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Artificial Intelligence and Big Data Analytics for Sustainable Value Creation: A Systematic Review of Digital Capabilities Across Supply Chains and Industrial Ecosystems

Ismail Rasulong[1]*, Abdul Khaliq[1], Kahar[2], Asrijal Bintang[1]

1 Faculty of Economics and Business, Universitas Muhammadiyah Makassar
2 Department of Management, Universitas Syekh Yusuf Al Makassari Gowa

*Corresponding Author: ismail.rasulong@unismuh.ac.id

Abstract

Artificial intelligence (AI) and big data analytics (BDA) are increasingly recognized as strategic enablers of sustainable value creation across supply chains and industrial ecosystems. Despite the rapid growth of research on AI- and data-driven sustainability initiatives, existing studies remain fragmented across sectors, theoretical perspectives, and levels of analysis. This systematic literature review (SLR) synthesizes peer-reviewed research to elucidate how AI- and BDA-enabled digital capabilities contribute to economic, environmental, and social sustainability outcomes. Guided by the PRISMA framework, the review examines 26 journal articles indexed in Scopus. Drawing on dynamic capability theory, the resource-based view, and complementary institutional and ecosystem perspectives, the findings are organized into four thematic domains: (1) AI and BDA as digital capabilities for sustainable value creation, (2) mediating mechanisms linking digital capabilities to sustainability outcomes, (3) ecosystem- and institution-level contingencies shaping impact realization, and (4) emerging research frontiers, including Industry 5.0, circular economy models, and responsible AI. The review reveals that AI and BDA seldom generate sustainability outcomes directly; instead, their impacts are largely mediated by organizational capabilities, supply chain coordination, and governance structures. Moreover, contextual factors such as regulatory environments, market turbulence, and ecosystem maturity significantly influence the direction and magnitude of sustainability outcomes. Persistent research gaps are identified, including limited longitudinal evidence, inconsistent sustainability metrics, the underrepresentation of social sustainability, and insufficient integration of ethical and governance considerations. Overall, this SLR advances a capability-based understanding of AI-enabled sustainability and provides actionable insights for scholars, managers, and policymakers seeking to support responsible and ecosystem-oriented digital transformation.

Keywords: artificial intelligence, big data analytics, sustainable value creation, supply chains, industrial ecosystems

JEL Classification: O33, Q56, M15, L23 and D22

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INTRODUCTION

Artificial intelligence (AI) and big data analytics (BDA) are increasingly recognized as pivotal enablers of sustainable value creation in supply chains and industrial ecosystems. Their integration into operational and strategic frameworks allows for enhanced decision-making, greater transparency, and optimized resource use, outcomes that are vital to achieving economic, environmental, and social sustainability. AI, for instance, facilitates predictive analytics in supply chains, enabling timely responses to fluctuations in demand and supply, thereby reducing waste and inefficiencies (Kulkov et al., 2023; Nayal et al., 2021). Concurrently, digital transformation driven by AI and BDA helps organizations align with triple-bottom-line goals, supporting economic viability, environmental stewardship, and social equity (Fan et al., 2022; Sahoo et al., 2024). In this regard, big data analytics has been shown to enhance supply chain performance by fostering agility and enabling resource recovery processes in alignment with circular economy principles, promoting resilience and competitive advantage (Riggs et al., 2023; Raj et al., 2023).

Crucially, the sustainability implications of AI and BDA extend beyond the boundaries of individual firms. Supply chains and industrial ecosystems represent interconnected networks of organizations collaborating to deliver goods and services, and thus present distinct challenges and opportunities compared to firm-level analyses. While firm-level studies often focus on internal strategies and capabilities, supply chain perspectives illuminate the broader inter-organizational dynamics that influence sustainability performance (Shafique et al., 2024; Xu et al., 2024). Within these systems, AI and BDA support traceability, improve transparency, and enable collaborative decision-making that balances environmental, economic, and social objectives (Makhloufi, 2023; Naz et al., 2022). The interconnected nature of supply chains also facilitates the adoption of circular economy principles, such as waste reduction and closed-loop logistics, more effectively than isolated firm-level efforts (Kumar et al., 2024; Broo et al., 2022).

Over time, the research focus on AI and BDA has shifted significantly from efficiency-centric applications to sustainability-driven outcomes. Early work predominantly emphasized technological advancements aimed at boosting productivity and reducing operational costs (Tsolakis et al., 2022; Shafique et al., 2024). However, contemporary studies now highlight the potential of AI and BDA to support organizational resilience, enhance environmental performance, and address long-term sustainability challenges (Riggs et al., 2023; Wang et al., 2024). AI-powered tools, for instance, have been adopted to mitigate climate risks, optimize energy consumption, and support circular strategies within supply chains (Tseng et al., 2022; Xu et al., 2024). This evolution underscores a growing understanding of the interdependence among ecological, social, and economic systems and positions digital technologies as central to achieving sustainability goals.

Despite the growing scholarly interest in artificial intelligence (AI), big data analytics (BDA), and sustainability, existing review studies have addressed these themes in a fragmented manner. Prior reviews have provided valuable insights into digital transformation, Industry 4.0 technologies, circular economy practices, and sustainable supply chain management. For example, some reviews have examined the role of digital technologies in supporting circular economy transitions, while others have focused on AI applications in supply chain optimization, operational efficiency, or environmental performance. These contributions have advanced understanding of how digital technologies can support sustainability-oriented transformation. However, most prior reviews tend to emphasize specific technologies, individual sectors, or isolated sustainability dimensions, rather than offering an integrated explanation of how AI and BDA function as strategic digital capabilities for sustainable value creation across supply chains and industrial ecosystems.

Several important gaps remain in the existing review literature. First, previous reviews often discuss AI, BDA, blockchain, IoT, or digital twins as separate technological domains, with limited attention to how these technologies interact as complementary digital capabilities. Second, many review studies focus predominantly on operational efficiency, environmental performance, or circular economy outcomes, while the broader triple-bottom-line dimensions of sustainability, namely economic, environmental, and social dimensions, remain unevenly examined. Third, although prior studies acknowledge the potential of AI and BDA to improve sustainability performance, fewer reviews systematically explain the mediating mechanisms through which digital capabilities are translated into sustainable value. Mechanisms such as knowledge sharing, absorptive capacity, innovation capability, supply chain collaboration, transparency, and governance structures are often treated separately rather than integrated into a coherent analytical framework. Fourth, existing reviews give insufficient attention to contextual and institutional contingencies, including regulatory environments, ecosystem maturity, stakeholder trust, infrastructure readiness, and market turbulence, all of which may shape the effectiveness of AI- and BDA-enabled sustainability initiatives.

These limitations indicate the need for a systematic review that moves beyond a technology-centric or sector-specific perspective. A review of this nature is important because AI and BDA do not automatically generate sustainability outcomes through adoption alone. Instead, their contribution to sustainable value creation depends on how organizations develop, combine, and reconfigure digital capabilities within broader supply chain and ecosystem contexts. By synthesizing the existing literature through a capability-based and ecosystem-oriented lens, this review can clarify not only what is known about AI- and BDA-enabled sustainability, but also how, under what conditions, and through which mechanisms these technologies contribute to sustainable value creation.

In response to these gaps, this systematic literature review aims to: (1) synthesize existing knowledge on the role of AI and BDA in enabling sustainable value creation across supply chains and industrial ecosystems; (2) identify the digital capabilities and mediating mechanisms through which AI and BDA influence economic, environmental, and social sustainability outcomes; (3) examine contextual, institutional, and ecosystem-level contingencies that shape the realization of sustainability value; and (4) propose an integrative framework and future research agenda to guide further inquiry in this field.

This review focuses on peer-reviewed journal articles indexed in Scopus and examines empirical, conceptual, and mixed-methods studies published over the past decade. The reviewed literature spans multiple industrial contexts, including manufacturing, logistics, services, energy, and broader industrial ecosystems. Particular attention is given to AI- and BDA-related technologies and applications, including machine learning, predictive analytics, digital twins, IoT-enabled data infrastructures, and blockchain-supported transparency mechanisms. Guided by the PRISMA framework, this systematic literature review follows a structured procedure involving article identification, screening, eligibility assessment, quality appraisal, data extraction, and thematic synthesis. Through this approach, the study seeks to provide a transparent, rigorous, and theoretically grounded synthesis of how AI and BDA contribute to sustainable value creation in contemporary supply chains and industrial ecosystems.

