Journal of African Real Estate Research
Volume 8, Issue 1
www.journals.uct.ac.za/index.php/JARER/

Factors Influencing the Adoption of Automating Systems in the Facilities Management of High-Rise Buildings in Lagos, Nigeria

Orayinka Stephen Awosode [1] Cyril Ayodele Ajayi[2] and (https://orcid.org/0009-0004-1220-9124)

[1,2]Department of Estate Management, Redeemer's University, Ede, Osun State, Nigeria

To cite this article: Awosode, O.S., and Ajayi, C. A. (2023) Factors Influencing the Adoption of Automating Systems in the Facilities Management of High-Rise Buildings in Lagos, Nigeria. *Journal of African Real Estate Research,* 8(1), pg. 18–34. https://doi.org/10.15641/jarer.v8i1.1274

Abstract

The paper examined factors influencing the adoption of automating systems in high-rise buildings in Lagos, Nigeria, to provide information that could enhance facilities management practice. The study adopted a quantitative research approach, administering 53 copies of a questionnaire to resident facilities managers of selected high-rise buildings in Lagos with a response rate of 77.4%. Simple frequency distribution, percentage (%) weighted mean score on a point-Likert scale measurement and factor analysis were used to analyse responses.

The study revealed that the need to protect buildings against failure was considered the most significant factor influencing the adoption of automation in the management of facilities in high-rise buildings. The researcher encountered bureaucratic bottlenecks, which required writing letters to the board of directors before the questionnaire could be filled; this slowed down the pace of data collection. Also, the level at which respondents treated information with secrecy affected data collection; hence, the sampling technique was limited to purposive sampling.

The use of automating systems presents facilities managers with innovative ways of ensuring the functionality of the built environment through the integration of people, place, process and technology. The study contributes to the frontier of knowledge on the adoption of automation in the facilities management of high-rise buildings.

Keywords: *automation, automating system, facilities management, high-rise buildings, resident facilities managers, Lagos, Nigeria*

[1] Corresponding author's email address: awosodeola@run.edu.ng

1. Introduction

The reality that buildings built decades ago are ageing and that they need more upkeep, recurrent repairs and upgrades poses serious challenges to building operators (building owners and facilities managers). Also, the nature and function of building facilities continue to evolve in the face of technological innovation and the overall digitalisation of our modern space. This evolution is constantly changing the roles of facilities managers and making building operators continuously find innovative ways of controlling and managing facilities. These roles could get more complex for facilities managers of high-rise buildings. This is because high-rise buildings are a particular type of construction based on their height, structural stability and various mechanical and electrical systems needed to make occupation conducive. Hence, facilities managers are increasingly striving for better control over resource utilisation rates of their facilities for a more economical, environment-friendly and optimised facilities management experience through the use of information technology herein referred to as facilities management automation (East, Bogen, and Rashid, 2012; Parasanazhad and Tarandi, 2012).

Facilities management automation provides the facilities manager with the tools and methods that aid control over the facilities management process, which can be said to be complex in nature. It spurs facilities management implementation and also serves as an integrating factor for people, places and facilities (Lunn and Stephenson, 2000; Madritsch and May, 2009). Studies have revealed that data repository technology such as Building Information Management (BIM), interoperability software like Industry Foundation Class (IFC), workflow systems such as Computer Aided Facilities Management (CAFM), facilities intelligence software such as Building Maintenance System (BMS) sensor mobile like Augmented Reality (AR) and field capture technology such as (drone) are the common automating systems used in facilities management practice (Wang, Wang, Yung and Jun, 2013; Coenen and Felten, 2014; Scupola, 2014; Ebbesen 2015; Lok and Baldry, 2015). Automation is not a new term in facilities management because the term "facilities management" originated from the hi-tech world, and it was adapted into the built environment by space planners and office manufacturers (Owen 1995). It has since evolved in the last four decades from pneumatic and mechanical devices into direct digital controls and later into electronic devices with microprocessors and communication capabilities (Lunn and Stephenson, 2000; Ebbesen, 2015; Golabachi and Kamat, 2016).

According to Azarh (2011), introducing and adopting new technology usually require factors which may affect the use of such technology for its successful take-off and subsequent benefits to be derived. Hewawasam *et al.* (2016) identified high initial cost, lack of knowledge and competencies, technical faults and design failures, staff attitude and resistance to change as factors affecting the adoption of automating systems in the construction industry. Hassainain *et al.* (2017) also identified inappropriate selection of facilities management personnel, inadequate training of facilities personnel and poor operation and maintenance activities as factors affecting the adoption of automation in the construction industry. Studies on automation have been broadly discussed in relation to the construction industry. Meanwhile, studies on facilities management automation (Oladokun, 2011; Aliyu, 2015; Ebbesen, 2015; Golabachi & Kamat, 2016; Ogunleye, 2017) have not explicitly addressed the use of automation in facilities management of high-rise buildings, especially in Nigeria. Also, there is the need to show that advancement in the country'sv built environment is not a mere imitation of Western technology but a result of advancement in technological development and the needs of building operators within Nigeria. This study examined factors influencing facilities management automation in high-rise buildings in an attempt to fill the gap in the literature and also to provoke advancement in facilities management practice in Nigeria.

