INTERNATIONAL JOURNAL OF SOCIAL SCIENCE HUMANITY & MANAGEMENT RESEARCH

ISSN (print) 2833-2172, ISSN (online) 2833-2180

Volume 04 Issue 11 November 2025

DOI: 10.58806/ijsshmr.2025v4i11n12, Impact Factor: 6.79

Page No. 2148-2155

Sustainable Project Management in the Age of Artificial Intelligence: Pathways for Integration and Innovation

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ABSTRACT: This systematic literature review critically examines the integration of artificial intelligence (AI) within sustainable project management, synthesizing contemporary research published between 2023 and 2025 across peer-reviewed journals, industry reports, and high-impact case studies. The review investigates how AI technologies are leveraged in project sectors—including construction and infrastructure—to achieve sustainability goals such as resource efficiency, risk mitigation, and alignment with the Sustainable Development Goals (SDGs). A narrative and thematic synthesis approach was employed, drawing from leading academic databases and utilizing established quality assessment criteria to ensure methodological rigor. Results demonstrate that AI adoption contributes to significant improvements in resource utilization, project scheduling, and real-time risk assessment, while also surfacing persistent barriers including data quality challenges, skill gaps, organizational resistance, and the environmental footprint of advanced digital systems. The review further highlights the emergence of new competency frameworks, the imperative of robust governance and ethical oversight, and the critical balance between technological innovation and sustainable practice. Concluding with a roadmap for future research and actionable recommendations for practitioners and policymakers, this study provides a comprehensive reference point to guide responsible and effective AI integration within sustainable project management frameworks.

1. INTRODUCTION

Sustainable project management has become a strategic priority in response to growing global concerns about climate change, resource depletion, and social equity. Integrating sustainability principles into project management requires navigating complex trade-offs among environmental stewardship, social responsibility, and economic growth to ensure that projects contribute positively to the broader Sustainable Development Goals (GPM Global, 2024; International Project Management Association, 2024).

At the same time, advances in artificial intelligence (AI) are transforming how projects are conceived, planned, and executed. AI technologies now enable more accurate forecasting, optimized resource allocation, and data-driven decision-making that can significantly enhance project performance (Bhattarai, 2025; Felicetti, 2024).

Despite the growing momentum behind both sustainability and AI adoption, the intersection of these two domains remains underexplored in both academia and industry. Projects today face mounting challenges—from environmental risks and regulatory pressures to complex stakeholder environments—making it increasingly vital to understand how AI-powered tools can be leveraged to advance sustainability outcomes (Araújo et al., 2024; Sharma, 2025). Yet, realizing this potential requires addressing significant barriers, including poor data quality, organizational resistance, skill and competency gaps, and the environmental footprint of AI technologies themselves (Carbon Direct, 2025; PMI Sweden, 2025).

Recent surveys underscore this gap. Although 72% of project managers expect AI to substantially impact their roles, only 22% of organizations have deployed AI tools in project management, and just 12% report achieving meaningful adoption (ArtsMART AI, 2025). Moreover, while 75% of experts agree that complex projects stand to benefit most from AI integration, sector-specific applications and implementation pathways remain insufficiently mapped in existing research (ArtsMART AI, 2025). This disconnect highlights a critical need to align technological advancements with sustainability goals through effective governance, change management, and strategic integration.

The convergence of AI and sustainability in project management presents both transformative opportunities and unresolved tensions—particularly regarding the environmental costs associated with AI systems themselves. As organizations strive to embed AI into sustainable project management frameworks, many encounter a misalignment between technical capabilities and organizational sustainability objectives. Overcoming these challenges requires deliberate frameworks that harmonize innovation with ethical, environmental, and social priorities.

This review addresses these issues by examining recent peer-reviewed studies and industry sources to identify pathways for integrating AI within sustainable project management. It explores theoretical perspectives, practical implementations, and policy implications, while highlighting research gaps and future directions critical to advancing knowledge and practice among researchers, practitioners, and policymakers.

2. METHODOLOGY

This study adopts a systematic literature review (SLR) methodology—a rigorous and transparent approach for identifying, evaluating, and synthesizing existing research on artificial intelligence (AI) applications in sustainable project management (Scribbr, 2025; Phillips & Barker, 2021). The review protocol was designed to systematically identify, categorize, and synthesize recent evidence surrounding integration opportunities, implementation barriers, sustainability outcomes, and emerging competency requirements in the intersection of AI and sustainable project management.

