Next Scientists
Journal of Management and Economics

TYPE Original Research
PAGE NO. 4-7
DOI 10.55640/jme-05-12-02

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The Significance And Environmental Efficiency Of Digitalization Processes In Sustainable Economic Development

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OPEN ACCESS

SUBMITED 16 October 2025
ACCEPTED 10 November 2025
PUBLISHED 12 December 2025
VOLUME Vol.05 Issue12 2025

Abstract: The article analyzes the role and effectiveness of digital technologies in the green economy. The opportunities of AI, IoT, Big Data and cloud computing in saving energy, reducing carbon emissions, managing resources and improving environmental monitoring are examined. Based on international experience, these technologies are shown to be the main driver of the green economy. For the case of Uzbekistan, priority tasks are identified in such areas as renewable energy, smart agriculture, digital water management and smart cities.

Keywords: Digital technologies, green economy, artificial intelligence (AI), IoT, big data analytics, cloud computing, energy efficiency, environmental sustainability, digital transformation, digital inclusion, sustainable development.

Introduction: At the current stage of global development, the mutual integration of the complex of digital technologies and the concept of environmental sustainability forms the methodological basis for the emergence of a new economic paradigm. In the macroeconomic dynamics of the 21st century, two strategic directions are becoming increasingly important: the institutional transition to a “green” economy and the deep digital transformation of the economy, which are manifested as complementary processes. According to the World Bank [7], the concept of a green economy today is not only related to environmental problems, but is also considered a basis for global economic stability. This economic model is aimed at ensuring low-carbon, resource-efficient and socially inclusive development.

Advanced digital technologies such as artificial intelligence, IoT, big data analytics and cloud computing are recognized as factors accelerating structural changes in the formation and increasing efficiency of the "green" economic system. According to the research of Abadi and Brunnermeier [2], these technologies not only increase economic efficiency, but also significantly reduce the negative impact on the environment. This scientific article is aimed at conducting an in-depth analysis of the functional role of digital technologies within the concept of the green economy, as well as assessing the mechanisms of their practical implementation under the economic conditions of Uzbekistan, substantiated on the basis of advanced international research and practical experience.

RESULTS

The conceptual basis of the green economy is formed on the principles of a low-carbon economic model and sustainable development. As emphasized in the global strategies published by the World Bank [7], the green economy comprises three main directions: economic growth, environmental sustainability and social justice. Each of these directions can be implemented more effectively through the use of digital technologies.

According to the research by He et al. [3], digital technologies make it possible to reduce energy consumption by 30-40%. Smart grids and AI-based management systems play an important role in the optimal allocation of energy resources. Digital monitoring systems provide accurate measurement and control of carbon emissions of enterprises and cities. On the basis of the analysis of these data, clearly targeted strategic approaches are formed. Digital technologies make it possible to model the potential consequences of climate change in advance and to develop optimal decisions in this regard. Forecasting systems serve as an important tool in increasing the level of preparedness for natural hazards. The integration of digital solutions and environmental technologies opens up new economic prospects and shapes a solid trajectory of sustainable development for countries. This process not only strengthens environmental sustainability, but also enhances economic efficiency.

In the current international economic space, digital solutions are actively used in various sectors of environmentally oriented transformation. A large-scale study conducted by Song et al. [4] shows that these technologies create specific opportunities in each sector. In particular, smart manufacturing and modern industrial technologies make it possible to fully digitalize production systems and significantly reduce resource consumption. The use of robotics, artificial intelligence and IoT-based sensors can increase production productivity by around 50%. According to World Bank [7] data, smart city technologies reduce energy consumption in urban environments by up to 30%. Smart transport, lighting and waste management systems are fundamentally changing urban life.

In addition, blockchain- and fintech-based mechanisms make investments directed to environmentally oriented projects more transparent and efficient. Through digital platforms, small investors also gain the opportunity to channel capital into "green" initiatives.

Artificial intelligence and big data analytics are among the most powerful tools of the modern green economy. The research by Abadi and Brunnermeier [2] shows that AI algorithms, by forecasting demand in the energy grid and optimizing energy consumption in real time, ensure energy savings of 25-35%.

IoT sensors and smart devices make it possible to collect data in real time on energy consumption, environmental parameters and production processes. Large-scale data analytics and machine learning models are used to process this information and forecast future development trends. AI systems, in turn, automatically optimize energy distribution and significantly reduce resource consumption based on the obtained analytical results.

The study conducted by He et al. [3] indicates that big data analytics also creates great opportunities in environmental monitoring. AI solutions are used to continuously monitor water and air quality, control industrial emissions and assess the state of ecosystems. In some cases, smart energy grids not only ensure a reduction in energy consumption, but also enable highly efficient integration of renewable energy sources into the power system. Large corporations such as Google and Microsoft have managed to reduce energy consumption in their data centers by almost 40% by using artificial intelligence to manage cooling processes.

Internet of Things (IoT) technologies are one of the most promising segments of the green economy, having strategic significance in environmental monitoring and the rational management of resources. According to the research by Song et al. [4], IoT devices make it possible to monitor and analyze environmental indicators in real time, which helps to make quick decisions.

First, in environmental monitoring, IoT sensors continuously measure the quality of air, water and soil. Any environmental disturbance is detected immediately and reported to the relevant authorities. Second, in the implementation of smart agriculture, as shown by Romero Zaleta et al. [5], it is possible to save up to 40% of water resources using IoT. Smart irrigation systems

take into account soil moisture and weather conditions. Third, in waste management, smart bins monitor the level of filling and optimize waste collection routes. This leads to a reduction in logistics costs and carbon emissions. In addition, in waste recycling processes, IoT technologies automate sorting and processing stages, making it possible to increase the share of reusable materials by up to 60%.

