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Proposed model for integrating risk management into facility operations

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Abstract
Facility operations are increasingly exposed to a diverse set of risks arising from technological complexity, climate change, financial pressures, and evolving regulatory environments. Traditional facility management (FM) approaches, which often emphasize cost control and reactive maintenance, are insufficient to ensure resilience in the face of these challenges. This proposes a conceptual model for integrating risk management into facility operations, enabling organizations to proactively identify, assess, mitigate, and monitor risks while maintaining alignment with broader sustainability and resilience goals. The proposed model is structured around six interdependent components. First, risk identification involves systematic mapping of assets, processes, and stakeholder vulnerabilities through audits, checklists, and scenario analysis. Second, risk assessment and prioritization apply both qualitative and quantitative tools, including likelihood–impact matrices, to rank risks by significance. Third, risk mitigation strategies focus on preventive maintenance, redundancies, emergency planning, and compliance with safety protocols. Fourth, integration into facility operations ensures that risk considerations are embedded within daily processes, contracts, and service delivery models, reinforcing business continuity and sustainable practices. Fifth, monitoring and review leverage real-time technologies such as IoT sensors, digital twins, and predictive analytics to track performance and adapt strategies dynamically. Sixth, communication and stakeholder engagement enhance transparency, building confidence among occupants, regulators, and investors while ensuring collective ownership of risk governance. Enabling factors include leadership commitment, organizational culture, capacity building, and supportive regulatory frameworks. The model anticipates outcomes such as improved operational resilience, reduced disruptions and losses, enhanced compliance, and stronger stakeholder trust. By shifting FM from a reactive to a proactive discipline, the integration of risk management establishes facilities not only as functional assets but also as resilient, adaptive, and sustainable components of urban infrastructure.

Keywords: Risk Management, Facility Operations, Operational Resilience, Hazard Identification, Mitigation Strategies, Contingency Planning, Resource Allocation, Safety Compliance

1. Introduction
Facility operations represent a critical domain within urban and organizational systems, encompassing the management of buildings, utilities, assets, and services that enable daily functioning (Lawal and Afolabi; 2015; Nwokediegwu *et al*., 2019). These facilities—ranging from hospitals and airports to educational institutions and commercial complexes—form the backbone of economic productivity and societal well-being. However, they are inherently exposed to a wide spectrum of risks, including equipment failures, natural hazards, cybersecurity threats, regulatory non-compliance, and financial instability (Lawal, 2015; Iyabode, 2015). When such risks materialize, the consequences can be severe: disruptions in essential services, threats to human safety, reputational damage, and substantial economic losses (Otokiti, 2012; SHARMA *et al*., 2019).
Risk management in facility operations is therefore indispensable, not only for safeguarding assets and ensuring continuity of services but also for enhancing resilience and stakeholder confidence (Akinbola and Otokiti, 2012; Lawal *et al*., 2014). A structured risk management approach enables facility managers to anticipate vulnerabilities, implement preventive measures, and establish response protocols that mitigate potential impacts. Beyond minimizing losses, effective risk management aligns

with broader organizational goals by protecting investments, maintaining compliance, and supporting sustainable operations (Lawal *et al*., 2014; Otokiti, 2018).

Modern facilities are more complex than ever before. Technological integration, sustainability imperatives, and heightened safety expectations have expanded the operational landscape (Amos *et al*., 2014; Otokiti, 2017). Facilities are no longer static physical structures; they are dynamic, technology-enabled ecosystems that must meet diverse and evolving demands.

Safety remains a paramount concern, encompassing occupational health, fire prevention, structural integrity, and emergency preparedness. Failures in these areas jeopardize not only facility users but also surrounding communities. Security has broadened beyond physical access control to include cybersecurity, given the increasing reliance on digital systems such as building automation, smart sensors, and data platforms (Ajonbadi *et al*., 2014; Otokiti and Akorede, 2018).

At the same time, sustainability has become an essential dimension of facility operations. Facilities are significant consumers of energy and water, and major contributors to greenhouse gas emissions. Risk management must therefore account for environmental risks, such as resource scarcity or non-compliance with sustainability regulations, which can affect both operational viability and social legitimacy (Bankole *et al*., 2020; OLAJIDE *et al*., 2020).

Finally, resilience has emerged as a defining criterion of contemporary facility operations. Climate change, urbanization, and global interdependencies expose facilities to shocks ranging from extreme weather events to supply chain disruptions. Embedding resilience within risk management ensures that facilities can not only withstand disruptions but also adapt and recover swiftly, thereby maintaining critical functions during crises (OLAJIDE *et al*., 2020; ILORI *et al*., 2020).

While the importance of risk management is well recognized, its integration into facility management practices often remains fragmented or reactive. Many facilities adopt risk management only after disruptions occur, focusing narrowly on compliance or immediate crisis response (FAGBORE *et al*., 2020; EYINADE *et al*., 2020). Such approaches are insufficient in a landscape marked by growing uncertainty and interconnectivity.

