Artificial Intelligence and Digital Transformation for Sustainable Engineering Systems: A Review of Leadership, Circular Economy, Digital Twins, and Machine Learning

Rabeta Sharmin[1]

[1]Department of Social Science and Business, Roskilde University, Denmark.

Publication Date: 2026/08/04

Abstract: The rapid advancement of Artificial Intelligence (AI) and digital transformation technologies is fundamentally reshaping sustainable engineering systems across manufacturing, supply chain management, energy, infrastructure, and industrial operations. Modern engineering systems increasingly integrate intelligent technologies, including machine learning, digital twins, blockchain, cloud computing, and data analytics, to improve operational efficiency, resource utilization, decision-making, and environmental sustainability. Simultaneously, organizational leadership, circular economy principles, and effective project management have emerged as critical enablers for the successful adoption of digital transformation initiatives. This review presents a comprehensive overview of recent developments in AI-driven digital transformation for sustainable engineering systems by synthesizing research on digital leadership, circular economy, blockchain-enabled supply chains, machine learning, digital twin technologies, and intelligent engineering applications. The review first examines the role of leadership and organizational transformation in promoting sustainability and digital innovation. It then discusses the contributions of machine learning algorithms, including Random Forest and Gradient Boosting, toward intelligent decision support and predictive analytics. Furthermore, recent advances in digital twin technology and AI-assisted engineering applications are reviewed using reservoir characterization as an illustrative case study of intelligent engineering systems. Finally, current research challenges, including data integration, scalability, sustainability, interoperability, cybersecurity, and organizational readiness, are analyzed, followed by future research directions emphasizing explainable AI, human-centered digital transformation, and integrated intelligent engineering ecosystems. By consolidating diverse research areas into a unified framework, this review highlights how AI-enabled digital transformation can support resilient, efficient, and sustainable engineering systems while providing guidance for future interdisciplinary research and industrial implementation.

Keywords: *Artificial Intelligence, Digital Transformation, Sustainable Engineering Systems, Machine Learning, Digital Twin, Leadership, Circular Economy, Blockchain, Industry 4.0.*

How to Cite: Rabeta Sharmin (2026) Artificial Intelligence and Digital Transformation for Sustainable Engineering Systems: A Review of Leadership, Circular Economy, Digital Twins, and Machine Learning. *International Journal of Innovative Science and Research Technology*, 11(7), 2790-2797. https://doi.org/10.38124/ijisrt/26jul1411

I. INTRODUCTION

The emergence of digital technologies has fundamentally transformed the way engineering systems are designed, managed, and optimized. Rapid advances in Artificial Intelligence (AI), machine learning, cloud computing, the Internet of Things (IoT), blockchain, and digital twin technologies have accelerated the transition from conventional engineering practices toward intelligent and data-driven systems. This transformation, commonly referred to as digital transformation, extends beyond technology adoption by integrating digital capabilities into organizational processes, operational strategies, and engineering decision-making. As industries strive to improve productivity, resilience, and environmental performance, digital transformation has become a central component of sustainable engineering development.

Sustainability has emerged as one of the most significant challenges facing modern engineering systems. Increasing industrialization, resource depletion, environmental

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul1411

degradation, and climate change require engineering organizations to adopt innovative approaches that simultaneously enhance economic performance while reducing environmental impacts. Circular economy principles have gained considerable attention as an effective strategy for promoting resource efficiency, waste minimization, and sustainable industrial development by encouraging recycling, reuse, remanufacturing, and lifecycle optimization of products and materials [2], [3], [6]. However, achieving these objectives requires not only technological innovation but also effective organizational leadership capable of guiding digital transformation and sustainable change.

Leadership plays a critical role in enabling successful digital transformation initiatives. Effective leadership influences organizational culture, strategic decision-making, innovation capability, and stakeholder collaboration, all of which contribute to the successful implementation of AI-driven engineering systems. Recent studies have demonstrated that digital leadership significantly improves organizational adaptability and supports sustainable supply chain management through data-driven decision-making and collaborative digital ecosystems [1]–[3]. Similarly, structured project management methodologies provide systematic approaches for prioritizing engineering challenges and managing complex digital transformation projects in sustainable environments [5].