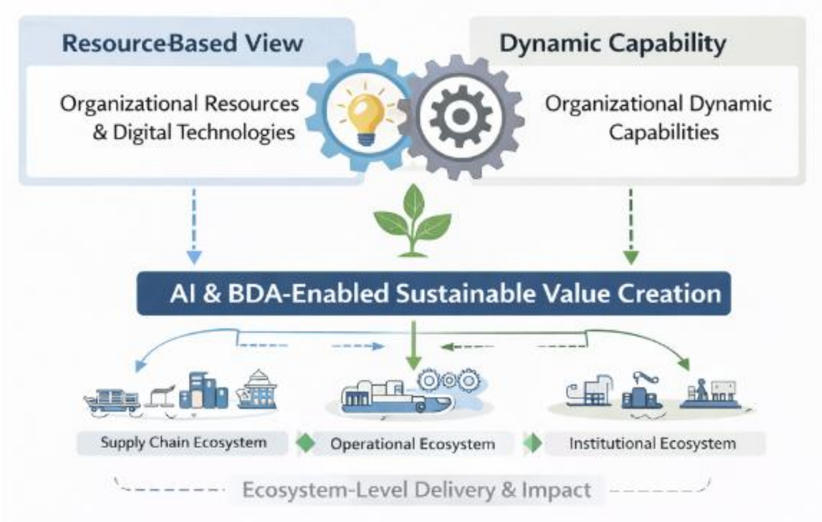
LITERATURE REVIEW

Value Creation Theories: Dynamic Capabilities and Resource-Based View

The integration of artificial intelligence (AI) and big data analytics (BDA) into sustainability strategies is best understood through the complementary lenses of Dynamic Capability Theory (DCT) and the Resource-Based View (RBV).

Figure 1 illustrates the integrative theoretical framework that underpins the role of AI and BDA in sustainable value creation. On one side, the Resource-Based View (RBV) positions AI and BDA as valuable, rare, and inimitable digital resources that can offer competitive advantage when properly harnessed. On the other side, Dynamic Capability Theory (DCT) explains how organizations deploy and reconfigure these digital assets through processes of sensing, seizing, and transforming to respond to rapidly evolving sustainability demands. The figure illustrates how these two theoretical perspectives jointly contribute to the achievement of triple-bottom-line sustainability outcomes, encompassing economic, environmental, and social dimensions. This integrated perspective reinforces the argument that the effectiveness of AI and BDA lies not only in their technical sophistication but in how firms dynamically align them with strategic capabilities and external environments. By positioning AI and BDA within both static resource and adaptive capability logics, the framework offers a more comprehensive explanation of their transformative potential in sustainability-focused supply chains and ecosystems.

Figure 1. Integrated Theoretical Foundations for AI- and BDA-Enabled Sustainable Value Creation



Source: Authors' own illustration.

DCT emphasizes an organization's ability to sense, seize, and reconfigure competencies to respond to rapidly evolving environments. AI and BDA equip firms with predictive analytics, scenario modeling, and adaptive decision-making capabilities that are crucial for aligning operations with sustainability imperatives (George & Wooden, 2023). For example, predictive AI models help minimize operational waste and improve energy efficiency, thereby strengthening both environmental sustainability and operational responsiveness (Schöggl et al., 2023; Janković & Curovic, 2023). These technologies embody dynamic capabilities by enabling continuous innovation and responsiveness to environmental, regulatory, and stakeholder demands.

Conversely, RBV views AI and BDA as strategic resources that yield competitive advantages when they are valuable, rare, inimitable, and organizationally embedded. From this perspective, firms with advanced BDA capabilities and AI infrastructure are better positioned to innovate, reduce emissions, and engage in sustainable practices (Riggs et al., 2023; Kumar et al., 2024). However, these technologies must be complemented by organizational and supply chain management capabilities to fully realize sustainability impacts (Chaudhuri et al., 2022). In summary, DCT and RBV jointly explain how digital and organizational assets co-evolve to create sustainable value.

Theoretical Models Linking Digital Capabilities, SCM, and Sustainable Advantage

The integration of digital capabilities and supply chain management capabilities (SCMC) plays a crucial role in developing sustainable competitive advantage (SCA). Digital capabilities, including real-time data analytics, IoT-enabled integration, and AI-supported monitoring, strengthen firms' capacity to allocate resources more efficiently and anticipate environmental disruptions more effectively (Guo & Cugurullo, 2025; Buceta-Albillos & Ayuga-Téllez, 2025). These capabilities improve agility, reduce waste, and facilitate the implementation of circular economy principles (Mehmood et al., 2024).

Meanwhile, SCMC involve the strategic coordination of logistics, supplier relationships, and inventory systems. When integrated with digital tools, SCMC drive improvements in traceability, emissions reduction, and resource optimization (Riggs et al., 2023; Asokan et al., 2022). Emerging frameworks synthesize DCT and RBV, proposing that digital capabilities enhance SCM responsiveness, while SCMC enable firms to extract sustainability value from technological investments (Buceta-Albillos & Ayuga-Téllez, 2025; Mehmood et al., 2024).

Dynamic capabilities such as learning and innovation allow organizations to adapt SCM strategies in real time, ensuring alignment with evolving sustainability demands (Sidani & Harb, 2025; Tanantong & Wongras, 2024). Consequently, sustainable competitive advantage arises from the joint evolution of digital infrastructure, supply chain agility, and strategic foresight (Said et al., 2023).

Historical and Contemporary Perspectives

Historically, research emphasized IT business value in terms of cost reduction and operational efficiency. However, the rise of BDA capabilities shifted the narrative toward leveraging data as a strategic asset (Tsolakis et al., 2022; Asokan et al., 2022). Organizations increasingly focus on deriving actionable insights from big data to support sustainability initiatives, including emissions monitoring, resource recovery, and process optimization. More recently, AI-driven decision automation has further enhanced firms' ability to process real-time data and forecast sustainability risks. Machine learning algorithms enable adaptive logistics, energy optimization, and smart manufacturing, which directly support triple-bottom-line outcomes.

The transition from Industry 4.0 to Industry 5.0 represents a paradigmatic shift. While Industry 4.0 focused on automation and efficiency, Industry 5.0 emphasizes human-machine collaboration, sustainability, and resilience (Broo et al., 2022; Samuels & Pelser, 2025). Key milestones include:

- Emphasis on human-centric AI for collaborative sustainability (Peña et al., 2022)
- Enhanced adoption of circular economy models and resource recovery
- Integration of emerging technologies (e.g., blockchain, IoT) to monitor emissions and waste (Tsolakis et al., 2022; Asokan et al., 2022)
- Strengthened resilience frameworks for navigating market shocks (Riad et al., 2024)
- Decision-making based on collaborative intelligence that integrates human expertise with AI reasoning (Signorini & Pomè, 2025; Meinhold et al., 2024)

Debates and Controversies in AI for Sustainability

Scholars debate whether AI and BDA yield direct sustainability benefits or if their effects are mediated through organizational enablers. Evidence shows that AI can directly improve operational efficiencies and reduce environmental impacts (Alnamrouti et al., 2022; Schöggl et al., 2023; Tseng et al., 2022; Onu et al., 2023). However, the full potential of these technologies is realized when coupled with mature SCMC, employee capabilities, and managerial commitment (Chaudhuri et al., 2022; Riggs et al., 2023).

Several critical challenges are actively debated:

- Measurement challenges in AI-enabled sustainability assessment remain difficult to address because social and ethical dimensions are often hard to quantify and are evaluated using inconsistent indicators and limited standardized metrics (Cumba et al., 2023; Tassabehji et al., 2024; Javed et al., 2025; Shaamala et al., 2025).
- Ethics and governance challenges in AI deployment arise from concerns related to bias, privacy, accountability, and labor displacement, which may compromise long-term sustainability goals when not supported by robust governance mechanisms (Koukaras et al., 2025; Lu et al., 2025).
- Rebound effects from AI-enabled efficiency gains may unintentionally increase overall consumption and reduce ecological benefits, making system-wide lifecycle thinking necessary to ensure net-positive sustainability impacts (Lu et al., 2025; Meinhold et al., 2024).

