# Sustainability in the Era of Digital Transformation and Environmental Innovation

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***Abstract***

*Sustainability in the era of digital transformation and environmental innovation is an essential direction for the development of modern society. Environmental innovation focuses on the development of green technologies, renewable energy sources, and circular solutions that limit pollution and waste. Through digitization, organizations can monitor energy consumption, reduce carbon emissions, and make decisions based on real-time data. In this context, to carry out this study, we built a database from Web of Science, using VOSviewer software to generate a bibliometric map. This analysis allowed us to explore the predominant themes in recent academic literature, highlighting research trends and interconnections between keywords associated with sustainability, digital transformation, and environmental innovation. The purpose of this research is to identify the main areas of scientific interest, such as the use of digital technologies in support of sustainable development, the transition to green economies, and the role of technological innovation in reducing environmental impact, as well as their evolution over time.*

**Keywords:** *digital transformation, environmental innovation, sustainability, green technologies, sustainable development.*

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## 1. Introduction

Digital process innovation involves creating new ways of operating in organizations with the support of digital technologies, which subsequently

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influence how decisions are made, transactions are carried out, and work is done (Mikalef & Krogstie, 2018; Saldanha et al., 2017). Thus, digitization becomes a determining factor in contemporary economic and organizational transformations, contributing to the redefinition of traditional operating models. In this context, digitization creates the conditions for integrating sustainability objectives into organizational strategies, facilitating the efficient use of resources and the adoption of environmentally responsible business models (Huang, X., et al, 2025).

In an increasingly interconnected economic context, Luo (2021) stated that digitization and IT development in the economy stimulate globalization, allowing countries to benefit from each other's knowledge and capital. This global dynamic, in turn, highlights the need to align digital progress with sustainable development goals to ensure a balance between growth and responsibility.

From the perspective of public policy and economic strategies, Söderholm (2020) emphasized that an important part of the green economic strategy is promoting the development and implementation of sustainable technologies. Therefore, digital transformation cannot be analyzed in isolation, but in close connection with concerns for environmental protection and efficient use of resources.

In this context, the main objective of digital transformation is to facilitate substantial improvements and promote transformative adjustments that bring value to stakeholders (Barrutia & Echebarria, 2021). However, the benefits must be linked to the responsible use of natural resources so that technological progress does not generate long-term environmental costs. In the absence of such correlation, the depletion of natural resources has caused ecosystem destruction, biodiversity loss, deforestation, and environmental pollution. In this regard, Hussain et al. (2020) addressed the depletion of natural resources as a growing dilemma in recent decades. These global challenges require the adoption of alternative and sustainable economic models capable of reducing pressure on the environment (Bugheanu, A. M., et al, 2026).

In this context of transition, innovation is essential for navigating the digital world and exploiting new business opportunities, encouraging the adoption of the circular economy (Oluleye et al., 2023). Implementing this model directly contributes to reducing pressure on the environment and optimizing resource use.

Reinforcing this perspective, Zhao and Rasoulinezhad (2023) show that the efficient use of natural resources contributes to reducing the intensity of their exploitation, the amount of waste, and environmental pollution, thus supporting the mitigation of the challenges posed by climate change. In order to use natural resources efficiently, the concept of the circular economy needs to be expanded globally (Xu et al., 2023). This global expansion is directly supported by technological progress and digitalisation.

Thus, technological innovation has the potential to facilitate the achievement of sustainability goals by creating new solutions or technologies that are more environmentally friendly, improve resource efficiency, and promote sustainable economic progress (Zhang et al., 2019). Based on these theoretical

considerations, the following section presents a detailed analysis of the literature, focusing on the relationship between digital transformation, technological innovation, and sustainability.

Despite growing academic interest in the relationship between digital transformation, environmental innovation, and sustainability, the literature remains fragmented, characterized by sectoral approaches and diverse disciplinary perspectives (Năstase, M., et al, 2024). Although numerous studies analyze separately the impact of digitization or technological innovation on sustainable development, there is still a lack of research providing an overview of thematic developments, conceptual connections, and emerging research directions at the intersection of these fields.

In this context, the use of bibliometric analysis is justified by the high volume of publications and the need for a systematic and objective approach capable of highlighting the intellectual structure of the field, the relationships between key concepts, and the dynamics of scientific interest over time. Bibliometric analysis allows the identification of dominant themes, emerging trends, and insufficiently explored areas, thus providing relevant support for both researchers and decision-makers in the economic and political spheres.

Therefore, the purpose of this study is to systematically analyze the literature on sustainability in the context of digital transformation and environmental innovation, using bibliometric methods to map the main research directions, thematic evolution, and conceptual interconnections.

## 2. Literature review

Digital transformation represents a paradigm shift that affects industries and companies around the world (Fitzgerald et al., 2014; Ferraris et al., 2019), having a positive influence on the development of society (Popkova et al., 2022). In this sense, digitization is increasingly perceived as a catalyst for economic and social progress.

From a conceptual perspective, Plekhanov et al. (2022) define digitization as a transformation of the space of activities from physical to virtual. As this process advances, artificial intelligence (AI) can mimic complex reasoning and analysis tasks that were previously performed by human experts (Liu et al., 2020; Tschang & Mezquita, 2020), leading to a redefinition of the professional boundaries between human and machine expertise. In addition, the use of AI amplifies the ability of organizations to generate value from data, accelerating the discovery process (Fleming, 2019) and the development of new solutions and services (Lehrer et al., 2018; Lusch & Nambisan, 2015), even in environments characterized by a high degree of complexity (Cristache, N. et al, 2024)

At the same time, the process of digitization and the adoption of new technologies in companies involves significant organizational changes, which require different managerial skills and the development of innovative human resource management practices (Benson et al., 2002; Sousa & Rocha, 2019).

Therefore, the success of digital transformation is closely linked to the ability of human capital to adapt to new technological requirements (Zlati, M. L. et al, 2026).

From a sustainability perspective, innovation and technological advances play an essential role in facilitating the transition to a circular economy (Srisathan & Naruetharadhol, 2022), generating economic benefits such as job creation, increased competitiveness, and ensuring resource availability (Wu et al., 2021). Moreover, the circular economy also contributes to achieving social objectives by promoting equity and strengthening community resilience (Walker et al., 2021).

Complementing these perspectives, innovation accelerates the integration of information technology and production links at the enterprise level, leading to improved production capacity (Edwards-Schachter, 2018, Cristache, N., et al, 2023) and supporting the transition to more efficient and sustainable production models.

However, environmental degradation remains a critical issue, with direct consequences for human existence and as one of the major causes of global warming (Zhao et al., 2022). Globally, climate change manifests itself in extreme weather events, melting glaciers, rising sea levels, and increasing average temperatures. In this context of ecological pressure, digital technologies can support sustainable behaviors, their adoption being influenced by factors such as accessibility and ease of use (Casalo et al., 2019). Digital platforms contribute to waste reduction (Liao et al., 2019) and facilitate active consumer engagement. Complementarily, smartphone applications allow energy consumption to be monitored, eco-friendly products to be identified, and users to be connected with communities that share similar values (Paneru & Tarigan, 2023, Oana, P., et al, 2020).

