

ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

SCARCE RESOURCES, GREAT CHALLENGE: TURKISTAN'S WATER  
CRISIS AND ENVIRONMENTAL SUSTAINABILITY

KIT KAYNAKLAR, BÜYÜK MÜCADELE: TÜRKİSTAN'IN SU KRİZİ VE  
ÇEVRESEL SÜRDÜRÜLEBİLİRLİK

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**Abstract**

The main objective of this study is to examine the growing water crisis and environmental sustainability issue in the Turkestan region in the context of the impacts on the regional ecosystem, agricultural production, and social life. Although the region has significant water resources such as the Aral Sea, Amu Darya and Syr Darya, it faces a serious water crisis that threatens both environmental sustainability and economic development. Moreover, this situation leads to ecological degradation and socio-economic challenges and increases the importance of water management. The imbalance between water demand and the limited water supply in various sectors such as irrigation, industry and domestic use threatens water security in the region. In this study, it is hypothesized that the failure to manage and conserve water resources is one of the main factors that disrupt the ecological balance and increase social unrest in Turkestan. Therefore, the study emphasises the necessity of integrated water management approaches and sustainable policies to address the multifaceted water crisis. In addition, regional cooperation is important for the effective management of water resources, and the study will emphasize the importance of water-saving technologies and equitable water sharing.

**Keywords:** Turkestan, Water Crisis, Environmental Sustainability, Regional Cooperation, Water Management

**JEL Classification:** F53, N95, Q34

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## Öz

Bu çalışmanın temel amacı, Türkistan bölgesinde giderek büyüyen su krizini ve çevresel sürdürülebilirlik sorunlarını bölgesel ekosistem, tarımsal üretim ve sosyal yaşam üzerindeki etkileri bağlamında incelemektir. Bölge Aral Denizi, Amu Derya ve Syr Derya gibi önemli su kaynaklarına sahip olmasına rağmen hem çevresel sürdürülebilirliği hem de ekonomik kalkınmayı tehdit eden ciddi bir su kriziyle karşı karşıyadır. Ayrıca bu durum ekolojik bozulmaya ve sosyo-ekonomik zorluklara yol açmakta ve su yönetiminin önemini artırmaktadır. Sulama, sanayi ve evsel kullanım gibi çeşitli sektörlerdeki su talebi ile sınırlı su arzı arasındaki dengesizlik, bölgedeki su güvenliğini tehdit etmektedir. Bu çalışmada, su kaynaklarının yönetimi ve korunmasındaki başarısızlığın Türkistan'daki ekolojik dengeyi bozduğu ve sosyal huzursuzluğu artıran başlıca faktörlerden birisi olduğu varsayılmaktadır. Bu nedenle çalışmada, çok yönlü su krizini ele almak için entegre su yönetimi yaklaşımlarının ve sürdürülebilir politikaların gerekliliği vurgulanmaktadır. Ayrıca su kaynaklarının etkin yönetimi için bölgesel iş birliğinin önemli olduğu vurgulanan çalışmada, su tasarrufu sağlayan teknolojilerin ve suyun adil paylaşımının önemi üzerinde durulacaktır.

**Anahtar Kelimeler:** Türkistan, Su Krizi, Çevresel Sürdürülebilirlik, Bölgesel İş Birliği, Su Yönetimi  
**JEL Sınıflandırması:** F53, N95, Q34

## 1. Introduction

The Turkestan region is geographically expansive and endowed with abundant natural resources. The region has considerable water resources, including Lake Aral, the Amu Darya and the Sir Darya. However, it is confronted with significant challenges in managing its water resources and also faces considerable challenges in the sustainable management of these resources. These challenges have the potential to disrupt the region's ecological balance and exert a detrimental influence on its social and economic structures (Duzdaban, 2021).

The principal objective of this study is to analyse the dimensions and causes of the water crisis in Turkestan, evaluate the current management strategies and make recommendations for sustainable water management. In this context, the specific objectives of the study can be enumerated as follows:

- To determine the current status of Turkestan's water resources and the pressures on these resources.
- To evaluate the effectiveness of water management policies in the region and to reveal their shortcomings.
- To examine the ecological, economic and social effects of the water crisis.
- To develop recommendations for sustainable water management and to propose feasible policies.

This study aims to contribute to the ongoing efforts to address the water crisis in Turkestan from a multidimensional perspective. In light of the geographical, political and economic characteristics of the region, it will examine the challenges faced in the utilisation and management of water resources. Furthermore, it will examine in detail on the impacts of the water crisis on the region's ecosystems and its repercussions on different sectors such as agriculture, industry and daily life.

This paper posits that the water crisis in Turkestan represents a significant threat to the region's environmental sustainability and economic development. It is suggested that shortcomings in the

management and conservation of water resources have resulted in disruptions to the region's ecosystem balances and the emergence of social unrest. Furthermore, it is hypothesised that the formulation of an effective water management strategy is vital for the advancement of both environmental sustainability and economic growth. Therefore, in this study, the hypothesis is determined that the lack of effective policies and sustainable water management strategies to address the water crisis in Turkestan will harm social stability and social welfare in the region.

The water crisis in Turkestan has global implications, as it is not only a regional issue, but also part of a larger picture of environmental challenges worldwide. The depletion and pollution of water resources are a result of climate change and human activities, and this situation points to similar ecological crises around the world. This study seeks to contribute to global environmental management and sustainable development goals by addressing the dimensions and solutions of the water crisis in Turkestan.

It would be remiss of us not to consider the ecological dimensions of the water crisis, which have manifested in a number of ways. These include the decline of biodiversity in the region, the desertification of agricultural lands and the drying up of important water bodies such as the Aral Lake. This situation can potentially disrupt the functioning of ecosystems in the region and could even threaten natural habitats. The economic dimension is manifested in the decline in the productivity of water-dependent sectors such as agriculture and livestock breeding, the increase in water-borne diseases and problems in energy production. In this context, it is becoming increasingly clear that the water crisis is a multi-dimensional problem that could have serious implications for both ecological balance and economic development (Mbow & Rosenzweig, 2019).

