



Cloud Computing, Automation, and Green IT Practices: A Framework for Sustainable Innovation in Small Enterprises

Computación en la Nube, Automatización y Prácticas de TI Verde: Un Marco para la Innovación Sostenible en Pequeñas Empresas

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Abstract. Cloud computing has become an important enabler of digital transformation by providing organizations with scalable, flexible, and on-demand access to computing resources. For small and medium-sized enterprises (SMEs), cloud-based services offer opportunities to modernize operations while reducing the need for substantial investments in local infrastructure and specialized IT resources. This study presents a structured literature review of research published between 2010 and 2024 examining the relationships among cloud computing, automation technologies, and Green IT practices in SME environments. The findings indicate that cloud adoption may enhance operational efficiency through improved scalability, resource optimization, and process automation. In addition, cloud-enabled infrastructures can support sustainability objectives by promoting more efficient resource utilization and reducing dependence on locally maintained hardware. However, the literature also identifies important challenges, including cybersecurity concerns, vendor lock-in, migration complexity, and governance requirements associated with the Shared Responsibility Model. Based on the synthesis of the reviewed studies, a conceptual framework is proposed that integrates operational efficiency, automation capabilities, sustainability outcomes, and governance considerations as interconnected dimensions of sustainable digital transformation in SMEs. The review suggests that the benefits of cloud adoption depend on organizational readiness, effective governance, and alignment between technological implementation and sustainability goals.

Keywords. Cloud computing; automation technologies; sustainable digital transformation; Green IT; SMEs; governance

Resumen. La computación en la nube se ha consolidado como un habilitador importante de la transformación digital al proporcionar a las organizaciones acceso escalable, flexible y bajo demanda a recursos informáticos. Para las pequeñas y medianas empresas (PYMES), los servicios basados en la nube ofrecen oportunidades para modernizar operaciones reduciendo la necesidad de realizar inversiones significativas en infraestructura local y recursos especializados de TI. Este estudio presenta una revisión estructurada de la literatura publicada entre 2010 y 2024 sobre las relaciones entre la computación en la nube, las tecnologías de automatización y las prácticas de TI Verde en entornos de PYMES. Los hallazgos indican que la adopción de la nube puede

mejorar la eficiencia operativa mediante una mayor escalabilidad, optimización de recursos y automatización de procesos. Asimismo, las infraestructuras habilitadas por la nube pueden contribuir a los objetivos de sostenibilidad al favorecer un uso más eficiente de los recursos y reducir la dependencia del hardware mantenido localmente. Sin embargo, la literatura también identifica desafíos relevantes, entre ellos preocupaciones relacionadas con la ciberseguridad, la dependencia del proveedor (vendor lock-in), la complejidad de la migración y los requisitos de gobernanza asociados con el Modelo de Responsabilidad Compartida. A partir de la síntesis de los estudios revisados, se propone un marco conceptual que integra la eficiencia operativa, las capacidades de automatización, los resultados de sostenibilidad y las consideraciones de gobernanza como dimensiones interrelacionadas de la transformación digital sostenible en las PYMES. La revisión sugiere que los beneficios de la adopción de la nube dependen de la preparación organizacional, una gobernanza efectiva y la alineación entre la implementación tecnológica y los objetivos de sostenibilidad.

Palabras clave. Computación en la nube; tecnologías de automatización; transformación digital sostenible; TI Verde; PYMES; gobernanza

1. Introduction

Cloud computing has become a widely adopted model for delivering information technology services, enabling organizations to access computing resources through scalable and on-demand infrastructures (Mathur, 2024; Sharifzadeha et al., 2022). By shifting from locally managed systems to cloud-based services, organizations can obtain infrastructure, platforms, and software without maintaining extensive physical hardware. This transformation has altered how firms acquire and manage technological resources, particularly in environments characterized by limited financial and technical capacity (Arogundade & Palla, 2023).

For small and medium-sized enterprises (SMEs), cloud computing has attracted considerable attention because it may reduce barriers associated with traditional IT investments. Service models such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) provide access to technologies that were previously difficult for smaller organizations to adopt (Younis et al., 2024). However, the benefits of cloud adoption are not uniform across firms, and outcomes often depend on organizational capabilities, implementation strategies, and external conditions.

