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Fishery culture, sustainable resources usage and transformations needed for local community development: the case of Aral Sea

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The Aral Sea, once one of the largest lakes in the world, has been rapidly disappearing due to human activities such as irrigation and dam construction. This has had a significant impact on the fishery culture of the region, which has relied on the sea for centuries. This scientific article uses primary and secondary data to explore the history and current status of fishery culture in the Aral Sea region, the connection between the fishery culture and community. The interviews with local residents, eco-activists and students help to understand different perspectives on the matter and evaluate the challenges faced by the fishery industry due to the shrinking of the sea, including declining fish populations and changes in fishing practices. Potential solutions for sustaining fishery culture in the Aral Sea region or for transforming it in another source of income for the local community, such as promoting sustainable fishing practices, community-based tourism activities, festivals and developing alternative economic opportunities for local communities, are discussed in connection with network-based interventions. Overall, this article provides insights into how to support sustainable resource use in the region, and how the local communities are affected by disappearance of Aral Sea.

KEYWORDS

Aral Sea, Uzbekistan, fishery culture, network interventions, community development

1 Introduction

Commencing in the 1950s, the Soviet Union initiated and effectively executed strategies aimed at significantly augmenting cotton cultivation in the Aral Sea region, thereby establishing it as one of the foremost global hubs for cotton production. The achievement of this result was facilitated by the implementation of an extensive network of irrigation canals spanning thousands of kilometers, as well as the redirection of water

resources from the Syr Darya and the Amu Darya rivers, therefore mitigating their flow into the Aral Sea.

Consequently, the Aral Sea, formerly ranking as the fourth biggest landlocked body of water globally, has been seeing a consistent reduction in its dimensions. Throughout the Soviet era (1924-1991), and especially from the late 1950s onwards, there was a significant increase in the utilization of the Amu Darya and Syr Darya rivers for extensive irrigation systems aimed at ensuring the cultivation of cotton. Currently, the extent of sea coverage is around one-third of what it was in 1960 (Figure 1), but the salinity of seawater has increased from 10 g/l to around 35 g/l. This salinity level is similar to that seen in the world's seas (Dukhovny and Kindler, 1999). According to Micklin (2007), the sea's level experienced a decline of 23 meters by the year 2006. Additionally, the volume of the sea decreased by 90%, while the salinity increased to above 100 grams per liter.

The extent of irrigated land in the Aral Sea had a nearly twofold increase, rising from 4.5 million hectares during the 1950s to 7.9 million hectares by the year 2006. The significant expansion of the irrigation system led to a considerable reduction in the volume of water flowing into the Aral Sea, declining from 43 km^3 per year in the 1960s to a mere 9 km^3 per year between 2001 and 2005.

As a result, the Aral Sea underwent a significant reduction in size over a span of several decades, diminishing from its previous status as the fourth biggest freshwater lake globally, with a surface area of 6.8 million hectares, to less than one-fifth of its original expanse.

The Aral Sea region, historically known for its thriving fisheries, has a rich and deeply rooted fishery culture that has evolved over centuries. This culture has been shaped by the natural abundance of the Aral Sea and its tributaries, and it plays a significant role in the identity and livelihoods of the communities in the region (Khudaybergenov, 2021).

Fishing in the Aral Sea region has a long history, dating back to ancient times (Ermakhanov et al., 2012). It has been a vital source of sustenance and economic activity for generations of people living along the sea's shores. The region's fishery culture was characterized by traditional fishing techniques, such as using nets and small boats, which were passed down through families and communities. Fishery culture in the Aral Sea region extended beyond economic importance (Glantz and Figueroa, 1997). Fish played a role in cultural practices and rituals. Festivals and celebrations often revolved around the fishing season, with communities coming together to commemorate successful catches and share in the bounty of the sea. Stories, songs, and folklore celebrated the significance of fish and fishing in the local heritage.

The fishery culture served as the economic backbone of many communities in the region. It provided income and employment for fishermen and their families, as well as supporting related industries such as fish processing and trade. Fishing communities developed their own distinct ways of life, often closely tied to the rhythm of the fishing seasons. Unfortunately, the Aral Sea disaster brought about a dramatic decline in the fishery culture of the region. The diversion of the sea's tributaries for irrigation purposes, resulting in the sea's shrinking and salinization, led to the collapse of fish stocks. This ecological catastrophe not only devastated the environment but also disrupted the traditional way of life for many fishing communities. Many fishermen lost their livelihoods, and cultural practices associated with fishing faced immense challenges.

The Aral Sea disaster serves as a prominent case study in the field of environmental science. The analysis of this catastrophe highlights the devastating consequences of human-induced changes to ecosystems. The studies conducted on Aral Sea and similar natural disasters help to understand the ecological, social, and economic impacts, as well as to derive valuable lessons. The 3.5 million people living around the Aral Sea, including 1.5 million children, have been severely affected. The Republic of Karakalpakstan in Uzbekistan, where the majority of the population consists of ethnic Karakalpaks, is the most affected region (Ataniyazova, 2003).

Researchers like Glantz and Zonn (2005), Peterson (2019) have documented the decline of Aral Sea attributing the disaster to unregulated water diversion for agricultural purposes. The case in question became a poignant reminder of the far-reaching repercussions of shortsighted water management practices. The Aral Sea's desiccation undercovers the disastrous outcomes of

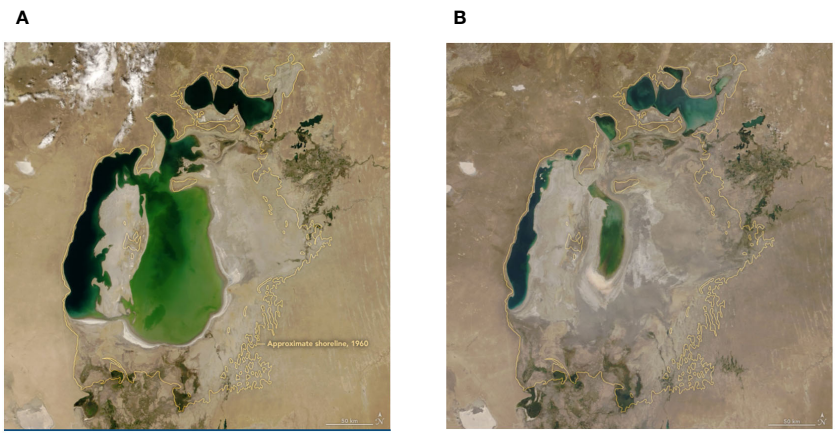

FIGURE 1
Shrinking Aral Sea: **(A)** August 25, 2000; **(B)** August 21, 2018. Source: NASA's Earth Observatory, 2023.

neglecting the need for integrated water resource management. It exemplifies how interconnected ecosystems are, as the diversion of its tributaries disrupted not only the water balance but also the web of life it once supported (Glantz and Zonn, 2005).

Other researchers bring into focus the profound ecological implications of the Aral Sea's demise (Robinson, 2005). The once-vibrant ecosystem of the Aral Sea region has witnessed a staggering loss of biodiversity (Plotnikov et al., 2023). The intricate interconnections within ecosystems can quickly unravel when subjected to environmental stressors. On the other hand, local population faces numerous health challenges. Numerous studies expose the sever human health impacts resulting from dust storms laden with saline and chemical residues originating from the exposed seabed (Zetterström, 1999; Small et al., 2001; Whish-Wilson, 2002; Ataniyazova, 2003; Tussupova et al., 2020; Anchita Zhupankhan et al., 2021). The consequences of ecosystem disruption extend far beyond ecological concerns, with direct repercussions on the health and livelihoods of the communities that rely on these ecosystems.