The major research question that this paper will address is: what factors influence the adoption of automating systems in facilities management of high-rise buildings? This intends to identify factors that are peculiar to developing countries like Nigeria and provide information that could enhance advancement in facilities management practice.

2. Literature Review

2.1 The Concept of High-Rise Buildings

The Council of Tall Buildings and Urban Habitat (2004) defined high-rise buildings as buildings that create distinct conditions in terms of design and construction when compared to other buildings in a particular region and specific period as a result of their height. The definitions of high-rise buildings have been based on height and number of floors. These definitions differ based on time, region and technological innovation. For instance, Nigeria had no high-rise buildings when the Western world decided on the vertical transformation of horizontal expansion in the 1870s (Ajayi and Awosode, 2019). Awotona (1987) defined a high-rise building as any building higher than a three-storey walk-up. Lagos State Urban and Regional Planning Development Law (LSURPD, 2005) considers any building with a minimum of five floors of high-rise buildings (Ezema and Olutayo, 2014). This is quite different from the definition of the National Fire Protection Association in the United States (NFPPA, 2016), which identified high-rise building as a building with a minimum overall height of 28 meters from the ground level to the highest floor.

High-rise buildings were first built in the United States of America in the 1870s. In contrast, tall buildings began to surface in Shangai, Hong Kong, Sao Paulo, and other important Asian and Latin American cities in the 1930s. Europe and Australia decided to go vertical in the mid-twentieth century. Meanwhile, the first high-rise building in Nigeria and West Africa (The Cocoa House) was built in 1965 with 26 floors and a height of 105 meters. The operational definition of high-rise buildings for this research is based on the standard height of the fire equipment department, which ranges between 28 and 32 meters. For the purpose of this study, any building with a minimum number of 10 floors was considered a high-rise building. This is in line with Knoke's (2006) definition of a high-rise building as a building considered with a height that is beyond the maximum reach of available fire-fighting equipment (23- 30 meters), provided the floor height is three meters. According to High-Rise Security and Fire Safety (2009), three essential inventions that gave birth to the construction of high-rise buildings are the invention of the world's first safety elevator in 1853, the replacement of the fragile combination of cast iron and wood with steel frame in 1870s and the invention of air conditioning in 1902.

It is worth noting that high-rise buildings were first built as a response to continuous industrialisation and swift population growth of the late nineteenth century, which led to a significant demand for office space. Early high-rise buildings were targeted to meet the increasing demand for office space, while the first residential high-rise building (Ritz Tower), with 41 stories and 165 meters in height, was built in 1926. The cost of developing high-rise buildings is often high when compared to low-line buildings. To ensure the long-term sustainability of investment made in these structures, there is a need to protect such investment through maintenance of the building fabrics, building systems and building services, which will make occupation conducive for users.

2.2 Concept of Facilities Management Automation

Maintenance of building fabric and its services (which is an aspect of facilities management) during the operation phase of the building contributes immensely to the sustainable performance of the building (Ding *et al*., 2009). A good maintenance culture is needed for a nation to maintain the value and amenity of its building stock; however, the consistent change in the nature and function of building systems coupled with the level of sophistication of users of high-rise buildings require that facilities managers find innovative ways to control and manage facilities. More so, facilities management requires in-depth knowledge of skills and tools for building operations, maintenance, engineering, forecasting, budgeting, health, safety and security. Information and communication technology tools, herein referred to as automation, have influenced facilities management in recent years (Thompson, 2000). Facilities management automation, which is defined as "the use of computerised system to perform or supplement facilities management functions, spurs facilities management implementation. It also serves as an integrating factor for people, place and facilities" (Lunn and Stephenson, 2000; Madritsch and May 2009). According to Wang *et al*. (2013), information technological tools used in facilities management are divided into two: data containers (e.g. FTP servers, BIM and GIS etc.) and workflow systems (e.g. CMMS, CAFM and IWMS). In comparison, Ebbesen (2015) gave a more elaborate list of the commonly used automating systems in facilities management: data repository technology, interoperability software, workflow system, facilities intelligence software, sensor mobile and field capture technology.

Lunn and Stephenson (2000), cited in Awosode (2018), stated that facilities management has evolved in four distinct generations since the initial computerised of the early 1960s through the technology push of the mid-1980s down to the current communications generations, which has been defined by communications infrastructures, mobile and the Internet and communication between programming languages, structures and interoperability. The study further stated that the extent to which automation is adopted in facilities management is hinged on several factors, which are not limited to the level of information technology, global competition, rate of churn, employee expectations, demand for information, cost of mistakes, design standards and inventory, strategic resource, change, high cost of facilities and space among others.

2.3 Empirical Studies

Ebbesen (2015) reviewed the literature on information technology in facilities management. The study considered the current state of research on the use of information technology in facilities management. The study revealed that data repository technology (BIM), interoperability software (IFC), workflow system (CAFM), facilities intelligence software (BMS), sensor mobile (augmented reality AR) and field capture technology (drone) are the standard automating systems used in facilities management practice. It further stated that BIM is the most researched technology while CAFM is the most used technology. The study is not empirical and thus based on the author's opinion rather than replicable data. Also, the study focused on facilities management practices in Europe. However, this study focused on Nigeria, where facilities management automation is relatively new and uses empirical data.

