International Journal of Basic and Applied Sciences, 14 (SI-1) (2025) 139-146

International Journal of Basic and Applied Sciences

Website: www.sciencepubco.com/index.php/IJBAS
https://doi.org/10.14419/a3j94v26
Research paper

Leveraging Information Systems, Applications, and Technologies for Energy-Efficient, Resource-Saving Sustainable Innovation and Strategic Development in The Hospitality Industry: Interactions Between Corporate Law and Public Administration

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Received: May 2, 2025, Accepted: May 29, 2025, Published: July 7 2025

Abstract

The contemporary hospitality industry faces significant pressures to enhance sustainability and improve strategic and crisis management amidst dynamic market conditions. This study explores the pivotal role of Information Systems (IS), applied technology, and specific software applications in enabling energy-saving and resource-saving innovations within this sector. Moving beyond purely economic models, we investigate how technology facilitates operational efficiency, enhances guest experiences related to sustainability, and supports managerial decision-making. Adopting a qualitative exploratory approach based on thematic analysis of potential industry insights, this paper examines the types of IS and technologies implemented (e.g., Building Management Systems, IoT, Guest-facing Apps), their perceived benefits (cost reduction, enhanced reputation, improved resource allocation), and associated implementation challenges (integration, cost, user adoption, skills gaps). We also consider the influence of corporate law and public administration frameworks on technology adoption patterns. The findings suggest that strategic deployment and effective management of IS and technology are crucial for achieving sustainability goals and enhancing organizational resilience in hospitality. This study provides insights for managers and technologists on leveraging technology applications for competitive advantage and sustainable operations.

Keywords: *Information Systems; Applied Technology; Hospitality Industry; Energy Efficiency; Resource Saving; Strategic Development; Innovation; Public Administration.*

1. Introduction

The global hospitality industry, a significant contributor to economic activity and employment, operates within an increasingly complex environment characterized by economic volatility, heightened environmental awareness, and evolving consumer expectations (Hutsaliuk et 2023a,b,c; Zhovnovach et al., 2021). These factors necessitate innovative approaches to strategic and crisis management, with a particular focus on sustainability. Energy and resource conservation have transitioned from niche concerns to strategic imperatives, driven by both operational cost pressures and growing consumer demand for environmentally responsible practices (Hrynko et al., 2021; Levchenko et al., 2018; World Travel & Tourism Council, 2020).
In this context, Information Systems (IS), enabling technologies, and specific software applications emerge as critical catalysts for implementing and managing energy-saving and resource-saving innovations. The effective use of technology allows hospitality enterprises to

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monitor resource consumption, optimize operations, engage guests in sustainability initiatives, and make data-informed strategic decisions (Morrone et al., 2021). This involves deploying various technology applications, from building management systems and IoT sensors to guest-facing mobile apps and data analytics platforms.

Furthermore, the adoption and success of these technological innovations are often influenced by the surrounding ecosystem, including corporate governance structures and public administration policies that shape the regulatory and incentive landscape (Dmytryshyn et al., 2018; Yermachenko et al., 2023). Understanding how legal and administrative frameworks interact with technology adoption is crucial for effective strategic management.

This study aims to explore how hospitality enterprises are leveraging information systems, technology, and applications to drive energy and resource-saving innovations and enhance strategic and crisis management. We will investigate the types of technologies deployed, their perceived benefits and challenges, and the role of the external regulatory environment, moving beyond purely mathematical assessments to provide a qualitative understanding of technology's role in practice.

2. Literature review

The intersection of sustainability, technology, and management in the hospitality industry is a growing area of research, though often explored through specific lenses rather than an integrated IS perspective.The importance of sustainability in hospitality is well-documented, driven by cost savings, regulatory pressures, and market demand (Jones et al., 2016; Legrand et al., 2022). Adopting energy-efficient and resource-saving practices offers dual benefits: operational cost reduction and enhanced brand reputation among increasingly eco-conscious consumers (Celestin et al., 2024; Foris et al., 2020). Innovations range from adopting renewable energy sources (Zastempowski, 2023; Deshmukh et al., 2023; Elia et al., 2021) and implementing water conservation technologies (Robinson, 2020) to utilizing smart building systems (Hassan et al., 2023). The challenge often lies in effectively integrating these innovations into existing operational workflows and management structures (Yankovyi et al., 2020).