Not only health, but also economic consequences of the Aral Sea disaster are faced by the community. The collapse of fisheries and the degradation of agricultural lands have unleashed a cascade of economic challenges, creating a perfect storm for local economy (Micklin et al., 2020). The interdependence between economic well-being and the vitality of ecosystems leads in the situation of declination of ecosystem to precipitation of the impoverishment of entire communities and regions (Pianciola, 2020; Abidova and Rustamovich, 2021; White and Micklin, 2021). Such situation highlights the importance of adopting holistic and forward-thinking strategies that harmonize human needs with the preservation of the natural environment to secure the prosperity and resilience of communities.

According to a World Bank report (World Bank, 2004), the causes of the Aral Sea crisis have been acknowledged by the five countries affected by it – Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan, and Afghanistan. The importance of efficient use and management of water resources in international river basins and the need for cooperation among riparian countries are emphasized. The World Bank has intervened in the Aral Sea basin, along with the Indus and Mekong basins, to foster riparian dialogue and cooperation (Kirmani and Guy, 1997). Additionally, a proposed framework of activities has been put forward by the World Bank to address the Aral Sea crisis (Weinthal, 2001).

The disappearance of the sea has resulted in the exposure of saline seabed and the desertification of ecosystems, altering the landscape and posing challenges for the local communities. Fishermen have lost their livelihoods as commercial fishing catches declined. The region's economy has also been impacted by the dying of the sea, exacerbated by the cotton monoculture and the use of pesticides. Additionally, pollution from upstream activities, such as chemical and biological weapons tests, has further worsened the situation (Ataniyazova, 2003).

The Aral Sea disaster challenged the resilience of communities in the region. As the sea retreated, traditional livelihoods such as fishing and agriculture were severely disrupted. Communities had to adapt and find new ways to sustain themselves. Some turned to alternative livelihoods, such as animal husbandry or migration to urban areas. Research (Srivastava et al., 2022; Rustamova et al., 2023) has shown that resilience in the face of such environmental upheaval often depended on factors like access to resources, social support networks, and the ability to diversify income sources.

The disaster also tested the strength and highlighted the importance of community ties. As people faced economic hardships and displacement, community solidarity became crucial for survival. Research by Dukhovny and Sokolov (2003) has highlighted the resilience of local communities in maintaining social bonds and supporting each other during these challenging times. However, it has also exposed instances of strain as competition for dwindling resources intensified.

The present research aims to comprehensively examine the current state of the Aral Sea catastrophe and its multifaceted impact on local communities. The primary objective is to provide an up-to-date picture of the Aral Sea catastrophe development, taking into account the latest environmental and ecological conditions in the region. This involves description of the extent of the sea's shrinkage, changes in water quality, and the status of ecosystems in the affected areas.

Another key objective is to gain a deep understanding of how the Aral Sea catastrophe has affected the lives of local communities. This includes evaluating the socio-economic, health, and cultural impacts experienced by individuals and families living in the vicinity of the Aral Sea. The research places a significant emphasis on evaluating the perspectives of various stakeholder groups. The objective is to capture a diverse range of viewpoints, experiences, and opinions related to the Aral Sea disaster.

Finally, the research seeks to provide practical suggestions and recommendations for supporting local communities affected by the Aral Sea catastrophe through the networks and other methods that can be applied to the policies and programs in the region. The overarching goal is to aid local communities in readapting to their changing environment and enhancing their resilience in the face of ongoing ecological challenges.

2 Materials and methods

The research of Aral Sea catastrophe and its impact on community is a multi-disciplinary work that is based on different sources and methodology. Following the objectives stated above, the mixed-method methodology was used.

The researchers used secondary data analysis for obtaining the historical perspective on Aral Sea catastrophe and contextualizing the problems faced by the community. Such approach involves the systemic review and synthesis of existing literature, reports and data collected by international organizations, governmental bodies and academic institutions. Policy sources contribute to exploration of ecological degradation, socio-economical consequences and policy responses related to the Aral Sea crisis.

Fifteen reports published by international organizations such as the United Nations Environment Program (UNEP), the World Bank and Food and Agriculture Organization (FAO) were used to gather comprehensive data on ecological degradation, its causes and

related consequences. These reports provide valuable statistical data, satellite imagery and expert analysis.

Thirty-eight academic research articles, books and studies related to the Aral Sea catastrophe were examined to gain a deeper insight of ecological dynamics, hydrological changes and historical contexts that led to the crisis. This literature review also helped to identify the key ideas and concepts used for analysis of ecological and social consequences of large-scale water resource mismanagement.

To explore more in detail the insights gained from secondary data analysis and to capture the human perspective on the Aral Sea catastrophe, the researchers collected primary data through qualitative interviews with people connected directly to the region. The sample used in that research was intentionally limited and carefully selected to provide a comprehensive overview of the Aral Sea catastrophe from different angles. Three groups of participants were invited for in-depth semi-structured interviews on the situation. The interviews followed a flexible, yet focused approach, allowing for open-ended discussions on key topics. They were conducted individually face-to-face or through video conferencing, depending on logistical considerations. The interviews varied in duration, but on average lasted between 45 minutes to 1.5 hours. The length of each interview was adjusted depending on the depth of discussion and the participant's willingness to share their experiences.

Interviews with each group of participants were focused on different problems, depending on the relationship of the participant with the crisis. Ecological activists (five participants) were chosen because of their active engagement in raising awareness about the Aral Sea crisis. They possess a deep understanding of the ecological changes, the responses of local and international organizations, and the challenges they face while advocating for sustainable solutions. Their personal experiences shed light on the broader environmental context and the efforts being made to address the crisis. The average period of their involvement in ecological action related to Aral Sea catastrophe is 10.3 years, all five participants collaborated with international organizations, local government and authorities in projects aimed in dealing with consequences of the crisis. The interviews with ecological activists helped to gain a perspective from those actively involved in addressing the issue.

The group of fishermen and fishing families (seven participants) was selected to understand the direct socio-economic consequences of the Aral Sea's shrinking. There participants are among the most directly affected by the crisis. Their narratives provide invaluable information about the decline of fish stocks, changes in livelihoods, and shifts in social dynamics within fishing communities. All participants from thar group live in Uzbek side of Aral Sea their whole life, they interact with international organizations and eco-activists looking for the solutions to deal with the effect of the crisis on the community. By interviewing this group, the researchers aimed to capture the personal experiences and challenges faced by those who depend on the Aral Sea for their livelihoods, thus offering a real-world perspective on the crisis's impact.

The third group of participants was formed by eleven students. The inclusion of students in the sample was motivated by the desire to explore the awareness and engagement of younger generation in the Aral Sea catastrophe. These individuals often bring a fresh perspective, innovative ideas, and a unique generational outlook to complex ecological problems. Six participants from that group have economical background, five – ecological one. None is them is from Karakalpakstan – the region where Aral Sea is located, so they have not directly witnessed the consequences of the crisis. Their interviews contribute to understanding of the level of awareness among the youth and their exploration of the problem, as well as their perception of potential solutions. Involvement of students in the research allows to have a multi-generational perspective on the issue and the potential for future engagement in addressing it.

