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# Digital transformation and IoT in the facilities management industry: Assessment of key drivers and challenges

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**Abstract** This study explores the drivers and challenges for utilizing the Internet of Things (IoT) in the Saudi Arabian facilities management (FM) Industry. A literature review identified IoT applications, drivers, and challenges in FM, followed by a survey of 60 practitioners (30 facilities managers and 30 IoT specialists) on IoT utilization in the Saudi FM industry. The analyzed results informed recommendations to enhance IoT adoption. The common drivers between the two groups of survey participants (with frequencies of 50.0% or more) included cost saving by optimizing energy usage, improving maintenance schedules and reducing downtime; and improving the efficiency of operations by providing real-time data on systems' performance and usage patterns. The common challenges between the two stakeholder groups (with frequencies of 50.0% or more) included the lack of skills and knowledge about new technologies in FM organizations; and the inability to integrate legacy FM systems with IoT devices and platforms. This research contributes to the FM literature and industry by exploring various knowledge domains within a highly relevant and demanding area of the profession. The study's outcomes offer potential for enhancing the current level of IoT adoption in Saudi Arabia's FM industry. This is the first study that provides an analysis of the drivers and challenges for IoT utilization in the Saudi Arabian FM Industry. The outcomes provide a potential for improving the current level of IoT adoption.

**Index Terms** : internet of things, facilities management, industry, drivers, challenges, Saudi Arabia

## I. Introduction

To date, traditional, or conventional techniques for facilities management (FM) have involved manual processes, basic technologies, and limited automation [1]. Traditional FM has primarily relied on manual data collection and analysis for key functions, making processes time-consuming and error-prone, often resulting in delays or inefficiencies. Decision-making has often been based on experience and intuition [2], with technology adoption limited to basic tools like spreadsheets and simple software applications. Essential FM functions, such as maintenance, have often been conducted on a reactive-basis, where repairs are performed only after a failure occurs, an approach that has led to higher costs and downtime [3].

While traditional FM has been the norm for many years, intelligent FM offers a more proactive and data-driven approach to the industry [4]. The introduction and utilization of the Internet of Things (IoT) in in FM industry has presented innovative methods for managing various facility functions. The utilization of IoT technologies has enabled the rise of intelligent FM, which involves the use of sensor-based technologies, data analytics, and automation to optimize FM processes and improve efficiency [5]. This shift has led to increased productivity, improved user comfort, and greater safety and security.

IoT solutions operate on the principle of utilizing data analytics to gather insights from real-time data, hence, thereby enabling more informed decision-making [6]. Predictive analytics have been employed to identify trends, optimize resource allocation, and improve operational efficiency [7]. IoT solutions have also integrated automation into various FM processes. These automated systems can monitor energy usage, perform predictive maintenance, optimize space utilization, and control workflows [8].

Saudi Arabia's Vision 2030 is an ambitious strategy aimed at diversifying the nation's economy and decreasing its dependency on oil revenues. As part of this vision, the Kingdom aims to transform into a digital economy and utilize emerging technologies, such as IoT to improove various sectors [9], including FM. Nonetheless, while the utilization of IoT in the Saudi Arabian FM industry holds great potential, there is need to understand the drivers and challenges affecting its wide scale adoption. Therefore, this study endeavors on answering the following research questions:

**RQ1.** What are the drivers for IoT utilization in the FM industry?

**RQ2.** What are the challenges for IoT utilization in the FM industry?

**RQ3.** How can facilities managers promote the adoption of IoT technologies within Saudi Arabia's FM industry?

This study aspires to examine the drivers and challenges for the adoption of IoT technologies in the Saudi Arabia's FM industry. It investigates the perspectives of two primary stakeholder groups: facilities managers (FMs) and IoT specialists, as each group would naturally have different perceptions of the drivers and challenges. The study contributes to a deeper understanding of IoT adoption in the Saudi FM industry by highlighting its drivers and challenges, addressing a significant gap in the existing literature. It emphasizes the potential of IoT to reduce inefficiencies, improve decision-making, and promote sustainability in FM practices. The insights shared by FMs and IoT specialists provide a foundation for collaborative efforts and future research.

