



Digital transformation and the rise of digital leadership: A bibliometric science mapping analysis

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ABSTRACT

Digital transformation has become a strategic phenomenon that fundamentally changes the way organizations operate, innovate, and are led. The development of digital technologies such as artificial intelligence, big data, and cloud computing requires organizations to not only adapt technically but also make significant changes in leadership paradigms. This study aims to analyze the development of scientific literature related to the impact of digital transformation on leadership using a bibliometric approach. The research data was obtained from the Scopus database with a total of 106 articles published in the period 2021–2025 and selected using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method. The analysis was conducted through performance analysis and science mapping with the help of bibliometric visualization software. The results show a very significant growth in publications, indicating increasing academic attention to digital leadership. The findings also reveal that leadership in the digital era is multidisciplinary, collaborative, and dynamic, and is influenced by the interaction between technology, organizational culture, and individual leader capabilities. However, there are still research gaps related to the dimensions of ethics, sustainability, and the local context of the organization. This study confirms that the success of digital transformation is highly dependent on the readiness and capabilities of holistic and contextual digital leadership.

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1. INTRODUCTION

The industrial revolution has brought fundamental changes to the way organizations operate and compete in the global marketplace. Digital transformation has become an unavoidable phenomenon, forcing companies across various sectors to adapt their business models, operational processes, and leadership strategies (Bux et al., 2025; Matt et al., 2015; Mollah et al., 2023; Namatovu & Kyambade, 2025; Nsiah et al., 2025; Rinaldo et al., 2025). This rapid and disruptive change creates complex challenges for organizational leaders who must navigate an increasingly uncertain and dynamic business environment. The availability of advanced technologies such as artificial intelligence, big data analytics, the internet of things (IoT), and cloud computing has opened up new opportunities while simultaneously creating existential threats for companies that fail to adapt (Joel et al., 2024). The strongest argument is that the acceleration of AI, big data, and cloud technologies fundamentally redistributes decision making authority and

information flows, forcing leaders to shift from hierarchical control toward adaptive, data-driven, and network based leadership paradigms. In this context, the role of leadership is crucial in determining the success of an organization's digital transformation (Shie et al., 2025; van Roekel et al., 2025). However, many leaders still struggle to understand and implement leadership strategies relevant to the digital era.

The research problem that arises from this phenomenon is the significant gap between leadership requirements in the digital era and the capabilities of existing leaders. Many organizations fail in their digital transformation initiatives not because of technological limitations, but because of a lack of leadership preparedness to manage the necessary fundamental changes (Deshpande, 2025; Gilli et al., 2024; Javed & al., 2025; Malik et al., 2024; Shie et al., 2025; Zhang et al., 2025). Traditional leaders are often trapped in old paradigms that rely on bureaucratic hierarchies and centralized decision-making, which are no longer effective in a digital ecosystem that requires agility, collaboration, and continuous innovation. Furthermore, there is an imbalance between investment in technology versus investment in developing digital leadership capabilities, resulting in a suboptimal return on investment from digital transformation initiatives (Jhawar et al., 2025).

Previous research has explored various aspects of digital transformation and its impact on organizations (Bux et al., 2025; Namatovu & Kyambade, 2025). Researchers have identified that digital transformation requires a fundamental shift in leadership models from autocratic direction to a more collaborative and empowerment-oriented approach (Mitroulis et al., 2020; Westerman et al., 2014). Other studies have shown that digital leaders must develop new capabilities such as digital literacy, emotional intelligence in a virtual context, and the ability to lead geographically dispersed teams (Kaihlanen & al., 2025; Kane, 2019; Tigre et al., 2025; van Roekel et al., 2025). Research in the Indonesian context also found that organizational culture and local regulations influence the success of digital transformation implementation (Al-Faihani & Al-Alawi, 2020; Wintarto et al., 2023). However, most existing research focuses on the technical or strategic aspects of digital transformation, with little attention to the holistic leadership dimension (Lobo et al., 2025; Ly, 2025; Malik et al., 2024). Compared to prior bibliometric reviews, this study makes a specific contribution by integrating performance analysis with advanced science mapping techniques co occurrence networks, thematic maps, and thematic evolution to highlight conceptual blind spots and the temporal dynamics of digital leadership research.

