SUSTAINABLE WATER MANAGEMENT AND ELIMINATION OF WATER SCARCITY: A CASE STUDY IN A REMOTE DISTRICT OF UZBEKISTAN

JURAEV ZUHRIDDIN[*], AHN YOUNG-JIN[**1]

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Gestion durable de l'eau et élimination de la pénurie d'eau : l'étude de cas dans un district éloigné de l'Ouzbékistan. La diminution significative du niveau d'eau de la mer d'Aral au cours des cinquante dernières années représente un défi environnemental majeur en Asie centrale. L'Ouzbékistan, autrefois riche en ressources hydriques, doit désormais faire face à la menace de pénurie d'eau dans des zones spécifiques. La mauvaise gestion de l'irrigation est devenue un contributeur important aux problèmes environnementaux mondiaux. Cette étude examine les problèmes liés à la mauvaise gestion de l'irrigation dans les zones rurales d'une province méridionale éloignée de l'Ouzbékistan. L'objectif principal de cette étude est de développer des solutions pratiques pour résoudre efficacement le problème urgent de pénurie d'eau dans la région ciblée. L'étude met en avant l'importance de la planification stratégique et de mesures proactives pour établir une base solide en vue d'une durabilité à long terme au niveau local. Cette étude n'examine pas l'effet de la variabilité climatique mondiale sur la diminution des réservoirs d'eau en Ouzbékistan. Les conclusions de l'étude s'alignent sur les efforts de recherche mondiaux, contribuant ainsi au discours plus large sur la gestion durable de l'eau. Cette recherche a le potentiel de transcender les frontières, de partager les bénéfices avec des études de cas similaires et de promouvoir l'alignement des stratégies liées à l'eau à l'échelle mondiale.

1. INTRODUCTION

The global challenge of water scarcity and its complex management requires careful consideration. Severe climatic events, especially droughts, have a significant impact on both the quality and quantity of water, which highlights the need to urgently address the negative consequences of these events (Swain, 2016). The importance of addressing the negative consequences of water scarcity is emphasized (Mitrică *et al.*, 2017). Exploring potential socioeconomic scenarios for water users can facilitate the proactive anticipation and mitigation of the consequences of water scarcity, especially in the context of public water supply (Mitrică *et al.*, 2017). The consequences of global water scarcity also include the depletion of groundwater. The expansion of agriculture, which is closely linked to water, energy, and food policies contributes to unsustainable patterns of water and energy consumption (Mukherjee, 2020).

The importance of water as a crucial resource for both socioeconomic well-being and ecological balance is widely recognized. Prudent water resource management is crucial for development and has the potential to reduce poverty and inequality. The symbiotic relationship between human expertise and digital AI tools offers new opportunities to improve water efficiency through data-driven decision-making. This results in an agile and intelligent approach to dynamic planning for water resources (Xiang *et al.*, 2021).

[*] PhD student, Department of Geography, Chonnam National University, Gwangju, South Korea, Yongbong-ro 77, Buk-Gu Gwangju 61186, South Korea, 198928@jnu.ac.kr.

[**] Professor, Department of Geography, Chonnam National University, Gwangju, Korea, Yongbong-ro 77,Buk-Gu Gwangju 61186, South Korea, yjahn@chonnam.ac.kr.

[1] Corresponding author.

Striking a delicate balance between increasing water scarcity and the need for higher agricultural productivity is a crucial challenge. Geographical regions like India, China, the Western part of the US, and Palestine face complex water management challenges that go beyond traditional investments in irrigation infrastructure. The evolution of irrigation practices requires structural transformations, well-thought-out irrigation policies, and strategies to promote reduced consumption. This trajectory includes innovative methods such as desalination and wastewater reclamation, which are closely linked to water, energy, and food policies (Balasubramanya *et al.*, 2022). The successful implementation of these strategies relies on effectively managing geographical and logistical complexities, highlighting the complex nature of ensuring a reliable water supply.

Accurately assessing water scarcity is crucial for effective resource management. Although some studies have presented various indicators to measure this phenomenon, it remains difficult to find a single indicator that encompasses all its complex dimensions (Hussain *et al.*, 2022). Conventional benchmarks, while informative, often fail to capture important nuances such as the neglect of green water, the interconnectedness of water scarcity and quality, temporal fluctuations, ecological water flow requirements, and virtual water transfers.

The Middle East, Saudi Arabia in particular, stands out as a prime example of the intersection between water scarcity and sustainable development on a global scale. Escalating groundwater extraction and energy-intensive desalination methods worsens the severity of the water crisis, requiring immediate and ongoing interventions. Navigating the complex framework of water resource management requires comprehensive strategies that include conservation efforts, technological advancements, fair pricing mechanisms, and regulatory frameworks (Alotaibi *et al.*, 2023).

