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Transformative Technologies for Facility Management Professionals: A Technical Review

Adedamola Olufunke Oluwunmi
Department of Estate Management,
University of Lagos, Akoka, Lagos

ABSTRACT
Globally, the facility management (FM) profession has seen significant transformations. The role of FM professionals has moved beyond simply managing facilities to creating, implementing, and maintaining strategic value in facilities by utilizing technology. FM professionals - particularly in developing countries - must develop the capacity to boost business performance by leveraging relevant technologies. Taking this into account, this study conducted a thorough evaluation of the literature on FM technologies published in both developed and developing nations. Materials were reviewed on technologies that can potentially transform the FM profession (that is, FM technologies). The findings revealed that Building Information Modeling (BIM) and the Internet of Things (IoT) accounted for the larger percentage (58%) of research efforts. Moreover, the review also showed that research efforts on FM technologies are recent because a lot of materials (53%) on the topic were published between 2021 and 2022. It was suggested that FM professionals keep an eye out for emerging technologies that can help them manage buildings, people and processes more efficiently, while also boosting business performance and occupiers' satisfaction. This research will help in achieving the United Nations' Sustainable Development Goal (SDG) number 9 (Industry, Innovation, and Infrastructure).

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INTRODUCTION

Facilities Management (FM) is a multi-disciplinary profession that focuses on the operations aspect of real estate. The ultimate goal is to provide owners and occupiers with a cost-effective, comfortable, and long-lasting environment (Berger, 2021). Today, FM professionals are not only tasked with increasing productivity and reducing costs, but also providing better living and working conditions. Accomplishing some of these tasks seamlessly can sometimes be achieved through technologically advanced tools (McDonald, 2022).

The world is becoming increasingly digitized. This is affecting every sector of the economy, disrupting some while improving others, and this is a trend that will continue. New technologies have revolutionized organisations and compelled them to reassess how they function, sector by sector, including companies FM professionals service/work for. From cleaning to security and maintenance to customer service, digitization changes procedures on a continual basis. Technology is increasingly transforming the places we work (e.g office), play (e.g recreational centre), and live (e.g apartment complex) as a result of increased innovation and smart solutions in the FM profession (Berger, 2021).

Technology is critical in the FM profession. The FM sector has been transformed by technology during the last few decades. Technology has become an indispensable part of FM, making FM professionals more productive while minimising environmental impact (Babajide-Kassim, 2021). The importance of technology to FM is further buttressed by the International

Corresponding author: Oluwunmi, A. O. ooluwunmi@unilag.edu.ng Department of Estate Management, University of Lagos, Akoka, Lagos State.

Facility Management Association (IFMA), which emphasises that FM professionals must guarantee efficiency, comfort, functionality, and safety of the built-environment by integrating people, process, place, and technology (Blondeau, 2021). This means that people, process, place and technology are the four pillars of FM (Biswas, 2021; Sheynkman, 2022). However, previous research has focused heavily on the first three - people (e.g. end users, space occupants, visitors), processes (e.g work relating to emergency action planning, submission of work order request, among others), and place (the building). It is only of recent that research efforts have been devoted to technology, particularly in developing nations. In Nigeria, for example, there seems to be little effort given to research that is centred on FM technology. The few studies that exist focus on BIM (Ikediashi and Uyanga, 2016; Olapade and Ekemode, 2018; Aguome, Egolum and Ogbuefi, 2019; Jambil, 2020; Babajide-Kassim, 2021) at the expense of other valuable technologies that can be added to the toolset of FM professionals. There is therefore a need to close this gap; this is the reason for this research. Hence, this study explores technologies that can potentially transform the FM profession.

The findings of this study will help FM professionals in Nigeria and other developing nations to realise the benefits of adopting technologies for FM operations. Additionally, this research will help in achieving SDG 9 of the United Nations (Industry, Innovation, and Infrastructure).

