Aral Sea cannot afford to move away, thus lacking a chance to cope with climate change and/or environmental degradation through migration. Hence, they are supposed to be equipped with skills for the conservation and rational use of fragile and unique natural resources.

Agriculture, Food Security, and Biodiversity

Dams and irrigation systems have restricted water flow to the Aral Sea and divided it into multiple salinity and depth zones. The Aral Sea is a brackish lake with a higher salt content than its tributaries, but open irrigation tunnels created during the Soviet Union continue to evaporate water and raise salt concentration. Higher salt concentrations harm biodiversity. Erdinger (136) notes that irrigation without drainage leads "to a continuous

decline in soil productivity." Once considered the fish basket of the region, the Aral Sea eventually depleted of its fisheries stock. The Soviet Union's centrally planned economy accelerated irrigation in the Aral Basin to increase cotton and other agricultural products, ignoring environmental degradation and the adverse effects on people. Only 2 of 20 commercially valuable fish species remain. The fishing sector (canaries, processing plants, and fishing vessels) provided food and jobs. When communities switched from fishing to farming, soil stress caused salinization and agricultural yield loss. Women and children were malnourished due to poverty and low crop yields. Gintzburger (9) states that poor management of farmlands threatens both food security and biodiversity because of unsustainable agricultural production and natural resource exploitation. Yu Yang et al. (10) state that "there is a lack of cooperation among national authorities and ministries responsible for water policies and environmental protection" as the situation in the Aral Sea Basin has proven.

Ecosystem functions and ecosystem services (ES) must be considered to comprehend human-ecosystem connections. De Groot (394) defines ecosystem function as nature's ability to meet human needs directly or indirectly; "natural processes, in turn, are the result of complex interactions between biotic (living organisms) and abiotic (chemical and physical) components of ecosystems through the universal driving forces of matter and energy." The inherently anthropocentric concept of ecosystem services means that ecosystem functions benefit humans and provide for their needs. While natural processes such as photosynthesis remove carbon dioxide and supply oxygen to humans, soil provides humans with the resources to feed and raise agricultural products. Yu Yang et al. (10) argue that for stable and sustainable ecosystem services in Central Asia, it is crucial to establish "the fully integrated management of water, land use, and industrial development" with a framework that incorporates "policy, finance, environmental regulations, relevant organizations and technologies".

Moreover, de Groot et al. (402-403) note that "to ensure the continued availability of ecosystem functions, the use of the associated goods and services should be limited to sustainable levels," which are "determined by ecological criteria such as integrity, resilience, and resistance." Many ES are decreasing due to human activities that affect the structure and function of

the entire ecosystem in the Aral Sea Basin, where rapid urban expansion and cultivated land reclamation are the main factors driving land use change (Chen et al.). In the meantime, forestland and wetland areas decrease. The expansion of urban land, cropland, and grassland areas increases the consumption of water. Even economic approaches like those of Chen et al. emphasize that there is a synergistic relationship between environmental functions. In arid regions, surface vegetation regulates the climate. Climate regulation and biodiversity work synergistically in areas with significant vegetation coverage and various plant species. Therefore, countries in the region should follow environmental protection policies that will prevent the consumption of more water.

Climate change in Central Asia will increase temperatures and stress on water resources, necessitating countries to adopt international climate action and SDGs for future environmental, agricultural, urbanization, and industrial policies. These policies should include selecting water-efficient crops, using drip irrigation, preserving arable lands, and protecting grassland. Cooperation among countries with diverse ecosystems can track ecological changes, protect the environment, and support climate mitigation and adaptation strategies for sustainable development.

The Aral Sea Crisis in the Context of Sustainable Development

Socio-economic issues such as poverty, hunger, insufficient health and education services, gender inequality, lack of sanitation systems and infrastructure, as well as environmental degradation and loss of biodiversity have created many challenges for societies. Introduction of the sustainable development concept and setting SDG targets has contributed to the improvement of many ecological and development issues.