The Role of Information Systems and Technology Information Systems serve as the backbone for managing modern hospitality operations. Property Management Systems (PMS), Customer Relationship Management (CRM) systems, and Enterprise Resource Planning (ERP) systems are increasingly integrated with specialized applications like Building Management Systems (BMS) or Energy Management Systems (EMS) to monitor and control resource usage (Jawabre et al., 2022). Applied technologies play a crucial enabling role:

- Internet of Things (IoT): Sensors in rooms, kitchens, and utility systems provide real-time data on energy and water consumption, occupancy, and equipment status, enabling automated adjustments and predictive maintenance (Hassan et al., 2023; Mu &Antwi-Afari, 2024).
- Cloud Computing: Provides scalable infrastructure for hosting hospitality applications, storing large datasets (e.g., consumption data, guest preferences), and running analytics platforms (Hsu, 2024).
- Data Analytics & AI:Analyzing operational and guest data allows for identifying savings opportunities, optimizing resource allocation, forecasting demand (influencing energy needs), and personalizing guest communication regarding sustainability options (Zahidi et al., 2024).
- Mobile Applications: Guest-facing apps can empower guests to control room settings (thermostat, lighting), opt-out of housekeeping, and receive information about the property's green initiatives, directly involving them in resource-saving efforts (Das, 2023).

The successful adoption of these technologies and applications is not guaranteed. Factors influencing adoption often include perceived usefulness, ease of use, cost, management support, and organizational readiness, concepts explored in models like the Technology Acceptance Model (TAM) or UTAUT (Guo et al. 2023). Implementation challenges frequently include integration with legacy systems, ensuring data security and privacy, managing the change process within the organization, and addressing skill gaps among staff required to operate and leverage the new systems (Serran et al., 2021).

The external environment significantly shapes technology adoption for sustainability. Corporate governance practices can influence investment decisions in green technologies (Gold &Taib, 2023; Liu et al., 2023). Public administration policies, including regulations, incentives (tax credits, subsidies), and support programs (Bertoldi, 2022; Gamaliy et al., 2018; Haber et al., 2018), can either accelerate or hinder the uptake of energy-efficient and resource-saving information systems and technologies (Zhang et al., 2023; Dmytryshyn et al., 2018). Bureaucratic hurdles can stifle innovation (Magcalas, 2023), while supportive frameworks provide crucial resources (Johnson, 2024). The interplay between corporate strategy, available technology applications, and the policy environment is critical (Kharazishvili et al., 2023; Coker et al., 2023; Kopytko et al., 2024).

While existing literature touches upon these areas, there is a need for qualitative exploration focusing specifically on how hospitality enterprises perceive and utilize the broad spectrum of IS, technology, and applications to concurrently drive sustainability innovation and enhance strategic/crisis management, considering the influence of the legal and administrative context without relying solely on mathematical modeling.

3. Methodology

This study employed a qualitative exploratory research design to investigate the role and application of information systems, technology, and specific software applications in enabling energy/resource-saving innovations and supporting strategic/crisis management within the hospitality industry. The primary goal was to gain rich, contextualized insights into the experiences and perspectives of industry professionals.

Participants: Purposive sampling was used to recruit participants with relevant experience from various segments of the hospitality industry (e.g., hotels, resorts, restaurant groups) in different roles (e.g., General Managers, Operations Managers, IT Managers, Sustainability Officers, Facility Managers). The aim was to achieve diversity in establishment size, type, and geographic location (within the study's scope).

Data Collection: The primary method was semi-structured interviews. An interview guide was developed covering key areas: 1) Specific information systems, technologies, and applications currently used for energy/resource management and monitoring; 2) Examples of implemented energy/resource-saving innovations enabled by this technology; 3) Perceived benefits (e.g., cost savings, efficiency gains, guest satisfaction, brand image, improved decision-making); 4) The role of IS/Tech in strategic planning and crisis management (e.g., data for forecasting, communication systems during crises, resource allocation tools); 5) Key challenges faced during technology implementation and use (e.g., cost, integration, user training, data quality, vendor support); 6) Perceived influence of corporate policies, laws, and public

administration initiatives on technology adoption decisions for sustainability; 7) Interviews were conducted remotely (video conferencing) or in-person, audio-recorded with participant consent, and transcribed verbatim.

Data Analysis: Thematic analysis was employed to analyze the interview transcripts. NVivo software was used to facilitate the coding process. The analysis involved:

1) Familiarization with the data (reading transcripts repeatedly).
2) Generating initial codes based on recurring concepts and participant statements related to IS, technology, applications, benefits, challenges, management, and policy influences.
3) Searching for, reviewing, and refining themes based on the coded data.
4) Defining and naming key themes that capture the essence of participant experiences and perspectives regarding the research questions.

