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Sustainable Water Management for Agricultural Productivity and Climate Resilience: A Case Study of Uzbekistan with a Focus on Cotton Cultivation

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EXECUTIVE SUMMARY

Uzbekistan relies heavily on water resources and its agriculture sector, yet it faces rising challenges from emerging threats like water scarcity and climate change. The agricultural landscape, particularly with regards water-intensive practices such as cotton cultivation, is confronting unprecedented challenges. Arid conditions, limited adaptive capacity, low economic development, and significant dependence on agriculture make Uzbekistan very vulnerable. As the country addresses these challenges, implementing effective water management policies and sustainable agricultural practices is crucial. This involves incorporating innovative water management techniques and prioritizing water-sensitive approaches. The main objective of this policy brief is to contribute to effective and efficient water management techniques in Uzbekistan, particularly within the context of cotton cultivation, emphasizing their pivotal role in fostering sustainable and adaptable agriculture.

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Introduction

Uzbekistan faces formidable challenges in sustainable water management and agriculture. Decades of ineffective water management and unsustainable farming practices have resulted in environmental degradation, notably a 90 per cent reduction in the Aral Sea (Micklin, 2016). Excessive diversion for irrigation has contributed to water scarcity, pollution, and diminished water quality, with agricultural pollutants further contaminating rivers and the Aral Sea, leading to increased salinity and soil degradation (Turdiyeva and Lee, 2023). Furthermore, the decline of the Aral Sea poses health risks from dust storms laden with salt and pollutants, impacting respiratory health (Zhurabekova et al., 2018).

Climate change further exacerbates these challenges, with shifts in weather patterns and rising temperatures affecting water management, agriculture, and overall sustainability in Central Asia (Li et al., 2015). Moreover, Uzbekistan, along with other Central Asian countries, is highly vulnerable to the impacts of climate change (Qi and Kulmatov, 2008). This vulnerability is exacerbated by its heavy reliance on agriculture, scarcity of water resources, limited mitigation and adaptation capabilities, and the relatively underdeveloped state of its economy (Manandhar, 2018). In addition, Central Asia, including Uzbekistan, experiences a higher rate of global warming than the global average, with predictions of increased temperatures and more severe droughts (Lioubimtseva, 2015).

Effective water management in Uzbekistan and Central Asia is crucial for preserving ecological balance, supporting agriculture, and preventing water shortages. To tackle the challenges posed by water scarcity, the implementation of sustainable policies is essential. These policies aim to mitigate extensive ecological, environmental, and socio-economic impacts, fostering regional stability and easing tensions in the broader Central Asian context (Janusz-Pawletta and Gubaidullina, 2015).

In this context, enhancing climate resilience and agricultural productivity, particularly in water-intensive practices like cotton cultivation, is paramount for Uzbekistan's sustainable agricultural future. As Uzbekistan confronts these challenges, incorporating innovative water management techniques, embracing sustainable agricultural practices, and prioritizing water-sensitive approaches will be crucial in building a resilient and sustainable future for the nation.

The primary objective of this study is to provide a thorough understanding of effective and efficient water management techniques within Uzbekistan's agricultural sector, with a specific focus on cotton cultivation. The study analyses current water management practices in Uzbekistan's agriculture sector, identifies effective and climate-resilient approaches, and proposes sustainable farming practices, emphasizing water efficiency and ecological resilience.

Evaluating Agriculture Challenges in Uzbekistan

Uzbekistan stands out as the most agriculturally dependent nation in Central Asia, with agriculture contributing to 23.5 per cent of its GDP in 2022 (World Bank, 2022), employing over a quarter of the workforce (Abdurashidova and Balbaa, 2023). A significant portion, 58.3 per cent, of the total land area is designated for agriculture, and 14.5 per cent of this agricultural land is irrigated, marking the highest percentage in Central Asia (World Bank, 2021). Uzbekistan holds the position of the largest cotton producer in Central Asia, generating around 940,000 tons annually and ranking sixth globally (Wise Voter n.d.). In 2020, Uzbekistan earned 1.2 billion US dollars from its cotton exports, accounting for 9 per cent of the country's total exports and 2.7 per cent of global cotton exports (Asfaw, 2021).

However, in Uzbekistan the primary crop irrigation methods revolve around traditional practices, including basin, border, and furrow irrigation, leading to challenges such as waterlogging, salinity, and a decrease in irrigation efficiency. Waterlogging and

salinization already affect 50 per cent of irrigated areas, and irrigation efficiency barely reaches 50-60 per cent (Djumaboev et al., 2019). Therefore, the excessive use of water resources for irrigation, particularly in the cultivation of water-intensive crops like cotton since 1960, has been a major contributor to the issue of water scarcity. The inefficiency of the irrigation system has further compounded the problem, with nearly half of the abstracted water being lost during distribution (Kirilenko et al., 2008).