It appears that there are some shortcomings in the way water management is carried out in Turkestan. These may be due to a lack of coordination between central and local governments, inadequate infrastructure and financing problems. It is also possible that the policies developed for the equitable and sustainable use of water resources are not as effective as they could be in practice (Zhupankhan et al., 2018). This study will reveal the shortcomings of current water management policies and their contribution to the water crisis. In addition, it will evaluate the role of international cooperation and regional integration in water management.

Turkestan's solutions to the water crisis play an instrumental role in addressing not only regional environmental concerns but also global environmental issues. The findings of this study will provide valuable information for policymakers and researchers on water management and environmental sustainability. The development of effective and sustainable water management strategies is critical for the preservation of the ecological balance of the region and the sustainability of economic development. In this context, it is hoped that the results of the study will make significant contributions to the solution of the water crisis in Turkestan and regional development.

The study's conceptual framework is based on the principles of a sustainable environment, within which the water problem is addressed. In addition, international sources in Turkish, English, Russian, Uzbek and Kazakh have been thoroughly reviewed. Content and document analysis, which

are a qualitative research method, were used to analyse the materials containing information on the subject of the research.

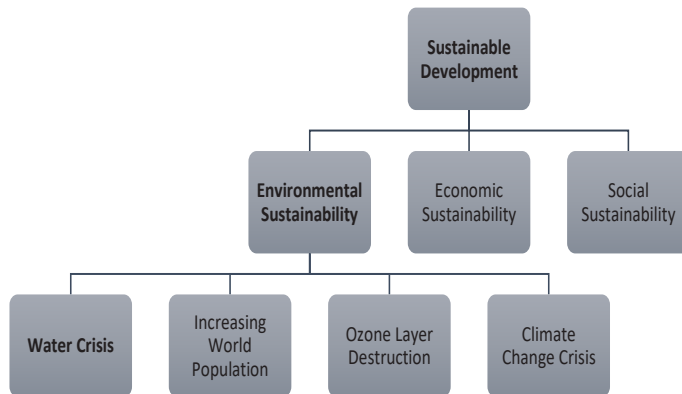
This study consists of three main chapters, following the introduction. The first main part will analyse the concept of a sustainable environment as a theoretical framework, before discussing environmental problems in Turkestan. The second main section will examine the current situation of Turkestan's water resources and the pressures on these resources in detail, before discussing the reflections of these effects on regional development. Finally, the recommendations developed for sustainable water management will be presented, along with an analysis of their applicability.

## 2. Theoretical Framework: Environmental Sustainability

This study employs environmental sustainability as its theoretical framework. This choice is predicated on the recognition of the intrinsic link between environmental sustainability and the water crisis precipitated by the depletion of water resources, which constitutes the article's primary focus. These two concepts are inextricably intertwined, underscoring the pivotal role of environmental sustainability in the pursuit of sustainable development.

The concepts of sustainable development, a sustainable environment and the water crisis are mutually reinforcing and interact with each other, as illustrated in the diagram below. The conservation and the efficient utilization of water resources are fundamental elements of both environmental sustainability and sustainable development (UN Environment Programme, 2023).

**Table 1:** Diagram of Sustainable Development



**Source:** UN Environment Programme (2023)

This study will specifically focus on the sub-themes of “environmental sustainability” and the “water crisis”. However, an accurate understanding of these sub-headings cannot be achieved without first establishing a comprehensive grasp of the main title, “sustainable development”. It is crucial to clearly define what is meant by the term “sustainable development” to facilitate a full and accurate analysis of the sub-headings.

The concept of sustainability emerged from concerns over resource depletion and environmental degradation, particularly during the latter half of the 20th century. Since then, sustainability has become a guiding principle in global policies and practices aimed at mitigating climate change, conserving biodiversity, and promoting the efficient use of resources. In this context, environmental sustainability focuses on the natural systems and processes that support life on Earth, ensuring they remain functional and resilient in the face of human activity (Fergus & Rowney, 2005).

The concept of sustainable development was globally introduced in 1987 in the “Our Common Future-Brundtland “ Report, published by the World Commission on Environment and Development (UN, 1987). As outlined in the report, sustainable development can be defined as a form of growth that ensures the fulfilment of living standards and necessities for future generations, while simultaneously addressing the requirements of existing societies (Bansal, 2005). This concept has been rapidly adopted at the national and international levels and has become the fundamental element in the policy documents of policymakers, national and international institutions, and companies in every state (Mebratu, 1998). The concept is based on three fundamental moral values: the necessity of meeting the needs of all individuals on Earth, the importance of ensuring social equality, and the imperative of respecting the limitations of the natural environment (Holden et al., 2017).

In defining the concept of sustainable development, the environmental, economic and social factors are taken as a starting point. It is therefore emphasised that the main headings for sustainable development are economic, social and ecological factors and that sustainable development can be achieved primarily through the promotion of ecological and social equality and justice (Dunphy, 2000).

The United Nations Sustainable Development Goals (SDGs) comprise 17 targets, collectively agreed upon by all United Nations Member States in 2015. These goals are designed to eradicate poverty, safeguard the planet and guarantee prosperity for all. The SDGs are universal, ambitious and far-reaching, applicable to all countries, irrespective of their level of development. The SDGs represent a significant advancement in the global endeavour to achieve sustainable development. They provide a framework for action that can facilitate the improvement of the lives of millions of people around the world (Esgthereport, 2023).



**SUSTAINABLE DEVELOPMENT GOALS**



**Figure 1:** Sustainable Development Goals

**Source:** UN (2024)

The SDGs are anticipated to achieve success due to their capacity to integrate non-governmental actors with states and local communities, who will facilitate the immediate dissemination of information to UN headquarters. Their second defining feature is their inclusivity. While countries face distinct challenges, they must collaborate to achieve shared objectives and cultivate partnerships at the local and regional levels to bridge the gaps between them. In this regard, inclusive and green growth strategies for implementing the goals are crucial for success (Erendor & Sunguray, 2019).

