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Sustainable Facilities Management for Smart Buildings: A Case Study of the Heritage Place, Lagos

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Abstract

A recent development within the metropolis of Lagos State, Nigeria is the emergence of smart buildings aimed at providing safer, more secure, productive and comfortable business environment. A major challenge to the sustenance of such edifice is the delivery of strategic facilities management services to maximise the building's efficiency and achieve expected return on investment. This study investigates sustainable facilities management practices in smart buildings using the Heritage Place as a case study. A cross-sectional survey was conducted on 19 facilities management personnel and 68 users of the facility. chart, mean score and Spearman's Correlation were used as the descriptive and inferential statistical tools, respectively. The results show the most frequently practiced sustainable facilities management practice to include: compliance to the preventive maintenance schedules for Heating Ventilation and Air Conditioning (HVAC) systems and prompt response to repairs and corrective work activities in the facility with mean scores of 5.00 and 4.90, respectively. The results further show that the facility users were dissatisfied with the level of implementation of sustainable facilities management practices, except in integrated pest management and optimised waste management where marginal satisfaction were recorded, respectively. The study recommends a sustained effort by smart buildings stakeholders at implementing sustainable facilities management practices in order to significantly and continually improve operations and maintenance activities in the buildings. And that the efforts of facilities managers for smart buildings should be geared at the delivery of strategic facilities management services that meet the expectations of users of the facilities..

Keywords: Buildings, Facilities, Management, Smart Buildings, Sustainable.

Introduction

The heritage place is the first environmentally certified commercial building in the city of Lagos, Nigeria. The 14-storey building comprises 15,736 m^2 of office space and 350 parking bays (Heritage Place, 2017). Commercial office buildings are structures erected to support a commercial strategy, accommodating innovative work processes, and broadcasting a particular set of business values, thereby contributing to the income of an organization owning or renting the building (Olagunju, 2012). According to Adams and Frost (2008), the design, construction, operation, refurbishment and demolition of smart office buildings makes use of natural resources. These resources are the prerequisite for certain internal activities such as heating, cooling, vertical transportation, and air conditioning, among others. The operation and maintenance activities in the interior and exterior of office buildings have major impacts on economic and social life of the building users as well as on the surrounding environmental quality at any point in time.

Babawale and Oyalowo (2011) posit that environmental sustainability combines the goal of protecting and enhancing the environment in such a way that allows for future needs to be met. Fujita and Takewaki (2011) assert that environmental sustainability, as related to commercial office building, requires that renewable resources must be consumed at a rate no greater than they can be generated while non-renewable resources must be used no faster than the renewables can be put in place as substitutes, and pollution wastes must be emitted at a rate within the assimilative capacity of the natural systems that absorb, recycle or render them harmless. As it were, the built and inbuilt premises of commercial office buildings account for, surprisingly, large portion of all environmental impacts in areas such as energy consumption, carbon dioxide emissions,

and waste generation among others (Ucar and Balo, 2010). Consequently, reducing the environmental impacts of commercial office buildings is critical while ensuring their consistent operation and maintenance represents significant potential.

Abigo, *et al.* (2012) opined that the concerns about environmental sustainability as related to operations and maintenance of commercial office building have led to sustainable facility management approach as a means of exercising control and mitigating the tendency of adverse impact. Similarly, Ellison and Sayce (2007) posit that the impact of the built and inbuilt activities of commercial office buildings on the environment coupled with the need to sustain the environment justifies the importance of environmental sustainability under the umbrella of facilities management. Shah (2007) describes facility management as a profession that manages the functionality of built environment by balancing economic, social and environmental aspects through continuous performance evaluation and assistance of green building technologies.

Elmualim, *et al.* (2012) posited that sustainable facility management is an approach for coordinating the operation of a physical nature and the human environment in an organisation, uniting the whole principle of business administration, as well as, process design and engineering matters related to the environment. Lawrence *et al.* (2012) also defined sustainable facility management as the scope of building efficiency involving the operation and maintenance of building while giving priority to the built environment and functionality of the inbuilt facilities, reducing the environmental impact thereof.

Kuhlman and Farrington (2010) defined sustainability as maintaining well-being over a long, perhaps even an indefinite period. According to Karji *et al.* (2019), sustainability in construction seeks to maintain a balance between environmental, economical and social considerations throughout the construction cycle.