According to Azhar (2011), introducing and adopting new technology usually require factors which may affect the adoption of such technology for its successful take-off and subsequent benefits to be derived. Factors affecting facilities management automation in high-rise buildings can be grouped into those specific to the nature and level of sophistication of high-rise buildings and those specific to different models and software adopted in facilities management automation. In contrast, others are general to the diffusion of information technology into facilities management practice. Hewawasam *et al.* (2016) identified high initial cost, lack of knowledge and competencies, technical faults and design failures, staff attitude and resistance to change as factors affecting the adoption of automating systems in the construction industry. Hassainain *et al.* (2017) also identified inappropriate selection of facilities management personnel, inadequate training of facilities personnel and poor operation and maintenance activities as factors affecting the adoption of automation in the construction industry. All these studies were carried out in developed countries. Although these factors can be ubiquitous, there is a need to identify those peculiar to developing countries like Nigeria, where this study is domiciled.

3. Methodology

To provide answers to factors influencing the adoption of facilities management automation in high-rise buildings in Lagos, the study adopted survey research where 53 high-rise commercial buildings were purposively selected out of the 95 that were identified through field survey in Ikoyi, Lagos Island and Victoria Island all in Lagos State Nigeria. These locations were selected for the study because they have the highest concentration of high-rise Lagos 159 (97.5%), whereas Lagos has the highest number of high-rise buildings (163) Aliyu *et al.* (2015). This selection was based on accessibility to the building and the willingness of respondents to provide useful information. Primary data from a questionnaire administered to facilities managers of high-rise buildings was used for the study. A total number of 53 hard copies of the questionnaire were issued, while 41 copies of the questionnaire were returned and found useful for analysis. Information collected included types of automating systems used in high-rise buildings, time of acquisition of the system, factors that influenced the choice of the systems used and the factors influencing the adoption of facilities management automation. A frequency distribution table, mean ranking of a 5-point Likert scale and factor analysis techniques were used for appropriate data analysis of the information gathered from respondents.

3.1 Data Validity Test

Table 3.1 illustrates the test of assumptions on the adequacy of the matrix and the significance of the factors influencing the adoption of automation in the management of high-rise buildings in the study area. With a determinant level of .001, the assumption is that the listed factors affect the adoption of automation in the management of high-rise buildings in the study area. More so, with a KMO of .770, greater than 0.70, this indicates that enough items were predicted by each (principal factor component). And since Bartlett's test has a significant value of .000, which is less than .05, this implies that the variables (factors affecting the adoption of automation in high-rise buildings in Nigeria are correlated highly enough to provide a reasonable basis for factor analysis).

Table 3.1: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.770
Bartlett's Test of Sphericity	Approx.Chi-Square	433.488
	Df	.91

	Sig.	0.000

Table 3.2 Distribution of high-rise buildings in Lagos Metropolis

Local Government	**Frequency**
Apapa	1
Eti-Osa	106
Lagos Island	53
Lagos Mainland	2
Total	**163**
Nature of Use	**Frequency**
Commercial Office Space	98
Healthcare	1
Hospitality	8
Mixed-use	13
Residential	43
Total	**163**

Source: Author's Field Survey 2019

4. Analysis and Results

This section presents findings from the field survey, which were introduced in line with the research objective, while inferences were drawn from the data gathered.

Table 4.1 shows that 19 (46.3%) of the sampled commercial high-rise buildings had property maintenance or management department that performs the traditional role of property managers. In comparison, 17 (41.5%) had structured facilities management departments or units. This corroborates the findings of Aliyu *et al.* (2015) that public and private corporation operators consider facilities management an effective tool for managing their buildings. However, facilities management application in managing high-rise buildings in Lagos is still below average. One can infer that there is no significant relationship between ownership of high-rise buildings and the presence of facilities management departments. The Table also indicated that 21 (51.2%) of the sampled buildings had in-house facilities management departments, while 10 (24.4%) adopted outsourced facilities management strategy, and the remaining 10 (24.4%) adopted hybrid facilities management strategy. A keen look at the facilities management strategy and ownership of the buildings shows that a more significant percentage of the public buildings, 13 (76.5%,) adopted an in-house facilities management strategy against outsourcing management. This indicates that public building operators prefer employing staff treated as civil servants in the facilities management department rather than contracting their services out to experts constantly updated with developments in the facilities management industry. This could explain why most of our public buildings were in a state of disrepair (Iyagba 2005).

Table 4.1: Facilities Management Strategies Adopted in High-Rise Buildings

Facilities Management Department	**Frequency**	**Percentage (%)**
Property/Maintenance department	19	46.3

Facilities Management Department	17	41.5
None	5	12.2
Total	**41**	**100.0**
Facilities Management Strategies		
Inhouse Facilities Management	21	51.2
Outsourced Management	10	24.4
Hybrid Facilities Management	10	24.4
Total	**41**	**100.0**

Facilities Management Strategy* Ownership of Buildings	**Ownership**		**Total**
	Public	*Private*	
Inhouse Facilities Management	8	13	21
Outsourced Management	7	3	10
Hybrid Facilities Management	9	1	10
Total	**24**	**17**	**41**

Table 4.2 indicates that facilities managers were more familiar with computer-aided facilities management (CFAM), with 26(19.8%) followed by computer maintenance management system (CMMS), 23(17.6%) and building information model (BIM), 20(15.3%). Industry foundation class (IFC) and integrated workspace management system (IWMS) have the lowest frequency 8(6.1%). Computer-aided facilities management (CFAM) has been around for a while, and its ease of use makes it a more popular building information model (BIM). It is the latest technology in the built environment, and every facilities manager wants to know its usage.