Alongside cloud adoption, automation technologies have become increasingly important in the management of digital infrastructures (Argyroudis et al., 2022). Tools for resource orchestration, system monitoring, workflow management, and automated provisioning can reduce routine administrative tasks and support more consistent operations. Previous studies suggest that automation may contribute to improved reliability and operational efficiency, although the extent of these benefits varies according to organizational context and technological maturity.

The relationship between cloud computing and sustainability has also emerged as a significant research topic. Cloud providers often operate large-scale data centers that benefit from virtualization, resource consolidation, and, in some cases, renewable energy integration (Adepu, 2025). These characteristics may contribute to lower energy consumption and reduced electronic waste compared with traditional on-premises infrastructures. Nevertheless, environmental benefits should not be assumed automatically, as they depend on factors such as workload management, provider practices, and regional energy sources.

Despite these potential advantages, SMEs face several challenges when adopting cloud-based and automated solutions. Concerns related to cybersecurity, data privacy, vendor lock-in, migration complexity, and skills shortages remain important barriers. The limited availability of specialized personnel and financial resources may further constrain the ability of SMEs to implement and govern these technologies effectively. As a result, cloud adoption should be viewed not only as a technological decision but also as an organizational and strategic process.

Recent studies have increasingly explored the relationship between cloud computing and sustainability in SMEs, although from different perspectives. (Natrajan et al., 2024) examined cloud computing as an enabler of circular economy practices and proposed an integrated framework linking technological, organizational, and environmental factors with sustainable business outcomes. Their findings highlight the potential of cloud-based solutions to support resource efficiency and broader sustainability objectives. Similarly, (Al-Sharafi et al., 2023) investigated the determinants of cloud computing integration in SMEs and demonstrated that cloud adoption can positively influence environmental, financial, and social performance, while also emphasizing the importance of organizational and institutional factors. (Al-Sharafi et al., 2023) focused on the relationship between cloud computing adoption and SME sustainability, reporting that factors such as cost reduction, reliability, ease of use, and collaboration capabilities contribute significantly to sustainable business performance.

Despite these contributions, the literature remains fragmented. Existing studies tend to examine cloud adoption determinants, sustainability outcomes, or specific organizational benefits in isolation. Comparatively less attention has been given to how cloud computing, automation technologies, and Green IT practices interact as complementary elements of sustainable digital transformation in SMEs.

To address this gap, this study presents a structured literature review of research published between 2010 and 2024 and proposes a conceptual framework that integrates the key drivers, benefits, challenges, and governance considerations associated with cloud-enabled sustainable innovation in SMEs. By synthesizing evidence across operational, financial, environmental, and organizational dimensions, the study seeks to identify the conditions under which these technologies can contribute to both efficiency and sustainability outcomes.

The remainder of this article is organized as follows. Section 2 describes the review methodology, Section 3 presents the results, Section 4 discusses the findings and introduces the proposed conceptual framework, and Section 5 concludes with the main implications, limitations, and directions for future research.

2. Methods

2.1. Design and search strategy

This study employed a structured literature review approach to examine the relationship between cloud computing, automation technologies, and Green IT practices in SMEs and to develop a conceptual framework for sustainable digital transformation. The review process was guided by principles commonly used in evidence synthesis studies, including systematic search, screening, and thematic analysis procedures.

The literature search was conducted across five major academic databases: IEEE Xplore, ScienceDirect, SpringerLink, ACM Digital Library, and Google Scholar. These databases were selected because they provide extensive coverage of information systems, cloud computing, sustainability, and digital transformation research.

Search stings were developed using combinations of the following keywords: “cloud computing,” “automation,” “SMEs,” “small and medium-sized enterprises,” “digital transformation,” “Green IT,” “sustainable IT,” and “energy-efficient computing.” Boolean operators (AND, OR) were used to construct search queries. Examples included: “cloud computing AND SMEs,” “cloud computing AND automation AND sustainability,” and “Green IT AND digital transformation AND SMEs.” The search was limited to studies published between 2010 and 2024 to capture contemporary developments in cloud technologies and sustainable computing practices.

2.2. Inclusion and exclusion criteria

To ensure the relevance of the selected studies, the following inclusion criteria were applied: peer-reviewed articles or academic books addressing cloud computing models, automation, or sustainability; studies focused on enterprise environments, with emphasis on small and medium-sized businesses; empirical or theoretical research with a solid methodological foundation regarding energy-efficient computing; publications written in English.

