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Research Article

A Blind Spot in Water Policy. Is Uzbekistan a Net Water Exporter or Importer?

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Highlights:

- Uzbekistan can optimize its water resource management by focusing on exporting products with lower water consumption in production (e.g., pharmaceuticals, processed foods, electronics, machinery et al.) while importing water-intensive products (e.g., cotton, beef, nuts, rice, wheat, almonds, sugar, textiles et al.).
- An estimated 8,46 trillion liters of virtual water have been exported from Uzbekistan through the trade of gold.
- Recent trade policy indicates positive developments in managing virtual water; however, it remains unclear whether these objectives were deliberately pursued or arose as unintended benefits.
- Although the virtual water trade balance appears positive, with exports surpassing imports by approximately 2,08 trillion liters, this outcome is misleading. As a water-stressed nation, Uzbekistan's role as a net virtual water exporter poses critical challenges for sustainable water management and raises concerns about long-term water security.

Abbreviations

- **SDG** - Sustainable Development Goal
- **VW** - Virtual Water
- **WF** - Water Footprint
- **JSC “NMMC”** - Joint Stock Company “Navoi Mining and Metallurgy Combinat”
- **N/A** - Not Available



I. Introduction

The famous quote, usually attributed to Benjamin Franklin, “When the well is dry, we know the worth of water” has conventionally been used as a metaphor to imply that the true value of a resource is only recognized once it becomes scarce. However, in the context of escalating water shortages and conflicts [1], the literal meaning of this quotation has gained increasing relevance. It underscores the urgent need for the rational use, sustainable management, and equitable distribution of water resources. Uzbekistan’s geographical location, as a downstream and double-landlocked country surrounded by vast deserts and distant from major water bodies presents a unique set of environmental and economic challenges. The country is highly dependent on water from upstream neighbors with approximately 80% of its water resources originating from Tajikistan and Kyrgyzstan, while only 20% is generated domestically [2]. This dependence on shared transboundary waters renders Uzbekistan vulnerable to fluctuations in water availability and increases the potential for disputes with neighboring countries. As Uzbekistan’s first president, Islam Karimov, stated in 2012, tensions over water could escalate to the point of conflict, possibly even war [3]. These challenges are further exacerbated by the region’s high evaporation rates and low precipitation, emphasizing the critical need for water diplomacy, especially in light of increasing climate variability and growing demands for shared water resources. Currently, Uzbekistan is placed 34th out of 164 countries in the World Resources Institute’s water stress index, with a score of 3.63 out of 5-point, highlighting the severity of its water challenges [4]. Water is a critical resource that

[1] "На грани воды. Что стоит за конфликтом Киргизии и Таджикистана," TASS, April 30, 2021. <https://tass.ru/mezhdunarodnaya-panorama/11287787>. Also: "Конфликт из-за воды: Бишкек заявил об атаке Таджикистана на пять погранзастав," BBC Russian, April 29, 2021. <https://www.bbc.com/russian/news-56930390>

[2] Ministry of Water Resources of the Republic of Uzbekistan. "Press Release." Gov.uz, August 25, 2023. <https://gov.uz/oz/suvchi/news/view/12398>.

[3] Daryo. "Противостояние Каримова и Рахмона: история конфликта." Daryo, March 4, 2024. <https://daryo.uz/ru/2024/03/04/protivostoanie-karimova-i-rahmona-istoria-konflikta>.

[4] "Aqueduct Country Rankings," World Resources Institute, accessed September 23, 2024, <https://www.wri.org/applications/aqueduct/country-rankings/>.



underpins sustainable development, playing a vital role in both environmental sustainability and economic growth. **Sustainable Development Goal (SDG) 6 (Clean Water and Sanitation)** emphasizes of the critical need for ensuring the availability and sustainable management of water for all, particularly in water-scarce regions like Uzbekistan. It calls for addressing water scarcity, improving water quality, and enhancing water-use efficiency. Additionally, **SDG 8 (Decent Work and Economic Growth)** focuses on promoting inclusive and sustainable economic growth, employment, and decent work for all. Efficient water use is directly linked to key sectors such as agriculture and industry, which are vital to Uzbekistan's economy. In response to these challenges, Uzbekistan has initiated several projects aimed at improving water management and reducing water losses, which include:

1. **3-year canal lining program (canal concreting)** aiming to concrete 5,000 kilometers of irrigation networks, including 1,500 km of main and inter-farm networks, and 3,500 km of on-farm networks and at least 2000 km in 2025, expecting to reduce water losses by 30%, according to international expert analysis [5]. *(For instance, in the republic, 10,540 km of internal irrigation networks were concreted at the expense of clusters and farms.)* [6]

2. **Devices for efficient water resource management** have been installed:

- *The “Smart Water” system*, which refers to an automated water measurement and monitoring technology designed for the efficient management of water resources, particularly in open-channel systems, has been installed at 11,446 water management facilities [7].