Table 4.2: Types of Automating Systems that Facilities Managers are Familiar with

Automating System	Frequency	Percentage (%)
Building Automating (BAS)	19	14.5
Building Information Model (BIM)	20	15.3
Building Maintenance System (BMS)	16	12.2
Computer Aided Facilities Management (CAFM)	26	19.8
Computer Maintenance and Management System (CMMS)	23	17.6
Construction Operation Building Information Exchange (COBie)	11	8.4
Industry Foundation Class (IFC)	8	6.1

Integrated Workspace Management System (IWMS)	8	6.1
Total	**131*****	**100.0**

*A Note: *** This figure exceeded the number of respondents because multiple responses were allowed.*

As indicated in Table 4.3, 19 (48.7%) of facilities managers use computer-aided facilities management (CAFM) to manage their facilities. In comparison, 9 (23.10%), 7 (18.0%), 3 (7.7%) and 1 (2.5%) used computer maintenance and management systems, building automating systems, building maintenance systems and building information models, respectively. Automating systems such as Construction operation building information exchange (COBie), industry foundation class (IFC), and integrated workspace management system (IWMS) are not being used by facilities managers in the study area. Integrated workspace management (IWMS) performs similar functions to CAFM. Most facilities managers choose CAFM because it aids the capturing, usage and electronic analysis of all data that applies to the life cycle of facilities. According to (GEFMA, 2007), CAFM provides numerous key functions to meet the required standard expected by its users (building owners and facilities managers) satisfactorily, and these functions include lease administration, project management, space management, maintenance management processing and resource planning.

Hence making CAFM attractive for real estate and facilities management companies. This could be the reason most facilities managers chose CAFM over other computerised systems. This corroborates the view of Ebbesen (2015) that CAFM is the only technology being used in facilities management organisations, and implementation of BIM technology in the facilities management industry is at the initial stage. Building information model is a data repository technology that is relatively new to the Nigerian construction industry. It is used traditionally right from the design stage of construction, considering the vast amount of information needed to manage the life cycle of a building. However, 29 (76.3%) of the sampled high-rise buildings were constructed between 11 and 50 years ago. This makes it difficult for facilities managers to use BIM for facilities management, which explains why only 1 (2.5%) facilities manager adopted BIM. This could be because the building (Heritage Place Building) is relatively new and considered the only fully automated commercial high-rise building in Nigeria. The response ratio of the awareness facilities managers about different automating systems to use these systems is 3:1 (0.3). This means that other factors aside from the level of awareness of facilities managers about these systems affect the choice of computerised systems used by facilities managers.

Table 4.3: Types of Automating Systems Used by Facilities Managers

Types of Automating Systems Used by Facilities Managers	Frequency	Percentage (%)
Computer Aided Facilities Management (CAFM)	19	48.7
Computer Maintenance and Management System (CMMS)	9	23.1
Building Automating (BAS)	7	18.0
Building Maintenance System (BMS)	3	7.7
Building Information Model (BIM)	1	2.5

Construction Operation Building Information Exchange (COBie)	-	-
Industry Foundation Class (IFC)	-	-
Integrated Work Space Management System (IWMS)	-	-
Total	**39*****	**100**

As presented in Table 4.4, a total number of 22 (53.7%) high-rise buildings are being managed using a computerised system, most of which were acquired between 5 and 9 years ago. The result indicates that computerised systems in the study area became popular in the last decade. And that automation is still in its early stages in Nigeria. More so, 6 (27.3%) of the sampled facilities managers stated that the computerised system was acquired at the construction stage of the building, and these high-rise buildings were built in the last five years. Computerised systems were installed at the operation stage of 16 (72.7%) high-rise buildings. Based on these findings, one can infer that professionals in the built environment in Nigeria are gradually catching up with the happenings in the global built environment in the last decade.

Table 4.4: Acquisition of Automating System

Time of Acquisition of Computerised System		
Years	**Frequency**	**Percentage (%)**
1-2	1	4.5
3-4	9	41.0
5-6	8	36.4
7-8	3	13.6
9-10	1	4.5