Studies (Howe, 2010; Hopwood *et al.,* 2005) have further identified sustainable development as the key to sustainability at all levels. Sustainability has also been strongly projected as an integral part of public policies (Bonevac, 2010; Kuhlman and Farrington, 2010) which must be vigorously pursued by both government and organizations' policies. The term sustainability has evolved over the years with different people proffering different meanings within the context of their professions. For instance, (Callicott and Mumford, 1997) developed the meaning of the term "ecological sustainability" as a useful concept for conservation biologists; portraying it as ability to meet human needs without compromising the health of the ecosystems. However, a good number of studies such as (Balslev and Galamba, 2016; Morelli, 2011) have viewed sustainability within the dimensions of economics, social equality and environmental protection.

Geissler and Österreicher (2018) defined social sustainability as a life-enhancing condition within communities, and a process within communities that can achieve that condition. Faremi *et al.* (2021) further explain social sustainability as entailing workers' health and safety, impact on local communities, quality of life, benefits to disadvantaged groups, for example, the disabled. In Economic sustainability, Alley (2005) portrayed it as being the ability to create new markets and opportunities for sales growth, cost reduction through efficiency improvements and reduced energy and raw material inputs, and creation of additional value. Sun *et al.* (2015) posited that economic sustainability focuses on efficiency of the use of goods and equity of distribution. The author further portrays it as maintenance of capital or keeping capital intact. In the case of environmental sustainability, it deals with the condition or future of the environment, and considers the life cycle of a product (good or service), from the extraction and processing of the resources, over production and further processing, distribution and transport, use and consumption to recycling and disposal (Finkbeiner *et al.,* 2010). These have to be assessed with regard to all relevant material and energy flows.

With increasing urbanization, higher in developing countries, the number and size of buildings in urban areas will increase, resulting in an increased demand for electricity and other forms of energy commonly used in buildings. This suggests that development or urbanization is the major cause of various environmental sustainability issues due to increased human activity. Ighravwe and Oke (2019) linked development as one of the problems facing environmental sustainability. According to Li and Ma (2014), the process of urbanization affects the condition of the environment by changing the levels of polluting emissions as a consequence of the shift in production and changes in the population's behaviour patterns after migrating from rural to urban areas. This means that environmental pollution is mainly as a result of the paradigm shift from rural to urban areas. According to Oduwaye and Lawanson (2007), some of the critical problems facing cities of the developing world are deteriorating living conditions, increasing rates of death and diseases caused by pollution and poor sanitation. Thus, these authors argue that the environmental and social consequences of urbanization are quite visible such as conversion of environmentally fragile areas to shantytowns by indigent migrants. They highlight the inextricable relationship between environmental degradation and poverty.

Taking into cognizance the adverse effects of development on the environment through increased human activity, hence the need for sustainable development. In other words, the idea of sustainable development arose essentially from concerns relating to over exploitation of natural and environmental resources (Anand and Sen, 2000). According to Hopwood *et al.* (2005), the concept of sustainable development is the result of the growing awareness of the global links between mounting environmental problems, socio-economic issues to do with poverty and inequality and concerns about a healthy future for humanity. In the context of United Nations (UN) World Committee on Environment and Development, Agenda 21, sustainable development is "Development that meets the need of the present without compromising the ability of the future generations to meet their own needs". From a holistic point of view, studies (Karji *et al.,* 2019; Kates, *et al.,* 2016; Obabori *et al.,* 2009; Goodland, 1995) have shown the goal of sustainable development to be the attainment of balance among three contending subsystems (economic, social and environmental). This means that sustainability involves economic activity, social equality and environmental sustainability (Mwanaumo *et al.,* 2020) that promote the ability of the present and future generations to live within the earth's capacity to support us. These three dimensions of sustainability must be in harmony as opined by Kuhlman and Farrington, (2010). In other words, economic development, social development and environmental protection are interdependent and mutually reinforcing components of sustainable development.

Zawawi *et al.* (2016) posited that proactive operation and maintenance can yield benefits especially for smart commercial buildings. Such benefits that could accrue from the implementation of sustainable facilities management practice include: reduced solid and hazardous waste generation, less hazardous air pollution, extended service life of equipment and building materials, better indoor air quality, and fewer occupant complaints (Faremi *et al.,* 2017).

