

# Artificial Intelligence in Water–Energy–Food Model

Subjects: Business | Management

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The role of artificial intelligence (AI) in the Water–Energy–Food (WEF) nexus under the lens of institutional, stakeholder, and innovation theories has been studied recently. Research on AI for WEF nexus management has adopted mostly a technical perspective, neglecting the relevance of management tools and the business model concept. An integrated approach for managing the nexus through AI technologies is proposed to meet sustainable and responsible business models. The gap between research and policy making could be filled by combining scientific data and policy needs with inclusive tools that are technically viable for sustainable resource utilization.

Keywords: artificial intelligence (AI) ; Water–Energy–Food (WEF) nexus ; business models

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Over the past two decades, scholars and practitioners have been paying increasing attention to the concept of Water–Energy–Food (WEF). This process has tried to become a nexus for the “right way” to optimize the use of natural resources, promoting environmental sustainability goals <sup>[1][2][3]</sup>. The WEF nexus concept originates from the international discussion on sustainable development during the World Economic Forum in 2011, used to describe the interconnections and interdependencies among water, food, and energy sectors <sup>[4]</sup>. Water is needed to generate energy and grow food; energy is required for water supply and produces food; and food can generate energy, reducing waste <sup>[5]</sup>. This means that any issue in managing one of these resources can affect the others, and each resource can benefit from the synergies coming from an integrated approach to their use.

Conceived as a tool “to promote policy coherence through identifying optimal policy mixes and governance arrangements across the water, energy and food sectors” (<sup>[6]</sup>, p. 165), the WEF nexus has gained prominence after the adoption of the UN 2030 Agenda in 2015 for handling the sustainable development goal (SDG) interconnections, specifically for SDG#2 (zero hunger), SDG#6 (clean water and sanitation), and SDG#7 (affordable and clean energy) <sup>[7][8]</sup>. According to Le Blanc <sup>[9]</sup>, the successful achievement of the UN 2030 Agenda needs to consider the potential trade-offs and synergies among several SDGs. Indeed, the UN 2030 Agenda footprint recognizes in its conceptualization the existence of interconnections among targets to achieve the SDGs, which require the implementation of coherent policies and solutions across different actors and sectors <sup>[10]</sup>. Despite the great efforts of academia concerning these issues, there has not been much progress in developing and adopting coherent policies and tools to handle SDGs' interlinkages <sup>[7][11][12]</sup>. The literature on the WEF approach has highlighted the existence of several constraints to its implementation to meet SDGs, such as rigid frameworks, entrenched interests, planning and implementation procedures, and a lack of information tools capable of supporting decision-making processes <sup>[7][8][12]</sup>. Scholars agree on the need to establish coordination and cooperation mechanisms applicable to support institutions and governments in the definition of policy goals and actions for leading to the desired outcomes. However, they struggle to provide insights on the conditions, dynamics, and factors that enable cross-sector coordination and collaboration <sup>[6]</sup>.

Recent studies <sup>[12][13][14]</sup> found sustainability goals and sustainable performance cannot be achieved without innovations. The overlapping of data and information, the lack of adequate knowledge of human resources, and the unpredictability of climate events could severely affect decision-making processes, leading to sub-optimal solutions and slowing down the sustainability agenda. Artificial intelligence (AI) technologies can process large amounts of data, reveal information that otherwise would remain hidden, and solve complex problems. Yet, the contribution of AI is not limited to data processing. Still, it has the potential to identify science-based solutions for environmental and climate degradation problems that are not biased by specific individual or groups interests <sup>[13]</sup>, supporting multi-stakeholder decision-making processes towards sustainability. AI can help the multiple players involved in the water, energy, and food industries to meet the UN 2030 Agenda.

Some scholars <sup>[15][16][17]</sup> have highlighted how AI is able to change not only the way to generate and use information for decision making <sup>[18]</sup>, but also the ways of doing business from a sustainable and socially responsible perspective <sup>[19][20]</sup>. Caprani <sup>[21]</sup> (p. 103) highlights the significant role of business in achieving global transformational development, but this has been almost entirely ignored by the literature on the WEF that has focused mostly on the other stakeholders (e.g., governments and community). Moreover, while some scholars have highlighted the relevance of digital technologies in the

water, energy, and food sectors [15][17][22][23], the potential role of AI for the management of the WEF nexus has been underestimated, as has its contribution to the governance of multiple interactions among the resources, sectors, and institutions involved.

The analysis of the articles in current data collection highlights that the policy and decision makers lack access to comprehensive tools that include all stakeholders and consider the multi-scale nature and context-dependence of the nexus. Digital platforms have been developed to define and quantify the interconnectivity between water, energy, and food resources and include integrative and holistic management strategies to plan the future allocation of these resources. Moreover, current results evidence that in the literature, the attention to the role of AI for rethinking and redesigning business models for sustainability, including the WEF nexus challenge, is still under-researched. The combination of WEF natural resource information with a business model, thanks to the use of AI, may allow considering both technical and financial issues within companies while respecting the WEF approach and contributing to the UN 2030 Agenda [24]. AI applications, with the support of other digital technologies, capable of gathering and elaborating biophysical and technical data with financial data, may support business managers' and external investors' decision-making processes by proposing alternative solutions of investments. A digitalized platform or database can offer alternative solutions that include data on water, energy, and land consumption, and the cost analysis for each solution could support consistently addressing the WEF nexus.

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