Through all the research process ethical considerations were crucial. The informed consent was obtained from all participants involved in primary data collection ensuring that their rights, confidentiality and privacy were respected. The researchers aimed to minimize any potential harm that might arise from discussing sensitive topics related to the Aral Sea crisis and its impact on the community.

3 Results

3.1 Aral Sea catastrophe and its development

3.1.1 Geographical scale of impact

The region of Central Asia encompasses a landmass of approximately 2 million km^2, strategically located within the heart of the Eurasian continent (Figure 2). This region comprises five nations, namely Kyrgyzstan (with an area of 198,500 km^2), Tajikistan (with an area of 143,100 km^2), Turkmenistan (with an area of 448,100 km^2), Uzbekistan (with an area of 447,000 km^2), and the southern portion of Kazakhstan. Approximately 70% of the Central Asia region is characterized by vast expanses of steppes and deserts, while the other 30% is comprised of mountainous terrain.

The major portion of the region is occupied by the basin of the Aral Sea. The climate in the region is characterized by its landlocked location and its exposure to the north, resulting in a highly continental environment with significant aridity. Approximately 20% of the region experiences annual precipitation levels below 100 mm, while 90% of the region receives less than 300 mm of precipitation annually. Characterized by substantial variations in temperature on both a monthly and daily basis, the climate exhibits significant changes.

The ongoing desiccation of significant portions of the Sea poses a persistent hazard to both ecosystems and livelihoods, with particular emphasis on the circum-Aral region. The feasibility of restoring the Aral Sea to its pre-1960s level, size, and ecological state is highly questionable, primarily due to the substantial reduction in yearly irrigation withdrawals of 105 km^3 that would be required, amounting to a 51% decrease.

Considering the reliance of Uzbekistan and Turkmenistan, the main users of irrigation water in the basin, on cotton cultivation as a principal means of generating foreign currency revenues, it seems improbable that substantial reductions in irrigated area and water consumption would be realized in the foreseeable future, spanning from the immediate to medium-term.

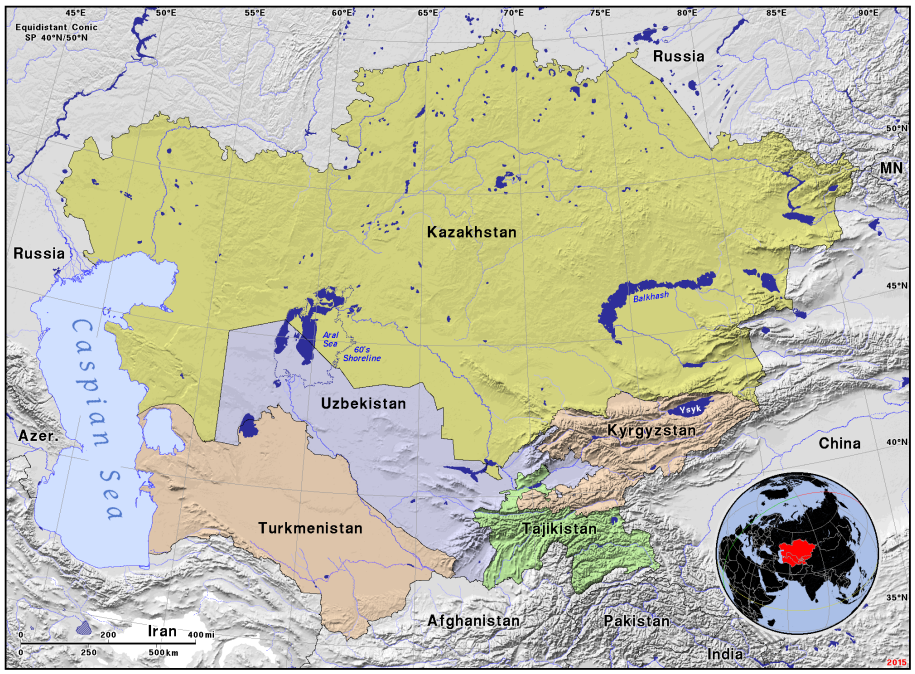

FIGURE 2
Central Asia region. Source: Ian Macky, PAT. Central Intelligence Agency, Library of Congress.

The identification and implementation of strategies to address the detrimental environmental, economic, and social consequences resulting from the Aral Sea catastrophe are imperative for the promotion of sustainable development within the basin.

Nonetheless, the phenomenon of "creeping environmental problems," exemplified by the desiccation of the Aral Sea, necessitates the implementation of "creeping solutions" (Glantz, 2008). These solutions refer to gradual and incremental measures that can be used to enhance resource utilization efficiency, while simultaneously addressing the environmental and socio-economic challenges at hand.

3.1.2 Cotton cultivation and water crisis

Cotton significantly dominates the regional economy and have been seen as main cause of Aral Sea disaster in Khorezm and Karakalpak regions, as it encompasses half of the irrigated cropland, utilizes over 40% of the region's total water supply, contributes up to 16% to the Gross Domestic Product (GDP), and generates nearly 99% of the export revenues for Khorezm (Zholdasova et al., 1999).

The implementation of winter wheat cultivation was initiated in 1992 as a component of the nationwide initiative aimed at attaining food self-sufficiency. As a result, there was a notable rise in the cultivation of wheat in the region of Khorezm, accounting for around 20% of the total agricultural area. This increase was mostly achieved by reallocating land previously used for growing fodder crops, such as lucerne, which had been extensively planted in conjunction with cotton during the Soviet Union era (Pavlovskaya, 1995).

Rice holds a significant position as the third most crucial crop in the Khorezm region, contributing to nearly one-third of Uzbekistan's total rice production. Despite covering a mere 10% of the cultivated land, rice cultivation accounts for over 30% of the overall water usage due to its cultivation in flooded paddies. These paddies, acting as miniature basins, are submerged in water for a significant portion of the growing season, spanning from April to May until September.

The utilization of water for agricultural purposes exceeds 95%. The water of the Amu Darya river originates from the mountainous regions of the Pamirs and Tien-Shan, situated in the upstream nations of Kyrgyzstan, Tajikistan, and Afghanistan. Approximately 85% of the aggregate surface water resources within the Aral Sea region, amounting to 117 km^3, are generated inside the borders of the countries in question. The primary consumers of water within the basin are the downstream countries of Uzbekistan, Turkmenistan, and Kazakhstan, collectively responsible for 82% of total water utilization. Uzbekistan independently accounts for almost 50% of the aggregate river flow within the basin.

The transportation of irrigation water to the fields is typically done by open canals that are primarily unlined. This method leads to significant losses of water owing to percolation, seepage, evaporation, and overflow into the drainage system. According to Conrad et al. (2016), in the year 2005, a period characterized by ample water availability, around 60% of the incoming water was directed towards the drainage system, ultimately pouring into desert sinks.

The Amu Darya river diverts around 3.5 - 5 km^3 of water annually to irrigated areas in Khorezm, facilitated by an extensive network of irrigation channels spanning 16000 km. During periods of extreme drought, such as those experienced in 2000, 2001, and 2008, it is observed that the water supply to the region might be diminished by approximately 40%. A portion of the water that reaches Khorezm and Karakalpak regions is held within the

Tuyamuyun water reservoir, with its allocation being determined based on the monthly water requirements of the regions.

The rising market costs for oil and gas in the post-Soviet era, along with the unreliability of their delivery and the imperative to ensure energy security in the upstream countries, have led to a heightened demand for hydropower in these republics. Consequently, during the winter season, upstream countries release significant volumes of water to create heat and electricity, aiming to meet the high demand.

