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DIGITAL TRANSFORMATION IN WATER MANAGEMENT: PROBLEMS, OPPORTUNITIES AND PROSPECTS

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Abstract This article provides a comprehensive analysis of digital transformation processes in the water management sector of the Republic of Uzbekistan. The study examines the theoretical foundations of digitalization, its role in water resources management, ongoing reforms in Uzbekistan, institutional mechanisms established, and technologies introduced ("Smart Water", "DIVER", SCADA, IoT, GIS, artificial intelligence). At the same time, the problems encountered in the process — outdated infrastructure, shortage of qualified personnel, financial constraints, data integration and cybersecurity issues — are thoroughly analyzed. The opportunities opened by digital transformation: reducing water losses, ensuring transparency, energy efficiency, expanding private sector participation and adapting to climate change are given special attention. Practical recommendations are developed based on the goals of the 2025–2028 program, international experience and future prospects. The article is intended for water management specialists, lawyers, public administration officials and researchers.

Keywords: digital transformation, water management, Smart Water, IoT, SCADA, GIS, Digital Water Management Platform, water accounting, monitoring center, artificial intelligence, Uzbekistan, water security, water conservation.

Introduction Water is the foundation of human life, an important factor of economic development and a guarantee of ecological sustainability. In the 21st century, global climate change, rapid population growth, industrialization and intensification of agriculture are sharply increasing the demand for water resources. According to United Nations forecasts, by 2050 almost half of the world's population may live under conditions of water scarcity. This problem is of strategic importance especially for the Central Asian region, which is located in an arid and semi-arid climate zone.

The Republic of Uzbekistan receives approximately 80 percent of its water resources from neighboring countries. On average, 51–53 billion cubic meters of water are used annually in the country, of which nearly 90 percent is allocated to agriculture. There are more than 50 thousand kilometers of irrigation networks, 1.6 thousand pumping stations and over 10 thousand water facilities. Effective management of such a vast and complex infrastructure by traditional "paper" methods is almost impossible today. As President Shavkat Mirziyoyev has repeatedly emphasized: "The only way to make radical changes in the water management sector is digitalization. Through this, transparency and accuracy are ensured, and corruption is prevented."

Digital transformation is not merely a technical process, but a fundamental change in management culture, decision-making mechanisms and interactions with users. It enables accurate

water accounting, reduction of losses, fair distribution of resources, increase of energy efficiency and adaptation to climate change. Therefore, the "Digital Uzbekistan – 2030" Strategy, the Concept for the Development of Water Management for 2020–2030, and Presidential Decree No. PF-183 of 13 October 2025 have defined the digitalization of the sector as a strategic priority.

The purpose of the article is to reveal the theoretical and practical aspects of digital transformation in water management, analyze the current situation in Uzbekistan, identify existing problems, assess emerging opportunities and outline prospective directions. The research integrates legal, technical, economic and institutional approaches.

Theoretical Foundations Of Digital Transformation And Its Role In Water Management Digital transformation is the process of restructuring the activities of an organization or sector on the basis of digital technologies, automating processes, introducing data-driven decision-making and creating new value. It differs from simple "digitization" (converting paper into electronic form) and "digitalization" (improving processes with digital tools). Transformation means changing the entire system, culture and business models.

Digital transformation in water management pursues the following main goals: increasing the efficiency of water resources use; reducing losses; ensuring transparency in accounting; making prompt and well-founded decisions; improving interaction with users; strengthening sustainability under climate change conditions.

The main technological pillars of digital transformation in water management are as follows:

- **IoT (Internet of Things).** Collecting real-time data on water level, flow, pressure, temperature and quality through sensors. In Uzbekistan, "Smart Water" devices are based exactly on this principle.
- **SCADA (Supervisory Control and Data Acquisition).** A system for remote monitoring and control of pumping stations, reservoirs and large hydraulic structures. It enables rapid response to emergency situations.
- **GIS (Geographic Information System) and remote sensing.** Mapping of irrigated areas, canal networks, water loss zones and crop conditions. Monitoring of evapotranspiration through satellite data (Uzbekcosmos, Esri partnership).
- **Artificial intelligence (AI) and Big Data.** Forecasting water demand, calculating optimal distribution, detecting anomalies (waste, malfunctions) and supporting decision-making.
- **Unified digital platforms and cloud technologies.** Systems that enable collecting, analyzing, visualizing all data in one place and sharing it among different agencies.