[5] Gazeta.uz. "Глобальные проблемы водоснабжения в Узбекистане." Gazeta.uz, November 30, 2023. <https://www.gazeta.uz/ru/2023/11/30/water/>.

[6] Senate of Uzbekistan. "Plenary session of the Senate of Oliy Majlis of the Republic of Uzbekistan". Senate.uz, December 10, 2023. <https://senat.uz/ru/plenary-sessions/post-2533>. Also: Правда Востока. "Не теряющий актуальности вопрос." № 94 (30403), May 16, 2024. <https://yuz.uz/file/newspaper/7e715dc5ac34245707df741b9639e148.pdf>

[7] Senate of Uzbekistan. "Plenary session of the Senate of Oliy Majlis of the Republic of Uzbekistan". Senate.uz, December 10, 2023. <https://senat.uz/ru/plenary-sessions/post-2533>. Information about the system: «SMART WATER» avtomatlashtirilgan suv o'lchash va nazorat qilish uskunasi joyiga chiqib o'rganildi. Uzeltech, 2024. <https://uzeltech.uz/uz/smart-water/#:-:text=Suv%20xo'jaligi%20vazirligi%20hamda,asosida%20xorijdan%20olib%20kelinar%20edi>.



- “Diver” devices have been installed at 6,953 facilities [8].
- Online monitoring devices have been implemented at 1,709 pumping stations [9].
- A total of 67 major water management facilities have been fully automated [10].

(For instance, as a result of application of digital technologies, introduction of water-saving technologies on the area of more than 400 thousand hectares, implementation of necessary irrigation and land reclamation measures, more than 2 billion cubic meters of water were saved in the first half of the ongoing year.) [11]

3. The “suvkredit.uz” platform has been launched. The “suvkredit.uz” platform is an initiative designed to provide financial support to agricultural producers for implementing water-saving irrigation technologies. Through this platform, agricultural producers can obtain loans for a period of 5 years, including a 2-year grace period, at an annual interest rate of 14% [12].

(For instance: Till now, preferential credit funds amounting to more than 2 trillion sums have been allocated for introduction of drip, rain and discrete irrigation on the area of 134.3 thousand hectares.) [13]

4. The School of Water Resource Management namely “Suvchilar Maktabi” was established [14]. “Suvchilar maktabi” (Water Users' School) is a social project that offers free education for representatives of agricultural sector. The main goal of establishing the school is to improve water-use practices among users, particularly farmers, and increase crop yields by enhancing their knowledge and skills in applying innovative technologies. The project aims to develop educational programs based on international experience, create video tutorials on water-saving technologies, and offer online courses

[8] Ibid.

[9] Ibid.

[10] Ibid

[11] Ibid.

[12] O‘zbekiston Respublikasi Prezidentining Qarori. "Quyida bo‘g‘inda suv resurslarini boshqarish tizimini takomillashtirish hamda suv resurslaridan foydalanish samaradorligini oshirish chora-tadbirlari to‘g‘risida". Lex.uz, 2024. <https://lex.uz/docs/-6734972>.

[13] Senate of Uzbekistan. “Plenary session of the Senate of Oliy Majlis of the Republic of Uzbekistan”. Senate.uz, December 10, 2023. <https://senat.uz/ru/plenary-sessions/post-2533>.

[14] Gazeta.uz. “По инициативе президента стартовала «Сувчилар мактаби».” June 3, 2023. <https://www.gazeta.uz/ru/2023/06/03/agrobank/>.



through a dedicated platform [15].

For reference: Only in 2 sessions, more than 120,000 local farmers had an opportunity to take guidance from both local and international experts [16].

As Uzbekistan continues to explore innovative approaches and technologies for more sustainable water management, understanding the concept of virtual *water flow* becomes increasingly important. Virtual water refers to the volume of water embedded in the goods a country imports and exports. Thus, this paper aims to examine how Uzbekistan's foreign trade dynamics impact the country's *virtual water balance* as well as overall sustainability, offering policy recommendations strategic trade adjustments to enhance water management practices and ensure long-term water security.

[15] "Agrobankning "Suvchilar maktabi" loyihasi muvaffaqiyatli amalga oshirilmoqda." Kun.uz. October 6, 2023. <https://kun.uz/news/2023/10/06/agrobankning-suvchilar-maktabi-loyihasi-muvaffaqiyatli-amalga-osHIRILMOQDA?q=%2Fuz%2Fnews%2F2023%2F10%2F06%2Fagrobankning-suvchilar-maktabi-loyihasi-muvaffaqiyatli-amalga-osHIRILMOQDA>

[16] Senate of Uzbekistan. "Plenary session of the Senate of Oliy Majlis of the Republic of Uzbekistan". Senate.uz, December 10, 2023. <https://senat.uz/ru/plenary-sessions/post-2533>.



