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**THE EFFECTIVENESS OF DIGITAL TECHNOLOGIES IN WATER RESOURCE
MANAGEMENT**<http://dx.doi.org/10.5281/zenodo.20155980>

Abstract: This article examines the effectiveness of digital technologies in managing Uzbekistan's water resources based on the principles of the green economy. The study examines the challenges of water scarcity, transboundary dependence, and low water productivity in the country. The role of technologies such as IoT sensors, SCADA systems, and NDVI monitoring in saving water, reducing energy consumption, and increasing yields is demonstrated through comparative tables. The results indicate that through digital transformation and government subsidies, water consumption can be reduced by up to 50%, and significantly enhance agricultural resilience to climate change.

Key words: Green economy, Integrated Water Resources Management (IRWM), digital technologies, IoT sensors, SCADA systems, water productivity, drip irrigation, Uzbekistan, sustainable development.

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**ЭФФЕКТИВНОСТЬ ЦИФРОВЫХ ТЕХНОЛОГИЙ В УПРАВЛЕНИИ ВОДНЫМИ
РЕСУРСАМИ**

Аннотация: В данной статье рассматривается эффективность цифровых технологий в управлении водными ресурсами Узбекистана на основе принципов зеленой экономики. В исследовании рассматриваются проблемы дефицита воды, трансграничной зависимости и низкой производительности воды в стране. Роль таких технологий, как датчики IoT, системы SCADA и мониторинг NDVI, в экономии воды, снижении энергопотребления и повышении урожайности показана в сравнительных таблицах. Результаты показывают, что за счет цифровой трансформации и государственных субсидий можно сократить потребление воды до 50% и значительно повысить устойчивость сельского хозяйства к изменению климата.

Ключевые слова: Зеленая экономика, интегрированное управление водными ресурсами (ИУВР), цифровые технологии, датчики IoT, системы SCADA, производительность воды, капельное орошение, Узбекистан, устойчивое развитие.

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SUV RESURSLARINI BOSHQARISHDA RAQAMLI TEXNOLOGIYALARNING SAMARADORLIGI

Annotatsiya: Ushbu maqolada O‘zbekistonning suv resurslarini yashil iqtisodiyot tamoyillari asosida boshqarishda raqamli texnologiyalarning samaradorligi ko‘rib chiqiladi. Tadqiqot mamlakatda suv tanqisligi, transchegaraviy bog‘liqlik va suv unumdorligining pastligi muammolarini o‘rganadi. Suvni tejash, energiya sarfini kamaytirish va hosildorlikni oshirishda IoT sensorlari, SCADA tizimlari va NDVI monitoringi kabi texnologiyalarning o‘rni qiyosiy jadvallar orqali ko‘rsatilgan. Natijalar shuni ko‘rsatadiki, raqamli transformatsiya va davlat subsidiyalari orqali suv sarfini 50 foizgacha kamaytirish va qishloq xo‘jaligining iqlim o‘zgarishiga chidamliligini sezilarli darajada oshirish mumkin.

Kalit so‘zlar: Yashil iqtisodiyot, Integratsiyalashgan Suv Resurslarini Boshqarish (IWRM), raqamli texnologiyalar, IoT sensorlari, SCADA tizimlari, suv unumdorligi, tomchilatib sug‘orish, O‘zbekiston, barqaror rivojlanish.

Global urbanization is rapidly intensifying, with the urban population increasing from 29.06 % (0.8 billion) in 1950 to 56.2% (4.4 billion) in 2020, and it is projected to reach 68.4% (6.7 billion) by 2050 [1]. As for Uzbekistan, this challenge is particularly acute as agriculture consumes approximately 90-92% of the county’s water [2]. Recent official data and international reports confirm that agriculture continues to account for about 90% of total water consumption in Uzbekistan, making efficient water use in this sector critical for national water security [3]. Due to the impacts of climate change, the Amu Darya and Syr Darya basins are projected to face a water deficit exceeding 20% by 2030 [1], necessitating a swift transition toward the principles of a Green Economy. Updated projections indicate that the water deficit could reach 15 billion cubic meters by 2030, with further increases expected by 2040 due to rising temperatures, glacier melt, and population growth [4]. The Green Economy is defined as a development paradigm where economic growth is decoupled from environmental degradation, threatening natural resource depletion as a risk to productivity rather than a post-hoc externally [5]. This model ensures that natural capital such as water, soil, and biodiversity continues to provide the ecosystem services essential for human well-being. Within this framework, Integrated Water Resources Management (IWRM) plays a critical role as a process that coordinates the management of water, land, and related resources to maximize socio-economic benefits without compromising the integrity of vital ecosystems [2].