In conclusion, while the theoretical foundations affirm AI and BDA's potential, the realization of sustainability outcomes is contingent upon organizational alignment, ethical deployment, and strategic integration across ecosystems.

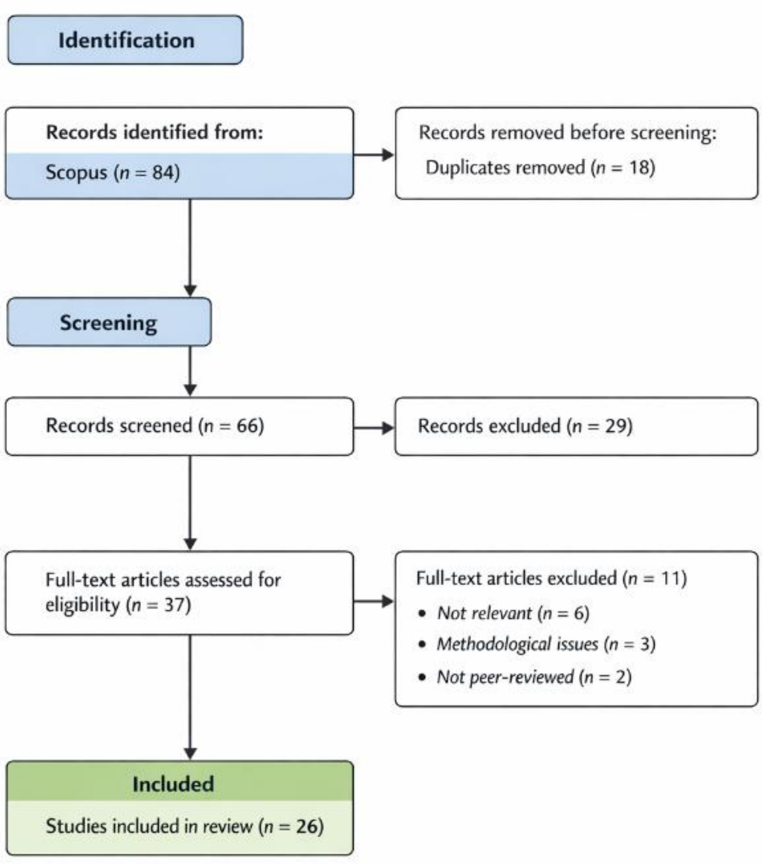
METHODS

Search Strategy

This study adopts a systematic literature review (SLR) approach guided by the PRISMA 2020 framework to ensure methodological rigor, transparency, and reproducibility. PRISMA is widely used in sustainability and operations-related review studies and provides a structured protocol for identifying, screening, and synthesizing prior research. Following established practices in AI- and BDA-related sustainability reviews (Bag & Rahman, 2021; Rusch et al., 2022; Cerchione et al., 2024), a comprehensive search was conducted using the Scopus database, which was selected due to its broad coverage of high-quality, peer-reviewed journals across management, operations, and engineering domains. To further enhance coverage and minimize the risk of omitting relevant studies, backward and forward citation tracking was applied to the articles retained after full-text screening.

The search strategy employed a combination of controlled vocabulary and Boolean operators. Core search terms included variations of: "artificial intelligence," "big data analytics," "sustainable supply chain," "digital capabilities," "circular economy," and "industrial ecosystem." These keywords were iteratively refined through pilot searches to balance sensitivity and specificity and to ensure alignment with the study objectives (Pasupuleti et al., 2024; Bang-Ning et al., 2025). The final search string was applied consistently across the Scopus database, and the search was limited to journal articles published in English.

Figure 2. PRISMA Flow Diagram



Source: Authors' own illustration.

Inclusion and Exclusion Criteria

Clear inclusion and exclusion criteria were defined a priori to ensure consistency and reduce selection bias, following best practices in prior SLRs on AI, BDA, and sustainability.

Inclusion criteria:

- Empirical studies examining the application of AI and/or BDA in relation to sustainability outcomes.

- Research employing qualitative, quantitative, or mixed-method empirical designs, including case studies, surveys, archival analyses, or hybrid approaches.
- Peer-reviewed journal articles published in English.
- Studies situated within supply chains, operations, manufacturing, logistics, or industrial ecosystem contexts (Štreimikienė et al., 2025; Janković & Curovic, 2023).

Exclusion criteria:

- Non-peer-reviewed sources such as conference papers, books, book chapters, editorials, practitioner reports, and white papers.
- Conceptual or purely theoretical studies without an empirical component.
- Studies that addressed AI or BDA in domains unrelated to sustainability or disconnected from supply chain and operational contexts (Stefanović et al., 2025; Qahman et al., 2025).

Screening and Selection

The screening and selection of studies followed the four-phase PRISMA procedure: Identification, Screening, Eligibility, and Inclusion. The initial database search yielded 84 records. After removing 18 duplicate entries, 66 unique articles remained for title and abstract screening. During this phase, 29 articles were excluded due to insufficient relevance to AI/BDA-enabled sustainability in supply chain or ecosystem contexts.

Subsequently, full-text assessments were conducted on 37 articles to evaluate eligibility against the predefined criteria. Eleven articles were excluded at this stage, primarily because they lacked empirical evidence or did not address sustainability outcomes explicitly. As a result, 26 empirical studies were retained for the final synthesis. The complete screening workflow and exclusion decisions are summarized in the PRISMA 2020 flow diagram (Figure 2).

Quality Appraisal and Data Extraction

To enhance the credibility and robustness of the review, the methodological quality of the included studies was appraised using established assessment tools selected according to study design. The Critical Appraisal Skills Programme (CASP) checklists were applied to qualitative and quantitative studies to assess research rigor, clarity, and validity (Agrawal et al., 2025; Wang et al., 2023). The Joanna Briggs Institute (JBI) Critical Appraisal Tools were used to evaluate methodological consistency and design robustness across diverse empirical approaches (Senni et al., 2025; Karimova et al., 2025). For studies employing mixed-method designs, the Mixed Methods Appraisal Tool (MMAT) was applied to ensure coherence between qualitative and quantitative components (Meinhold et al., 2024; Gebresenbet et al., 2023).

Data extraction was conducted systematically for each included article. Extracted information included authorship, publication year, research design, empirical context, theoretical framing, digital capability constructs, and reported sustainability-related outcomes. This information formed the basis for thematic coding and cross-study comparison (Hsu et al., 2023; Ogbeibu et al., 2023).

The final synthesis relied primarily on qualitative content analysis to identify recurring themes, capability pathways, mediating mechanisms, and contextual contingencies across studies (Shafique et al., 2024; Kumar et al., 2024). To maintain methodological conservatism and alignment with the empirical focus of the review, the analysis emphasizes thematic synthesis rather than standalone bibliometric mapping, allowing for deeper interpretive integration of empirical findings across heterogeneous study designs.

RESULT AND DISCUSSION

Result

This section presents the results of the systematic literature review based on the 26 empirical studies retained after the PRISMA screening and quality appraisal process. The findings are organized thematically to reflect how AI and Big Data Analytics (BDA) enable sustainable value creation across supply chains and industrial ecosystems.

Across the review, studies span multiple industrial contexts, with a dominant concentration in manufacturing and supply chain settings, followed by more limited representation from financial services, energy, and macroeconomic or multi-sectoral ecosystems. The empirical designs include surveys, case studies, panel data analyses, and mixed-method approaches, reflecting methodological diversity but also contributing to heterogeneity in constructs and outcome measures.

The thematic structure described reflects a synthesis of recurring analytical patterns, not a grouping of mutually exclusive studies. Thus, individual articles may contribute to more than one thematic category (e.g., digital affordances, mediating mechanisms, or contextual contingencies). Consequently, the number of studies reported in individual tables is non-additive and should be interpreted as overlapping contributions, not as separate subsets.

AI/BDA as Digital Capabilities for Sustainable Value Creation

Artificial intelligence (AI) and Big Data Analytics (BDA) emerge from the reviewed literature as central digital capabilities enabling sustainable value creation across diverse industrial domains. A synthesis of twelve empirical studies summarized in Table 1 indicates that AI and BDA capabilities contribute to sustainability through multiple pathways, particularly in manufacturing (six studies), supply chain contexts (four studies), financial services (one study), and macroeconomic or multi-sectoral ecosystems (one study).

