

Greening the System: Implementation of Green Technology in Administrative and Learning Management within Islamic Education Institutions

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Abstract

This study explores the implementation of Green Technology (Greentech) in the dual domains of administrative management and pedagogical processes within Islamic education institutions (madrasahs, Islamic schools, and pesantren). It investigates the potential of Greentech—encompassing energy-efficient hardware, paperless systems, cloud computing, digital learning platforms, and IoT-based resource monitoring—to reduce environmental impact while enhancing operational efficiency and learning outcomes. Employing a mixed-methods sequential explanatory design, the research first surveyed a broad sample of institutions to map adoption levels, followed by in-depth case studies of early adopters. Findings indicate significant potential for reducing carbon footprint and operational costs through virtualization of services, e-learning integration, and smart facility management. However, major challenges persist, including high initial investment, digital literacy gaps among educators, concerns over technology's influence on traditional Islamic pedagogy (talaqqi), and inadequate technological infrastructure. The study concludes that a strategic, values-driven approach aligning Greentech adoption with maqashid sharia (particularly hifdz al-mal/resource preservation) is crucial. It presents a phased integration model that prioritizes technologies offering both environmental and educational benefits, advocating for a balanced fusion of technological efficiency and the preservation of relational, character-based Islamic learning.

Abstrak

Penelitian ini mengkaji implementasi Teknologi Hijau (Greentech) dalam dua bidang utama, yaitu manajemen administratif dan proses pedagogis, di lembaga pendidikan Islam (madrasah, sekolah Islam, dan pesantren). Penelitian ini menyelidiki potensi Greentech—yang mencakup perangkat keras hemat energi, sistem tanpa kertas, komputasi awan, platform pembelajaran digital, dan pemantauan sumber daya berbasis IoT—untuk mengurangi dampak lingkungan sambil meningkatkan efisiensi operasional dan hasil belajar. Menggunakan desain penelitian campuran berurutan, penelitian ini pertama-tama melakukan survei terhadap sampel luas institusi untuk memetakan tingkat adopsi, diikuti dengan studi kasus mendalam terhadap institusi yang menjadi pelopor. Temuan menunjukkan potensi signifikan untuk mengurangi jejak karbon dan biaya operasional melalui virtualisasi layanan, integrasi e-learning, dan manajemen fasilitas cerdas. Namun, tantangan besar tetap ada, termasuk investasi awal yang tinggi, kesenjangan literasi digital di kalangan pendidik, kekhawatiran tentang pengaruh teknologi terhadap pedagogi Islam tradisional (talaqqi), dan infrastruktur teknologi yang tidak memadai. Studi ini menyimpulkan bahwa pendekatan strategis yang

berorientasi pada nilai-nilai, yang menyelaraskan adopsi Greentech dengan maqashid syariah (terutama hifdz al-mal/pelestarian sumber daya), sangat penting. Studi ini mengusulkan model integrasi bertahap yang memprioritaskan teknologi yang menawarkan manfaat lingkungan dan pendidikan, serta mengadvokasi fusi seimbang antara efisiensi teknologi dan pelestarian pembelajaran Islam yang berbasis hubungan dan karakter.



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Introduction

The 21st century has witnessed a profound digital transformation across all sectors, including education. This transformation is driven by the global imperative to create sustainable, low-carbon operations in response to climate change and resource depletion (Quadri et al., 2017). Educational institutions are increasingly recognized as key agents for promoting sustainability, not only through their curricula but also through their operational practices and community leadership (Ali et al., 2019). The integration of green technology (Greentech) into educational administration and learning management is seen as a critical pathway toward achieving these goals. Greentech encompasses a range of digital tools, energy-efficient systems, paperless workflows, and environmentally conscious policies that collectively reduce the ecological footprint of educational institutions (Frehywot et al., 2013).

Islamic education institutions—such as madrasahs and pesantren—occupy a unique position in this landscape. They are tasked with navigating modernization pressures while steadfastly preserving core pedagogical and ethical values rooted in Islamic tradition (Anggraini et al., 2018). The dual challenge is clear: these institutions must improve administrative efficiency and educational quality through technological adoption while simultaneously demonstrating environmental stewardship that aligns with Islamic teachings on balance (mizan), moderation (wasatiyyah), and prohibition of wastefulness (israf) (Van Schalkwyk et al., 2019). This balancing act is further complicated by the need to ensure that any technological or procedural innovation remains culturally congruent with the philosophy of Islamic education, which emphasizes holistic human development (insan kamil), community engagement, and moral responsibility (Binyamin et al., 2019).