Finally, the adoption of circular economy practices, focused on resource efficiency, waste reduction, and recycling, addresses the environmental dimension of sustainability and proves essential in sectors such as supply chain management (Askoxylakis, 2018), construction (Shooshtarian et al., 2022), and food waste management (Babbitt et al., 2021).

Overall, the literature highlights the central role of digital transformation and technological innovation in supporting sustainability and the transition to a circular economy (Si, C., Hassan, F. A., et al, 2025). However, the fragmentation of existing approaches indicates the need for systematic analyses that capture the interconnections between digitization, resource efficiency, and environmental impact, justifying the research approach of the present study.

## 3. Research methodology and stages

Through bibliometric analysis, this research provides an objective, clear, and comprehensive overview of the scientific literature on sustainability in the context of digital transformation and environmental innovation, highlighting the main research directions, dominant concepts, and relevant thematic connections. The quantitative approach allows the identification of emerging trends and areas of

strategic interest for both the academic community and practitioners involved in the development and implementation of sustainable strategies.

This study contributes to a deeper understanding of how digital transformation and technological innovation influence the transition to sustainable economic models and the circular economy. At the same time, the research highlights the interdependencies between digitization, organizational performance, and environmental impact, as well as gaps in the literature that may provide directions for future research.

In this context, the central research question is: *What are the main research directions and thematic trends highlighted in the literature on sustainability in the era of digital transformation and environmental innovation?*

The Web of Science database was used to collect scientific articles. In order to build the database, search filters were applied for keywords (handicrafts, industrial products, consumer behavior, brand authenticity, consumer perception), research areas (Business Economics, Operations Research Management Science), publication period (2020-2025), document type (article), publication language (English), and accessibility of the papers (open access).

After applying all the selection criteria, a database of 25 651 articles was obtained. The evolution of the number of specialized articles published during the analyzed period is presented in Table 1, highlighting a constant and growing interest of researchers in the topic of sustainability in the context of digital transformation and environmental innovation.

**Results of filtering the Web of Science scientific publications database, distribution over the period 2020-2025**

**Table 1**

| Year of publication | No. of publications |
|---|---|
| 2025 | 7151 |
| 2024 | 5507 |
| 2023 | 4357 |
| 2022 | 3593 |
| 2021 | 2906 |
| 2020 | 2137 |

*Source:* own processing based on data from Web of Science

The bibliometric map generated using VOSviewer software highlights the conceptual structure of the literature on sustainability in the context of digital transformation and environmental innovation, as well as the relationships between the main keywords analyzed. The size of the nodes reflects the frequency of occurrence of the terms, and the links between them indicate the intensity of co-occurrence in scientific publications. The analysis reveals the existence of several distinct but interconnected thematic clusters, suggesting the interdisciplinary nature of the field.

**The red cluster** is centered around the concepts of "circular economy", "sustainability", "innovation", "waste", and "artificial intelligence". This cluster reflects the emphasis in recent literature on the transition to a circular economy, the role of innovation and emerging technologies, such as artificial intelligence, in reducing waste and promoting sustainability. The presence of the term creation suggests that research is oriented towards generating sustainable value.

**The green cluster** is dominated by terms such as "digital transformation", "environmental sustainability", "performance", "impact", and "dynamic capabilities". This group highlights the link between digital transformation and organizational performance, emphasizing the importance of dynamic capabilities in adapting companies to sustainability requirements. The high connectivity of the term digital transformation indicates its central role in the analyzed literature.

**The blue cluster** includes concepts such as "technology", "financial performance", "eco-innovation", "environmental innovation", "absorptive capacity", and "empirical evidence". This cluster reflects empirical approaches that analyze the impact of technology and eco-innovation on financial and environmental performance, highlighting the importance of organizations' absorptive capacity in capitalizing on innovations.

**The yellow cluster** brings together terms such as "management", "green", "strategy", and "determinants", suggesting a managerial and strategic orientation of the research. This cluster emphasizes the role of managerial decisions and green strategies in integrating sustainability and digital transformation at the organizational level.

The central positioning of the terms "*sustainability", "circular economy", "digital transformation",* and "*environmental sustainability"* indicates that they represent the conceptual core of the field. The dense links between clusters suggest that the literature treats sustainability not as an isolated concept, but as the result of the interaction between technology, innovation, management, and economic performance.

In particular, the connections between digital transformation and eco-innovation, respectively environmental sustainability, indicate an emerging trend to analyze digitization as a facilitator of ecological transition. Also, the association of the terms artificial intelligence and circular economy suggests a recent direction of research, still under development, which may represent an opportunity for future studies.

Although the literature highlights the positive relationship between digital transformation, environmental innovation, and performance, the bibliometric map suggests gaps in the holistic integration of these dimensions, particularly regarding the mechanisms through which digital technologies support the circular economy in the long term. These observations justify the need for further analysis and support the relevance of the present study.

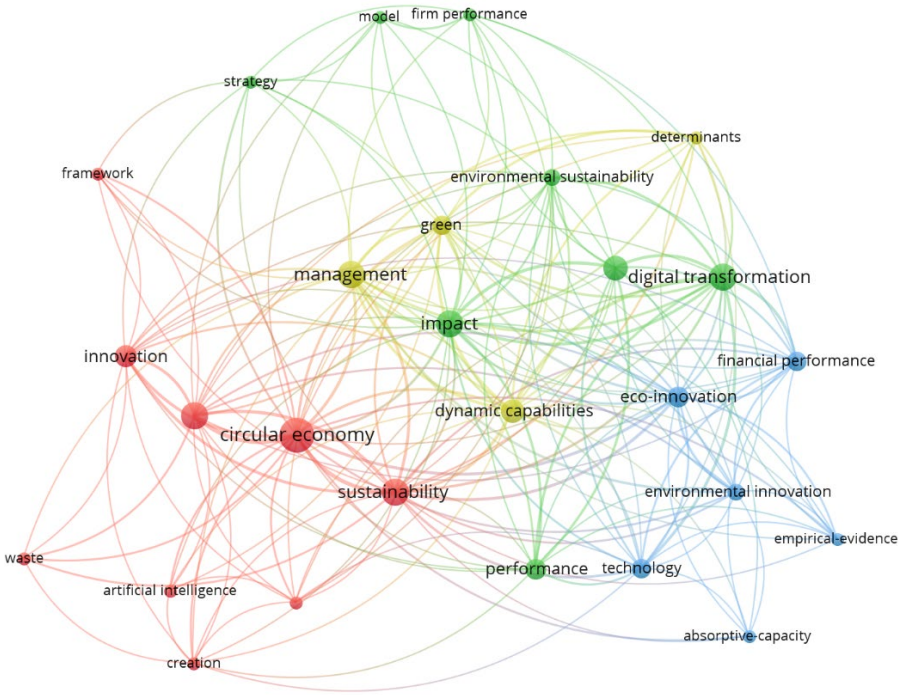


**Figure 1. Network Visualization. Source: VOSviewer software output version 1.6.19**

**The bibliometric overlay visualization map** highlights the evolution over time of the main keywords in the analyzed literature on sustainability, digital transformation, and environmental innovation. The colors of the nodes reflect the average year of occurrence of the terms, ranging from shades of blue (older topics) to green and yellow (more recent topics), according to the time scale indicated.