Exclusion criteria included: non-academic publications such as blogs, opinion pieces, or promotional reports; papers without methodological transparency or lacking empirical depth; studies focused exclusively on large-scale data centers without applicability to the small enterprise scale; duplicated studies across different databases.

2.3. Study selection process

The study selection process was conducted in two stages. First, titles and abstracts were screened to assess relevance to the research objectives. Duplicate records identified across databases were removed prior to screening. Studies that did not address cloud computing, automation technologies, sustainability, or SME contexts were excluded during this stage.

Second, the remaining articles underwent full-text assessment. Each study was evaluated against the predefined inclusion and exclusion criteria. Particular attention was given to the relevance of the study to SME environments, the discussion of operational, sustainability, or governance outcomes, and the methodological transparency of the research. Following the screening and eligibility assessment process, a final sample of 52 studies was retained for qualitative synthesis and framework development.

2.4. Data analysis

A thematic content analysis was conducted to synthesize the selected studies. Information extracted from each article included publication year, research objectives, methodological approach, technological focus, reported benefits, adoption barriers, sustainability implications, and SME-specific findings.

The analysis was performed iteratively through coding and categorization of recurring themes. Four overarching dimensions emerged consistently across the literature: operational efficiency, sustainability outcomes, governance and risk management, and organizational capabilities. These dimensions were subsequently integrated into a conceptual framework that illustrates the relationships between cloud computing adoption, automation practices, and sustainable innovation in SMEs. The objective of the framework is not to establish causal relationships, but to provide a structured synthesis of the factors most frequently associated with successful cloud-enabled sustainable transformation in SME contexts.

3. Results

The thematic analysis of the selected literature revealed four recurring dimensions associated with the adoption of cloud computing, automation technologies, and Green IT practices in SMEs: (1) operational efficiency and technical capabilities, (2) automation and process optimization, (3) sustainability and environmental performance, and (4) organizational and governance challenges.

3.1. Operational Efficiency and Technical Capabilities

Operational efficiency was one of the most frequently reported benefits across the reviewed studies. Several authors suggest that cloud adoption enables SMEs to reduce dependence on local infrastructure while increasing scalability and flexibility in resource utilization (Modisane & Jokonya, 2021; Natrajan et al., 2024). These characteristics allow organizations to adjust computing resources according to demand without substantial upfront investments.

The literature also highlights the growing relevance of Infrastructure as Code (IaC), virtualization, and container orchestration technologies. According to (Alaqidi, 2022), these approaches can improve deployment consistency and reduce configuration-related errors. However, the reported benefits often depend on the technical capabilities available within the organization and the maturity of the adopted cloud environment.

3.2. Benefits of Automation Tools

Automation emerged as a complementary capability that enhances the operational value of cloud environments. Across the reviewed studies, the most commonly reported applications include automated backup procedures, resource provisioning, workload scheduling, and real-time monitoring systems (Imhanwa et al., 2015).

Several studies indicate that these tools can contribute to greater process consistency, faster response times, and improved system availability (Padukkage et al., 2016). Nevertheless, the literature also suggests that the effectiveness of automation depends on appropriate implementation and governance practices, as poorly configured automated processes may introduce operational risks rather than eliminate them.

3.3. Effects on Sustainability and Green IT

Environmental sustainability was identified as another recurring theme in the literature. Several studies associate cloud computing with lower energy consumption, improved resource utilization, and reduced electronic waste compared with traditional on-premises infrastructures (Buyya et al., 2024; Radu, 2017).

A frequently cited indicator is Power Usage Effectiveness (PUE), which is often reported to be lower in large-scale cloud data centers than in conventional local infrastructures. Studies reviewed in this research indicate that leading cloud providers may operate with PUE values close to 1.1, whereas traditional facilities commonly report higher values, suggesting greater energy efficiency. However, the literature consistently emphasizes that energy efficiency alone should not be interpreted as a direct measure of sustainability. The overall environmental impact of cloud adoption also depends on factors such as the provider's energy sources, data center location, and broader sustainability policies.

3.4. Identified Challenges and Limitations

Despite the operational advantages, the literature identifies persistent challenges related to data security, vendor lock-in, and initial technical complexity. Small businesses often face greater difficulties during the migration phase due to a lack of trained personnel and steep learning curves (Santoso & Pratama, 2024). Likewise, the risk of vendor lock-in limits long-term flexibility, while concerns regarding the privacy of sensitive information stored on external servers continue to be a significant barrier to full adoption (Buyya et al., 2010).