After their independence, Central Asian states faced economic and environmental challenges in transitioning to a market economy. As their unsustainable development has heavily relied on natural resources, the water use (particularly in the Aral Sea Basin, which is used for drinking water, irrigation, and hydropower) continued after independence. For instance, agricultural irrigation, especially during summertime, in Uzbekistan and Turkmenistan still consumes a vast amount of water in the Aral Basin (McKinney 187). Along with unsustainable resource-demand for irrigation,

basin countries' reliance on water resources for economic growth has worsened social, economic and environmental conditions (International Crisis Group 2002). The over-dependence of the Central Asian countries on water resources for development is the basic economic-political source of the current problem (Uslu et al. 144) that affects implementation of sustainable development principles (Weinthal 19).

Sustainable development opportunities to fulfill future demands have mostly been consumed in the Aral Sea Basin due to the excessive use of water for economic demands (Uslu et al. 146). Uzbekistan's Aral coast, once home to developing cities and a large fishing industry, has been severely impacted by the deterioration in water quantity and quality, leading to the loss of homes, jobs, and habitats for around 60,000 fishing workers. Environmental changes in the Aral Sea Basin have caused growing problems such as salinization, pollution, widening temperature differences between summer and winter, and acid storms (Strickman and Porkka 111), thus undermining the sustainability of ecosystems as well as social and economic structures.

Sattorov examines Earth's challenges, including climate change, deforestation, pollution, and ecological crises, and emphasizes the need for sustainable practices and alignment with global strategies like the UN's Sustainable Development Goals. Chen et al. use econometric models, statistical data, case studies, and innovative solutions to provide evidence-based strategies for a sustainable future. The study analyzes changes and drivers of SDG7: Affordable and clean energy in the Aral Sea Basin from 2000-2020, revealing an uneven development pattern and rapid GDP increase. To achieve SDG7 in 2030, it suggests deepening inter-basin energy cooperation, enhancing renewable energy investment, and increasing energy intensity. Nagabhatla et al. also explore the relationship between water and migration, focusing on SDGs 6, 11, and 16, Clean water and sanitation; Sustainable cities and communities; Peace, justice and strong institutions, respectively. The study highlights the high impact of water and climate crises on rural-urban migration due to dependence on nature-based livelihoods. Schneider and Avellán also discuss water security in the context of global change syndromes, discussing drivers and pressures on water resources and their impacts on the UN Sustainable Development Goals and Agenda 2030. Baubekova

and Kvasha state that joint efforts by all states are needed to address water-related issues. Hence, implementing a water-energy-food nexus concept and promoting water-efficient practices can improve resource availability. Yet, lack of reliable data on indicators is a pressing issue. Hanyan proposes green energy development, small hydro-power stations, and agricultural modernization in Central Asia to reverse the drying trend and improve the ecological environment. On the other hand, Ma et al. emphasize that the Aral Sea Basin faces water scarcity and ecological degradation, but research on collaborative water-related nexus system management is limited due to uncertainties. Hence, Ma et al. explain the literature gap with the fact that previous studies have simplified agriculture's impact on water resources and ecosystems. Accordingly, a nexus framework combining water, agriculture, and ecosystem is needed for sustainable management in response to changing environments. Even this up-to-date study lacks to observe and evaluate the nexus between the degradation of ecosystems and human well-being. This article aims to analyze the situation of the riparian countries with the selected SDGs to understand the impact of environmental degradation on human well-being.

Unsustainable economic activities of the basin countries can be listed as follows: Uzbekistan, the largest cotton producer in the basin, uses an average of 14,000 m3 of water per hectare. In a comparison in terms of water efficiency, this is 10,000 m3 in Egypt and Pakistan (World Factbook e). Kazakhstan's development and growth are not primarily influenced by water, despite having the lowest economic dependence among the Aral Sea Basin states, but water still significantly impacts national employment (Abbink et al. 286; World Factbook a). The Kyrgyz Republic's sustainable development relies heavily on its crucial natural resources, including water and arable land, which are primarily utilized by the agricultural sector (Abbink et al. 285; World Factbook b). Tajikistan's 92% agricultural water consumption, largely due to intensive agricultural employment, underscores the country's significant dependence on water resources and calls for increased awareness of sustainable development (World Factbook c). Lastly, in Turkmenistan, water consumption is realized in the agricultural sector at a high rate of 98%, and the share of the agricultural sector in national income is 10% (World Factbook d).