Terms such as "sustainability", "circular economy", "waste", "framework", "strategy", and "innovation" are represented in shades of blue and blue-green, indicating that they constitute the theoretical foundations of the field, having been intensively studied in 2023. These concepts reflect the initial concerns of the literature on sustainable development models and the transition to a circular economy.

Also, concepts such as artificial intelligence and creation appear in proximity to these established themes, suggesting an early stage of integration of advanced technologies into discussions about sustainability. Terms highlighted in green, such as "management", "impact", "dynamic capabilities", "performance", and "environmental sustainability", indicate research directions that are gaining momentum. These themes reflect the growing interest in analyzing the mechanisms through which digital transformation and innovation influence organizational performance and environmental impact. The central positioning of these concepts suggests their role as links between traditional theoretical approaches and emerging research directions.

Terms such as “digital transformation”, “eco-innovation”, “environmental innovation”, “financial performance”, “absorptive capacity”, “technology”, “determinants”, and “empirical evidence” are represented in shades of yellow, indicating that they are the most recent and emerging research topics (approximately 2024–2025).

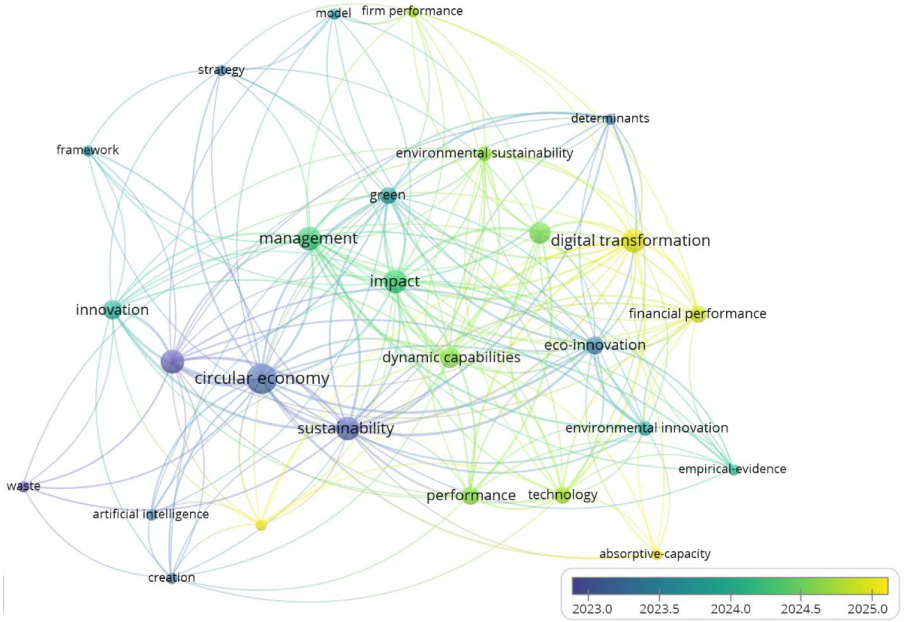


**Figure 2. Overlay visualization. Source: VOSviewer software output version 1.6.19**

**The item density visualization bibliometric map** highlights the intensity of research associated with the analyzed keywords through variations in color and brightness. Areas of high intensity indicate topics frequently addressed in the literature, while darker areas suggest less explored themes.

The most intense areas are concentrated around the terms “circular economy” and “sustainability”, which appear in shades of red and yellow. This indicates that these concepts are central to the analyzed literature and have been intensively investigated in recent studies. Their close association suggests an integrated approach to sustainability through the lens of the circular economy. Also, terms such as “*management”, “impact”,* and *“dynamic capabilities”* show high levels of density, indicating significant interest in the role of management and organizational capabilities in implementing sustainable strategies.

Concepts such as “*digital transformation”, “environmental sustainability”, “performance”, and “green”* appear in areas of moderate density, reflecting research directions that are developing and consolidating. These themes suggest a transition in the literature toward analyzing how digitization and green strategies influence organizational performance and environmental impact.

The presence of the term strategy in proximity to these areas indicates the importance of aligning digital strategies with sustainability goals. Terms such as "artificial intelligence", "eco-innovation", "environmental innovation", "absorptive capacity", "empirical evidence", and *technology* appear in less intense areas, suggesting that these topics are relatively recent or insufficiently investigated in the integrated context of sustainability and digital transformation. In particular, the peripheral positioning of the terms artificial intelligence and absorptive capacity indicates clear opportunities for future research, especially regarding the role of advanced technologies in supporting the circular economy and sustainable performance.

Overall, the density map highlights a well-established literature around traditional concepts of sustainability and the circular economy, but also a progressive evolution towards the integration of digital transformation and technological innovation. This distribution suggests a maturing of the field, along with the emergence of new directions that require further exploration.