Figure 3. AI and Big Data Analytics as Digital Capabilities for Sustainable Value Creation

Source: Authors' own illustration.

Figure 3 illustrates a hierarchical capability structure that conceptualizes how AI and BDA function as enablers of sustainable value creation. At the foundational level, technological infrastructure, including data platforms, algorithms, and computational capacity, provides the basis for analytics deployment. The intermediate level captures advanced analytics capabilities such as prediction, traceability, decision automation, and transparency. These capabilities translate digital resources into actionable insights that inform operational and strategic decisions. At the strategic level, these analytics-enabled capabilities are linked to sustainability outcomes, including improved resilience, waste reduction, environmental compliance, and competitive advantage. This structure highlights that AI and BDA contribute to sustainability not merely as technologies, but as capabilities that must be aligned with organizational objectives and sustainability strategies. Similar capability-based pathways are emphasized in prior empirical studies, including Fan et al. (2022), Sahoo et al. (2024), and Makhloufi (2023).

Empirical evidence suggests that AI and BDA support economic, environmental, and, to a lesser extent, social dimensions of sustainability. In manufacturing contexts, Horng et al. (2022) and

Cheng et al. (2023) demonstrate that BDA enhances competitiveness and environmental performance through improved decision-making and knowledge-sharing infrastructures. Makhloufi (2024) further shows that green absorptive capacity mediates the relationship between BDA and green entrepreneurship orientation, highlighting the importance of organizational learning mechanisms. Studies by Raj et al. (2023) and Nozari et al. (2021) corroborate the role of AI and BDA in mitigating operational disruptions and improving resilience in sustainable manufacturing and fast-moving consumer goods (FMCG) supply chains.

Across the reviewed studies, AI and BDA capabilities are frequently interpreted through the lenses of the resource-based view (RBV) and dynamic capabilities theory (DCT). For instance, Bag et al. (2021) and Riggs et al. (2023) conceptualize BDA as a strategic resource whose sustainability impact depends on complementary organizational capabilities, such as institutional support and knowledge sharing. Similarly, Gupta et al. (2019) emphasize stakeholder engagement and transparency as enabling capabilities that amplify AI/BDA-driven value creation in circular economy settings. These findings align with broader arguments that position AI and BDA as dynamic enablers of sustainability-oriented transformation rather than standalone technological assets.

Several studies report associations between AI/BDA adoption and improved triple-bottom-line outcomes. Ali et al. (2020) and Wang et al. (2024), focusing on financial and macroeconomic contexts, identify links between analytics-enabled decision-making, reductions in ecological footprints, and improved financial performance. Wang et al. (2019) further demonstrate how smart manufacturing systems can align energy efficiency with climate objectives through data-driven process optimization. However, while positive sustainability-related outcomes are consistently reported, only a limited subset of studies explicitly examines economic, environmental, and social dimensions simultaneously, indicating an imbalance in multidimensional assessment.

Supply chain–focused studies further underscore the role of BDA in coordinating distributed actors and managing volatility. Konanahalli et al. (2022) identify transparency and technical interoperability as critical digital capabilities in facilities management supply chains, while Kumar and Barua (2022) show that digital integration can support emissions control and circular innovation even in resource-intensive petroleum supply chains.

Table 1. AI/BDA as Digital Capabilities for Sustainable Value Creation

Ref.	**Context**	**Capability Constructs**	**Framing/Mechanisms**	**Sustainability Value Outcomes**	**Theory/Model**
Horng et al. (2022)	Manufacturing (hospitality)	Big Data Capability (BDC), Knowledge Infrastructure	Enhances performance via data processing & sharing	Competitive advantage, improved sustainability	RBV
Cheng et al. (2023)	Manufacturing	Business Intelligence, BDA Capabilities	Green knowledge sharing & absorptive capacity	Environmental & competitive performance	RBV
Ali et al. (2020)	Financial services (ASEAN)	BDA as dynamic capability	Strategic value creation	Sustainability & financial performance	DCT
Riggs et al. (2023)	Multi-sector ecosystems	BDA as strategic asset;	Mediated value creation via knowledge flows	Organizational resilience & sustainability	DCT + RBV

Ref.	Context	Capability Constructs	Framing/Mechanisms	Sustainability Value Outcomes	Theory/Model
		absorptive capacity			
Bag et al. (2021)	Manufacturing	BDA-Powered AI; Institutional support	Institutional pressure → adoption mechanisms	Sustainability in manufacturing	RBV + Institutional theory
Makhloufi (2024)	Manufacturing	BDC, Green Absorptive Capacity	Green innovation mediation	Green entrepreneurship orientation	RBV
Wang et al. (2024)	Macro-economic (panel)	AI infrastructure & analytics	Reduces ecological footprint, emissions	Country-level sustainability impacts	Econometric modeling
Raj et al. (2023)	Manufacturing supply chain	AI/BDA for resilience	Mitigating supply risks in sustainable manufacturing	Improved performance & recovery	SCM + DCT
Nozari et al. (2021)	FMCG supply chains	IoT-based BDA	Enhances traceability, inventory efficiency	Sustainable logistics & demand prediction	Techno-economic modeling
Konanahalli et al. (2022)	Supply chain (Facilities Management)	BDA drivers/barriers	Technical integration & transparency	Circular innovation in facilities sector	Qualitative analysis
Kumar & Barua (2022)	Petroleum supply chain	Disruptive Tech (AI/BDA), IoT	Emissions reduction via digital integration	Sustainable operations in resource-intensive sectors	Technology adoption models
Gupta et al. (2019)	Circular economy / stakeholder governance	Big Data Capability & stakeholder trust	Transparency and stakeholder engagement	Resource recovery & trust-based value creation	Circular Economy Model

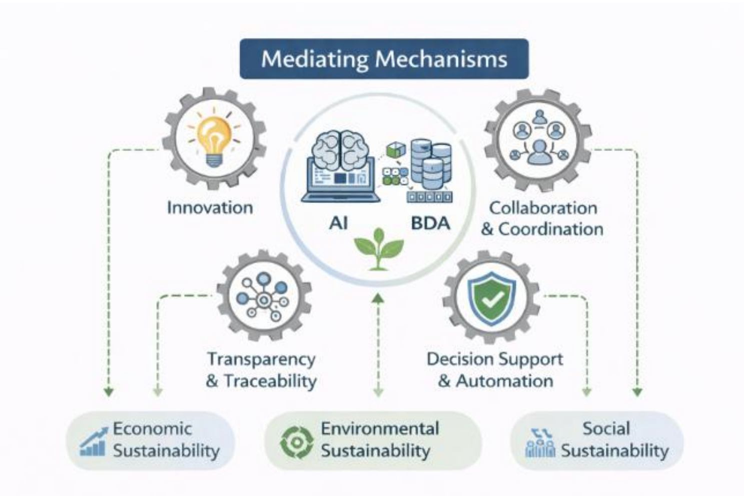
Overall, Table 1 indicates that manufacturing-oriented studies account for approximately half of the empirical evidence, followed by supply chain–focused research, whereas financial and macro-level analyses remain comparatively underrepresented. While the reviewed studies predominantly report favorable associations between AI/BDA capabilities and sustainability outcomes, the strength, scope, and dimensions of these outcomes vary across contexts and measurement approaches. This pattern reinforces the need for more comprehensive and comparable empirical assessments, particularly those that integrate economic, environmental, and social performance indicators.

Mechanisms and Mediators Linking Digital Capabilities to Sustainability Outcomes

A detailed examination of twelve studies summarized in Table 2 reveals that the impact of Artificial Intelligence (AI) and Big Data Analytics (BDA) on sustainability is often mediated or enabled by organizational capabilities, supply chain configurations, and knowledge processes. While digital capabilities provide the foundation, their influence on environmental, social, and economic outcomes is contingent on a range of internal and relational mechanisms.