Table 4.5 shows factors influencing the adoption of automating systems in the facilities management of high-rise buildings in the study area. Protection against failure with relative importance index RII of 4.27 is considered the most critical factor influencing the use of computerised systems in managing facilities in high-rise buildings. The reason for this could be partly due to the assertion that high-rise buildings are considered as a particular type of building because of their height and the need for facilities within the building to make them conducive for occupation. The failure of any mechanical system for an extended period could pose a serious threat to the occupiers/users. More so, investment in high-rise buildings requires a tremendous amount of capital. The increasing cost of property, fixed assets and maintenance has led to the use of different techniques to identify and allocate space together with furniture, equipment and power. However, automating tools is said to help maximise the use of existing and expensive facilities such as the HVAC or lift system to prolong their economic life. Hence, the high cost of facilities is ranked 2nd with a RII of 4.24. Iyabga (2005) stated that Nigeria has a poor maintenance culture, which has made many high-rise buildings to be economically obsolete. This is not unconnected to the use of paper boxes in carrying out facilities management activities. To improve facilities management activities, facilities managers have identified using automated tools to enhance facilities management activities, prolonging the economic life of high-rise buildings. In lieu of this,

poor operation and maintenance activities ranked 3rd with a RII of 4.05 among factors that influence the adoption of automation in managing facilities in high-rise buildings. In contrast, the initial installation and implementation cost ranked 4th with a RII of 4.02.

Lunn and Stephenson (2000) stated that the perceived cost of installing and managing automating tools dissuades many organisations from adopting them to manage their facilities. Also, high implementation cost, as indicated in the work of Czmocha and Pokala (2014), poses a serious challenge in the form of enormous hardware and software prices. This is reflected in the result shown in Table 4.6. Another factor that influences the adoption of facilities management automation is the availability of an information system capable of embracing various data types throughout the life cycle of the building. This is more peculiar to developing countries in general and Nigeria in particular because there is a lack of sound data recording and filing systems. This explains the reason for the availability of information, with RII of 3.98 Ranked 6th. Furthermore, the built industry has been perceived to be rigid in its approach to new technology, which is why the fear of some matured facilities management staff of replacing human personnel with automated systems adapted to changes ranked 7th with RII of 3.95.

In line with the adaptation to changes by the facilities management department, the ineptitude of decision makers with a RII of 3.85 ranked 8th and inadequate enlightenment on the part of the decision-makers as to the importance of automation has led to the lack of support in the adoption of automating tools in facilities management. Management strategies and staff strength ranked 9th with a RII of 3.83. The need to reduce maintenance costs ranked 11th with a RII of 3.81. Enormous investment is committed to high-rise buildings, and studies have shown that a large portion of it is committed to their maintenance to make them physically stable and economically viable. The majority of facilities managers believe that the use of automating tools will reduce maintenance costs in the long run, especially for organisations that have considerable assets. Interoperability, organisation age, faulty designs and lack of graphical interface all have a relative importance index lesser than 3.0. This shows that their influence is less significant in the adoption of automation in facilities management of high-rise buildings. A comparison between the Nigeria Reinsurance Company building, established in 1949 and had no trace of automation, and the First Bank of Nigeria building, established in 1894, with a considerable level of automation. One can infer that the age of the organisation is not as important as the nature of business of the organisation or occupier of the buildings: the age of the building itself, among other factors.

Table 4.5 Factors Influencing the Adoption of Automation

Items	1	2	3	4	5	RII	Rank
Protection Against Failure	-	-	4(9.8%)	31(75.6%)	12(29.3%)	4.27	1st
High cost of facilities	-	-	3(7.3%)	25(61%)	13(31.7%)	4.24	2nd
Poor Operation and Maintenance Activities	-	-	4(9.8%)	31(75.6%)	6(14.6%)	4.05	3rd
Initial Cost of Installation	-	-	7(17.1%)	26(63.4%)	8(19.5%)	4.02	4th

High Implementation Cost	-	-	7(17.1%)	26(63.4%)	8(19.5%)	4.02	4th
Availability of Information	2(4.9%)	2(4.9%)	3(7.3%)	22(53.7%)	12(29.3%)	3.98	6th
Adaptation to Changes	-	-	11(26.8%)	21(51.2%)	9(22%)	3.95	7th
The ineptitude of D ecision Makers	-	-	12(29.3%)	23(56.1%)	6(14.6)	3.85	8th
Management Strategies	1(2.4%)	6(14.6%)	3(7.3%)	20(48.8%)	11(26.8%)	3.83	9th
Staff Strength	1(2.4%)	5(12.2%)	6(14.6%)	17(41.5%)	12(29.3%)	3.83	9th
Need to Reduce Maintenance Cost	1(2.4%)	-	12(29.3%)	21(51.2%)	7(17.1%)	3.81	11th
Age of Building	-	6(14.6%)	5(12.2%)	22(53.7%)	8(19.5%)	3.78	12th
Demand for Information	-	2(4.9%)	9(22%)	27(65.9%)	3(7.3%)	3.76	13th
Global Competition	1(2.4%)	9(22%)	-	22(53.7%)	-	3.71	14th
Ownership of Building	1(2.4%)	3(7.3%)	10(24.4%)	20(48.8%)	7(17.1%)	3.71	14th
Inappropriate S election of Facilities Management Personnel	-	4(9.8%)	7(17.1%)	29(70.7%)	1(2.4%)	3.66	16th
Design S tandard and Inventory	1(2.4%)	5(12.2%)	10(24.4%)	20(48.8%)	5(12.2%)	3.56	17th
Cost of mistakes	1(2.4%)	4(9.8%)	12(29.3%)	21(51.2%)	3(7.3%)	3.51	18th
Lack of Demands by Building Owners	-	8(19.5%)	5(12.2%)	27(65.9%)	1(2.4%)	3.51	18th
Lack of Skilled Personnel	1(2.4%)	5(12.2%)	9(22%)	26(63.4%)	-	3.46	20th
Low Level of Awareness	1(2.4%)	6(14.6%)	12(29.3%)	20(48.8%)	2(4.9%)	3.40	21st
Strategic Resource	2(4.9%)	10(24.4%)	9(22%)	18(43.9%)	2(4.9%)	3.20	22nd
Numbers of Floors	-	16(39%)	10(24.4%)	6(14.6%)	9(22%)	3.20	22nd
Rate of Churn	2(4.9%)	12(29.3%)	10(24.4%)	17(41.5%)	-	3.02	23rd
Employee Expectation	2(4.9%)	16(39%)	6(14.6%)	15(36.6%)	2(4.9%)	3.00	24th
Interoperability	3(7.3%)	12(29.3%)	15(36.6%)	10(24.4%)	1(2.4%)	2,85	25th
Age of Organization	2(4.9%)	22(53.7%)	7(17.1%)	3(7.3%)	7(17.1%)	2.78	26th
Faulty Designs and Failures	4(9.8%)	21(51%)	4(9.8%)	12(29.3%)	-	2.59	27th