This practice, however, leads to a reduced availability of water during the summer irrigation season in downstream regions. Thus far, Central Asian nations have successfully averted overt water-related wars; but, there exists a potential for the issue to escalate beyond manageable proportions in the coming years.

The region will inevitably experience a rise in extreme weather events, including frost, droughts, and floods, as a result of climate change, the rapid melting of glaciers, and alterations in temperature and rainfall patterns. In the year 2008, a notable occurrence took place in Central Asia whereby a severe drought coincided with an exceptionally cold winter. This convergence led to a complex problem involving water, energy, and food, ultimately causing significant political tensions in the region.

Moreover, it is anticipated that the supply of downstream water may deteriorate in the event of Afghanistan achieving stability and embarking on the implementation of new irrigation projects, resulting in increased water consumption (about 800,000 hectares are now scheduled for development). Hence, it is probable that the regions located downstream, such as Khorezm province, will see a notable impact due to the diminishing availability of water resources.

3.1.3 Fishery community of the region

The existence of the Amu-Darya and Syr-Darya rivers in the Aral Sea basin is reliant on the presence of elevated mountain ranges, as these rivers primarily derive their water from the melting of snow and ice. The catchment areas they encompass represent a significant portion of the overall Aral Sea watershed. Prior to reaching the ocean, the water undergoes storage in multiple reservoirs, which serve the purpose of both agriculture and hydropower generation.

The Amu-Darya, with a length of 1,440 kilometers, exhibits an annual water outflow of around 78 km^2. The Syr-Darya river exhibits a drainage area of 36 square kilometers and spans a length of 2,140 kilometers. The rivers in the region mostly derive their water supply from the mountainous regions of Tajikistan and Kyrgyzstan, with a relatively minor contribution of 10 km^3 originating from the Uzbekistan Mountains. However, the water demand in Uzbekistan significantly surpasses this available water resource, estimated at 62-65 km^2 annually. Approximately 85% (equivalent to 53-55 km^2) of the available water resources are allocated for agricultural use, while 12% (approximately 6 km^2) is utilized by the industrial sector. The remaining 3% (approximately 1.7 km^2) is allocated for municipal water supply.

The fishery industry benefits from the utilization of these water resources, catchment areas within the Aral Sea basin and the present-day population distribution within these areas. Central Asia is home to around 60 reservoirs, together possessing a total volume of 61.6 km^3. These reservoirs have been strategically created inside the basins of major rivers across the region. Within the basins of Amu-Darya and Syr-Darya a total of 55 reservoirs can be found. Specifically, the Amu-Darya basin encompasses 36 of these reservoirs, while the Syr-Darya basin has 19. Uzbekistan possesses a total of 22 reservoirs, whereas Turkmenistan boasts 13, Tajikistan maintains 8, Kyrgyzstan sustains 6, and Kazakhstan possesses 2. According to Nikitin (1991), the collective water surface area of reservoirs that hold significance for fisheries is 3,310 km^2.

Uzbekistan, Kazakhstan, and Turkmenistan exhibit promising prospects for the growth of both capture fisheries and aquaculture. However, the achievement of successful development is contingent upon some factors that still require further establishment. During the period from 1996 to 2001, two project ideas were devised in Uzbekistan with the aid of foreign assistance. These proposals aimed to enhance the fisheries sector through the establishment of fish farms. The first proposal focused on the creation of a model aquaculture farm utilizing semi-intensive technology, while the second plan aimed to construct a fish farm specifically for sturgeon production. Both projects are now on hold due to a shortage of funding on the Uzbek side and a lack of expertise among Uzbek fishery specialists in executing such initiatives (Umarov, 2003).

Furthermore, a notable issue observed in certain successful initiatives, such as the implementation of irrigation systems for fish production in the Golodnaya and Karshy steppes, is the absence of continuity.

Several fish hatcheries in Uzbekistan and Kazakhstan continue to operate, engaging in activities such as the breeding and production of fish fry and fingerlings belonging to the cyprinid family. According to Kamilov (2003), and Ismukhanov and Mukhamedzhanov (2003), the entities in question possess an ample amount of capability to supply aspiring farmers with the necessary quantities of fry, fingerlings, and yearlings in order to enhance fish output. One of the primary limitations is the substantial expense associated with fish feed.

Uzbekistan possesses a robust transportation and industrial infrastructure, alongside a substantial rural population and a varied agricultural sector. This phenomenon facilitates the establishment of advantageous social and economic circumstances that promote the growth and advancement of fish production within irrigation water bodies. The current scarcity of fish in Central Asian countries could potentially be resolved with the implementation of enhanced fish production methods.

All nations within the Aral Sea basin possess ideal climatic conditions and ample water resources. Uzbekistan has an ideal population density, coupled with a sufficient labor force and favorable market accessibility, particularly in urban centers. The lowland aquatic environments exhibit favorable conditions for the establishment of fisheries centers around warmwater Chinese carps, including silver carp, bighead carp, grass carp, and common carp. The utilization of mountain and foothill storage reservoirs has the potential to support the cultivation of cold-water fish species, including rainbow trout, Issyk-kul salmon, and whitefish. Utilizing the already privately-owned ponds for the establishment

of fish farms could yield considerable economic benefits. By implementing a viable small-scale fish farming strategy, farmers in Uzbekistan have the potential to integrate pond fish cultivation with conventional agricultural practices. This approach seems to offer a potentially effective means of enhancing the country's fish production (Petr, 2003).

In order to address the need for a novel management method, it is possible to draw upon existing information pertaining to reservoir fish and fisheries, particularly from analogous scenarios involving the construction of dams for hydropower generation in river systems. Furthermore, certain reservoirs have been consistently replenished with fingerlings that are cultivated in hatcheries. In previous years, the aforementioned practices led to the establishment of a viable fish production system in various reservoirs located in Uzbekistan, Turkmenistan, and Kazakhstan. Notably, one particular reservoir demonstrated the most favorable outcome, yielding 30.9 kg per hectare. It is worth mentioning that this reservoir had the potential to sustainably produce up to 78 kg per hectare if consistently stocked with silver, grass, and common carps (Zholdasova et al., 1999).

Fishery managers possess many alternatives for the advancement of fisheries within irrigation systems. Many available choices are a direct reaction to the consequences resulting from the manipulation of water resources for non-fishery reasons. Irrigation systems are influenced by various factors, including precipitation and evaporation rates, as well as ambient air temperature, which plays a crucial role in determining the extent of snow and ice melt from glaciers.

Agricultural methods, including crop selection, exhibit variability and may undergo annual changes, hence affecting the water requirements and timing necessary for optimal crop yield. Additionally, the utilization of agrochemicals may vary on an annual basis. Fisheries managers may require contingency plans in addition to their overarching master plan, as fisheries within irrigation systems are subordinate to competing water demands.

The inadequate allocation of finances by the government to the fishery industry in Central Asian countries often imposes constraints on the actions and capabilities of fisheries management. Unfavorable spawning conditions and nursery habitats, as well as unoccupied ecological niches that have yet to be populated by economically significant fish species. In certain reservoirs, there is a lack of utilization of aquatic plants, whereas fish species of low economic significance predominantly rely on benthic organisms as a food source.