The impact of IoT technologies on the economy in various sectors can be observed as follows:

- Agricultural productivity increases by 30-45%;

- Water consumption decreases by 35-40%;

- Energy costs are reduced by about 25%;

- Transport logistics is optimized by 20%.

Cloud computing technologies are of great importance in the development of the green economy. The research by Abadi and Brunnermeier [2] shows that storing and processing large volumes of data through cloud technologies significantly increases energy efficiency. Compared to traditional data centers, cloud infrastructure consumes 30% less energy and reduces the carbon footprint by 70%.

First of all, cloud platforms create an integrated environment by consolidating data in a single center and providing access to them from various devices, which significantly reduces excessive document circulation. Second, the cloud-based work model supports remote activity and reduces transport-related costs and carbon emissions by 20-30%. Third, the processes of processing and analyzing large amounts of data become faster and more efficient in cloud infrastructure, while artificial intelligence algorithms optimize business processes. In addition, cloud infrastructure provides the possibility of rational use of resources and their flexible distribution among various users.

According to a World Bank [6] report, e-commerce and smart logistics systems also significantly reduce the carbon footprint. Digital platforms make it possible to shorten supply chains by delivering products directly from producer to consumer, thereby enabling effective management of logistics costs. Moreover, smart route optimization systems reduce freight transport distances by 15–20%. “Green” services such as electronic document management, distance learning and telemedicine reduce paper consumption and the number of trips, thus lowering environmental pressure. Digital platforms expand access to markets for environmentally friendly products and enable consumers to make more conscious and environmentally responsible choices.

Uzbekistan has taken important steps in recent years towards the transition to a green economy and digital transformation. The report “Green Growth and Climate Change Policy Dialogues in Uzbekistan”, prepared by the World Bank [1], presents specific strategies for the country.

Uzbekistan has approved a strategy for the transition to a green economy until 2030, in which increasing the share of renewable energy sources to 25%, improving energy efficiency and modernizing industrial infrastructure are defined as priority tasks. Digital technologies serve as a key factor accelerating these transformational processes.

According to the World Bank [7] report, the development of the digital economy is important for addressing youth employment issues in Uzbekistan. The IT sector, digital services and innovative start-ups are expected to create thousands of new jobs. The state is introducing training programs to improve digital skills.

A number of pilot projects are being implemented in Uzbekistan: smart cities (Tashkent, Samarkand), smart agriculture (Fergana Valley), renewable energy parks (Navoi and Bukhara regions). These projects are planned to be scaled up at the national level.

Based on the analysis, it is advisable to define the following priority directions for Uzbekistan:

- Implementation of smart energy grids;

- Expansion of digital water resources management systems;

- Development of green financing mechanisms;

- Ensuring digital inclusion;

- Establishment of international cooperation and technology transfer.

Given its geographical location and resource potential, Uzbekistan can gain significant benefits from combining green and digital economies. In particular, the country has enormous potential in the field of solar energy: annual solar radiation amounts to 2000-3000 kWh/m², which is one of the highest indicators in the world.

A suitable legal environment is necessary for the successful introduction of digital technologies. The state should work in the following areas:

- Development of digital security standards;

- Adoption of legislation on the protection of personal data;

- Combating digital monopolies;

- Encouraging technological innovation;

- International cooperation and exchange of experience;

- Supporting programs to increase digital literacy.

CONCLUSION

The prospects for the integration of the green economy and digital technologies are assessed as very high. International trends show that the integration of these two directions will become a leading factor of global economic development by the 2030s. Below, strategic directions for future development and recommendations adapted to the conditions of Uzbekistan are presented.

1. Short-term strategy (2024-2026) – Creation of the basic layer of digital infrastructure: ensuring universal access to the internet, implementation of pilot projects, and training of specialists. Introduction of financial mechanisms to support investments in green technologies.

2. Medium-term strategy (2027-2030) – Wide-scale implementation of digital and green technologies: expansion of smart city systems, development of green industry and increasing export potential. Strengthening regional cooperation.

3. Long-term strategy (2031-2040) – Transition to a fully digital and green economy: export of advanced technologies, transformation into a global hub for green technologies and full achievement of sustainable development goals.

In this scientific article, the functional significance and efficiency of digital technologies in the formation and development of the green economy have been comprehensively analyzed. The examination of international scientific sources and practical experience recognizes digital technologies as the main driving force of the green economy and confirms their importance for achieving sustainable development.

Digital technologies such as artificial intelligence, IoT, big data analytics and cloud computing are of strategic importance in combating climate change, supporting economic growth and strengthening sustainability. These technologies provide an effective instrumental base for increasing energy efficiency, reducing carbon emissions, rational use of resources and improving environmental monitoring. Under the conditions of Uzbekistan, expanding digital innovations and ensuring equal access of the population to digital opportunities are priority tasks. The country has significant potential in solar energy, smart agriculture and water resources management. The success of the digital–green transformation depends on the harmonization of state policy, private sector investments and international cooperation.

In the future, the synergy of digital and environmental technologies is expected to make a significant contribution not only to the sustainable development of Uzbekistan, but of the entire Central Asian region. By 2030, Uzbekistan has a high probability of becoming a regional leader in the field of the digital-green economy and integrating into the global green technology market. However, to achieve these prospects, it is necessary to reduce the digital divide, strengthen cybersecurity, develop a high-quality education system and create a regulatory environment that stimulates innovation. Only a comprehensive approach can ensure sustainable and inclusive economic development. In the economy of the 21st century, the integration of digital technologies and the green model plays a central role and is a key factor of long-term sustainability.

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