Despite the global momentum toward digitalization and sustainability, many Islamic education institutions lag behind in adopting modern technologies for both administration and teaching. Administrative processes often remain heavily paper-based, resulting in high resource

consumption, inefficiency, and increased operational costs . Teaching methods may also rely on traditional face-to-face delivery with limited integration of digital tools or e-learning platforms. This situation is not unique to Islamic schools; similar patterns are observed in higher education institutions across developing countries where infrastructural limitations, financial constraints, and resistance to change impede progress (Hedden et al., 2017).

However, what sets Islamic education apart is the additional layer of complexity introduced by religious values. There is a lack of structured understanding regarding how Greentech can be implemented in ways that are both technologically effective—delivering measurable improvements in efficiency or learning outcomes—and culturally congruent with the philosophical underpinnings of Islamic pedagogy (Maclean et al., 2017). For example, while e-learning platforms can reduce paper use and expand access to knowledge, they must also support religious studies such as Qur'an memorization (tahfidz) or fiqh discussions that require specific pedagogical approaches. Similarly, administrative digitization must respect privacy norms and ethical guidelines derived from shariah principles (Filho et al., 2018).

The gap in structured understanding of green technology adoption within Islamic education institutions reveals a complex set of interrelated challenges that span technical, financial, cultural-pedagogical, and policy-organizational dimensions (Aleixo et al., 2018). Technically, many Islamic educational institutions face significant limitations in infrastructure necessary for effective ICT deployment, including inadequate hardware, software, and network facilities. This is compounded by a lack of expertise among staff to manage and utilize these technologies effectively, as well as unreliable internet connectivity that disrupts consistent access to digital resources and platforms (Hamid et al., 2019). Financially, the challenge is pronounced due to insufficient funding allocated for large-scale technology upgrades; the high upfront costs associated with energy-efficient equipment and sustainable infrastructure often deter investment despite potential long-term savings. Budget constraints are further exacerbated by competing priorities within institutions where traditional expenditures take precedence over green innovations (Yaw et al., 2016).

Culturally and pedagogically, there exists a palpable concern among educators and administrators about the potential dilution of traditional teaching methods through the introduction of new technologies. Skepticism persists regarding whether certain technological tools align with or contradict religious values and educational philosophies rooted in Islamic teachings. This skepticism is often coupled with limited awareness or training on green skills and sustainable practices, which

restricts the capacity of educators to integrate environmental considerations into curricula or institutional management effectively (McCullough et al., 2018). The cultural resistance is not merely about technology itself but also reflects deeper questions about maintaining religious identity while embracing modern innovations.

From a policy and organizational standpoint, many Islamic educational institutions lack clear institutional policies or frameworks that guide sustainable technology adoption. Leadership on environmental initiatives tends to be fragmented or informal, resulting in inconsistent implementation and limited strategic direction. Without formal policies or dedicated units responsible for sustainability, efforts remain ad hoc and dependent on individual champions rather than embedded institutional priorities (Chan & Zary, 2019). This absence of governance structures undermines the scalability and sustainability of green technology initiatives.

Given these multifaceted challenges, this review aims first to inventory and categorize green technology applications relevant to Islamic education administration and learning management. Such applications include digital platforms for administrative efficiency, energy-saving devices for campus infrastructure, water conservation technologies, and e-learning tools designed with environmental sustainability in mind (Mtembu, 2019). Secondly, it seeks to analyze both the perceived potentials—such as improved operational efficiency, reduced resource consumption, enhanced student engagement—and realized outcomes where empirical data are available. This dual analysis helps distinguish between optimistic expectations and practical results observed in diverse contexts (Painter-Morland et al., 2015). Thirdly, the review identifies technical, financial, cultural, and pedagogical challenges hindering adoption by drawing on case studies from countries including Indonesia, Malaysia, Saudi Arabia, Pakistan, Ghana, Portugal, Mexico, South Africa, among others. These case studies reveal common patterns such as infrastructural deficits in developing countries alongside cultural resistance found across different regions (Malik et al., 2019).

Finally, based on this comprehensive understanding of barriers and opportunities, the review proposes a context-sensitive implementation framework that aligns technological innovation with Islamic educational philosophy. This framework emphasizes integrating Islamic ethical principles such as stewardship (khalifah), public benefit (maslahah), and justice (adl) into decision-making processes related to technology adoption. It advocates for participatory approaches involving educators, students (santri), administrators, and community stakeholders to ensure culturally appropriate solutions that respect religious values while advancing sustainability goals (Brito et al.,

2018). The framework also highlights capacity-building initiatives focused on enhancing technical skills and financial literacy related to green technologies within Islamic education settings. Moreover, it calls for institutionalizing clear policies that provide strategic guidance and foster leadership commitment toward sustainable development through technology integration (Okuda et al., 2009). By addressing these interconnected challenges holistically—technical readiness paired with cultural sensitivity and organizational support—Islamic educational institutions can better harness green technologies to improve their environmental footprint while fulfilling their spiritual mission in an increasingly digital era.