The findings provide valuable guidance for key stakeholders in the Saudi FM industry. FMs can utilize insights into cost savings and operational efficiency to justify IoT investments while proactively addressing integration and training challenges. Policymakers can develop supportive policies aligned with Vision 2030 to incentivize IoT adoption. Technology providers will have a clearer understanding of market needs, enabling them to develop tailored solutions. Clients and investors are better positioned to recognize IoT's long-term value, encouraging greater investment.

## II. Research methodology

The following activities were undertaken to achieve the study's objectives:

### *II. A. Literature review*

The literature review explored IoT applications for intelligent FM and analyzed the drivers and challenges of IoT adoption within the FM industry. The reviewed sources included recent papers pertaining to the adoption of IoT technologies in FM.

### *II. B. Development of questionnaire survey*

A questionnaire survey was developed to identify the frequencies of the drivers and challenges for utilizing IoT in the Saudi Arabian FM industry. The survey included 10 drivers and 9 challenges, which were identified through an extensive literature review. The survey was administered to 60 practitioners involved in the design and management of IoT projects in the Eastern Province of Saudi Arabia. These practitioners represented two key stakeholder groups: FMs and IoT specialists. FMs bring invaluable expertise in assessing the drivers and challenges of IoT adoption in the FM sector. Their knowledge of existing infrastructure, processes, and operational workflows enables them to identify areas where IoT can deliver the most significant improvements, such as cost savings, operational efficiency, and sustainability. They also provide practical insights into the day-to-day challenges of FM, facilitating a realistic evaluation of how IoT technologies can address inefficiencies or improve performance. IoT specialists, on the other hand, contribute their technical expertise in designing and implementing IoT solutions tailored to the specific needs of FM organizations. They bring advanced knowledge in sensor deployment, data analytics, system integration, and cybersecurity, making them instrumental in overcoming technical barriers such as interoperability with legacy systems. Their insights are essential for developing innovative, data-driven approaches that optimize FM operations.

The respondents were requested to indicate, through multiple selections, the drivers and challenges for utilizing IoT in the Saudi Arabian FM industry. Table 1 provides the demographics of the 60 respondents to the questionnaire survey, categorized by professional years of experience and number of IoT projects they have been involved in.

Table 1: Profile of the study participants

| Parameter | FMs Frequency (n = 30) | % | IoT specialists Frequency (n = 30) | % |
|---|---|---|---|---|
| Years of experience | | | | |
| Less than 5 years | 5 | 16.7 | 6 | 20.0 |
| 5-10 years | 16 | 53.3 | 11 | 36.7 |
| 11-15 years | 5 | 16.7 | 6 | 20.0 |
| More than 16 years | 4 | 13.3 | 7 | 23.3 |
| Number of IoT projects | | | | |
| 1-5 projects | 15 | 50.0 | 19 | 63.3 |
| 5-10 projects | 11 | 36.7 | 8 | 26.7 |
| More than 10 projects | 4 | 13.3 | 3 | 10.0 |

The questionnaire survey was pre-tested with a group of 10 practitioners, including five FMs and five IoT specialists. The purpose of the pilot-testing was to assess the clarity of the identified drivers and challenges for the utilization of IoT technologies in the FM industry.

### *II. C. Data collection*

Based on the guidelines of the "central limit theorem", 30 responses were collected, as a sample size, for each stakeholder group for the developed questionnaire survey. The theorem specifies that when performing a random survey on a specialized population, questionnaire-based studies must involve a sample size of at least 30 participants. This serves to obtain an almost normal distribution of the data, for analysis [10].

### *II. D. Data analysis*

The data collected through the multiple-answer questionnaire survey were utilized to determine the frequencies and the percent frequencies of all the identified drivers and challenges. This facilitated determining the rank of each variable, thus reflecting the significance of each driver and challenge [11], for the utilization of IoT technologies in the Saudi Arabian FM industry.

### *II. E. Development of recommendations for FMs*

This research developed a group of practical recommendations for FMs based on the outcomes of the study. These recommendations aim to facilitate the wide-scale adoption of IoT technologies in the Saudi Arabian FM industry.