3.5. Financial Impact and Talent Management

The financial implications of cloud adoption were frequently discussed in the reviewed literature. Several studies suggest that cloud-based service models may enable SMEs to shift part of their technology spending from capital expenditures (CapEx) to operational expenditures (OpEx), potentially increasing financial flexibility and reducing the need for large upfront investments (Al-Sharafi et al., 2023); (Al-Mutawa & Saeed Al Mubarak, 2023). However, the magnitude of these benefits varies depending on organizational size, service usage patterns, and migration costs.

From a human capital perspective, automation technologies may reduce the amount of time devoted to repetitive administrative and technical activities, allowing employees to focus on higher-value tasks such as customer support, innovation, and strategic planning (Rao & Pullagura, 2024). At the same time, several studies note that digital transformation initiatives often require workforce adaptation, training programs, and change management efforts to address resistance and skills gaps. Table 1 summarizes the principal benefits and challenges associated with cloud computing adoption in SMEs as reported across the reviewed literature.

Table 1. Comparative Summary of Findings in Cloud Adoption.

Dimension of Analysis	Main Benefits	Main Challenges
Operational	Scalability, elasticity, and reduction of physical infrastructure.	Technical complexity in initial configuration and migration.
Financial	Reduction of fixed costs and alignment of spending with actual consumption.	Risk of long-term dependence on a single provider (Vendor lock-in).
Sustainability	Lower electricity consumption and reduction of hardware waste.	Dependence on the energy grid and the location of the provider's data center.
Security	Access to automated backups and real-time monitoring.	Concerns about data privacy and loss of control over information.

3.6. Governance and the Shared Responsibility Model

Governance and security responsibilities emerged as recurring themes in the reviewed studies. Several authors emphasize that cloud adoption does not eliminate organizational responsibility for information security; rather, responsibilities are distributed between the cloud provider and the customer according to the selected service model.

Under the Shared Responsibility Model, providers assume increasing responsibility for infrastructure management as organizations move from Infrastructure as a Service (IaaS) to Platform as a Service (PaaS) and Software as a Service (SaaS). However, responsibility for data management, user access control, and

identity governance remains largely with the customer regardless of the service model adopted. Table 2 summarizes the distribution of responsibilities across different cloud deployment models and highlights the governance considerations that SMEs should address when adopting cloud-based solutions.

Table 2. Shared responsibility model across cloud service models.

Technology Layer	SaaS (Software)	PaaS (Platform)	IaaS (Infrastructure)	On-Premise (Local)
Data & Content	Customer	Customer	Customer	Customer
Identity & Access (IAM)	Customer	Customer	Customer	Customer
Applications	Provider	Customer	Customer	Customer
Operating System	Provider	Provider	Customer	Customer
Network & Firewall	Provider	Provider	Customer	Customer
Virtualization	Provider	Provider	Provider	Customer
Physical Infrastructure	Provider	Provider	Provider	Customer

4. Discussion

4.1. Operational Efficiency and Technological Enablement

The findings suggest that cloud computing continues to provide SMEs with opportunities to access scalable computing resources without the substantial infrastructure investments traditionally associated with enterprise information systems. This observation is consistent with the foundational arguments of (Armbrust et al., 2010), who identified elasticity and resource scalability as central advantages of cloud computing. Similarly, (Marston et al., 2011) argued that cloud services lower technological barriers by allowing organizations to consume computing resources as services rather than assets.

However, the evidence reviewed indicates that the benefits of cloud adoption are not automatic. Operational improvements depend on organizational readiness, technical capabilities, and the effective integration of cloud services into existing business processes. This finding supports technology adoption research based on the Technology–Organization–Environment (TOE) perspective, which emphasizes that technological value is shaped by organizational and environmental conditions rather than by technology alone (Low et al., 2011; Tornatzky et al., 1990).

4.2. Sustainability Beyond Energy Efficiency

One of the most significant findings emerging from literature concerns the relationship between cloud computing and sustainability. While many studies associate cloud adoption with lower energy consumption and improved resource utilization, the evidence suggests that sustainability outcomes are more complex than simple efficiency gains.