Figure 4 illustrates the mediating mechanisms that bridge the link between AI and BDA capabilities and sustainability outcomes. Rather than yielding immediate impacts, digital capabilities interact with and activate a set of intermediate organizational enablers, such as absorptive capacity, knowledge sharing, innovation capability, trust, and governance structures, that ultimately determine the realization of sustainability value. This flow-oriented depiction reflects empirical findings in studies like Chaudhuri et al. (2022), Riggs et al. (2023), and Schöggl et al. (2023), which emphasize that digital transformation must be embedded in organizational routines, cultures, and decision-making systems to produce systemic sustainability effects. For example, innovation capability enables firms to adapt insights from AI into greener product designs or circular processes, while governance and trust facilitate inter-organizational coordination necessary for sustainable supply chains. The figure reinforces the notion that these mediators are not optional; they are essential conduits through which technological potential is converted into social, environmental, and economic value. Without strong mediating mechanisms, AI and BDA may fail to create meaningful or lasting sustainability impacts.

Figure 4. Mediating Mechanisms Linking AI and BDA to Sustainability Outcomes



Source: Authors' own illustration.

Among the twelve studies reviewed, six (50%) explicitly model mediation or indirect effects, while the remainder identify enabling mechanisms conceptually or through empirical moderation. Key mediators include supply chain collaboration, transparency, innovation capability, and green absorptive capacity, themes that reflect theoretical positions advanced by Dynamic Capabilities Theory (DCT) and the Resource-Based View (RBV), as discussed in Section 3 (George & Wooden, 2023; Riggs et al., 2023).

Several studies emphasize the role of supply chain collaboration and coordination. Kumar et al. (2024) identify that the effectiveness of AI in circular economy transitions is significantly enhanced by supplier integration and stakeholder engagement, which act as channels for knowledge flows. Likewise, Shahrivar et al. (2025) and Riggs et al. (2023) highlight the need for transparency and trust to activate the potential of BDA in achieving sustainable logistics and stakeholder-aligned innovation. These findings align with Gupta et al. (2019), who argue that stakeholder trust functions as both a prerequisite and a consequence of big data-enabled transparency.

A cluster of studies focuses on knowledge-based enablers, particularly green absorptive capacity. Makhloufi (2023) and Schöggl et al. (2023) find that firms that can internalize, adapt, and disseminate sustainability-related data achieve more consistent triple-bottom-line outcomes. This supports the dynamic capabilities argument that learning and innovation processes mediate the transformation of digital inputs into sustainable outputs (Janković & Curovic, 2023).

Innovation capability also appears as a prominent mechanism. Naz et al. (2022) and Tseng et al. (2022) demonstrate that when firms leverage AI to boost product and process innovation, they achieve superior environmental and social results. These results are consistent with the notion of AI as a trigger for business model adaptation and resource reconfiguration, rather than as a direct sustainability driver.

Three studies explicitly utilize causal modeling or mediation analysis to establish indirect effects. Cerchione et al. (2024) link BDA to circular economy performance via learning orientation. Shafique et al. (2024) reveal that AI's impact on resilience is conditioned by ambidextrous supply chain structures. Similarly, Chaudhuri et al. (2022) find that big data governance plays a mediating role in linking digital infrastructure to sustainability analytics. The presence of these mediating constructs demonstrates an important shift from deterministic to contingent models of digital sustainability.

Notably, 9 out of 12 studies (75%) reference or imply organizational capabilities (e.g., knowledge, transparency, governance) as critical to realizing sustainability value, reinforcing the centrality of organizational maturity and system-wide coordination. However, only a minority explicitly address the social dimension of sustainability, suggesting an overemphasis on environmental and economic indicators.

In sum, Table 2 illustrates that while AI and BDA are critical enablers, their value is realized through complementary assets and practices, especially those facilitating knowledge flows, stakeholder alignment, and adaptive governance.

Table 2. Mechanisms and Mediators Linking Digital Capabilities to Sustainability Outcomes

Ref.	Sector	Digital Capability	Enabling Mechanism / Mediator	Sustainability Outcomes	Theoretical Lens
Kumar et al. (2024)	Circular economy (India)	AI adoption, Big Data Analytics	Circular transition drivers (supplier integration, collaboration)	Environmental & social performance	RBV + CE
Shahrivar et al. (2025)	Sustainable logistics	AI and traceability systems	Transparency, risk mitigation	Green logistics, emission reduction	RBV + Tech Adoption
Cerchione et al. (2024)	Manufacturing (Italy)	Big Data Analytics Capability	Learning orientation (mediator)	Circular economy performance	DCT + CE
Makhloufi (2023)	Green entrepreneurship	Green absorptive capacity (GAC), BDA	GAC as mediator	Green innovation and resilience	RBV + DCT
Schöggl et al. (2023)	Multi-industry / SCM	AI tools for climate strategy	Knowledge processes	TBL outcomes (climate, economic, social)	DCT
Chaudhuri et al. (2022)	Multinational logistics	Big Data Governance	BDG as mediator; analytics orientation	Environmental analytics, performance	Data Governance + DCT
Tseng et al. (2022)	Manufacturing / SCM	BDA-enabled AI	Innovation capability	Resource efficiency, social impact	DCT + RBV

Ref.	Sector	Digital Capability	Enabling Mechanism / Mediator	Sustainability Outcomes	Theoretical Lens
Riggs et al. (2023)	Industrial ecosystems	BDA as strategic capability	Absorptive capacity, trust-based alignment	Resilience, innovation, CE performance	DCT + Stakeholder Theory
Naz et al. (2022)	FMCG supply chains	AI for innovation	Supply chain capability	Environmental innovation & agility	Tech Adoption Model
Janković & Curovic (2023)	Manufacturing	Sustainability analytics	Internal capability building	Climate-driven innovation & compliance	RBV
Gupta et al. (2019)	Circular economy	Big Data Capability	Stakeholder trust, transparency	Resource recovery, legitimacy	Circular Economy Theory
Shafique et al. (2024)	Supply chain resilience	AI-enabled capabilities	Ambidextrous SC structures	Resilience & sustainability	DCT + Org. Ambidexterity

Ecosystem and Institutional Contingencies Shaping Digital Sustainability Outcomes

A detailed examination of the studies summarized in Table 3 indicates that ecosystem and institutional conditions strongly shape whether Artificial Intelligence (AI) and Big Data Analytics (BDA) generate sustainability value. Rather than operating through technology adoption alone, digital sustainability outcomes are conditioned by regulatory quality, policy coherence, institutional trust, ecosystem maturity, infrastructure readiness, and public-private coordination.

Figure 5 illustrates the ecosystem and institutional contingencies that shape AI-enabled sustainability. The figure shows how regulatory frameworks, market turbulence, institutional pressure, stakeholder trust, and ecosystem readiness can amplify, stabilize, or limit sustainability outcomes. This contingency-oriented view is consistent with studies that emphasize policy support, governance alignment, and ecosystem maturity as critical conditions for effective digital sustainability initiatives.

Across the studies reviewed, frequently identified contingencies include regulatory quality, institutional pressure, ecosystem maturity, market turbulence, stakeholder trust, and infrastructure readiness. These contingencies are consistent with institutional theory and ecosystem perspectives, which emphasize that digital capabilities create sustainability value only when supported by suitable external conditions.

Figure 5. Ecosystem and Institutional Contingencies Shaping AI-Enabled Sustainability

Source: Authors' own illustration.

Several studies highlight the importance of policy alignment and institutional support. Peña et al. (2022) show that circular economy policy and regional initiatives can facilitate smart-city and circular transitions, while Riad et al. (2024) emphasize the role of national governance and transport regulation in sustainable mobility design. Conversely, Kumar and Barua (2022) and Janković and Curovic (2023) suggest that institutional voids and weak climate-policy enforcement may restrict the sustainability value of digital technologies.

A further group of studies emphasizes ecosystem maturity, stakeholder trust, and coordination. Broo et al. (2022) associate ecosystem fragmentation and trust gaps with barriers to Industry 5.0 readiness, while Gupta et al. (2019), Riggs et al. (2023), and Shahrivar et al. (2025) indicate that stakeholder legitimacy, trust-based governance, and public-private coordination shape the success of transparent and sustainable digital ecosystems.

Systems-oriented studies also point to lifecycle and rebound-effect risks. Meinhold et al. (2024) argue that ecosystem-wide data coordination is necessary to manage lifecycle sustainability and rebound effects, while Ali et al. (2020) show that cross-country policy variance can shape the adoption of analytics-enabled green investment and digital finance.

Together, these studies demonstrate that institutional and ecosystem conditions function as important moderators of AI- and BDA-enabled sustainability. Supportive policies, coherent governance, mature infrastructures, and trusted stakeholder relationships can strengthen digital sustainability outcomes, whereas fragmented institutions, weak regulation, and low ecosystem readiness can weaken or delay them.