Lack of Graphical Interface	3(7.3%)	20(48.8%)	16(39%)	2(4.95)	-	2.41	29th

Table 4. 6 depicts the test of assumptions on the adequacy of the matrix and the significance of the factors influencing the adoption of automation in the facilities management of high-rise buildings in the study area. With a determinant level of .001, the prediction that the listed factors affect the adoption of automation in the facilities management of high-rise buildings in the study area is valid. More so, the Kaiser-Meer Olkin Measure of Sampling of .770 is greater than .70; this indicates that enough items were predicted by each (principal factor component). Bartlett's test also has a significant value of .000, less than .05, implying that the variables are correlated highly enough to provide a basis for factor analysis.

Table 4.6 KMO Bartlett's Test

Kaiser- Meyer Olkin Measure of Sampling	
Adequacy	.770
Bartlett's test of Approximately Chi Squared	433.488
Sphericity df	.91
Sig.	.000

Table 4.7 shows how the variance was divided among 29 possible factors. Four factors have eigenvalues (i.e., a measure of explained variance) greater than 1.0, which serve as a standard criterion for a factor to be valid.

Table 4.7 Total Variance Explained

<table>
<tr><th>Component</th><th colspan="4">Initial Eigen Values</th><th colspan="2">Rotation Sums of Squad Loadings</th></tr>
<tr><th></th><th>Total</th><th>% of Variance</th><th>Cumulative %</th><th>Total</th><th>% of Variance</th><th>Cumulativ e %</th></tr>
<tr><td>1</td><td>12.098</td><td>41.717</td><td>41.717</td><td>9.064</td><td>32.254</td><td>31.254</td></tr>
<tr><td>2</td><td>7.449</td><td>25.686</td><td>67.403</td><td>8.869</td><td>29.857</td><td>61.11</td></tr>
<tr><td>3</td><td>5.683</td><td>19.596</td><td>87.000</td><td>7.146</td><td>24.642</td><td>85.754</td></tr>
<tr><td>4</td><td>2.153</td><td>7.424</td><td>94.423</td><td>2.514</td><td>8.670</td><td>94.423</td></tr>
<tr><td>5</td><td>.469</td><td>1.617</td><td>96.041</td><td></td><td></td><td></td></tr>
<tr><td>6</td><td>.355</td><td>1.223</td><td>97.264</td><td></td><td></td><td></td></tr>
<tr><td>7</td><td>.330</td><td>1.138</td><td>98.402</td><td></td><td></td><td></td></tr>
<tr><td>8</td><td>.289</td><td>.996</td><td>99.397</td><td></td><td></td><td></td></tr>
<tr><td>9</td><td>.053</td><td>.184</td><td>99.581</td><td></td><td></td><td></td></tr>
<tr><td>10</td><td>.052</td><td>.179</td><td>99.761</td><td></td><td></td><td></td></tr>
<tr><td>11</td><td>.022</td><td>.075</td><td>99.836</td><td></td><td></td><td></td></tr>
<tr><td>12</td><td>.021</td><td>.071</td><td>99.907</td><td></td><td></td><td></td></tr>
</table>

13	.071	.058	99.967	
14	.010	.035	100.000	
15	2.879E-	9.929E-	100.000	
16	8.765E-	3.022E-	100.000	
17	5.001E-	1.724E-	100.000	
18	4.337E-	1.495E-	100.000	
19	1.717E-	5.921E-	100.000	
20	2.078E-	7.165E-	100.000	
21	8.930E-	3.079E-	100.000	
22	9.612E-	3.314E-	100.000	
23	3.941E-	1.359E-	100.000	
24	3.715E-	1.281E-	100.000	
25	-	-2.260E-	100.000	
26	-	-9.796E-	100.000	
27	-	-4.981E-	100.000	
28	-	-8.953E-	100.000	
29	-	-1.358E-	100.000	