A significant research gap identified in the digital leadership literature is the lack of understanding of how digital transformation fundamentally changes effective leadership competencies and behaviors. Most previous studies have considered leadership as a secondary factor in digital transformation or only measured limited aspects such as leader adoption of technology. Furthermore, there is a lack of research examining how the interaction between leaders' personal characteristics, organizational context, and digital ecosystems influences leadership effectiveness in driving digital transformation. This gap is reflected in the lack of a comprehensive theoretical framework for understanding and measuring digital leadership capabilities that is relevant to the Indonesian context and emerging markets in general.

The novelty of this research lies in the development of an integrated and contextual digital leadership framework, which combines theoretical perspectives from multiple disciplines, including strategic management, organizational psychology, and information technology. This research will be one of the first to systematically identify and measure digital leadership competencies specifically relevant to the Indonesian organizational context, taking into account unique cultural factors, regulations, and levels of digital maturity. Furthermore, the methodological approach, which combines qualitative and quantitative analysis, will provide a deeper understanding of the dynamics of leadership in digital transformation, which has rarely been explored in previous, unidimensional studies. The main objective of this research is to identify, analyze, and develop an effective leadership model in the era of digital transformation in Indonesia. Specifically, this research aims to: (1) identify crucial leadership competencies needed to successfully lead digital transformation; (2) analyze factors that influence the effectiveness of digital leadership in various organizational contexts; (3) develop a valid and reliable measurement instrument to assess digital leadership readiness; and (4) formulate practical recommendations for organizations in developing digital

leaders capable of managing transformation holistically. To achieve these objectives, this research is designed to answer several key research questions that will guide the entire scientific investigation process.

The research questions to be answered through this study include: First, what leadership competencies are most crucial for the success of digital transformation in Indonesian organizations? Second, how do leaders' personal characteristics, organizational contextual factors, and the digital ecosystem interact to influence the effectiveness of digital leadership? Third, how do the dynamics of leadership behavior change occur during the digital transformation process and what factors moderate these changes? Fourth, what is the role of organizational culture and local factors in shaping effective digital leadership models in Indonesia? And fifth, what is the most effective implementation of digital leadership development programs to enhance leaders' capabilities in managing digital transformation? These research questions will be answered through a comprehensive methodological approach that combines in depth case studies with broad surveys to provide a complete understanding of the digital leadership phenomenon.

2. RESEARCH METHOD

This study employed a bibliometric approach as an analytical strategy to map and evaluate the development of scientific studies addressing the relationship between digital transformation and leadership. Data were collected from the Scopus database, with a total of 106 scientific articles selected as the units of analysis. The literature selection process was conducted systematically, adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, which aim to ensure traceability, consistency, and accuracy in selecting articles relevant to the research focus. Bibliometric analysis provides the ability to trace research development patterns, interrelationships between concepts, and the structure of collaboration between authors and journals that have significant influence in a field of study (Donthu et al., 2021). Through the use of visualization software such as VOSviewer and Biblioshiny, this study can identify thematic clusters and conceptual relationships that illustrate how digital transformation is studied in the context of leadership.

The application of the PRISMA framework ensures that articles analyzed have undergone a rigorous selection process and meet academic quality standards. As noted by Page et al. (2021), PRISMA provides a structured process that encompasses initial identification, screening, and feasibility evaluation, ultimately determining whether the final article is worthy of scientific analysis.

The initial stage of literature selection involved searching for articles based on keywords that directly represent the research scope. Next, a screening process was conducted using predetermined inclusion and exclusion criteria. Articles meeting the inclusion criteria were English-language publications containing key terms such as "digital," "transformation," and "leadership," and published in indexed journals. Conversely, editorial publications, book reviews, and articles without full-text access were excluded from the analysis. The final Scopus query used was: TITLE (("Digital") AND ("Transformation") AND ("Leadership")), which intentionally narrowed the scope to studies explicitly positioning leadership as a core construct, thereby excluding articles that discussed digital transformation or leadership only implicitly or as secondary themes.