METHODOLOGY

For this review, the phrase "FM technologies" and “Technologies transforming the FM Profession” were searched for in the academic and general online material search engines (researchgate, semantic scholar, Google scholar, and Google search), and 77 pertinent items were returned. These search engines were selected because they are some of the most popular tools for online research (Hornak, 2021; Joannah, 2022). Out of the 77 documents, only 70 were germane to the study. The author examined all 70 papers in order to provide reliable results. These papers were published from 2015 to 2022. The data from the 70 documents is organised and reviewed using four criteria: FM technology, benefits, author(s)/year of publication and number of articles examined. A chronological literature review methodology was used. This is due to the fact that this type of evaluation enables the researcher to track the development of specific topics over time (Rommelspacher, 2020). The researcher read and evaluated the publications with the goal of learning more about FM technologies. All of the articles were analysed using frequencies and percentages. The results were presented using charts and tables so that they can be quickly understood.

LITERATURE REVIEW

Prior to the deployment of any technology solution, it has to be first identified, evaluated, then installed and integrated into existing systems, and finally utilised. The tasks of identifying, evaluating and utilising fall on the FM professional, while the Information Technology (I.T) department handles the other tasks, that is, installation and integration (Sheynkman, 2022). Technology enables FM professionals to plan, monitor assets and data, schedule repair and data maintenance jobs, track work orders, and satisfy compliance requirements. It can also help FM professionals determine expenses, the condition and quality of present equipment, and vendor performance (BustersGroup, 2022).

Technologies Transforming Facility Management (FM) Profession

FM is a constantly changing field. Today's FM professionals are entrusted with not only improving operations and lowering costs, but also providing a more pleasant environment for work and play (Berger, 2021). Hundreds of FM technology solutions, including advanced mobile applications and other software, have emerged in recent years to assist FM professionals (McDonald, 2022). Table 1 shows some of the technologies that are transforming the field of FM globally (Lee, Irisboev and Ryu, 2021; Babajide-Kassim, 2021; Berger, 2021; Dahanayake and Sumanarathna, 2021).

Corresponding author: Oluwunmi, A. O. ooluwunmi@unilag.edu.ng Department of Estate Management, University of Lagos, Akoka, Lagos State.

Table 1: Technologies Transforming FM Profession

S/N	Technology	Benefits	Authors/Year of Publication	Number of Articles
1	Building information modeling (BIM) technology	Organisations can utilise BIM technology to visualize specific details of a location, such as structural elements (e.g windows, walls) and asset locations. BIM is a supercharged, extremely intelligent version of 3-D modeling. FM professionals can use BIM to make data-driven decisions about space usage, energy consumption, and redesigns, among others	Kassem, et al. (2015); Aziz, Nawawi and Ariff (2016); Patacas, Dawood, Vukovic and Kassem (2015); Matějka, et al. (2016); Ikediashi and Uyanga (2016); Naghshbandi (2016) Facility Executive (2018); Matarneh, Danso-Amoako, Al-Bizri, Gaterell and Matarneh (2018); Olapade and Ekemode (2018); Aguome, Egolum and Ogbuefi (2019); Toh, Mustapa and Mustapa (2019); Ghodasara, Patel, Bhatt and Thaker (2019) Jambil (2020); Ashworth (2020); Lowe (2020); Aldowayan, Dweiri and Venkatachalam (2020); Lee, Irisboev and Ryu (2021); Dahanayake and Sumanarathna (2021); Berger (2021); Babajide-Kassim (2021); Naushad (2021); Sun, Wang, and Li (2021) McDonald (2022); Durdyev, Ashour, Connelly, and Mahdiyar (2022); Wang, Ali, and Au-Yong (2022); Leygonie, Motamedi, and Iordanova (2022); Moreno, Machete, Falco, Gonçalves, and Bento (2022)	27
2	Internet of Things (IoT) sensors	IoT sensors provide significant information that FM professionals may use to save money for their employer and boost employee/residents' satisfaction. Hotel booking, maintenance, and asset management can all be made more effective by using sensors. Sensors will reveal which spaces were used throughout the day, making it simple to save time and money. As a result, smarter and more comfortable working and living spaces can be created	Adama and Michell (2017); Sethi (2018); Facility Executive (2018); Intellis (2019); Sarkar, By, Paribas and Numbai (2021); Lee, Irisboev and Ryu (2021); Matviichuk (2021); Dahanayake and Sumanarathna (2021); Babajide-Kassim (2021); Berger (2021); Naushad (2021); McDonald (2022); BustersGroup (2022); Klatt (2022)	14
3	Machine learning (ML) and Artificial	In AI-based technologies, computer systems are employed to carry out complex tasks that used to require human intelligence. ML is a type of	Sethi (2018); Intellis (2019); Sarkar, By, Paribas and Numbai (2021); Naushad (2021); Berger (2021); McDonald (2022); Klatt (2022)	7

