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RESPONSIBLE ARTIFICIAL INTELLIGENCE AND SUSTAINABLE MANAGEMENT PRACTICES IN THE CONTEXT OF INDUSTRY 5.0

BY

PETRINA-DELIA VAGIUC*, LAURA-CRINA MIRAUTE (COCA), NICOLETA-MIHAELA CASANEANU (DASCALU), ȘTEFANA-CĂTĂLINA POHONȚU-DRAGOMIR and IONUȚ-VIOREL HERGHILIGIU

“Gheorghe Asachi” Technical University of Iași, Faculty of Industrial Design and Business Management, Department of Engineering and Management, 700050, Iași, Romania

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Abstract. Based on the idea of the Industry 5.0 paradigm, Artificial Intelligence (AI) is used for more than automation; it supports collaboration and sustainable organizational operations. The present paper focuses on the concept of responsible AI, highlighting the importance of moral values, transparency, ecological management, and social responsibility. Through a qualitative approach based on reviewing the academic literature and analyzing representative organizational practices, the study identifies principles and ways to apply responsible AI. The findings suggest that responsible AI helps organizations make better decisions, use resources more efficiently, support workers’ well-being, and build trust with stakeholders by using clear, sustainability-focused practices. In this way, organizations need to increasingly integrate the human-centered principles of Industry 5.0 into their strategic approaches. To implement Industry 5.0, a balanced approach is needed between the responsible use of artificial intelligence and sustainable management practices. This study offers a conceptual starting point for researchers and organizations that supports this direction.

*Corresponding author; *e-mail*: petrina-delia.vagiuc@academic.tuiasi.ro

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1. Introduction

In contrast with Industry 4.0, which focuses on automation, efficiency, and smart technologies, Industry 5.0 represents a new step in industrial development. It values humans, sustainability, and organizational resilience, combining advanced technologies with human skills and creativity (Vagiuc *et al*., 2025).

Artificial Intelligence (AI) is a branch of computer science that helps us to create systems that can do tasks usually done by people, like learning, reasoning, solving problems, and making decisions, but lacks the human qualities such as emotional intelligence and moral judgment. For this reason, Industry 5.0 points out the need to combine technology with human talent, making sure AI is helpful too, instead of acting on its own (Martini *et al*., 2024). In this context, responsible artificial intelligence is essential. This means using AI technologies in ways that are ethical, transparent, fair, and accountable, while keeping users' data private and secured (Göellner *et al*., 2024). It helps ensure decisions are unbiased and protects people and the environment from harm or unfair results (Gunasekara *et al*., 2025). At the same time, sustainable management practices are now crucial for modern industries. Reaching a sustainability state means finding a balance between economic growth, caring for the environment, and social responsibility (Vagiuc *et al*., 2025). According to Gunasekara et al. (2025), when responsible AI is combined with sustainable management, it can improve production, minimize environmental impacts, and help organizations make better decisions.

Including AI into sustainable industrial practices in a responsible way is challenging. Organizations must deal with complex technology, follow regulations, and measure both ethical and environmental outcomes. Most studies look at AI and sustainability separately, and there are a few that examine their interconnections. This paper uses a qualitative, systematic approach and explores how responsible AI and sustainable management work together and how combining these can contribute to operational efficiency, compliance with ethical principles, and environmental sustainability in industry. Regarding these, the following research questions are addressed:

1. What role can the responsible artificial intelligence play in supporting sustainable management practices in Industry 5.0?

2. What are the main challenges and benefits of the ethical use of AI in sustainable industrial systems?

The main hypothesis of this research is that combining responsible AI with sustainable management can improve industrial performance, reduce

negative environmental effects, and encourage social responsibility. Through reviewing studies, models, and real-world examples, this paper aims to offer useful insights for researchers, industry professionals, and others who want a more sustainable and human-centered industrial future.

