THE ROLE OF ARTIFICIAL INTELLIGENCE IN SUPPORTING SUSTAINABILITY IN THE FOOD INDUSTRY: INSIGHTS FROM ICELAND

Throstur Olaf Sigurjonsson [*], Stefan Wendt [**]

* School of Business, University of Iceland, Reykjavík, Iceland
** Reykjavík University, Reykjavík, Iceland

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Abstract

This study investigates the role of artificial intelligence (AI) in promoting environmentally friendly and socially responsible business practices within the food industry. This research explores how AI is integrated into corporate strategies and its impact on sustainability by analyzing the entire value chain- from production to processing and distribution. Using a qualitative approach, the study is based on semi-structured interviews with stakeholders across various stages of the food value chain in Iceland. The interviews focus on the current application of AI in corporate strategies, its significant effects on different segments of the value chain, and its contribution to sustainability goals. The findings reveal that AI is perceived as a vital component of companies' digital transformation, enhancing efficiency and addressing labor shortages. AI is crucial in quality control processes, optimizing operations, and reducing resource consumption, such as water and electricity. Contrary to concerns in some studies, AI has not led to increased resource consumption. Instead, it supports sustainability by improving efficiency and reducing waste. Additionally, the results align with international

research, highlighting improvements in quality control and waste reduction due to AI integration. The study also supports findings that AI-based automation enhances working conditions, particularly regarding workplace safety. The research underscores AI's potential to advance efficiency and sustainability in the food industry.

1. INTRODUCTION

Sustainability in corporate value chains has garnered increasing attention as stakeholders recognize businesses' critical role in addressing global challenges such as climate change, resource depletion, and social inequity. Sustainability in value chains is multifaceted, encompassing a company's internal processes and interactions with suppliers, distributors, and customers. The alignment of these entities with sustainability goals determines the effectiveness of corporate sustainability strategies (Seuring & Müller, 2008). Central to these strategies is the integration of the "Scope 1, 2, and 3" framework, which delineates greenhouse gas (GHG) emissions across direct emissions (Scope 1), indirect emissions from energy use (Scope 2), and other indirect emissions across the value chain (Scope 3) (World Resources Institute [WRI] & World Business Council for Sustainable Development [WBCSD], 2004).

As a cornerstone of human survival and economic activity, the food industry is a major contributor to and a victim of environmental degradation. Nearly one-third of global GHG emissions stem from the food sector, from resource-intensive agricultural practices to energy-consuming food processing and transportation systems (Climate and Environment, 2021). Coupled with food security and safety concerns, the sustainability of this industry is imperative. Consequently, initiatives such as the European Commission's Farm to Fork strategy within the European Green Deal aim to transform the food value chain into a fairer, healthier, and more sustainable system (European Commission, 2020). However, achieving these ambitious goals requires innovative tools and practices.

Artificial intelligence (AI), characterized by its ability to analyze vast amounts of data and automate complex tasks, holds significant promise for enhancing sustainability across value chains. AI applications have demonstrated the potential to optimize resource use, reduce waste, and improve operational efficiency, thereby supporting environmental and social goals (Mavani et al., 2022; Raghavendra et al., 2022). Yet, its role in sustainability, particularly within the food value chain, remains underexplored. This research examines how Icelandic companies in the food industry integrate AI into their operations and assess its impact on sustainability goals, particularly in areas such as resource efficiency, waste reduction, and workplace safety.

The study adopts a qualitative methodology, drawing on semi-structured interviews with stakeholders across the food value chain. By focusing on Iceland — a nation renowned for its emphasis on sustainability and digital innovation — this research contributes to the global discourse on the role of AI in achieving sustainable development goals (SDGs), such as "Zero Hunger", "Responsible Consumption and Production", and "Life Below Water and Life on Land" (United Nations, n.d.). The findings provide actionable insights into how AI can drive transformative change in food production, processing, and distribution.

2. THEORETICAL FRAMEWORK

2.1. Sustainability in the food value chain

The food industry value chain spans multiple stages, from primary production (e.g., agriculture and fishing) to processing, distribution, and consumption. Each stage has unique sustainability challenges, including water usage, fertilizer application, animal welfare, and food waste. Addressing these challenges requires systemic changes underpinned by robust frameworks like the SDGs and targeted policies like the European Green Deal.