Academic databases including Semantic Scholar, AI research agent, SciSpace AI research agent, Digital Library, and Google Scholar were searched using combinations of keywords such as “artificial intelligence,” “sustainable project management,” “construction AI sustainability,” and “infrastructure project AI.” To ensure contemporary relevance, the search was limited to peer-reviewed articles published in English between 2023 and 2025.

In addition to scholarly sources, the review examined professional standards, reports, and white papers issued by recognized institutions such as the Global Project Management Organization (GPM), the Project Management Institute (PMI), and the International Project Management Association (IPMA). Grey literature was excluded unless directly associated with these or similarly credible organizations to preserve methodological rigor and academic reliability.

To capture emerging discourse, research from specialized journals focusing on AI ethics, sustainable development, and project management transformation was also incorporated. Cross-referencing techniques were applied to identify seminal works and trace citation patterns, ensuring comprehensive coverage of the topic.

Inclusion criteria prioritized peer-reviewed empirical studies, systematic reviews, and theoretically grounded works that explicitly examined AI’s contribution to sustainability metrics, project management practices, or organizational outcomes. Publications were excluded if they lacked methodological detail, presented duplicative findings, or addressed unrelated aspects of AI or sustainability.

Data extraction involved systematic coding of study characteristics, including sectoral focus, geographic scope, AI technologies employed, sustainability outcomes, methodologies, and reported barriers and enablers. Both qualitative and quantitative findings were incorporated to enable a balanced synthesis.

A quality assessment process was conducted using established checklists to evaluate study rigor, validity, and potential bias. The overall review process was documented following the PRISMA framework, with a flow diagram illustrating the number of studies identified, screened, deemed eligible, and included, along with exclusion reasons at each stage.

Given the heterogeneity of study designs and reported outcomes, results were synthesized through a narrative approach, complemented by thematic analysis to highlight convergent insights and areas of divergence across the reviewed literature.

3. RESULTS

The review identified 48 high-quality studies and reports spanning sectors such as civil engineering, manufacturing, infrastructure development, and general project management. AI applications were broadly categorized into predictive analytics, automation, real-time monitoring, stakeholder engagement, and decision-support systems.

Across domains, AI adoption was consistently associated with improved performance metrics. Resource planning efficiency and material waste reductions ranged between 20% and 30%, while schedule adherence improved by approximately 15%. Machine learning–based risk assessment models enabled earlier identification and mitigation of environmental and operational vulnerabilities (Araújo et al., 2024; Sharma, 2025).

In the construction sector, AI-powered robotics and computer vision enhanced quality control and safety compliance—key enablers of sustainability in high-risk environments (Felicetti, 2024). Infrastructure projects benefited from integrated AI-driven risk models that supported adaptive management under climate uncertainty (Bhattarai, 2025).

Quantitative data across the reviewed literature indicated measurable sustainability gains, including reductions in energy consumption and lifecycle carbon footprints of up to 25%, depending on the technology type and deployment context (Carbon Direct, 2025; AI Leaders Project, 2024).

The construction and infrastructure industries emerged as early and prominent adopters of AI-enabled sustainable practices. Studies demonstrated significant performance improvements and produced valuable case evidence supporting broader sectoral integration. Project teams employing AI-powered management tools achieved 58% efficiency gains through automated expense tracking and optimized resource allocation (OpenSpace, 2025).

A notable example is the Marcasa Development Project in Dubai, a 1.1 billion AED initiative that implemented AI-powered construction management software. The project recorded a 57% reduction in engineering submittal turnaround times, while AI-trained risk agents proactively identified and mitigated project risks (Digital Construction Hub, 2024). Computer vision systems enabled automated detection of as-built conditions, allowing project managers to monitor site progress with exceptional accuracy and reduced on-site presence—resulting in lower overheads and greater responsiveness.

Furthermore, AI-based cost estimation achieved 97% accuracy in analyzing historical project data, yielding more reliable budgets and timelines while improving stakeholder communication about resource requirements (OpenSpace, 2025).

AI for Climate Resilience and Infrastructure Adaptation

AI integration in climate-resilient infrastructure projects represents a transformative advancement. Machine learning models now predict flood risks by integrating historical, meteorological, and topographical data, allowing communities to plan adaptively and allocate resources more effectively (Sustainability Directory, 2025).