The present paper starts by presenting the key concepts of artificial intelligence, responsible AI, and sustainability management practices, and their interactions, by explaining why they are important in Industry 5.0's context. The literature review covers existing studies and frameworks, showing how these concepts are linked in industry. The methodology section explains how the literature was selected and analyzed. In the end, the study discusses the main findings, potential challenges, and the benefits of combining responsible AI and sustainable management. In addition, it also presents some limitations and offers suggestions for future research.

2. Literature review

Recent studies describe sustainability as a key part of Industry 5.0, showing how it helps shape industrial systems that balance new technology with social and environmental responsibility. From this point of view, sustainability means more than just protecting the environment. It also covers economic stability, social inclusion, and long-term organizational resilience. Researchers believe that sustainable management is necessary to make sure technological progress leads to lasting industrial growth (Arputharaj and Pal, 2024).

A common view in the literature is that Industry 5.0 places people at the center of industrial development, which sets it apart from earlier industrial models. It has been noted that this new paradigm encourages humans and smart systems to work together, keeping human talent, knowledge, creativity, and ethical values at its core. This view connects closely to sustainability, since human well-being, meaningful work, and social responsibility are seen as important parts of industries that are oriented to sustainability (Alves *et al*., 2023; Baig and Yadegaridehkordi, 2024).

Artificial intelligence systems have the potential to build up production sustainability, optimize planning processes, and improve storage by reducing errors. They can keep operations running smoothly and use resources more efficiently (Ahmed *et al*., 2023). Studies also examine how artificial intelligence is increasingly used to help meet the Sustainable Development Goals (SDGs) (Vinuesa *et al*., 2020), especially when it comes to efficient use of resources, optimization of energy consumption, and improvement of decision-making processes. To address this, recent research introduces responsible artificial intelligence to ensure artificial intelligence systems align with human values and support sustainability.

2.1. Responsible artificial intelligence within Industry 5.0

Authors Papagiannidis *et al*. (2025) define responsible AI as a set of practices for designing, developing, deploying, and monitoring AI systems in ways that are ethical, safe, fair, transparent, and human-centered, ensuring that AI functions properly throughout its lifecycle.

One of the principles of responsible AI is human-centered design, meaning artificial intelligence systems should support people in making decisions, being creative, and using their judgment instead of taking over these roles. It also highlights the accountability, meaning that organizations and developers must take responsibility for the outcomes of using AI, including ethical, social, and environmental effects. Transparency is also important because stakeholders need to know how AI systems make decisions, especially in key areas like energy, healthcare, and industrial safety. Fairness should not make existing biases worse or create new inequalities. In addition, safety is also essential because AI in the context of Industry 5.0 might manage important resources, handle sensitive information that needs to be protected, and privacy is necessary for personal, company, and industrial data (Göellner *et al*., 2024; Martini *et al*., 2024; Papagiannidis *et al*., 2025; Pislaru *et al*., 2024).

To use AI responsibly in Industry 5.0, organizations should follow the principles outlined below in Fig. 1 to balance new technology with sustainability and social responsibility, while reducing risks such as bias, inequality, and unintended liability.

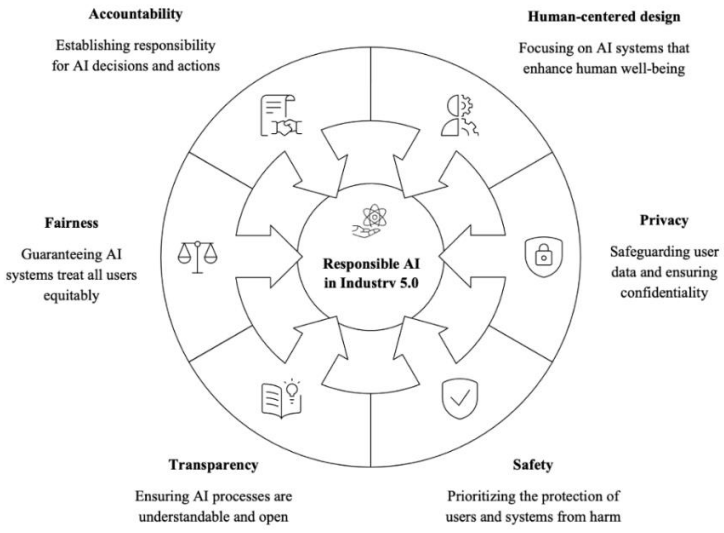


Fig. 1 − The main principles of responsible artificial intelligence (Gunasekara *et al.*, 2025; Papagiannidis *et al.*, 2025).