## III. IoT applications for intelligent FM

Digital transformation and sustainability are central pillars of Saudi Arabia's Vision 2030. FMs and IoT specialists are key players in realizing these goals within the FM sector by driving IoT adoption and addressing related challenges. IoT applications have transformed how facilities are managed [8]. In fact, IoT technologies have enabled intelligent FM, resulting in improved productivity, efficiency, enhanced user comfort, increased safety and security, and the development of data-driven insights for decision-making [5]. IoT can be used to monitor and control different systems in a facility, like lighting, HVAC, and security, based on data gathered by sensors. This can lead to significant energy savings and reduced operation and maintenance (O&M) expenses [12]. In predictive maintenance, sensors are used to monitor equipment performance and identify potential issues before they arise. This can result in reduced downtime and a longer service life for the equipment [7]. IoT can be used to develop intelligent buildings that provide users with personalized and smooth experiences, thereby improving user comfort. For example, sensors can be used to identify users in a space and adjust the lighting to their preferences. As a result, users may feel more comfortable [13]. Further, IoT can be used to improve facilities' security and safety. Sensors enable real-time monitoring and threat detection, notifying security personnel of any unauthorized access to restricted areas. Furthermore, sensors can detect and respond to emergency situations, like fires or gas leaks [14]. IoT systems can also support decision-making, through collecting and analyzing data pertaining to various aspects of FM, such as energy consumption, occupancy levels, and maintenance activities. This data can be used for identifying trends and patterns, allocating resources more effectively, for rational decision-making [15]. Finally, IoT enables remote FM. This is achieved through remotely monitoring and controlling various building systems, like lighting, HVAC, and security [16]. This allows FMs to monitor and control several facilities from a single location, reducing the need for on-site staff.

## IV. Drivers for the utilization of IoT in the FM industry

The utilization of IoT in the FM industry can be motivated by several drivers that contribute to its usefulness. These drivers include:

### *IV. A. Cost savings*

IoT solutions can assist FMs optimize their O&M expenditures through reducing energy usage, extending the lifespan of building systems and equipment, automating manual procedures, and reducing downtime. Real-time data provides FMs with visibility into their facilities' performance and resource utilization [6]. This allows them to identify opportunities for cost saving, through reducing unnecessary operations of building systems and equipment, as well as detecting deviations from optimal operating conditions [17].

### *IV. B. Efficient facilities' operations*

Real-time monitoring of facilities through IoT sensors has empowered FMs to remotely monitor usage patterns and detect inefficiencies in building systems' operation [18]. Fast corrective measures can then be carried out to avoid waste, down time, excessive maintenance expenses and gain back optimum operational conditions [15].

### *IV. C. Fulfilling sustainability goals*

IoT solutions, through control systems and building management platforms can significantly support sustainability initiatives. IoT sensors deployed throughout facilities provide real-time data on the consumption levels of several resources, like electricity used for operating HVAC and lighting systems. This data enables FMs to develop strategies to lower resource consumption,

reduce waste, and avoid inefficiencies, thereby lowering carbon emissions [19]. Similarly, leak detectors and smart meters for water and gas can be utilized for identifying leaks and defects that lead to increased resource consumption [20].

### *IV. D. Enhancing safety practices*

IoT systems, through remote real-time environmental monitoring, can assist FMs improve safety, monitor risks, and prevent accidents. IoT sensors and networks deployed throughout facilities can continuously track parameters such as temperature, smoke and carbon monoxide concentrations [21]. This enables FMs to recognize unsafe conditions that require attention through automated alerts based on sensor data [15].

### *IV. E. Implementing predictive maintenance*

While reactive maintenance relies on manual inspections, scheduled servicing, and response after systems' failure [22], IoT solutions enable FMs to capitalize on the benefits of predictive maintenance. This is achieved through continuously monitoring equipment performance parameters to detect deviations from normal operating ranges. Such insights prompt maintenance teams to take proactive actions that prevent system downtime and operational disruptions [23].