Key issues of sustainable development such as agricultural production, food security, labor and employment issues, environmental protection, and water usage are as significant in the Aral Sea Basin as in other regions of the world (Rakhmatullaev et al. 308). Mitigating the Aral Sea catastrophe rather than reconstruction of the ecosystem is the most feasible approach due to time and economic constraints. Local communities should focus on damage control and cooperative management of limited water resources to avoid an unprecedented economic, social, and environmental crisis (Peachey 2004). The states should work with independent NGOs to address sectoral requirements such as agricultural and industrial diversification and the use of water utilization quotas (Sievers 204). Regional cooperation is effective for sharing natural resources and maximizing benefits, but there is no efficient framework for promoting common water resource use, especially in regions facing environmental crises (Vinca et al. 2021; Qin et al. 2022). To support these requirements, SDGs could be considered a cornerstone.

Selected Sustainable Development Goals for the Aral Sea Basin Countries in Central Asia

SDGs reveal the performance of the states through indicators that are closely related to environmental degradation. Uzbekistan faces significant challenges in all SDGs with limited progress in some. However, major and significant challenges remain in SDG3: Good health and well-being, SDG6: Clean water and sanitation, SDG7: Affordable and clean energy, SDG15: Life on land, SDG17: Partnerships for the goals. When we investigate these SDGs with major challenges, the indicators support our argument that environmental degradation due to the desiccation of the Aral Sea is the biggest obstacle to sustainable development, social peace, and human health. Not only are these SDGs interrelated, but they also point to similar trends in other basin countries with issues alike (Sustainable Development Report a).

SDG3 in Uzbekistan states that the "age-standardized death rate due to cardiovascular disease, cancer, diabetes, or chronic respiratory disease in adults aged 30–70 years" is still high, the incidence of tuberculosis is a significant challenge, and ambient outdoor air pollution remains a major challenge, although there is no long-term objective for this indicator. According to SDG6, the level of water stress, which is the ratio of freshwater withdrawal

intensity to total renewable resources after considering environmental requirements, is high, too. Major sectors, including agriculture, forestry, fishing, manufacturing, electricity, and services, withdraw most of the freshwater. In the first place, the unregulated and unsustainable use of fresh water has led to the problems that today manifest themselves in desertification, decline in biodiversity, poverty, poor health, and respiratory diseases. While SDG7 shows that CO2 emissions from fuel combustion per total electricity output are high, major challenges remain to reach the long-term objective, and the share of renewable energy in the total final energy consumption is desperately low. The indicators for SDG15 reveal that the mean percentage area of terrestrial and freshwater key biodiversity areas are 17.73 and 13.44 respectively in 2022. Whereas the long-term objective for government spending on health and education in SDG17 is 15%, Uzbekistan scores 8.03% in 2020 (Sustainable Development Report a).

In Kazakhstan for SDG3, we observe a similar trait with Uzbekistan and see that incidence of tuberculosis, outdoor air pollution, cardiovascular disease, cancer, diabetes, or chronic respiratory disease continue to threaten adults' health. Sustainable Development Report states that challenges remain with almost every indicator for SDG6 except for the population using at least a basic sanitation service. Accordingly, "the percentage of the population using at least a basic drinking water service, such as drinking water from an improved source" is 95.44%. Yet, trend information on freshwater withdrawal and the proportion of wastewater that receives treatment does not exist. SDG7 also shows that energy production remains carbon-intensive and renewable energy share is as low as 1.7% in 2019. The indicators for SDG15 in Kazakhstan for the mean percentage area of terrestrial and freshwater key biodiversity areas are 28.55 and 20.47 respectively, in 2022. Government spending on health and education in Kazakhstan amounts to only 6.96% of GDP in 2020, thus Kazakhstan lags behind the long-term objective for an important indicator of SDG17 (Sustainable Development Report b).