According to Kamilov (2003), the fisheries sector in Uzbekistan is facing challenges due to limited access to oceans and the decline of the Aral Sea fisheries. As a result, the author suggests that the future of Uzbekistan's fisheries industry might be improved through the development of aquaculture and the enhancement of capture fisheries. Pond aquaculture is a prominent and pivotal sector within the fisheries industry, accounting for a significant proportion of the current fish production, specifically 60%.

Approximately 20 firms are responsible for the operation of hatcheries, wherein they engage in the practice of inducing breeding and cultivating various fish species, primarily silver carp, bighead carp, and grass carp. The reproduction of common carp occurs through both artificial and natural means within these hatcheries. The fish are cultivated in aquaculture facilities until they reach the appropriate size for commercial sale. During the 1990s, the cumulative surface area of ponds amounted to 10,400 hectares, with the individual ponds varying in size from 10 to 150 hectares.

The potential for implementing small-scale aquaculture initiatives within reservoirs, canals, and lakes, involving the active engagement of local villagers and administrative bodies, is worth exploring. Once a comprehensive understanding of the credit mechanism has been attained, the facilitation of new small-scale aquaculture companies should be readily achievable with the assistance of the local authorities.

3.2 Community voice and experience

3.2.1 Fishery culture in Aral Sea region

The history of fishery in the Aral Sea dates back to ancient times, with local communities relying on its resources for sustenance. However, over the past few decades, the Aral Sea has experienced significant environmental degradation due to large-scale irrigation projects that diverted water from its main tributaries, leading to a drastic decrease in its size and salinity. According to Micklin (2010) by 2009 the surface area of Aral sea shrank 8 times and water volume almost 13 times.

As a result of these changes, the fishery industry in the Aral Sea collapsed, the fishery culture in the region has changed dramatically, affected directly the amount and diversity of the fish caught in the region. The decline in water levels and increasing salinity led to the extinction of native fish species, making it nearly impossible for fish to survive in the remaining water.

Historically Aral Sea, with a status of fourth biggest lake in the world, had a potential to cover the essential nutritional fish needs of the population in Central Asia region. Fishing and consumption of fish and seafood were part of the culture of the population living around the sea region. According to Karimov (2011) in Uzbekistan, where the main source of fish products were captures from Aral Sea and its deltas, the consumption of fish and fish products per capita has decreased almost ten times, from 4.5-5 kg/year in late 1980s to 0.4kg/year in 2000s. Fish capture around Aral Sea fell dramatically in 1960s and 1970s and totally disappeared in 1983 because of high salinity and shrinkage of the surface area. Uzbekistan was able to improve per capita consumption of fish to approximately 2.8 kg/year in recent years through aquaculture development, but still it is lower than World, Asian and landlocked developing countries' averages (FAO, 2021).

The collapse of the fishery in the Aral Sea has had significant economic impacts on the communities and regions that once relied on it for livelihoods. No accurate value is given to the total economic consequences of Aral Sea, but some reports in the former USSR show estimates of 1.5 to 2 billion rubles as the annual losses in 1985 (Kovalev, 1986). The decline of fish populations led to the loss of jobs for those engaged in fishing, processing, and related industries. This loss of employment and income affected both local communities and the wider regional economy. A reported 60 000 workers explicitly or implicitly

employed in Aral Sea fishery had to leave their jobs in 1950s and more than 40 000 had to leave the northeast regions of Aral in search for jobs as people struggled to find alternative means of making a living (Micklin, 1988). On a wider range the collapse of the fishery industry resulted in ripple effect on supply chains, affecting businesses that provided equipment, transportation, and other services to the industry. This disruption had economic repercussions beyond the direct fishing activities.

The effect of the Aral Sea crisis is not solely economic, it has deep-rooted social, ecological and health effects, the value of which should yet be estimated.

The traditional fish species captured in Aral Sea were carp (*Cyprinus carpio*), bream (*Abramis brama*), barbel (*Barbus brachycephalus*), roach (*Rutilus rutilus aralensis*) and shemaya (*Chalcalburnus chalcoides aralensis*). Less common were wels (*Silurus glanis*), pike (*Esox lucius*), asp (*Aspius aspius*), sturgeon (*Acipenser nudiventris*), and pikeperch (*Stizostedon lucioperca*). As the Aral Sea's water levels and salinity changed due to environmental degradation, the fish populations suffered, leading to the decline or extinction of many native species. According to Micklin (1988) 20 of 24 native fish species have disappeared during 1950-1980.

To compensate for the loss of native fish species, and in an effort to sustain the fishery industry and adapt to changing environmental conditions some non-native fish species were introduced. One of them is the common carp which is known for its adaptability to various water conditions and is often farmed in aquaculture settings. Another one is Pikeperch (*Sander lucioperca*), also known as zander. It is a predatory fish species that was introduced to the Aral Sea to help control the populations of smaller fish species. Its introduction was intended to stabilize the ecosystem by balancing the fish population dynamics. Silver Carp (*Hypophthalmichthys molitrix*) and Bighead Carp (*Hypophthalmichthys nobilis*), collectively known as "Asian carp", were introduced in some parts of the Aral Sea to address the decline of native fish and promote fishery. However, the introduction of these carp species can sometimes have unintended ecological consequences, as they are known for their rapid growth and potential competition with native species. Grass carp (*Ctenopharyngodon idella*) is another herbivorous fish species that has been introduced to the Aral Sea. It is often used for weed control in aquatic ecosystems, as it feeds on aquatic plants. However, the introduction of grass carp can also impact native plant and animal communities.

It's important to note that the introduction of non-native fish species can have complex ecological and environmental impacts, and their success and interactions with the local ecosystem can vary. In some cases, introduced species may become invasive and disrupt native species and ecosystems. The decision to introduce fish species should be based on careful consideration of ecological, economic, and social factors. These species together now represent 73.7 and 51.8% of the aquaculture and capture fisheries production in Uzbekistan (FAO, 2021).

The shrinking of the Aral Sea has necessitated changes in fishery practices in the region. As an example can be taken the towns and villages in Kazakhstan (White and Micklin, 2021). As the water level dropped and the sea divided into separate lakes, fishermen had to adapt their traditional fishing gear and techniques to the changing conditions. However, with the expansion of the water surface and the resurgence of fish populations, new opportunities emerged for the fishing industry. Fishermen now employ different types of nets, hooks, and fishing methods to target different types of fish that have returned to the Aral Sea. This adaptation has allowed them to capitalize on the rising income from the revitalized fishing industry. The ability to adapt to the changing conditions has been crucial for the fishermen's success in the region.

In an effort to supplement declining fish catches from the wild, aquaculture initiatives were introduced in Uzbekistan as well. Fish farming operations were set up to cultivate fish species that could thrive in the altered conditions of the Aral Sea ecosystem. In Uzbekistan the aquaculture is being developed through various tax incentives and benefits in almost all regions of the country with significant success. Currently aquaculture became the main source of fish with a production amount of more than 80 thousand tons and making 67% of total fish catch (FAO, 2021).

Lack of access to nutritious fish also impacted the diets and overall health of those who relied on fish as a primary protein source. The decrease of fishery can have significant health implications for both human populations and ecosystems. Fish is a rich source of essential nutrients such as omega-3 fatty acids, high-quality protein, vitamins (such as vitamin D), and minerals (such as iodine and selenium). The reduction in fishery can lead to decreased access to these important nutrients, potentially affecting the nutritional status and health of populations, particularly in areas of Aral region where fish is a primary protein source. People might turn to alternative protein sources, which may not be as nutritionally rich as fish. This could potentially lead to dietary imbalances and health issues. The decline of fishery can also contribute to malnutrition, especially among vulnerable populations such as children and pregnant women who rely on fish for its nutritional benefits.