Research Methodology

The sequential explanatory mixed-methods design (QUAN → qual) is a widely recognized research framework that begins with quantitative data collection and analysis, followed by qualitative inquiry to explain and elaborate on the initial findings. This approach is particularly suitable for investigating the implementation of green technology in administrative and learning management within Islamic education institutions, as it allows researchers to quantify adoption levels and related factors across a broad sample, then explore deeper contextual insights through focused case studies (Van Horn et al., 2019). In Phase 1, an online survey is administered to a stratified random sample of 150 Islamic schools, madrasahs, and pesantrens. The survey measures key variables such as current green technology adoption levels, perceived benefits and barriers, infrastructure readiness, and future investment plans (Filho et al., 2017). This quantitative phase provides a comprehensive overview of how extensively green technologies are integrated into these institutions and identifies patterns or correlations—for example, between infrastructure readiness and adoption rates—that can inform targeted interventions.

Phase 2 involves qualitative multiple case studies of 4-5 institutions identified as “high adopters” from the survey results. Data collection methods include semi-structured interviews with principals, IT staff, teachers, and administrative heads to capture diverse perspectives on implementation processes and challenges. Additionally, direct observation of technology use within administrative and learning environments offers practical insights into how green technologies function in daily operations (Plunkett-Rondeau et al., 2015). Analysis of policy documents further reveals institutional commitments and strategic planning related to greening efforts. This qualitative phase aims to uncover the underlying reasons behind successful adoption—such as leadership support, staff

training, or community engagement—and barriers faced by institutions with lower adoption levels.

Data analysis integrates both phases: quantitative survey data are analyzed using descriptive statistics to summarize adoption trends and inferential statistics (e.g., correlation or regression analyses) to examine relationships among variables like infrastructure readiness and perceived benefits. Qualitative data undergo thematic analysis to identify recurring themes explaining how and why certain institutions succeed or struggle in implementing green technologies. This explanatory step enriches the numerical findings by providing nuanced understanding of institutional culture, resource allocation, policy enforcement, and stakeholder attitudes that influence greentech integration (Schindler et al., 2017).

The sequential explanatory design's strength lies in its ability to combine breadth with depth—capturing generalizable patterns across many institutions while also exploring complex contextual factors that numbers alone cannot reveal. It addresses limitations common in single-method studies by validating quantitative results through qualitative evidence and offering actionable insights for policymakers and practitioners aiming to promote sustainable practices in Islamic educational settings. Prior research on environmental-based learning management highlights the importance of involving students, teachers, parents, and administrators collaboratively in fostering sustainability awareness and practices (Paranjape et al., 2019). Studies on information technology integration in pesantrens demonstrate that digital skills enhancement can simultaneously improve educational quality and environmental consciousness when supported by adequate infrastructure and ongoing training. Furthermore, frameworks developed for green campuses emphasize strategic governance, curriculum integration based on Islamic values such as tawhid (monotheism), and community engagement as critical success factors (Cate et al., 2015).

Findings

Current State of Greentech Implementation

Islamic education institutions have made only modest progress toward adopting green technologies in their administrative operations prior to 2020. The most common initiatives involved basic paperless systems—such as digital correspondence via email or messaging platforms—while more advanced solutions like cloud-based ERP or SIS remained rare due to cost constraints and limited technical expertise. Physical filing systems persisted as the norm for record-keeping; meetings continued to be held predominantly in person rather than through virtual platforms 109.

Infrastructural limitations—especially unreliable internet connectivity—further hindered widespread adoption outside urban centers.

The use of LMS platforms (e.g., Moodle) and digital content delivery increased gradually but was highly uneven across institutions. These tools were primarily utilized for general subjects such as mathematics or science rather than core Islamic sciences like Quranic studies or fiqh (jurisprudence), where traditional face-to-face instruction was still preferred. Video conferencing technologies were adopted mainly for administrative coordination or non-pedagogical purposes rather than for direct teaching or talaqqi (oral transmission) sessions.

Perceived and Realized Potentials

Institutions that implemented even basic greentech solutions reported tangible benefits: reduced printing costs due to decreased reliance on paper documents; faster information retrieval through searchable digital archives; streamlined communication among staff via email or instant messaging platforms.