Turkmenistan has the worst indicators of SDGs among these countries. In SDG3, mortality rates for newborns, infants under 5, "the probability of dying between the ages of 30 and 70 years from cardiovascular diseases, cancer, diabetes or chronic respiratory diseases," and "the mortality rate

that is attributable to the joint effects of fuels used for cooking indoors and ambient outdoor air pollution" remain significantly high. Sustainable Development Report (c) states that indicators for SDG6 such as freshwater withdrawal and the percentage of anthropogenic wastewater that receives treatment indicate major challenges remain. As SDG7 shows, energy production is carbon intensive in Turkmenistan, and renewable energy share is 0.1% in 2019. The indicators for SDG15 in Turkmenistan for the mean percentage area of terrestrial and freshwater key biodiversity areas are 14.04 and 12.75 respectively in 2022. Government spending on health and education in Kazakhstan sums only 4.13% of GDP in 2020; thus, Turkmenistan is the lowest scoring country for the long-term objective of an important indicator of SDG17 (Sustainable Development Report c).

SDG3 indicators in Tajikistan have similarities with Uzbekistan, Kazakhstan, and Turkmenistan; hence, the incidence of tuberculosis, cardiovascular diseases, cancer, diabetes, or chronic respiratory diseases indoors and ambient outdoor air pollution are major threats to human health. Aside from that, life expectancy at birth is almost 3% lower than the long-term objective as of 2019. Subjective self-evaluation of life values as low as 5.2 in 2022, whereas the long-term objective for this indicator is a value of 7.6. Significant and major challenges for the indicators of SDG6 persist; hence, 18.15% of the population lacks at least basic drinking water services. The Sustainable Development Report notes significant challenges for the indicator of freshwater withdrawal, as well as major challenges for anthropogenic wastewater that receives treatment. Tajikistan surpasses the rest of the basin countries in SDG7, except for the indicator for the population's access to clean fuels and cooking technology, which still faces challenges but is making progress. The protection of terrestrial and freshwater sites important to biodiversity in Tajikistan remains a major challenge. As a result, SDG15 emphasizes the importance of environmental preservation for Tajikistan. While Tajikistan is on track for SDG17, government spending on health and education needs to improve (Sustainable Development Report d).

In Kyrgyz Republic, the age-standardized death rate due to cardiovascular disease, cancer, diabetes, or chronic respiratory disease in adults aged 30–70 years, as well as the mortality rate attributable to household air pollution and ambient air pollution, are significantly high. The incidence of tuberculosis

is a common indicator for SDG3, which remains a major challenge in the Kyrgyz Republic. The indicators with significant and major challenges in SGD6 are, respectively, freshwater withdrawal and anthropogenic wastewater that receives treatment. SDG7 highlights the ongoing challenges faced by the population in accessing clean fuels and technology for cooking, as well as the share of renewable energy in total final energy consumption. However, the Kyrgyz Republic has achieved a long-term objective for CO2 emissions from fuel combustion per total electricity output. SGD15 still faces significant challenges, as the average protected area in terrestrial and freshwater sites crucial to biodiversity remains significantly low. SGD17 indicates that government expenditure on public health and education remains low, with a decreasing score (Sustainable Development Report e).