TITLE (("Digital") AND ("Transformation") AND ("Leadership")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (OA, "all"))

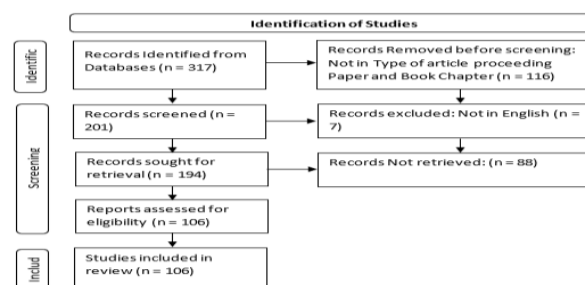


Figure 1. PRISMA process, source: prepared by author

3. RESULTS AND DISCUSSIONS

Performance Analysis

- a. Descriptive, the research data visualization presented in Figure 2 reveals a dynamic and rapidly growing research ecosystem on digital transformation and leadership. With 106 papers published from 80 different sources in just four years (2021-2025), this data demonstrates the high urgency and relevance within the academic community to understand this phenomenon. The 95.7% annual growth rate not only indicates exponentially increasing interest but also reflects the acceleration of digital transformation itself across various industry sectors. The participation of 348 authors, with an average of 3.35 authors per paper, demonstrates strong collaboration in this research, while the 37.74% proportion of international co-authors underscores the global nature of digital transformation and the leadership challenges that accompany it. This data fundamentally identifies a key research problem: the need for a deeper understanding of how leadership must adapt to the accelerating wave of digital transformation.



Figure 2. Overview of research data, source: processed by author, 2026

A significant research gap is evident in the presence of only 11 single-authored works, indicating that research on digital transformation and leadership inherently requires a multidisciplinary and collaborative perspective. These findings underscore the complexity of the topic, which cannot be fully understood through a single disciplinary lens but rather requires the integration of insights from management, information technology, organizational sociology, and leadership psychology. The novelty of this study lies in its comprehensive bibliometric approach that not only quantifies the volume of scholarly production but also reveals the structure of collaboration and patterns of geographic distribution of research. From a theoretical perspective, these data support the application of Complexity Leadership Theory, which suggests that leadership in the digital age can no longer be understood as a centralized entity but rather as an emergent phenomenon arising from complex interactions between actors within organizational networks and digital ecosystems (Begeç & Akyüz, 2023; Cortellazzo et al., 2019; Cyfert et al., 2025). The purpose of this article becomes even more relevant given the rapid dynamics revealed by the data: to provide a systematic framework for understanding that can help practitioners and academics navigate the complexities of digital transformation and its implications for leadership practice. The finding of an average document age of 2.01 years indicates that most of the research is very recent, implying that this research domain is still in its formative stages with many unanswered questions requiring further investigation. An average of 18.12 citations per document indicates a significant impact of publications in this domain, indicating that these studies are not only productive but also influential in shaping academic and practical insights.

- b. Trend Analysis, the publication trend graph presented in Figure 3 reveals a compelling narrative about the evolution of research interest in digital transformation and leadership from 2021 to 2025. The exponential growth pattern of published papers, starting from a relatively low number in 2021 to a peak of approximately 45 papers in 2025, reflects a rapid academic response to the practical urgency facing organizations worldwide. This trend not only confirms the increasing relevance of the topic but also indicates accelerated research momentum, likely driven by global events such as the COVID-19 pandemic, which has forced accelerated digital adoption across various sectors. This growth rate identifies a fundamental research problem: how leadership practices can keep pace with the rapid pace of technological change while

maintaining organizational effectiveness and employee well-being. The dramatic increase in publications also reflects a growing awareness that traditional leadership models may no longer be adequate to address the complexities of the ever-changing digital environment (Malik et al., 2024; Tsekouropoulos et al., 2025).