The Aral Sea has had a profound impact on the fishing communities that once relied on its waters for their livelihoods, causing substantial socio-economic and cultural changes. The displacement and migration in search of better place contributed to the breakdown of traditional fishing communities and the loss of their cultural ties to the region. Fishing was not just an economic activity, but also a deeply ingrained cultural practice for many communities around the Aral Sea. The collapse of the industry disrupted traditional ways of life and eroded cultural identity, as generations of knowledge and skills related to fishing were no longer relevant.

The collapse of the fishing industry due to environmental degradation highlighted the importance of sustainable resource management. It drew attention to the consequences of unchecked water diversion and led to increased awareness about the need for responsible water management practices.

Efforts to restore the Aral Sea and its fishery culture have been ongoing. The construction of dams and other measures aimed at replenishing water levels and improving water quality have shown some signs of success in certain areas. Some fish species have been reintroduced, but the ecosystem still remains fragile.

Overall, the fishery culture in the Aral Sea has suffered immensely due to environmental degradation, and its recovery is a complex challenge requiring both ecological and economic interventions.

3.2.2 Connection between fishery culture and community

The fishery culture and the community are closely connected, having complex and multifaceted relationship. Fishery culture refers to the set of beliefs, practices, and traditions that are associated with fishing activities within a community or a particular region (Lorenzen et al., 1998; Ross, 2015). It includes not only technical aspects of fishing process, but also the social, economic, and environmental ones that shape and are shaped simultaneously by the fishing community.

Fishery culture plays a crucial role in the formation of the identity and social structure of fishing communities. It is deeply connected with history, heritage and sense of place of the community. Fishing practice and knowledge are passed down through generations and fishery becomes the style of life for many members of the community (McMillan and Prosper, 2016; Norgaard et al., 2018). This cultural heritage fosters a sense of belonging and shared responsibility for sustainability and management of local marine resources.

The connection between community and fishery culture goes beyond economic considerations (Haque and Dey, 2016). Fishery not only provides economic resources needed for many community members, but also serves as a source of social cohesion (Basavakumar et al., 2011). Fishing activities involve collective rituals, celebrations, and collaboration, strengthening social ties and fostering the sense of belonging between community members (McGoodwin, 2001; Reddy, 2020).

Furthermore, fishery culture is closely linked to local environment and ecosystem services (Mangel and Levin, 2005). Fishery communities often have a deep understanding of local marine ecosystem, its dynamics, and interdependencies between different species. This ecological knowledge is acquired through long-term interactions with the environment and experience in the field.

However, fishing communities and their fishery culture face numerous challenges in the modern world. Environmental degradation, overfishing, climate change, and changes in policy and rules create serious obstacles to sustainability of fish stocks and fishing way of life. These challenges can lead to economic decline, social disruption, and adverse health effects in the community.

> "I grew up hearing stories of the Aral Sea's grandeur, but I've only seen its decline. The shrinking sea altered our reality. Many left for the cities, seeking alternatives. Our community lost not only income but also a way of life. Still, I see hope. We're learning new techniques, working with experts to revive the sea and our culture." (member of fishermen family, 28 years old, male)

Despite these challenges fishing communities have demonstrated remarkable resilience and adaptability. Efforts are made to revive the fishing industry through sustainable practices, community driving initiatives and collaboration with politicians, scientists, and non-governmental organizations. These efforts aim to preserve and develop fishery culture while ensuring the long-term viability of fish stock and the well-being of the community.

The connection between fishery culture and the community is an important aspect of social, economical, and ecological structure of fishing communities. It encompasses history, identity, social cohesion and ecological knowledge of the community. While facing numerous challenges fishing communities continue demonstrating adaptability and resilience trying to maintain sustainable development and preserve their cultural heritage.

The Aral Sea catastrophe had far-reaching consequences for the fishery community residing on the shores of the sea (Kumar, 2002). The collapse of the fishing industry has left many people unemployed. The loss of a traditional occupation affected the cultural structure of these communities impacting their identity and social cohesion.

> "The Aral Sea's retreat cast a shadow on our family's hopes. Fishing used to provide security, but now uncertainty reigns. Drinking water turned scarce, and illness spread. We banded together, supporting each other through these hardships … We've embraced new roles, farming and crafting, preserving our traditions while adapting to a changing world." (member of fishermen family, 34 years old, female)

The shrinking of the Aral Sea led to adverse health effects on the local population (Whish-Wilson, 2002). The increase in salinity levels has resulted in contamination of drinking water sources leading to various waterborne diseases. Moreover, the migration from the region in search of better life has disrupted community structures and increased social disparities.

The Aral Sea catastrophe has caused a significant economic decline, increasing poverty levels in the region. The collapse of the fishing industry, once a major source of income, has left many families impoverished. The socio-economical crisis was further deepen by the lack of alternative employment opportunities and general decrease of economic activity.

The desiccation of the Aral Sea has resulted in alteration of landscapes and destruction of natural habitat. The loss of fish species and ecological disbalance have consequences for the whole ecosystem. The absence of a healthy fish population has also affected other species dependent on the sea leading to a cascading effect on biodiversity.

> "I participate in activities of an environmental awareness group that works with Aral Sea problems. Through international programs, we planted drought-resistant trees and shrubs to combat desertification. We engage in shoreline cleanups and advocate for responsible water usage. We collaborate with global organizations to restore wetlands, a lifeline for local biodiversity." (student and eco-activist, 23 years old, female)

Despite all the problems mentioned above, the fishery community demonstrated resilience and adaptability. Efforts have been made to diversify livelihoods and explore alternative sources of income such as agriculture and tourism. Local initiatives supported by government and non-governmental organizations aim to revive the fishing industry through sustainable practices and conservation efforts.

The long-term consequences of the Aral Sea catastrophe for the fishery community remain uncertain. The ongoing efforts to restore the sea and promote sustainable fishing practices bring hope for the revival of the industry. However, climate change, water scarcity and socio-economical disparity continue posing obstacles to the community recovery.

> "I belong to a generation that witnessed the Aral Sea's decline from the books and stories of the elders. We learned about its beauty, but our eyes witnessed its desolation. I was terrified when I came for the first time to Muynak and saw it with my own eyes. I think we all need to learn that lesson of environmental fragility and its impact on communities." (student, 23 years old, female)

Once the Aral Sea was a big hub of fishing activity in the region. However, its dramatic retreat has transformed the lives of fishermen, significantly impacting traditional practices, the livelihoods of community members and social dynamics. Where once the fisherman cast their nets and lines into thriving waters, now they navigate landscape marked by exposed seabeds and saline wastelands. The traditional fishing techniques passed down through generations are now challenged by the need to adapt to the changing conditions.