2.2. Sustainable management practices within Industry 5.0

Sustainable management practices also have significant implications for the newly emerging industry, as organizations must balance profitability, environmental considerations, and social responsibilities. Sustainable management not only points out profits but also addresses environmental sustainability while encouraging growth. It helps industrial systems deal with sustainability in modern industry. In Industry 5.0, sustainable management practices are included in the operations, which helps production systems stay sustainable (Vagiuc *et al*., 2025).

Another significant concept in sustainable management is the circular economy. The circular economy approach is teaching us to use resources in an efficient way, reduce waste, and keep materials in use for as long as possible. Recent studies show that automation, artificial intelligence, Internet of Things (IoT), additive manufacturing (AM) (Martini *et al*., 2024), and edge computing can support circular production by offering monitoring in real time, better resource management, and smarter decision-making systems (Rejeb *et al*., 2025; Rumman *et al*., 2025).

Maybe the most significant one is that sustainable practices are also about people and organizations. Industry 5.0, as already mentioned, encourages a human-centered approach, valuing worker well-being, community impact, and social fairness along with environmental goals. This broader view of sustainability covers not only technology, but also fair decision-making and responsible use of resources to meet society's needs and to protect them for future generations (Vagiuc *et al*., 2025; Van Erp *et al*., 2024).

Despite their benefits, putting them into practice can be challenging. Companies regularly deal with high costs, limited experience, and the need for new ways to measure both environmental and social outcomes. To meet these challenges, organizations need careful planning, teamwork among departments, and constant innovation to make sure sustainability becomes a core part of their operations (Rumman *et al*., 2025).

To sum up, sustainable management practices involve bringing together new technologies with the sustainability dimensions goals to create systems that are efficient, responsible, and prepared for the future. When combined with responsible AI, sustainable management helps industries build ethical, resilient, and people-focused production that benefits both businesses and society.

2.3. The connection between the responsible use of artificial intelligence and sustainable management practices in Industry 5.0

There is a close connection between responsible AI and sustainable management practices. Both aim to create industrial systems that are efficient, ethical, and human-centered, considering the long-term influence on

environmental, social, and economic aspects of sustainability (Van Erp *et al*., 2024). The benefits discussed previously can be achieved in the real world if AI is viewed not only as an essential tool but also used responsibly. Without transparency, control, and responsibility, the solutions generated by AI tend to generate negative effects, like inequality growth, the exclusion of some groups, or the increase in impact on the environment through the high level of energy consumed (Gunasekara *et al*., 2025).

A central element of this connection is the human-centered dimension, or pillar, of Industry 5.0. The literature highlights that AI doesn't need to replace human decisions; it needs to support them, and maybe offer new analytical perspectives, for better decisions. It can also be named human-centered AI (Martini *et al*., 2024). The integration of human knowledge in developing the AI models can contribute to reducing computational resources and to increasing the relevance and fairness of the outcomes. In this way, sustainability is not viewed only from the ecological point of view, but also from the social and ethical ones (Göellner *et al*., 2024; Martini *et al*., 2024).

In their study, authors Papagiannidis *et al*. (2025) highlight a series of challenges that appear in the process of governance, implementation, and utilization of the AI systems. Cultural diversity and ethics are some complex issues. Many responsible AI frameworks start from the assumption of the existence of some universal ethical values, but the assumptions of what is considered acceptable, fair, or responsible differ significantly between countries, organizations, and groups of users. Because of this diversity, the applicability of some principles is difficult, and it needs to adapt the AI solutions to the specific social and cultural context where they are used.