Currently Uzbekistan ranks in the bottom 20 globally in terms of water productivity, generating only \$0.6 per cubic meter of water compared to the world average of \$15. This indicates that water use efficiency in the country is approximately 25 times lower than the global benchmark. Furthermore, over 80% of Uzbekistan’s water originates in neighboring upstream countries, making the nation highly vulnerable to regional hydrological changes [1]. Projections suggest that by 2040, Uzbekistan will be among the 33 countries most affected by water scarcity [6]. These challenges are compounded by aging irrigation infrastructure and inefficient traditional practices, which result in high water losses through seepage and evaporation. Digital technologies offer essential tools to address these challenges through precise monitoring and automation. For instance, Internet of things (IoT) sensors measure soil moisture and temperature in real-time, allowing for optimized irrigation

scheduling . Similarly, Supervisory Control and Data Acquisition (SCADA) systems automate irrigation networks, regulating water flow based on real-time data to prevent overflow and waste . Additionally, satellite-based Normalized Difference Vegetation Index (NDVI) data helps monitor crop health and identify water scarcity areas remotely [7]. In recent years, Uzbekistan has actively deployed these technologies through national initiatives, including the establishment of a Center for Water Management Digitalization in 2025 and GIS-based systems developed in partnership with Esri and the Uzspace Agency, which enable real-time water consumption monitoring rather than traditional supply-focused metrics [8].

The experience of Netherlands serves as a global benchmark, where “Smart Farming” and integrated water policies have successfully aligned agricultural productivity with environmental sustainability [5]. Their “Green Deal for smart Agriculture” emphasizes innovation and precision technologies to reduce pressure on natural capital. In Uzbekistan, the implementation of similar digital and water-saving technologies is showing significant results. Government programs, supported by international partners like the Asian Development Bank’s \$125 million Climate-Smart Water Management Improvement Project (approved in 2025), are accelerating this transition by introducing smart metering, automated systems, and digital platforms for water accounting [9].

While traditional furrow irrigation typically consumes 7.000-9.000m³/ha, modern smart drip irrigation systems reduce energy consumption to 3.500-4.500m³/ha [10]. Furthermore, smart systems can reduce energy consumption by up to 30% [11] and increase crop yields for cotton and wheat by 10-15 % [12]. From an economic perspective, these technologies also reduce operational costs such as fertilizer use by 20-25% through fertigation systems that deliver nutrients directly to the plant roots [7]. Field studies and national reports show that drip irrigation can achieve water savings of up to 50% while boosting yields by 13% or more in cotton fields, and recent policy updates in 2025-2026 have enhanced subsidies to cover up to 50% of installation costs in water-scarce areas, with advanced payments for self-funded projects [3].

Table 1. Efficiency indicators of water saving technologies

Technology	Water Saved (%)	Cost (per 1 ha)	Skill Level Required	Energy Savings
Drip Irrigation	50 %	High (\$200-\$3000)	Medium	30 %
Smart Sensors (IoT)	20-30 %	Medium	High	15 %
Laser Leveling	25 %	Low	Low	10 %
SCADA Systems	15-20 %	High	Professional	20 %

Source: author’s compilation

Updated implementations under national strategies have expanded drip irrigation to over 200,000 hectares by 2023, saving more than 1,5 billion cubic meters annually, with plans to reach 300,000 additional hectares by 2026 through enhanced subsidies and digital integration [13].

Despite this benefits, significant financial and infrastructural barriers remain. The installation of smart systems costs between \$2000 and \$3000 per hectare, which is major hurdle for small-scale farmers . Regional disparities in infrastructure also pose a challenge: while internet penetration in Tashkent exceeds 80 % , it is as low as 20 % in the Jizzakh region, limiting the effectiveness of IoT-based solutions [6]. However, national internet penetration has dramatically improved to 94.2% by mid-2025, with rural areas reaching 93.9%, significantly reducing previous digital divides and enabling broader adoption of IoT and SCADA systems across regions [14]. This digital transformation not only conserves water but also prevents soil salinization by controlling groundwater levels [1], thereby increasing the agricultural sector’s resilience to climate change.

Additional benefits include the prevention of waterlogging and salinity through precise groundwater monitoring via digital twins and smart devices installed in thousands of locations nationwide [13].

In recent developments, Uzbekistan has launched unified digital water management system, including “Smart Water” devices on over 11,000 sites and automated management of 65 major facilities, aiming to save 8 billion cubic meters in 2024 alone through concreting, digitization, and smart technologies [8]. These efforts align with the national Strategy for Transition to a Green Economy (2019-2030), which prioritizes water-use efficiency, renewable energy integration, and digital innovation to decouple growth from resource depletion.

In conclusion, digital technologies are the primary mechanism for implementing Green Economy principles in Uzbekistan’s water sector. Recent advancements in smart metering, international funding for climate smart systems, and digital platforms for water accounting demonstrate substantial progress. These initiatives aim to minimize losses, increase transparency, and promote efficient resource use through automation and international collaboration. Future progress will depend on improving digital infrastructure, integrating satellite data into public portals, fostering public-private partnerships, and enhancing farmers technological literacy through training programs. By leveraging these strategies, Uzbekistan can reduce water consumption by up to 50 %, boost agricultural resilience, and position itself as a regional leader in green economic practices, ensuring long-term environmental sustainability and economic prosperity. With ongoing projects like the World Bank’s irrigation modernization initiative and ADB’s digital transformation support, combined with domestic policies for subsidies and carbon market integration, Uzbekistan is well-positioned to achieve these goals and contribute to broader Central Asian water cooperation.

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Требования к оформлению научной статьи:

1. Статьи должны содержать 6 страниц, в формате Times New Roman на Microsoft Word, 12 кегль, 1 см, со всех сторон 2 см.
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