Current State Of Digitalization Of Water Management In Uzbekistan The legal foundation for digitalizing the sector is strengthened by several important documents. The "Digital Uzbekistan – 2030" Strategy defines the general directions for the development of the digital economy. The Concept for the Development of Water Management of the Republic of Uzbekistan for 2020–2030 (PF-6024) has designated the introduction of digital technologies in the sector as a separate priority direction.

One of the most important documents is Presidential Decree No. PF-183 of 13 October 2025 "On Measures to Further Accelerate and Ensure Sustainable Development of the Digitalization Process in the Water Sector." On the basis of this decree, the following have been established:

complete accounting of water resources used in the republic; digitalization of more than 400 types of data; electronic formation of data on more than 600 thousand water consumers and 4.3 million hectares of irrigated land; reduction of the human factor and widespread introduction of innovative technologies.

Within the framework of the decree's implementation, the state institution "Center for Digitalization and Monitoring of Water Management" was established under the Ministry of Water Management. A modern "Situation Center" was launched under the Center. The unified "Digital Water Management" platform, which integrates all information systems in the sector, was developed. In addition, the "State Water Cadastre" information system is planned to be launched by April 2026.

Significant practical results have been achieved in recent years. "Smart Water" devices have been installed at more than 13 thousand water measurement points. These devices enable real-time monitoring of water level and flow. "DIVER" devices have been installed in approximately 10–11 thousand meliorative observation wells, allowing online monitoring of groundwater levels and the degree of land salinity. Online water flow monitoring systems have been introduced at approximately 1.7 thousand pumping stations. The management of more than 100 large water management facilities has been automated.

Through the "Water Accounting" information platform, the amount of water used is accurately calculated and delivered to consumers electronically. This system reduces the human factor in accounting, eliminates bureaucracy and increases the efficiency of resource use. The platform is being integrated with the "Digital Agriculture" system. As a result, data on irrigated lands, crop types and water limits are automatically updated.

The coverage of water-saving technologies has approached 60 percent. In 2025 alone, 2.3–2.5 billion cubic meters of water were saved due to water-saving technologies. Within the framework of the "Program for the Development of Water Resources Management and the Irrigation Sector for 2025–2028," the goal has been set to save up to 14 billion cubic meters of water per year by 2028. It is planned to reduce annual electricity consumption at pumping stations from 6.8 billion kWh to 6.2 billion kWh.

International financial institutions play an important role in accelerating digital transformation. The Asian Development Bank (ADB) has allocated a loan of 125 million US dollars to support digital transformation in the water sector of Uzbekistan. Within the project, water flow accounting and telemetry systems, GIS mapping, asset inventory and climate-adaptive management systems are being introduced. A 4.6 million dollar project on introducing digital water monitoring systems in the Aral Sea region is being implemented in cooperation with UNDP and the Government of Japan. A system for monitoring water consumption based on satellite technologies is being developed in partnership between Uzbekcosmos and Esri.

Problems In The Digital Transformation Process The digital transformation process faces a number of serious problems. Their in-depth analysis is important for increasing the effectiveness of future reforms.

Many canals, pumping stations and measuring devices are outdated. Some of them are not fully compatible with digital sensors and automated systems. Installing devices, providing technical

maintenance and ensuring continuous internet connection require additional investment and logistics. In some remote areas, mobile communication and internet coverage are insufficient, which complicates real-time monitoring.

Full integration between different information systems (water accounting, pumping stations, melioration, agriculture) has not yet been ensured. Data quality, uniformity and update speed remain problems. Although the unified "Digital Water Management" platform has been launched, its full functionality and connection with all subsystems require time.