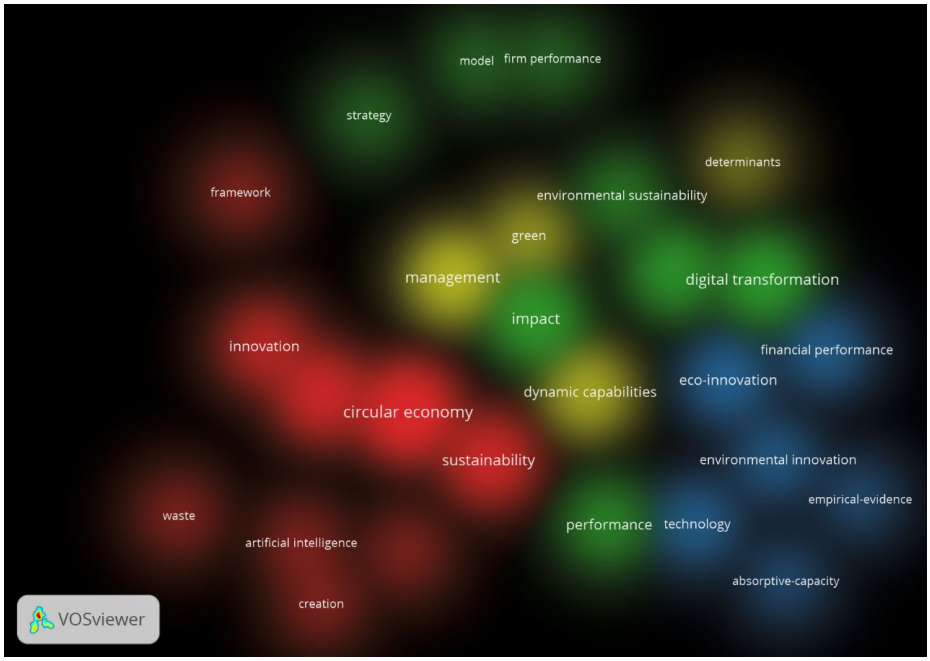


**Figure 3. Item density visualization. Source: VOSviewer software output version 1.6.19**

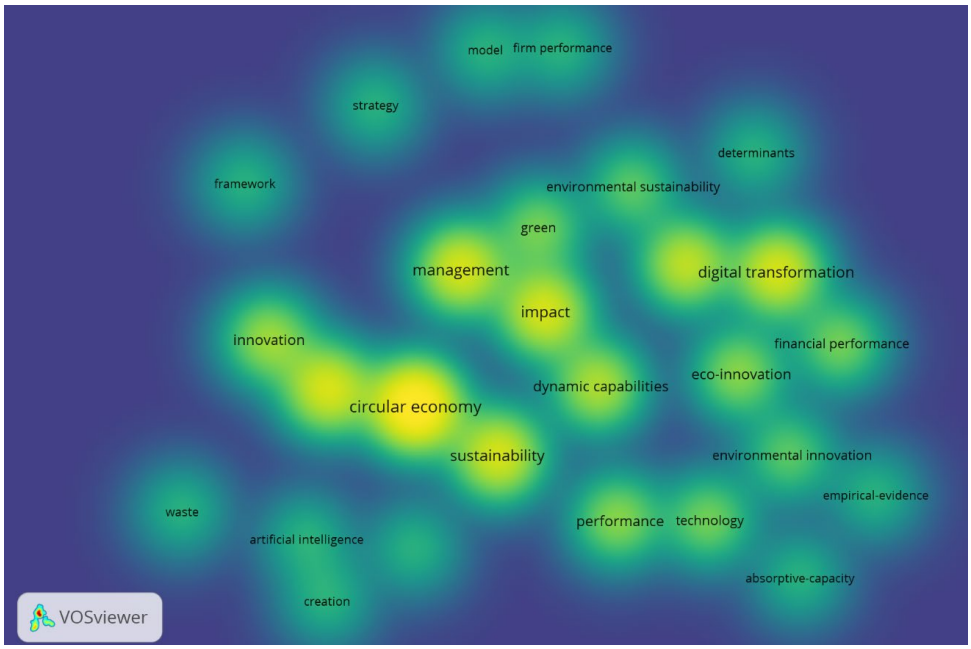


**Figure 4. Density visualization cluster. Source: VOSviewer software output version 1.6.19**

**Cluster 1 (red)** groups together key concepts associated with sustainability, the circular economy, and innovation geared towards sustainable development. The central term of this cluster is "circular economy," which has the highest number of occurrences (20), a high number of links (22), and a total link strength of 59, highlighting its dominant position in the conceptual network. This result suggests that the circular economy is an essential pillar in the analysed literature, being frequently correlated with sustainability objectives and efficient resource management practices.

Similarly, the concepts of "sustainability" and "sustainable development" have significant values in terms of both occurrences and link strength, indicating that research in this cluster approaches sustainability from an integrated perspective that includes economic, social, and environmental dimensions. The presence of the terms "innovation" and "sustainable innovation" highlights the role of innovation as a key mechanism for facilitating the transition to sustainable economic models, while the appearance of the word "waste" reflects the concern for waste reduction and recovery within the circular economy.

In addition, the inclusion of the terms "artificial intelligence," "framework," and "creation" indicates the emergence of modern technological and conceptual approaches used to develop analytical frameworks and innovative solutions designed to support the implementation of circular economy and sustainable development principles.

Overall, Cluster 1 (Table 2) highlights a research direction focused on integrating the circular economy, innovation, and emerging technologies in

promoting sustainability and sustainable development, outlining a solid conceptual framework for addressing contemporary environmental challenges.

**Cluster 1 (red)**

**Table 2**

| Keyword | Cluster | Links | Total link strength | Occurrences |
|---|---|---|---|---|
| artificial intelligence | 1 | 7 | 8 | 3 |
| circular economy | | 22 | 59 | 20 |
| creation | | 12 | 13 | 3 |
| framework | | 7 | 8 | 3 |
| innovation | | 15 | 26 | 8 |
| sustainability | | 23 | 55 | 12 |
| sustainable development | | 18 | 37 | 12 |
| sustainable innovation | | 12 | 13 | 3 |
| waste | | 6 | 9 | 3 |

*Source:* own processing based on data from VOSviewer software version 1.6.19

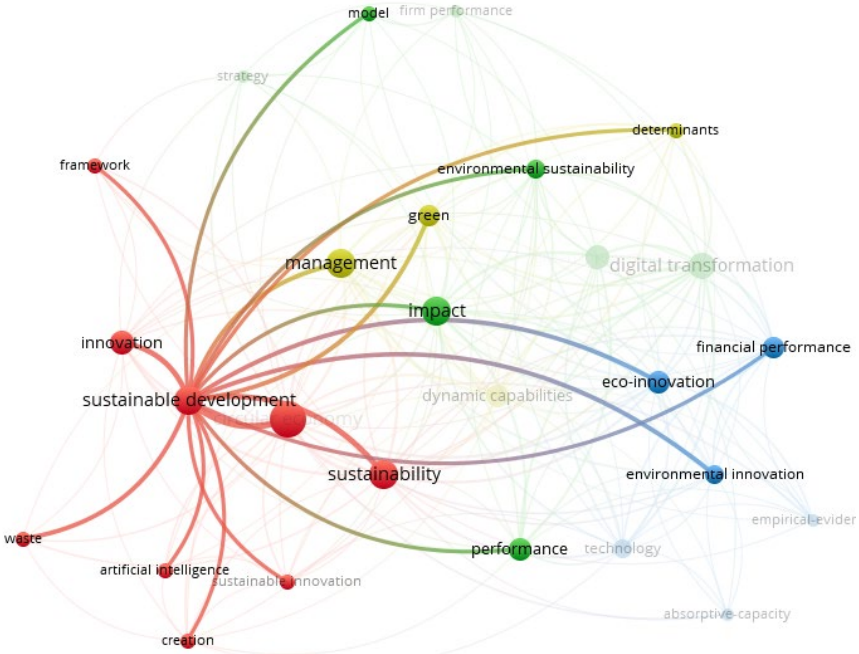


**Figure 5. Cluster 1 (red). Source: VOSviewer software output version 1.6.19**

**Cluster 2 (green)** highlights a thematic focus on digital transformation and organizational performance, correlated with environmental sustainability and green innovation. The central keyword of this cluster is "digital transformation," which has a high number of links (18), a total link strength of 46, and 12 occurrences, indicating its pivotal role in the conceptual network analyzed. This result suggests

that digital transformation is frequently associated in the literature with multiple dimensions of performance and sustainability.