Corresponding author: Oluwunmi, A. O. ooluwunmi@unilag.edu.ng Department of Estate Management, University of Lagos, Akoka, Lagos State.

	intelligence (AI)	AI that enables the development of systems that automatically gather and analyze data in order to predict occurrences without the need for explicit programming. AI has the potential to automate a number of repetitive and time-consuming FM tasks. For instance, it can quickly acquire, store, and analyze massive data sets. It also helps FM professionals to approach asset management more proactively		
4	Virtual reality (VR) and Augmented reality (AR)	VR and AR are cutting-edge FM technologies with a variety of applications, including making virtual meetings more lifelike by producing holograms of participants and displaying 3-D floor plans. FM practice could be more efficient, and more exact with the help of AR technology. It provides access to data without having to carry around blueprints and other documentation, in addition to providing an at-a-glance view of equipment. This type of technology can help bring maintenance instructions and building components to life	Sethi (2018); Lee, Irisboev and Ryu (2021); Naushad (2021); McDonald (2022)	4
5	Drones	Drones are changing the way FM is done. They provide a step forward in efficiency for a profession that has traditionally relied on inspectors to tour grounds, climb ladders, and brave rooftops. FM professionals are witnessing a significant reduction in the time it takes to acquire, evaluate, and transmit data by using drones instead of humans to capture data on a facility - whether it is pavement, landscaping, roofs, or facades. In summary, drones can be used for surveillance and inspection purposes	Esch and Leslie (2016); Hounsell (2016); Adama and Michell (2017); Bobby, (2017); Sethi (2018); Facility Executive (2018); Rabine (2019); Berger (2021); Babajide-Kassim (2021)	9
6	Big Data	FM professionals can derive useful information from a plethora of data generated by various machines and sensors.	Ahmed, Tezel, Aziz and Sibley (2017); Yang and Bayapu (2019); Pinto (2020); Babajide-Kassim (2021); Berger (2021); Naushad	6

Corresponding author: Oluwunmi, A. O. ooluwunmi@unilag.edu.ng Department of Estate Management, University of Lagos, Akoka, Lagos State.

		Big data can be used to have a better understanding of resource utilization (energy and water), benchmarking facility performance, tenant behaviour, and service requirements, improved utilisation of human resources, detect future power outages or equipment failure, as well as manage buildings' performance	(2021)	
7	Blockchain Technology	FM is one of the numerous industries that might benefit from blockchain technology. In FM, blockchain technology will provide smart contracts (replacing paper-based contracts), warranty automation for malfunctioning equipment, tenant billing, and other features	Gunasekara, Sridarran and Rajaratnam (2021); Babajide-Kassim (2021); Naushad (2021)	3

Source: Author's Compilation

The review in Table 1 is a combination of online articles and academic papers. Most of the papers (online and academic) have concentrated on BIM. There are only a few studies on other technologies such as IoT, drones, big data, and blockchain (Pinto, 2020; Dahanayake and Sumanarathna, 2021; Babajide-Kassim, 2021; Gunasekara, Sridarran and Rajaratnam, 2021). Therefore, it is clear from this review that there is a gap in the compendium of knowledge on FM technology.

MAJOR FINDINGS

Year of Publication of Papers Reviewed

The analysis in Table 2 shows the distribution of the papers reviewed in both developed and developing nations on FM technologies from 2015 - 2022. Out of the 70 papers reviewed, 11% were published between 2015 and 2016, 19% between 2017 and 2018, and 17% between 2019 and 2020, while the majority of the papers (53%) were published between 2021 and 2022. This outcome clearly shows that the research focus on FM technologies is a recent thing considering that a greater percentage of the materials were published between 2021 and 2022. Furthermore, the table shows that most of the papers were on BIM (38%) and IoT (20%). They both accounted for 58% of the FM technologies reviewed.