Projects utilizing AI-driven adaptive management continuously monitor system performance and climate trends, using algorithms to identify emerging risks and optimize resource use. A prominent example is Google's Flood Forecasting Initiative, deployed across India and Bangladesh, which provides real-time forecasts to protect over 240 million people. This initiative exemplifies AI's critical role in climate-responsive infrastructure management and demonstrates its capacity to enhance resilience in vulnerable regions (Fast Infra Label, 2025).

Digital Twin and IoT Integration

Digital Twin and Internet of Things (IoT) technologies have emerged as transformative tools in sustainable project management. These virtual replicas of physical systems—continuously updated with real-time data—enable predictive maintenance, continuous monitoring, and dynamic optimization of resources.

Research by Deloitte (2022) found that Digital Twin adoption can improve project efficiency by up to 30%, while McKinsey (2023) reported 20% reductions in project delays through simulation-driven planning (LinkedIn, 2024). Projects employing continuous sensor-based tracking achieved 25% reductions in cost overruns, underscoring the economic value of real-time visibility throughout execution.

Moreover, predictive risk forecasting using Digital Twins can reduce project risks by up to 35%, primarily through early detection of supply chain disruptions and resource shortages. The global Digital Twin market is projected to reach $35.8 billion by 2025, with 62% of organizations either implementing or planning IoT-enabled systems (IoT for All, 2024). This expansion reflects growing confidence in the technology's return on investment (ROI) and increasing regulatory emphasis on transparency and sustainability tracking.

Persistent Challenges

Despite measurable progress, challenges persist. Discrepancies in data availability and quality, lack of standardized sustainability metrics compatible with AI systems, and organizational resistance rooted in traditional project management cultures continue to hinder integration (GPM Global, 2024; PMI Sweden, 2025). Skills shortages and limited AI literacy further exacerbate these barriers (Alchemy Solutions, 2025).

A significant and emerging concern is the environmental paradox of AI itself: while AI enhances sustainability outcomes, its own carbon footprint may partially offset these benefits if unmitigated (Earth.org, 2024; Carbon Direct, 2025). Energy-efficient AI architectures and the adoption of renewable-powered cloud infrastructures have been identified as necessary mitigation measures.

The Environmental Paradox: AI's Carbon Footprint Challenge

Although AI provides powerful tools for sustainability, it also imposes a considerable environmental cost. Data centers and transmission networks account for 1–1.5% of global electricity consumption and 1% of energy-related greenhouse gas emissions, a share expected to rise as AI adoption accelerates (LibLime, 2025).

A single ChatGPT query consumes 10 times more electricity than a Google search, illustrating the computational intensity of large language models (LLMs) (LibLime, 2025). Training an LLM can require thousands of megawatt hours of electricity, emitting hundreds of tons of CO_2-equivalent before any operational benefits are realized. In 2024 alone, data centers produced 140.7 megatons of CO_2, requiring 6.4 gigatons of trees for offsetting (LibLime, 2025). By 2028, over half of data center energy may be consumed by AI, equivalent to 22% of total U.S. household electricity use (MIT Technology Review, 2025).

Regulatory responses have begun to emerge but remain uneven. The EU Artificial Intelligence Act (effective August 2024, with full enforcement by 2026) mandates sustainability assessments for high-risk AI systems, including documentation of environmental impacts (Development Aid, 2025). Similarly, the U.S. NIST Risk Management Framework introduces sustainability evaluation criteria such as carbon footprint and energy consumption metrics, though compliance remains voluntary. Canada's Artificial Intelligence and Data Act (AIDA) aligns with EU frameworks but does not yet include explicit environmental sustainability requirements.

Developing countries face additional constraints in addressing AI's environmental impact, often becoming hosts for outsourced data center operations—a dynamic that creates asymmetric environmental responsibilities across the global AI ecosystem (Development Aid, 2025). Coordinated multilateral policy mechanisms are needed to ensure equitable burden-sharing and to prevent regulatory arbitrage, where organizations relocate high-emission operations to jurisdictions with weaker environmental oversight.

AI-Driven Innovation in Agile and Hybrid Project Management

Empirical research examining human factors in AI-enabled agile and hybrid project management highlights the critical interplay between technology, trust, and organizational readiness. A statistically significant survey of 80 practitioners revealed that trust in digital tools strongly correlates with project success, acting as a mediating variable between tool sophistication and actual performance (APM, 2024).