The objective of this, is to propose a systematic model for embedding risk management into facility operations. The model seeks to transition FM from a reactive posture to a proactive and adaptive discipline, where risk awareness and resilience-building are integral to everyday operations. It emphasizes structured processes such as risk identification, assessment, mitigation, monitoring, and communication, while aligning with sustainability goals and stakeholder expectations.

By embedding risk management into the strategic and operational dimensions of FM, the model addresses multiple objectives: reducing vulnerabilities, enhancing resilience, ensuring regulatory compliance, and contributing to sustainable urban systems. This integrated approach positions facilities not only as operational assets but also as resilient infrastructures capable of supporting inclusive, safe, and sustainable urban growth.

2. Methodology

The study adopted the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology to ensure a structured and transparent synthesis of evidence that informed the proposed model for integrating risk management into facility operations. A comprehensive search was conducted across major databases including Scopus, Web of Science, ScienceDirect, SpringerLink, and Google Scholar using keyword combinations such as "facility management," "risk management integration," "operational risk," "infrastructure resilience," and "safety in facility operations." Gray literature from industry reports, standards organizations, and professional bodies was also included to capture applied perspectives often absent from academic publications. The search was restricted to publications from 2000 to 2025 to reflect contemporary practices and evolving risk management frameworks.

The initial pool of records underwent a multi-stage screening process. Duplicates were removed, followed by a relevance screening based on titles and abstracts. Full-text reviews were conducted against predetermined inclusion and exclusion criteria. Studies were included if they provided conceptual, empirical, or applied insights into integrating risk management practices within facility operations. Articles focusing exclusively on non-operational risk domains, or those unrelated to facility management contexts, were excluded. The eligibility process emphasized practical applicability, methodological rigor, and relevance to both public and private facility operations.

Data extraction focused on study objectives, context, methodologies, risk management tools, and implications for facility operations. Extracted information was coded thematically, enabling comparison across diverse sectors such as healthcare, transportation, education, and corporate facilities. Quality assessment was performed using adapted evaluation checklists that emphasized the clarity of conceptual frameworks, robustness of methodological design, and evidence of real-world applicability. This ensured that only studies with sufficient rigor and operational relevance contributed to the synthesis.

The synthesis process followed a narrative and thematic approach. Key themes identified included risk identification and assessment processes, integration of digital monitoring tools, regulatory and compliance mechanisms, organizational culture and communication, and frameworks for resilience and continuity planning. Cross-comparison highlighted convergences and divergences across sectors, while also revealing contextual challenges in emerging and developed economies. The thematic analysis informed the development of a proposed integrated model that emphasizes embedding risk management into routine facility operations through proactive planning, stakeholder engagement, and data-driven decision-making.

The PRISMA approach provided a transparent and systematic process fosr evidence gathering, screening, and synthesis, ensuring that the proposed model is grounded in robust and relevant knowledge. This methodology not only enhanced the credibility of the model but also ensured that it reflects best practices, emerging trends, and practical solutions for integrating risk management into facility operations in diverse organizational contexts.

2.1 Theoretical Foundations

Risk management is a structured discipline grounded in a series of iterative and interdependent principles. At its core, it involves the systematic process of risk identification, assessment, mitigation, monitoring, and communication.

Risk identification is the first principle, requiring organizations to systematically map vulnerabilities across assets, processes, and stakeholders. In facility operations, risks may arise from technical failures, human error, environmental hazards, cyberattacks, or regulatory shifts. Tools such as risk registers, facility audits, and scenario planning provide structured approaches for capturing potential threats before they escalate (Lawal *et al*., 2020; AJUWON *et al*., 2020).

Risk assessment builds on identification by evaluating the likelihood and potential consequences of identified risks. Facilities commonly adopt qualitative approaches, such as risk matrices, or quantitative methods, such as probabilistic modeling and cost-benefit analyses, to prioritize risks. The aim is to focus attention and resources on high-probability, high-impact events while maintaining awareness of emerging risks.

Risk mitigation refers to the design and implementation of strategies to minimize the likelihood or impact of risks. In facility management, mitigation includes preventive maintenance programs, installation of redundancies, employee training, emergency preparedness, and adherence to safety codes. Increasingly, mitigation strategies also encompass sustainability measures, such as energy-efficient systems or flood-resilient designs, which address both operational and environmental risks.

Risk monitoring ensures that risk management remains dynamic and adaptive. Facilities are complex, evolving systems where risk profiles can change rapidly due to technological upgrades, policy changes, or external shocks. Continuous monitoring, supported by digital tools such as Internet of Things (IoT) sensors, predictive analytics, and digital twins, enables real-time visibility into system performance and early detection of anomalies.

Finally, risk communication is vital for transparency, accountability, and coordinated responses. Stakeholders—including facility occupants, regulators, insurers, and investors—must be informed about risks, mitigation strategies, and emergency protocols (Oladuji *et al*., 2020; Akinrinoye *et al*., 2020). Effective communication fosters trust, ensures compliance, and encourages shared responsibility for resilience.