Table 2: Year of Papers Reviewed

S/N	Papers Reviewed	2015-2016		2017-2018		2019 -2020		2021-2022		Total	
		F	%	F	%	F	%	F	%	F	%
1	BIM	6	8	3	4	7	10	11	16	27	38
2	IoT	0	0	3	4	1	1	10	14	14	20
3	ML and AI	0	0	1	1	1	1	5	7	7	10
4	VR and AR	0	0	1	1	0	0	3	4	4	6
5	Drones	2	3	4	6	1	1	2	3	9	14
6	Big Data	0	0	1	1	2	3	3	4	6	8
7	Blockchain	0	0	0	0	0	0	3	4	3	4
Total		8	11	13	19	12	17	37	53	70	100

Note: F = Frequency; % = Percentage

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Nature of Papers Reviewed

Table 3 depicts the nature of the papers reviewed. From the analysis, online articles account for the majority of the papers (53%). Papers on IoT (14%), drones (10%) ML and AI (9%), and BIM (9%) account for more than half of the total number (37) of online articles. The table also shows that BIM accounts for 30% of the total number (33) of academic papers reviewed. The implication of this outcome is that there is a limited number of academic papers on FM technologies and the few available ones focus on BIM at the expense of others. Hence, this research which will add to the compendium of knowledge on academic publications.

Table 3: Nature of Papers Reviewed

S/N	Papers Reviewed	Online Articles		Academic Papers		Total	
		F	%	F	%	F	%
1	BIM	6	9	21	30	27	38
2	IoT	10	14	4	6	14	20
3	ML and AI	6	9	1	1	7	10
4	VR and AR	3	4	1	1	4	6
5	Drones	7	10	2	3	9	14
6	Big Data	3	4	3	4	6	8
7	Blockchain	2	3	1	1	3	4
Total		37	53	33	47	70	100

Note: F = Frequency; % = Percentage

Technology Focus of Academic Papers

The analysis in Table 4 reveals the distribution of academic papers on FM technologies in both developed and developing nations from 2015–2022. The result indicates that the majority (63%) of academic papers are on BIM. Also, 12% are on IoT, 9% on big data, 6% on drones and 3% each on the remaining technologies. Hence, it can be concluded that the majority of academic research efforts on FM technologies in both developed and developing nations are centred on BIM at the expense of other FM technologies.

Table 4: Technology Focus of Academic Papers

S/N	Papers Reviewed	Spread of Academic Papers			
		Developed Nations		Developing Nations	
		F	%	F	%
1	BIM	10	30	11	33
2	IoT	3	9	1	3
3	ML and AI	1	3	0	0
4	VR and AR	1	3	0	0
5	Drones	1	3	1	3
6	Big Data	3	9	0	0
7	Blockchain	0	0	1	3
Total		19	58	14	42

Note: F = Frequency; % = Percentage

Academic Papers by Country (Developed and Developing)

Figures 1 and 2 indicate the classification of academic papers reviewed on FM technologies based on their nations (i.e. developed and developing nations). Figure 1 shows that the 20 academic papers published in developed nations were from 8 countries. From the analysis, there are 9 publications (45%) from the UK, 3 (15%) from South Korea and 2 (10%)

Corresponding author: Oluwunmi, A. O. ooluwunmi@unilag.edu.ng Department of Estate Management, University of Lagos, Akoka, Lagos State.

each from Hong Kong and the US. The bar chart also shows that just 1 publication (5%) each is from the Czech Republic, New Zealand, Canada, and Portugal.