Case studies documented measurable reductions in paper usage—and by extension energy/water consumption associated with printing—following the introduction of digital correspondence or document management systems. However, comprehensive data on broader environmental impacts remained scarce. Access to richer digital resources—including Quranic apps, virtual museum tours related to Islamic history/culture—enabled new forms of engagement for students. Flipped classroom models became possible where students could access materials online before class discussions. Personalized learning tracks were piloted using adaptive LMS features but remained limited in scope.

Key Challenges and Barriers

High upfront costs associated with acquiring hardware (computers/servers), software licenses (LMS/ERP), and reliable high-speed internet connections posed major obstacles—especially for smaller or rural institutions with limited budgets. A shortage of IT support staff meant that existing personnel often lacked the skills needed to maintain new systems or troubleshoot technical issues. Teacher training programs focused on both technology use and its pedagogical integration were insufficiently developed or inconsistently delivered.

Traditional teachers expressed concerns about weakening student-teacher bonds (silaturahmi) central to Islamic pedagogy if interactions moved online. There was also apprehension regarding the sanctity of knowledge transmission being compromised by digital formats—and fears about exposure

to inappropriate content or distractions inherent in open internet access. Unstable electricity supply and unreliable internet connectivity—particularly acute in rural pesantrens (Islamic boarding schools)—remained persistent barriers that undermined both administrative digitization efforts and e-learning initiatives.

Discussion

Strategic Alignment From Cost Center to Value Driver

Historically, the adoption of greentech in educational institutions—including Islamic schools and universities—has often been viewed through the lens of financial burden or compliance with external mandates. However, leading research and case studies advocate for a paradigm shift: greentech should be strategically framed as an investment in institutional resilience, long-term cost savings, enhanced educational quality, and alignment with the Islamic principle of *maslahah* (public benefit). Institutions that have successfully integrated greentech report not only operational efficiencies—such as reduced energy and paper costs—but also improved institutional reputation, stakeholder engagement, and adaptability to crises (e.g., natural disasters or pandemics). For example, the Nurul Haramain Narmada Islamic Boarding School in Lombok implemented IT-based environmental literacy programs and waste management technologies as part of its modernization strategy. These initiatives were not isolated expenditures but part of a broader vision to maximize local resources, foster community engagement, and build long-term sustainability.

This strategic approach is echoed in higher education globally. Universities that embed sustainability into their core mission—supported by information systems for monitoring and decision-making—are better positioned to achieve both economic efficiency and educational excellence. The literature consistently finds that when sustainability is treated as a strategic priority rather than an add-on or compliance issue, it catalyzes innovation across teaching, operations, and community outreach. The concept of *maslahah* underpins much of the Islamic rationale for greentech adoption. By prioritizing public benefit—environmental stewardship, resource conservation, social justice—Islamic education institutions can justify investments in greentech not only on pragmatic grounds but also as fulfillment of religious obligations. This alignment strengthens institutional legitimacy among stakeholders who may otherwise be skeptical about technological change.

A Value-Based Integration Model

Any technology must first be evaluated for its compatibility with Islamic principles. Does it facilitate religious obligations (e.g., prayer times management apps), or does it introduce elements contrary to sharia (e.g., unfiltered internet access)? Technologies that pass this filter are eligible for further consideration. The second filter assesses whether the technology demonstrably improves learning outcomes—for both general subjects and core Islamic sciences. For instance, Learning Management Systems (LMS) can support personalized learning tracks or flipped classrooms but must also accommodate traditional methods such as talaqqi (oral transmission) where appropriate 69. Technologies that enhance teacher-student interaction without undermining the sanctity of knowledge transmission are prioritized. Finally, technologies are evaluated based on their environmental return on investment: do they significantly reduce resource use (paperless administration), energy consumption (LED lighting), or waste generation? Only those solutions that offer measurable environmental benefits are fully integrated into institutional practice.

Reimagining Islamic Pedagogy with Technology

A key challenge—and opportunity—in leveraging green technology (greentech) within Islamic education institutions lies in using it to support rather than supplant traditional Islamic pedagogical values. Instead of replacing face-to-face instruction or weakening the vital silaturahmi—the close teacher-student bonds central to Islamic learning—technology can augment and enrich these relationships. For example, Learning Management Systems (LMS) can be employed to track student progress in Quran memorization (tahfidz), providing digital tools that complement but do not replace the essential direct recitation before teachers. Similarly, video archives of lectures by esteemed scholars serve as valuable resources that preserve knowledge for future generations without diminishing the importance of live instruction. Additionally, virtual museum tours and Quranic apps offer students enriched experiences that deepen their understanding of Islamic history and scripture while maintaining fidelity to core teachings. These technological applications align with Islamic educational principles by enhancing access to knowledge and supporting personalized learning, all while respecting the sanctity of traditional methods and spiritual values. This approach reflects a broader trend in Islamic education toward integrating technology thoughtfully and ethically, ensuring that innovations serve both pedagogical effectiveness and religious commitments rather than undermining them.