Together, these principles form a cyclical process rather than a linear sequence, reinforcing continuous improvement in facility operations.

From the perspective of facility management (FM), risk management is not an abstract concept but a practical necessity. Facilities exist to support organizational missions, whether in healthcare, education, transportation, or commercial operations. Any disruption to these facilities translates into service interruptions, safety hazards, and financial losses.

Operational continuity lies at the heart of FM's risk perspective. Facility managers must guarantee that critical services—such as electricity, water, ventilation, and digital connectivity—remain functional even under adverse conditions. Business continuity planning, supported by redundancy systems and emergency protocols, ensures minimal downtime during crises.

Safety is another cornerstone. Facilities must comply with occupational health and safety standards to protect workers, occupants, and visitors. Risk management in this context involves fire safety systems, structural integrity assessments, access controls, and sanitation protocols. In high-risk environments, such as hospitals or chemical plants, the stakes are even higher, requiring stringent risk protocols.

Compliance with regulatory and legal requirements is equally fundamental. Facilities operate within a framework of building codes, environmental standards, energy efficiency targets, and occupational health regulations. Failure to comply can lead to penalties, reputational damage, and even operational shutdowns. Risk management ensures continuous adherence to these frameworks while anticipating future regulatory shifts, such as stricter climate policies (Akinbola *et al*., 2020; Nwani *et al*., 2020).

In addition, FM increasingly incorporates sustainability as an operational imperative. Energy efficiency, waste management, and resource circularity are not only environmental responsibilities but also mechanisms for risk reduction, as they decrease dependence on volatile energy markets and regulatory penalties.

Thus, from an FM perspective, risk management is directly tied to the core mission of delivering safe, reliable, and compliant services that sustain organizational performance and community well-being.

Despite its acknowledged importance, risk management is often approached reactively within facility operations. Many organizations adopt corrective measures only after incidents occur—whether equipment breakdowns, accidents, or regulatory breaches (Nwani *et al*., 2020; Odofin *et al*., 2020). While reactive responses may resolve immediate problems, they do little to build long-term resilience or prevent future occurrences.

A proactive integration of risk management into FM represents a paradigm shift. By embedding risk awareness and mitigation strategies into routine processes, organizations can anticipate threats, reduce vulnerabilities, and respond more effectively to disruptions. This proactive stance is particularly crucial in today's context of increasing complexity. Facilities are more interconnected, reliant on digital technologies, and exposed to external shocks than ever before. Without proactive risk integration, the probability of cascading failures escalates.

Proactive integration also aligns risk management with broader strategic objectives. For example, incorporating climate resilience measures—such as green roofs, flood barriers, or energy-efficient retrofits—does not only mitigate risks but also advances sustainability goals, reduces costs, and strengthens compliance with emerging regulations. Likewise, integrating cybersecurity protocols within building management systems ensures both operational continuity and regulatory adherence.

Moreover, a proactive approach enhances organizational adaptability. Facilities that regularly monitor, assess, and communicate risks are better positioned to adjust strategies in real time, whether responding to policy changes, technological innovations, or community expectations. This adaptability reduces long-term operational costs and bolsters stakeholder trust, positioning the facility as a resilient, future-ready asset.

The rationale for integration lies in the recognition that risk management is not a discrete activity but a continuous process that should be embedded into the very fabric of facility operations. Proactive integration ensures that facilities are not only safe and compliant but also resilient, sustainable, and capable of supporting organizational missions in uncertain environments (Akpe *et al*., 2020; Umoren *et al*., 2020).

2.2. Categories of Risks in Facility Operations

Facility operations are increasingly recognized as complex systems that must balance efficiency, safety, resilience, and sustainability. As facilities in both public and private sectors grow in scale and technological sophistication, they face a wide range of risks that can disrupt continuity, escalate costs, and threaten user wellbeing. These risks span multiple domains, from day-to-day operational challenges to systemic threats driven by environmental, financial, or regulatory pressures. Understanding and categorizing these risks is a foundational step toward building robust risk management strategies that safeguard assets, enhance resilience, and ensure that facilities continue to meet organizational and societal needs (Nwani *et al*., 2020; Umoren *et al*., 2020). The major categories of risks in facility operations include operational, environmental, health and safety, financial, security, and regulatory risks as shown in figure 1.

Operational risks constitute one of the most immediate threats to facility management, as they directly impact the efficiency and reliability of core services. Equipment failure—such as malfunctioning HVAC systems, elevators, or electrical components—can disrupt daily operations and compromise occupant comfort and safety. Utility outages, particularly electricity and water supply interruptions, further compound these risks by halting critical functions and undermining productivity. Supply chain disruptions represent another dimension of operational risk, especially as facilities increasingly depend on globalized networks for spare parts, maintenance materials, and technological upgrades. Disruptions in procurement can delay repairs, extend downtime, and increase costs, reducing the reliability and resilience of facilities.