Regional and International Recuperation Efforts

The extent of intertwined problems and the insufficient SDG performances of basin countries explained in the previous sections indicate that regional and international efforts are crucial for the recuperation of the Aral Sea. When the desiccation and other ecological changes in the Aral Sea Basin started to affect social and economic structures and cause health problems for the people, the Soviet government began several recuperation projects for the Aral and wetlands of the lower Amu Darya Delta in the late 1980s (Micklin, *Efforts* 376). After the collapse of the Soviet Union, there have been conservation and restoration initiatives conducted by the riparian countries to save the remaining parts of the sea and its ecosystems, the Small Aral, the Large Aral, and the deltas and deltaic waters of Syr Darya and Amu Darya (Aladin et al. 73). As a result of these efforts the flow of the Syr Darya slightly increased, reaching 5 km^3 per year and causing its delta to shift northward. Thus, some freshwater reservoirs were built, and near the Small Aral, some freshwater lakes were restored. Thanks to these projects, freshwater fisheries, hunting, and trapping activities in that area were reinitiated, while young fish were reintroduced to the renewed fish farms. Similarly, several freshwater and brackish water reservoirs and lakes were created in the Amu Darya to help ecosystems' rehabilitation and the recovery of fisheries and hunting activities (Aladin et al. 92-93). Moreover, the fact that the per capita irrigated agricultural land in the basin countries, particularly in Uzbekistan, has been decreasing for some time and that

Uzbekistan has gradually moved away from being a cotton economy are positive developments towards solving the water problem in the basin (Sakal 250).

The Aral Sea Basin faces challenges in water management and climate mitigation, necessitating closer cooperation among states for conservation and preservation efforts. These efforts will be most effective if the regional states view the Aral Sea Basin "holistically as a 'meta-ecosystem': a system that cannot be separated into its many linked parts" (Glantz 24). Hence, policies targeting sustainable development and adaptation to the present and changing environmental conditions must regard "spatial flows between different ecosystems" such as water, energy, nutrients, fish, agricultural chemicals, and dust (White 305). Different parts of the sea may require different solutions to the existing socio-ecological crisis, yet political will and financial resources are necessary.

Human intervention in the Aral Sea, which led to its destruction during the Soviet era, may now serve ecological integrity, biodiversity, and ecosystem functioning. The construction of dams, dikes, and river rechanneling has increased fish stocks, providing income and employment opportunities. Conservative agriculture can improve socio-economic conditions and preserve ecology (Nurbekov et al.). Understanding the cause-and-effect characteristics of nature and society's relationships is the key to making the right human management decisions. Adoption of a scientific, interdisciplinary approach that regards *do no harm* as a fundamental principle is important to promote the sustainability of ecosystems and economies.

The Aral Sea region's environmental disaster and desiccation have sparked international attention. In 1990, UNEP signed a memorandum for an action plan for rehabilitation, and "the Global Infrastructure Fund Research Foundation Japan" (GIFRFJ) conducted extensive research on the issue (Narbayep and Pavlova 22). GIFRFJ proposes a regional infrastructure fund to restore the Aral Sea, requiring massive funds and industrially developed countries' participation, integrating all sectors of the economy.

The Soviet water authorities established water organizations in the 1980s to manage Amu Darya and Syr Darya, which are familiar to the Aral Sea Basin. The newly independent states of Central Asia signed the Almaty Agreement

in 1992, establishing "the Interstate Commission for Water Coordination of Central Asia" (ICWC). Although they recognize the importance of collectively managing these organizations, they have not improved the limited dialogue among the riparian states.

In 1993, Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan formed the Interstate Council on the Problems of the Aral Sea Basin to collaborate on regional issues and support international donor aid and regional assistance programs (ICAS). They also established an "International Fund for the Aral Sea" (IFAS) to collect basin state funds for restoration. The ICAS was abolished in 1997 and merged into a revamped IFAS, whose presidency rotates every two years among Central Asian heads of state. The Ashgabat Declaration in 1999 outlined the role of ICWC and its executive branches under the IFAS, later establishing "the ICWC Scientific Information Centre" (SIC). However, Kyrgyz Republic has frozen its membership since 2016. The basin countries need to build closer dialogue, mutual trust, and more effective governance structures.

One of the most important rehabilitation initiatives was "the Aral Sea Wetland Restoration Project" (ASWRP), implemented by the IFAS and funded by "the Global Environmental Facility" (GEF). Micklin (*Efforts* 377) explains the aim of the project as the restoration of biodiversity and productivity of water bodies that have ecological significance for fauna as well as substantial economic value as sources of fishery, fur-bearing mammals, and reeds for domestic animal feed and for construction purposes.