The 2030 Agenda for Sustainable Development has the objective of focusing efforts on the reduction of poverty, the enhancement of prosperity, the protection of cultural heritage, the prevention of the destruction of values and the environment, and the creation of a liveable world for future generations (Symons, 2024). This will be achieved by engaging all relevant parties on a global scale. The objective of this novel development approach is to prevent gender inequalities, meet the needs of disadvantaged groups, reduce food waste, protect underground and above-ground resources, sustain biodiversity, promote technological and innovative solutions, stimulate economic growth and facilitate the development of employment and industry (Türkiye Cumhuriyeti Cumhurbaşkanlığı, 2019).

The concept of sustainable development is contingent upon the maintenance of a sustainable environment. The concept of environmental sustainability can be defined as the assurance of the

continued availability of natural resources. The rate of utilisation of resources must not exceed the rate of self-renewal of these resources; similarly, the rate of pollutants emitted must not exceed the rate at which natural resources process these pollutants. It seems inevitable that sustainable development will become one of the principal concerns of future societies. However, for this concept to address the environmental challenges currently facing humanity, it must be aligned with the principles of equality, justice, social cohesion, democracy, human needs and environmental value. The assurance of economic welfare, social justice, environmental protection and development necessitates the pursuit of complementary and mutually reinforcing objectives (Commission of the European Communities, 1998).

While some states are implementing policies to promote sustainable development, the prevalence of environmental issues is increasing on a global scale. One of the most significant challenges that will define the near future is the impending water crisis. While some regions are experiencing the threat of flooding due to rising sea levels, drought is becoming increasingly prevalent in other areas. The utilisation of water for commercial purposes is on the rise, while access to water is becoming increasingly challenging for economically disadvantaged individuals. In developing countries, approximately one-fifth of the population lacks access to sufficient and clean drinking water (UN, The Sustainable Development Goals Report, 2024). This situation has a detrimental impact on the availability of clean drinking water. Furthermore, the number of individuals who are unable to maintain adequate hygiene due to a lack of water is also rising rapidly. Currently, approximately 3.6 billion people worldwide, or nearly half of the global population, lack access to adequate sanitation (UNEP, 2021). The lack of adequate sanitation has a significant negative impact on human health, the environment and socio-economic development. The contamination of water sources and the subsequent spread of waterborne diseases are direct consequences of inadequate sanitation. In developing countries, the lack of sanitation is responsible for the deaths of more than 700 children every day from diarrhoea-related diseases (UNEP, 2022).

### **3. Status of Water Resources in Turkestan**

The water crisis has had a significant impact on Turkestan, a region that is particularly vulnerable to its effects. Turkestan is facing several significant environmental challenges. These include the drying up of Lake Aral, water pollution and deterioration of water quality, and a reduction in water resources due to climate change (Zeitoun, 2015).

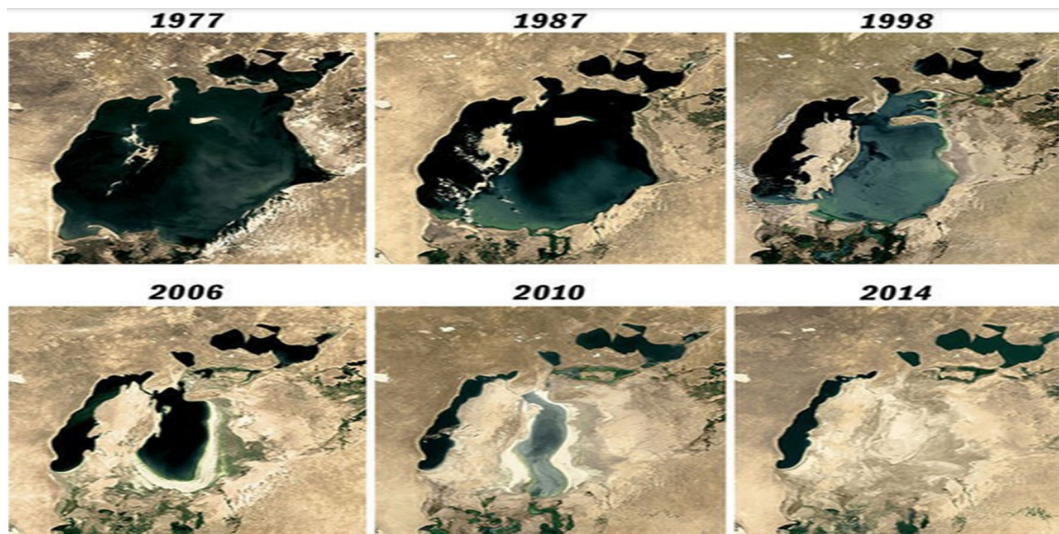
Lake Aral, formerly regarded as the fourth largest lake globally, serves as a crucial water source for the surrounding ecosystems and communities in Turkestan. However, since the mid-twentieth century, the lake has begun to shrink significantly as a result of human activities. This process can be considered a reflection of the water crises in the region, and it contains serious warnings about environmental sustainability. Lake Aral is situated between the countries of Kazakhstan and Uzbekistan, with its waters nourished by the Amu Darya and Syr Darya rivers. The lake is a critical source of water for the surrounding agricultural lands and is also a major contributor to the



fishing industry. The biodiversity of the lake is of vital importance for the maintenance of regional ecosystems (Micklin, 2007).

The primary cause of the shrinking of Lake Aral can be attributed to the diversion of the Amu Darya and Syr Darya rivers' waters for the irrigation of agricultural lands during the Soviet era. In particular, the expansion of cotton production led to the intensive utilisation of these water resources. The implementation of irrigation projects resulted in a significant reduction in the lake's water level, leading to its division into two smaller water bodies (Glantz, 1999).