Research on sustainable facilities management with reference to operations and maintenance of commercial buildings are limited. Previous studies have dealt with barriers to sustainable facilities management, identifying various factors such as capabilities, knowledge and organizational issues as the barriers that inhibit sustainability implementation. Capability issues in achieving sustainability in Facilities Management (FM) including the lack of professional capability, capability discrepancies and skills and capability magnitude have been emphasized in several extant research studies as being crucial challenges that need to be addressed in an effort to promote sustainability (Hodges 2005; Shah 2007). In addition, issues such as the lack of sustainability knowledge, knowledge chasm and challenges faced in the knowledge transfer process have been highlighted (Elmualim *et al.,* 2009; 2010; Shah 2007). These have been viewed as the most critical barriers to the implementation of sustainable FM in management of buildings.

Notwithstanding, the facilities manager is at the forefront of delivering sustainable facilities management and contributing to sustainable development (Elmualim *et al.*, 2009).

Some of the predominant sustainable facilities management practice highlighted in literature include: predictive maintenance activities, preventive maintenance activities, improvement maintenance, corrective maintenance, waste management, water management, establishment of green procurement policy, integrated pest management, energy audit and erosion control (Barker, 2007; Neve and Selman, 2000). The focus of the study therefore is to investigate the level to which the sustainability is operationalised in smart buildings and the extent to which sustainability practices influence building users satisfaction. This study examines the level at which all the stated sustainable facilities management practices are implemented at the Heritage Place building.

This paper aims at examining the extent to which sustainable facilities management (FM) practices influence the level of users' satisfaction in the management of smart commercial buildings in Lagos State Nigeria. The specific objectives are to:

1. Identify sustainable FM practices/approaches frequently adopted for the management of commercial office buildings in Lagos State
2. To assess level of users' satisfaction with FM Practices/Approaches adopted for Operation and Maintenance of a commercial Office Building in Lagos State

The hypothesis formulated for the study is stated below:

H_0: There is no significant relationship between sustainable facilities management (FM) practices and the level of users' satisfaction with operations and maintenance of the building.

Materials and Methods

The cross-sectional survey research design was adopted for the study as data were collected from the survey particpants on a one-off basis. This research strategy was considered suitable because of its ability to view comprehensively and in detail the major questions raised in the study. According to Creswell (2012), this research design is an efficient way of collecting information from a large number of respondents and the ability to use statistical techniques to determine statistical significance of the data.

The population of the study consists of users and facilities management personnel using and working in the building as at the time of the survey. A structured questionnaire was developed as the instrument for collecting primary data for the study. A sampling frame consisting of the details of ninety-three (93) users and twenty (20) facilities management personnel in the building was compiled. A census sampling was adopted for the facilities management personnel while the Yamane (1967) equation for determining sample size was used to determine the sample size for the building users as shown in Equation 1:

$$Sample\ size = \frac{N}{1 + N(e)^2} \quad (1)$$

Where:
N is the population size (93)
e is the level of precision (0.05)

$$Sample\ size = \frac{93}{1 + 93(0.05)^2} \quad (2)$$

A sample size of seventy-six (76) was obtained as the minimum sample size for the building users. Adopting a census of facilities management personnel and using the random sampling technique for the building users, one hundred (100) questionnaires were self-administered to targeted respondents comprising eighty (80) building users questionnaires and twenty (20) facilities management personnel questionnaires respectively.

Out of the administered questionnaires, 87 were retrieved comprising sixty-seven (67) building users and twenty (20) facilities manangement personnel questionnaires respectively. Each of the retrieved questionnaires were checked for errors and level of completeness. Eight of the retrieved questionnaires were found to have been poorly completed (3 from building users and 5 from facilities management personnel questionnaires) and were discarded. This implies that a total of seventy-nine (79) questionnaires comprising sixty-four (64) building users questionnaire and fifteen (15) facilitie management personnel questionnaires were adequately completed and used for the study representing 79% response rate.

To achieve this first objective of the study, sixteen (16) FM practices were identified from previous studies. The respondents were asked to rate the level of implementation of each of the sustainable facilities management practices using a 5-point Likert scale ranging from never to always. To achieve the second objective, set of sustainable FM practices were presented to the respondents for them to assess.