Another major challenge concerns the AI organizational governance structures. To implement responsible AI, the roles, responsibilities, and rights of the stakeholders involved in developing and using the AI systems need to be defined clearly. The academic literature indicates that many organizations face difficulties establishing efficient mechanisms for coordination across both vertical (decisional) and horizontal (departmental) levels. The lack of clarity in the share of responsibilities can affect transparency, responsibility, and efficiency of decision-making processes, increasing the risk of the occurrence of some unwanted results or ethically questionable (Papagiannidis *et al*., 2025; Pislaru *et al*., 2024).

In terms of procedural practices, Papagiannidis *et al*. (2025) point out that the organizations are encountering issues related to data management, AI models evaluation, and ongoing monitoring of their performance. Data quality assurance, algorithmic bias reduction, and confidentiality protection represent constant challenges, especially in complex industrial applications. In addition, there is a limited understanding of how responsible AI principles can be translated from the operational level into coherent organizational strategies that support both ethical responsibility and economic competitiveness. From the perspective

of organizational connections, a challenge is involving relevant stakeholders in the development process of artificial intelligence. Even though an inclusive approach can contribute to more ethical and socially acceptable outcomes, this can slow down the decision-making process and can create tensions between the rapid innovation goals and risk management ones. The contribution of authors Göellner *et al*. (2024) indicates that one of the most challenging parts of responsible AI isn't defining the ethical principles but implementing them in concrete practices applicable throughout the entire lifecycle of AI systems. For this reason, recent studies tend to structure ethical AI into frameworks, models, and operational tools that aim to reduce the gap between theory and implementation. Likewise, the low level of alphabetization or expertise in the responsible AI domain among employees limits the capacity of organizations to identify and manage the ethical and social problems associated with using AI.

Nevertheless, studies also highlight the significant opportunities associated with adopting responsible AI in Industry 5.0. Implementing some solid frameworks of governance can contribute to increasing the level of stakeholders' trust, improving organizational reputation, and achieving a stronger competitive position in the long run. Responsible AI is increasingly correlated to the performance in ESG terms (Environmental, Social, and Governance), becoming an important criterion for investors and strategic partners. On top of that, as already mentioned, the use of responsible AI can have a positive impact on the employees' general well-being, reducing anxiety tied to automation and increasing the acceptance of smart technologies. When artificial intelligence is viewed as a supporting tool and not a threat, this can improve professional satisfaction, human-machine cooperation, and productivity. At the social level, this tool offers the opportunity to align technological innovation with social values and contribute to the definition of some emerging ethical norms related to using artificial intelligence (Papagiannidis *et al*., 2025).

All in all, the association between the use of responsible AI and implementing sustainable management practices in Industry 5.0 suggests a careful guidance of some sort of sensitive balance between control and flexibility, ethics and competitiveness, innovation and inclusivity. Even though the challenges exist, the associated opportunities can shift this approach into a strategic advantage and an essential pillar of industrial sustainable development.

3. Methodology

Literature analysis represents an essential step in writing any research study, because it offers the needed base for gathering existing knowledge, identifying the gaps from the previous studies, and outlining future research directions. Regarding the present paper, the adopted methodology follows a qualitative and systematic approach of academic literature, aiming to analyze the way responsible artificial intelligence and sustainable management practices are

addressed within Industry 5.0. For conducting this review, the systematic and qualitative approach is structured into some steps, which allow collecting, analyzing, and synthesizing the relevant studies. The overall goal is to obtain a clear image of the current stage of research, to highlight the main concepts, challenges, and opportunities identified in the literature, and to underline the future underexplored directions.