The drying up of Lake Aral had significant environmental and social repercussions. The saline soils that emerged with the recession of the lake were carried by the winds, resulting in a reduction in agricultural productivity across a significant portion of the region and negatively impacting human health. Furthermore, the collapse of the fishing industry has had a significant negative impact on the region's economy, resulting in a notable decline in the standard of living for the local population (Saiko & Zonn, 2000). The shrinking of Lake Aral is indicative of the broader water crises afflicting Turkistan. The management of water resources in the region is subject to persistent pressure, particularly from water-intensive activities such as agriculture and energy production. (Spoor, 1998) Furthermore, climate change is intensifying the strain on water resources.



**Figure 2:** Changes in Lake Aral from 1977 to 2014

Source: ИКМФСА (2024).

In 1989, the Aral Sea was divided into two distinct reservoirs: the northern Little Aral, situated within the Kazakh region, and the southern Great Aral, located within the Uzbek region. In 2002, the Great Sea underwent a size reduction and was subsequently divided into two distinct reservoirs, namely the eastern and western reservoirs. By 2014, the eastern basin had completely evaporated and disappeared. In response to the crisis, several international and regional initiatives have been



launched to save Lake Aral and manage water crises in the region. To conserve a portion of the Northern Aral Lake, Kazakhstan has initiated the “Little Aral Project” (Кысов, 2022).

The Kazakhstan Little Aral Project is an initiative aimed at revitalizing the northern part of the Aral Lake. The project was initiated in 2005 in collaboration with the World Bank and the government of Kazakhstan. The project entails the construction of the Kokaral Dam, which serves to separate the northern portion of the lake, designated as the Lesser Aral, from the southern portion, designated as the Greater Aral. The principal objective of the project is to restore the ecosystem and revitalise the fishing industry by raising the water level of the lake. The construction of the Kokaral Dam increased the water level of the lake, achieved by redirecting the flow of the Amu Darya and Siri Darya rivers into the Lesser Aral. Consequently, the quality of the water and biodiversity have improved, as have the economic and social conditions in the region (Micklin, 2010).

Since its inception, the Small Aral Project has achieved notable success. As a consequence of the increase in water level, fishing activities have been revitalised, thereby improving the livelihoods of the local population. Furthermore, the frequency of salt storms in the region has diminished, and agricultural productivity has increased (Martius, 2006). As per the consensus of experts, the Aral Sea has reached a point of no return in terms of restoration. However, Kazakhstan’s initiative has yielded partial success. In addition to the water surface level reaching 42 metres on the Baltic scale, the salinity of the Aral Sea also reached the levels that should have been reached in 2010 by 2007. Furthermore, the population of fish species has begun to increase rapidly once more, which has had a positive impact on fisheries (Казинформ, 2023). Nevertheless, the sustainable management of water resources and regional cooperation are indispensable for the implementation of long-term solutions.

A further significant environmental issue in Turkestan is the contamination of water resources and the deterioration of water quality. Despite the region’s considerable and varied water resources, Turkestan is confronted with significant challenges pertaining to water pollution and water quality. The contamination of the region’s water resources results from a multitude of factors, including industrial waste, agricultural chemicals, and domestic waste (Libert, 2008). These issues have significant implications for human health and the integrity of ecosystems. The following provides an overview of the main sources of water pollution:

- **Industrial Waste:** Industrialisation is a significant contributor to water pollution in Turkestan. Major industrial facilities, particularly in countries such as Kazakhstan, Uzbekistan and Turkmenistan, discharge their wastewater into water bodies without prior treatment. Industrial sectors such as metal processing, and chemical and textile manufacturing generate wastewater containing heavy metals, organic pollutants and toxic chemicals. These pollutants enter waterways, resulting in adverse effects on both water quality and aquatic ecosystems (Мырзабекова, 2015).
- **Agricultural Chemicals:** The region of Turkestan is renowned for its economies that are based on agriculture. Consequently, agricultural activities have a significant impact on water pollution. The widespread use of fertilisers and pesticides in the region has resulted in nitrate

and phosphate contamination of surface and groundwater. In particular, the Aral Lake basin has witnessed a considerable decline in water quality due to the excessive utilisation of chemicals for the cultivation of cotton (Carpenter et al., 1998).

- **Domestic Waste:** A significant number of settlements in Turkestan lack the necessary infrastructure to treat domestic wastewater. This results in the discharge of wastewater directly into waterways, which is a major contributor to the deterioration of water quality. The presence of pathogens, organic matter, and various chemicals in domestic waste has a particularly detrimental impact on water quality, especially in urban areas with high population density (Роспотребнадзор, 2019).

The presence of contaminants in water can facilitate the transmission of waterborne diseases, including cholera, dysentery, and typhoid. In particular, in rural areas where access to clean water is restricted, such diseases are prevalent and result in significant public health concerns. Ingestion of contaminated water can result in the development of diarrhoea and other gastrointestinal disorders, which can prove fatal, particularly in children and the elderly (Gould & Nissen-Petersen, 1999). The presence of toxic substances from industrial waste into water bodies represents a significant risk to human health. Heavy metals, including lead, mercury, and cadmium, have been demonstrated to exert detrimental effects on the nervous system, kidneys and liver. Furthermore, it is established that certain chemical compounds are carcinogenic (Бурашников & Максимов, 2010).

The contamination of water sources has been identified as a significant contributing factor to the decline in biodiversity observed in aquatic ecosystems. The presence of chemical pollutants in aquatic environments can exert toxic effects on the flora and fauna that inhabit these ecosystems. For example, the use of pesticides and heavy metals has been demonstrated to harm the reproductive and growth processes of fish, which in turn has resulted in a decline in fish populations. The drying up of Lake Aral and the deterioration of water quality represent one of the most striking examples of biodiversity loss in the region (Tilman et al., 2001).