> "The community organized workshops to teach new skills, and it's great that there are opportunities for development apart of traditional practices. We've also engaged in international programs focused on restoring the Aral Sea, attending workshops on sustainable practices and collaborating with experts to find solutions." (community member, 44 years old, male)
>
> "We established a cooperative to farm fish in artificial ponds, using sustainable methods. It's not just about income; it's about reimagining our future. We also organized workshops on ecotourism, inviting travelers to experience our culture and the beauty that remains. Collaborating with global organizations, we're part of projects restoring wetlands and planting trees. Hope it will help the community to come back to normal and feel safety and stability." (community member, 38 years old, female)

The fishing communities have recognized the importance of adaptation of sustainable fishing practices to mitigate the impact of the Aral Sea catastrophe. This includes implementing catch limits using more selective fishing gear and promoting responsible fishing techniques to ensure long-term viability of fish stocks. Many fishing communities looked for alternative sources of income to reduce their dependency on declining fishery industry. Their members started dedicating themselves to agriculture, tourism and other economic activities that can provide a more stable income. The fishing communities collaborate with scientists, ecological organizations and governmental bodies to develop strategies for restoration and preservation of the Aral Sea. Such collaboration led to the implementation of projects in dam construction, water management initiatives and promotion of sustainable land use practices. Fishing communities around the Aral Sea have shown the willingness to embrace change, implement new technologies and cooperate with various interested stakeholders to ensure the preservation of their cultural heritage and the community in general.

The youth in fishing communities became witnesses of the drastic comparison between historical tales of the Aral Sea abundance and the current reality. While their elders may still have memories of times of plenty, young generation faces the harsh choices presented by environmental degradation. The dwindling fish stocks and limited opportunities in the shrinking fishing industry make the youth seek alternative path for the future. In response to these challenges fishing communities are embracing new fishery practices. Fishermen are diversifying their activities turning to aquaculture, pond farming and selective breeding of resilient fish species. These practices aim to adapt to the changing ecosystem and supplement traditional fishing.

The recovery of the fishery community around the Aral Sea heavily relies on strong community ties. The local communities in the region have been greatly impacted by the Aral Sea crisis, with the loss of livelihoods for fishermen and economic decline. However, the revitalization of fish populations has presented new opportunities for the fishing industry, and fishermen have adapted their techniques to capitalize on this.

Community ties play a crucial role in this recovery process. By fostering collaboration and cooperation among fishermen, they can share knowledge, resources, and best practices for sustainable fishing practices. Through collective efforts, they can work together to overcome the challenges posed by the shrinking sea and adapt to the changing conditions (Kirmani and Guy, 1997). Furthermore, community ties can also facilitate access to resources and support from external organizations, such as the World Bank, which has been actively involved in addressing the Aral Sea crisis. By leveraging community networks and partnerships, fishermen can advocate for their rights and interests, ensuring that their voices are heard in decision-making processes and resource management initiatives.

The emergence of new fishery practices tries to revitalize the communities' spirit and rejuvenate economic prospects. Community-led efforts to restore the Aral Sea through habitat rehabilitation and conservation initiatives foster a sense of shared purpose. The adoption of sustainable practices goes in line with growing understanding of environmental stewardship, transcending generations and creating tighter social bonds.

> "The Aral Sea's retreat forced the fishermen to relearn the art of fishing. The waters they once navigated have vanished, and so have our old practices. People turned to fish farming in ponds,

> cultivating species that tolerate the changed conditions. Additionally, they now harvest aquatic plants for various purposes." (eco-activist, 39 years old, male)

However, the shift to new fishery practices doesn't go without challenges. It requires acquiring new skills, navigating regulatory frameworks, and securing resources for innovation. Moreover, while those practices can provide alternative livelihoods, they might not match the economic stability that traditional fishery once offered.

In conclusion, the shrinking of the Aral Sea has transformed drastically fishery practices and the lives of fishermen. Traditional practices have given away to a blunt of adaptation and innovations as communities meet the changing ecological landscape. The impact on youth is especially significant because it shapes their perspectives on heritage, traditions, and urgent need for environmental conservation. Through these changes fishery communities intend to find the balance between preserving their cultural roots, addressing the challenges of environmental decline and forging a sustainable path forward.

> "In my youth, the Aral Sea was our lifeblood, teeming with fish that sustained our families for generations. Today, it's a painful memory. The sea's retreat devastated our fishery culture. The dwindling catches left us unemployed, struggling to support our families. The sea's disappearance disrupted our way of life and eroded the bonds that held our community together." (member of fishermen family, 82 years old, male).

4 Concluding remarks

The research based on international organizations reports, analysis of historical records, academic sources, and testimonials from locals have fulfilled the objectives planned. First, the analysis of the historical context and the evaluation of the current state of the Aral Sea crisis were completed. Second, the understanding of the impact of the disaster on local communities was reached. Finally, the suggestion of network-based strategies and approaches will be presented below.

The study conducted has unequivocally demonstrated the crucial role of community in addressing the multifaceted ramifications of the Aral Sea crisis. The magnitude of the challenges faced in this situation is immense; however, the inherent bonds and interdependencies within the affected communities have shown promise in surmounting these obstacles. The significance of community engagement and collaboration cannot be overstated, as it serves as a potential catalyst for effective solutions and sustainable outcomes in the face of such complex environmental crises.

The absence of governmental and non-governmental institutional structures that facilitate the promotion and utilization of irrigation systems for fish production poses significant restrictions. There may be a potential absence of legislation that adequately safeguards the entitlements of private fish farmers to a secure water supply within specified boundaries, as well as their ability to engage in fish trading activities. One of the primary challenges faced by the fisheries sector is the presence of economic restraints, characterized by a dearth or limited provision of financial assistance from the government and insufficient private investments. There are no specific credit lines available to ensure the financial support of local initiatives.

One of the technical limitations that arise in water management is the inability to maintain an appropriate water supply for fish spawning and nursery grounds due to competing priorities such as irrigation demand and hydropower production. The absence of protective measures for young fish to prevent their discharge with irrigation water onto irrigated fields, the lack of interconnected pathways between water bodies such as floodplains, river reaches, and canals to facilitate the migration of fish and fish fry to and from spawning areas, reproductive habitats, and other essential environments, as well as the inadequacy or absence of fish passes, are significant challenges as well.

One of the ecological limitations that can be observed in irrigation systems is water pollution, which encompasses several factors such as elevated salinity levels and increased toxicity. Among the social and cultural barriers that hinders the utilization of the irrigation network for fish production there is low degree of public awareness regarding this potential application. There is a notable scarcity of fisheries experts and a dearth of fisheries training programs.

The aforementioned limits may pose challenges, particularly in the early stages. These limits may also be applicable to other countries within the Central Asian region, including in the Aral Sea basin, particularly in the catchments of the Amu-Darya and Syr-Darya rivers. Their basins exhibit promising prospects for the development of fisheries, owing to the advantageous climatic conditions that are prevalent in this geographical region. The socio-economic framework further reinforces this assertion, as it is characterized by a surplus of available workers. The exponential growth of the population necessitates a corresponding rise in the demand for sustenance.

Consequently, the augmentation and enlargement of fisheries emerge as a viable avenue to address this challenge. The fish output potential of lakes, rivers, and reservoirs in Central Asia, particularly in the catchments of the Syr-Darya and Amu-Darya Rivers, is estimated to be approximately 100 kg per hectare per year. This has the potential to yield an annual fish supply of 200,000 tons for the market. According to Umarov (2003), of all the countries in the region, Uzbekistan exhibits the highest potential for the utilization of irrigation systems in fish production.

The establishment and expansion of fisheries within reservoirs that serve irrigation purposes can yield significant employment opportunities and contribute to the diversity of food supplies. The implementation of aquaculture within irrigation systems has the potential to significantly augment the availability of fish in markets.