The first step is selecting the known academic databases (i.e., IEEE Xplore, ScienceDirect, SpringerLink, MDPI, and Google Scholar) to guarantee access to qualitative scientific publications. These sources were selected for their relevance to artificial intelligence, sustainability management, and Industry 5.0. Following this, a set of relevant keywords was defined for individual use and in combination for identifying the proper articles for the research scope. The set includes "responsible artificial intelligence", "Industry 5.0", "sustainable management", "AI governance", "human-centered AI", and "sustainability". The searches were limited to published articles in the English language. The selection criteria were inclusive, considering articles that directly or indirectly address the role of responsible AI in supporting sustainability and management practices in Industry 5.0. The selected studies were published between 2020 and 2025, as they provide current perspectives relevant to the present topic of this paper. The identified studies included articles from scientific journals, conference papers, and conceptual or review studies. In the final stage, the selected papers were read, critically analyzed, and synthesized, aiming to extract the main ideas, recurring themes, and differences in approach between authors. Qualitative analysis allowed the grouping of results into thematic categories, such as the principles of responsible AI, sustainable management practices, the link between both, and implications for Industry 5.0. Based on this analysis, conclusions and directions for future research were formulated. This process is represented below, in Fig. 2.

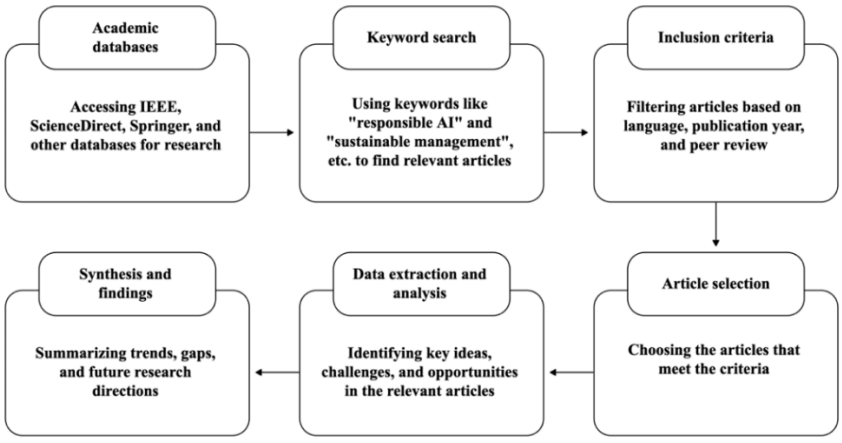


Fig. 2 − Research methodology model.

4. Results and discussions

This synthesized study highlights a clear alignment between responsible artificial intelligence, Industry 5.0 principles, and sustainable management objectives, showing that the transition from Industry 4.0, mainly focused on technological efficiency, to a human-centric approach has both benefits and challenges at the organizational and societal level (Rejeb *et al*., 2025; Rumman *et al*., 2025).

Martini *et al*. (2024) show that in intelligent production systems, Industry 5.0 is strongly linked to human-centered AI. Thus, in this sense, the implementation of AI, IoT, and AM turns industrial processes into more flexible, customized systems oriented toward workers' well-being. AI is no longer used only for technical optimization; it supports decision-making, quality control and assurance, and user experience improvement. An important result is the fact that AM, supported by AI and IoT, directly contributes to sustainability through reducing the waste of materials, production at demand, and efficient use of resources. Thereby, responsible AI serves as a catalyst for the circular economy, particularly in contexts such as supply chains, bioprinting, and the biomedical and food industries. Simultaneously, the literature underlines the critical role of advanced digital infrastructures, like 5G/6G networks, which allow low latency, high security, and real-time processing of large volumes of data. These technologies create opportunities for safe automation and human-machine cooperation, but introduce issues related to security, reliability, and governance.

The findings of authors Alves *et al*. (2023) and Vagiuc *et al*. (2025) point out that Industry 5.0 does not represent just a technological evolution, but a redefinition of the scope of industries. The focus shifted from purely economic performance to the impact on people and their surroundings. In this setting, responsible AI is essential for maintaining trust, acceptance, and social legitimacy of emergent technologies. Among the main identified obstacles are a lack of trust in AI systems, fears related to replacing human workers, cybersecurity risks, difficulties in integration with current systems, and weak training of the workforce. Alves *et al*. (2023) make a point that human-machine relation remains a major limitation, especially in the absence of transparent, explainable systems adapted to the individual characteristics of operators. On this matter, the principles of responsible AI – transparency, accountability, safety, and privacy – are becoming essential conditions for technology acceptance. At the same time, studies highlight opportunities such as workforce dynamics transformations, the development of digital competencies, lifelong learning, and increased human-machine association.