Sustainability in the value chain also encompasses social dimensions, such as improving labor conditions and ensuring food security. AI offers the potential to address these challenges by automating labor-intensive tasks, enhancing quality control, and optimizing resource use. For instance, AI-powered predictive models can forecast crop yields and identify inefficiencies in irrigation systems, thereby reducing water consumption. Similarly, AI-driven robotics can improve workplace safety by performing hazardous tasks, thus supporting social sustainability goals.

2.2. Artificial intelligence in the context of sustainability

AI technologies are evolving rapidly, with machine learning and deep learning enabling advanced data processing capabilities. Machine learning involves statistical techniques that allow systems to learn from experience and improve over time, while deep learning focuses on recognizing patterns in large datasets through neural networks (Misra et al., 2022). These capabilities make AI particularly suited for tackling sustainability challenges, where data-driven insights and automation are essential.

In the food industry, AI applications range from precision agriculture to supply chain optimization. Precision agriculture leverages AI to monitor soil health, predict weather patterns, and manage pests, reducing farming's environmental footprint. AI can enhance efficiency in processing and distribution by identifying bottlenecks, reducing energy

consumption, and minimizing waste. Despite these advancements, adopting AI in sustainability-focused initiatives is often hindered by cost, lack of expertise, and limited awareness of its potential benefits.

3. METHODOLOGY

This research employs a qualitative approach to explore the role of AI in supporting sustainability in Iceland's food industry. Semi-structured interviews were conducted with participants representing various stages of the food value chain, including producers, processors, and distributors. This method was chosen to capture diverse perspectives and gain in-depth insights into AI adoption's current status, challenges, and opportunities.

The interviews focused on three key themes:

1) *Integrating AI into corporate strategy*: Examining how companies incorporate AI into their strategic objectives, particularly concerning sustainability.

2) *Impact of AI on the value chain*: Identifying areas where AI has the most significant impact, such as resource efficiency, waste reduction, and quality control.

3) *Alignment with sustainability goals*: Assessing whether AI initiatives are explicitly designed to support environmental and social sustainability.

The interview data were analyzed using thematic analysis, which allowed the identification of patterns and themes related to the research objectives.

4. FINDINGS

4.1. AI as a component of digital transformation

Participants emphasized that AI is integral to the digital transformation of their organizations. Companies view AI as a tool for enhancing operational efficiency and competitiveness rather than a primary driver of sustainability. While some participants acknowledged AI's potential to support sustainability goals, this was often seen as a secondary benefit rather than a core objective.

4.2. Optimization and resource efficiency

AI was found to play a critical role in optimizing resource use, particularly in contexts where labor availability is limited. For instance, AI-powered systems monitor energy consumption in processing facilities, identify inefficiencies, and implement corrective actions. Participants highlighted that these systems contribute to sustainability by reducing water and electricity usage.

4.3. Quality control and waste reduction

Quality control emerged as a key area where AI has made significant contributions. AI-powered sensors and analytics tools detect defects in raw materials, monitor production processes, and ensure product consistency. These measures improve product quality and minimize waste, aligning with sustainability goals.

4.4. Challenges and limitations

Despite its benefits, adopting AI in the food industry is not without challenges. Participants noted that implementing AI systems requires substantial investment in technology and training. Additionally, there is a perception that AI's role in sustainability is limited to indirect effects, such as efficiency gains, rather than addressing broader environmental and social issues.

5. DISCUSSION

The findings align with international studies highlighting AI's potential to enhance efficiency and reduce waste in the food industry. However, this research underscores the need for a more strategic approach to integrating AI into sustainability initiatives. While Icelandic companies leverage AI to optimize operations, there is room to expand its application to address systemic challenges such as supply chain transparency and climate resilience.

Future research should focus on developing frameworks to guide the implementation of AI in sustainability-focused initiatives. This includes exploring innovative AI applications, such as blockchain for supply chain traceability and predictive analytics for climate adaptation. By aligning AI with broader sustainability goals, companies can maximize their potential to drive transformative change in the food industry.

6. CONCLUSION

This research sheds light on the role of AI in supporting sustainability in Iceland's food industry. While AI is primarily viewed as a tool for improving efficiency, its contributions to resource conservation, waste reduction, and workplace safety highlight its potential to advance sustainability goals. Companies can harness its transformative power to build a more sustainable and resilient food value chain by addressing adoption challenges and fostering a strategic approach to AI integration.

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