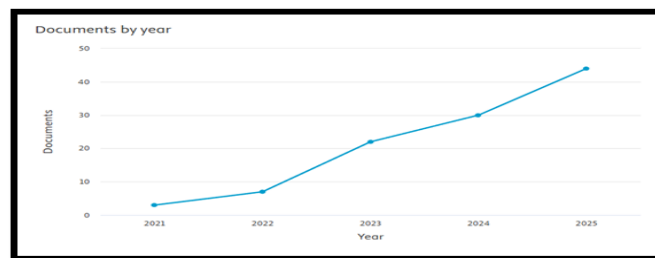


Figure 3. Trend analysis, source: processed by author, 2026

A prominent research gap from this trend analysis is the need for longitudinal research that can capture the temporal dynamics of digital leadership strategy implementation. While publication volume is increasing rapidly, there is a lack of research that follows organizations over the long term to understand how digital leadership practices evolve and mature over time. The novelty of this analysis lies in its ability to identify inflection points in the development of academic understanding, for example, whether there are specific years where the research focus shifts from basic conceptualization to practical implementation or impact evaluation. From a theoretical perspective, this trend supports the application of Dynamic Capabilities Theory, which suggests that organizations and their leaders must continuously develop capabilities for sensing, seizing, and transforming in the face of rapid technological change (Martins, 2023; Schilke et al., 2018; Teece, 2007; Warner & Wäger, 2019). The consistent increase in scholarly output each year indicates a growing recognition that digital leadership is not a static competency, but rather a dynamic capability that must be continually developed and adapted. The purpose of this research becomes even more crucial given the trends revealed: to provide an evolutionary roadmap that helps practitioners understand the stages of digital leadership development and identify key milestones in their transformation journey. The finding of consistent linear growth also implies that interest in this topic has not yet plateaued, suggesting that this research domain still has substantial growth potential and will continue to be an important area of inquiry for years to come. Trend data also indicates a possible lag time between the emergence of new technologies and the development of corresponding leadership frameworks, highlighting the need for a proactive research agenda that can anticipate future challenges rather than simply responding to current ones.

Science Mapping

- a. Co-occurrence Network, the co-occurrence network illustrated in Figure 4 reveals the complex and interconnected conceptual structure of the digital transformation and leadership research domain. This visualization shows “digital transformation” as a central node connected to various key concepts such as leadership, innovation, strategy, and digital leadership, forming a dense and interconnected conceptual ecosystem. The centrality of the “digital transformation” node indicates that this concept functions as an umbrella concept that integrates various aspects of leadership in a digital context. The close connection between “digital leadership” and “leadership” indicates an evolving conceptualization where digital leadership is not viewed as a separate discipline, but rather as an extension and evolution of traditional leadership concepts adapted to new technological contexts. This network identifies a fundamental research problem: how to integrate traditionally fragmented leadership concepts into a coherent framework that can holistically address the complexities of digital transformation. The network density and multiple connections between nodes indicate that

research in this domain has reached a high level of conceptual sophistication, but also reflects the potential for conceptual overload that can confuse practitioners. The most central themes in the co-occurrence and thematic maps were 'digital transformation' and 'leadership,' as indicated by their high keyword frequency, strong total link strength, and dominant central positioning within the network clusters generated by VOSviewer and Biblioshiny.

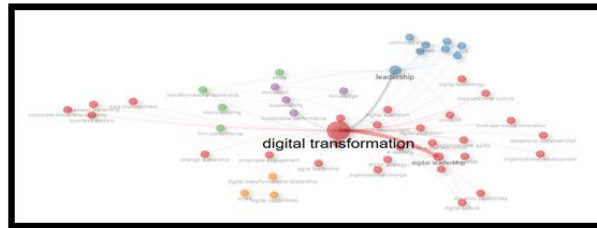


Figure 4. Co-occurrence network, source: processed by author, 2026

A significant research gap is evident in the lack of prominence of concepts related to ethical leadership and sustainability in networks, indicating that the literature may be underemphasizing the human and ethical dimensions of digital leadership. The absence or marginal presence of these concepts suggests a potential blind spot in the current research agenda, which Focusing on technical and strategic aspects at the expense of moral and ethical considerations, which are increasingly important in the digital age. The novelty of this network analysis lies in its ability to reveal implicit assumptions and conceptual biases underlying the current literature by visualizing what is connected and what remains peripheral. From a theoretical perspective, this network structure supports the application of Complexity Leadership Theory and Network Theory, which suggest that leadership in the digital age cannot be understood as linear cause-and-effect relationships, but rather as emergent properties resulting from complex interactions between multiple, mutually influencing factors (Hazy, 2008). The purpose of this research becomes increasingly relevant: to provide a conceptual mapping that Navigating the complexity of the literature and identifying blind spots in our understanding of digital leadership. Findings about the concentration of concepts around transformation and innovation indicate a dominant paradigm that views digital leadership primarily as an agent of change, potentially overlooking the equally important dimensions of stability and continuity, which are also crucial in organizational life. This network also reveals a potential echo chamber effect, where certain concepts become increasingly interconnected without sufficient input from external perspectives that can challenge dominant narratives, highlighting the need for more intentional interdisciplinary engagement to enrich the conceptual landscape of digital leadership research.