Eutrophication of waterways caused by agricultural chemicals results in the proliferation of algae, which accumulate in dense concentrations on the surface of the water. This phenomenon obstructs the penetration of sunlight to the lower layers of the water column, thereby impeding the photosynthetic processes of submerged plants. Furthermore, the bacterial decomposition of algae during their death and decay reduces the oxygen levels in the water, leading to fish kills and a deterioration in the living conditions of other aquatic organisms (Smith et al., 1999).

Recommendations for solutions to the aforementioned issue can be classified into three principal categories (Singh et al., 2023):

- **Waste Water Treatment Plants:** To enhance water quality, it is essential to augment the capacity of wastewater treatment facilities and guarantee their efficacy. The optimal management of industrial and domestic waste is a pivotal measure in the conservation of water resources.

- Sustainable Agricultural Practices: The reduction of chemical usage in agricultural practices and the promotion of sustainable agricultural techniques can assist in the prevention of water contamination. The implementation of methods such as organic farming, integrated pest management and the optimisation of fertilizer use can serve as effective strategies for the protection of water quality.
- Public Education and Awareness Raising: The general public must be educated and made aware of the importance of water pollution and water quality if long-term solutions are to be achieved. An increase in environmental awareness will serve to reinforce social support for the protection and sustainable management of water resources.

The region of Turkestan is one where the effects of climate change significantly impact the availability of water resources. The region is experiencing some challenges, including rising temperatures, reduced precipitation and the depletion of water resources. This situation presents significant environmental and socio-economic challenges. The climate of Turkestan is predominantly continental, and the region is experiencing a disproportionate impact from rising temperatures. Decreased snowfall has a detrimental effect on the flow of rivers and lakes. Climate change has resulted in significant alterations to precipitation patterns, with an anticipated increase in droughts, particularly during the summer months. This has the potential to compromise food security by directly affecting agricultural and animal husbandry practices. The Amu Derya and Sir Derya, two of Turkestan's major rivers, are witnessing a notable decline in their water levels (Klein et al., 2014).

The majority of the population in the region derives their livelihood from agricultural and animal husbandry activities. The reduction in available water resources has a direct impact on this sector. The scarcity of water results in increased costs of irrigation and a reduction in crop productivity. The reduction in available water resources has led to increased internal migration, with a corresponding movement of the population from rural to urban areas. The scarcity of water may give rise to social conflicts over the sharing of resources (Oberhänsli & Molnar, 2012).

The development of effective water management strategies is essential for the sustainable utilisation of water resources. The promotion of modern irrigation techniques and the economical use of water should be encouraged. Regional cooperation on the protection and management of water resources is crucial (Tchobanoglous & Angelakis, 1996). The objective should be the fair and sustainable utilisation of water resources through joint projects and agreements. Further research is required on the interrelationship between climate change and water resources, and policies should be developed in light of the data obtained. Public awareness and education are vital for the conservation of water and the sustainability of the environment.

The Amu Darya River has its source in the Pamir Mountains and flows for approximately 2,400 kilometres before entering Lake Aral. The river has a vast catchment area that encompasses Tajikistan, Afghanistan, Turkmenistan and Uzbekistan. The Amu Darya is one of the most significant water resources in Turkestan and plays a pivotal role in agricultural production. The river's water level has

been significantly depleted due to the intensive use of its resources, particularly for irrigation projects associated with cotton cultivation (Micklin, 2007).

The Syr Derya River has its source in the Tien Shan Mountains, flows for approximately 2,212 km and ultimately discharges into Lake Aral. The river traverses the territories of Kyrgyzstan, Uzbekistan, Tajikistan and Kazakhstan. The Syr Derya River plays a pivotal role in the management of water resources in the region. The river provides water for agricultural purposes and is also utilised for the generation of hydroelectric power (Zonn et al., 2009).

As illustrated in the map below, the majority of water resources are transboundary. The majority of the region's surface water resources are located in the mountainous regions of Kyrgyzstan, Tajikistan and Afghanistan. These waters flow as two principal rivers to downstream countries, including Kazakhstan, Turkmenistan and Uzbekistan, which are also part of the Aral Sea basin. The region's economy, population and environment are all dependent on the availability of water resources (Yalçın & Imagambetova, 2022). The importance of irrigation for agricultural production is exemplified by the fact that a significant proportion of the population in Tajikistan, Turkmenistan and Uzbekistan is either directly or indirectly dependent on irrigated agriculture. Furthermore, water is a crucial resource for energy production, with hydropower accounting for over 90% of the total electricity demand in Kyrgyzstan and Tajikistan. It is also an export commodity. The competitive demands for water for agriculture and hydropower between downstream and upstream countries have led to significant political disputes in the region, highlighting the central role of water in regional security and stability (Дегтярева, 2014).



**Figure 3:** Map of Water Resources of Turkistan

**Source:** тасним новости. (2023).

Only three percent of Kazakhstan's territory is endowed with water resources. In contrast, Kyrgyzstan is endowed with 40 percent of Turkestan's water resources. In his 2023 annual message to the people, President Tokayev Kassym-Zhomart emphasised that one of the most urgent problems facing the country is the issue of water supply. In this context, Tokayev set several tasks for the government, including the adaptation of water-saving technologies, the construction of new reservoirs and the repair of existing ones, and the reform of the water supply system, among other measures. However, the most crucial issue is resolving problems related to transboundary water use (ТАСНИМ НОВОСТИ, 2023).

Lake Aral was the fourth largest lake in the world until the 1960s. However, it has undergone a significant reduction in size as a consequence of the implementation of intensive irrigation projects. The shrinking of Lake Aral has had a significant impact on the regional ecosystem, with adverse effects on human health. The soil around the lake has been contaminated with salts and chemicals, which has negatively affected agricultural productivity and human health (Glantz, 1999).