### *IV. F. Improving asset management*

IoT systems offer various capabilities that enable FMs to more effectively track, monitor, control and optimize facilities' assets. These capabilities are attained through remotely collecting and analyzing real-time data on equipment location, performance, and maintenance history [24]. The control and optimization features provided by IoT solutions have improved asset management practices within facilities, through improving equipment performance, uptime and utilization [2].

### *IV. G. Complying with regulatory requirements*

IoT technologies provide FMs with tools to meet regulatory mandates pertaining to energy efficiency, sustainability, safety and the environment [21]. IoT devices, such as sensors and control systems, offer real-time data, enabling FMs to develop insights into resource consumption within facilities. This helps reduce energy use and ensures compliance with regulatory benchmarks [23].

### *IV. H. Delivering innovative facilities' services*

IoT technologies enable FMs to innovate in the delivery of facilities' services. Real-time monitoring of facilities and assets provides continuous visibility into performance parameters, resource consumption levels, equipment status and environmental conditions [25]. Access to such data, empowers FMs to dynamically identify opportunities, optimize operations and improve services through fact-based decision making, in contrast to static pre-programmed parameters of traditional approaches [15].

### *IV. I. Improving customer satisfaction*

IoT sensors installed throughout facilities allow for continuous monitoring of thermal and visual comfort performance, which is essential for occupants [26]. When deviations from normal ranges occur, automated alerts often notify facility teams to make immediate corrective actions. Further, occupants can be altered to potential hazards, and safety risks, thereby improving their perceptions of safety and wellbeing. This improves customer satisfaction through providing more responsive facility services [21].

### *IV. J. Remotely managing facilities and assets*

IoT devices provide FMs with real-time remote visibility into the conditions of their buildings. This is accomplished by monitoring and controlling performance parameters from any location, requiring little, to no on-site presence [19]. Automated alerts based on sensor data can promptly notify facility teams of any deviations from typical ranges [27]. This feature enables more dynamic and responsive facility operations, which improves efficiency, reduces travel expenses, and increases flexibility.

## V. Challenges affecting the utilization of IoT in the FM industry

Introducing the IoT technologies into the FM sector presents a range of challenges. These challenges include:

### *V. A. Cost-driven clients who are focused on short-term savings*

IoT solutions require the acquisition of hardware such as sensors and control systems, software platforms, integration services and data communication and management infrastructure. The costs of such solutions can be substantial, with large upfront fees that cost-conscious clients often seek to minimize [28]. Many FMs and owners favor immediate cost savings over long-term investments, as the focus on short-term savings. As a result, they are often reluctant to adopt IoT solutions that offer benefits over multi-year payback periods [29].

### *V. B. Lack of skills and knowledge about new technologies*

IoT solutions are constantly improving, providing numerous advantages for optimizing operations and asset management. The transformation to data-driven and digitally enabled FM necessitates the development of new skills that many facility teams presently lack [30]. Nevertheless, FMs focused on day-to-day operations often find it challenging to keep pace with emerging technologies, despite their potential to improve capabilities.

### *V. C. Inability to integrate legacy FM systems with IoT devices and platforms*

IoT systems provide many benefits through real-time data, automation and control capabilities. Nevertheless, legacy FM systems used to manage assets, work orders and maintenance records, often lack the agility, standards and interfaces required to derive full value from IoT deployments [31]. Retrofitting these outdated systems to integrate real-time sensor data, automation rules, and software-defined control capabilities is a complex and costly task for FMs [32].

### *V. D. Risk-averse clients who are uncertain to invest*

IoT technologies offer various benefits through improved efficiency, optimization and data-driven insights. Yet, IoT implementations require upfront capital for purchasing sensors, control systems, software platforms, installation services and supporting infrastructure [33]. Nevertheless, convincing FMs and clients who are uncertain to take on risks associated with new technologies can be difficult [34].

### *V. E. Ensuring security against potential cyberattacks*

The utilization of IoT within facilities entails connecting physical assets and operational systems to internet-enabled networks. This exposes control systems, sensors and software platforms to potential cyberattacks, which threatens facilities' operations, assets and occupant safety [35]. Legacy security systems are often inadequate for protecting rapidly evolving IoT environments. This presents significant challenges to organizations seeking to integrate IoT technologies in their operations [36].

