

## **ECO-DIGITAL TRANSFORMATION: HOW TECHNOLOGY IS CHANGING THE GAME IN THE GREEN ECONOMY**

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**Abstract:** In modern society, the green economy and digital transformation represent two key developmental directions shaping a sustainable future. This paper explores the interrelationship between digital technologies and the green transition, specifically how digital transformation influences the redefinition of economic models toward greater environmental sustainability. Through the analysis of contemporary digital tools such as artificial intelligence, the Internet of Things (IoT), blockchain technology, and big data analytics, the paper demonstrates how these tools enable the optimization of resource consumption, reduction of harmful gas emissions, and advancement of the circular economy.

Special focus is given to the energy, agriculture, and urban planning sectors, where digital technologies are already showing significant potential for both ecological and economic benefits. The paper also addresses implementation challenges, such as the digital divide, high initial investments, and regulatory barriers. It emphasizes the need for a multisectoral approach, connecting the public sector, industry, and research institutions to create efficient and inclusive strategies for eco-digital transition.

The conclusion highlights that digital transformation is not merely a technical, but also a societal process that is changing the rules of the game within the context

of the green economy – enabling the shift from a linear to a sustainable, circular, and data-driven economic system.

**Keywords:** *Digital Transformation, Green Economy, Sustainable Development, Technological Innovation, Circular Economy.*

## INTRODUCTION

In today's global context, we are increasingly confronted with pressing environmental challenges – climate change, depletion of natural resources, pollution, and biodiversity loss. Traditional models of economic growth, based on linear resource consumption, have proven to be unsustainable in the long term. As a response to these challenges, the concept of the green economy has emerged, promoting sustainable development based on low carbon emissions, efficient resource use, and social inclusion.

At the same time, the world is undergoing an intense process of digital transformation, which not only reshapes how we communicate and work, but increasingly influences how we produce, consume, and manage resources. Innovations such as artificial intelligence, the Internet of Things (IoT), blockchain, robotics, and big data analytics are opening new possibilities for enhancing sustainability across nearly all economic sectors.

Eco-digital transformation represents the intersection between the green economy and digital technologies – a new developmental paradigm that enables technological advancement to serve environmental preservation and social responsibility. This paper aims to explore how digital technologies are changing the rules of the game in the context of the green economy, by analyzing concrete application examples, identifying benefits and challenges, and offering recommendations for a successful transition toward a sustainable and digitally empowered society.

In this sense, the paper contributes to a deeper understanding of how technology can become a key ally in the fight against climate change and environmental degradation, and emphasizes the importance of an integrated approach in the creation of policies, strategies, and innovative solutions.

## Theoretical Framework

The conceptual framework of this paper is based on the integration of theories and approaches from the fields of green economy, digital transformation, and sustainable development (Joksimović, M. 2025), with an analysis of their interrelations and mutual influences.

Green Economy – Theoretical Approach the concept of the green economy gained significance in the late 20th and early 21st centuries as a response to the ecological and social consequences of industrial development. According to the United

Nations Environment Programme (UNEP), a green economy is one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological degradation. Its key characteristics include:

- Sustainable use of natural resources
- Reduction of greenhouse gas emissions
- Promotion of the circular economy
- Employment in “green” industries

Theoretically, the green economy draws on approaches from ecological economics, which seeks to integrate ecological limits into the economic system – as opposed to neoclassical economics, which often treats natural resources as externalities.

Digital Transformation – Definition and Significance digital transformation refers to a deep and systemic change in how technology is used in the economy, society, and public administration. More than just the adoption of new tools, it involves changes in organizational models, decision-making processes, and value systems. Key technologies driving digital transformation include (Joksimović, M. 2025):

- Artificial Intelligence (AI) – for process optimization and predictive analytics
- Internet of Things (IoT) – for real-time monitoring and resource management
- Blockchain – for transparency and supply chain tracking
- Big Data and Analytics – for data-driven decision-making
- Cloud Computing – for flexibility and access to digital infrastructure

From a theoretical standpoint, digital transformation can be examined through the lens of theories of technological change, diffusion of innovations and technological determinism, which explore how technology shapes social and economic systems.

Eco-Digital Synergy: The Intersection Point there is a growing interest in the literature regarding the intersection of digital (Nwoga, B. 2023) and green transitions, often referred to as “digital sustainability” or “eco-digital transformation.” This synergy involves the use of digital technologies to:

- Monitor environmental parameters and improve resource management
- Increase energy efficiency
- Develop smart cities and sustainable mobility solutions
- Digitize supply chains to reduce waste and emissions

Relevant theoretical frameworks include the theory of sustainable, which emphasizes the need to balance economic growth, social equity, and environmental protection, as well as the concept of smart sustainability (Mehmood, R., Yigitcanlar, T., & Corchado, J. M. 2024), which integrates technological innovation into sustainable practices. (VK, R. K., Saunila, M., Rantala, T., & Ukko, J. 2025).