The issue of mismanaged irrigation in Uzbekistan represents a small part of the larger problem of global water scarcity. Sustainable water management requires a deep understanding of both local and international dynamics, guided by global insights. The dramatic decline of the Aral Sea serves as a powerful example of how water scarcity can devastate a local environment (Hamidov *et al.*, 2020). The desiccation of this once-thriving water body has had a significant impact on Central Asia, particularly Uzbekistan. This concerning trend has led to water scarcity in regions that were once rich in water resources (Khasanov *et al.*, 2022). The significant role of poorly managed irrigation practices in worsening the water scarcity crisis cannot be ignored, even in the face of global environmental factors (Huang *et al.*, 2023). This study does not directly examine the impact of global warming on the reduction of water resources in Uzbekistan. However, it does provide insight into water scarcity in the specific context of Oltinsoy (i.e., *Golden Stream*), a remote district within the Surkhandarya province (Figs. 1 & 2). This district, known for its flourishing vineyards, faces challenges such as soil erosion and declining agricultural yields caused by inadequate water resources. The misallocation of water resources, especially in relation to local agriculture, is a significant concern (Satorov, 2022). The pressing water crisis in this district highlights the need for immediate community action.

This article highlights the crucial role of geographical analysis in understanding the complex water challenges in Uzbekistan, specifically in the mentioned district. This article explores Uzbekistan's water challenges from a geographical and environmental perspective, highlighting the importance of communication networks in connecting local governance with the community and raising awareness about water scarcity. The study focuses on the challenges caused by poorly managed irrigation in a water-scarce area of Uzbekistan. By conducting a localized case study that combines insights from both local and global contexts, this study aims to contribute to the global discussion on water scarcity. Additionally, it emphasizes the importance of sustainable water management strategies in addressing this crisis. The research aims to identify the causes of irrigation mismanagement, address challenges specific to each district, and propose solutions to alleviate water scarcity. This study serves as a call to action, reminding us of the collective effort needed to ensure a sustainable water future for Uzbekistan.

2. THEORETICAL BACKGROUND

The water shortage in the chosen area for this study shares similarities with other water problems around the world. The situation has similarities to the Aral Sea crisis, which has crossed national borders and gained the interest of neighbouring countries. The Mekong River basin, like many other regions, faces complex interactions and conflicts over water distribution due to multiple nations relying on a shared water source (Gao *et al.*, 2022). The cases of the Aral Sea and Mekong River Basin demonstrate the negative consequences of mismanaging shared water resources, including ecological degradation and socioeconomic instability. These cases parallel the challenges faced in the Oltinsoy area.

The Integrated Water Resources Management (IWRM) approach is a geographically relevant theory with great potential for addressing water scarcity in Oltinsoy District. IWRM advocates for a holistic approach that incorporates social, economic, and environmental considerations in water resource management (Lenton & Muller, 2012). Given the intricate relationship between human activities and the natural systems that contribute to the water crisis in Oltinsoy, implementing the IWRM approach could offer a comprehensive framework for achieving sustainable water management (Grison *et al.*, 2023). This strategy aims to promote collaboration among stakeholders, such as local communities, government agencies, and environmental organizations, to address water scarcity and maintain ecological balance.

One effective solution to combat water scarcity is the implementation of rainwater harvesting systems. Rainwater capture and storage systems are widely recognized for their effectiveness. Rainwater harvesting could greatly supplement water sources and relieve pressure on groundwater reservoirs, particularly in arid climates. Rainwater harvesting is a sustainable practice that can help mitigate the impact of water scarcity on agricultural and domestic needs in Oltinsoy district.

Numerous international studies support the challenges discussed in this study. UNESCO's World Water Development Report highlights the global water crisis and emphasizes the importance of coordinated action (CDP Global Water Report, 2022). The United Nations Decade of Action "Water for Life" (2005–2015) also prioritized sustainable water management practices (Turok-Squire, 2022). These studies emphasize the importance of addressing water scarcity and offer valuable insights that can inform the strategies proposed in this study.

The specific focus of this study on water scarcity in Uzbekistan's Oltinsoy district provides valuable insight into the broader context of global water studies. Localized case studies, like this one, provide valuable insight into the intricate relationship between human activities and natural systems, shedding light on the complex nature of global water issues. This study provides valuable data and perspectives that enhance our understanding of global water-related issues by analysing challenges specific to a particular region. The proposed solutions and recommendations from this case study can serve as a blueprint for addressing water crises in different regions, thus improving the toolkit for global water management. This approach of applying lessons learned and best practices from local contexts to the global level will enable more effective and context-specific interventions to address global water scarcity.