In order to accurately measure the satisfaction level of respondents, the Expectation Disconfirmation Theory (EDT) was employed. The EDT measures the gap between expected level of service and the perceived level of service. For this study, the gap in service was measured by plotting the values of expected and perceived service level. Expectations are related to the pre-experience time period that users have initial expectation or desire about sustainable FM practices. Experience of perceived performance are related to the post experience time period that the users get based on his experience of actual service delivery. The mean score of both the expectations and perceptions of FM practices were measured on a 7- point Likert scale ranging from very low to extremely high.

The result of the difference can be positive or negative. When users' perceived performance is better than their expectation, a positive disconfirmation will occur. However, when users perceived performance is worse than they expected, the negative disconfirmation will occur. Positive disconfirmation will lead to customer satisfaction and negative disconfirmation means implies dissatisfaction.

Furthermore, the postulated hypothesis for the study was tested using the Spearman's Correlation.

Results and Discussion

Respondents' demographics

Figure 1 shows that the respondents for the study comprises facility management personnel (19%) and users (81%) of the Heritage Place building. It is expected that the cross section of respondents comprising the buildings users as well as the facilities management team members would provide a robust data for the study.

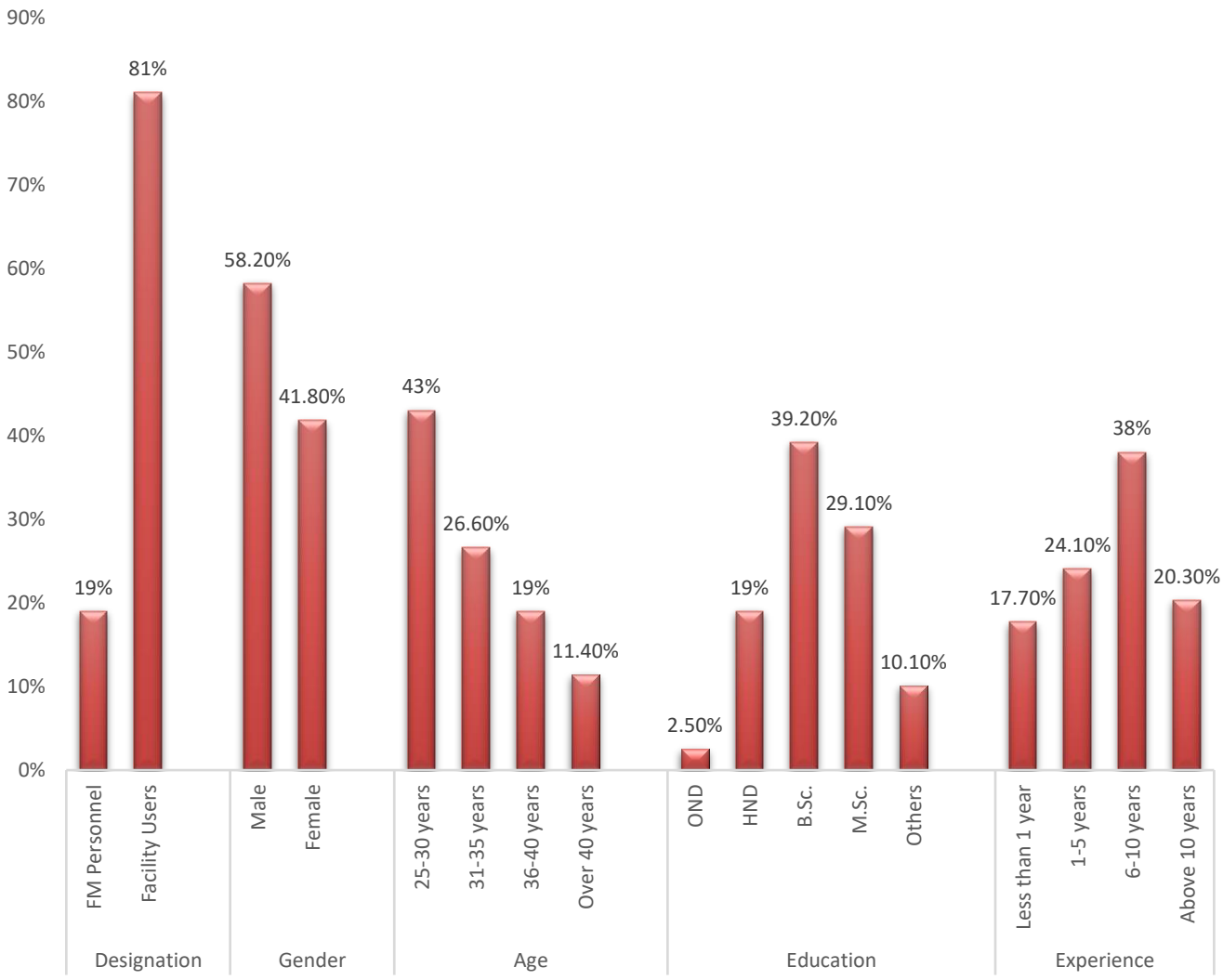

Figure 1: Demographics of Respondents

Figure 1 also shows that about 58% of the respondents were male while about 42% of the respondents were female. The result indicates that both gender categories were well represented in substantial proportion without bias.

The respondents were asked to indicate the class of their respective ages as at their respective last birthdays , the result shows that 43% of the respondents were within the age bracket of 25-30 years, about 27% of the respondents were of age 31-35years, 19 % of the were of age 36-40 years, while about 11% of the respondents were over the age of 40 years. It could thus be established that the respondents were not minors but mostly mature adult whose opinion could be regarded as reliable.

Furthermore, with respect to the respondent's academic qualification, Figure 1 shows that 2.5% of the respondents had OND, 19% of the respondents had HND, 39.2% of the respondents had B.Sc., 29.1% of the respondents had M.Sc. and 10.1% of the respondents possessed other educational qualification. Inference drawn from the result indicates that the respondents had appreciable level of education and were capable of comprehending the questions posed to them. The respondents' significant level of education also implies that they were knowledgeable people whose opinions on the subject of investigation could be relied upon.