The studies carried out by authors Gunasekara *et al*. (2025) and Papagiannidis *et al*. (2025) point out that sometimes implementing responsible AI can be difficult because of the cultural (values and perceptions), ethical, and institutional differences. Papagiannidis *et al*. (2025) outline three types of

organizational practices, namely "structural", "procedural", and "relational". At a structural level, clarifying roles and responsibilities is important to prevent ethical risks and loss of stakeholder trust. At the procedural level, the need for solid data management, model evaluation, and risk oversight is discussed to prevent social and organizational prejudices. Interdisciplinary partnership and stakeholder involvement are critical. However, an overly cautious approach can slow innovation, which highlights the need for control and flexibility from the relational perspective.

The contribution of authors Göellner *et al*. (2024) indicates that the literature on ethical and responsible AI is broader, involving principles like fairness, transparency, accountability, and safety. Thus, a recurrent outcome is the existence of a gap between principles and practice. Even though numerous frameworks and tools have been proposed, their actual implementation in organizations remains limited. It is important to note that the authors conducted a comprehensive analysis of the synthesis type across many studies in the ethical and responsible AI fields. Through this examination, they contribute to multiple research directions, from theoretical studies and normative frameworks to technical tools and sectoral applications, offering a coherent image of the current state of this area. This technique of meta-analysis allows identification of the main recurrent themes, mutual limitations, and existing gaps in the practical application of responsible AI. Although there is a wide consensus of fundamental principles, their implementation remains insufficiently standardized and fragmented. Consequently, authors synthesized the contributions of many studies in the form of frameworks, models, and evaluation tools, essentially for reducing that gap.

Among the highlighted models explored by Göellner *et al*. (2024), "Chain of Trust" proposes a process-oriented approach in which each stage of an AI system's lifecycle (from projection and development to implementation and monitoring) contributes to building trust. This concept is relevant for Industry 5.0 because it underscores that trust is not just a result, but a sustained process tied to the responsibility of each involved stakeholder. Another important model is "MATCH", which explains how trust is communicated to users through transparency and interaction. This points out that users don't evaluate AI through performance alone but through signals of clarity, explainability, and perceived control. This aspect is essential in a human-oriented context, where technology acceptance depends on how people understand and interact with AI systems. The "Ethics by design" framework places ethics at the earliest stages of the lifecycle, not just at the final evaluation stage. Based on principles of responsible AI, it highlights the critical role of prototyping in establishing stronger ethical foundations. Its relevance lies in promoting ethical risk prevention, not just future correction. From a complementary perspective, "ECCOLA" introduces an innovative method based on gamification. This is intended to involve stakeholders in an active manner in the implementation process of responsible

AI. This approach is important because it acknowledges the organizational and social dimensions of responsible artificial intelligence, facilitating interdisciplinary dialogue and the collective assumption of ethical principles. For bias risks and fairness, the "FMEA-AI" model extends the classic "failure mode analysis" (FMEA) method to the AI context. This instrument allows the identification and assessment of the impact of algorithmic decisions on different groups, supporting organizations in managing ethical risks in a structured and quantifiable way. Besides, some studies provide a holistic perspective on the ethical maturity of organizations. The model highlights six important dimensions that enable the assessment of progress in operationalizing responsible AI, particularly useful for organizations implementing AI on a large scale and seeking alignment with ESG and Industry 5.0 core values.

Vinuesa *et al*. (2020) analyze the impact of artificial intelligence on the SDGs. The authors use a process based on expert consensus to evaluate whether AI can support or hinder the achievement of the 17 goals and the 169 associated targets. The results show that AI can assist in achieving 134 SDG targets, providing advanced tools for efficiency, productivity, and innovative solutions. At the same time, AI has the potential to hinder 59 targets, especially through the growth of inequalities or through the application of technologies without proper monitoring. The research highlights the critical need for policies, regulations, and oversight mechanisms to ensure the principles of responsible AI, so that advanced systems can truly contribute to sustainable development.