Similarly, the terms "impact" and "green innovation" have significant values in terms of both the number of links and their total strength, reflecting the increased interest of researchers in the effects of digital transformation on green innovation and the environment. The presence of the keyword "environmental sustainability" confirms that this cluster explicitly integrates the ecological dimension into the analysis of company performance.

Furthermore, the terms "firm performance," "performance," and "strategy" indicate that digital transformation and green innovation are approached not only from a technological perspective, but also from a strategic one, being analyzed as determinants of organizational performance. The appearance of the words "model" and "impact" suggests the existence of conceptual frameworks and empirical models used to assess the relationships between digitization, sustainability, and economic outcomes.

Overall, Cluster 2 (Table 3) reflects an important research direction that highlights the role of digital transformation as a strategic tool for stimulating green innovation, improving business performance, and promoting environmental sustainability.

**Cluster 2 (green)**

**Table 3**

| Keyword | Cluster | Links | Total link strength | Occurrences |
|---|---|---|---|---|
| digital transformation | 2 | 18 | 46 | 12 |
| environmental sustainability | | 17 | 23 | 5 |
| firm performance | | 10 | 11 | 3 |
| green innovation | | 15 | 27 | 10 |
| impact | | 24 | 48 | 12 |
| model | | 8 | 9 | 3 |
| performance | | 14 | 22 | 7 |
| strategy | | 10 | 11 | 3 |

*Source:* own processing based on data from VOSviewer software version 1.6.19

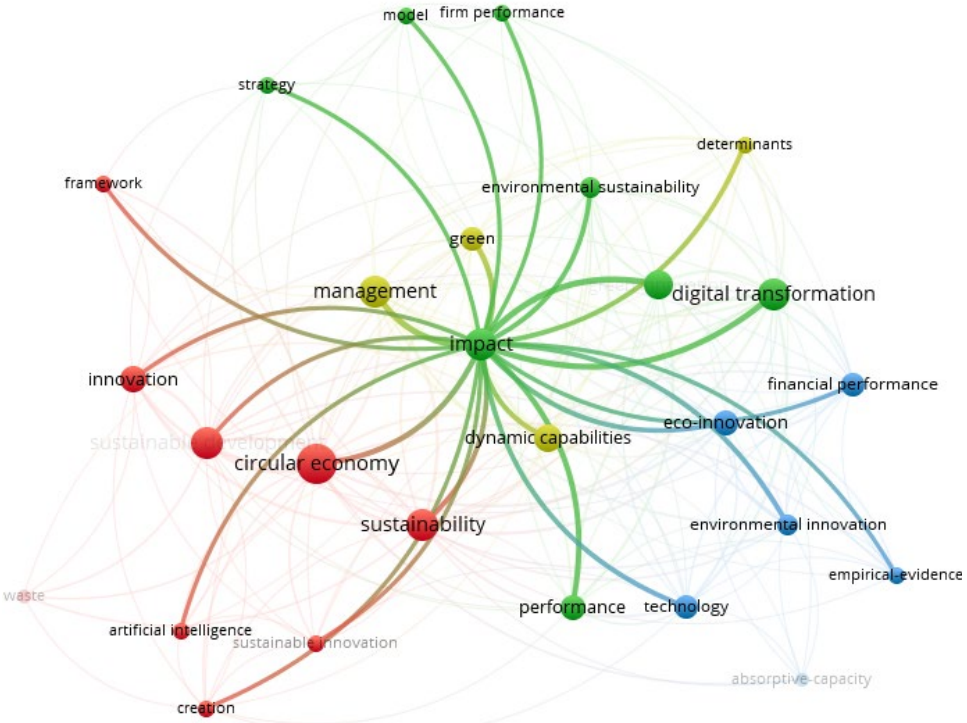


**Figure 6. Cluster 2 (green). Source: VOSviewer software output version 1.6.19**

**Cluster 3 (blue)** highlights the relationship between absorption capacity, eco-innovation, and financial performance in a context dominated by the use of technology and empirical validation of results.

The key concept of "eco-innovation" occupies a central position within this cluster, with a high number of links (18), a total link strength of 37, and 7 occurrences, indicating its essential role in connecting the technological and economic dimensions of sustainability. Similarly, the term "environmental innovation" confirms the literature's interest in the development and implementation of innovative solutions aimed at reducing environmental impact.

The presence of the concept of "absorptive capacity" suggests the importance of organizations' ability to identify, assimilate, and capitalize on external knowledge as a determining factor for the success of eco-innovations. This dimension is closely related to the term "technology," which highlights the role of technology as a facilitator of innovation processes and organizational performance improvement.

Furthermore, the inclusion of the keyword "financial performance" indicates that the studies in this cluster analyze the impact of eco-innovation on the economic results of companies, suggesting a positive link between sustainability and financial performance. The term "empirical evidence" emphasizes the focus of

research on the empirical validation of these relationships through econometric models and quantitative analyses.

Overall, Cluster 3 (Table 4) reflects a research direction focused on the mechanisms through which the absorption capacity and use of technology stimulate eco-innovation and contribute to improving financial performance, providing relevant empirical evidence to support sustainable development strategies.

**Cluster 3 (blue)**

**Table 4**

| Keyword | Cluster | Links | Total link strength | Occurrences |
|---|---|---|---|---|
| absorptive-capacity | 3 | 8 | 9 | 3 |
| eco-innovation | | 18 | 37 | 7 |
| empirical-evidence | | 11 | 13 | 3 |
| environmental innovation | | 15 | 24 | 5 |
| financial performance | | 16 | 25 | 6 |
| technology | | 17 | 22 | 6 |