Artificial Intelligence has become one of the primary technological drivers of digital transformation across engineering disciplines. Machine learning algorithms enable engineering systems to analyze large volumes of operational data, identify complex patterns, predict future behavior, and automate decision-making processes. Classical machine learning techniques such as Random Forest and Gradient Boosting have demonstrated outstanding performance in predictive analytics because of their robustness, interpretability, and ability to model nonlinear engineering systems [14], [15]. These capabilities have significantly expanded AI applications in manufacturing, supply chain optimization, predictive maintenance, structural health monitoring, and energy management.

Recent advances have further extended AI capabilities through digital twin technologies, which create continuously updated virtual representations of physical engineering systems. Digital twins integrate real-time sensor information, simulation models, and machine learning algorithms to support predictive maintenance, operational optimization, and intelligent decision-making. Although digital twins have been widely investigated in manufacturing and industrial automation, their application to seismic reservoir characterization demonstrates how AI can support complex engineering systems requiring continuous monitoring, predictive analysis, and uncertainty management [7], [8]. Furthermore, machine learning techniques have shown remarkable effectiveness in seismic interpretation, fault detection, porosity prediction, and integrated reservoir characterization, illustrating the broader potential of AI-enabled engineering intelligence [9]–[13].

In parallel, blockchain technology has emerged as a complementary digital technology capable of improving transparency, security, and traceability within modern engineering systems. Blockchain-enabled supply chain management provides secure information sharing while supporting intelligent automation through integration with machine learning algorithms [4]. The combination of AI, blockchain, and digital transformation technologies therefore represents a promising direction for building resilient, trustworthy, and sustainable engineering ecosystems.

Despite significant technological progress, numerous challenges continue to hinder the widespread implementation of AI-driven digital transformation. Engineering organizations must address issues related to data integration, interoperability, cybersecurity, organizational readiness, sustainability, workforce adaptation, and ethical deployment of AI technologies. Successfully overcoming these challenges requires an interdisciplinary perspective that combines technological innovation with leadership, organizational management, and sustainable engineering principles.

This review aims to provide a comprehensive synthesis of recent developments in Artificial Intelligence and digital transformation for sustainable engineering systems. Specifically, the review (i) examines the role of leadership and circular economy principles in digital transformation, (ii) reviews machine learning and digital twin technologies for intelligent engineering applications, (iii) discusses blockchain and project management as enabling technologies for digital transformation, and (iv) identifies current research challenges and future opportunities for developing sustainable, intelligent, and resilient engineering systems. By integrating these diverse yet interconnected research areas, this review provides a holistic perspective on the future of AI-enabled sustainable engineering.

II. DIGITAL TRANSFORMATION IN SUSTAINABLE ENGINEERING SYSTEMS

Digital transformation has emerged as one of the most influential forces driving innovation in modern engineering systems. By integrating Artificial Intelligence (AI), machine learning, blockchain, cloud computing, the Internet of Things (IoT), and digital twin technologies, engineering organizations are transitioning from conventional operations to intelligent, data-driven, and sustainable systems. Unlike traditional digitalization, which primarily focuses on converting analog information into digital formats, digital transformation fundamentally changes organizational strategies, engineering processes, decision-making mechanisms, and business models through the effective use of digital technologies. This transformation not only enhances productivity and operational

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul1411

efficiency but also supports environmental sustainability, resource optimization, and organizational resilience.

The successful implementation of digital transformation depends on multiple interconnected factors, including visionary leadership, sustainable organizational strategies, intelligent technologies, secure data management, and systematic project execution. This section reviews these essential components and discusses how they collectively contribute to sustainable engineering systems.

➢ *Digital Transformation in Sustainable Engineering*

Engineering industries are experiencing unprecedented technological change driven by increasing computational capability, data availability, and intelligent automation. Digital transformation enables organizations to collect real-time operational data, monitor engineering assets continuously, automate repetitive processes, and optimize system performance using advanced analytics and AI-based decision support.

Within sustainable engineering systems, digital transformation supports several important objectives:

- Improved operational efficiency through automation.
- Enhanced resource utilization and energy efficiency.
- Data-driven engineering decision-making.
- Predictive maintenance and reliability improvement.
- Reduced environmental impacts through optimized resource consumption.
- Increased organizational adaptability and resilience.