### *V. F. Initial costs of hardware, software and workforce training*

Implementing IoT systems necessitates significant investment in hardware, such as sensors, control systems and gateways, as well as software, such as platforms, data management solutions, integration services and infrastructure for connectivity and cybersecurity [37]. Aside from the expenses of hardware and software, FM organizations need to budget for workforce training on various of IoT usage, which imposes additional significant financial commitments [20].

### *V. G. Recurring maintenance costs for hardware and software*

The adoption of IoT solutions within facilities entails recurring expenses for hardware and software maintenance, upgrading and support [22]. Recurring hardware expenses primarily include the maintenance, replacement and refurbishment of sensors, control systems and gateways. Further, recurring software-related expenses include licensing fees, upgrades, and updates, integration services, data management solutions, and internet connectivity [38].

### *V. H. Lack of facilities' capabilities to support the installation of IoT networks*

Implementing IoT in older facilities necessitates retrofitting with sensors, control systems, software platforms and networking infrastructure. These modifications demand major expenditures and can disrupt daily operations [39]. Moreover, physical constraints such as tight spaces, inaccessible locations, complex structures, and obstructions can limit the prospects for IoT implementations. Further, environmental concerns, like temperature extremes, moisture exposure and indoor air quality issues may pose challenges to the durability and longevity of IoT devices in retrofitted facilities [40].

### *V. I. Lack of organized data collection and reporting procedures*

Many FM functions lack standardized protocols for handling IoT-generated data. Sensor data tracking physical parameters is often isolated from information related to assets, work orders, locations and occupants [22]. This fragmentation hinders the contextualization needed to extract meaningful insights, optimize processes and improve decision-making [41].

## VI. Findings and discussion

### *VI. A. Drivers for the utilization of IoT in the FM industry in Saudi Arabia*

Table 2 illustrates the drivers for utilizing IoT technologies in the FM industry. The findings indicated that FMs identified four drivers as critical, each with a frequency of 50% or more, leading to an advanced ranking. Similarly, IoT specialists identified five drivers as critical based on the same frequency threshold, resulting in an advanced ranking.

Table 2: Facilities managers and IoT specialists' perspectives about the drivers for the utilization of IoT technologies in the Saudi Arabian FM industry

| No. | Drivers for the utilization of IoT technologies in the Saudi Arabian FM industry | References | FMs | | | IoT specialists | | |
|---|---|---|---|---|---|---|---|---|
| | | | Frequency (n = 30) | Percent frequency (%) | Rank | Frequency (n = 30) | Percent frequency (%) | Rank |
| 1 | Cost saving by optimizing energy usage, improving maintenance schedules and reducing downtime | [6], [17] | 22 | 73.3 | 1 | 26 | 86.7 | 1 |
| 2 | Improving the efficiency of operations by providing real-time data on systems' performance and usage patterns | [15], [18] | 20 | 66.7 | 2 | 16 | 53.3 | 4 |
| 3 | Fulfilling sustainability goals by reducing resource consumption and carbon emissions | [4], [20] | 13 | 43.3 | 7 | 9 | 30.0 | 8 |
| 4 | Improving safety with real-time hazard alerts and remote facility monitoring | [15], [21] | 12 | 40.0 | 8 | 22 | 73.3 | 2 |
| 5 | Implementing predictive maintenance programs, to identify systems' issues prior to operational disruptions | [22], [23] | 12 | 40.0 | 8 | 16 | 53.3 | 4 |
| 6 | Improving asset management with real-time data on equipment location, usage, and maintenance history | [2], [24] | 17 | 56.7 | 3 | 11 | 36.7 | 6 |
| 7 | Fulfilling regulatory compliance requirements by providing real-time data on energy usage and emissions | [21], [23] | 15 | 50.0 | 4 | 7 | 23.3 | 10 |
| 8 | Delivering innovative facilities' services through real-time monitoring of facilities and assets | [15], [25] | 14 | 46.7 | 5 | 9 | 30.0 | 8 |
| 9 | Improving user satisfaction through real-time monitoring of facility performance to provide more responsive services | [21], [26] | 6 | 20.0 | 10 | 10 | 33.3 | 7 |
| 10 | Remotely managing facilities and asset, reducing the need for onsite personnel and enabling more flexibility | [19], [27] | 14 | 46.7 | 5 | 17 | 56.7 | 3 |