3. STUDY AREA

Uzbekistan, located in Central Asia (Fig. 1), faces the challenge of water scarcity in its complex water landscape. The nation's water resources include renewable surface water, groundwater, wastewater, and drainage water generated by human activities (Jelen *et al.*, 2020).

Uzbekistan's water consumption is currently at 906 cubic meters per second, with 606 cubic meters per second coming from groundwater and 300 cubic meters per second from freshwater sources. The dynamic underground water reserve is a crucial aspect, reaching 1038.1 cubic meters per second in 2020. The transboundary Syr Darya and Amu Darya rivers are significant sources of surface water, collectively sustaining an average long-term flow of 114.4 cubic kilometres. The water system consists of 17,777 naturally flowing water sources, 9,930 of which are located within the Amu Darya basin. Additionally, Uzbekistan is home to 97 reservoirs with a total capacity of 64 million cubic meters.

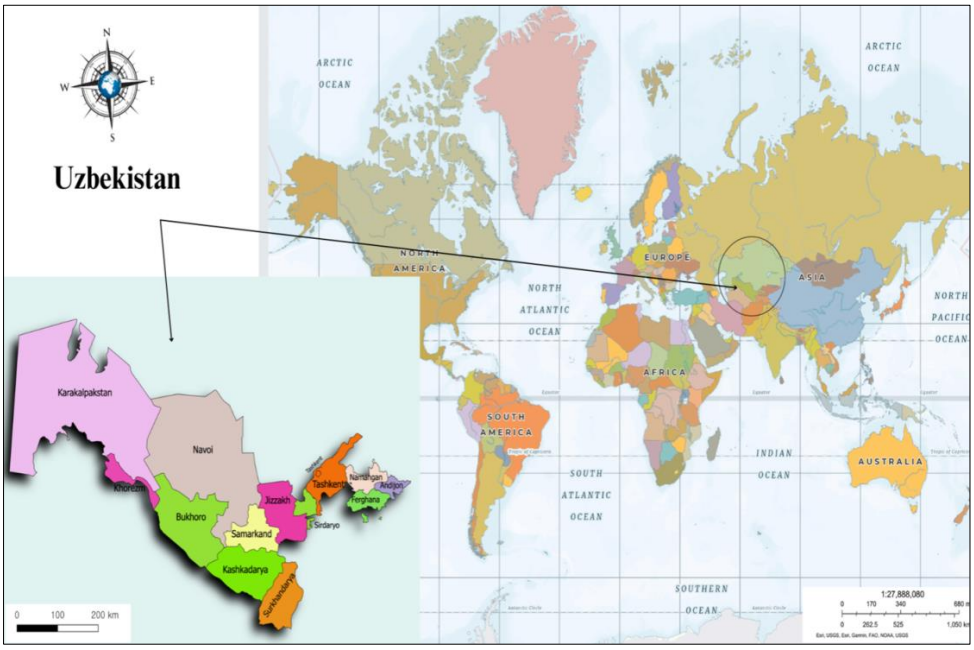

Fig. 1 – Map of Uzbekistan.

However, the water situation in Uzbekistan is complex. According to calculations by the Uzbek Water Supplement Joint Stock Corporation, current water resources range from 52 to 53 thousand cubic kilometres, while the population's water demands are around 62 thousand cubic kilometres. Despite achieving a commendable 71.2% centralized drinking water supply coverage by mid-2022, concerns remain due to a shortage of 6–8 thousand cubic kilometres of water faced by the growing population. This crisis is a result of inefficient irrigation practices and unregulated drinking water usage. Approximately 26,000 wells are used to access underground freshwater and slightly saline reservoirs, resulting in daily withdrawals of 75.5 million cubic meters. As of 2022, Uzbekistan's reservoirs hold a total of 9.6 billion cubic meters of water. Water resources are geographically unevenly distributed, having their origin in the mountains, but being primarily used in the plains through an extensive network of irrigation canals (Chathuranika *et al.*, 2022).

Geographical disparities in water availability are worsened by uneven distribution across different regions (Zhiltsov *et al.*, 2018). Water diversion measures are used to redirect water flow from one region to another, particularly on a large scale in the Amu Darya and Syr Darya river basins. The complex nature of the water crisis makes it difficult to find quick solutions. Uzbekistan ranks 25th out of 164 nations on the Water Scarcity Index, with 17 countries classified as "severely" water-scarce (USAID Global Waters, 2019). The availability of safe drinking water continues to be a critical concern. Agriculture takes up the majority of the nation's freshwater resources, accounting for 91.3 percent, or 53.5 billion cubic meters. Figure 2 clearly depicts the significant trend of water consumption. By early 2022, irrigation technologies had been adopted across 344,008 hectares of land, with a total water usage of 2.58 billion cubic meters (4.4 percent) for various purposes (Tsukhlo *et al.*, 2019).