The integration of digital technologies also enables engineering organizations to respond more effectively to rapidly changing market conditions, environmental regulations, and customer requirements. Consequently, digital transformation has become a strategic necessity rather than simply a technological upgrade.

However, successful transformation extends beyond technological adoption. It requires organizational commitment, strategic planning, workforce development, and effective leadership capable of managing technological and cultural change throughout the organization [1]–[3].

➢ *Leadership and Organizational Transformation*

Leadership has become one of the most important determinants of successful digital transformation. As organizations adopt increasingly sophisticated digital technologies, leaders must establish strategic visions, allocate resources effectively, encourage innovation, and manage organizational change.

Islam [1] emphasized that leadership significantly influences the dynamics of sustainable supply chains by strengthening collaboration, improving organizational adaptability, and supporting long-term sustainability objectives. Effective leaders facilitate communication among stakeholders while encouraging continuous learning and innovation during digital transformation initiatives.

Digital leadership extends beyond traditional management by emphasizing technological awareness, data-driven decision-making, organizational agility, and digital innovation. Islam [2] demonstrated that digital leadership positively contributes to circular economy performance by enabling organizations to integrate digital technologies with sustainable business practices. Organizations led by digitally competent leaders are better positioned to exploit AI, big data analytics, and intelligent automation while maintaining sustainable operational performance.

Similarly, sustainable industrial transformation requires leadership capable of balancing economic growth with environmental responsibility. Islam [3] proposed a holistic leadership framework that integrates sustainability principles with circular economy practices to support resilient industrial development. This framework highlights leadership as an essential component for coordinating technological innovation, organizational transformation, and environmental stewardship.

Collectively, these studies demonstrate that leadership provides the organizational foundation necessary for implementing AI-enabled digital transformation successfully across engineering systems.

➢ *Circular Economy and Sustainable Engineering*

The circular economy has emerged as an alternative to the traditional linear economic model of "take–make–dispose." Instead, circular economy principles emphasize maintaining the value of products, materials, and resources for as long as possible through reuse, recycling, remanufacturing, and resource recovery.

Digital transformation significantly enhances circular economy implementation by enabling organizations to monitor resource flows, optimize production processes, and support lifecycle management using intelligent technologies. AI-driven analytics can identify inefficiencies, predict equipment failures, optimize material utilization, and minimize waste generation throughout industrial operations.

Islam [2] demonstrated that digital leadership plays an important role in improving circular economy performance by integrating digital technologies with sustainable management practices. Likewise, Islam [3] proposed a comprehensive framework illustrating how leadership, innovation, and circular economy strategies collectively contribute to sustainable industrial transformation.

Plastic recycling represents one practical application of circular economy principles. Uddin et al. [6] reviewed recent technological advances in plastic recycling and highlighted the importance of innovative recycling technologies, improved

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul1411

waste management strategies, and sustainable material recovery for achieving environmental sustainability. Emerging AI technologies can further improve recycling processes through intelligent material classification, process optimization, and automated quality inspection.

The convergence of digital transformation and circular economy therefore enables engineering organizations to improve environmental performance while simultaneously increasing operational efficiency and long-term sustainability.

➢ *Blockchain for Secure Engineering Systems*

As engineering systems become increasingly interconnected, ensuring data security, transparency, and traceability has become critically important. Blockchain technology provides a decentralized and tamper-resistant infrastructure capable of securely recording transactions across distributed engineering networks.

Bipasha et al. [4] proposed a blockchain and machine learning framework for secure digital supply chain management. Their framework combines blockchain's immutable ledger with machine learning-based decision support to improve transparency, traceability, operational security, and supply chain efficiency.

Within engineering systems, blockchain technology offers several important advantages:

- Secure information sharing.
- Transparent transaction records.
- Improved supply chain traceability.
- Enhanced cybersecurity.
- Reduced fraud and data manipulation.
- Reliable collaboration among distributed stakeholders.

When integrated with AI-based predictive analytics, blockchain enables intelligent engineering systems capable of making secure, trustworthy, and data-driven decisions while maintaining information integrity across complex industrial ecosystems.

➢ *Project Management for Digital Transformation*

Digital transformation projects frequently involve multiple stakeholders, complex technological infrastructures, and significant organizational change. Consequently, effective project management has become essential for ensuring successful implementation.