At the same time, the reviewed literature still provides limited comparative evidence across institutional settings. More research is needed to examine how digital sustainability pathways differ between developed and emerging economies, high- and low-infrastructure contexts, and mature and fragmented ecosystems.

In summary, Table 3 shows that AI and BDA create sustainability value within broader institutional and ecosystem environments. Their effectiveness depends not only on internal organizational capabilities, but also on regulatory clarity, stakeholder trust, policy support, and the maturity of inter-organizational ecosystems.

Table 3. Ecosystem and Institutional Contingencies Shaping Digital Sustainability Outcomes

Ref.	Ecosystem / Sector	Institutional Context / Contingency	Digital Sustainability Outcomes	Moderator Role / Influence	Theory / Model
Peña et al. (2022)	Urban ecosystem (Spain)	Circular economy policy and regional initiatives	Circular transitions and smart city infrastructure	Institutional alignment and stakeholder collaboration	Circular Economy Governance
Kumar & Barua (2022)	Petroleum supply chains	Institutional voids and regulatory limits	Emissions control and tech adoption	Weak institutions hinder digital circularity	Institutional Theory
Riad et al. (2024)	Smart mobility (Egypt)	National governance, transport regulation	Sustainable mobility design	Policy frameworks shape AI uptake	Policy Analysis Model
Broo et al. (2022)	Industry 4.0 to 5.0 transitions	Ecosystem fragmentation and trust gaps	Resilience and interoperability	Maturity gap blocks Industry 5.0	Industry 5.0 Readiness Model

Ref.	Ecosystem / Sector	Institutional Context / Contingency	Digital Sustainability Outcomes	Moderator Role / Influence	Theory / Model
Meinhold et al. (2024)	Circular economy ecosystems	Ecosystem complexity, rebound effects	Lifecycle sustainability and rebound risks	Ecosystem-wide data coordination needed	Systems Theory
Gupta et al. (2019)	Circular value chains	Stakeholder legitimacy, trust, engagement	Transparent circular operations	Trust mediates AI-driven circular models	Stakeholder Governance
Riggs et al. (2023)	Industrial ecosystems	Stakeholder alignment, trust-based governance	Sustainability-oriented innovation	Trust moderates digital value realization	DCT + Stakeholder Theory
Shahrivar et al. (2025)	Food logistics (multi-country)	Public-private coordination gaps	Sustainable traceability and logistics	Collaboration intensity shapes AI impact	Collaborative Governance
Janković & Curovic (2023)	Manufacturing (Serbia)	Weak climate policy enforcement	Climate innovation and compliance	Policy inertia blocks AI value	RBV + Institutional Theory
Ali et al. (2020)	Financial sector (ASEAN)	Cross-country policy variance	Green investment and digital finance	Institutional coherence affects adoption	Comparative Institutionalism

AI Frontiers for Sustainable Transformation

This subsection synthesizes eleven empirical studies that explore emerging technological frontiers and strategic frameworks shaping the future role of Artificial Intelligence (AI) and Big Data Analytics (BDA) in sustainability-oriented transformation. As summarized in Table 4, these studies extend the analysis beyond current operational applications and examine how advanced digital architectures, such as digital twins, blockchain, AI-enabled automation, and circular business models, may support the gradual transition from Industry 4.0 toward more human-centric, resilient, and sustainability-oriented Industry 5.0 paradigms.

Figure 6 presents a forward-looking roadmap that conceptualizes emerging frontiers of AI-enabled sustainability. Rather than implying a deterministic or linear progression, the roadmap illustrates a set of interconnected trajectories through which digital technologies, organizational practices, and institutional arrangements may co-evolve. Central to this depiction is the shift from efficiency-driven Industry 4.0 logics toward Industry 5.0 perspectives that emphasize resilience, inclusivity, and environmental stewardship. Along this trajectory, the reviewed studies highlight several enabling developments, including the adoption of circular economy business models, the use of digital twins for lifecycle optimization, blockchain-based transparency and traceability mechanisms, and the emergence of responsible AI governance frameworks. Empirical contributions by Broo et al. (2022), Peña et al. (2022), and Meinhold et al. (2024) suggest that these frontiers are most effective when technological innovation is accompanied by organizational adaptation and institutional support.

Figure 6. Emerging Frontiers of AI-Enabled Sustainable Transformation

Source: Authors' own illustration.

A recurring theme across the reviewed studies is the movement toward integrated digital ecosystems that combine multiple technologies to address sustainability challenges. For example, Broo et al. (2022) and Meinhold et al. (2024) document how digital twins and smart infrastructure can support lifecycle-oriented sustainability through real-time monitoring, feedback loops, and system-level optimization. While these approaches are associated with improved decision-making and enhanced resilience, the reported outcomes vary across industrial contexts and depend on the maturity of organizational and inter-organizational capabilities. These findings resonate with the collaborative intelligence perspective discussed in Section 3, which emphasizes the co-evolution of human and artificial decision-making systems (Signorini & Pomè, 2025).

Blockchain-enabled applications also feature prominently in the literature. Studies by Alnamrouti et al. (2022) and Florek-Paszkowska and Ujwary-Gil (2025) illustrate how blockchain can enhance transparency, traceability, and accountability in digital circular value chains. Rather than acting as a standalone solution, blockchain is typically positioned as a complementary infrastructure that supports trust-building and governance mechanisms in AI-enabled ecosystems. These insights extend earlier observations regarding the importance of transparency and stakeholder alignment in digital sustainability initiatives (Riggs et al., 2023; Gupta et al., 2019).

Several studies focus on strategic business models and organizational frameworks that align AI deployment with circular economy principles. Cumba et al. (2023) highlight the role of digital transformation and big data analytics in improving firms' sustainability performance, while Mohsen (2024) emphasizes the contribution of AI, autonomous systems, and IoT to more efficient and sustainable urban logistics. Taken together, these studies suggest that AI-enabled digitalization can support sustainability-oriented business and operational models by improving data-driven decision-making, process efficiency, resource coordination, and logistics optimization. However, the empirical evidence suggests that the sustainability benefits of such models are contingent on contextual factors, including regulatory environments, organizational readiness, and cross-sector collaboration.

Growing attention is also directed toward governance models and performance measurement frameworks. Chang and Hossain (2024) and Ieva et al. (2025) propose integrated indicator systems linking AI maturity, digital capability adoption, and sustainability key performance indicators (KPIs). These contributions respond to ongoing measurement challenges identified in the literature, but they also underscore the lack of standardized metrics and longitudinal evidence needed to assess long-term sustainability impacts consistently.

Table 4. AI Frontiers for Sustainable Transformation

Ref.	Focus Area	Frontier Technology or Framework	Sustainability Outcome / Theme	Model or Theoretical Framing
Broo et al. (2022)	Industry 4.0–5.0	Digital twins, lifecycle digitalization	Resource efficiency, supply resilience	Industry 5.0 Framework
Meinhold et al. (2024)	Smart manufacturing	Cross-sector intelligence systems	Rebound mitigation, lifecycle sustainability	Systems Theory
Signorini & Pomè (2025)	Collaborative intelligence	AI-human integration, co-creation logic	Social resilience, agile governance	Collaborative Intelligence
Alnamrouti et al. (2022)	Smart logistics	AI + Blockchain + IoT	Transparency, emissions reduction	Decentralized Tech Architecture
Florek-Paszkowska & Ujwary-Gil (2025)	Circular economy ecosystems	Blockchain governance	Traceability and stakeholder accountability	CE Governance Framework
Chang & Hossain (2024)	Manufacturing (Asia-Pacific)	AI + digital KPIs integration	Data-driven performance tracking	Sustainability Metrics Framework
Cumba et al. (2023)	Sustainable business models	AI-enabled product/service loops	Value co-creation, circular flows	Circular Business Model Design
Mohsen (2024)	Industrial CE transitions	Digital servitization + AI	Waste reduction and resource valorization	CE-Driven Digitalization Model
Ieva et al. (2025)	Smart supply chains	AI maturity and capability metrics	Circular and agile supply chains	Digital Capability Maturity Model
Koukaras et al. (2025)	Governance and AI policy	Risk governance and ethical AI	Compliance, resilience, accountability	AI Ethics Framework
Lu et al. (2025)	Circular manufacturing	AI lifecycle tools and monitoring	Measurement, rebound effect mitigation	Lifecycle Governance Model

Descriptively, Table 4 indicates that a majority of the reviewed studies address multi-technology integration, reflecting a shift toward system-oriented digital architectures rather than isolated technological applications. A substantial subset engages explicitly with Industry 5.0 concepts, signaling a gradual departure from purely operational efficiency concerns toward broader socio-technical considerations. At the same time, only a limited number of studies engage directly with issues of AI ethics, governance, and systemic risk management, suggesting that critical and normative perspectives remain underrepresented in empirical research.