Research on sustainable cloud computing emphasizes that reductions in environmental impact depend not only on infrastructure efficiency but also on energy sourcing and data center management practices (Buyya et al., 2010). Similarly, (Natrajan et al., 2024) argue that cloud technologies can support broader sustainability objectives and circular economy practices when integrated with organizational sustainability strategies. Consequently, cloud adoption should not be viewed as inherently “green.” Rather, sustainability benefits are contingent upon provider practices, regional energy mixes, and the governance mechanisms adopted by organizations.

This finding has important implications for SMEs, which often select cloud providers based primarily on cost considerations. The literature suggests that sustainability-oriented decision-making should also incorporate environmental performance indicators, renewable energy commitments, and transparency regarding data center operations.

4.3. Governance, Risk, and Organizational Readiness

A recurring theme across the reviewed studies is that the barriers to cloud adoption are often organizational rather than purely technological. Concerns regarding data privacy, cybersecurity, vendor lock-in, and migration complexity remain among the most frequently reported challenges, particularly for SMEs with limited technical expertise.

The findings indicate that cloud adoption shifts rather than eliminates governance responsibilities. The Shared Responsibility Model illustrates that while providers assume increasing responsibility for infrastructure management, organizations retain accountability for data governance, identity management, and access control. This observation reinforces previous research suggesting that successful cloud adoption requires a combination of technological capability and governance maturity.

Furthermore, the literature highlights the importance of management support, organizational readiness, and workforce skills in determining adoption outcomes. These factors were also identified by Al-Sharafi et al. (2023) as significant determinants of cloud integration and subsequent sustainability performance in SMEs.

4.4. Toward an Integrated Framework for Sustainable Digital Transformation

The principal contribution of this study is the development of a conceptual framework that integrates the recurring dimensions identified across the literature. Rather than treating cloud computing, automation, sustainability, and governance as independent topics, the framework conceptualizes them as interrelated components of sustainable digital transformation in SMEs.

The framework suggests that cloud computing provides the technological foundation, automation enhances operational capabilities, sustainability objectives guide responsible resource utilization, and governance mechanisms mitigate organizational and security risks. The interaction among these dimensions influences the extent to which SMEs can achieve both efficiency gains and long-term sustainability outcomes.

This integrated perspective extends prior studies that have examined cloud adoption determinants or sustainability impacts separately. By synthesizing technological, organizational, environmental, and governance considerations within a single framework, the study offers a more comprehensive understanding of how SMEs can leverage cloud-enabled innovation while managing associated risks and constraints.

5. Conclusion

This study reviewed the literature on cloud computing, automation technologies, and Green IT practices in SMEs to examine their potential contribution to sustainable digital transformation. The findings suggest that cloud-based solutions may provide SMEs with greater operational flexibility, improved access to digital resources, and opportunities to optimize technology-related expenditures. In addition, automation technologies appear to support process consistency and operational efficiency, while sustainability-oriented cloud infrastructures may contribute to improved resource utilization and reduced environmental impacts.

However, the evidence reviewed also indicates that these benefits are contingent upon several organizational and contextual factors. Challenges related to cybersecurity, vendor lock-in, migration complexity, workforce capabilities, and governance remain important considerations for SMEs. Likewise, sustainability outcomes depend not only on technological efficiency but also on factors such as provider practices, energy sources, and organizational decision-making processes.

Based on the synthesis of the literature, this study proposes a conceptual framework that integrates four interrelated dimensions of sustainable digital transformation in SMEs: operational efficiency, automation capabilities, sustainability outcomes, and governance considerations. The framework provides a structured perspective for understanding how these elements interact and may support informed decision-making in cloud adoption initiatives. This study has several limitations. First, it is based on a structured literature review and therefore relies on evidence reported in previous studies rather than primary empirical data. Second, the review focused primarily on English-language publications, which may have excluded relevant contributions from other regions and contexts. Third, the heterogeneity of methodologies and organizational settings across the reviewed studies limits the possibility of drawing generalized conclusions regarding the magnitude of cloud computing benefits for SMEs. Future research could validate and refine the proposed framework through empirical studies involving SMEs from different sectors and geographical regions. Additional research is also needed to examine the long-term sustainability impacts of cloud adoption, the role of artificial intelligence and automation in SME digital transformation, and the governance mechanisms that enable organizations to balance innovation, security, and environmental responsibility.

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