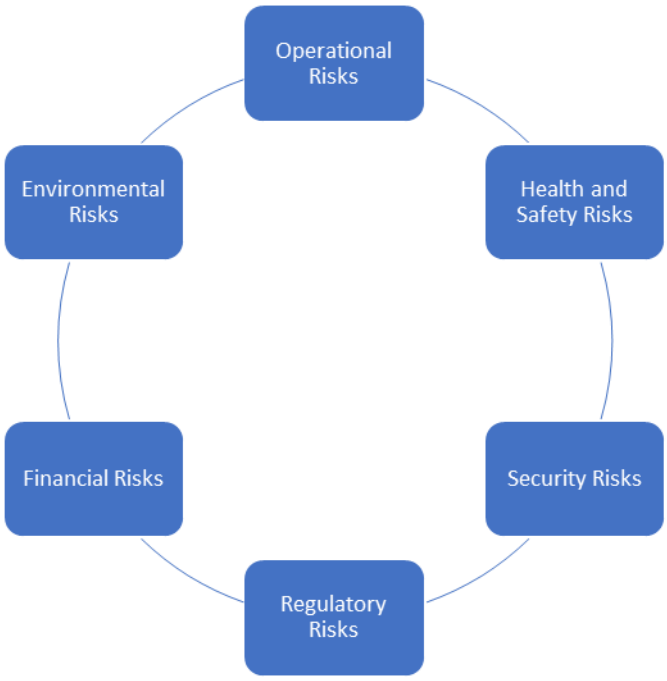

Fig 1: Categories of Risks in Facility Operations

Environmental risks are increasingly significant in an era of climate change and ecological stress. Facilities are vulnerable to natural disasters such as floods, earthquakes, hurricanes, and heatwaves, which can cause extensive damage to infrastructure and interrupt services. Beyond acute events, gradual climate change impacts such as rising temperatures, shifting rainfall patterns, and sea-level rise create chronic risks for facility performance, energy consumption, and long-term sustainability. Pollution also presents operational challenges, with air and water quality deterioration affecting both equipment performance and occupant health. For example, high particulate matter levels can increase the load on ventilation systems while also posing risks to respiratory health. Facilities located in environmentally vulnerable regions must therefore integrate adaptive and resilient design strategies to mitigate these risks.

Health and safety risks are central to facility operations, given the responsibility of managers to safeguard occupants, staff, and visitors. Accidents arising from slips, falls, or equipment misuse can lead to injuries and liability issues. Fire hazards remain a persistent concern, necessitating comprehensive fire detection, suppression, and evacuation systems (Asata *et al*., 2020; Umoren *et al*., 2020). Occupational hazards, such as prolonged exposure to noise, poor indoor air quality, or unsafe machinery, directly impact staff wellbeing and productivity. The COVID-19 pandemic underscored the significance of pandemics as a systemic health risk, highlighting the need for flexible facility management strategies that include enhanced cleaning protocols, improved ventilation, and space reconfigurations for social distancing. These risks emphasize that health and safety considerations extend beyond compliance; they are integral to ensuring operational continuity and social responsibility.

Financial risks pose a significant challenge to facility operations due to the resource-intensive nature of maintaining and upgrading infrastructure. Cost overruns frequently arise during construction, renovation, or maintenance projects, often linked to inaccurate forecasting, supply chain variability, or unanticipated technical challenges. Budget constraints further limit the ability of facility managers to invest in preventive maintenance, sustainable technologies, or resilience measures, leading to a cycle of deferred maintenance and heightened vulnerability (Au-Yong *et al*., 2019; Islam *et al*., 2019). Insurance liabilities also represent a financial risk, as inadequate or poorly structured coverage may expose organizations to

significant losses in the event of disasters or accidents. Managing financial risks requires rigorous planning, robust cost-control mechanisms, and innovative financing strategies.

Security risks have expanded significantly in scope, encompassing both physical and digital threats. Physical security breaches such as unauthorized entry, vandalism, or theft compromise not only the safety of assets but also the confidence of occupants and stakeholders. At the same time, the rise of digitalization in facility operations—through smart building technologies, IoT-enabled systems, and integrated data platforms—has increased exposure to cyber threats. Cyberattacks can disrupt building management systems, disable critical operations, or lead to data breaches, with severe operational and reputational consequences. Given the increasing interconnection of physical and digital systems, security risks demand a holistic approach that integrates surveillance, access control, cybersecurity protocols, and user awareness (Baig *et al*., 2017; Kure *et al*., 2018).