#### VI. A. 1) Facilities managers' perspective on IT adoption in FM

FMs saw IT adoption as a means to boost efficiency, cut costs, and ensure regulatory compliance. Their primary concern was cost savings, which ranked first with a frequency of 73.3%, identifying it as the most important driver. This suggested that they saw IoT as a means to optimize energy usage, improve maintenance schedules, and minimize downtime, all of which directly impacted operational expenses. The second most important driver for FMs was improving operational efficiency, with a frequency of 66.7%. They recognized the potential of real-time data to optimize FM processes, such as monitoring system performance and usage patterns. This insight suggested that FMs valued IoT for its ability to provide practical data that enhanced decision-making and resource allocation. Improving asset management, ranked third, with a frequency of 56.7%, was another priority, highlighting its importance. IoT-driven asset tracking offered real-time updates on equipment location, usage, and maintenance history, reducing the likelihood of asset mismanagement. For FMs, effective asset tracking leads to cost savings and reduced equipment downtime. Lastly, regulatory compliance, ranked fourth, with a frequency of 50.0%, was a key driver, indicating that FMs viewed IoT as a tool for monitoring energy consumption and emissions to ensure adherence to governmental and industry standards. This helped FMs maintain compliance with sustainability mandates.

#### VI. A. 2) IoT specialists' perspective on integrating IoT into FM

IoT specialists had a broader, more technology-focused perspective on IoT adoption in FM. Like FMs, they ranked cost savings as the most critical driver, with a frequency of 86.7%, reinforcing the widely recognized benefit of IoT in optimizing energy use and reducing maintenance costs. Safety improvements, which ranked second, emerged as a much higher concern for IoT specialists, with a frequency of 73.3%. This suggests that they saw significant value in real-time hazard detection, remote monitoring, and automated safety protocols to prevent accidents and enhance workplace security. Another key difference was the emphasis on remote FM, which ranked third, with a frequency of 56.7%. IoT specialists recognized that smart building technologies could enable remote control of various facility functions, reducing the need for on-site personnel, while increasing operational flexibility. This aligned with their broader focus on automation and digital transformation. IoT specialists also ranked predictive maintenance fourth, with a frequency of 53.3%, reflecting their deeper understanding of how IoT could identify system failures before they occurred. Unlike FMs, who might have been more comfortable twith traditional maintenance approaches, IoT specialists were more inclined to utilize machine learning and AI-powered diagnostics to prevent costly disruptions.

#### VI. A. 3) Stakeholders' shared perspectives on the key drivers of IoT adoption in FM

Despite their differences, both FMs and IoT specialists agreed that cost savings was the top driver for IoT adoption in FM. They identified reducing energy consumption, optimizing maintenance schedules, and minimizing downtime as the primary

motivations for IoT integration. Moreover, both groups acknowledged the importance of operational efficiency, though FMs ranked it higher (second) compared to IoT specialists (fourth). This suggested that both groups recognized the significant impact of real-time data and system performance monitoring on improving FM processes. This shared focus on cost savings and operational efficiency indicated that IoT adoption in FM was likely to continue growing, provided that both parties aligned their objectives and addressed their differing priorities.

### *VI. B. Challenges affecting the utilization of IoT in the FM industry in Saudi Arabia*

Table 3 illustrates the challenges affecting the utilization of IoT technologies in the FM industry. The findings indicated that FMs perceived three challenges as critical, with percentage frequencies of 50% or higher, leading to an advanced ranking. Similarly, IoT specialists identified four challenges as critical based on the same percentage threshold, also resulting in an advanced ranking.