The Caspian Sea is the world's largest enclosed body of water, situated between Asia and Europe. The sea is bordered by the countries of Azerbaijan, Iran, Kazakhstan, Russia and Turkmenistan. The Caspian Sea is of significant importance concerning energy resources. The oil and natural gas reserves in the region are of critical importance for both the regional and global energy markets (Kalyuzhnova, 2008).

The agricultural sector is the largest consumer of water in Turkestan. In particular, the cultivation of cotton has resulted in a significant and intensive utilisation of the region's water resources. Indeed, over 90% of the total water consumption in Turkestan is attributed to the agricultural sector. This ratio illustrates that the majority of the water extracted from the Amu Derya and Syr Derya rivers is employed for irrigation purposes (Micklin, 2007). The irrigation of agricultural lands around Lake Aral has resulted in a significant increase in water usage, which has in turn led to a notable reduction in the flow rate of the rivers that feed the lake and the subsequent drying up of the lake itself. (Glantz, 1999)

Although the industrial sector accounts for a relatively minor proportion of total water consumption in Turkestan, it plays a notable role in certain regions. For instance, the oil and gas industry in the vicinity of the Caspian Sea has a considerable impact on water usage, with water employed in both production and cooling processes (Kalyuzhnova, 2008). Approximately 7-10% of water consumption in Turkestan is attributed to the industrial sector. While this proportion varies across countries, it is typically considerably lower than that observed in the agricultural sector (UNEP, Water Resources Management in Central Asia, 2011).

Domestic water consumption represents the smallest proportion of total water use in Turkestan. Approximately 2-3% of water consumption in Turkestan is allocated to domestic use. While this rate is lower in rural areas, it increases in urban areas (WorldBank, 2014). One of the most significant challenges associated with domestic water consumption is the limited accessibility to clean water and

the contamination of existing water resources. This results in a dual burden, namely health problems and water scarcity. (Rudenko et al., 2013).

As with numerous other issues in Turkestan, the water problem was created by the Soviet Union. The Soviet Union initiated a series of large-scale irrigation projects to expand agricultural areas in Turkestan. These projects, collectively known as the "Irrigation Projects", led to a significant increase in water use in the region. The primary objective of the extensive irrigation projects was to enhance cotton production. Moscow has effectively treated Turkestan as an extension of its own agricultural zone, without adequately considering the specific circumstances and future prospects of the region's inhabitants (Spoor, 1993).

During this period, the waters of the Amu Darya and Syr Darya rivers were intensively used for agricultural irrigation, which precipitated the rapid drying up of Lake Aral. The drying up of Lake Aral is recognised as one of the world's most significant environmental disasters. The surface area of the lake has been reduced by 90 per cent, giving rise to a plethora of environmental, economic and health issues (Micklin, 2007).

The consequences of Soviet agricultural policies have resulted in the current water scarcity crisis in Turkestan. The region of Turkestan is currently experiencing a significant water crisis, which not only poses a threat to economic development but also to the lives of millions of people. The scarcity of fresh water, Due to climate change and the ineffectiveness of water resource management, presents considerable challenges for the countries in the region. During the summer months, the capitals and numerous smaller towns in Turkestan encounter considerable difficulties in accessing potable water (CANEECCA, 2023). To achieve sustainable development goals, it is necessary to revise water management policies in the region.

#### **4. Solution Proposals and Sustainable Water Management**

The solution proposals outlined in the study for addressing the water problem in Turkestan consist of three distinct parts. The initial proposal is the development of sustainable water management strategies. In this context, the measures and strategies that can be taken for the sustainable management of water resources should be detailed. The applicability of examples of good practices to Turkestan should be discussed. Secondly, the development of cooperation and joint projects in water resources management among Turkestan countries should be considered. The role of international organisations and agreements in this context should be acknowledged. Finally, the development of water-saving and water-management technologies should be explored. Innovative solutions and ways to increase water efficiency should be sought.

When analysing the measures and strategies that can be adopted for the sustainable management of water resources, the first one that comes to mind is Integrated Water Resources Management (IWRM). IWRM is a strategy for managing water resources sustainably and holistically. It aims to protect ecosystems while balancing water supply and demand. IWRM ensures the participation of



all stakeholders (public, private, civil society) in water management and promotes cooperation in the management of transboundary water resources (FAO, 2014).

In addition to IWRM, there are various water-saving technologies and practices. The most common are drip irrigation and the treatment and reuse of wastewater with modern irrigation techniques. For example, in a region with limited water resources, Israel has increased agricultural productivity and optimised water use through drip irrigation technologies. These systems conserve water and ensure that it goes directly to the roots of plants (Вострова, 2022). The use of similar technologies in Turkestan could lead to significant savings in agricultural water use.

Raising awareness among the public and water users is important for the conservation and sustainable use of water resources. Education programmes and public campaigns can raise awareness of water conservation. In addition, measures must be taken to counter the negative effects of climate change on water resources. Developing water management systems that are resilient to extreme weather events such as droughts and floods is one such strategy. Basin-based approaches to water resources management should be adopted. These approaches ensure the protection and sustainable use of water resources by taking into account natural water flows and ecosystem services.

When analysing examples of good practices and their applicability to Turkestan, the example of Singapore, in addition to that of Israel mentioned above, is important. Singapore is a global model of sustainable water resource management. Rainwater harvesting systems, wastewater treatment and reuse programmes are widely implemented in the country. Singapore's "NEWater" programme ensures that wastewater is treated with advanced technologies and reused as drinking water (RTVI, 2024). Similar programmes in Turkestan could provide a solution to water scarcity.

China has implemented the South-North Water Transfer Project to address the unbalanced distribution of water resources. This project allows water to be transferred from the water-rich southern regions to the arid northern regions (шанс книжный, 2024). Similar water transfer projects in Turkestan could provide a solution to water scarcity.