Also, Figure 1 reveals that 17.7% of the respondents had work experience of less than 1year, 24.1% of the respondents had work experience of 1-5years, and 38.0% of the respondents had work experience of 6-10years, while 20.3% of the respondents had work experience of above 10years. Respondents were presumed to be better informed by the reason of their years of experience. This implies that the responses collated are reliable given respondents' years of experience in the use and management of facilities.

Sustainable FM practices for operation and maintenance

One of the objectives of the study is to identify sustainable FM practices/approaches frequently adopted for operation and maintenance of a commercial office building in Lagos state (FM personnel) in Lagos State. The result of the analysis is shown in Table 1.

Table 1: Sustainable FM Practices for Operation and Maintenance of Buildings

Sustainable FM Practices	Mean	Rank
HVAC maintenance (system efficiency and occupant comfort)	5.00	1st
Lift maintenance	5.00	1st
Prompt repairs and corrective measures of facilities	4.90	3rd
Daily maintenance and Constant check of all facilities	4.80	4th
Constant check of smoke alarms and detectors	4.74	5th
Optimal Solid Waste management	4.56	6th
Water management (water metering and minimum indoor plumbing fixture and fittings efficiency)	4.27	7th
Green Procurement Policy (Procurement of environmentally friendly commodities and products)	4.22	8th
Integrated Pest management	4.06	9th
Lighting system Upgrade	3.78	10th
Building Exterior Management (Cleaning of building exterior)	3.66	11th
Green and Non-toxic cleaning	3.64	12th
Green Landscaping of buildings	3.4	13th
Energy Audit	3.04	14th
New environmental control system, i.e CO2, FAHU, filtration, etc.	2.56	15th
Erosion control and Landscape Management	1.00	16th

Source: Field Survey (2018)

Table 1 shows the analysis for the sustainable FM practices frequently implemented for operation and maintenance of the Heritage Place building in Lagos State. The result shows rank order of the sustainable facilities management practices. The top ranked sustainable facilities management practices include HVAC maintenance (system efficiency and occupant comfort) and Lift maintenance with maximum mean scores of 5.00, respectively. Prompt repairs and corrective measures of facilities ranked 3rd among the sustainable facilities management practices with a mean score of 4.90. The result suggests the level of importance of the function of HVAC system in achieving thermal comfort in smart buildings. The tie of lift maintenance with HVAC maintenance shows that both systems are critical in the operations of smart office buildings. While the lift system is very crucial in the movement of people and goods in the building, the HVAC system is essentially meant to provide a healthy and comfortable indoor environment with acceptable indoor air

quality. Therefore, maintenance of these facilities requires adequate attention as it must function without interruption.