Regulatory risks emerge from the complex and evolving landscape of standards, codes, and policies governing facility operations. Non-compliance with environmental regulations, occupational safety standards, or building codes can lead to penalties, reputational damage, and operational shutdowns. Regulatory risks are particularly pronounced in emerging economies, where policy frameworks may change rapidly in response to international commitments or local development pressures. Furthermore, global sustainability initiatives such as carbon reduction targets are pushing facility operators to adopt stricter compliance measures (Umoren *et al*., 2020; Nwokediegwu *et al*., 2020). Failure to adapt to these evolving requirements can create long-term vulnerabilities, as outdated practices become misaligned with legal and societal expectations.

Facility operations are exposed to a diverse range of risks that cut across technical, environmental, financial, health, security, and regulatory domains. Each category of risk presents unique challenges but is also interconnected with others, creating a web of vulnerabilities that can amplify systemic failures if left unmanaged. Operational failures may trigger financial losses, environmental disruptions can exacerbate health and safety threats, and regulatory non-compliance may heighten financial and reputational risks. A comprehensive risk management strategy must therefore adopt a holistic perspective that anticipates and addresses risks across all categories. By doing so, facility operations can enhance resilience, safeguard stakeholder interests, and ensure continuity in the face of growing uncertainties.

2.3. Core Components of the Proposed Model

The integration of risk management into facility operations requires a structured and holistic framework that captures the dynamic nature of risks while embedding preventive and adaptive measures across organizational practices (Umoren *et al*., 2020). The proposed model is composed of six interrelated components: risk identification, risk assessment and prioritization, risk mitigation strategies, integration into facility operations, monitoring and review, and communication and stakeholder engagement as shown in figure 2. Each component addresses a specific dimension of the risk management cycle, yet together they form a continuous and iterative system that supports resilience, safety, and sustainability in facility management (FM).

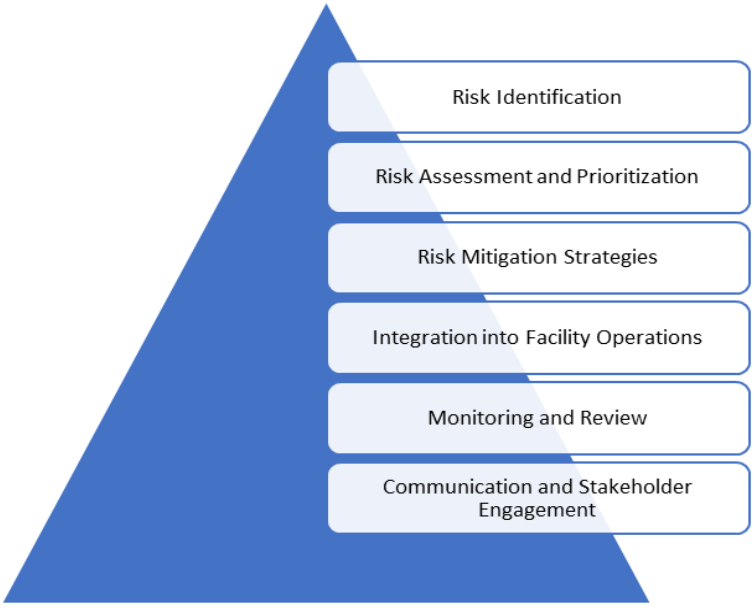

Fig 2: Core Components of the Proposed Model

The first step in effective risk management is risk identification, which entails mapping assets, processes, and stakeholders to uncover potential vulnerabilities. Facilities are complex ecosystems where risks can emerge from multiple domains: structural systems, energy infrastructure, digital networks, human behavior, or external shocks such as climate events. A systematic approach ensures that no critical element is overlooked.

Tools such as checklists, audits, and scenario analysis support the identification process. Checklists provide structured prompts for facility managers to examine areas such as fire safety, HVAC systems, cyber vulnerabilities, and emergency exits. Audits, often conducted by third parties, allow objective assessment of compliance with standards and regulations. Scenario analysis broadens the perspective by exploring "what if" situations—such as prolonged power outages or flooding—that may not be part of routine inspections but could pose catastrophic consequences.

Together, these methods enable comprehensive mapping of risks across physical, operational, and organizational dimensions.

Once risks are identified, they must be assessed and ranked according to their potential impact. The central tool in this process is the likelihood vs. impact matrix, which plots risks based on probability of occurrence and severity of consequences. High-likelihood, high-impact risks—such as equipment failures in critical facilities like hospitals—are prioritized for immediate action, while low-likelihood, low-impact risks are monitored with less urgency (Paton and Johnston, 2017; Levett *et al*., 2017).

Assessment methods may be both qualitative and quantitative. Qualitative approaches involve expert judgment, stakeholder consultations, and descriptive scales (e.g., low, medium, high). Quantitative methods apply statistical models, probabilistic simulations, or cost-benefit analysis to calculate expected losses and risk exposure in monetary terms. In practice, facility operations benefit from a hybrid approach, combining expert intuition with empirical data to generate robust, context-specific risk profiles. The outcome of this step is a prioritized risk register that guides resource allocation for mitigation efforts.

Risk mitigation constitutes the proactive core of the model, involving the design and implementation of interventions to reduce vulnerabilities. Several categories of strategies are central to facility operations.