Extraction Method: Principal Component Analysis

The Rotated Component Matrix presented in Table 4.8 shows loadings of the variables on each Factor, which is paramount in understanding the analysis results. All 29 variables were sorted into four overlapping groups of factors, which are (the nature and management style of the organisation, diffusion of information technology into facilities management, nature and level of sophistication of the building and type of software used by facilities managers**).** Factor 1 accounted for 31.3% of the variance; Factor 2 accounted for 29.9%, while Factor 3 and Factor 4 accounted for 24.6% variance and 8.7% variance, respectively. Each of these variables has a loading greater than .50, which shows the reliability of the test. Conclusively, principal component factor analysis with varimax rotation was conducted to assess the underlying structure for the twenty-nine items of the factors influencing the adoption of automation in the facilities management of high-rise buildings. These items were aggregated into four principal factor components: Nature and Management styles of the organisation, diffusion of information technology into facilities management, nature and level of sophistication of the building and type of software used by facilities managers.

The first factor accounted for 31.3% of the variance; the second accounted for 29.9% of the variance, while the third and fourth factors accounted for 24.6% and 8.7%, respectively. The first component has nine (9) variables loaded highly on it. These variables are the rate of churn (0.977), employee expectation (0.977), lack of skilled personnel (0.977), inappropriate selection of facilities management staff (0.982), strategic resource (0.982), ineptitude of decision makers (0.982), age of organisation (0.982), management strategies (0.982), staff strength (0.982). These factors are grouped under the principal component "nature and management style of the organisation". The second component factor also has nine (9) highly loaded variables. These variables include high implementation cost (0.952), lack of demand by building owners (0.961), cost of mistakes (0.961), adaptation to change (0.961), global competition (0.964), availability of information technology (0.965), initial cost of installation (0.965), low level of awareness (0.967), demand for information (0.967). This factor was named diffusion of information technology into facilities management. The third component factor has eight (8) highly loaded variables. These variables are high cost of facilities and space (0.761), design standards and inventory (0.946), need for reduced maintenance and logistics (0.946), poor operation and maintenance activities (0.946), age of building (0.967), management strategies (0.967), number of floors (0.967), protection against failure of buildings (0.978). This factor was named the nature and level of sophistication of the building. At the same time, the fourth component factor has three (3) variables highly loaded on it. These variables are lack of graphical interface (0.959), interoperability (0.959) and faulty designs and failures. This factor was named the type of software used by facilities managers. The result presented in the table shows that all these factors significantly affect the adoption of automation in facilities management of high-rise buildings in Lagos, Nigeria.

Table 4.8 Rotated Component Matrixes

Rotated Component Matrix	**Component**			
	1	**2**	**3**	**4**
Rate of Churn	.977			
Employee Expectation	.977			
Lack of Skilled Personnel	.977			
Inappropriate Selection of Facilities Management Staff	.982			
Strategic Resource	.982			
The ineptitude of Decision Makers	.982			
Age of Organization	.982			
Management Strategies	.982			
Staff Strength	.982			
High Implementation Cost		.952		
Lack of Demand by Building Owners		.961		
Cost of Mistakes		.961		
Adaptation to Change		.961		
Global Competition		.964		
Availability of Information Technology		.965		
Initial Cost Installation		.965		
Low Level of Awareness		.967		
Demand for Information		.967		

High Cost of Facilities and Space			.761	
Design Standards and Inventory			.946	
Need for Reduced Maintenance and Logistics			.946	
Poor Operation and Maintenance Activities			.964	
Age of Building			.967	
Management Strategies			.967	
Number of Floors			.967	
Protection Against Failure of Buildings			.978	
Lack of Graphical Interface				.959
Interoperability				.959
Faulty Designs and Failures				.751
Eigenvalue	9.064	8.869	7.146	2.514
% Variance Explained	31.254	29.857	24.642	8.670
Cumulative % Variance Explained	31.254	61.11	85.754	94.423

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization

a. *Rotation converged in 5 iterations.*

5. Conclusions

Factors influencing the adoption of automating systems in high-rise buildings were examined to identify factors peculiar to developing countries and provide information that could enhance advancement in facilities management practice. The study adopted a quantitative research approach, administering 53 structured questionnaires on purposively selected facilities managers of high-rise buildings. The study revealed that CAFM is the most popular and the most used automating system. In contrast, the choice of automating systems was significantly influenced by the cost of acquisition, technical capability of personnel, organisation strategy, system availability, organisation need and ease of use. It was also revealed that the need to protect buildings against failure is the most significant factor influencing the adoption of automated systems in the management of facilities in high-rise buildings.

The study concluded that the use of automating systems presents facilities managers with innovative ways of ensuring the functionality of the built environment through the integration of people, place, process and technology. However, building operators should ensure that the initial acquisition cost does not solely determine their choice of automating systems. Staff expertise level of compatibility of the system, among others, should be considered.

It must be noted that this research work could have been more robust if the authors had access to information available in all the identified ninety-five (95) commercial high-rise buildings.

Further research can be carried out on the comparative analysis of adopting automating facilities management systems between residential and commercial high-rise buildings.

References

Aliyu, A.A, Ahmad, A. and Usman, M. (2015). Application of facilities management Practice in high-rise Commercial properties: Jos in perspective. *Civil and Environmental Research,* 7*(4),* 10-19.