II. Conceptual background

The majority of commodities produced today involve significant water use throughout their production processes. The water consumed or polluted during the entire production cycle of a product is referred to as the **virtual water (VW) content**. This concept, coined by John Anthony Allan, aka Tony Allan, a British geographer and water resource expert, in the early 1990s, was intended to highlight the “hidden water” embedded in global trade. Alan’s work was later expanded in his publications, “**The Middle East Water Question: Hydropolitics and the Global Economy**” (2001) and “**Virtual Water: Tackling the Threat to Our Planet's Most Precious Resource**” (2008), earning him the Stockholm Water Prize in 2008. This concept underscores the indirect use of water resources tied to the production and trade of goods, making it a critical tool for understanding water scarcity and resource management.

For instance, Uzbekistan’s cotton production is illustrative of the virtual water concept. According to the 2022 Blue Peace Central Asia report on “Water Footprint Analyses of Central Asia”, producing 1 kilogram of cotton in Uzbekistan requires about 10,000 liters (10 cubic meters) of water [17]. This figure provides a tangible way to conceptualize virtual water, equating to roughly 2,700 liters for a single cotton T-shirt. This amount is equivalent to filling a standard swimming pool with dimensions of 2 meters in depth, 5 meters in length, and 3 meters in width. As such, when one purchases cotton-based clothing, they are, in effect, “consuming” the water resources from the region where the cotton was cultivated. This process exemplifies the idea of virtual water flow, where the consumption of goods can indirectly transfer water resources across borders, contributing to the global exchange of water through trade. The concept of virtual water is closely linked to “exogenous water”, which refers to water resources used in other countries to produce goods

[17] Blue Peace Central Asia. "Water Footprint Analysis in Central Asia." Blue Peace Central Asia, December 2022. https://bluepeace-centralasia.ch/knowledge/publications/BluePeace-Water_Footprint_Analysis_en.pdf.



imported by a particular region [18]. This dynamic forms the basis of *virtual-water flows* between geographically distinct areas and emphasizes the interconnectedness of water resource management on a global scale [19]. *Virtual-water imports* denote the volume of water embedded in the goods or services into brought into a region, supplementing local water availability [20].

Conversely, *virtual-water exports* account for the water consumed in producing goods or services for export, reflecting the externalization of water resource pressures [21]. The net balance of a country's virtual water trade - calculated by subtracting virtual-water exports from imports - can indicate the extent of its dependence on or contribution to global water resource distribution [22].

To further quantify water use, Arjen Y. Hoekstra, a Dutch researcher and professor at the University of Twente (Netherlands), coined the concept of the **water footprint (WF)** in 2002 [23]. His framework categorizes the water footprint into three distinct types: blue, green and grey. **The Blue Water Footprint (Blue WF)** refers to the volume of surface water (e.g., rivers, lakes) and groundwater (e.g., rainfall, aquifers) consumed or evaporated during the production of goods and services. It encompasses water used for irrigation, industrial processes, and municipal water supply. Understanding the blue water footprint is crucial for assessing the impact of water withdrawals on local water availability. In Uzbekistan, the primary sources of blue water are the Amu Darya and Syr Darya rivers, which are replenished by snowmelt from surrounding mountain ranges. Water is

[18] Hoekstra, A.Y., editor. Virtual Water Trade: Proceedings of the International Expert Meeting on Virtual Water Trade. Value of Water Research Report Series No. 12. February 2003. https://www.worldwatercouncil.org/fileadmin/wwc/Programs/Virtual_Water/VirtualWater_Proceedings_IH_E.pdf

[19] Water Footprint Network, "Glossary: Key Terms Related to Water Footprint," Water Footprint Network, 2023, <https://www.waterfootprint.org/water-footprint-2/glossary/>.

[20] Ibid.

[21] Ibid.

[22] Ibid.