Another important factor contributing to water scarcity is the significant waste of water, as highlighted by data and reports. In the capital city of Tashkent, daily water consumption per person can reach a peak of 330 litres. The city's water supply system, which provides 2.5 million cubic meters of drinking water daily, is facing a concerning 20 percent waste rate. By 2020, Uzbekistan had secured water reserves of 193,000 cubic meters per day, which is enough to meet the needs of 1,140 thousand people. Per capita water consumption ranges from 115 to 240 litres per day, which is below

the global average. However, according to Worldometers (2023), Uzbekistan has a staggering daily per capita water consumption of 4,754 litres.

In response to these challenges, the Uzbek government has taken proactive measures. The Cabinet of Ministers issued a decree on May 25, 2013, providing guidelines for sustainable and efficient water usage across various sectors. A resolution endorsed on May 10, 2022, outlined measures to ensure a reliable water supply for agricultural crops and mitigate the impact of water scarcity, in anticipation of future water scarcity. Moreover, Presidential Decree No. 5863, enacted on October 30, 2019, introduced the Concept of Environmental Protection of the Republic of Uzbekistan until 2030. This decree aims to address broader environmental concerns by implementing a comprehensive strategy for conservation and sustainability.

The ecological challenges associated with water scarcity in Uzbekistan's regions are caused by changes in river flows and irrigation practices (Green, 2001). The discharge of wastewater into rivers, especially the Amu Darya, is a major cause of water pollution (Tookey, 2007; Karthe *et al.*, 2017). While this study acknowledges these concerns, it emphasizes the importance of additional independent research to fully understand these complex issues. The widespread use of contaminated water for agriculture leads to soil salinization (Kulmatov *et al.*, 2015) and poses potential health risks, particularly in livestock irrigation (Crosa *et al.*, 2006). Neglecting water scarcity worsens the decline of the shallow water areas used for irrigation, especially when combined with ineffective water management practices (Jarsjö & Destouni, 2004). The increasing agricultural demands in the region exacerbate these problems. Declining clean water supplies and river contamination are leading private individuals and official farmers to rely more on groundwater, which causes soil salinization (Johansson *et al.*, 2009). Residents' grievances highlight the deterioration of groundwater quality. The Amu Darya watershed receives direct wastewater inflow, primarily from household toilets located near homes. This contamination of shallow groundwater is caused by the prevalence of basic latrines (Rakhmatullaev *et al.*, 2012). To overcome these challenges, a comprehensive approach is necessary, including an improved wastewater management, modern sanitation systems, and effective water resource management practices. International collaboration, knowledge exchange, and infrastructure investments play crucial roles in overcoming these challenges and ensuring equitable access to clean and safe water.

Oltinsoy district in Surkhandarya Province is a region where focused efforts are being made to address water scarcity. A decree by the Cabinet of Ministers titled *"Comprehensive Socio-Economic Development Measures of Oltinsoy District in Surkhandarya Province in 2020–2022"* has allocated 14.3 billion USD for the reconstruction and improvement of drinking water and wastewater networks in the region (Lex.Uz). International funding also supported the construction of a new pumping station, which can deliver 250–300 litres of water per second from the Hazorbog Canal. This was a crucial contribution to addressing water scarcity (Fig. 6).

The ecological challenges caused by water scarcity in Uzbekistan's regions can be attributed to changes in river flows and irrigation practices. This study recognizes these concerns and emphasizes the importance of additional independent research to fully understand these complex issues. The extensive use of contaminated water in agriculture has led to soil salinization (Kulmatov *et al.*, 2015) and potential health risks, especially in livestock irrigation (Crosa *et al.*, 2006). Neglecting water scarcity worsens the decline of shallow water areas used for irrigation, especially when combined with inadequate water management practices (Jarsjö and Destouni, 2004; Feng and Yamamoto, 2020). The increasing agricultural demands in the region exacerbate these issues. The decreasing availability of clean water and pollution in rivers has led private individuals and official farmers to depend more on groundwater, which has resulted in soil salinization (Johansson *et al.*, 2009). The grievances of residents highlight the decline in groundwater quality. The Amu Darya watershed is directly affected by wastewater inflow, mainly from household toilets located near homes. This contamination of

shallow groundwater is caused by the widespread use of basic latrines (Rakhmatullaev *et al.*, 2012). To overcome these challenges, a comprehensive approach is necessary, including an improved wastewater management, modern sanitation systems, and effective water resource management practices. International collaboration, knowledge exchange, and infrastructure investments play crucial roles in overcoming these challenges and ensuring equal access to clean and safe water.