These strategies and examples of good practice provide comprehensive solutions for the sustainable management of water resources in Turkestan. These approaches can contribute to the conservation and sustainable use of water resources by enabling effective responses to the water crisis in the region.

Cooperation and joint projects in water management between Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan are essential for the sustainable use of water resources. Partnerships between the Turkestan states with other states and international organisations are also important. The Aral Sea crisis demonstrated the importance of cooperation among Turkestan countries in water management. Several projects and agreements have been made for the recovery of Lake Aral. The most important of these is the "International Fund for the Recovery of Lake Aral" (IFAS), which was signed in 1994. This fund, which is still active, aims to solve water and environmental problems in the Aral Sea basin (ИКМФСА, 2024).



Turkestan countries have signed several agreements on the management of transboundary water resources. These agreements aim to share water fairly and sustainably. For example, the Alma-Ata Agreement, signed in 1992, provides for cooperation in the management of transboundary water resources and the adoption of the principle of equal water use (ЭШМЕНТ, 2011).

Turkestan countries are developing joint water management projects. These projects aim to make more efficient use of water and protect water resources. For example, the Vakhsh River Management Project in Tajikistan aims to strengthen regional cooperation in river basin management. The Vakhsh River Management Project was initiated in Tajikistan to manage the water resources of the Vakhsh River more efficiently and sustainably. The project, which commenced in 2021, has three main objectives: to enhance water quality, to mitigate the risk of flooding and to optimise agricultural irrigation. To this end, the project encompasses the implementation of contemporary irrigation techniques and the renovation of relevant infrastructure. At the time of writing, the project has largely achieved its planned activities and has made notable headway in the management of water resources and the enhancement of agricultural productivity. It is anticipated that the project will ultimately lead to more sustainable and efficient utilisation of water resources in the region (группа всемирного банка, 2023). Such projects make a substantial contribution to the sustainable management of water resources.

International organisations and agreements play a significant role in addressing water-related challenges in Turkestan. These entities contribute to regional water management efforts through the provision of technical assistance, financial resources, and expertise. The United Nations (UN) is a prominent supporter of water management initiatives in Turkestan. Multiple UN agencies offer technical assistance and funding for the sustainable management of water resources. For instance, the UN Development Programme (UNDP) provides financial support to water management projects in the region (Kun.Uz., 2018).

The World Bank provides substantial financial support for water management initiatives in Turkestan. The Bank's contributions encompass the enhancement of water management infrastructure, the dissemination of water-saving technologies, and the development of capacity-building projects in water management. The World Bank's "Turkestan Water Resources Management and Modernization Project" represents a noteworthy example in this domain (World Bank Group, 2024).

The European Union offers technical and financial assistance to water management initiatives in Turkestan. The EU is implementing a series of projects to ensure the sustainable management of water resources in the region. The EU's "Central Asia Water Cooperation Platform" (CAWEP) represents a significant initiative aimed at fostering collaboration in this domain (EU, 2020).

The water crisis in Turkestan has become an increasingly significant issue, largely due to the region's climate and the limited availability of water resources. The third category of responses to this crisis is the deployment of technological and innovative solutions. The conservation and management of water resources are of paramount importance in alleviating the water crisis. Some significant technological solutions are available for implementation in Turkestan, including:

- **Drip Irrigation Systems:** Drip irrigation systems are a highly efficient alternative to traditional irrigation methods. By delivering water directly to plant roots, they minimise evaporation and surface runoff, ensuring optimal use of water resources and enhancing agricultural productivity (Perry & Steduto, 2017).
- **Smart Water Management Systems:** These systems employ advanced sensors and data analysis tools to monitor and optimise water use. They provide farmers and water managers with real-time information on the appropriate times and quantities of water to use, thus preventing wastage and supporting the sustainable use of water resources (USAID, 2020).
- **Recycling and Reuse Technologies:** The treatment and reuse of wastewater are crucial aspects of the protection of water resources. Modern wastewater treatment plants are capable of cleaning domestic and industrial wastewater to a standard that allows its reuse in a variety of contexts, including agriculture and industry (USAID, 2020).
- **Rainwater Harvesting:** Rainwater harvesting systems facilitate the collection and storage of water during periods of precipitation. This stored water can then be utilized for agricultural and other purposes during periods of drought. This approach contributes to the diversification of water resources and serves as a safeguard against water scarcity (Zheng Li et al., 2020).

To resolve the water crisis, it is necessary to consider not only existing technologies but also to explore alternative solutions. It is also crucial to pursue innovative approaches and strategies that enhance water efficiency. The following are some innovative solutions that could be implemented in Turkestan:

- **Digital Water Mapping:** The utilisation of Geographic Information Systems (GIS) and remote sensing technologies for the mapping of water resources and areas of use provides invaluable data for the optimisation of water management strategies. These technologies facilitate the identification of the status of water resources, patterns of water use and potential crises in advance, thereby enabling the implementation of effective contingency plans (Mekonnen & Hoekstra, 2020).
- **Efficient Agricultural Techniques:** The implementation of sustainable farming methods, including no-till farming, the utilisation of vegetative covers and agroforestry, has been demonstrated to enhance water retention and mitigate erosion. These techniques facilitate the prolongation of water residence time within the soil, thereby facilitating more efficacious plant access to water (International Water Management Institute, 2021).
- **Nanotechnology and Materials Science:** The utilisation of nanotechnology in water treatment and filtration systems enables the effective cleansing of water. Nano-filters, for instance, are capable of efficiently eliminating contaminants and microorganisms from water, thereby enhancing the quality of drinking water (Savage & Diallo, 2005).

- **Artificial Intelligence and Machine Learning:** The use of artificial intelligence and machine learning algorithms can facilitate the formulation of more intelligent and predictable decisions in the domain of water management. This is achieved through the analysis of data about the utilisation of water resources. The deployment of these technologies enables the optimisation of water usage, as they facilitate the generation of forecasts concerning the water demand (Elshafei & Sivapalan, 2016).
- **Education and Awareness Campaigns:** Dissemination of knowledge and the promotion of awareness concerning the conservation and management of water resources enhance the efficacy of strategies to address the water crisis. Educational initiatives and campaigns facilitate the conscious utilisation of water at the individual and community levels (UNESCO, 2015).