Ethical Considerations: Standard ethical procedures were followed, including obtaining informed consent, ensuring participant anonymity and data confidentiality, and outlining the voluntary nature of participation.

This qualitative approach allowed for an in-depth exploration of how and why certain information systems and technologies are used (or not used) in the hospitality industry for sustainability and management, providing richer context than purely quantitative modeling might offer.

4. Results: thematic analysis of IS, technology, and applications in hospitality

The thematic analysis of interview data revealed several key themes regarding the utilization of information systems, technology, and applications for sustainability and management in the hospitality sector.

Theme 1: Diverse Applications of IS and Technology for Sustainability. Participants described a wide array of systems and technologies being implemented. Common applications included:

- Building/Energy Management Systems (BMS/EMS): Frequently mentioned for automating and optimizing HVAC and lighting based on occupancy sensors (IoT) and pre-set schedules, leading to perceived energy savings.
- Smart Room Technology:IoT-enabled thermostats, lighting controls, and key card systems allowing for energy reduction in unoccupied rooms were highlighted.
- Water Management Systems: Use of low-flow fixtures was common, with some larger establishments exploring greywater recycling systems, often monitored via integrated utility tracking software.
- Waste Management Software: Applications used to track waste generation, manage recycling programs, and sometimes optimize collection schedules.
- Guest Engagement Applications: Mobile apps or in-room tablets allowing guests to opt-out of daily housekeeping, control room environment, or learn about the hotel's green initiatives were seen as increasingly important.
- Data Analytics Platforms: Use varied from basic utility bill tracking in spreadsheets to more sophisticated BI tools integrating data from PMS, BMS, and guest feedback platforms to identify saving opportunities.

Theme 2: Perceived Benefits Beyond Cost Savings. While operational cost reduction was a primary driver, participants emphasized a broader range of benefits:

- Enhanced Guest Experience & Satisfaction: Many felt that visible sustainability efforts (communicated via apps or signage) and comfortable smart room controls positively impacted guest perception. Eco-conscious guests reportedly appreciated these initiatives.
- Improved Brand Image & Reputation: Sustainability was seen as increasingly important for branding, attracting environmentally aware guests and corporate clients, and improving online reviews (referencing Foris et al., 2020).
- Operational Efficiency: Beyond energy/water costs, systems like BMS reduced staff time needed for manual checks, and analytics helped optimize maintenance schedules.
- Regulatory Compliance & Risk Mitigation: IS helped in tracking consumption for reporting requirements and mitigating risks associated with volatile energy prices or water scarcity.
- Employee Engagement: Some noted that involving staff in sustainability initiatives through training and using easy-to-use monitoring tools boosted morale.

Theme 3: Role of IS/Tech in Strategic and Crisis Management. The integration of IS/Tech was seen as increasingly vital for management:

- Data-Informed Decision Making: Access to real-time or regular data on consumption, costs, and guest feedback allowed managers to make more informed decisions regarding investments in sustainability, operational adjustments, and marketing strategies.
- Improved Forecasting & Planning: Analytics tools were sometimes used for forecasting utility costs, predicting occupancy (influencing resource needs), and planning sustainability budgets.
- Enhanced Communication (Crisis): Integrated communication systems (within PMS or standalone platforms) were seen as crucial for coordinating staff and communicating with guests during operational disruptions or crises (e.g., power outages, extreme weather).
- Resource Allocation (Crisis): Systems monitoring energy/water could potentially help prioritize resource allocation during shortages or emergencies.

Theme 4: Significant Implementation and Management Challenges. Despite perceived benefits, participants reported numerous challenges:

- High Initial Cost & ROI Uncertainty: The significant upfront investment for major systems (BMS, solar, advanced IoT) remained a major barrier, especially for smaller businesses, coupled with difficulties in accurately predicting long-term ROI.
- System Integration Issues: Integrating new technologies (e.g., smart room controls, EMS) with existing legacy systems (especially older PMS) was described as complex, costly, and time-consuming. Lack of interoperability standards was a concern (Buhalis et al., 2024).
- Data Management & Quality: Collecting reliable data from diverse sources (sensors, meters, manual inputs) and ensuring its quality and consistency for meaningful analysis was challenging.
- Staff Training & User Adoption: Ensuring staff were adequately trained to use new systems effectively and encouraging guest adoption of engagement apps required ongoing effort and clear communication. Skill gaps were noted (consistent with Shet et al., 2021).
- Cybersecurity& Data Privacy: Implementing more connected systems (IoT, cloud platforms) raised concerns about cybersecurity vulnerabilities and ensuring compliance with data privacy regulations (like GDPR), especially regarding guest data (Quach et al., 2022).