4. MATERIALS AND METHODS

This study adopts a non-empirical approach and employs official documents and raw statistical data from reputable sources, such as the World Bank, the United Nations Development Program (UNDP) in Uzbekistan, and the Statistical Authority of the President of the Republic of Uzbekistan. The study ensures accuracy and reliability in analysing the water scarcity problem in Uzbekistan's Oltinsoy district by using credible and proven sources. The study materials include a wide range of reports, publications, and data sets on water resources, irrigation practices, environmental conditions, and socioeconomic factors in the region. These sources encompass a variety of data, such as historical records of water usage, irrigation methods, land use changes, climate patterns, and population trends. The main goal is to gather and analyse existing information un order to gain a valuable insight into the causes and effects of water scarcity in Oltinsoy district. The methodology used includes a comprehensive review and analysis of official documents and data sets. By employing data triangulation, researchers can identify patterns, trends, and correlations between factors such as water availability, agricultural practices, climatic conditions, and socioeconomic indicators. This study aims to provide a comprehensive overview of the complex interplay between various elements contributing to water scarcity in the region by making use of established data sources.

The findings of this study have significant implications for water issues at both local and global levels. Insight gained from analysing official documents and statistical data can provide valuable information about the specific challenges Oltinsoy district (the case study area) faces. The study contributes to informed decision-making processes at the local government level by identifying the causes of water scarcity. This can help in developing specific policies and strategies to enhance water management, encourage sustainable agricultural practices, and alleviate the effects of water scarcity on local communities.

The findings of this study are also relevant for global water management. The strategic use of existing data sources shows how local challenges can be tackled using readily accessible information. This study highlights the significance of collaboration among local institutions, international organizations, and government agencies in tackling water challenges. This collaboration not only enriches our understanding of local water issues but also contributes to the global conversation on sustainable water management practices.

5. CASE STUDY: WATER SCARCITY IN OLTINSOY DISTRICT

This case study examines the historical context, underlying factors, and consequences of water scarcity in the Oltinsoy district of Surkhandarya, the southernmost province of Uzbekistan (Fig. 2).

The study aims to comprehensively understand the complex challenge of water scarcity, including its origins and potential sustainable solutions. Oltinsoy district, which borders northern Afghanistan, covers an area of 570 square kilometres and has a population of around 180,200 residents as of 2021. The district, which consists of 14 urban and 9 rural (villages) settlements, is currently facing a significant environmental challenge caused by water shortage.

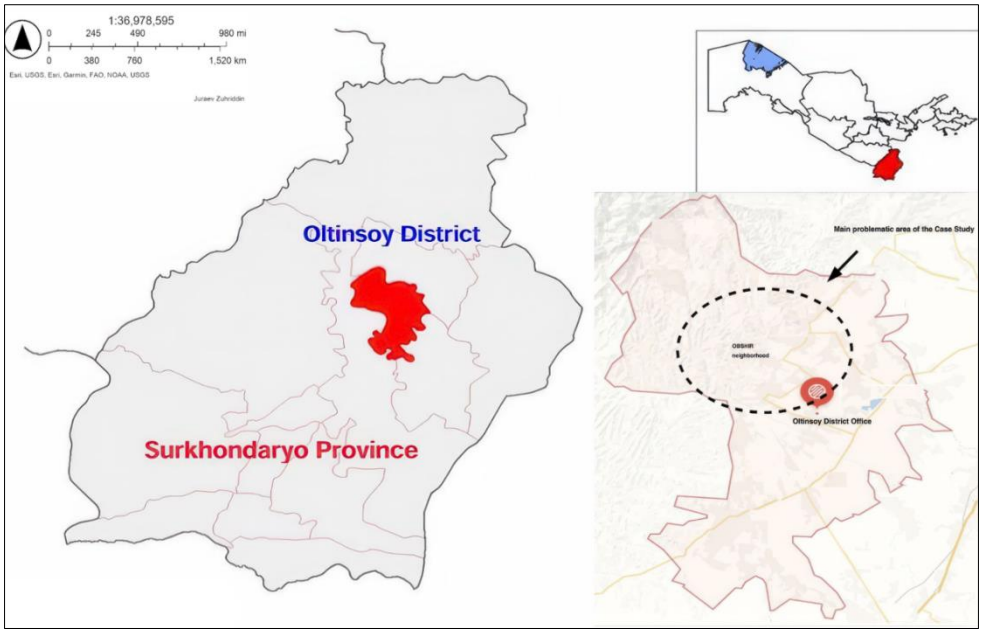

Fig. 2 – Map of the Case Study Area.
This district map also indicates the "Problematic area" in the Oltinsoy district.
Note: This Figure depicts a general view of the case study area and aids in understanding the locations depicted in other figures.