- b. Thematic Map, themes related to ethics, sustainability, and local context appear peripheral, as reflected by their low keyword frequency, weak total link strength, and marginal positions outside the core clusters in the co-occurrence and thematic maps. The thematic map presented in Figure 5 reveals the intellectual structure of the digital transformation and leadership research domain by displaying various themes and their intersubjective relationships. This visualization shows "digital transformation" as the central theme surrounded by thematic clusters such as leadership, strategy, innovation, and capabilities, creating a multidimensional and complex research landscape. The relative positioning of these themes indicates a hierarchy of importance in the literature, with central themes such as digital transformation and leadership occupying core positions, while more specific themes such as innovation and capabilities serve as supporting concepts that enrich the core understanding. This thematic configuration identifies a crucial research problem: how to integrate fragmented thematic perspectives into a coherent theoretical framework that can effectively guide both research and practice. The density and interconnectedness of the thematic clusters indicate

that the field has reached a substantial level of conceptual development, but also indicates the potential for thematic saturation, where new research may only add diminishing returns to existing understanding.

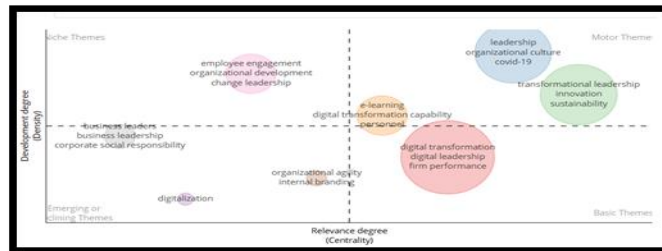


Figure 5. Thematic map, source: processed by author, 2026

A prominent research gap in this thematic map is the limited representation of contextual factors such as industry-specific challenges, cultural considerations, and organizational size within the thematic landscape. The lack of themes addressing variance in digital leadership implementation across different contexts indicates a one-size-fits-all bias in the literature that may not capture the nuanced reality of digital transformation across diverse organizational settings. The novelty of this thematic analysis lies in its ability to uncover blind spots in thematic coverage and identify areas where the literature may be overfocusing on certain aspects at the expense of others that are equally important. From a theoretical perspective, this thematic structure supports the application of Contingency Theory and Institutional Theory, which suggest that effective digital leadership cannot be separated from the organizational and institutional context in which it is implemented (Hazy, 2008). This research goal becomes increasingly urgent: to provide thematic guidance that researchers identify underexplored areas and practitioners navigate the complexity of implementing digital leadership initiatives in their specific contexts. The finding of the dominance of generic themes such as transformation and innovation indicates a need for greater contextualization in research, where universal principles must be adapted and modified to fit specific organizational realities. The thematic map also reveals potential theoretical fragmentation, where multiple themes develop in parallel without sufficient integration, highlighting the need for meta-synthetic research that can connect various thematic strands into a more coherent theoretical architecture. This indicates that although the field has grown substantially in terms of thematic richness, there is still a significant need for integrative frameworks that can connect various thematic dots into a comprehensive picture of the digital leadership phenomenon.

- c. Thematic Evolution, the thematic evolution diagram illustrated in Figure 6 offers a unique temporal perspective on how the digital transformation and leadership research landscape evolved from 2021–2024 to 2025. This Sankey visualization reveals the flow and transformation of key themes such as leadership, digital transformation, and COVID-19, demonstrating how research focus shifted and matured over time. The trajectory of the theme “COVID-19,” which was prominent in the early period but disappeared or transformed in the later period, reflects how external shocks can act as catalysts for research acceleration, but also how academic attention can shift once the immediate crisis passes. The evolution of the theme “leadership,” which maintains its presence but transforms in terms of associated concepts, indicates a deepening understanding that develops over time, where basic concepts become increasingly nuanced and context-specific. This evolutionary pattern identifies a fundamental research problem: how to understand the trajectory of digital leadership research and forecast future directions based on the revealed historical evolutionary pattern. The flow diagram also demonstrates thematic continuity, where certain concepts persist across time periods but with evolving interpretations and applications, suggesting the cumulative knowledge building characteristic of a maturing scientific field.