***Source:*** **own processing based on data from VOSviewer software version 1.6.19**

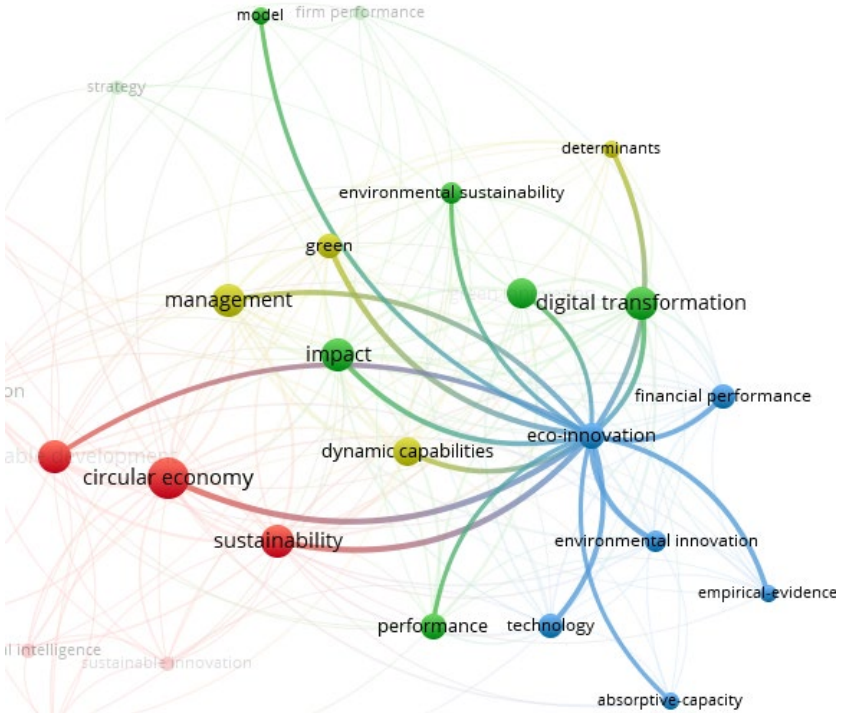


**Figure 7. Cluster 3 (blue). Source: VOSviewer software output version 1.6.19**

**Cluster 4 (yellow)** highlights the role of dynamic capabilities and management in supporting the transition to green practices and sustainable performance. The central concept of this cluster is "management," which has the

highest number of occurrences (12), a high number of links (21), and a total link strength of 45, indicating its dominant position in the network structure. This result suggests that the literature pays particular attention to the role of managerial decisions and leadership practices in the implementation of green strategies.

Similarly, the term "dynamic capabilities" has significant values in terms of the number of links (20) and their total strength (42), highlighting the importance of organizations' ability to integrate, reconfigure, and adapt internal and external resources in response to environmental pressures and technological changes. This perspective is closely related to the term "green," which reflects the strategic orientation of firms toward environmentally friendly practices and objectives.

The presence of the keyword "determinants" indicates the interest of research in identifying the determining factors that influence the adoption of green management strategies and the development of dynamic capabilities. Thus, this cluster approaches sustainability from an organizational and decision-making perspective, emphasizing the internal mechanisms that facilitate ecological transition.

Overall, Cluster 4 reflects a research direction focused on the role of management and dynamic capacities in promoting green strategies, highlighting the importance of organizational and managerial factors in achieving sustainability goals.

**Cluster 4 (yellow)**

**Table 4**

| Keyword | Cluster | Links | Total link strength | Occurrences |
|---|---|---|---|---|
| determinants | 4 | 12 | 20 | 3 |
| dynamic capabilities | | 20 | 42 | 9 |
| green | | 18 | 36 | 6 |
| management | | 21 | 45 | 12 |

*Source:* own processing based on data from VOSviewer software version 1.6.19

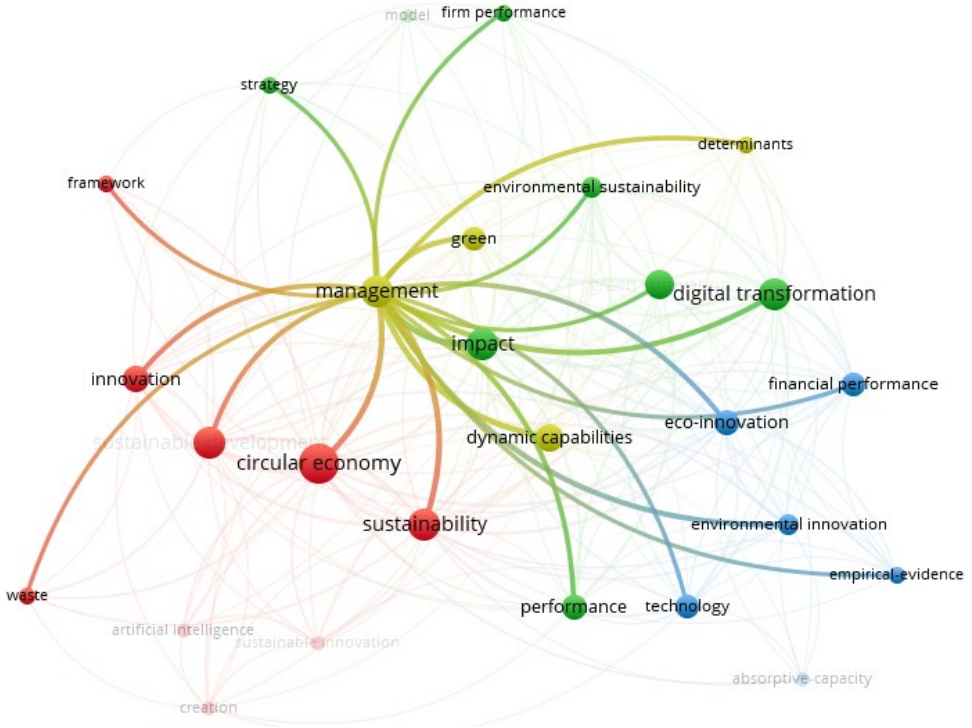


**Figure 8. Cluster 4 (yellow). Source: VOSviewer software output version 1.6.19**

## 4. Contributions, implications, and future directions

This study makes a relevant contribution to the literature by using bibliometric analysis to structure and systematize research on the relationship between technological innovation, digital transformation, and sustainability. The identification of the four thematic clusters highlights that these concepts are not addressed in isolation but form an interdependent framework in which the circular economy, green innovation, organizational capabilities, and economic performance are mutually supportive.

From a practical perspective, the results suggest that organizations can achieve sustainable competitive advantages by integrating digital technologies with circular economy and green innovation strategies. In this context, the role of management and dynamic capabilities becomes essential for adapting to environmental changes and capitalizing on the opportunities generated by digital transformation. At the same time, for public decision-makers, the conclusions highlight the importance of formulating policies that encourage investment in digital technologies, green innovation, and the efficient use of natural resources as pillars of sustainable development.

However, the study has certain limitations, determined by its dependence on the analyzed database and the selection of keywords used, which may influence the structure of the identified conceptual network. Furthermore, bibliometric

analysis allows the relationships between concepts to be highlighted, but does not provide a detailed assessment of the content of each paper included in the analysis.

In this regard, future research could extend the analysis by including other databases or by combining the bibliometric method with qualitative and empirical analyses. Future studies could also investigate, at the national level, the concrete impact of emerging digital technologies on environmental and economic performance, thus contributing to a deeper understanding of the mechanisms that support the transition to sustainable development models.