Preventive maintenance and redundancies ensure the reliability of critical systems. Regular inspection of equipment such as elevators, HVAC systems, or fire alarms minimizes unexpected breakdowns, while redundant systems (e.g., backup generators, dual data servers) provide fail-safe options during disruptions (Rinehart *et al*., 2018; Ardemani *et al*., 2018).

Safety protocols and training are equally vital. Facility staff and occupants must be trained in evacuation procedures, fire drills, and occupational health measures. Technology integration further strengthens mitigation, with smart sensors detecting gas leaks or AI-driven systems predicting equipment failures before they occur.

Emergency response planning forms the third pillar of mitigation. Comprehensive response plans cover communication protocols, resource mobilization, and recovery procedures for scenarios such as floods, cyberattacks, or pandemics. Regular simulations and drills ensure that staff can respond swiftly and effectively under real conditions.

Risk management cannot remain a siloed activity; it must be embedded into daily operations, contracts, and service delivery models. Embedding ensures that risk considerations are not reactive responses but continuous practices aligned with organizational processes.

For example, contracts with maintenance providers should include clauses on compliance with safety standards and emergency response readiness. Procurement policies can require suppliers to meet sustainability and risk reduction benchmarks. Service delivery models should integrate resilience goals, such as minimizing downtime and ensuring continuity under stress.

Crucially, integration aligns risk management with business continuity and sustainability goals. Facilities that operate sustainably—through energy efficiency, resource circularity, and resilient infrastructure—are inherently less vulnerable to external shocks such as energy price fluctuations or climate events (Kim, 2017; Sertyesilisik, 2019). This alignment elevates risk management from a defensive mechanism to a strategic enabler of long-term resilience and value creation.

Because risks evolve with technological, regulatory, and environmental changes, monitoring and review are essential to keep facility operations adaptive.

Real-time monitoring technologies, such as IoT sensors, predictive analytics, and digital twins, allow continuous visibility into facility performance. For instance, sensors embedded in HVAC systems can detect anomalies in energy consumption, signaling potential failures before they disrupt operations. Predictive analytics enhance foresight by identifying patterns that precede breakdowns or inefficiencies.

Monitoring must be complemented by periodic reassessment. Annual or semi-annual reviews of risk registers, audits of compliance, and revisions to emergency plans ensure that strategies remain relevant. Importantly, monitoring and review are iterative, feeding lessons learned back into the identification and assessment stages to drive continuous improvement cycles.

Risk management succeeds only when it is inclusive and transparent. Communication and stakeholder engagement are therefore central to the model. Transparent reporting of risks, mitigation strategies, and performance metrics builds trust among regulators, investors, employees, and occupants. Communication tools include digital dashboards, risk reports, and awareness campaigns that keep stakeholders informed and prepared.

Engagement requires involving diverse actors in risk governance. Occupants can provide feedback on safety protocols, while regulators ensure compliance with evolving standards. Investors increasingly demand disclosure of risk and resilience measures as part of environmental, social, and governance (ESG) reporting. By co-creating risk management strategies with stakeholders, facilities can develop solutions that are practical, context-sensitive, and widely supported (Jones, 2019).

The six core components of the proposed model form a comprehensive framework for integrating risk management into facility operations. From identification and assessment to mitigation, integration, monitoring, and engagement, the model captures the full risk lifecycle while aligning with sustainability and resilience objectives (Mickovski and Thomson, 2017; Chapman, 2019). By adopting this approach, facilities can move beyond reactive problem-solving toward proactive governance, ensuring continuity, safety, compliance, and long-term adaptability in increasingly complex operational environments.

2.4. Enabling Factors

The successful integration of risk management into facility operations depends not only on identifying and categorizing risks but also on creating enabling conditions that allow organizations to anticipate, mitigate, and adapt to these challenges effectively. Enabling factors provide the structural, cultural, and technological foundation upon which facility managers can embed risk management into everyday practices (Dong *et al*., 2018; Slade *et al*., 2018). Four critical enablers stand out: leadership commitment and organizational culture, training and capacity building, integration with digital tools, and policy and regulatory frameworks that support proactive risk management. Together, these factors shape the environment in which risk

management strategies can evolve from reactive responses to proactive, resilient systems.

Leadership commitment and organizational culture are central to embedding risk management into facility operations. Leaders set the tone for organizational priorities, resource allocation, and accountability. When top management visibly prioritizes risk management and sustainability, it signals to all employees that these practices are integral rather than peripheral. A culture that values safety, transparency, and resilience empower facility teams to report issues promptly, experiment with innovative solutions, and engage in continuous improvement. Organizational culture also shapes how risks are perceived and addressed; for instance, whether near misses are treated as learning opportunities or ignored until they escalate into crises. In emerging urban economies, where competing demands often stretch resources, leadership commitment ensures that risk management is not sidelined in favor of short-term financial considerations. By embedding risk awareness into decision-making and daily routines, leaders foster a resilient organizational culture capable of anticipating and adapting to uncertainties.