The theoretical framework of this paper is grounded in the assumption that digital transformation is a key catalyst for accelerating the transition toward a green economy. However, its impact depends on the mode of implementation, regulatory frameworks, resource availability, and the level of digital literacy in society.

## SCIENTIFIC RESEARCH METHODOLOGY

The main goal of the research is to examine how digital transformation supports the development of the green economy. It focuses on identifying key technologies, sectors, and models that enable this synergy, as well as understanding the challenges in implementing such solutions.

The primary objective of this study is to explore how digital transformation contributes to the development of the green economy (Zhou, Y. 2024). It aims to identify specific technologies, sectors, and models that enable this synergy, while also addressing implementation challenges and limitations (Liu, Y., Dong, F., Yu, J., & Liu, A. 2024).

Research Questions the study is guided by questions that examine the role of digital technologies in achieving green economy goals, which sectors are leading in combining green and digital innovations, the practical benefits and challenges of this transformation, and the roles of various stakeholders.

The research is guided by the following questions:

- How do digital technologies support the goals of the green economy?
- Which sectors show the highest integration of green and digital innovations?
- What are the benefits and challenges of eco-digital transformation in practice?
- How do different stakeholders (business, government, civil society) contribute to this process?

Research Method a qualitative methodology is used, primarily based on secondary data analysis. This includes literature reviews, analysis of strategic documents, and case studies. The study also compares national and regional models to identify best practices.

This research uses a qualitative approach, focusing on: Secondary data analysis: including academic literature, reports from international organizations, and policy documents related to green and digital transitions. Case studies: analyzing specific examples such as smart cities, digital agriculture, and Industry 4.0 applications in the circular economy. Comparative analysis: comparing eco-digital transition models in the EU, Serbia, and the Western Balkans to identify best practices.

## CASE STUDY ANALYSIS

To illustrate the practical application of digital technologies in support of the green economy, this section presents case studies from three distinct sectors: urban development (smart cities), agriculture (digital agri-tech), and industrial manufacturing (Industry 4.0 in the context of the circular economy). The analysis is based on

literature reviews, reports from international organizations, and verified data from real-world practice.

## **1. Smart Cities: Amsterdam Smart City**

Amsterdam Smart City (ASC) is one of the leading examples of how digital technologies can be integrated to improve urban sustainability.

Key technologies include IoT sensors for managing traffic and energy consumption, data-sharing platforms connecting citizens, businesses, and government, as well as AI systems used for pollution forecasting and optimizing public transportation.

Green components of the initiative involve smart street lighting that reduces energy use by up to 70%, waste management systems using sensor-equipped bins, and a strong push for electric mobility through charging networks and e-vehicle incentives.

Results achieved include lower CO<sub>2</sub> emissions in the city center, more efficient use of public resources, and greater citizen participation in sustainable urban planning. Amsterdam demonstrates how digital infrastructure can serve as the backbone of resilient, eco-friendly cities.

## **2. Digital Agriculture: Precision Agri-Tech in Israel**

Israel is recognized as a global leader in applying digital technologies to agriculture, particularly in water-scarce conditions.

Technologies in use include IoT soil moisture sensors, drones for monitoring crops and detecting diseases, and advanced software (e.g., Netafim systems) for optimizing irrigation and fertilization.

Environmental benefits include up to 40% reduction in water usage per hectare, less soil and groundwater pollution thanks to precise fertilization, and reduced pesticide use through predictive analytics.

Economic impacts include higher crop yields with fewer inputs and increased competitiveness in global markets. This case confirms that digital innovation can transform traditional sectors into sustainable and high-yield industries.

## **3. Industry 4.0 and the Circular Economy: Siemens in Germany**

Siemens AG, through its digital and green transition strategy, applies Industry 4.0 principles to boost resource efficiency and implement circular production models.

Technologies used include digital twins for optimizing product life cycles, automated data-driven production systems, and blockchain for tracking materials throughout the value chain.

Circular practices involve eco-design for recyclability, shifting from product sales to service models (e.g., equipment leasing), and recovering raw materials from used products.

Outcomes include up to 25% reduction in industrial waste, lower energy consumption per product unit, and enhanced transparency and accountability across the supply chain. This example shows how large-scale industries can adopt digital tools to embed circular principles into their operations, aligning with green economy goals.