## 5. Conclusions

Researchers around the world have examined the relationship between technological innovation and economic growth, as technological innovation provides advantages to firms by creating new economic opportunities. Chaudhry et al. (2021) argue that innovation is an important driver of growth; similarly, Aali Bujari & Venegas Martínez (2016) state that technological innovation and economic growth are interconnected in the long term. These findings highlight that technological progress is not just a cyclical factor, but a structural element of sustainable economic development.

Technological innovation includes changes in products, services, production methods, or business models that increase efficiency and effectiveness or introduce new offerings to the market (Sutrisno et al., 2023). This definition emphasizes the multidimensional nature of innovation, with impacts at both the microeconomic and macroeconomic levels. Therefore, technological innovation has the potential to contribute significantly to economic growth and to enhance efficiency and competitiveness for both countries and organizations (Mohamed, Liu & Nie, 2022). In this context, investment in technology becomes a key factor in strengthening competitive advantage and supporting the transition to more sustainable economic models.

Alongside the economic dimension, the literature highlights the role of the circular economy in the efficient use of natural resources. Valenturf & Purnell (2021) consider the circular economy to be the most appropriate system for supporting resource efficiency, while Melo et al. (2022) emphasize that it represents a revised version of the linear economy. Through policies and strategies based on reuse and recycling, the circular economy contributes to reducing pressure on the environment and increasing long-term sustainability.

At the same time, digital technology has been essential in achieving business objectives, and its pervasive effects have enabled the transformation of entire industries (Nylen & Holmstrom, 2015), leading to the development of innovative products, services, processes, and business models. Digitalization is thus emerging as a link between technological innovation and sustainability, facilitating the adoption of more resource-efficient practices.

In this regard, Kalar et al. (2021) emphasized the importance of resource efficiency for the protection of natural resources, considering it an essential tool for

reducing the negative impact of extraction on the environment. Wang & Razzaq (2022) highlight the role of efficient use of natural resources in supporting green growth by linking GDP growth to environmental concerns. These perspectives suggest that sustainable development is contingent on the coherent integration of technological innovation, digitalization, and resource efficiency.

Overall, the conclusions of this study highlight that sustainability in the era of digital transformation and environmental innovation cannot be achieved without an integrated approach that combines technological progress, the circular economy, and the responsible use of natural resources. The bibliometric analysis provides an overview of the major research directions and confirms the scientific community's growing interest in these interdependencies. At the same time, the results indicate the need for further research on the concrete impact of digital technologies on environmental and economic performance, as well as on the implementation of sustainable practices at the organizational and national levels.

## References


1. Aali Bujari, A., & Venegas Martínez, F. (2016). Technological innovation and economic growth in Latin America. *Revista mexicana de economía y finanzas*, *11*(2), 77-89.
2. Askoxylakis, I. (2018, May). A framework for pairing circular economy and the Internet of Things. In *2018 IEEE international conference on communications (ICC)* (pp. 1-6). IEEE.
3. Babbitt, C. W., Babbitt, G. A., & Oehman, J. M. (2021). Behavioral impacts on residential food provisioning, use, and waste during the COVID-19 pandemic. *Sustainable Production and Consumption*, *28*, 315-325.
4. Barrutia, J. M., & Echebarria, C. (2021). Effect of the COVID-19 pandemic on public managers' attitudes toward digital transformation. *Technology in Society*, *67*, 101776.
5. Benson, A. D., Johnson, S. D., & Kuchinke, K. P. (2002). The use of technology in the digital workplace: A framework for human resource development. *Advances in Developing Human Resources*, *4*(4), 392-404.
6. Bugheanu, A. M., Pricopoaia, O., Beldiman, C. M., Popa, I., Cristache, N., Iancu, D., & Lazarescu, I. (2026). The implications of innovation in traditional industries: Revitalizing mature economic sectors. *Journal of Innovation & Knowledge*, *14*, 100959.
7. Casaló, L. V., Escario, J. J., & Rodríguez-Sánchez, C. (2019). Analyzing differences between different types of pro-environmental behaviors: Do attitude intensity and type of knowledge matter?. *Resources, Conservation and Recycling*, *149*, 56-64.
8. Casaló, L. V., Escario, J. J., & Rodríguez-Sánchez, C. (2019). Analyzing differences between different types of pro-environmental behaviors: Do attitude intensity and type of knowledge matter?. *Resources, Conservation and Recycling*, *149*, 56-64.
9. Chaudhry, I. S., Ali, S., Bhatti, S. H., Anser, M. K., Khan, A. I., & Nazar, R. (2021). Dynamic common correlated effects of technological innovations and institutional performance on environmental quality: Evidence from East-Asia and Pacific countries. *Environmental Science & Policy*, *124*, 313-323.

10. Cristache, N., Pricopoaia, O., Năstase, M., Dobrea, R. C., Ibinceanu, M. O., & Coroban, L. (2024). The Impact of Digitalisation on The Performance of Companies at National Level. *Economic Computation & Economic Cybernetics Studies & Research*, *58*(2).
11. Cristache, N., Ivan, I., Chihaia, A. S., Matei, A., & Stanciu, T. I. (2023). Analysis of the Impact of Barriers on the Careers of Women Managers and Entrepreneurs. *Annals of the University Dunarea de Jos of Galati: Fascicle: I, Economics & Applied Informatics*, *29*(3).
12. de Melo, T. A., de Oliveira, M. A., de Sousa, S. R., Vieira, R. K., & Amaral, T. S. (2022). Circular economy public policies: A systematic literature review. *Procedia Computer Science*, *204*, 652-662.
13. Edwards-Schachter, M. (2018). The nature and variety of innovation. *International Journal of Innovation Studies*, *2*(2), 65-79.
14. Ferraris, A., Mazzoleni, A., Devalle, A., & Couturier, J. (2019). Big data analytics capabilities and knowledge management: impact on firm performance. *Management Decision*, *57*(8), 1923-1936.
15. Fitzgerald, M., Kruschwitz, N., Bonnet, D., & Welch, M. (2014). Embracing digital technology: A new strategic imperative. *MIT sloan management review*, *55*(2), 1.
16. Huang, X., Ahmad, W., Umair, M., Antohi, V. M., Fortea, C., & Cristache, N. (2025). Foreign direct investment, trade openness and environmental pollution in Pakistan: does renewable energy mitigate environmental degradation?. *Frontiers in Environmental Science*, *13*, 1618767.
17. Hussain, J., Khan, A., & Zhou, K. (2020). The impact of natural resource depletion on energy use and CO2 emission in Belt & Road Initiative countries: a cross-country analysis. *Energy*, *199*, 117409.
18. Kalar, B., Primc, K., Erker, R. S., Dominko, M., & Ogorevc, M. (2021). Resource efficiency in the innovative and conservative stages of a firm's evolution. *Resources, Conservation and Recycling*, *164*, 105112.
19. Lehrer, C., Wieneke, A., Vom Brocke, J. A. N., Jung, R., & Seidel, S. (2018). How big data analytics enables service innovation: materiality, affordance, and the individualization of service. *Journal of Management Information Systems*, *35*(2), 424-460.
20. Liao, F., Molin, E., Timmermans, H., & van Wee, B. (2019). Consumer preferences for business models in electric vehicle adoption. *Transport Policy*, *73*, 12-24.
21. Liu, J., Chang, H., Forrest, J. Y. L., & Yang, B. (2020). Influence of artificial intelligence on technological innovation: Evidence from the panel data of china's manufacturing sectors. *Technological Forecasting and Social Change*, *158*, 120142.
22. Luo, Y. (2021). New OLI advantages in digital globalization. *International Business Review*, *30*(2), 101797.
23. Lusch, R. F., & Nambisan, S. (2015). Service innovation. *MIS quarterly*, *39*(1), 155-176.
24. Mikalef, P., & Krogstie, J. (2018, August). Big data analytics as an enabler of process innovation capabilities: a configurational approach. In *International conference on business process management* (pp. 426-441). Cham: Springer International Publishing.
25. Mohamed, M. M. A., Liu, P., & Nie, G. (2022). Causality between technological innovation and economic growth: Evidence from the economies of developing countries. *Sustainability*, *14*(6), 3586.
26. Năstase, M., Croitoru, G., Florea, N. V., Cristache, N., & Lile, R. (2024). The perceptions of employees from Romanian companies on adoption of artificial intelligence in recruitment and selection processes. *Amfiteatru Economic*, *26*(66), 421-439.

