DIGITAL TECHNOLOGY AND SUSTAINABLE DEVELOPMENT: A REVIEW OF ITS ROLE IN ADVANCING THE GREEN ECONOMY

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Abstract: Digital technology has become a pivotal driver of sustainable development, offering tools to address societal and environmental challenges while supporting global well-being. Harnessing vast datasets and interconnected systems through technologies such as the Internet of Things (IoT) has unlocked innovative strategies for achieving the United Nations Sustainable Development Goals (SDGs). These advancements present opportunities to transform critical sectors like agriculture, energy, and water management, ensuring a sustainable and equitable future.

This article explores how digital tools foster resilience in the food-water-energy nexus, enable cleaner energy solutions, and promote global health and education. Challenges such as the digital divide and ethical concerns regarding data use are also analyzed, emphasizing the importance of inclusivity and responsible technological integration.

Keywords: Digital transformation; IoT; Sustainable systems; Green energy; SDGs.

INTRODUCTION

With rapid advancements in technology, digitalization has emerged as a cornerstone for addressing sustainability challenges and achieving the SDGs established by the UN in 2015. Digitalization involves integrating digital tools into daily operations by converting physical information into a digital format, facilitating efficient management of resources. These integrated SDGs highlight our civilization's essential needs for a sustainable and competitive future. The innovative invention of digital technologies to generate, use, communicate, or source electronic

data for organizational activities can help fulfill the SDGs. These solutions that help to achieve these specific goals could be described as digital sustainability. Digital sustainability is defined as the attempt to develop and deploy smart technologies that provide long-term economic growth while taking into account and incorporating the SDGs. Modern digital advancements, such as artificial intelligence and machine learning techniques, have experienced exponential rise in value, with an anticipated 14% contribution to the world economy by 2030 (*THE 17 GOALS | Sustainable Development*, n.d.).

Smart systems and the Internet of Things (IoT) technologies have become instrumental in transforming industries. IoT connects physical devices through embedded sensors, enabling real-time data exchange, analysis, and informed decision-making. In education, digital platforms help bridge learning gaps, while in the energy and environment sectors, these technologies promote efficient resource use and conservation.

ENHANCING AGRICULTURE AND FOOD PRODUCTION

The ever-increasing worldwide demand for food, feed, fiber, and clean energy puts strain on agroecosystems. Increased stress reduces the natural resilience of agroecosystems and is predicted to lead to significant worldwide environmental changes. Changing climatic conditions are followed by high and low heat stress, changing rainfall patterns, rising carbon dioxide levels, an increase in the frequency of extreme weather events such as droughts, floods, and cyclonic disturbances, and salinization of soils (Abdo & Salloum, 2017). These consequences lead to production cost inflation, insect infestations, and disease outbreaks, all of which put strain on global agricultural land. The significance of digital technologies in the future of agriculture and food production systems is critical, with tremendous gains in efficiency, sustainability, and productivity (Raihan, 2024). (Table 1)

***Table 1**. The use of digital technologies to provide long-term solutions to various agricultural difficulties associated with different crop types farmed around the world.*

Crop Type	Agricultural Problem	Digital Technology Application	Sustainable Solutions
Fruits & Vegetables	Pest Management	AI-based Pest Prediction Models	Targeted pest control, minimized pesticide, reduced spoilage
Rice	Water Scarcity	Precision Irrigation Systems	Efficient water use, reduced use wastage
Cotton	Labor Shortage	Agricultural Robotics	Automated harvesting, reduced labor dependency
Coffee	Climate Change	Climate-smart Agriculture Practices	Resilience to climate variations, reduced risk
Cocoa	Supply Chain Transparency	Blockchain Technology	Traceability, authenticity assurance

The global demand for food continues to escalate, straining agroecosystems. Digital technologies are pivotal in promoting sustainable practices and mitigating climate-related impacts on agriculture. Precision farming employs drones, sensors, and analytics to optimize resource use while improving yields. AI algorithms predict crop diseases and recommend solutions tailored to specific conditions, while IoT devices streamline communication across the agricultural value chain.

Blockchain technology ensures transparency and traceability in food supply chains, addressing safety concerns. These innovations not only enhance efficiency but also ensure resilience in agriculture amid climate and population pressures.

ENSURING CLEAN WATER ACCESS

Efficient water management is critical to addressing global water scarcity. Digital solutions like IoT-based sensors monitor water quality, while AI and machine learning analyze trends to predict pollution and optimize treatment systems. Blockchain enhances data transparency in water management, supporting better decision-making (Xiao, Fei, 2024).

In recent years, artificial intelligence (AI) technologies have been widely used to convert passive data into actionable information, improving WTS operation and

decision-making. One of the first studies that used artificial intelligence to create a water treatment system advocated two phases: analysis and synthesis. In the analysis phase, an inductive learning algorithm and expert rules are combined to assess the treatment efficiency of numerous chemicals at varying doses using a single treatment method. In the synthesis phase, the sequence of different treatment procedures that satisfy the treatment aims is obtained using the neural network approach to generate knowledge rules from the analysis phase. (Deng et al., 2024).