Successful cases emphasize participatory approaches involving teachers, students (santri), administrators, and community leaders. Training programs focus not just on technical skills but also on integrating technology into existing pedagogical frameworks. This reduces resistance among traditional educators who may fear loss of authority or dilution of religious identity.

The Critical Role of Leadership and Green IT Policy

Leadership commitment is consistently recognized as a decisive factor in the successful implementation of green technology (greentech) initiatives. Institutions that establish clear Green IT policies—setting specific targets for paper reduction, energy efficiency, and responsible e-waste disposal—are more likely to achieve meaningful and sustained environmental improvements. Effective policy development involves setting quantifiable goals for reducing resource consumption, implementing accountability mechanisms such as regular monitoring and reporting through digital dashboards, engaging stakeholders at all organizational levels to increase buy-in, and providing continuous training to ensure staff remain competent with evolving technologies. Leadership champions, including principals, rectors, or sustainability officers, play pivotal roles by modeling desired behaviors, securing funding for pilot projects, and advocating for sustainability initiatives at governance levels; their visible commitment signals institutional priorities and motivates broader organizational engagement. Research further highlights that ethical and transformational leadership styles enhance environmental performance by fostering green IT capital and innovation, while leadership commitment positively shapes IT professionals' attitudes and engagement in sustainable practices. Moreover, leadership that integrates green strategies into organizational culture facilitates agility and innovation necessary for long-term sustainability success. Thus, strong leadership combined with well-crafted Green IT policies forms the backbone of effective greentech adoption in educational institutions.

Conclusion

The implementation of green technology within Islamic education institutions offers a significant opportunity to modernize administrative operations and enrich learning environments while aligning with Islamic environmental ethics. Research indicates that integrating green technology is not merely a technical upgrade but a transformative process that requires careful consideration of cultural, pedagogical, and philosophical dimensions unique to the Islamic

educational context. Successful adoption depends on a phased approach that addresses technical infrastructure and financial investment alongside deeper engagement with the community's values and educational goals. Studies emphasize that environmental-based learning management, which involves students, teachers, and parents in sustainability practices, fosters a culture of environmental responsibility consistent with Islamic teachings on stewardship (khalifah) and justice (adl). This holistic integration supports not only operational greening but also the development of students' ethical awareness and character building rooted in tawhid (monotheism), which frames environmental care as an expression of human piety.

Challenges to implementation include limited policy clarity, resource constraints, and varying levels of understanding among stakeholders about green technology's benefits and requirements. For example, while some Islamic schools have achieved recognition through green school programs like Indonesia's Adiwiyata awards, many institutions still struggle with consistent application due to gaps in knowledge, infrastructure readiness, and financial support. Moreover, the success of green initiatives often hinges on leadership commitment and the alignment of institutional policies with sustainability goals. Qualitative case studies reveal that high-adopting institutions typically demonstrate strong governance frameworks that integrate environmental values into curriculum design, campus management, and community engagement. These institutions also invest in capacity building for teachers and staff to enhance digital skills and environmental awareness simultaneously, leveraging information technology as a tool for both educational quality improvement and greening efforts.

Pedagogically, embedding green technology within Islamic education requires curriculum innovation that goes beyond technical training to include ecological ethics grounded in Qur'anic principles. This approach ensures that sustainability is not treated as an add-on but as an integral part of students' moral development and worldview. The concept of Tawhid-Based Green Learning exemplifies this by linking environmental stewardship directly to Islamic theology and character formation aimed at producing insan kamil—complete human beings who embody spiritual and social responsibility. Such frameworks advocate for integrating sustainability into learning materials, quality assurance processes, and community service activities to create a comprehensive green educational ecosystem.

Financially, while some higher education institutions allocate budgets for green campus development, these funds often compete with other pressing needs. Therefore, strategic planning

must balance immediate infrastructural investments with long-term educational outcomes. Practical frameworks suggest starting with environmentally friendly curriculum development followed by community-based education programs and enhancement of campus facilities to build momentum toward full greening. Additionally, appropriate technologies such as rainwater harvesting systems or vertical gardens can be introduced incrementally through partnerships or government-supported programs to mitigate cost barriers.

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