[23] Hoekstra, A.Y., editor. Virtual Water Trade: Proceedings of the International Expert Meeting on Virtual Water Trade. Value of Water Research Report Series No. 12. February 2003. https://www.worldwatercouncil.org/fileadmin/wwc/Programs/Virtual_Water/VirtualWater_Proceedings_IH_E.pdf



also diverted through an extensive networks of canals and pipelines, primarily for agriculture purposes, including the irrigation of cotton, fruit, and vegetable crops, as well as for domestic consumption. **The Green Water Footprint (Green WF)** represents the volume of rainwater absorbed by soil and utilized by plants, playing a critical role in rain-fed agriculture where crops rely primarily on precipitation rather than irrigation. This measure is particularly significant for regions with high rainfall and agricultural dependence on national precipitation. However, Uzbekistan's arid climate characterized by limited rainfall and prolonged sunny periods, makes it impractical example for illustrating green water concept. In contrast, regions within the Coffee Belt, where agriculture is heavily dependent on rainfall, provide a more appropriate case study. In these regions, green water, which refers to the soil moisture available for plant uptake from natural precipitation, plays a crucial role in agriculture, making them ideal for showcasing this concept [24]. For example, global estimates indicate that the production of 8 fluid ounces (about 236.59 milliliters) of coffee requires 66 gallons (250 liters) of water, of which 96% comes from green water, with only 1% from blue water and 3% from grey water [25]. **The Grey Water Footprint (Grey WF)** measures the volume of fresh water required to dilute pollutants generated during production processes to meet water quality standards. This component reflects the environmental impact of pollutants and quantifies the additional water needed to ensure that pollution does not exceed permissible levels in water bodies. The grey WF is essential for assessing the water quality challenges posed by industrial and agricultural activities. For instance, household washing machines contribute significantly to the grey WF by discharging detergents, fabric softeners, and microplastics into wastewater systems. These pollutants, if not adequately treated, can degrade nearby water bodies, necessitating large volumes of clean water to dilute and mitigate their

[24] Crimildo T. Cassamo, David Draper, Maria M. Romeiras, Isabel Marques, Rogério Chiulele, Marisa Rodrigues, Marc Stalmans, Fábio L. Partelli, Ana Ribeiro-Barros, José C. Ramalho, "Impact of climate changes in the suitable areas for *Coffea arabica* L. production in Mozambique: Agroforestry as an alternative management system to strengthen crop sustainability," *Agriculture, Ecosystems & Environment*, Volume 346, 2023, 108341, ISSN 0167-8809, <https://doi.org/10.1016/j.agee.2022.108341>.

[25] <https://watercalculator.org/water-footprint-of-food-guide/>



impact. To further illustrate the types of water footprint, it is important to consider the main crops cultivated in Uzbekistan—namely cotton, wheat, and rice [26]. Interestingly, these crops collectively contribute 54% of the global unsustainable blue WF associated with agricultural production, positioning Uzbekistan as the second highest contributor to unsustainable blue WF after Qatar [27]. Focusing on cotton as a case study, global cotton consumption between 1997 and 2001 required an estimated 256 billion cubic meters (256 trillion liters) of water annually [28]. Of this, approximately 42% was blue water, 39% was green water, and 19% was grey water [29]. Understanding the distinction between the concepts of “virtual water” and “water footprint” is essential for analyzing water use. Virtual water refers to the water embedded in the production and trade of goods, while the water footprint accounts for all freshwater use associated with both production and consumption. Additionally, the water footprint is disaggregated into three components—green, blue, and grey—whereas virtual water offers a singular measure of the water used for a specific product.

Understanding various types and quantities of water used across different stages of a product’s lifecycle provides critical insights into the sustainability of production processes. Uzbekistan can leverage these calculations to strategically manage its water resources. By prioritizing the export of products that are less water-intensive (e.g., pharmaceuticals, processed foods, electronics, machinery et al.) and importing water-intensive goods (e.g., cotton, beef, nuts, rice, wheat, almonds, sugar, textiles et al.), the country can alleviate pressure on its scarce water supplies while maintaining economic stability.

[26] Food and Agriculture Organization (FAO). "Organic Agriculture in Uzbekistan: Status, Practices and Prospects," by Aziz Nurbekov, Uygun Aksoy, Hafiz Muminjanov, and Alisher Shukurov. Open Knowledge FAO. <https://openknowledge.fao.org/server/api/core/bitstreams/531fae12-2984-4825-8ceb-fcb707decf8e/content>

[27] Mekonnen, Mesfin M., and Arjen Y. Hoekstra. "Sustainability of the Blue Water Footprint of Crops." *Advances in Water Resources*, vol. 143, 2020, 103679. ISSN 0309-1708. <https://doi.org/10.1016/j.advwatres.2020.103679>.

[28] Chapagain, A.K., A.Y. Hoekstra, H.H.G. Savenije, and R. Gautam. "The Water Footprint of Cotton Consumption: An Assessment of the Impact of Worldwide Consumption of Cotton Products on the Water Resources in the Cotton Producing Countries." *Ecological Economics*, vol. 60, no. 1, 2006, pp. 186-203. ISSN 0921-8009. <https://doi.org/10.1016/j.ecolecon.2005.11.027>.

[29] *Ibid.*



Importing water-intensive products helps to balance the national water footprint by mitigating the strain on domestic water resources that would otherwise result from their production.