Atanlode, A.O. (2017*). Impact of skyscrapers in urban area: Case study of Lagos Island, Lagos State, Nigeria*. retrieved from http//:www.academicjournal.org on August 6, 2017.

Atkin, B. and Bildsten, L. (2017). A future for facilities management. *Journal* of *Construction Innovation*. 17(2), 116-124.

Awotona A. (1987). *Nigerian institute of architecture journal*, 3(3) 23-34

Bernard D. F. Melissen R. W. (2012), "Facilities management: lost, or regained?" *Journal of facilities 30 (5*/6). 254 – 261.

Coenen, C., Von Felten, D. (2014). A service-oriented perspective of facilities management. *Journal of Facilities Management,* 32(9/10), 554 – 564.

Craighead, G. (2003). *High-rise security and fire life safety* (2nd ed). Butterworth-Heinemann, Woburn, MA.

Ding, L., Drogemuller, R., Akhurst, P., Hough, R., Bull, S., and Linning, C. (2009). Towards sustainable facilities management. *Technology, Design and Process Innovation in the Built Environment,* 6(4), 373-392.

Ebbesen, P. (2015). Information technology in facilities management- a literature review. *Research papers. advanced knowledge in facilities management: people making facilities management.*Retrieved from orbit.dtu.dk on February 01, 2017.

East, E., Bogen, C., and Rashid, M. (2012). Life-cycle building control. *eWork and eBusiness in Architecture, Engineering and Construction. ISBN 978-0-415-62128-1.*

Elmualim, A., Pelumi-Johnson, A. (2009). Application of computer-aided facilities Management FM for intelligent buildings operation. *Journal of facilities management, 27* (11/12), 421 – 428.

Ezema I.and Olutayo A. (2014). Densification as Sustainable Urban Poilcy: the Case of Ikoyi, Lagos, Nigeria. *Proceedings of the CIB W107 2014 International Conference, Lagos*, Nigeria, 28th-30th January.

Golabchi, A., Akula, M., Kamat, V. (2016). Automated building information modeling for fault detection and diagnostics in commercial HVAC systems. *Journal of Facilities Management*, 34(3/4), 233 – 246.

Hassanain, M.A. (2009). On the challenges of evacuation and rescue operations in high-rise buildings. *Journal of Structural Survey,* 27(2), 109 – 118.

Ho, D.C.W., Yau, Y., Wong, S.K., Cheung, A.K.C., Chau, K.W. and Leung, H.F. (2006). Effect of building management regimes of private apartment buildings in Hong Kong. *Property Management, 24* (3), 309-321.

Katipamula, S. and Brambley, M.R. (2005). Review article: methods for fault detection, diagnostics, and prognostics for building systems. *Heating Ventilation and Air Coordination Research.* 11(1), 3-25.

Lunn, S.D. and Stephenson, P. (2000). The impact of tactical and strategic FM automation. *Journal of Facilities Management,* 18(7/8), 312 – 323.

Madritsch, T. and May, M. (2009). *Successful IT implementation in facilities management.*
University of Applied Sciences HSK Kufstein, University of Applied Sciences HTW Berlin, Berlin, Germany.

McGrail, D.M. (2007). *Fire-fighting operations in high-rise and standpipe-equipped buildings.* PennWell, Tulsa, UK.

Oladokun, T.T. 2011. An examination of the practice of facilities management in Nigeria. *Journal of international real estate and construction studies, 1 (2), 167 178*

Olanrele, O.O., Ahmed, A., Smith, H.O. (2014). Facilities Management Service Delivery in Public and Private High-rise Residential Buildings in Nigeria: A Case Study of Eko Court Complex and Niger Towers. *Paper Presented at MATEC Web of Conferences on October 15, 2014*

Olapade D.T. Ekemode B.G, (2018). Awareness and utilisation of building information modeling for facilities management in developing economy. *Journal of facilities management*. Retrieved from http://www.emeraldisight.com/1472-5967.htm

Parsanezhad, P. and Tarandi, V. (2012). Is the age of facilities managers' paper boxes over?

Smith, A.M. and Hinchcliffe, G.R. (2004), RCM: *Gateway to World Class Maintenance.* Elsevier Butterworth Heinemann, Burlington, MA.

Syed Mustapa, S. A. H., & Jusoff, K. (2009). Facilities management challenges and opportunities in the Malaysian property sector. *Journal of Sustainable Development*, *1*(2), 79.

Thompson, B. (2005). Information and communications technologies and industrial property. *Journal of Property Investment & Finance*, 23(6), 506-15.

Yau, Y. (2011). Homeowners' participation in management of multi-storey residential buildings. *Journal of Property Management*, 29(4), 345 – 356.

Yu, A.T.W., Shen, Q., Kelly, J. and Hunter, K. (2007). An empirical study of the variables affecting construction project briefing/architectural programming. *International Journal of Project Management*, 25(2), 198-212.

Wang, Y., Wang, X., Wang, J., Yung, P. and Jun, G. (2013). Engagement of facilities management in design stage through BIM: framework and a case study. *Advances in Civil Engineering*, 29(5/6), 67-85.