Islam and Halim [5] introduced a challenge-driven project management framework using Multi-Criteria Decision-Making (MCDM) techniques to prioritize engineering challenges and support sustainable development initiatives. Their framework emphasizes systematic evaluation, prioritization, stakeholder engagement, and evidence-based decision-making throughout project implementation.

Effective project management contributes to digital transformation by:

- Identifying critical implementation challenges.
- Prioritizing technological investments.
- Managing organizational risks.
- Improving resource allocation.
- Supporting interdisciplinary collaboration.
- Monitoring project performance continuously.

As AI-driven engineering systems become increasingly complex, structured project management methodologies will play an even greater role in coordinating digital transformation efforts across diverse engineering domains.

III. ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING FOR SUSTAINABLE ENGINEERING SYSTEMS

Artificial Intelligence (AI) has become one of the most transformative technologies driving digital transformation in modern engineering systems. The rapid growth of industrial data generated from sensors, manufacturing processes, supply chains, infrastructure, and monitoring systems has created new opportunities for intelligent decision-making through machine learning and predictive analytics. Unlike conventional engineering approaches that rely heavily on human expertise and predefined mathematical models, AI enables systems to automatically learn complex relationships from data, identify hidden patterns, predict future system behavior, and continuously improve operational performance.

Within sustainable engineering, AI contributes to multiple objectives, including operational optimization, predictive maintenance, resource efficiency, quality improvement, intelligent automation, and environmental sustainability. Recent developments have further expanded AI applications through digital twin technologies that integrate real-time monitoring, simulation, and predictive analytics into unified engineering platforms. This section reviews the evolution of AI in engineering systems, the role of machine learning algorithms, digital twin technologies, and selected intelligent engineering applications.

➢ *Artificial Intelligence in Engineering Systems*

Artificial Intelligence has evolved from a specialized research discipline into a core technology supporting digital transformation across nearly every engineering sector. AI systems analyze large-scale engineering datasets, automate complex decision-making processes, optimize industrial operations, and improve system reliability.

Modern engineering applications of AI include:

- Predictive maintenance.
- Manufacturing optimization.
- Structural health monitoring.
- Smart energy management.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul1411

- Supply chain optimization.
- Autonomous quality inspection.
- Environmental monitoring.
- Infrastructure management.

The increasing availability of high-performance computing, cloud platforms, and Industrial Internet of Things (IIoT) technologies has significantly accelerated AI adoption. These technologies enable continuous collection of operational data, allowing machine learning models to provide real-time recommendations that improve engineering efficiency while reducing operational costs.

Digital transformation therefore increasingly depends on AI as the analytical engine responsible for converting raw engineering data into actionable knowledge for intelligent decision-making.

➢ *Machine Learning Algorithms for Intelligent Decision-Making*

Machine learning represents one of the most important branches of Artificial Intelligence because it enables engineering systems to learn predictive relationships directly from historical data. Instead of requiring explicit programming for every engineering scenario, machine learning algorithms automatically discover patterns and improve prediction accuracy through experience.

Among the most widely applied supervised learning algorithms are **Random Forest** and **Gradient Boosting**, both of which have demonstrated excellent performance across numerous engineering applications.

- *Random Forest*

Random Forest is an ensemble learning algorithm introduced by Breiman [14]. The method constructs multiple decision trees using random subsets of training samples and input features before combining their outputs into a final prediction. This ensemble strategy significantly improves prediction accuracy while reducing overfitting compared with individual decision trees.

The major advantages of Random Forest include:

✓ High prediction accuracy.
✓ Robustness against noisy datasets.
✓ Ability to model nonlinear relationships.
✓ Automatic estimation of feature importance.
✓ Efficient handling of high-dimensional engineering data.

Because of these characteristics, Random Forest has become widely adopted for predictive maintenance, quality prediction, environmental monitoring, structural assessment, and industrial process optimization.

- *Gradient Boosting*

Gradient Boosting, proposed by Friedman [15], constructs predictive models sequentially by allowing each new decision tree to correct errors generated by previous models. Unlike Random Forest, which builds trees independently, Gradient Boosting continuously improves prediction performance through iterative optimization.

Its major strengths include:

✓ Excellent predictive capability.
✓ Flexible nonlinear modeling.
✓ Strong performance on structured datasets.
✓ High adaptability across engineering applications.