In summary, this theme reflects an emerging but still evolving research agenda on AI frontiers for sustainable transformation. The reviewed studies suggest that next-generation AI architectures can support sustainability objectives when embedded within inclusive, adaptive, and ethically informed ecosystems. However, the variability of reported outcomes and the limited attention to governance and social dimensions indicate that these frontiers represent promising directions rather than established pathways for sustainable transformation.

Discussion

The findings synthesized across Tables 1 to 4 confirm the growing prominence of Artificial Intelligence (AI) and Big Data Analytics (BDA) as enablers of sustainable value creation in supply chains and industrial ecosystems. At the same time, the review reveals that sustainability outcomes associated with these digital technologies are neither automatic nor uniform. Instead, they emerge through complex interactions among digital capabilities, organizational and inter-organizational mechanisms, and contextual conditions operating at multiple levels. This reinforces the view that AI and BDA function less as standalone technological solutions and more as components of broader socio-technical systems whose performance depends on alignment across technological, organizational, and institutional domains (Riggs et al., 2023; Makhloufi, 2023; Shafique et al., 2024).

One of the central theoretical insights arising from this review is the persistent fragmentation across conceptual lenses used to explain AI-enabled sustainability. Prior studies variously draw on the resource-based view (RBV), dynamic capabilities theory (DCT), stakeholder theory, and governance perspectives, often in isolation. While each lens provides valuable partial explanations, their limited integration constrains the development of cumulative theory (Kulkov et al., 2023). Only a small number of studies, such as Riggs et al. (2023), explicitly combine multiple theoretical perspectives to account for capability development, relational coordination, and institutional embedding simultaneously. Building on this gap, the evidence synthesized in this review supports the need for an integrative framework that links (i) AI and BDA as digital resources, (ii) organizational and inter-organizational capabilities as mediating mechanisms, and (iii) contextual and institutional conditions as moderators shaping sustainability outcomes. Such a framework moves beyond deterministic or technology-centric explanations and instead conceptualizes sustainable value creation as a contingent, multi-level process unfolding across supply chains and ecosystems.

From an empirical standpoint, the review highlights persistent contextual biases in the literature. As indicated in Table 3, most ecosystem-level studies are concentrated in developed or institutionally mature economies, including parts of Europe and selected ASEAN countries, while emerging and resource-constrained contexts remain underexplored (Meinhold et al., 2024; Janković & Curovic, 2023). This imbalance limits the generalizability of current findings and overlooks settings where digital infrastructure gaps, regulatory uncertainty, and institutional voids may fundamentally alter AI and BDA adoption pathways. The findings thus echo calls for more context-sensitive research designs that explicitly incorporate institutional diversity and ecosystem heterogeneity into models of digital sustainability (Ogbeibu et al., 2023).

Another salient gap concerns the temporal dimension of AI-enabled sustainability. As reflected in Table 4, the majority of empirical studies emphasize short-term or immediate performance outcomes, such as improvements in traceability, efficiency, or selected environmental indicators (Alnamrouti et al., 2022; Chang & Hossain, 2024). Far fewer studies examine long-term trajectories, dynamic capability evolution, or unintended consequences such as rebound effects (Lu et al., 2025; Tsolakis et al., 2022). This limits understanding of whether observed sustainability gains are durable over time or merely transitional. Addressing this gap requires longitudinal and process-oriented research capable of capturing how digital capabilities, governance arrangements, and stakeholder relationships co-evolve.

Measurement inconsistency represents a further challenge to theory accumulation and practical application. Although several studies propose performance frameworks or digital sustainability indicators (Ieva et al., 2025; Cumba et al., 2023), there is little convergence around standardized metrics, particularly for social sustainability outcomes such as equity, legitimacy, or community resilience. This concern aligns with broader critiques in the sustainability and analytics literature regarding construct proliferation and limited comparability across studies (Rahman et al., 2024; Shaik et al., 2023). The lack of robust, multidimensional measurement frameworks constrains both empirical validation and managerial decision-making.

The review also underscores the importance of contextual and institutional moderators in shaping AI- and BDA-enabled sustainability outcomes. Regulatory frameworks, policy coherence, and ecosystem governance repeatedly emerge as critical conditions influencing adoption and effectiveness (Riad et al., 2024; Peña et al., 2022). Evidence from Table 3 suggests that weak institutional environments can impede digital investment and reduce incentives for sustainable innovation, as observed in resource-intensive or infrastructure-constrained contexts (Kumar & Barua, 2022; George & Wooden, 2023; Stefanović et al., 2025). At the same time, market turbulence and stakeholder norms further condition outcomes by shaping strategic priorities and risk perceptions. In volatile environments, firms may privilege short-term efficiency gains over longer-term resilience and sustainability, while stakeholder expectations can either enable or constrain digital transformation efforts (Broo et al., 2022; Gupta et al., 2019; Riggs et al., 2023). These findings reinforce the argument that adaptive capabilities and stakeholder-aligned governance are central to sustainable digital transformation (Janković & Curovic, 2023).

Drawing on these insights, this review proposes an integrative conceptual framework that positions AI and BDA as core digital resources. Their contribution to sustainability depends on the extent to which they are mobilized through complementary organizational capabilities, including green absorptive capacity, innovation capability, and governance mechanisms, and situated within supportive institutional and ecosystem conditions. Sustainability outcomes, in turn, manifest across economic, environmental, and social dimensions, with their scope and durability shaped by contextual contingencies and temporal dynamics. This framework provides a coherent structure for interpreting the fragmented empirical evidence and clarifies the pathways through which digital technologies may contribute to sustainable transformation.

The findings also yield important implications for managerial and policy practice. For managers, the evidence underscores the necessity of aligning digital investments with capability development, organizational learning, and governance arrangements. Building analytics maturity, developing sustainability-oriented talent, and fostering cross-functional and inter-organizational collaboration are critical steps in translating AI and BDA adoption into meaningful sustainability outcomes (Makhloufi, 2023; Tseng et al., 2022; Chaudhuri et al., 2022; Kulkov et al., 2023). For policymakers, the review highlights the role of regulatory clarity, ethical AI guidelines, and ecosystem-level coordination in enabling responsible and inclusive digital transformation. Supporting interoperability, incentivizing circular business models, and strengthening public–private partnerships can amplify the sustainability impacts of AI and BDA (Koukaras et al., 2025; Mohsen, 2024; Signorini & Pomè, 2025; Shahrivar et al., 2025).

Finally, the synthesis points to a coherent research agenda for future inquiry. First, there is a need for integrative, interdisciplinary frameworks that bridge insights from computer science, environmental science, and management to address governance, measurement, and societal implications of AI-enabled sustainability (Nicoletti & Appolloni, 2023). Second, longitudinal and process-based studies are required to examine how digital capabilities and sustainability outcomes evolve over time, particularly in emerging and resource-constrained ecosystems (Tsolakis et al., 2022). Third, greater scholarly attention should be directed toward ethical governance issues, including fairness, bias, transparency, and data protection, which remain underexplored in empirical research (Lu et al., 2025; Reddy, 2024). Fourth, future studies should prioritize inclusive engagement strategies that examine how digital transformation affects marginalized stakeholders and how participatory governance models can enhance social sustainability outcomes (Ogbeibu et al., 2021).

Overall, the discussion consolidates the review's central argument: while AI and BDA represent powerful digital enablers of sustainable transformation, their effectiveness depends on integrative theory, contextual sensitivity, and coordinated action across technological, organizational, and institutional levels.