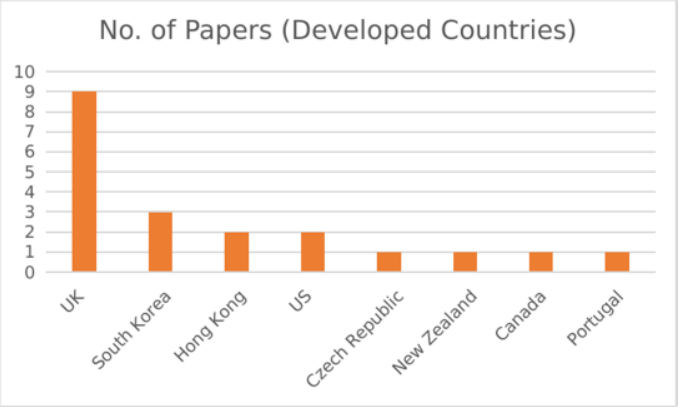

Figure 1: Developed Countries

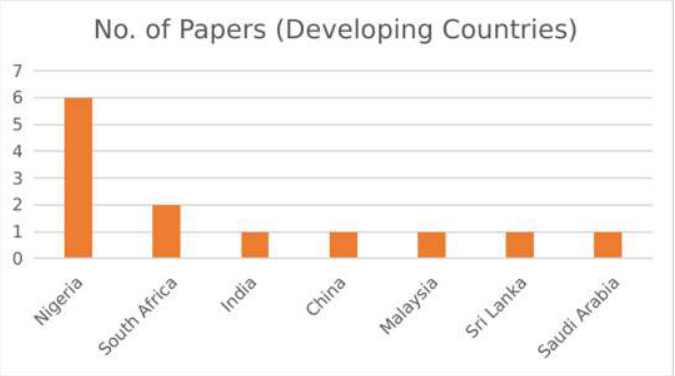

Figure 2: Developing Countries

The analysis in Figure 2 shows that 13 of the academic papers reviewed are from 7 developing countries. It is also obvious from the figure that the majority (6, or 46.1%) of academic papers in developing countries are from Nigeria, only 2 papers (15.3%) from South Africa, while 1 paper (7.7%) each is from India, China, Malaysia, Sri Lanka and Saudi Arabia.

Gaps in Literature

As shown from the reviews and the analyses, the majority of papers that focus on FM technologies are not academic papers. Most of the academic papers concentrated on a specific technology (BIM), particularly in developing nations. The few academic papers from developed nations focus on the use of BIM and IoT (in the UK - Kassem et al. 2015 and Sarkar et al., 2021); (in South Korea - Lee, Irisboev and Ryu, 2021); (in Hong Kong - Dahanayake and Sumanarathna, 2021). The implication of this is that there is limited academic literature on the technologies that can be adopted to enhance the performance of FM professionals.

CONCLUSION

This study reviewed materials on modern technologies that are changing the FM industry globally. The review showed that there is a paucity of academic literature on FM technologies, and even the available papers focus on BIM at the expense of other technologies. This gap must be filled in order for FM professionals to be abreast of emerging technologies and their uses. This study therefore suggested that it is critical for FM professionals to

Corresponding author: Oluwunmi, A. O. ooluwunmi@unilag.edu.ng Department of Estate Management, University of Lagos, Akoka, Lagos State.

keep an eye out for such technologies that can help them manage buildings, people and processes more efficiently while also improving the occupiers' satisfaction. Moreover, it is suggested that FM professionals and their professional body (International Facility Management Association) should create forums (e.g workshops, seminars or conferences) where professionals can be educated on the different FM technologies available and their usefulness. Finally, the study urges FM professionals that have not adopted global best practice in the use of technology to do so if they intend to compete favourably with their counterparts around the globe.

LIMITATIONS AND OPPORTUNITY FOR FURTHER STUDIES

As is typical of this kind of research, this study has limitations. This research was carried out using secondary data and only seven FM technologies formed the basis of the discussion. Hence, there is a possibility that the results of the study may be different if more technologies are added in further studies.

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Corresponding author: Oluwunmi, A. O. ooluwunmi@unilag.edu.ng Department of Estate Management, University of Lagos, Akoka, Lagos State.

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Corresponding author: Oluwunmi, A. O. ✉ ooluwunmi@unilag.edu.ng ✉ Department of Estate Management, University of Lagos, Akoka, Lagos State.