The result further shows that the least ranked sustainable facilities management practices include new environmental control system, i.e., CO_2, FAHU, filtration, etc. ranked 15th with a mean score of 2.56 and erosion control and Landscape Management ranked 16th with a mean score of 1.00. Issues relating to Energy Audit, New environmental control system, i.e., CO_2, FAHU, filtration, etc. and Erosion control and Landscape Management could be regarded as non-frequently implemented sustainable FM practices in the building.

Users' satisfaction level with Sustainable FM Practices

The second objective of this study is to assess the users' satisfaction level of Sustainable FM Practices implemented during operation and maintenance of the Heritage Place building. The result of the analysis is shown in Figure 2.

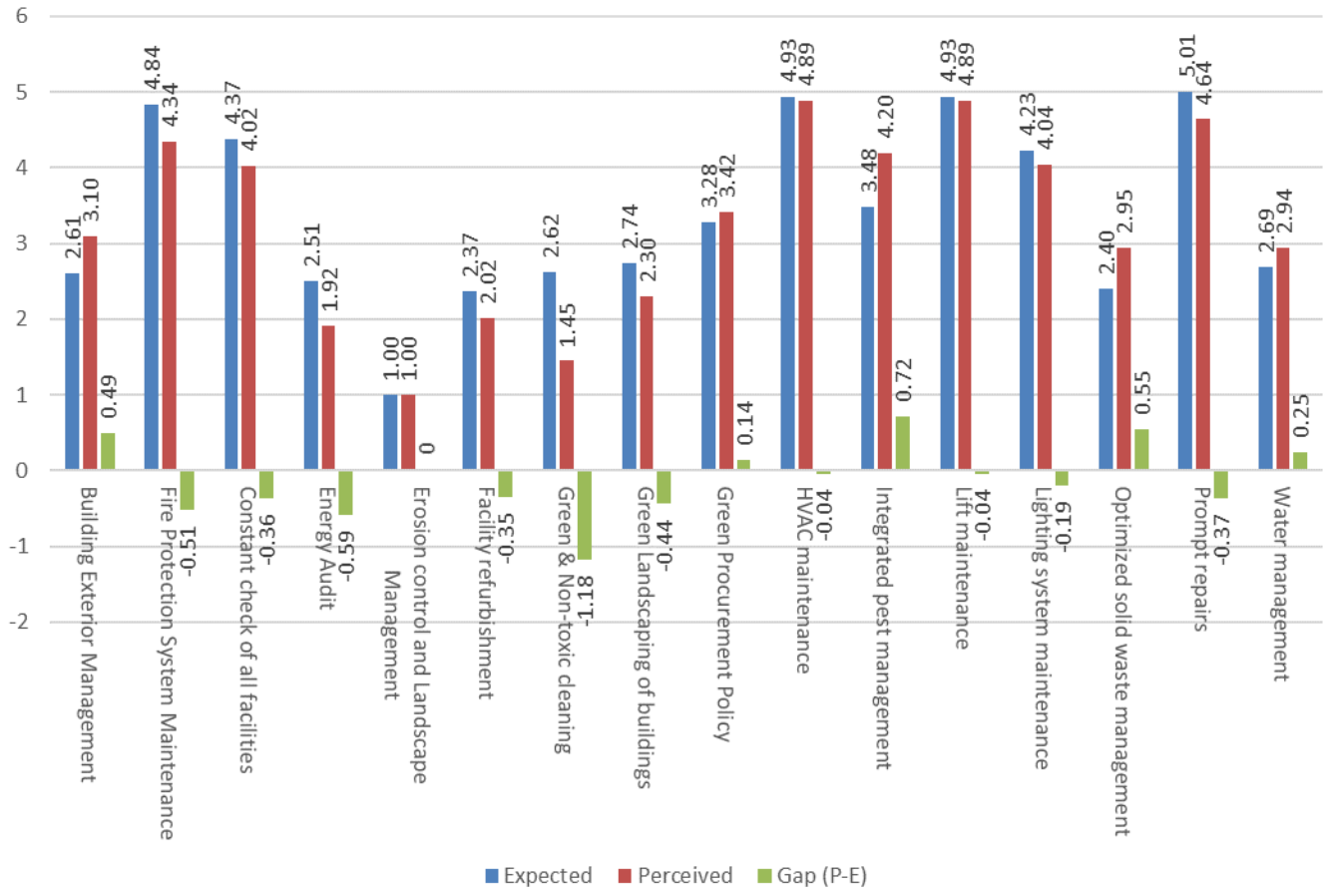

Figure 2: Level of Satisfaction with Sustainable FM Practices

Figure 2 shows that the respondents are unsatisfied with the level of implementation of majority of the sustainable FM practices as most of the results show negative disconfirmation. Sustainable facilities management practices such as constant check of smoke alarms and detectors, daily maintenance and constant check of all facilities, energy audit, facility refurbishment, green and non-toxic cleaning, green landscaping, HVAC maintenance (system efficiency and occupant comfort), lift maintenance, lighting system upgrade and maintenance, and prompt repairs have negative disconfirmation. This implies that the

respondents are dissatisfied with the level of implementation of these sustainable facilities management practices.

The postulated hypothesis for the study was analysed, and the result of the analysis is shown in Table 2. There is a weak positive correlation value of 0.33 between the two variables. The relationship is however significant (p=.01). The null hypothesis is rejected. The result implies that sustainable FM practices and the level of users' satisfaction with operations and maintenance of the building are complementary. The positive significant correlation further implies that as the implementation of sustainable FM practices increases so does the level of users' satisfaction .

Table 2: Correlation analysis between sustainable FM practices and level of satisfaction

	Sustainable FM practices	Level of satisfaction
Sustainable FM practices (r)	1	
Sustainable FM practices (*p)*	.00	
Level of satisfaction (r)	.33	1
Level of satisfaction (*p*)	.01	.00

Note: p is significant at $p \leq 0.01$