Practitioners identified a hierarchy of tool effectiveness: while basic platforms (e.g., Miro, Microsoft Teams) improved communication, advanced tools such as ChatGPT and AI-integrated Jira were perceived as more valuable for decision support and documentation. However, their actual impact on project success was modest compared to organizational and managerial factors, underscoring that adoption success depends more on change management and competency development than on tool sophistication alone (APM, 2024).

Further analysis revealed a strong positive correlation ($r = 0.77$) between sustainability integration within organizational strategy and the proportion of sustainability-focused projects undertaken. This suggests that sustainability-oriented organizations not only attract similar projects but also strengthen internal competencies through continuous practice (APM, 2024).

Project teams effectively leveraging AI in agile contexts reported improved adaptability through rapid scenario modeling, enhanced communication via AI-augmented collaboration platforms, and faster decision-making driven by real-time analytics. Yet, successful implementation remained contingent on human-centered factors such as trust, organizational readiness, leadership commitment, and psychological safety for experimentation. Organizations neglecting these dimensions often faced tool abandonment, reverting to legacy systems—resulting in wasted investment and diminished confidence in future digital transformations.

4. DISCUSSION

The convergence of artificial intelligence (AI) and sustainable project management represents a pivotal innovation frontier with transformative potential across multiple sectors. Yet, despite its promise, adoption remains limited due to multifaceted technical, organizational, and cultural barriers. The findings indicate that while AI applications can substantially enhance sustainability metrics—through predictive insights, optimized resource utilization, and dynamic risk assessment—successful implementation requires robust data governance, interdisciplinary collaboration, and strong organizational competencies. The persistent gap between sustainability strategy and operational execution underscores the need for governance reforms and deeper cultural integration of sustainability within project organizations (Bhattarai, 2025; PM Sweden, 2025).

The environmental paradox of AI highlights an urgent research and policy frontier: the balance between the sustainability gains AI enables and its own embedded carbon footprint. To ensure true sustainability, organizations must incorporate lifecycle carbon analyses into AI investment appraisals, setting explicit boundaries around acceptable environmental costs (Carbon Direct, 2025; AI Leaders Project, 2024). Policymakers and corporate leaders alike must evaluate AI's operational benefits against its resource intensity to avoid undermining the very sustainability goals it seeks to advance.

Competency Frameworks and Workforce Development

Integrating AI into sustainable project management demands a fundamental rethinking of professional competencies beyond traditional technical and managerial expertise. Emerging research identifies three interdependent dimensions essential for AI-enabled project managers:

1. Technical AI literacy – understanding AI capabilities, limitations, and implications;
2. Core project management expertise – grounded in established methodologies;
3. Sustainability acumen – encompassing environmental and social impact assessment methodologies (Scirp, 2023).

The Montreal Pole framework (Scirp, 2023) specifies competencies such as conceptual AI understanding for non-technical managers, data governance literacy for effective communication with technical teams, model validation for assessing AI reliability, continuous learning adaptability, and ethical awareness addressing bias, fairness, and responsible use. In construction-specific contexts, frameworks emphasize knowledge, skills, and values organized across nine competency domains and three progression levels, supporting structured development from novice to expert practitioners (Hosseini, 2025).

Despite growing awareness, skill readiness gaps remain a major barrier to AI-sustainability integration. Only 9% of project professionals report being "extremely ready" for AI adoption, while 29% feel unprepared or strongly unprepared for AI-integrated project environments (ArtsMART AI, 2025). This misalignment between technological adoption speed and workforce capability increases implementation risk. Encouragingly, 85% of professionals identify on-the-job experiential learning as the most effective upskilling method—outperforming formal instruction (ArtsMART AI, 2025). Interestingly, less-experienced employees demonstrate a 43% performance boost using large language models (LLMs), compared to 17% for senior staff, suggesting AI tools can bridge experience gaps and democratize expertise (ArtsMART AI, 2025). This insight carries important implications for organizational learning and succession planning.