"The International Union for Conservation of Nature and Natural Resources" (IUCN) and "the Regional Environmental Centre for Central Asia" (CAREC) are working on an EU-funded "Central Asia Nexus Dialogue" project to promote capacity and investment in water, energy, and food security (Carec). "The Central Asia Nexus" highlights the relationship between water, energy, and food security and the utilization of water, soil, and land. IUCN (2019) notes that Central Asia faces water scarcity problems that harm agricultural and energy production. Multi-sectoral decision-making and investment planning can increase human well-being and socio-economic growth while benefiting all sectors.

The "Blue Peace Index" by the Economist Intelligence Unit (EIU) emphasizes the need to strengthen legal, institutional, financial, and infrastructure frameworks for water management in Central Asian countries (EIU, 2020). Effective and long-term adaptation goals in transboundary river basins require transboundary coordination and cooperation, with political, legislative, and institutional frameworks at national and regional levels supporting adaptation to climate change (Narbayep and Pavlova 41).

EIU (12) notes that safe access to freshwater is critical to social and economic objectives outlined in the SDGs, in areas such agriculture, trade, economic growth, energy production, and biodiversity. Central Asian countries are making progress towards the SDGs in environmental protection, social justice, and economic growth. However, challenges include inadequate transboundary water management, ageing dams and reservoirs, limited trust and coordination between governments, unsustainable infrastructure management, and inadequate regional cooperation on pollution control, disaster management, and infrastructure development. These factors increase the basin's vulnerability to climate change impacts.

Conclusion

Sustainable development approach is crucial to respond economic, political, and environmental challenges in the Aral Sea Basin. However, there is no consensus among the basin countries due to economic and political issues. Riparian states in the Aral Sea need to work together with sustainability policies focusing on economic growth, environmental protection, and social awareness to address environmental problems, food crises, socio-economic problems, and human rights. Human rights to nature in the Aral Sea Basin are being overlooked, highlighting the need for a holistic approach to environmental protection. The disintegration of ecosystems in the region highlights the need for ecological integrity, as they are interdependent and interconnected. To answer these challenges, decision-makers and administrations must adopt a sustainable development perspective, supporting local communities and societies as well as ecological balance.

In this article, the performances of the Central Asian basin countries regarding the Aral Sea disaster in terms of the selected SDGs (SDG3: Good health and well-being, SDG6: Clean water and sanitation, SDG7:

Affordable and clean energy, SDG15: Life on land, SDG17: Partnerships for the goals) were examined. The previous studies summarized in the related sections of this article mostly focus on physical conditions of the Aral Sea, while sustainable development and SDGs are discussed from a rather narrow perspective. Except for the reports of the United Nations, no specific and in-depth study was found in the literature where the Aral Sea riparian countries are evaluated in terms of SDGs focusing on the nexus of environmental and human well-being. Therefore, this article contributes to relevant literature through analyzing the situation of the riparian countries in terms of the selected SDGs with an intention to serve as a reference point for new studies evaluating the issue within the framework of sustainable development.

The basin countries' poor performance in related SDGs serves as evidence that the damage to sustainable natural resources in and around the Aral Sea is the main source of many of the social and economic problems of these countries today. Thus, the development of environmental conditions is a prerequisite for improving human health and socio-economic circumstances. The findings show that human well-being is not separate from the well-being and sustainability of the natural environment but rather an integral part of them. Instead of treating data about ecological disasters as a warning for human health, it would be useful to consider ecological integrity and health as sine qua non for human health and to make all recovery and development plans in the Aral Sea Basin in accordance with this principle. Otherwise, all response strategies will be conditioned on the visibility of the adverse effects of environmental degradation on human health and will therefore be too late. Consequently, sustainable development cannot be achieved without a more responsible use of water and other natural resources and cooperation among the countries of the region.

Contribution Rate Statement

The authors' contribution rates in this study are equal.

Conflict of Interest Statement

There is no conflict of interest with any institution or person within the scope of this study. There is no conflict of interest between the authors.

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