Table 3: Facilities managers and IoT specialists' perspectives about the challenges for the utilization of IoT in the Saudi Arabian FM industry

| No. | challenges for the utilization of IoT in the Saudi Arabian FM industry | References | FMs | | | IoT specialists | | |
|---|---|---|---|---|---|---|---|---|
| | | | Frequency (n = 30) | Percent frequency (%) | Rank | Frequency (n = 30) | Percent frequency (%) | Rank |
| 1 | Cost-driven clients who are focused on short-term savings, rather than life-cycle cost savings | [28], [29] | 10 | 33.3 | 6 | 3 | 10.0 | 9 |
| 2 | Skill and knowledge gaps in new technologies within FM organizations | [30] | 21 | 70.0 | 1 | 22 | 73.3 | 1 |
| 3 | Inability to integrate legacy FM systems with IoT devices and platforms | [31], [32] | 20 | 66.7 | 2 | 18 | 60.0 | 2 |
| 4 | Risk-averse facilities managers and clients who are uncertain to invest in new technologies | [33], [34] | 7 | 23.3 | 9 | 18 | 60.0 | 2 |
| 5 | Ensuring security against potential cyberattacks | [35], [36] | 9 | 30.0 | 7 | 17 | 56.7 | 4 |
| 6 | Initial costs of hardware, software and workforce training | [20], [37] | 13 | 43.3 | 5 | 4 | 13.3 | 8 |
| 7 | Recurring maintenance costs for hardware and software | [22], [38] | 8 | 26.7 | 8 | 10 | 33.3 | 6 |
| 8 | Lack of facilities' capabilities to support the installation of IoT networks | [39], [40] | 14 | 46.7 | 4 | 12 | 40.0 | 5 |
| 9 | Lack of organized data collection and reporting procedures | [22], [41] | 18 | 60.0 | 3 | 6 | 20.0 | 7 |

#### VI. B. 1) Facilities managers' perspective on the challenges affecting IT utilization in FM

FMs identified the lack of skills and knowledge about new technologies as the most critical challenge, with a frequency of 70.0%, ranking first. This indicated that FM organizations struggled with technological literacy, which hindered the adoption of IT solutions. Without adequate training, FM personnel found it difficult to understand the potential benefits, implementation processes, and operational requirements of IoT technologies. This knowledge gap slowed down adoption and created resistance within organizations. The inability to integrate legacy FM systems with IoT devices and platforms ranked second, with a frequency of 66.7%. Many existing FM systems were not designed with IoT in mind, leading to compatibility issues when attempting to integrate modern IoT-enabled solutions. Retrofitting older systems with new technology requires substantial investment in software upgrades, middleware, and infrastructure enhancements, which is costly and complex. Another major concern was the lack of organized data collection and reporting procedures, which ranked third, with a frequency of 60.0%. Since IoT relied on continuous data collection and analysis for optimized building performance, predictive maintenance, and energy efficiency, FM organizations often lacked standardized methods for gathering, storing, and interpreting data. This limited the effectiveness of IoT applications. Without proper data management, decision-making remained fragmented, reducing the potential benefits of digital transformation in FM.

#### VI. B. 2) IoT specialists' perspective on challenges in IoT integration in FM

From the perspective of IoT specialists, the lack of skills and knowledge about new technologies in FM organizations was the most significant challenge, ranking first, with a frequency of 73.3%. This mirrored the FMs' concerns and highlighted the urgent need for training and capacity building within FM teams. Without a strong technical foundation, FM professionals struggled to operate and maintain IoT-based systems, leading to inefficiencies and underutilization of the technology. The inability to integrate legacy FM systems with IoT devices and platforms was another significant challenge, ranking second, with a frequency of 60.0%. Many IoT specialists recognized that older FM infrastructures were not inherently designed for smooth IoT integration. The need for substantial software reconfiguration, new communication protocols, and interoperability solutions presented a major hurdle, making IoT adoption more complex and resource-intensive. Further, risk aversion among

FMs and clients ranked second, also with a frequency of 60.0%. Many FM professionals and clients hesitated to invest in IoT due to concerns about costs, system reliability, and potential disruptions to existing workflows. Another critical challenge was ensuring security against potential cyberattacks, which ranked fourth, with a frequency of 56.7%. IoT specialists emphasized the need for robust cybersecurity strategies, including encryption, network segmentation, and real-time threat monitoring, to mitigate these risks.