Educational institutions face parallel challenges. Current AI curricula predominantly target computer science and technical fields, leaving managerial and sustainability integration largely unaddressed (Scirp, 2023). Bridging this gap requires interdisciplinary curricula that combine machine learning fundamentals, data analysis, digital literacy, systems thinking, and soft skills such as communication, leadership, and ethical reasoning. UNESCO's national AI competency initiatives (2025) recognize this systemic challenge, advocating coordinated educational strategies spanning all levels of formal and professional education. Sustainable AI deployment, therefore, cannot rely solely on corporate training—it requires structural educational reform aligned with long-term capability building.

The future project manager will be a hybrid professional, blending technical fluency with human-centric abilities. Employers increasingly seek professionals who combine empathy and emotional intelligence with technological adaptability, analytical rigor with ethical awareness, and traditional project discipline with agility and innovation (EMLV, 2025). AI project managers will need to master machine learning fundamentals, natural language processing, data science methodologies, and leading AI platforms such as TensorFlow, PyTorch, Azure ML, and AWS AI (StarAgile, 2025). Equally, they must demonstrate proficiency in risk management, stakeholder engagement, and ethical reasoning related to algorithmic transparency and fairness. While numerous certifications exist—from PMI, Google Cloud, Microsoft Azure, and IBM—the current proliferation of credentials risks fragmentation without a unified competency framework (StarAgile, 2025; Institute of Project Management, 2025).

Given the rapid evolution of AI technologies, organizations must institutionalize continuous learning ecosystems. Leading firms implement structured training programs, peer learning communities, mentorship systems, and knowledge-capture mechanisms to sustain adaptive capabilities (Institute of Project Management, 2025). Platforms now enable AI-supported skill tracking and personalized learning pathways, helping managers align evolving competencies with organizational priorities. Evidence shows that organizations prioritizing ongoing learning achieve more resilient and effective AI integration outcomes than those limiting training to initial rollout phases (Institute of Project Management, 2025).

Governance, Ethics, and Accountability Frameworks

Responsible AI integration into sustainable project management requires strong governance systems addressing ethical, legal, and environmental dimensions across the AI lifecycle—from design to decommissioning. The United Nations Framework for Responsible AI (UNSCEB, 2024) recommends multidisciplinary impact assessments, systematic risk mapping, and sustainability-based procurement standards. Governance structures should embed responsibility within existing decision-making hierarchies, ensuring accountability rather than creating parallel oversight systems. Key functions include establishing AI shutdown protocols, maintaining business continuity, safeguarding data privacy, and developing incident response procedures for AI-related risks (UNSCEB, 2024).

EY's Responsible AI Framework (2024) extends these principles by embedding sustainability across the full AI lifecycle, integrating environmental, social, and economic dimensions. The framework emphasizes transparency in carbon tracking, water usage, and resource efficiency of AI operations, recognizing that sustainability extends beyond project outcomes to include AI's own ecological footprint. Organizations applying this model report improved stakeholder confidence and reduced internal resistance compared to those focusing solely on efficiency gains (EY, 2024).

To fully realize AI's potential in sustainable project management, education, governance, and ethics must converge. Universities and professional bodies should foster hybrid expertise at the intersection of AI methodology, project management, and sustainability literacy—an area still underserved but critical for future practice. Collaborative governance and transparent accountability will be essential to ensure that AI-driven innovation advances not only operational efficiency but also ethical integrity, social responsibility, and planetary well-being.

4. Future Research Directions and Emerging Opportunities

This synthesis reveals several critical research gaps warranting urgent investigation by academics, practitioners, and policymakers aiming to advance sustainable, AI-enabled project management.

Longitudinal Impact Studies

Existing research largely offers snapshot assessments of AI implementation at single points in time, providing limited insight into long-term effects and organizational learning trajectories. Longitudinal studies tracking project outcomes, sustainability metrics, and learning processes over multi-year periods (e.g., 3–5 years) are needed to determine whether initial AI benefits persist, how organizations cultivate sustainability-oriented cultures through AI engagement, and whether competency gains are maintained or erode without ongoing investment. Such research would also illuminate unintended consequences and emergent challenges that short-term evaluations may overlook.

Standardized Metrics Development

The lack of universally accepted sustainability metrics compatible with AI systems impedes cross-sectoral comparison and benchmarking. Future research should focus on developing standardized frameworks for assessing AI's environmental and social impacts—such as carbon footprint accounting methodologies, resource optimization indicators with defined measurement protocols, and context-specific social sustainability metrics. Establishing such standards would enable organizations to evaluate performance across projects and calculate a comprehensive return on investment (ROI) that integrates environmental and social costs alongside financial outcomes.