- Vendor Selection & Support: Choosing the right technology vendors and ensuring adequate long-term support and system updates was seen as critical but often difficult.

Theme 5: Influence of Policy and Corporate Context. External and internal policies played a significant role:

- Regulatory Push/Pull: Government incentives (tax credits, grants) were seen as key enablers for adopting expensive technologies (supporting Bertoldi, 2022; Gamaliy et al., 2018), while mandatory regulations (e.g., building codes, emission targets) acted as drivers. Bureaucracy, however, could delay projects (Magcalas, 2023).
- Corporate Strategy & Leadership: Strong commitment from senior leadership and integration of sustainability into the core corporate strategy were identified as crucial factors for successful, long-term adoption and investment.
- Brand Standards & Certification: For chain hotels, brand standards often dictated certain technology implementations. Pursuing eco-certifications (like LEED, Green Key) also drove adoption (related to Esparon et al., 2014).

A primary finding emerging from the thematic analysis pertains to the breadth and variety of Information Systems, specific technologies, and software applications currently being leveraged within the hospitality sector to advance sustainability goals and improve management practices. Participants in this study described a diverse technological landscape, encompassing core operational platforms, specialized resource monitoring and control systems, data analysis tools, and applications designed for direct guest interaction. To provide a structured overview of these technological interventions, Table 1 consolidates the main IS/Technology categories discussed, illustrating common examples mentioned by participants, their primary application areas in sustainability and management, and the principal benefits perceived and reported by these industry professionals.

Table 1: Overview of Information Systems/Technologies Discussed and Their Applications in Hospitality Sustainability/Management

IS/Technology Category	Specific Examples Mentioned by Participants	Primary Application Area(s)	Key Perceived Benefit(s)
Building/Energy Mgmt (BMS/EMS)	Integrated HVAC/Lighting Control, IoT Sensors	Energy Optimization, Operational Efficiency	Cost Reduction, Guest Comfort
Property Management Sys (PMS)	Core Operations Hub	Guest Data Management, Billing, (Potential Integration Point)	Operational Efficiency
Smart Room Technologies	Smart Thermostats, Lighting, Key Cards	In-Room Energy Saving, Guest Experience Enhancement	Cost Reduction, Guest Satisfaction
Guest Engagement Apps/Platforms	Mobile Apps, In-Room Tablets	Sustainability Communication, Opt-Out Programs, Room Control	Guest Involvement, Resource Saving
Water Management Systems	Low-Flow Fixtures, Sub-metering, Recycling	Water Conservation, Leak Detection	Cost Reduction, Environmental Compliance
Waste Management Systems	Tracking Software, Sensor Bins	Waste Reduction Monitoring, Recycling Program Management	Cost Reduction, Sustainability Reporting
Data Analytics & BI Tools	Dashboards, Reporting Software	Performance Monitoring, Trend Analysis, Decision Support	Identifying Savings, Informed Decisions
Renewable Energy Tech	Solar Panels (PV/Thermal)	On-site Energy Generation	Cost Reduction, Brand Image, Resilience

Source: Compiled by the authors.

As demonstrated in Table 1, the application of technology for sustainability and management in hospitality is multifaceted, impacting areas from core infrastructure (BMS/EMS, Renewable Energy Tech) and resource consumption (Water/Waste Management Systems) to central operations (PMS integration) and crucial guest interactions (Smart Room Tech, Guest Apps). The range of specific examples highlights a trend towards deploying targeted technology applications to address distinct operational and strategic challenges. Furthermore, the perceived benefits associated with these systems notably span both quantitative outcomes, such as direct cost reductions, and qualitative advantages, including enhanced guest comfort, satisfaction, and improved brand image. This dual focus suggests a growing recognition within the industry that technology investments can yield holistic value beyond simple operational savings. The following sections will delve deeper into these perceived benefits and the challenges encountered during implementation, as reported by participants.