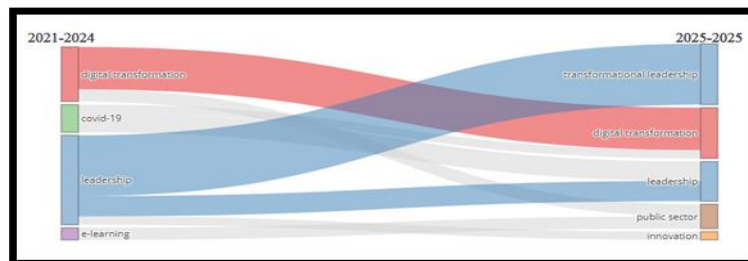


Figure 6. Thematic Evolution, Source: Processed by Author, 2026

A significant research gap is evident in the lack of forward-looking themes that anticipate future challenges such as ethical AI leadership, quantum computing implications, or metaverse leadership. The absence of forward-looking themes in the thematic evolution indicates that the literature may be more reactive than proactive in addressing emerging challenges, which can be problematic given the ever-increasing pace of technological change. The novelty of this evolutionary analysis lies in its ability to identify patterns in thematic development. A predictive tool for anticipating future research trends and identifying emerging areas that need attention. From a theoretical perspective, this evolutionary pattern supports the application of Evolutionary Theory and the Punctuated Equilibrium Model, which show that conceptual development in digital leadership research does not follow a linear progression, but is instead characterized by periods of rapid change followed by periods of consolidation and refinement (Woro & Herachwati, 2024). The goal of this research has become increasingly strategic: to provide an evolutionary perspective that Researchers and practitioners position themselves in terms of research agendas and capability development for future challenges. Findings about how themes like COVID-19 emerge and disappear indicate the need for more resilient research frameworks that are not only responsive to current crises but also build enduring theoretical foundations that can withstand shifting priorities. The evolution diagram also reveals potential path dependencies in thematic development, where certain research trajectories become entrenched due to early momentum, potentially limiting the exploration of alternative approaches that could be equally valuable. This highlights the need for intentional diversity in research agendas to ensure that the field does not become trapped in conceptual lock-in, which hinders innovation and adaptability to truly novel challenges that may emerge in the future.

4. CONCLUSION

Based on a bibliometric analysis of 106 Scopus-indexed articles discussing digital transformation and leadership, it can be concluded that digital transformation has become a determining factor fundamentally changing the paradigm, competencies, and practices of leadership in modern organizations. The significant growth in publications between 2021 and 2025 indicates that digital leadership is an academic response to the increasingly massive and disruptive adoption of digital technology across various industrial sectors.

The results of the performance analysis indicate that research on digital transformation and leadership is multidisciplinary, collaborative, and global, reflecting the complexity of leadership in the digital era. Leadership is no longer understood as a centralized, hierarchical function, but rather as a dynamic and emergent process influenced by the interaction between technology, organizational structure, culture, and individual leader capabilities. These findings reinforce the relevance of Complexity Leadership Theory and Dynamic Capabilities Theory in explaining leadership in the context of digital transformation.

Science mapping analysis using co-occurrence networks, thematic maps, and thematic evolution shows that the concepts of "digital transformation" and "leadership" are at the core of the research's intellectual structure, closely linked to the themes of strategy, innovation, and organizational capabilities. However, significant research gaps remain, particularly regarding the ethical and sustainability dimensions and local contexts such as organizational culture and

institutional characteristics of developing countries, including Indonesia. Existing literature tends to emphasize the technical and strategic aspects of digital transformation, while the humanistic and contextual aspects of digital leadership remain relatively underexplored.

The thematic evolution of research also shows that digital leadership studies have been reactive to global crises such as the COVID-19 pandemic, but have not been fully proactive in anticipating future challenges, such as AI-based ethical leadership, data governance, and the implications of new disruptive technologies. This emphasizes that digital leadership development must be understood as an ongoing process that requires an integration of technological mastery, emotional intelligence, ethical sensitivity, and an understanding of the organizational context.

Overall, this study concludes that the success of an organization's digital transformation is not solely determined by technology investment, but also depends heavily on the readiness and capabilities of digital leadership. Therefore, developing a holistic, contextual, and people-centric digital leadership model is a strategic necessity for organizations, particularly in developing countries, so that digital transformation can produce sustainable and inclusive organizational performance. The most logical next-step research agenda involves examining emerging and underdeveloped themes identified in the thematic map, particularly data governance integration, ethical AI leadership, and sustainability-oriented digital leadership, using empirical and longitudinal research designs. Future researchers are encouraged to conduct empirical and context-sensitive studies such as qualitative case studies, mixed method designs, and cross-country comparisons to examine ethical leadership, sustainability outcomes, and local institutional factors that remain underexplored in the digital leadership literature.

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