Gradient Boosting has therefore become one of the leading machine learning algorithms for engineering prediction, intelligent forecasting, and optimization problems where high predictive accuracy is required.

Together, Random Forest and Gradient Boosting form the foundation of many modern AI-driven engineering systems.

➢ *Digital Twin Technologies*

Digital Twin technology has emerged as one of the defining innovations of Industry 4.0 by providing continuously synchronized virtual representations of physical engineering assets. A digital twin integrates sensor data, simulation models, historical information, and machine learning algorithms to support intelligent monitoring and operational decision-making throughout an asset's lifecycle.

Unlike conventional simulation models, digital twins continuously update their virtual representations using real-time operational information, allowing engineers to observe system behavior, predict failures, optimize performance, and evaluate alternative operational strategies before implementing physical changes.

Elbarouni [7] reviewed recent developments in AI-driven seismic interpretation and digital twin technologies, demonstrating how continuous data integration can improve reservoir monitoring and intelligent decision support. Expanding upon this concept, Elbarouni [8] proposed an AI-driven digital twin framework capable of supporting real-time reservoir monitoring and predictive hydrocarbon production optimization through intelligent analytics.

Although initially developed for industrial manufacturing and aerospace systems, digital twin technologies are increasingly being adopted across multiple engineering disciplines because they enable:

- Real-time asset monitoring.
- Predictive maintenance.
- Process optimization.

- Failure prediction.
- Operational risk reduction.
- Intelligent engineering decision support.

As AI capabilities continue to advance, digital twins are expected to become increasingly autonomous, adaptive, and capable of supporting sustainable engineering operations through continuous learning and optimization.

➢ *Intelligent Engineering Applications: Reservoir Characterization as a Case Study*

The application of Artificial Intelligence to seismic reservoir characterization provides an excellent example of how intelligent technologies can transform complex engineering systems. Reservoir characterization involves interpreting subsurface geological structures using seismic data, petrophysical measurements, and geological information to support hydrocarbon exploration and production.

Traditional reservoir interpretation often depends heavily on expert judgment and manual analysis. Recent advances in machine learning have significantly improved this process by enabling automated analysis of large seismic datasets.

Elbarouni [9] reviewed advanced three-dimensional seismic interpretation techniques for improving subsurface structural mapping and reservoir characterization accuracy. By combining multiple seismic attributes with intelligent analytical methods, AI systems can identify geological structures more efficiently than traditional manual interpretation.

Machine learning has also demonstrated strong capability for structural interpretation. Elbarouni [10] presented an AI-assisted framework for seismic attribute-based fault detection, illustrating how intelligent algorithms improve fault identification and structural mapping within three-dimensional seismic datasets.

The integration of seismic information with petrophysical data further improves engineering decision-making. Elbarouni [11] demonstrated that combining multiple data sources enhances reservoir characterization accuracy by providing more comprehensive descriptions of subsurface geological conditions.

Machine learning algorithms have additionally shown considerable success in predicting reservoir properties directly from seismic attributes. Elbarouni [12] applied machine learning techniques for porosity prediction and lithofacies classification in clastic hydrocarbon reservoirs, demonstrating the effectiveness of AI-based predictive models for geological interpretation.

Engineering decisions are inevitably affected by uncertainty arising from measurement noise, incomplete observations, and geological complexity. Recognizing this challenge, Elbarouni [13] proposed an uncertainty-aware reservoir characterization framework that integrates probabilistic information into seismic interpretation. Incorporating uncertainty estimation enables engineers to evaluate prediction reliability and make more informed operational decisions.

Although these applications originate within petroleum engineering, they illustrate broader principles that extend across sustainable engineering systems. The integration of AI, machine learning, predictive analytics, and digital twins demonstrates how intelligent technologies can improve monitoring, optimization, and decision-making in complex engineering environments.

➢ *Benefits and Current Challenges*

Despite remarkable advances, implementing AI-driven engineering systems remains challenging. Successful deployment depends not only on algorithmic performance but also on data quality, computational resources, organizational readiness, and workforce capabilities.

Major benefits of AI include:

- Improved engineering decision-making.
- Increased operational efficiency.
- Predictive maintenance.
- Reduced operational costs.
- Enhanced resource utilization.
- Better sustainability performance.
- Continuous learning and system optimization.