Shifting toward high-value, low-water-use exports also enhances economic resilience, as these goods often command higher prices and margins in global markets. Focusing on high-value exports not only increases revenue but also reduces Uzbekistan's vulnerability to fluctuations in commodity prices. Additionally, this strategy promotes technological advancement and skills development, fostering long-term economic growth and stability. High-value industries, being less reliant on water, are more resilient to water scarcity, aligning with sustainable water management objectives while strengthening Uzbekistan's overall economic resilience.

Given the impracticality of physically transferring water between water-abundant and water-scarce regions due to geographic, political, and financial challenges, the trade of water-intensive goods – commonly referred to as *virtual water trade* – presents a viable alternative. This study aims to assess whether Uzbekistan is a net importer or exporter of virtual water. The analysis will focus on aggregate amounts of virtual water, without delving into the specific components of blue, green, and grey water. By adopting this streamlined approach, the research seeks to provide a clearer understanding of Uzbekistan's role in the global virtual water trade, while minimizing unnecessary complexities. This perspective will offer valuable insights into the country's water resource management strategy and its implications for sustainable development.



III. Is Uzbekistan a net virtual water importer or exporter?

To assess whether Uzbekistan is a net importer or exporter of virtual water, the concept of virtual water is applied to estimate the country's virtual water balance, even at a preliminary level. While this study does not provide detailed calculations of blue, green, and grey water, it offers a generalized assessment of virtual water trade. This approach enables insights into how Uzbekistan's trade activities impact its water resources, shedding light on the effectiveness of its water management strategies through imports and exports. Economically, Uzbekistan has historically run a trade deficit, where the value of its imports exceeds that of its exports. According to the State Agency of Uzbekistan, the country's foreign trade volume in 2023 amounted to \$62.56 billion in 2023, with exports totaling \$24.42 billion and imports reaching \$38.14 billion [30]. Yet, to assess the virtual water trade balance, the study focuses on estimating the virtual water content of key exported and imported products, particularly from water-intensive sectors, for the year 2023.

EXPORT

Mining industry leads Uzbekistan's exports, with gold representing roughly 33% of total exports in 2023, amounting to about 25 metric tons (25,000 kg) [31]. Due to the lack of precise data regarding the virtual water content of gold per kilogram, this analysis relies on international estimates. Drawing on the research conducted in Suárez, Cauca, Colombia, the average virtual water content for 1 kg of gold is approximately 338,555,160 liters [32]. Based on this data, the virtual water required for Uzbekistan's gold production can be calculated as follows:

[30] Agency of Statistics of Uzbekistan. "Внешнеторговый оборот Республики Узбекистан (за январь-декабрь 2023 г)." January 20, 2024. <https://stat.uz/ru/press-tsentr/novosti-goskomstata/4.9770-0-zbekiston-respublikasi-tashqi-savdo-aylanmasi-2023-yil-yanvar-dekabr-5>.

[31] Ibid.

[32] Alvarez-Pugliese, Christian E., Fiderman Machuca-Martínez, and Mario Pérez-Rincón. "Water Footprint in Gold Extraction: A Case-Study in Suárez, Cauca, Colombia." *Heliyon*, vol. 7, no. 9, 2021, e07949. ISSN 2405-8440. <https://doi.org/10.1016/j.heliyon.2021.e07949>.



Total Water Footprint = Average Water Footprint per kg × Total Weight

Given:

- Average water footprint per kg of gold = 338,555,160 liters
- Total weight = 25,000 kg

Total Water Footprint = 338, 555, 160 liters/kg × 25, 000 kg

Total Water Footprint = 8, 463, 879, 000, 000 liters

Thus, it is estimated that approximately 8,463 trillion liters of virtual water were exported from Uzbekistan through the trade of gold in 2023. Yet, these figures should be interpreted with caution due to data limitations and potential variations in the water required for gold production. Factors such as extraction methods (flotation, gravity and et al.) and ore composition can significantly influence water usage.

Recommendations are made for the Central Scientific Research Laboratory of Joint Stock Company “Navoi Mining and Metallurgical Company” (JSC NMMC) and other local gold producing companies to conduct detailed calculations to refine the data, thereby enabling more accurate and precise virtual water assessments in future research.

Next in the list of major export products is industrial goods sector, which accounts for 16.6% of total exports. However, due to the lack of data on the volume of these exports, it is currently impossible to calculate even an approximate amount of virtual water traded. *It is recommended that the Uzbekistan Statistics Agency disclose not only financial indicators but also the physical volume of each product traded. This would enable more accurate calculations of virtual water trade and enhance the precision of related research.* Food products, which are third in the list and represent 7.3% of Uzbekistan’s total export, are particularly critical to virtual water analysis. According to the World Bank, around 70 percent of global freshwater resources are used in



agriculture, with this figure rising to 90% in low-income countries [33]. However, due to insufficient data on individual food products, calculating the total virtual water content remains challenging.