Despite ongoing efforts to improve transparency and international cooperation, obtaining comprehensive data on regional water scarcity remains challenging. The local statistical committees and government agencies have started developing comprehensive statistics on salinized soils, drainage resistance, agricultural water consumption, and their impact on the agricultural sector. The current data is obtained from social media platforms and informational-analytical documents provided by the Statistics Agency under the President of the Republic of Uzbekistan. These entities are actively improving data collection and reporting methods to better understand water scarcity dynamics in the region. To tackle the water scarcity issue in Oltinsoy district, a two-pronged approach is suggested (Fig. 2).

The modernization of the Oksuv pumping station is crucial. Upgrades and optimizations are necessary to improve pumping efficiency and capacity, ensuring a reliable and sustainable water supply to agricultural areas. Restoration efforts to clean and renovate a significant segment of the Chilmirob canal, extending to the Kyzilsu River, are crucial. Over time, sedimentation and debris accumulation have hindered the flow of water, requiring extensive cleaning and repairs. This rehabilitation project aims to improve water conveyance and ensure fair distribution in the designated regions. Implementing both strategies simultaneously provides a comprehensive solution. Modernizing the pumping station increases water pumping capacity while restoring the canal improves water conveyance and distribution. This ultimately leads to sustainable water management and provides support to the agricultural sector (Fig. 3).

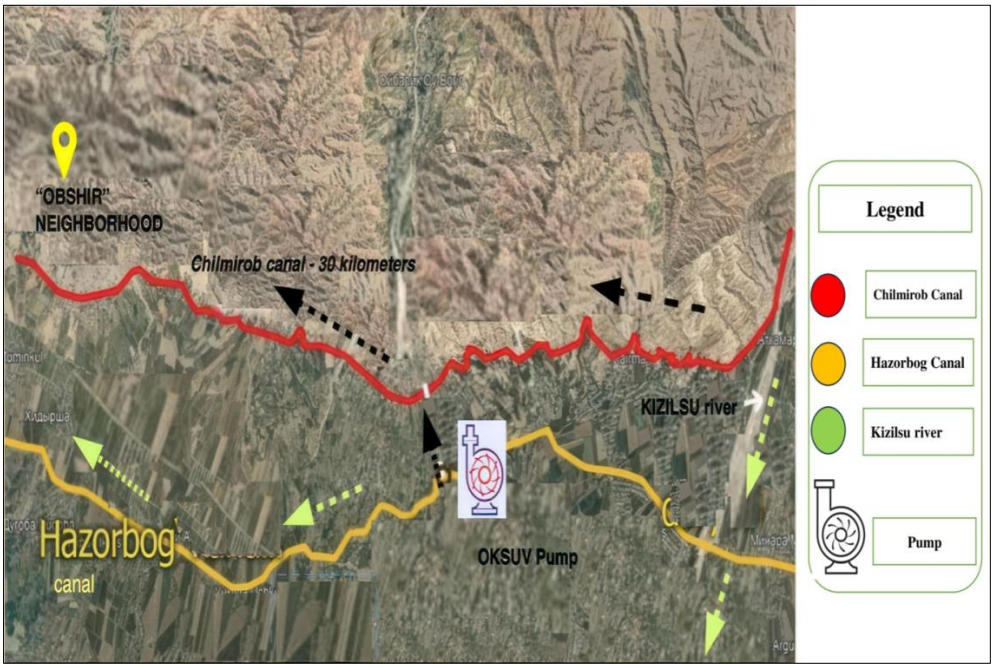

Fig. 3 – The disadvantage of controlling water.

A critical call for action is needed along a 20-kilometer stretch of the Chilmirob Canal, from the Oksuv pumping station to the diversion area on the Kyzilsu River. The deteriorating conditions of the river, including turbidity, flooding, and sediment deposition, have significantly affected the quality of life for residents in the upper Hazorbog Canal region. This issue has persisted throughout 2021. This study emphasizes the importance of recognizing the problem and finding a quick solution instead of assiging blame. The canal's water scarcity during the summer months negatively impacts crops in fields, gardens, and estates. Despite the district deputies' pleas to address the water quality problem, their concerns have been inexplicably ignored. Media narratives shed light on their difficult situation. In 2018, a commission was established to address the issue of water scarcity. However, its efforts were unsuccessful, leaving the problem of water shortage unresolved. Due to delays caused by governmental transitions, the construction of a new pumping station along the Hazorbog Canal took priority over the restoration of the Chilmirob Canal. This allocation of resources has been subject to public criticism, as investigated in this study and highlighted by online sources (KUN, 2022; Fig. 4).