Training and capacity building for FM teams represent another enabling factor, equipping professionals with the skills and knowledge necessary to manage complex risk environments. Facility management is increasingly multidisciplinary, requiring expertise in engineering, finance, health and safety, sustainability, and digital technologies. Training programs tailored to these diverse domains help FM teams develop the competencies needed to identify vulnerabilities, evaluate risk scenarios, and implement mitigation measures. Capacity building extends beyond technical skills to include leadership, communication, and stakeholder engagement, which are essential for aligning risk management efforts across departments and external partners. In contexts where skilled labor shortages are common, structured professional development pathways and certification programs strengthen the long-term resilience of facility operations. Additionally, continuous learning mechanisms—such as workshops, simulations, and knowledge-sharing platforms—enable FM teams to stay updated on emerging risks and evolving management practices.

The integration of digital tools is transforming risk management in facility operations by enabling real-time monitoring, predictive analysis, and informed decision-making. Digital twins—virtual replicas of physical assets—allow facility managers to simulate scenarios, test interventions, and predict system responses under various risk conditions. This enhances the ability to anticipate failures before they occur and to design more resilient systems. Similarly, AI-based risk modeling leverages large datasets from sensors, historical performance records, and external risk indicators to identify patterns and predict vulnerabilities with high accuracy (Omopariola, 2017; Mekonnen *et al*., 2019). These digital tools reduce uncertainty and enable proactive interventions, improving both efficiency and resilience. For example, predictive maintenance algorithms can identify equipment likely to fail, reducing downtime and preventing costly disruptions. In emerging urban economies, where resource constraints often limit capacity for large-scale interventions, digital tools provide cost-effective pathways to enhance situational awareness and optimize decision-making. However, their effectiveness depends on adequate investment, data infrastructure, and skilled personnel capable of interpreting and applying digital insights.

Finally, policy and regulatory frameworks supporting proactive risk management create the external enabling environment within which facilities operate. Governments and industry regulators play a critical role in setting standards, enforcing compliance, and incentivizing best practices. Clear and consistent policies, such as building codes that incorporate resilience measures, mandatory risk assessments, and reporting requirements, establish a baseline of accountability. Financial mechanisms, including subsidies, tax incentives, or insurance benefits tied to risk management performance, further encourage proactive adoption. Regulatory frameworks also foster collaboration across sectors, aligning facility operations with broader urban resilience, environmental, and public health goals. In emerging urban economies, strengthening institutional capacity for enforcement is particularly crucial, as weak oversight can undermine even the most well-designed regulations. Policies that promote transparency, encourage innovation, and support capacity-building efforts provide a supportive backdrop against which facility managers can implement robust risk management practices.

Enabling factors provide the essential conditions for embedding risk management into facility operations. Leadership commitment and a supportive organizational culture ensure that risk management is prioritized and normalized. Training and capacity building empower FM teams with the skills and confidence to manage complex risk landscapes. Digital tools extend analytical capabilities, allowing for predictive and proactive strategies. Policy and regulatory frameworks create the external environment that incentivizes and enforces good practices (Allinson *et al*., 2017; Koebel *et al*., 2018). Together, these enablers establish a comprehensive foundation for resilient, adaptive, and sustainable facility management in the face of growing uncertainties.

2.5. Expected Outcomes of the Model

The integration of risk management into facility operations through the proposed model is expected to deliver a range of tangible and intangible benefits (Madden, 2017; Prieto *et al*., 2019). These outcomes extend beyond reducing vulnerabilities to fostering a proactive culture of resilience, sustainability, and value creation within facility management (FM). By systematically embedding risk management principles into daily practices, organizations can enhance operational continuity, minimize losses, strengthen compliance, and align with broader sustainability and climate adaptation agendas.

One of the primary outcomes of the model is the strengthening of operational resilience and continuity. Facilities, whether in healthcare, education, commercial, or industrial sectors, are increasingly exposed to diverse risks ranging from equipment failures to cyberattacks and climate-related disruptions. By adopting structured risk identification, assessment, and mitigation processes, facilities can anticipate disruptions rather than merely react to them.

Preventive maintenance, predictive analytics, and redundant systems ensure that critical operations are not compromised. For instance, backup power systems can sustain essential services during grid failures, while digital twins can model stress scenarios to optimize recovery plans. This capacity to absorb shocks, adapt quickly, and resume operations with

minimal downtime elevates the role of FM from a support function to a strategic enabler of organizational resilience. Over time, enhanced continuity translates into greater reliability of services, which is particularly critical in mission-sensitive environments such as hospitals and transportation hubs.

Another expected outcome is a significant reduction in accidents, disruptions, and associated financial losses. Facilities often face risks related to occupational safety, equipment breakdown, and environmental hazards. Without a structured model, these risks can escalate into costly incidents, including workplace injuries, property damage, or regulatory fines.