## RESEARCH RESULTS AND DISCUSSION

Across all three case studies, several common success factors emerge: Effective integration of technology must align with local and sector-specific needs. Digital innovations should be directly linked to sustainability objectives. The active involvement of stakeholders – governments, businesses, and citizens – is essential. Supportive strategic and regulatory frameworks are necessary to enable and scale these initiatives

These findings highlight that eco-digital transformation is most effective when driven by collaboration, clear goals, and a well-structured ecosystem.

The case study analysis demonstrates that digital technologies play a pivotal role in optimizing resource use, reducing pollution, and increasing efficiency across sectors. In urban settings like Amsterdam, they support smart infrastructure management, while in agriculture, as seen in Israel, they enable precise control of water and chemical usage. In industry, companies like Siemens use digitalization to implement circular production models.

These findings support the theoretical claim that digital transformation is not a neutral process – it can actively shape economic systems toward sustainability, provided it is guided by strategic intent.

Digital-led green transformation brings multiple layers of benefits:

- Environmental: Reduced greenhouse gas emissions, lower resource consumption, and waste minimization
- Economic: Improved efficiency, cost savings, access to new markets, and development of innovative business models
- Social: Improved quality of life, enhanced citizen participation, and the creation of new jobs in the green and digital sectors

This confirms the alignment between digital and green agendas with broader Sustainable Development Goals (SDGs), particularly Goals 9 (industry, innovation, and infrastructure), 11 (sustainable cities), 12 (responsible consumption and production), and 13 (climate action).

Despite the positive potential, several challenges affect the implementation of eco-digital solutions:

- Digital divide: Inequalities in access to digital technologies limit inclusive transformation, especially in less developed areas
- High initial investment: Small and medium enterprises (SMEs) often lack the resources needed for digital adoption

- Regulatory gaps: Inadequate legal frameworks can hinder or discourage innovation
- Privacy and data security concerns: Digitalization introduces new risks that require proper regulation

Therefore, digital transformation for green purposes should not be seen purely as a technical process – it requires a comprehensive strategy that includes education, infrastructure, innovation support, and international collaboration.

The most successful eco-digital transformation models are those built on collaboration among key stakeholders:

- Public sector: Provides regulatory support, public investments, and strategic planning
- Private sector: Drives innovation and practical implementation of technologies
- Academic and research institutions: Develop new knowledge and assess impacts
- Citizens and civil society: Contribute through participation and changing consumption habits

Without this partnership, there is a risk that digital transformation could fail to support sustainability, or even worsen social and environmental inequalities.

While the analyzed case studies come from developed countries, the core lessons are relevant for developing regions as well, including Serbia and the Western Balkans. Key action steps include:

- Developing national strategies that connect green and digital transitions
- Supporting SMEs through subsidies and training programs
- Investing in digital infrastructure and education
- Creating a regulatory framework that encourages innovation while protecting the environment and citizens' rights

Digital transformation has the potential to act as a key accelerator of the green economy – but only if implemented in a strategic, inclusive, and responsible manner. Technology alone is not a guarantee of sustainability; it is a tool that can either advance or hinder the goals of green transition, depending on how it is applied.

## CONCLUSION

This paper analyzed the interrelationship between digital transformation and the green economy, aiming to determine how modern technologies contribute to achieving sustainable development goals. Based on the theoretical framework, case study analysis, and consideration of current trends, it can be concluded that digital transformation has the potential to become a key driver of the green transition, but only if applied strategically, responsibly, and inclusively.

Case studies from urban development, agriculture, and industry demonstrated how specific digital technologies – such as artificial intelligence, the Internet of Things, and blockchain – enable more efficient resource management, emission reduction, process optimization, and the development of circular business models. Digital solutions also offer new opportunities for citizen engagement, improved quality of life, and increased economic competitiveness.

However, numerous challenges were identified: the digital divide, regulatory misalignments, the need for substantial initial investments, and ethical issues such as data protection and algorithmic bias. Therefore, a successful eco-digital transition cannot depend solely on technology but must be part of a comprehensive development policy that integrates innovation, education, institutional support, and active participation from all societal actors.

In the context of developing countries, including Serbia and the Western Balkans region, eco-digital transformation can present an opportunity to bypass certain phases of traditional development and directly transition to sustainable and smart systems. This requires proactive government action, support for innovative enterprises, strengthening digital literacy, and establishing a regulatory framework that encourages rather than hinders change.

In conclusion, technology changes the rules of the game – but it is we who must write the rules. The key question is not whether we will use digital tools, but how we will use them in the service of sustainable development, environmental protection, and the creation of an inclusive society.

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