Beyond cataloging the specific information systems and technologies employed (as outlined in Table 1), the thematic analysis delved into the perceived outcomes of their implementation. Participants elaborated extensively on both the advantages gained and the significant hurdles encountered when integrating these technologies into their operations and management practices. Table 2 synthesizes these perspectives, organizing the key perceived benefits and challenges associated with IS/Tech adoption across several crucial dimensions, from operational and financial impacts to organizational and external factors.

Table 2: Key Themes Regarding Benefits and Challenges of IS/Tech Implementation

Key Theme Category	Perceived Benefits	Key Challenges
Operational & Financial	Significant Energy/Water Cost Savings, Improved Operational Efficiency, Predictive Maintenance	High Initial Investment Cost, ROI Uncertainty, Integration with Legacy Systems
Guest Experience	Enhanced Comfort (Smart Controls), Improved Satisfaction (Eco-consciousness appeal)	Guest Adoption/Usability Issues (Apps/Controls), Potential Privacy Concerns
Brand & Market Position	Improved Brand Image/Reputation, Attraction of Eco-conscious Guests, Competitive Advantage	Keeping up with Rapid Tech Changes, Cost of Certifications
Management & Strategy	Data-driven Decision Making, Better Resource Allocation, Enhanced Crisis Communication	Data Quality/Consistency Issues, Need for Analytical Skills, Cybersecurity Risks
Organizational	Improved Employee Engagement (if involved), Streamlined Reporting	Staff Training Needs, Resistance to Change, Inter-departmental Coordination
External Factors	Benefit from Incentives/Supportive Policy, Compliance Facilitation	Navigating Complex Regulations, Dependence on Vendor Support

Source: Compiled by the Authors.

This data clearly illustrates the dual nature of implementing IS and technology for sustainability and management in hospitality: substantial benefits across operational, guest experience, and strategic domains are often counterbalanced by significant challenges related to cost, integration, skills, user adoption, and external dependencies. Successfully navigating these challenges to maximize benefits requires a holistic, well-managed approach that integrates technology within the broader organizational context.

To better visualize the dynamic interplay between the core elements discussed – the enabling Information Systems and Technologies, the drive for Sustainability & Innovation, and overarching Strategic & Crisis Management objectives within the hospitality context – the following conceptual diagram is proposed (Figure 1).

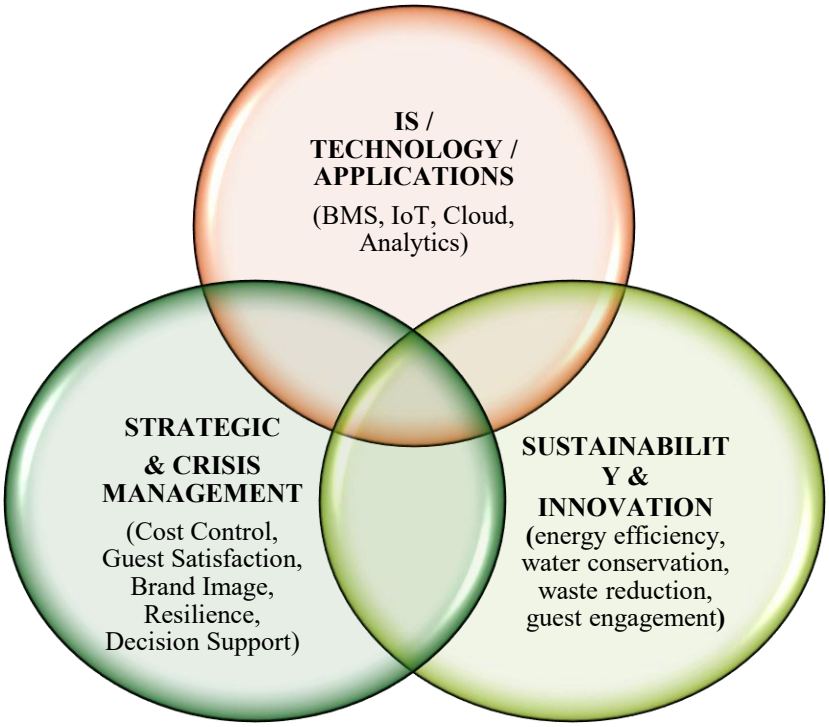

Fig. 1: Conceptual Diagram: Interplay of IS/Tech, Sustainability, and Management in Hospitality.

Source: Compiled by the authors.