District officials have extensively discussed their financial concerns regarding the construction of a new pump station. These concerns were also highlighted in online publications, indicating their importance in the analysis of the problem. After reviewing these sources, it was found that renovating the existing Oksuv pumping station is a more cost-effective option, requiring only half the investment compared to building a new facility. The proposal from a Russian industrial company to transport two pumps with a capacity of delivering 3 cubic meters of water per second to the Oksuv pumping station offers an economical solution. The decision to prioritize the water needs of the remote village of Obshir diverts attention from the crucial task of restoring the Chilmirob canal and supplying water to a larger area (Fig. 5).

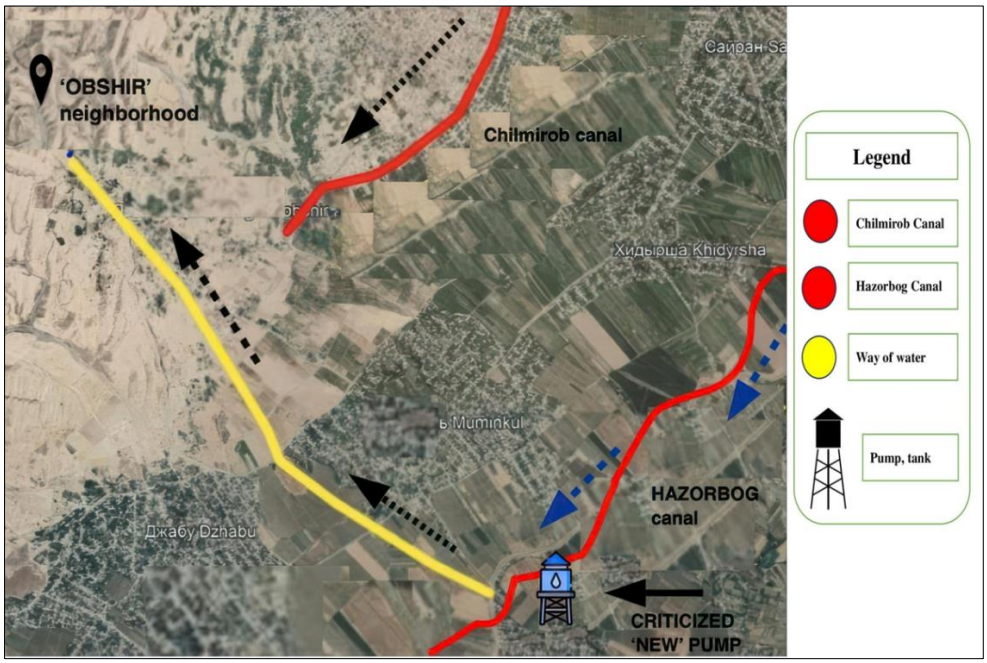

Fig. 4 – "Problematic" new pump.

Fig. 5 – Water tanks' view (Oltinsoy district).

The media has drawn attention to this location, prompting questions about the need to consider the broader context in decision-making. The presence of numerous private pumps along the Chilmirob Canal worsens water supply problems. This is evident from the activation of around 200 small private pumps, which depleted water reserves even when the Oksuv pumping station was functioning (KUN, 2021). Unauthorized construction of pumps by residents has exacerbated the problem, resulting in the destruction of houses, gardens, and trees.

Before the current water crisis, Uzbekistan had extensive vineyards and significant export-oriented grape cultivation. The lack of a comprehensive statistical database hampers the ability to accurately identify specific vineyard areas. Vineyards are already withering due to water scarcity. Some large vineyard plots have been converted into individual residences and farms. Drip irrigation systems have been installed in some fields to preserve the remaining vines, but their effectiveness is uncertain. The success of drip irrigation depends on the availability of underground water. Without sufficient irrigation, fields become completely dry. The Topalang reservoir, which provides drinking water, is facing challenges due to complaints regarding drying springs that have traditionally supplied drinking and domestic water. Online publications frequently report the widespread contamination of drinking water. The district municipality's project to build a drinking water network from the reservoir does not include provisions for supplying water to the residents of Oltinsoy district. The government's plan to provide clean drinking water to Surkhandarya province from 2022 to 2026 raises concerns with respect to unresolved water issues. The drinking water problem remains unaddressed while sewage systems are being constructed. The President has allocated 60 million USD to support the exploration of water supply from local springs (LEX, 2017).