Yet, horticultural products, which constitute 4.8% of total exports, have been analyzed and listed in the accompanying table to provide more precise insights into virtual water trade within the food sector:

Product name (descending order of volume)	Quantity	Estimated virtual water content (in liters)
Onion	300,000,000 kg	≈ 79,380,000,000
Grapes / dried grapes	183,400,000 kg	≈ 109,440,040,000
Mung bean	154,600,000 kg	≈ 239,630,000,000
Melons / water melons	148,100,000 kg	33,935,300,000
Cabbage	97,200,000 kg	25,727,200,000
Peach	87,200,000	78,557,600,000
Apricot	63,000,000	82,884,300,000
Tomatoes	57,500,000	11,743,500,000
Cherries	45,000,000	72,297,000,000
Prunes (dried plums)	36,000,000	224,946,000,000

Sources:

1. UzStat. News, December 5, 2023. <https://stat.uz/ru/press-tsentr/novosti-goskomstata/4,9770-o-zbekiston-respublikasi-tashqi-savdo-aylanmasi-2023-yil-yanvar-dekabr-5>
2. Water Calculator. Water Footprint of Food Guide - <https://watercalculator.org/water-footprint-of-food-guide/>
3. Abad-González, J., Nadi, F., & Pérez-Neira, D. (2024). Energy-water-food security nexus in mung bean production in Iran: An LCA approach. *Ecological Indicators*, 158, 111442. <https://doi.org/10.1016/j.ecolind.2023.111442>

In 2023, Uzbekistan's textile industry generated export revenues amounting to USD \$3,05 billion. Yarn and final textile products each contributed significantly to this figure, representing 41.1% and 41.0% of the export value, respectively [34]. Regrettably, there is no complete

[33] World Bank. "Strains on Freshwater Resources: Impact on Food Production and Water Consumption." <https://blogs.worldbank.org/en/opendata/strains-freshwater-resources-impact-food-production-water-consumption>.

[34] Agency of Statistics of Uzbekistan. "Внешнеторговый оборот Республики Узбекистан (за январь-декабрь 2023 г)." January 20, 2024. <https://stat.uz/ru/press-tsentr/novosti-goskomstata/4,9770-o-zbekiston-respublikasi-tashqi-savdo-aylanmasi-2023-yil-yanvar-dekabr-5>.



data available for the total volume of yarn exported in 2023; however, for the first four months, 164,600 tons of yarn were exported, valued at \$424.5 million [35]. By extrapolating this figure to represent the entire year, it can be estimated that an annual export volume is approximately 493,800 tons. Given that specific data on the types of yarn exported is unavailable, cotton yarn will be used as a proxy, as it is a significant component of Uzbekistan's yarn exports. The average virtual water content for cotton yarn in Uzbekistan is estimated at 11,343 liters per kilogram [36]. Therefore, the total virtual water content of cotton yarn exports is approximately 5,6 trillion liters. *Another limitation of this study is the lack of data on the types and exact volumes of yarn and finished textile products exported. Different types of yarn and textiles require varying amounts of water during production, and without specific information on these, virtual water content calculations remain imprecise.*

In summary, the approximate total virtual water content of the main exported products amounts to approximately **15,02 trillion liters**.

IMPORT

The main imported product into Uzbekistan in 2023 was automobiles, accounting for 39,2% of the total import value [37]. Uzbekistan imported 73,204 during the year [38]. Given the average virtual water content of 67,500 liters per car [39], this translates into a total virtual water import of approximately 4,93 billion liters.

[35] Telegram Channel of the State Committee on Statistics. "Ўзбекистон 34 та давлатга калава ип экспорт қилган." Telegram, December 2023. https://t.me/statistika_rasmiy/3663.

[36] Chapagain, A.K., Hoekstra, A.Y., Savenije, H.H.G., and Gautam, R. "The Water Footprint of Cotton Consumption: An Assessment of the Impact of Worldwide Consumption of Cotton Products on the Water Resources in the Cotton Producing Countries." *Ecological Economics*, vol. 60, no. 1, 2006, pp. 186–203. ISSN 0921-8009. <https://doi.org/10.1016/j.ecolecon.2005.11.027>.

[37] Agency of Statistics of Uzbekistan. "Внешнеторговый оборот Республики Узбекистан (за январь-декабрь 2023 г)." January 20, 2024. <https://stat.uz/ru/press-tsentr/novosti-goskomstata/49770-o-zbekiston-respublikasi-tashqi-savdo-aylanmasi-2023-yil-yanvar-dekabr-5>.