There is a shortage of qualified specialists for managing digital technologies, analyzing data, configuring and supporting systems. The digital literacy of local water management employees is low. Although "Water Workers' School" and dual education programs are being introduced, systematic personnel training has not yet been fully established.

Large-scale digitalization requires high initial costs. International loans and grants are important, but long-term sustainable financing mechanisms (including directing part of water tax revenues to strengthening the technical base) have not yet been fully developed. Organizationally, coordination and distribution of responsibilities among different agencies sometimes remain unclear.

As critical infrastructure (pumping stations, reservoirs, distribution systems) transitions to digital systems, the risk of cyber attacks increases. If the confidentiality, integrity and availability of data are not ensured, the system may become unreliable. Cybersecurity standards and staff training have not yet been introduced to a sufficient degree.

Opportunities Opened By Digital Transformation Despite the problems, digital transformation opens up enormous opportunities for water management. The main ones are as follows.

Real-time monitoring makes it possible to detect and eliminate waste in canals, pumping stations and fields. "Smart" irrigation systems (based on IoT) optimize water delivery according to soil moisture and weather data. In pilot projects, irrigation efficiency has increased by 30 percent, water losses have decreased by 25 percent, and yields have risen by 15 percent. The overall goal is to save 14 billion cubic meters of water per year by 2028.

Electronic water accounting and automated distribution reduce the human factor. This lowers the risk of corruption, ensures precise fulfillment of water limits and increases trust among users. Through the "Water Accounting" platform, every consumer can view their water consumption online. This is an important guarantee of transparency.

Optimization and automation of pumping stations significantly reduce electricity consumption. The goal is to reduce annual consumption from 6.8 billion to 6.2 billion kWh. This reduces not only budget expenditures but also the carbon footprint. Private sector participation in the management of pumping stations is being attracted through public-private partnership (PPP) mechanisms, which increases efficiency.

Forecast models, early warning systems and satellite monitoring enable early detection of drought, floods and other risks. Data-driven management helps distribute water resources more

adaptively under climate change conditions. Digital monitoring projects in the Aral Sea region serve exactly this purpose.

Prospects And Practical Recommendations In order to successfully complete digital transformation in water management in the coming years, the following directions should be of priority importance:

1. **Fully launching the unified platform and integrating all systems.** In 2026–2027, it is necessary to fully connect the "Digital Water Management" platform with all subsystems (water accounting, pumping stations, melioration, cadastre).
2. **Strengthening monitoring at state borders.** Monitoring transboundary water flow in real time by installing at least 300 digital water measuring devices.
3. **Widespread introduction of artificial intelligence and forecast models.** Developing systems for advance calculation of water demand, precipitation and crop needs.
4. **Strengthening the personnel training system.** Increasing the capacity of specialists through "Water Workers' School", dual education, advanced training courses and international internships.
5. **Expanding public-private partnership.** Expanding the experience of transferring the management of pumping stations in a number of regions to PPP basis in 2026–2027.
6. **Ensuring cybersecurity.** Developing national standards, training staff and introducing a continuous monitoring system.
7. **Studying and adapting international experience.** Using the experience of Israel, Australia, the Netherlands, the USA and other countries in "smart irrigation" and digital water management.

Conclusion Digital transformation in water management is not a choice for Uzbekistan, but a demand of the times and a strategic necessity. It is the most effective means of ensuring water security, rational use of resources, increasing transparency, reducing the risk of corruption and adapting to climate change. The institutional foundations currently created (the "Center for Digitalization and Monitoring", the "Digital Water Management" platform), thousands of installed "Smart Water" and "DIVER" devices, and adopted programs have created a solid foundation for taking the sector to a new stage.

However, success is not limited to installing technologies alone. It requires increasing personnel capacity, fully integrating systems, training users, sustainable financing and ensuring cybersecurity. If these conditions are consistently met, Uzbekistan will not only strengthen its water security, but also become a leading model for digitalizing water management in Central Asia. Digital transformation is the most reliable way to preserve water for future generations.

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