The results show that HVAC and Lift maintenance are of topmost priority to achieving sustainable facilities management in smart buildings. The findings concur with Karmann et al. (2018) and Gamero-Salinas et al. (2021) that the provision of satisfactory thermal comfort for at least 80% of the occupants of a building is essential as stipulated by several thermal comfort standards. Furthermore, Au-Yong et al. (2014) explain that the level of building occupants' productivity and comfort is highly influenced by the reliability of the HVAC system's services and such reliability is dependent on the implementation of a robust maintenance management regime. The results buttress the submission of Au-Yong et al. (2018) that a lift system requires regular maintenance and inspection in order to provide safe and effective service to the building occupants.

The results also support Lewis et al. (2010) that system thinking for critical building systems such as HVAC and Lift sytems are necessary to achieving successful, sustainable and high performace building operations. The findings suggest that the implementation of effective maintenance management programmes, especially for critical building systems; such as the HVAC and lift systems are prerequisites for driving sustainable facilities management for smart buildings.

Conclusions

The study examines the extent to which sustainable facilities management (FM) practices influence the level of users' satisfaction with operation and maintenance services in smart office buildings. Premised on the analysis of the data collected for the study, the following conclusions were drawn:

I. Only 75% of sustainable facilities management practices are frequently implemented at the Heritage Place building. This is indicative of sustainable facilities management practices that are implemented in smart office buildings in Lagos State. Sustainable facilities management practices that are frequently implemented include; the maintenance of heating, ventilation and air conditioning (HVAC) systems, periodic maintenance of lift system and prompt repairs of failed system or component.
II. Facilities managers of smart buildings consider the HVAC and vertical transportation systems as the most critical systems that are required for the smooth running of smart buildings.

III. Users of smart buildings are dissatisfied with the level at which 69% of the sustainable facilities management practices are implemented during the operation and maintenance phase of the building as the perceived level of implementation is grossly below the expected level.

IV. The more sustainable facilities management practices are implemented during the operation and maintenance of smart buildings, the more satisfied the building users would be.

The study recommends that managers of smart buildings should sustain the effort at implementing sustainable facilities management practices in order to significantly and continually improve operations and maintenance activities in the buildings. In addition, smart buildings' stakeholders should endeavour to implement in totality all the sustainable facilities management practices as this would enhance the functionality of the building, retard decay and ultimately impact positively on the environment.

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