[38] *Gazeta.uz*. "Импорт автомобилей в Узбекистан вырос в 2,4 раза, из Китая — в 5,2 раза." February 6, 2024. <https://www.gazeta.uz/ru/2024/02/06/auto-import/>.

[39] "The Hidden Water in Everyday Products: In Footprints, Water in the Things You Buy." Published July 2, 2017; Last updated October 20, 2022. <https://watercalculator.org/footprint/the-hidden-water-in-everyday-products/>.



Regarding food imports, wheat is the predominant item. Kazakhstan, as the principal exporter, supplied nearly 4,5million tons of wheat to Uzbekistan [40]. Given the virtual water content of 1,827 m³ per ton, Uzbekistan indirectly imported approximately 8,22 trillion liters of water through wheat imports from Kazakhstan [41]. For detailed insights, additional products are outlined in the table below:

Product name (descending order of volume)	Quantity	Source	Estimated virtual water content (in liters)	Source
Sugar	762,000,000 kg	https://t.me/uzagroministry/20509	≈1,360,000,000,000	https://tools.waterfootprint.org/product-gallery/
Sunflower oil	200,000,000 kg	https://www.agro.uz/wp-content/uploads/2024/03/agriculture-annual-report-2023.pdf	≈1,360,000,000,000	https://www.waterfootprint.org/resources/Mekonnen-Hoekstra-2011-WaterFootprintCrops.pdf
Banana	133,500,000 kg	https://t.me/statistika_rasmiy/4355	≈107,994,000,000	
Rice	≈ 53,500,000 kg	https://uza.uz/uz/posts/hitoydalan-suniy-guruch-import-qilinmagan-bozhxona-qomitasi_553717	≈ 130,247,500,000	https://watercalculator.org/water-footprint-of-food-guide/
Beef	49,300,000 kg	https://www.agro.uz/wp-content/uploads/2024/03/agriculture-annual-report-2023.pdf	≈761,612,700,000	
Chicken meat	47,900,000 kg	https://www.agro.uz/wp-content/uploads/2024/03/agriculture-annual-report-2023.pdf	≈205,870,000,000	https://www.waterfootprint.org/time-for-action/what-can-consumers-do/#:~:text=The%20water%20footprint%20of%20meat,300%20m%203%20%2Fton

[40] UzDaily. "Ўзбекистан импортировал из Казахстана 4,5 млн тонн пшеницы и муки в зерновом эквиваленте." September 1, 2024. <https://www.uzdaily.uz/ru/uzbekistan-importiroval-iz-kazakhstan-4,5-mln-tonn-pshenitsy-i-muki-v-zernovom-ekvivalente/>.

[41] Mekonnen, M. M., and Hoekstra, A. Y. The Green, Blue and Grey Water Footprint of Crops and Derived Crop Products. Twente Water Centre, University of Twente, Enschede, The Netherlands. Published May 25, 2011. <https://www.waterfootprint.org/resources/Mekonnen-Hoekstra-2011-WaterFootprintCrops.pdf>.



Product name (descending order of volume)	Quantity	Source	Estimated virtual water content (in liters)	Source
Chocolate	≈ 40,000,000 kg	N/A, estimates based on previous year statistics: 2022: (January–October) - 38.1 thousand tons of cocoa and chocolate - https://t.me/statistika_rasmiy/2973 2023: (January–June) 19,700 tons of chocolate and cocoa products - https://kun.uz/en/01271596#	≈ 688,800,000,000	https://watercalculator.org/water-footprint-of-food-guide/
Dates	≈ 8,681,590 kg	Data for 2022 y. - https://wits.worldbank.org/trade/comtrade/en/country/UZB/year/2022/tradeflow/Imports/partner/ALL/product/080410	≈ 19,624,229,400	
Mutton	7,100,000 kg	https://www.agro.uz/wp-content/uploads/2024/03/agriculture-annual-report-2023.pdf	≈74,220,000,000	
Potatoes	516,700 kg	https://www.agro.uz/wp-content/uploads/2024/03/agriculture-annual-report-2023.pdf	≈154,126,300	
Coffee	≈ 350,000 kg	N/A, estimates based on previous year statistics. 2020: Approximately 330.3 tons - https://stat.uz/ru/press-tsentr/novosti-goskomstata/17767-0-zbekiston-qariyb-333-tonna-kofe-import-qilgan-2 2021: Approximately 333 tons - https://stat.uz/ru/press-tsentr/novosti-goskomstata/17767-0-zbekiston-qariyb-333-tonna-kofe-import-qilgan-2 2022: 340 tons (from January to September) - https://t.me/statistika_rasmiy/2861 2023: 306 tons (from January to June) - https://t.me/statistika_rasmiy/3865	≈ 8,750,000,000	
Orange	≈ 11,500 kg	https://t.me/statistika_rasmiy/4172	≈6,511,600	



The total estimated volume of virtual water imported by Uzbekistan amounts to approximately **12,94 trillion liters**.