The water crisis in Turkestan can only be resolved through a comprehensive and multifaceted approach. Technological innovations and advances in water management are of vital importance to ensure the more efficient and sustainable use of water resources. From drip irrigation systems to smart water management, and recycling technologies to digital water mapping, many solutions are available which offer an effective response to the water crisis. At the same time, public awareness and education play a critical role in the responsible use of water. These innovative and technological solutions offer powerful tools which can be employed in order to overcome the water crisis in Turkestan.

## **5. Conclusion**

Environmental sustainability is an area that major international organizations such as the UN and the EU, as well as major countries, have been working on a lot in recent years. This is because the world's natural resources are in the process of being depleted or polluted due to overuse. If this situation continues, future generations will face serious problems in terms of natural resources and may even face life-threatening problems. As a result, environmental sustainability is an area that has entered the international relations literature but has not yet been sufficiently studied. The concept of "environmental sustainability" was selected as the overarching framework for this study for two primary reasons. Firstly, the article addresses the critical issue of water scarcity in Turkestan, which is a pivotal concern within the broader domain of environmental sustainability. Secondly, the focus on environmental sustainability aligns with the study's objective to examine the complex interrelationships between human activities, natural resources, and the environment.

The principal causes of the water crisis in the region include excessive water use, inefficient agricultural irrigation techniques, climate change and political instability. The drying up of Lake Aral serves to illustrate the profound and far-reaching nature of the water crisis in the region. The principal causes of the water crisis in the region include excessive water use, inefficient agricultural irrigation techniques, climate change and political instability. Although regional collaboration is a vital component of efficient water resource utilisation and management, there are inherent incompatibilities between the water management policies and strategies of different countries.

Agriculture represents a fundamental pillar of the Turkestan economy, with a significant proportion of water resources allocated to agricultural irrigation. However, these irrigation systems are frequently outdated and inefficient. The widespread cultivation of water-intensive crops, such as cotton, has resulted in unsustainable consumption of water resources. The effects of climate change are placing significant strain on the region's water resources, exacerbating the severity of the water crisis. The rise in temperatures and decline in precipitation are impeding the replenishment of existing water sources, creating challenges for both agricultural production and the provision of drinking water, and negatively impacting the quality of life for residents in the region.

The management of the water crisis in Turkestan is also affected by political instability and economic challenges in the region. Disagreements among countries over water resource sharing hinder the efficient management of these resources. Economic difficulties, on the other hand, lead to a lack of necessary investments for water management projects. Various strategies and policies have been implemented to address the water crisis in the region. However, the effectiveness and sustainability of these strategies are controversial.

Despite several agreements between Turkestan countries regarding the management of water resources, the implementation of these agreements has encountered significant challenges. The primary obstacles to cooperation are political differences and conflicts of interest between the countries. However, regional collaboration is essential for the sustainable management of water resources.

Technological innovations in water management and the use of modern irrigation techniques can help alleviate the water crisis. The pervasive implementation of water-saving methodologies, such as drip irrigation, enables a more efficacious utilisation of water resources. Furthermore, the deployment of water treatment and recycling technologies is of paramount importance for the sustainable management of water resources.

Public education and awareness-raising initiatives are pivotal in addressing the water crisis. The elevation of public consciousness regarding the significance and safeguarding of water resources represents a pivotal stride towards the more economical and efficient utilisation of water. The implementation of educational programmes and public information campaigns represents a crucial avenue for advancement in this regard.

To overcome Turkestan's water crisis and ensure environmental sustainability, it is necessary to develop a range of strategies and policies. The following section presents many suggestions in this regard.

***Regional Cooperation and Common Policies:*** Closer and more effective cooperation should be established among Turkestan countries on the management of water resources. These co-operations should ensure fair and efficient sharing of water resources. Joint policies and projects will play an important role in solving the water crisis.

**Modern Irrigation Techniques:** Modern irrigation techniques should be made widespread in order to make water use efficient in agriculture. The use of techniques such as drip irrigation and sprinkler irrigation should be encouraged. In this way, water resources will be used more efficiently for agricultural irrigation.

**Water Treatment and Recycling:** The use of water treatment and recycling technologies should be increased. These technologies will contribute to the protection of water resources by reusing wastewater. Water recycling systems should be established, especially in industrial facilities and agricultural areas.

Regional and international cooperation to combat climate change should be increased. These co-operations should be aimed at reducing the negative impacts of climate change on water resources. Climate-friendly agricultural practices and energy policies will play an important role in this struggle. Public education and awareness raising are critical in solving the water crisis. Education programmes and campaigns should be organised to raise public awareness of the protection and efficient use of water resources. These campaigns should encourage the public to use water economically.

The water crisis in Turkestan serves to illustrate the necessity for the efficient and sustainable management of the region's water resources. In this regard, regional cooperation and innovative water management strategies assume great importance. The implementation of sustainable water management practices will not only enhance the quality of life for the people of the region but will also ensure the long-term sustainability of the environment. To address the water crisis in Turkestan effectively in the future, it is necessary to implement more comprehensive and integrated strategies. These strategies must involve the cooperation of all stakeholders in the conservation and efficient use of water resources. Furthermore, combating climate change and popularising water recycling technologies are essential for the sustainable management of water resources.

In conclusion, the water crisis and environmental sustainability in Turkestan are significant issues at both regional and global levels. The measures to be implemented to address this crisis will not only guarantee the conservation and efficient use of water resources in the region but will also facilitate environmental sustainability. In this context, regional collaboration, innovative water management strategies and public awareness initiatives are crucial steps towards a sustainable future.

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