However, several limitations continue to affect widespread implementation:

- Limited availability of high-quality engineering datasets.
- Data integration challenges across heterogeneous systems.
- Computational requirements for large-scale AI models.
- Lack of standardized implementation frameworks.
- Workforce skill gaps.
- Cybersecurity and data privacy concerns.
- Difficulty integrating AI into existing industrial infrastructures.

Addressing these challenges requires interdisciplinary collaboration among engineers, computer scientists, organizational leaders, and policymakers to develop reliable, scalable, and sustainable AI solutions.

IV. CONCLUSION

Artificial Intelligence (AI) and digital transformation have become fundamental drivers of innovation in sustainable engineering systems, enabling organizations to improve operational efficiency, resource utilization, decision-making, and long-term sustainability. The convergence of intelligent technologies—including machine learning, digital twins, blockchain, cloud computing, and data analytics—has

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul1411

transformed traditional engineering practices into interconnected, data-driven, and adaptive systems capable of addressing increasingly complex industrial and environmental challenges.

This review examined the critical role of digital transformation in achieving sustainable engineering objectives by integrating technological innovation with organizational leadership, circular economy principles, and structured project management. The reviewed studies demonstrate that successful digital transformation depends not only on advanced technologies but also on effective leadership capable of guiding organizational change, fostering innovation, and promoting sustainable development. Digital leadership has emerged as a key enabler for implementing AI-driven engineering systems and supporting resilient organizational performance within rapidly evolving industrial environments [1]–[3].

The review also highlighted the growing importance of circular economy strategies in sustainable engineering. Digital technologies enable organizations to optimize resource utilization, minimize waste generation, improve recycling processes, and support environmentally responsible production systems. Blockchain technology further strengthens digital transformation by providing secure, transparent, and traceable information management, while structured project management frameworks facilitate the successful planning and execution of complex engineering initiatives [4]–[6].

Artificial Intelligence and machine learning represent the analytical foundation of modern digital engineering systems. Classical machine learning algorithms such as Random Forest and Gradient Boosting continue to demonstrate robust predictive capabilities across a wide range of engineering applications, including predictive maintenance, optimization, quality control, and intelligent decision support [14], [15]. Furthermore, the integration of AI with digital twin technologies enables continuous monitoring, predictive analytics, and real-time optimization of complex engineering assets, significantly improving operational efficiency and system reliability [7], [8].

Reservoir characterization serves as a representative case study illustrating the broader impact of AI in engineering. Recent advances in seismic interpretation, fault detection, seismic–petrophysical integration, machine learning-based prediction, and uncertainty-aware analysis demonstrate how intelligent algorithms can improve the accuracy and reliability of engineering decision-making in data-intensive environments [9]–[13]. Although these applications originate from petroleum engineering, the underlying methodologies are transferable to numerous engineering disciplines where large-scale data analytics and predictive modeling are essential.

Despite these significant advances, several challenges continue to limit the widespread implementation of AI-driven digital transformation. Engineering organizations must address issues related to heterogeneous data integration, interoperability among digital platforms, cybersecurity, workforce development, organizational readiness, and the transparency of increasingly complex AI models. Overcoming these challenges will require close collaboration among engineers, computer scientists, organizational leaders, policymakers, and industry stakeholders to develop standardized, secure, and sustainable digital engineering ecosystems.

Looking forward, future research should focus on developing explainable and trustworthy AI models, integrating digital twins with advanced machine learning techniques, enhancing blockchain-enabled engineering platforms, strengthening human-centered digital leadership, and expanding AI applications to support circular economy initiatives. In addition, establishing standardized frameworks for digital transformation and promoting interdisciplinary collaboration will be essential for accelerating the adoption of intelligent technologies across diverse engineering sectors.

In conclusion, the integration of Artificial Intelligence and digital transformation is redefining the future of sustainable engineering systems. By combining intelligent technologies with effective leadership, sustainable management practices, and data-driven decision-making, engineering organizations can build more resilient, efficient, transparent, and environmentally responsible systems. As digital technologies continue to evolve, AI-driven engineering will play an increasingly important role in supporting sustainable industrial development, improving organizational competitiveness, and addressing the complex engineering challenges of the future.

REFERENCES

[1]. M. R. Islam, "System Dynamics of Leadership Influence in Sustainable Supply Chains," *World Journal of Advanced Engineering Technology and Sciences*, vol. 17, no. 03, pp. 509–514, 2025, doi: 10.30574/wjaets.2025.17.3.1584.