FUTURE RESEARCH DIRECTIONS

Based on the synthesis of the reviewed literature, several directions for future research can be proposed. Although prior studies have advanced understanding of the role of artificial intelligence (AI) and big data analytics (BDA) in sustainable value creation, the field remains theoretically fragmented, methodologically uneven, and contextually limited. Future studies should therefore move beyond general claims about the benefits of digital technologies and examine more specifically how, why, and under what conditions AI and BDA contribute to sustainability outcomes across supply chains and industrial ecosystems.

Potential Mediators in AI- and BDA-Enabled Sustainable Value Creation

Future research should give greater attention to the mediating mechanisms through which AI and BDA influence sustainability outcomes. The findings of this review indicate that digital technologies rarely produce sustainability impacts directly. Instead, their effects are often transmitted through organizational and inter-organizational capabilities, such as knowledge sharing, absorptive capacity, innovation capability, supply chain collaboration, transparency, and data governance.

Further studies could examine how these mediators operate individually and collectively. For example, green absorptive capacity may explain how firms acquire, assimilate, and apply sustainability-related data generated through AI and BDA systems. Similarly, innovation capability may mediate the relationship between digital analytics and the development of greener products, cleaner production processes, or circular business models. Supply chain collaboration may also serve as a key mediating pathway by enabling data sharing, joint decision-making, and coordinated sustainability initiatives across multiple actors.

Future research should also test whether different mediators are more relevant for different sustainability dimensions. For instance, environmental outcomes may be more strongly mediated by process innovation and resource optimization, while social sustainability outcomes may depend more on stakeholder engagement, transparency, and ethical governance. By clarifying these mediating pathways, future studies can provide a more precise explanation of how AI and BDA are transformed into sustainable value.

Potential Moderators and Contextual Conditions

Future studies should also examine the moderating factors that shape the strength and direction of the relationship between AI, BDA, and sustainability performance. The reviewed literature suggests that the effectiveness of digital capabilities depends heavily on contextual and institutional conditions. However, these conditions are not yet systematically examined in existing studies.

Potential moderators include regulatory quality, institutional pressure, infrastructure readiness, ecosystem maturity, market turbulence, organizational size, digital maturity, leadership commitment, and stakeholder trust. For example, firms operating in environments with strong environmental regulations and clear digital governance frameworks may be more likely to convert AI and BDA capabilities into measurable sustainability outcomes. Conversely, weak institutional environments, limited infrastructure, low trust among supply chain partners, and fragmented data systems may reduce the effectiveness of digital sustainability initiatives.

Future research should also compare developed and emerging economy contexts. Much of the existing literature remains concentrated in institutionally mature settings, while emerging markets and resource-constrained ecosystems are less represented. This gap is important because the adoption and impact of AI and BDA may differ substantially across contexts due to variations in policy support, digital infrastructure, financial resources, and human capital. Comparative studies can therefore enrich understanding of how contextual conditions moderate AI- and BDA-enabled sustainable value creation.

Longitudinal and Multi-Level Research Designs

Another important direction concerns the need for longitudinal and multi-level research designs. Many existing studies rely on cross-sectional data, which limits understanding of how digital capabilities and sustainability outcomes evolve over time. Future research should examine whether the sustainability benefits of AI and BDA are sustained, strengthened, weakened, or even reversed across longer periods.

Longitudinal studies can help explain how firms develop AI and BDA capabilities, how these capabilities become embedded in organizational routines, and how they influence sustainability performance over time. Such studies are also important for examining unintended consequences, including rebound effects, data dependency, increased energy consumption from digital infrastructure, or unequal distribution of digital benefits across supply chain actors.

Multi-level research is also needed because AI- and BDA-enabled sustainability operates across different levels of analysis. At the firm level, studies may examine digital capability development, managerial decision-making, and innovation processes. At the supply chain level, research may focus on collaboration, traceability, and data-sharing mechanisms. At the ecosystem or institutional level, studies may investigate regulation, public-private partnerships, stakeholder governance, and digital infrastructure. Integrating these levels can provide a more comprehensive understanding of sustainable value creation.

Sustainability Measurement and Standardized Metrics

Future research should also address the inconsistency of sustainability measurement. The reviewed studies use diverse indicators, making it difficult to compare findings across sectors, countries, and methodological approaches. While economic and environmental indicators are frequently measured, social sustainability remains relatively underdeveloped.

Future studies should develop standardized and multidimensional metrics that capture economic, environmental, and social sustainability outcomes more equally. Economic indicators may include productivity, cost efficiency, resilience, and competitive advantage. Environmental indicators may include emission reduction, energy efficiency, waste reduction, resource recovery, and circularity. Social indicators should receive greater attention and may include employee well-being, labor conditions, inclusion, community impact, fairness, transparency, and stakeholder legitimacy.

More robust measurement frameworks would help scholars compare results more effectively and assist managers in evaluating whether AI and BDA investments produce genuine sustainability value rather than merely improving operational efficiency.

Ethics, Governance, and Responsible AI

Future research should place stronger emphasis on ethical and governance issues in AI- and BDA-enabled sustainability. Although responsible AI, data privacy, algorithmic bias, accountability, and transparency are increasingly discussed, they remain insufficiently integrated into empirical models of sustainable value creation.

Future studies should examine how ethical AI governance influences sustainability outcomes. This includes investigating how organizations design accountability mechanisms, manage data privacy risks, reduce algorithmic bias, and ensure that AI-supported decisions remain transparent and explainable. These issues are especially important in supply chains and industrial ecosystems, where digital decisions may affect multiple stakeholders, including suppliers, employees, customers, communities, and regulators.

Research on responsible AI should also be connected to social sustainability. AI and BDA may create efficiency gains, but they may also generate risks related to labor displacement, surveillance, exclusion, or unequal access to digital resources. Future studies should therefore examine how responsible governance can ensure that digital transformation supports inclusive and equitable sustainability outcomes.

CONCLUSION

This systematic literature review examined how artificial intelligence (AI) and big data analytics (BDA) contribute to sustainable value creation across supply chains and industrial ecosystems. By synthesizing evidence from 26 peer-reviewed studies, the review demonstrates that AI and BDA should not be understood merely as technological tools. Rather, they function as strategic digital capabilities whose sustainability impacts depend on complementary organizational, supply chain, and ecosystem-level conditions.

The review generated several key insights. First, AI and BDA are most effective in supporting sustainable value creation when embedded within dynamic capabilities such as learning, innovation, sensing, seizing, and reconfiguration. Their value also increases when aligned with supply chain management capabilities and stakeholder collaboration. Second, the relationship between digital capabilities and sustainability outcomes is largely indirect. Mechanisms such as knowledge sharing, transparency, absorptive capacity, innovation capability, supply chain collaboration, and governance play important mediating roles in translating AI and BDA into economic, environmental, and social value. Third, ecosystem and institutional contingencies, including regulatory frameworks, infrastructure readiness, digital maturity, market turbulence, and trust-based relationships, strongly shape the success of AI-enabled sustainability initiatives. Fourth, emerging frontiers such as Industry 5.0, circular economy business models, digital twins, blockchain-supported transparency, and responsible AI indicate a shift toward more human-centric, resilient, and system-oriented approaches to sustainability.

Overall, this review contributes to the literature by offering a capability-based and ecosystem-oriented understanding of AI- and BDA-enabled sustainable value creation. It clarifies that digital technologies do not automatically produce sustainability outcomes through adoption alone. Instead, sustainable value emerges when digital capabilities are supported by organizational learning, innovation, governance, stakeholder coordination, and favorable institutional conditions.

For practitioners, the findings highlight the importance of aligning AI and BDA investments with capability development, sustainability strategy, and inter-organizational collaboration. Managers should not focus only on acquiring advanced technologies, but also on building the human, organizational, and governance capabilities needed to use these technologies responsibly and effectively. For policymakers, the review underscores the importance of regulatory clarity, digital infrastructure, ethical AI guidelines, and ecosystem-level coordination to ensure that AI and BDA support inclusive and sustainable transformation.

In conclusion, this systematic literature review provides a theoretically grounded synthesis of the relationship between AI, BDA, and sustainable value creation. It advances understanding of the mechanisms, contingencies, and emerging research frontiers that shape digital sustainability in supply chains and industrial ecosystems. By integrating technological, organizational, and institutional perspectives, the review offers a foundation for future research and practical action at the intersection of AI, data analytics, and sustainability.

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