This overuse of water resources for irrigation, influenced by improper management of water resources and unsustainable agricultural practices, has played a pivotal role in the decline of the Aral Sea (Micklin, 2016). The Aral Sea, which originally covered 67,499 km^2 in 1960, had shrunk to 6,990 km^2 in 2014 (Table 1). Its volume decreased from 1,089 km^2 in 1960 to 48,2 km^2 in the same period, while salinity increased from 10 g/l in 1960 to around 150 g/l in 2014. The average sea depth likewise decreased from 16.1 meters in 1960 to 6.9 meters in 2014 (Micklin, 2016; Ermakhanov et al., 2012; Gaybullaev et al., 2012).

Table 1 *Changes in the main characteristics of the Aral Sea between the years 1960 and 2014*

Years	Area (km2)	Area (%)	Volume (km2)	Volume (%)	Average depth	Average salinity	Salinity (%)
1960 y.	67,499	100	1,089	100	16.1 m	10 g/l	100
2014 y.	6,990	10.4	48.2	4.4	6.9 m	>150 g/l	1500

Source: Based on data from Micklin (2016), Ermakhanov et al. (2012) and Gaybullaev et al. (2012)

Furthermore, the challenges of climate change will exacerbate the Aral Sea issue, not only impacting the ecological and environmental aspects, but also adversely affecting the agricultural sector. Figure 1 shows a detailed picture of the shrinking process of the Aral Sea, which has primarily occurred due to human factors and then been accelerated due to natural drivers, leading to significant impacts and negative consequences.

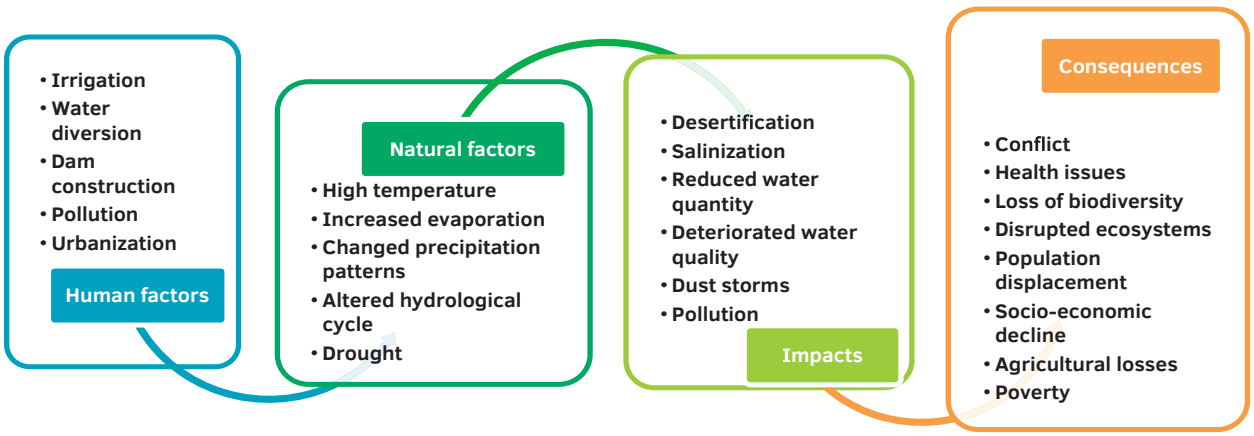

Figure 1 *The human and natural factors driving the Aral Sea shrinking process and its negative impacts and consequences*

Uzbekistan's Water Challenges

Uzbekistan holds the position of the largest consumer of agricultural water in Central Asia, boasting an irrigated area estimated at approximately 4.3 million hectares (Djumaboev et al., 2019). The country primarily relies on the Amu-Darya and Syr-Darya rivers for its water resources, with the Amu-Darya, originating mostly from Tajikistan, being the largest river in the region, and the Syr-Darya, with 75.2% of its runoff originating in the Kyrgyz Republic, the second-longest (CAWater-Info, 2023).

Table 2 *The water resources of Central Asia*

	Length	Total mean annual flow	Origins of water resources	
Amu-Darya	2540 km	79.4 km3/year	Tajikistan Iran and Afghanistan Uzbekistan	74% 13.9% 8.5%
Syr-Darya	3019 km	36.6 km3/year	Kyrgyz Republic Uzbekistan Kazakhstan Tajikistan	75.2% 15.2% 6.9% 2.7%

Source: Data from the CAWater-Info website (http://www.cawater-info.net/aral/water_e.htm)

After the Soviet Union's collapse, tensions over water usage escalated among the region's five states, hindering collaborative efforts to address water scarcity. The Soviet-era Basin Water Organizations were replaced by agreements like the ICWC, ICAS, IFAS, EC-ICAS, and SDC (Vinogradov and Langford, 2001). However, these agreements proved ineffective, with water becoming a major source of tension, leading to unsustainable policies and conflicts (Rakhmatullaev et al., 2018).