27. Nylén, D., & Holmström, J. (2015). Digital innovation strategy: A framework for diagnosing and improving digital product and service innovation. *Business horizons*, *58*(1), 57-67.
28. Nylén, D., & Holmström, J. (2015). Digital innovation strategy: A framework for diagnosing and improving digital product and service innovation. *Business horizons*, *58*(1), 57-67.
29. Oana, P., Mihai, C., Nicoleta, C., & Cosmin, M. (2020). The impact of excessive online shopping on consumer behaviour. *Risk in Contemporary Economy*, 35-46.
30. Oluleye, B. I., Chan, D. W., & Antwi-Afari, P. (2023). Adopting Artificial Intelligence for enhancing the implementation of systemic circularity in the construction industry: A critical review. *Sustainable Production and Consumption*, *35*, 509-524.
31. Paneru, C. P., & Tarigan, A. K. (2023). Reviewing the impacts of smart energy applications on energy behaviours in Norwegian households. *Renewable and Sustainable Energy Reviews*, *183*, 113511.
32. Plekhanov, D., Franke, H., & Netland, T. H. (2023). Digital transformation: A review and research agenda. *European management journal*, *41*(6), 821-844.
33. Popkova, E. G., De Bernardi, P., Tyurina, Y. G., & Sergi, B. S. (2022). A theory of digital technology advancement to address the grand challenges of sustainable development. *Technology in Society*, *68*, 101831.
34. Saldanha, T. J., Mithas, S., & Krishnan, M. S. (2017). Leveraging customer involvement for fueling innovation. *MIS quarterly*, *41*(1), 267-286.
35. Shooshtarian, S., Maqsood, T., Caldera, S., & Ryley, T. (2022). Transformation towards a circular economy in the Australian construction and demolition waste management system. *Sustainable Production and Consumption*, *30*, 89-106.
36. Si, C., Hassan, F. A., Antohi, V. M., Ahmad, W., Fortea, C., Cristache, N., ... & Zlati, M. L. (2025). Informal economy and environmental degradation in developing countries: the conditioning role of institutional quality. *Frontiers in Environmental Science*, *13*, 1645194.
37. Söderholm, P. (2020). The green economy transition: the challenges of technological change for sustainability. *Sustainable Earth*, *3*(1), 6.
38. Söderholm, P. (2020). The green economy transition: the challenges of technological change for sustainability. *Sustainable Earth*, *3*(1), 6.
39. Sousa, M. J., & Rocha, Á. (2019). Skills for disruptive digital business. *Journal of Business Research*, *94*, 257-263.
40. Srisathan, W. A., & Naruetharadhol, P. (2022). A COVID-19 disruption: The great acceleration of digitally planned and transformed behaviors in Thailand. *Technology in Society*, *68*, 101912.
41. Sutrisno, S., Kuraesin, A. D., Siminto, S., Irawansyah, I., & Ausat, A. M. A. (2023). The Role of Information Technology in Driving Innovation and Entrepreneurial Business Growth. *Jurnal Minfo Polgan*, *12*(1), 586-597.
42. Tschang, F. T., & Almirall, E. (2021). Artificial intelligence as augmenting automation: Implications for employment. *Academy of Management Perspectives*, *35*(4), 642-659.
43. Velenturf, A. P., & Purnell, P. (2021). Principles for a sustainable circular economy. *Sustainable production and consumption*, *27*, 1437-1457.
44. Velenturf, A. P., & Purnell, P. (2021). Principles for a sustainable circular economy. *Sustainable production and consumption*, *27*, 1437-1457.

45. Walker, A. M., Opferkuch, K., Lindgreen, E. R., Simboli, A., Vermeulen, W. J., & Raggi, A. (2021). Assessing the social sustainability of circular economy practices: Industry perspectives from Italy and the Netherlands. *Sustainable Production and Consumption*, *27*, 831-844.
46. Wang, Z., & Razzaq, A. (2022). Natural resources, energy efficiency transition and sustainable development: evidence from BRICS economies. *Resources Policy*, *79*, 103118.
47. Wu, C. Y., Hu, M. C., & Ni, F. C. (2021). Supporting a circular economy: Insights from Taiwan's plastic waste sector and lessons for developing countries. *Sustainable production and consumption*, *26*, 228-238.
48. Xu, A., Qian, F., Ding, H., & Zhang, X. (2023). Digitalization of logistics for transition to a resource-efficient and circular economy. *Resources Policy*, *83*, 103616.
49. Zhang, Y., Khan, U., Lee, S., & Salik, M. (2019). The influence of management innovation and technological innovation on organization performance. A mediating role of sustainability. *Sustainability*, *11*(2), 495.
50. Zhao, L., & Rasoulinezhad, E. (2023). Role of natural resources utilization efficiency in achieving green economic recovery: evidence from BRICS countries. *Resources Policy*, *80*, 103164.
51. Zhao, X., Ramzan, M., Sengupta, T., Sharma, G. D., Shahzad, U., & Cui, L. (2022). Impacts of bilateral trade on energy affordability and accessibility across Europe: does economic globalization reduce energy poverty?. *Energy and Buildings*, *262*, 112023.
52. Zlati, M. L., Fortea, C., Antohi, V. M., Cristache, N., Dinca, M. S., & Balsalobre-Lorente, D. (2026). Refreshing the design of a regional economic growth model in the context of the new digital decade. *Technological and Economic Development of Economy,* 32(2), 336-373.