Upon analyzing recent trends in trade policies, it is crucial to note that current policy management demonstrates positive progress for several reasons:

1. Uzbekistan has seen a notable rise in the importation of water-intensive products [42]. The following increases have been recorded:
 - Wheat products: up by 5.3%
 - Coffee, tea, cocoa, spices, and their derivatives: up by 23%
 - Fruits and vegetables: up by 23.5%
 - Meat and meat products: up by 9.1%
 - Dairy products and poultry eggs: up by 31.7%
 - Textile fibers and their waste: up by 6.1%
 - Vegetable oils and fats (raw, refined, or fractionated): up by 16.4%
 - Textile yarns, fabrics, ready-made garments, and similar products: up by 24.1%
2. Uzbekistan has experienced a significant decline in the export of water-intensive products, as evidenced by the following changes:
 - Sugar, sugar products, and honey: decreased by 4.4%
 - Dairy products and poultry eggs: decreased by 36.5%
 - Textile fibers and their waste: decreased by 5.5%
 - Vegetable oils and fats (raw, refined, or fractionated): decreased by 31.5%
 - Textile yarns, fabrics, finished products, and similar goods: decreased by 7.6%
3. From 2023 until January 1, 2024, Uzbekistan implemented a zero-tax policy on several products, most of which fall for the category of the water-intensive products [43].

[42] Agency of Statistics of Uzbekistan. "Внешнеторговый оборот Республики Узбекистан (за январь-декабрь 2023 г)." January 20, 2024. <https://stat.uz/ru/press-tsentri/novosti-goskomstata/49770-o-zbekiston-respublikasi-tashqi-savdo-aylanmasi-2023-yil-yanvar-dekabr-5>.

[43] Gazeta.uz. "Вводятся нулевые пошлины на ввоз 36 видов продуктов питания, включая шоколад." March 23, 2023. <https://www.gazeta.uz/ru/2023/03/23/zero-duty-rate/>. Also: Telegram Channel of the State Customs Service of the Republic of Uzbekistan. "Айрим истеъмол товарларига нисбатан божхона божи ноль ставкада қўлланилиши узайтирилди." December 28, 2023. <https://t.me/customschannel/33366>.



However, it remains unclear whether these objectives were pursued deliberately or if they emerged as an unintended positive consequence.

Additionally, considering Uzbekistan ranks sixth globally in beef consumption (about 31,6 kg per person annually) —one of the most water-intensive products—it is advisable to enhance beef imports from international sources [44]. A notable example is the agreement reached during the visit of Mongolia's President Ukhnaagiin Khürelsükh to Uzbekistan earlier this year, where both countries agreed to increase meat exports from Mongolia to Uzbekistan [45].

[44] "Uzbekistan took the sixth place in the world ranking of countries with high beef consumption", yuz.uz, <https://www.yuz.uz/en/news/uzbekistan-zanyal-shestoe-mesto-v-mirovom-reytinge-stran-s-vsokim-potreblenim-govyadin>.

[45] "Presidents of Uzbekistan and Mongolia Agree to Prepare New Program of Multifaceted Cooperation", 24.06.2024, official website of the President of Uzbekistan: <https://president.uz/en/lists/view/7336>



IV. Summary

The analysis indicates that the total virtual water content of exported products is approximately 15,02 trillion liters, while the total virtual water imported amounts to 12,94trillion liters. All these figures suggest a positive virtual water trade balance, with exports exceeding imports by around 2,08 trillion liters, this result is misleading. Given that Uzbekistan is classified as a water-stressed nation, being a net virtual water exporter poses critical challenges for sustainable water management and raises concerns about long-term water security. While the study aimed to provide precise and accurate data, it fell short due to limited available information. To achieve a more accurate assessment of Uzbekistan's virtual water trade balance, it is essential to improve collaboration with government bodies, ensure transparency in reporting the exact volumes of exports and imports, as well as research-based calculations of the water footprint for each product at the local level.

Furthermore, regular analysis of the virtual water trade is crucial. It offers valuable insights into water usage and enables more informed policy decisions that promote efficient resource management. By doing so, Uzbekistan can better navigate its water scarcity challenges and foster a more sustainable and balanced trade system. Uzbekistan has the capacity to produce most products domestically. However, given Central Asia's ongoing demographic growth and increasing water demand, the main recommendation from this research is for Uzbekistan to prioritize the import of water-intensive products. This strategy will help alleviate pressure on the country's water resources. At the same time, Uzbekistan should focus its domestic production on goods that require less water, ensuring a more sustainable use of its water reserves.



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