Emerging tensions between upstream and downstream countries, particularly due to hydropower dam construction, pose significant challenges. While some projects like the Kambarata-1 HPS in Kyrgyzstan show low environmental impact, others, like the Rogun Dam in Tajikistan, offer potential economic benefits (Betz et al., 2022; Jalilov et al., 2013). While large hydropower dams can address energy needs, they raise downstream concerns and may neglect downstream needs (Eshchanov et al., 2011). Therefore, cooperative water release policies and sustainable management strategies are essential to address water shortages. Utilizing existing infrastructure and enhancing regional cooperation are crucial for securing future water supplies, especially given the region's heavy reliance on agriculture (Rakhmatullaev et al., 2018). Enhanced cooperation is necessary to optimize efficiency, alleviate tensions, and ensure environmental stability and the well-being of all nations (Allouche, 2007).

Furthermore, in Uzbekistan, and throughout Central Asia, there is a noticeable shift in climate patterns marked by rising temperatures, alterations in weather conditions, changes in the hydrological cycle, alterations in evapotranspiration, shifting precipitation patterns, and an increased frequency of extreme weather events (Reyer et al., 2017). Situated in one of the world's most arid regions, Central Asia, including Uzbekistan, is already experiencing a higher rate of warming than the global average, with experts predicting more severe droughts in the future, leading to increased aridity and desertification throughout the region (Lioubimtseva, 2015). These climate-induced changes have substantial implications for water availability, ecosystem dynamics, the agricultural sector, and various socio-economic aspects of Uzbekistan and the broader Central Asian region.

To address these challenges effectively, Uzbekistan must bolster its resilience to climate change and enhance agricultural productivity, especially in water-intensive sectors like cotton cultivation. Navigating these issues requires the implementation of cutting-edge water management techniques, the adoption of sustainable agricultural practices, and a prioritization of approaches that are sensitive to water concerns. This comprehensive strategy aims to secure a sustainable and adaptable future for Uzbekistan amid the evolving climate and agricultural conditions.

Advancing Water and Agricultural Management in Uzbekistan

In Uzbekistan, using drip irrigation with a specific watering schedule significantly boosts efficiency, saving 71 per cent of water and increasing cotton yields by 14 per cent. This approach is recommended for the irrigated areas in Uzbekistan. However, further studies exploring cotton varieties for better results are suggested (Ibragimov et al., 2007).

A study in Uzbekistan emphasizes the benefits of conservation agriculture practices, specifically crop rotation with legumes like cotton/wheat/soybean under no-till conditions. This has been shown to improves soil quality by increasing important nutrients like nitrogen and phosphorus while making the soil less dense. This kind of farming can help improve cotton production and is a positive step for sustainable agriculture in Uzbekistan (Khaitov and Allanov, 2014).

According to Rakhimov et al. (2020), the essential measures to improve water efficiency in agriculture involve the upgrading of water distribution infrastructure, improvement of drainage networks and pumping stations, and the promotion of prudent water usage to reduce evaporation and filtration.

Policy Recommendations

The study anticipates achieving improved water efficiency, climate resilience, and sustainability in Uzbekistan's agricultural sector, with a particular emphasis on cotton cultivation. Enhancing water management and promoting sustainable agricultural practices in Uzbekistan involves implementing strategic measures. Integrating these measures into a comprehensive national agricultural policy is beneficial for addressing water management challenges and promoting sustainable agriculture.

- Promote Drip Irrigation Systems: Channel investments and actively promoting the adoption of advanced drip irrigation systems tailored for cotton fields. This targeted approach optimizes water use efficiency by delivering water directly to the cotton plants' roots, reducing wastage and enhancing overall crop yields. It also contributes to resource conservation and environmental sustainability.

- Encourage Crop Rotation Strategies: Implement systematic crop rotation practices, specifically designed for cotton cultivation, to enhance soil fertility and minimize the risk of pests and diseases. This strategic move not only ensures sustainable cotton farming practices but also fosters soil health and biodiversity, creating a more resilient agricultural ecosystem.

- Introduce Precision Irrigation: Implement precision irrigation methods customized for cotton cultivation to optimize water use. This tailored approach addresses the unique water requirements of cotton plants, ensuring efficient water utilization without compromising crop quality. This initiative aligns with broader goals of resource efficiency and environmentally sustainable cotton production.

- Enhance Water Infrastructure: Prioritize the maintenance and improvement of water infrastructure specifically tailored to meet the needs of cotton fields. This includes upgrading drainage systems, pumps, and re-

lated components. By focusing on the specific requirements of cotton cultivation, this strategic approach aims to minimize water losses and ensure efficient water delivery to cotton crops. Ultimately, it contributes to the overall modernization of the agricultural water management system.

- Promote Climate-Resilient and Water-Efficient Agriculture: Encourage diversification within agriculture by exploring variations in crop types, including those with higher climate resilience and lower water consumption. This approach considers crops beyond cotton and aims to enhance overall sustainability in Uzbekistan by introducing less water-intensive alternatives. It aligns with climate-smart agriculture principles for long-term resilience.

Additionally, the study underscores the need for a unified and integrated approach, emphasizing collaborative efforts involving various stakeholders such as local communities and government entities through regional cooperation and international collaboration. A concerted focus on cross-border collaboration, knowledge-sharing, and technology transfer among the Central Asian countries is crucial for optimizing water resource utilization and ensuring sustainable agricultural practices.

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