This study lay the groundwork for the later creation of a decision support system (DSS) for selecting and sequencing water treatment processes, as well as designing treatment facilities. Figure 1 depicts a typical four-stage DSS for WTS design that employs AI techniques, such as water treatment problem analysis and interpretation, reasoning model development, sequential decision optimization, DSS logic validation, and user interactivity enhancement (Shalaby, 2024).

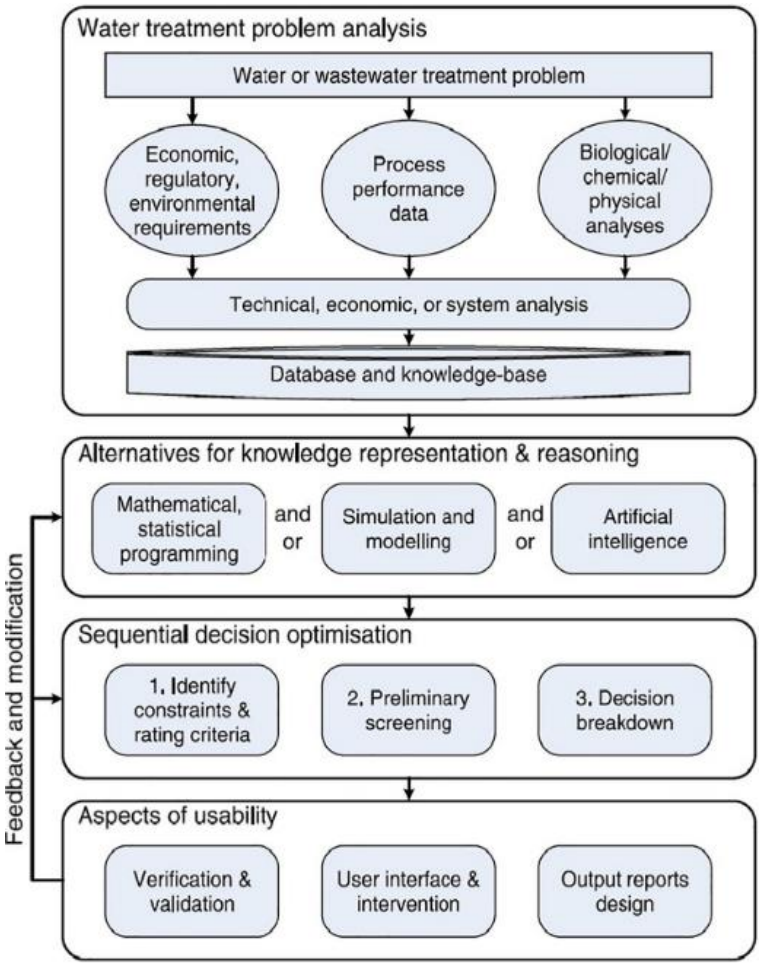

Fig. 1. Stages of developing a water treatment decision support system.

AI-driven decision support systems (DSS) have also revolutionized the design of water treatment systems, improved operational efficiency and ensured consistent water quality.

ADDRESSING ENERGY CHALLENGES WITH DIGITALIZATION

Digital technologies are redefining the energy sector by improving efficiency and promoting sustainable solutions. Smart grids facilitate energy distribution, integrating renewable sources seamlessly while minimizing waste. IoT devices and AI algorithms empower consumers to monitor and optimize their energy usage.

As with any technology breakthrough, digitalization opens up a wide range of exciting opportunities while also introducing a number of issues. The impact of digitalization on energy concerns is revolutionary, ushering in a new era of efficiency and sustainability. Smart grids use digital technologies to optimize energy distribution, eliminate losses, and seamlessly integrate renewable sources. Internet of Things (IoT) devices improve energy monitoring, enabling users to make more informed conservation decisions. Advanced analytics and artificial intelligence optimize energy use patterns, resulting in higher overall efficiency (Xiao, Fei, 2024). Digital platforms help to control energy demand and supply, resulting in a more balanced and resilient energy ecosystem. As we adopt digital solutions, the energy sector acquires the tools needed to alleviate issues, improve reliability, and migrate to a more sustainable and responsive energy landscape (Shalaby, 2024).

Moreover, digital platforms allow better alignment between energy supply and demand, fostering a resilient energy ecosystem. These innovations collectively contribute to mitigating environmental impacts while addressing growing energy needs.

CONCLUSION

The introduction of digital technologies is a symbol of hope on the horizon, guiding and catalyzing progress toward reaching all 17 SDGs (*THE 17 GOALS* |

Sustainable Development, n.d.). Digitalization and internet of things (IoT) technologies have been considered in terms of their ability to solve major difficulties in the food-water-energy nexus, as well as enable Industry 4.0, improve social wellbeing, and mitigate the consequences of climate change.

The ever-increasing worldwide demand for food is one of the most pressing issues of this century, exacerbated by unequal access to food resources. From healthcare and education to agriculture and energy, digital innovations empower communities by increasing efficiency and bridging gaps. The revolutionary impact goes beyond economics, fostering inclusivity and tackling societal issues.

Digitalization offers a transformative path toward achieving the SDGs by fostering innovation in key sectors like agriculture, energy, and water management. While challenges like digital inequities and ethical considerations persist, adopting inclusive and responsible approaches to technology can bridge these gaps. By leveraging smart systems, IoT, and AI, societies can move closer to a sustainable, balanced, and equitable future.

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