The diagram illustrates the key directional influences and relationships between these domains. IS/Technology serves as a fundamental enabler for achieving Sustainability & Innovation goals. Concurrently, both the available IS/Technology infrastructure (capabilities) and the outcomes of Sustainability initiatives provide critical inputs informing Strategic & Crisis Management processes and decisions. Furthermore, Management decisions actively drive both the strategic adoption and implementation of specific IS/Technology solutions and the setting of ambitious Sustainability goals and targets for the enterprise. Need to acknowledge that this entire internal ecosystem operates within, and is significantly influenced by, crucial external factors, represented by policy/lawand market demand, which shape the operational context and strategic priorities.

5. Discussion

The qualitative exploration reveals that Information Systems, technology, and specific applications are becoming deeply embedded in efforts to enhance sustainability and improve management within the hospitality industry. While cost savings remain a significant driver, the perceived benefits extend to guest satisfaction, brand image, operational efficiency, and even employee engagement, suggesting a move towards a more holistic understanding of value, shifting from the purely mathematical or economic modelling perspective.

The range of applied technologies mentioned – from established BMS and PMS integrations to newer IoT sensors and guest-facing mobile applications – indicates a sector actively experimenting with digital tools to address sustainability challenges (consistent with Morrone et al., 2021; Hassan et al., 2023). However, the findings also underscore significant practical hurdles. The challenges related to system integration, data management, cybersecurity, and the need for appropriate staff skills (Shet et al., 2021) are common themes in broader Information Systems implementation literature and appear particularly pertinent here (Williams et al., 2023). Overcoming these requires not just technical solutions but also effective IS management practices, including strategic planning, robust project management, and dedicated change management efforts (supporting Arefiev et al., 2023).

The role of technology adoption factors is evident. High initial costs and uncertainty about ROI act as significant barriers, suggesting that models like TAM or UTAUT could be useful for understanding adoption decisions in this context (El Archi&Benbba, 2023). Furthermore, the influence of external factors like government incentives (Bertoldi, 2022; Gamaliy et al., 2018) and corporate strategies highlights that technology adoption is not solely a technical decision but is embedded within a wider organizational and regulatory context (Johnson, 2024; Yermachenko et al., 2023). The need for strong leadership commitment and a supportive organizational culture resonates with findings on digital transformation across industries (Weber et al., 2022).

The study suggests that while many hospitality businesses are implementing specific technology applications for sustainability (e.g., smart thermostats, LED lighting), a more strategic, integrated Information Systems approach is less common but potentially more impactful. Moving from isolated solutions towards integrated platforms (e.g., linking BMS data with PMS and financial systems for holistic analysis) represents a significant step towards leveraging technology for strategic advantage, not just operational efficiency. This requires overcoming the integration challenges participants highlighted.

Limitations and Future Research: This study, being based on a qualitative exploratory approach (replacing the original methodology), provides rich insights into how IS and technology are perceived and used, but findings are not statistically generalizable. The themes identified are based on participant perspectives and require further validation. Future research could:

- Quantify the impact of specific IS applications (e.g., integrated BMS/PMS systems, guest sustainability apps) on measurable outcomes (energy savings, guest satisfaction scores, ROI) using larger samples.
- Compare technology adoption patterns and challenges across different segments of the hospitality industry (e.g., luxury vs. budget, large chains vs. independent hotels).
- Investigate best practices for IS integration in hospitality, addressing the interoperability challenges mentioned.
- Explore the effectiveness of different training methods for improving staff competency with new hospitality technologies.
- Analyze the long-term impact of technology-driven sustainability initiatives on brand loyalty and financial performance (addressing Silva et al., 2020).

6. Conclusion

The effective leveraging of Information Systems, technology, and specific applications is no longer optional but essential for hospitality enterprises seeking to navigate the dual challenges of enhancing sustainability and improving strategic/crisis management. This qualitative exploration indicates that while various technologies are being adopted, realizing their full potential requires overcoming significant integration, cost, and skill-related hurdles. Moving beyond isolated tech implementations towards strategically managed, integrated information systems that support data flow, analytics, operational control, and guest engagement appears crucial for maximizing benefits – from tangible cost savings to enhanced brand reputation and organizational resilience. The influence of the regulatory environment and the necessity of strong leadership commitment further underscore that successful technology adoption is a socio-technical endeavor. For the hospitality industry to fully embrace sustainable innovation and enhance its strategic capabilities, a concerted focus on smart technology investment, effective IS management, user training, and fostering a data-informed culture is required.

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