#### VI. B. 3) Stakeholders' shared perspectives on key challenges in IoT integration in FM

Both FMs and IoT specialists agreed that the lack of skills and knowledge was the most pressing issue. This highlighted an industry-wide gap in expertise, emphasizing the necessity of training programs, professional development initiatives, and industry collaborations to bridge this knowledge deficiency. Moreover, both groups acknowledged that the inability to integrate legacy FM systems with IoT is another major challenge. This reflected a shared understanding that outdated infrastructure posed a major barrier to IoT adoption. Overcoming this challenge required investment in adaptable, flexible IoT architectures that could interface with existing FM systems without excessive cost or operational disruptions.

## VII. Conclusion and recommendations

The utilization of IoT in the FM industry has introduced novel approaches for managing various functions within facilities. The implementation of IoT technologies has facilitated the advent of intelligent FM, leading to enhanced productivity, efficiency, improved user comfort, increased safety and security, and the generation of data-driven knowledge for informed decision-making. The study answered the first research question (RQ1: What are the drivers for IoT utilization in the FM industry?) by identifying ten drivers for IoT utilization in the FM industry. Understanding these drivers serves to expose organizations to technologies that could potentially enhance their operational efficiencies, decision-making abilities, service delivery and occupant satisfaction. Further, knowledge about the drivers for the utilization of IoT technologies would also enable organizations to achieve significant cost savings, through reducing energy wastage, avoiding expensive emergency repairs. These drivers would also acquaint organizations about technologies that could reduce their carbon footprint, and hence, contribute to a more sustainable future.

The study answered the second research question (RQ2: What are the challenges for IoT utilization in the FM industry?) by identifying nine challenges for IoT utilization in the FM industry. Both stakeholder groups highlighted distinct and overlapping challenges. For instance, FMs emphasized issues like skill gaps within FM teams and the cost implications of IoT adoption, while IoT specialists focused on technical hurdles, such as system interoperability and securing IoT networks. Understanding these challenges enable FM organizations anticipate potential roadblocks and be better prepared to address them. In essence, organizations can develop accurate cost estimates, evaluate the return on investment, and commission the development of customized solutions. They can also develop strategies and action plans to mitigate risks, minimize disruptions, and ensure a smoother integration of IoT technologies into their operations. FM organizations can also allocate sufficient funds, time and skills for IoT utilization, in order to successfully address these challenges.

Based on the characteristics of the drivers and challenges, and the outcomes of the research, the following recommendations are proposed for facilities managers to facilitate the implementation of IoT technologies in the FM industry in Saudi Arabia, as an answer to third research question (RQ3: How can facilities managers promote the adoption of IoT technologies within Saudi Arabia's FM industry?). In essence, FMs should:

1) Carry out a thorough assessment of their facilities' infrastructure, to identify FM functions where IoT technologies can added value to the organizations.
2) Develop a clear strategy for integrating IoT technologies into their operations. This strategy should outline the specific FM functions to be automated, along with a detailed implementation plan that accounts for budget, timeline, and resource allocation.
3) Engage all relevant stakeholders in the selection and implementation of IoT technologies to provide support for IoT deployment initiatives. These stakeholders may include facility users, the FM team, IoT specialists, and clients.
4) Continuously monitor the performance of installed IoT systems to ensure they function as intended and identify opportunities for improvement.
5) Collaborate with IoT specialists to provide the necessary training for FM personnel, ensuring they have the knowledge and skills to effectively utilize the deployed IoT technologies.

This paper is a valuable contribution to the FM literature, being the first study that examines the drivers and challenges for IoT utilization in the Saudi Arabian FM Industry. The outcomes provide a potential for improving the current level of IoT adoption in the Saudi Arabian FM industry.

## Data availability statement

The data that support the findings of this study are available upon request.

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## Conflict of interest

The authors declare no conflict of interest.

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