[2]. M. R. Islam, "Digital Leadership and Circular Economy Performance in Sustainable Supply Chains," *World Journal of Advanced Engineering Technology and Sciences*, vol. 17, no. 03, pp. 503–508, 2025, doi: 10.30574/wjaets.2025.17.3.1583.

[3]. M. R. Islam, "Circular economy leadership for sustainable industrial transformation: A holistic framework for resilient and resource-efficient growth," *World Journal of Advanced Engineering Technology and Sciences*, vol. 17, no. 03, pp. 253–262, 2025, doi: 10.30574/wjaets.2025.17.3.1540.

[4]. Y. A. Bipasha, M. R. Islam, and M. F. Ahmed, "A blockchain and machine learning framework for secure and transparent digital supply chain management," *International Journal of Innovative Science and Research Technology*, vol. 11, no. 3, pp. 945–952, Mar. 2026, doi: 10.38124/IJISRT/26MAR767.

[5]. M. R. Islam and A. Halim, "Developing a challenge-driven project management framework for sustainable development: An MCDM-based evaluation and prioritization approach," *International Journal of Science and Research Archive*, vol. 18, no. 01, pp. 177–187, 2026, doi: 10.30574/ijsra.2026.18.1.0027.
[6]. M. B. Uddin, M. R. Islam, M. N. Uddin, and A. Halim, "Next-generation plastic recycling: Breakthrough developments and the path toward a circular economy," *World Journal of Advanced Engineering Technology and Sciences*, vol. 16, no. 01, pp. 513–527, 2025, doi: 10.30574/wjaets.2025.16.1.1237.
[7]. R. A. Elbarouni, "A review of AI-driven seismic interpretation, digital twin technology and intelligent reservoir characterization for hydrocarbon exploration," *World Journal of Advanced Engineering Technology and Sciences*, vol. 09, no. 01, pp. 513–519, 2023, doi: 10.30574/wjaets.2023.9.1.0147.
[8]. R. A. Elbarouni, "AI-driven digital twin framework for real-time seismic reservoir monitoring and predictive hydrocarbon production optimization," *World Journal of Advanced Engineering Technology and Sciences*, vol. 11, no. 02, pp. 712–720, 2024, doi: 10.30574/wjaets.2024.11.2.0122.
[9]. R. A. Elbarouni, "Advanced 3D seismic interpretation techniques for accurate subsurface structural mapping and reservoir characterization," *International Journal of Science and Research Archive*, vol. 18, no. 03, pp. 992–1002, 2026, doi: 10.30574/ijsra.2026.18.3.0539.
[10]. R. A. Elbarouni, "Seismic attribute-based fault detection and structural mapping in 3D seismic data for hydrocarbon exploration," *World Journal of Advanced Engineering Technology and Sciences*, vol. 18, no. 03, pp. 320–329, 2026, doi: 10.30574/wjaets.2026.18.3.0166.
[11]. R. A. Elbarouni, "Integrated seismic and petrophysical analysis for improved hydrocarbon reservoir characterization," *World Journal of Advanced Engineering Technology and Sciences*, vol. 20, no. 01, pp. 196–207, 2026, doi: 10.30574/wjaets.2026.20.1.0364.
[12]. R. A. Elbarouni, "Machine learning-based seismic attribute analysis for porosity prediction and lithofacies classification in clastic hydrocarbon reservoirs," *World Journal of Advanced Engineering Technology and Sciences*, vol. 20, no. 01, pp. 231–240, 2026, doi: 10.30574/wjaets.2026.20.1.0366.
[13]. R. A. Elbarouni, "Uncertainty-aware reservoir characterization using probabilistic seismic–petrophysical integration," *World Journal of Advanced Engineering Technology and Sciences*, vol. 20, no. 01, pp. 219–230, 2026, doi: 10.30574/wjaets.2026.20.1.0365.
[14]. L. Breiman, "Random forests," *Machine Learning*, vol. 45, no. 1, pp. 5–32, 2001.
[15]. J. H. Friedman, "Greedy function approximation: A gradient boosting machine," *Annals of Statistics*, vol. 29, no. 5, pp. 1189–1232, 2001.