The transition from a centrally planned economy to a market-oriented one in the Aral Sea region has indeed been a complex and protracted journey, marked by numerous challenges that have not unfolded seamlessly. This transition represents a fundamental shift in economic ideology and structure, and it has had significant implications for various sectors, including the fisheries industry.

One of the enduring challenges faced by the fisheries sector in this transition is the limited access to credit. In a centrally planned economy, state institutions typically controlled the allocation of resources, including financial support for industries. However, the shift towards a market economy requires businesses to seek credit from private banks and financial institutions. This transition has proven challenging for many small-scale fishermen and fishing communities in the Aral Sea region, who may lack the collateral or financial history required to secure loans. As a result, accessing the necessary capital for investment in modernized fishing operations or infrastructure improvements has remained a formidable obstacle.

Furthermore, the financial burden of maintaining and upgrading existing facilities has substantially increased. In the era of a centrally planned economy, government funding often played a pivotal role in supporting the maintenance and development of critical infrastructure within the fisheries sector. However, as the transition to a market economy has progressed, the reduction in government subsidies and funding has placed a heavier financial burden on industry participants. This has included expenses related to the upkeep of fishing boats, processing facilities, and storage units, all of which require ongoing investments to remain competitive in a market-driven environment.

The current downward trend appears to have been arrested, however the subsequent recuperation is characterized by a notably sluggish pace. The scarcity of private cash has resulted in the squandering of a valuable resource.

To address the abovementioned problems, the policy-makers and other stakeholders can use network-based approaches (Valente, 2012; Maya-Jariego and Holgado, 2015). The framework of the governance of marine resources in the context of Aral Sea crisis should encompass four categories of networks.

First, the participatory network building must be completed. This can be done through establishment of community-based networks that include fishermen, local residents, and community leaders. These networks will facilitate participatory decision-making in managing fishing resources and ecological restoration efforts. Regular meetings, dialogues, and knowledge-sharing sessions can empower local stakeholders. In addition, it is recommended to forge networks between scientific institutions, universities, and local experts. These collaborations can support data collection, research, and the development of sustainable fishing practices, offering evidence-based solutions for governance.

Second, the government should organize information exchange and capacity building. Development of digital platforms or online networks will allow the exchange of information among fishermen, government agencies, NGOs, and scientific organizations. These platforms can disseminate updates on regulations, market trends, and environmental monitoring data. Organization of capacity-building workshops within the network to enhance the knowledge and skills of fishermen and local communities. Training programs can cover topics such as sustainable fishing practices, resource conservation, and conflict resolution.

Third types of networks to develop should be policy and advocacy oriented. It is recommended to create advocacy networks comprising NGOs, environmental organizations, and local advocates. These coalitions can collaborate to influence policy decisions at local and national levels, advocating for sustainable resource management and ecological restoration. On the other hand, establishment of research networks involving academic institutions and policy think tanks is needed. These networks can conduct research on the Aral Sea crisis's socio-economic and environmental impacts, providing data-driven insights for policy formulation.

Finally, the transboundary and international cooperation importance is undeniable. Currently, there is a lack of a regional network dedicated to addressing the utilization of irrigation systems for the purpose of fish production. The possibility of addressing this matter could be explored by the Ministry of Natural Resources, an organization headquartered in Tashkent, Uzbekistan. The Ministry in question has already been involved in addressing many facets of regional collaboration pertaining to water resources within the Aral Sea basin (Umarov, 2003). The ministers representing the top-level management organizations of the five nations in the Aral Sea basin convene at the quarterly meetings of the International Commission for Water Coordination (ICWC). These meetings serve as a platform to debate the prevailing conditions pertaining to water distribution and utilization, as well as to develop a water strategy for the upcoming period.

The ministry should expand its focus to encompass the concerns of other stakeholders in water resource management, such as the fisheries sector. The objectives of the initiative should focus on addressing and overcoming administrative obstacles by actively engaging many stakeholders, including the general public, private sector, non-governmental organizations, and water consumers. This approach seeks to promote integrated water resources management at both national and regional scales (Dukhovny and Kindler, 1999).

According to Umarov (2003), the government sector partnership with NGOs could be considered the most appropriate structure for facilitating information support and the establishment of a regional network focused on utilizing irrigation systems for fish production. This is primarily due to the existing institutional framework for water management at the regional level, as well as the potential for consistent engagement with governments, relevant ministries, and the general public.

Community should continue praying a crucial role in overcoming obstacles created by the Aral Sea shrinking. Ties within it can help to progress further in development of solutions needed for helping locals. It is required to encourage active participation and involvement of the local community in decision-making processes and initiatives related to the Aral Sea catastrophe. This can be done through community meetings, workshops, and forums where individuals can voice their concerns, ideas, and suggestions for mitigation and adaptation strategies.

Leveraging the fishery heritage of the Aral Sea region as a tourist attraction while promoting local fishing culture and traditions can be a multifaceted strategy with economic, cultural, and environmental benefits. First, the government can contemplate the foundation of cultural tourism centers in fishing communities along the Aral Sea, where tourists can learn about the rich history and traditions of the local fishing culture. These centers can include interactive exhibits, storytelling sessions, and hands-on activities like net making or traditional fishing techniques demonstrations.

Another approach might encompass the development of heritage tours that take tourists on journeys through the region's fishing history. These tours can include visits to historic fishing villages, local

markets where fresh catches were sold, and opportunities to interact with fishermen and their families. Tourists can gain firsthand experience of the daily life of local communities. Another way of engagement might be focused on the opportunity to engage in recreational fishing activities under the guidance of local fishermen. This not only provides a memorable experience for visitors but also generates additional income for the local fishing communities.

In addition, the government could evaluate the possibility of the organization of cultural festivals and events celebrating the fishing heritage of the Aral Sea region. These festivals can feature music, dance, art exhibitions, and storytelling sessions, creating a vibrant atmosphere that showcases the cultural richness of the area.

Moreover, to increase the levels of awareness, it is recommended to conduct educational workshops on topics such as sustainable fishing practices, environmental conservation, and the importance of preserving the Aral Sea ecosystem. These workshops can be targeted at both tourists and local communities, fostering a sense of environmental stewardship. They can encourage storytelling sessions where local fishermen and elders share their stories and experiences with tourists. These personal narratives can provide deeper insights into the history and challenges faced by fishing communities.

By implementing these ideas, the Aral Sea region can capitalize on its fishery heritage to attract tourists, generate income for local communities, and ensure the preservation of traditional fishing culture and traditions. This approach not only enhances the region's economic prospects but also fosters a sense of pride and cultural continuity among its inhabitants.

Finally, the health and well-being of the affected communities around the Aral Sea is a crucial aspect that needs to be prioritized. Access to healthcare services, clean drinking water, and sanitation facilities is essential to mitigate the health risks associated with the Aral Sea crisis. Providing these basic necessities can help address respiratory health issues and reduce the strain on the healthcare system. Furthermore, raising awareness about the health risks and providing necessary support to affected individuals is important for their overall well-being. By focusing on these aspects, efforts can be made to improve the quality of life and promote the recovery of the communities affected by the Aral Sea disaster.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The requirement of ethical approval was waived by The Ethics Committee of the Management Development Institute of Singapore in Tashkent for the studies involving humans because the study did not involve experiments or any other manipulation with human subjects. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

DA: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. GU: Formal Analysis, Investigation, Writing – original draft. SS: Formal Analysis, Investigation, Writing – original draft. SA: Writing – original draft.

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