Finally, these models are relevant because they demonstrate the concrete applicability of responsible AI principles in a sensitive area with a direct impact on human life. These examples support the idea that responsible AI is not an abstract concept but can be contextually adapted, depending on the subject, domain, risks, and social needs. In addition, within Industry 5.0, they contribute to the development of efficient, but also transparent, socially accepted, and human-centered AI systems.

5. Conclusions

The present paper analyzed the connection between responsible artificial intelligence and sustainable management practices within Industry 5.0. Considering the findings, it can be affirmed that the research questions are met and the main hypothesis is supported.

The literature analysis highlights that these current industrial transformations require a combined approach in which technology, managerial decisions, and social values are treated as interlinked elements. By doing so, artificial intelligence can significantly contribute to supporting economic and organizational goals without compromising the balance among social and environmental aspects of sustainable development. In this setting, the focus is on how these systems influence managerial processes, the relationship between

humans and technology, and stakeholders' trust. Considering this aspect-oriented approach through responsibility offers a framework for risk management, unwanted effects limitation, and integration of ethical values in organizational practices.

Side by side, the literature brings into focus the role of management oriented toward sustainability as a balancing factor between innovation and responsibility. Practices that take into consideration the productive use of resources, the implications for the environment, and the workforce create the starting points for a coherent and accepted adoption of advanced technologies based on AI. Viewed this way, AI is not a goal in itself; it is rather a tool that supports broader organizational goals oriented toward the long run.

A key aspect highlighted in the literature on the specialty is the close relationship between responsible AI and sustainable management strategies. These concepts reinforce each other; responsible AI principles guide the development and use of technology, while responsible management ensures its integration into a harmonious organizational framework aligned with societal and surrounding expectations and needs. This complementarity is particularly relevant within Industry 5.0, where cooperation among humans and smart systems becomes a central element of competitiveness.

Due to its nature, this study has some limitations. First, the selection of literature may be influenced by the availability of published studies, which can lead to alternative perspectives or less favourable results. Second, the methodological diversity of the included studies can affect the consistency of the conclusions drawn. Lastly, the applicability of the outcomes may be limited by the specific contexts examined in existing studies.

Future research could contribute through empirical studies that analyze the concrete implementation of AI in industrial organizations, with a focus on effects on managerial processes, workers, and long-term performance. In addition, investigating governance frameworks could help adapt them to different industries and regions, and evaluate the long-term impact of AI-based decisions on organizations and society.

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INTELIGENȚA ARTIFICIALĂ RESPONSABILĂ ȘI PRACTICILE DE MANAGEMENT DURABIL ÎN CONTEXTUL INDUSTRIEI 5.0

(Rezumat)

Pornind de la paradigma Industriei 5.0, inteligența artificială (IA) nu se limitează la automatizare, ci susține colaborarea și funcționarea durabilă a organizațiilor. Prezenta lucrare se concentrează asupra conceptului de IA responsabilă, subliniind importanța valorilor morale, a transparenței, a managementului ecologic și a responsabilității sociale. Printr-o abordare calitativă bazată pe analiza literaturii de specialitate și pe studierea unor practici organizaționale reprezentative, studiul identifică principii și modalități de aplicare a IA responsabile. Rezultatele sugerează că IA responsabilă ajută organizațiile să ia decizii mai bune, să utilizeze resursele mai eficient, să susțină bunăstarea angajaților și să construiască încredere cu părțile interesate prin utilizarea unor practici clare, axate pe sustenabilitate. În acest fel, organizațiile trebuie să integreze din ce în ce mai mult principiile Industriei 5.0 centrate pe om în abordările lor strategice. Pentru a implementa Industria 5.0, este necesară o abordare echilibrată între utilizarea responsabilă a inteligenței artificiale și practicile de management durabil. Acest studiu oferă un punct de plecare conceptual pentru cercetători și organizații care susțin această direcție.