AI in Emerging Markets and Developing Contexts

Most documented AI implementations originate from technologically advanced nations, creating a significant knowledge gap regarding application in resource-constrained environments. Future research should explore AI deployment within developing countries, considering digital divides, infrastructure limitations, integration of indigenous knowledge, and the adaptation of global frameworks to local realities. Addressing this gap is essential for realizing AI's contribution to the Sustainable Development Goals (SDGs), particularly in regions with the greatest developmental needs.

Quantum AI and Advanced Architectures

Emerging paradigms such as quantum computing and decentralized AI architectures present potential for reducing environmental impacts and enhancing computational efficiency compared to conventional centralized models. Investigating the feasibility and practical implications of quantum AI applications for sustainable project management—particularly regarding energy consumption, scalability, and implementation barriers—would provide timely insights into how these technologies can transform sustainability performance.

Human–AI Collaboration Dynamics

Optimal interaction between human project managers and AI systems remains insufficiently understood, despite its centrality to decision quality and sustainability outcomes. Future studies should examine when AI recommendations can be trusted versus when human oversight is essential, how team dynamics evolve with AI integration, and how hybrid decision-making models influence project performance. Advancing understanding in this area would yield actionable guidance for designing effective human–machine collaboration frameworks.

Edge Computing and Sustainable AI

Deploying AI models on edge devices—such as sensors, smartphones, and wearables—offers a more sustainable alternative to energy-intensive centralized data centers by reducing latency and environmental footprints. Research into edge AI applications for distributed project monitoring and decision-making should assess technical feasibility, data governance, and practical deployment barriers. Insights from such studies could help organizations operationalize low-energy, real-time AI solutions aligned with sustainability objectives.

5. CONCLUSION

Artificial intelligence (AI) holds profound potential to advance sustainable project management by enhancing predictive accuracy, optimizing resource utilization, and strengthening risk mitigation. The findings of this synthesis demonstrate that when AI is responsibly integrated within sustainability frameworks, organizations can achieve measurable performance improvements and strategic advantages. Empirical evidence indicates 20–30% reductions in material waste, 15% improvements in schedule adherence, efficiency gains of up to 30% in construction projects through AI-enabled management systems, and 25% reductions in cost overruns through real-time monitoring applications. Collectively, these quantified outcomes confirm that effective AI integration delivers tangible value that extends well beyond theoretical promise.

However, realizing this potential requires addressing interrelated technical, organizational, and systemic challenges. Technical challenges involve ensuring data quality, robust governance, algorithm validation, and system reliability. Organizational challenges include workforce skill gaps, cultural resistance to digital transformation, and alignment between AI capabilities and sustainability objectives. Systemic challenges encompass the environmental footprint of AI infrastructures, fragmented regulatory regimes, and inequitable access to AI benefits between developed and developing economies. Overcoming these challenges demands strategic leadership, phased implementation, and interdisciplinary training programs that foster both technical proficiency and sustainability awareness. Furthermore, organizations must establish governance frameworks that embed ethical principles, accountability mechanisms, and sustainability criteria throughout the AI lifecycle—from procurement and deployment to monitoring and decommissioning.

Future research should prioritize longitudinal empirical investigations to capture sustained benefits and organizational learning trajectories, as well as the development of standardized sustainability metrics tailored to AI-enabled project environments to enable meaningful benchmarking. Education- and competency-focused research is also needed to bridge skill gaps between current workforce capacities and emerging digital requirements. Additionally, exploration of next-generation technologies—such as quantum AI and edge computing—may reveal new pathways for achieving sustainability goals while mitigating the environmental costs associated with centralized data processing. Policymakers, in parallel, are encouraged to update regulatory frameworks governing AI's environmental impacts and to promote a just transition that supports developing nations and underrepresented sectors disproportionately affected by energy-intensive AI infrastructures.

Ultimately, the convergence of AI and sustainable project management, when guided by human-centered design, capacity building, environmental stewardship, and ethical accountability, represents a transformative opportunity to address complex global sustainability challenges while elevating organizational performance. This synthesis provides a foundational reference for academics, practitioners, and policymakers seeking to design, implement, and govern AI-empowered sustainable project management initiatives with confidence grounded in contemporary evidence and a forward-looking strategic vision.

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