By embedding safety protocols, employee training, and emergency response plans, the model fosters a culture of vigilance that reduces the likelihood of accidents. For example, IoT sensors monitoring air quality or structural integrity can provide early warnings that prevent hazardous situations. Similarly, scenario-based planning ensures preparedness for natural disasters, minimizing downtime and repair costs.

Financially, the model reduces both direct costs (such as repairs and compensation) and indirect costs (such as reputational damage or business interruption). Over the long term, facilities implementing robust risk management systems benefit from lower insurance premiums, improved asset longevity, and higher returns on investment (Hopkin, 2018; Ivanov, 2018). The financial stability achieved reinforces the attractiveness of risk-integrated FM as a strategic business practice.

Compliance with regulatory standards and industry certifications is an essential dimension of modern facility operations. The proposed model's emphasis on governance, monitoring, and transparent communication enhances an organization's ability to meet and exceed compliance requirements. Regular audits, adherence to ISO risk management frameworks, and alignment with certifications such as LEED or BREEAM demonstrate commitment to safety and sustainability.

Beyond compliance, the model nurtures stakeholder confidence. Regulators, investors, employees, and occupants are increasingly concerned with how organizations manage risk in light of rising global uncertainties. Transparent reporting of risk mitigation measures, coupled with demonstrable resilience strategies, strengthens trust and credibility. For investors, particularly those guided by environmental, social, and governance (ESG) criteria, risk-integrated FM provides assurance of long-term stability. For occupants and employees, visible safety measures foster a sense of security and engagement, which in turn enhances productivity and satisfaction.

The final, and perhaps most transformative, outcome of the model is its alignment with sustainability and climate adaptation strategies. As urban facilities increasingly operate in the context of climate variability, risk management must extend beyond immediate operational threats to long-term resilience.

The model supports this alignment through its focus on energy efficiency, resource optimization, and integration of renewable technologies within risk mitigation measures. For example, reliance on solar-powered backup systems not only ensures continuity during blackouts but also reduces carbon emissions. Similarly, water recycling systems mitigate risks of supply shortages while advancing sustainable resource use.

From a climate adaptation perspective, scenario analyses and predictive modeling enable facilities to prepare for extreme weather events, rising temperatures, or flooding. Embedding such foresight into FM practices ensures that facilities are not only resilient to present risks but also adaptable to future uncertainties. This positions risk-integrated FM as a key contributor to broader urban sustainability goals, including those aligned with the United Nations Sustainable Development Goals (SDGs) and national climate adaptation policies.

The proposed model for integrating risk management into facility operations is expected to yield multi-dimensional benefits that reinforce the strategic value of FM. Enhanced resilience and continuity ensure uninterrupted service delivery, while reduced accidents and financial losses safeguard both human lives and organizational assets (Carlin *et al*., 2017; Hallegatte *et al*., 2019). Improved compliance and stakeholder confidence foster trust, accountability, and long-term partnerships. Finally, alignment with sustainability and climate adaptation strategies embeds risk management within the global agenda for resilient, low-carbon, and inclusive development. Collectively, these outcomes underline the necessity of shifting risk management from a reactive function to a proactive, embedded practice that defines the future of facility management.

3. Conclusion

The necessity of integrated risk management in facility management (FM) cannot be overstated, particularly in the context of increasingly complex, resource-constrained, and unpredictable urban environments. Facilities today operate at the intersection of technological, environmental, financial, and social systems, making them highly vulnerable to diverse and interrelated risks. Traditional reactive approaches, where risks are addressed only after they manifest as crises, are insufficient for ensuring continuity, safety, and sustainability. An integrated risk management approach offers a structured pathway for embedding resilience into daily operations, aligning organizational strategies with broader societal needs for stability and sustainability.

The proposed model for integrating risk management into facility operations plays a crucial role in shifting the paradigm from reactive problem-solving to proactive resilience-building. By embedding risk identification, assessment, monitoring, and mitigation into routine facility operations, the model enables managers to anticipate vulnerabilities and respond with agility. Incorporating digital tools, organizational culture, and supportive policies, the model ensures that risk management is not an isolated process but a continuous, adaptive, and participatory practice. This shift fosters operational reliability, financial efficiency, and user wellbeing while positioning facilities as critical contributors to urban resilience.

Future research should explore context-specific applications of the model, particularly in emerging urban economies where infrastructural deficits, financial constraints, and institutional weaknesses heighten risk exposure. Empirical studies evaluating the performance of integrated risk management frameworks across different facility types—such as healthcare, educational, and commercial buildings—would provide valuable insights into scalability and adaptability. Practical implementation pathways should also prioritize stakeholder engagement, cross-sector

collaboration, and alignment with evolving digital and regulatory landscapes. By advancing both theoretical and applied dimensions, integrated risk management in FM can evolve into a cornerstone of resilient, sustainable, and future-ready urban systems.

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