Water scarcity has a significant impact on people's lives, causing a wide range of problems and challenges. The lack of safe drinking and irrigation water has a negative impact on health and well-being, especially for vulnerable groups like women and children, who are more susceptible to waterborne diseases (Hunter *et al.*, 2010). The impracticality of transporting water over long distances leaves residents dependent on inadequate sources, worsening issues related to water scarcity. The threat to public health and hygiene standards is significant, as over 80 percent of infectious diseases are caused by contaminated water (World Health Organization, 2022). According to experts, maintaining hygiene and a healthy lifestyle requires approximately 50 litres of water per person per day (Climate Promise, 2021).

Media narratives also emphasize the negative effects of water scarcity on living standards, specifically the rise in livestock diseases. Disputes regarding access to drinking and irrigation water have gained attention online, extending beyond Oltinsoy district. Reports of conflicts in neighbouring areas point to possible tensions within this area. Authorities and law enforcement handle these disputes, sometimes leading to violence and even deaths. Allegations have been made regarding deliberate actions to deny specific individuals access to water. Consequently, water-related disputes have become common, especially when significant agricultural investments are involved. The Ministry of Agriculture of the Republic of Uzbekistan responded by establishing a dedicated commission and providing regular monitoring updates through an official web report (2022). This study uses analytical texts from online publications to gain insight and contribute to a comprehensive understanding of the implications of water scarcity for the affected population.

6. DISCUSSION AND CONCLUSION

The water scarcity issue in Uzbekistan is of global significance and falls in line with current discussions in the integrated social and humanitarian sciences. The ecological crisis caused by poor water management and environmental factors leads to water scarcity in river basins, indicating the need for immediate ecosystem restoration and implementation of sustainable water policies. These findings contribute to ongoing discourses in ecology, urban planning, and cultural studies, and enrich the international literature on water issues and geographic studies.

This study contributes to the global discourse on sustainable development and the United Nations Sustainable Development Goals (SDGs). The integration of water resources management and ensuring equal access to clean water falls in line with SDG Goal 6 (please refer to www.onedrop.org), which focuses on making water and sanitation available and sustainably managed for everyone. This emphasizes the significance of effective water usage and the welfare of present and future generations. The geopolitical dimension of water scarcity highlights the significance of transboundary cooperation and diplomacy in promoting peace and stability. This aligns with the spatially integrated social

sciences' emphasis on resource allocation and international relations, and provides insights into ecological consequences such as biodiversity loss and desertification. These findings contribute to the field of environmental studies and emphasize the importance of ecosystem restoration and the integration of environmental factors into decision-making processes.

The urgency of addressing social inequalities and implementing inclusive socioeconomic policies is underscored by the impact of water scarcity on the most vulnerable individuals or groups within the population. This is consistent with the spatial dimensions of health and economic inequalities in the social sciences and humanities. The potential risks of internal conflict and social unrest arising from competition for limited water resources highlight the spatial dimensions of social and political dynamics. The book contributes to interdisciplinary debates in political science, sociology, and history.

This study emphasizes the importance of addressing water scarcity in Uzbekistan, specifically in Oltinsoy district. The proposed strategies offer a comprehensive framework to address the water crisis and ensure a sustainable future for water resources. Allocating sufficient state budget resources is a positive step, and optimizing their use is crucial. Several important observations, conclusions, and actionable recommendations emerge from a geographic and environmental perspective. The state budget has sufficient resources to address water scarcity, as demonstrated by the funding of specific projects. Suggested strategies to address scarcity include education, funding, legal oversight, and advanced technologies. It is essential to have a comprehensive change in consumption habits and monitor agricultural practices. It is recommended to make advances in waste processing and adopt innovative technologies, as well as implement water collection systems and collaborate with renewable energy companies.

Transparent regional statistical reporting and the use of geographic information systems (GIS) are essential for the development of effective policies. GIS can identify sources of water pollution and other environmental issues, promoting the sustainable use of resources. Scientific advancements are crucial for effective water resource management. By implementing these measures and promoting collaboration among stakeholders, Uzbekistan can overcome water scarcity challenges and secure a prosperous water future. The collaboration between government agencies, communities, and international partners is crucial in addressing this urgent environmental issue and ensuring sustainable water supplies for present and future generations. The multidimensional inquiry of this study contributes to the international literature on water issues and geographic studies, nurturing interdisciplinary dialogue within the spatially integrated social sciences and humanities.

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