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ASSESSMENT OF INTEGRATION OF BUILDING AUTOMATION SYSTEMS IN RESIDENTIAL BUILDINGS IN DEVELOPING COUNTRIES: PROFESSIONALS` PERSPECTIVES

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ABSTRACT

The study assessed the integration of various Building Automation Systems (BAS) to enhance efficiency and productivity in residential buildings in developing countries: Professionals` perspectives. A survey technique was used for this research. Both Qualitative data and Quantitative data were obtained. 100 structured questionnaires were distributed to the professionals involved in construction of the systems. The data were analyzed and ranked based on Relative Importance Index (RII) calculation. The result showed that high energy management, improved security, improved safety in buildings were the most important benefits while High cost of purchasing devices and high maintenance cost., lack of adequate power supply, lack of technical-know where the challenges encountered in the use of BAS. There is lack of awareness of BAS by professionals. It recommended that there should more enlightenment and training of the construction professionals on the importance of building automation for better efficiency and productivity.

Keywords: Building Automation Systems Residential Buildings· Developing Countries Professionals.
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1. INTRODUCTION

A building is often seen by most individuals as not more than mere fulfillment of shelter as a basic need[1]; it is an expression of self, privacy, investment and above all a safe haven in which property owners, business manager and occupants experiences comfort, convenience, safety, security, long-term flexibility and marketability [2}. A conventional building can be defined as that which traditionally separates building systems or functions such as temperature control, energy management, fire and security. A building controlled by a building automation system is also called an intelligent building or a smart home. An intelligent building, according to the Intelligent Building Institute (IBI) is that which produces a useful, valuable and efficient environment by making best use of basic elements of structure, systems, service and management and how they are related to each other.

Building automation means the use of computer and Information Technology (IT) to manage building appliances for better performance of an automated building. The control system consists of smart network of electronic devices designed to check and control the mechanical, electronic and lighting systems in a building [3} Building automation system requires engineering services and products for automatic control, operation, monitoring and optimization, human management to achieve energy efficiency, economical and safe operation of building services systems. Building automation system is sometimes called Building Automation and Control Systems (BACS), Energy Management system (EMS), Central Control Monitoring system (CCMS) or Building Management Systems (BMS), [4] [5]. An effective Building Automation and Control Systems (BACS) produces the lowest energy cost, manages occupied space and makes occupancy productive through centralized control and automation and avoids waste of energy. The HVAC system plays a very important role in energy consumption and construction cost of buildings, [6].

2. REVIEW OF RELATED STUDIES

2.1. Building Automation Systems (BAS)

Building is the product of humanity that has been in existence from creation. [7] Building automation system implies the technical control of heating and air-conditioning, lighting, security, fire protection, telecommunication and data services. BAS refers to a system of network integrated computer components which automatically controls many building operations like access control, lighting, HVAC, fire protection, audio-visual systems security and more. It is known to have a centralized, interlinked networks that have hardware and software, which monitors and controls the environment in any type of facility [8]. The automation system saves energy, lightens loads, and ensures the facilities operate effectively and efficiently so the occupants are comfortable and safe. In other words, building automation begins with control of mechanical, electrical, and plumbing systems. A building controlled by a BAS is called an intelligent building, smart building or a smart. It can be computerised to minimize HVAC and lighting energy usage, and for other conveniences.[8].

The development trends of BAS is enhanced greatly by the advancement of Information Technology (IT) and Communications Networks (CN) resulting in the increasing demand for Intelligent Buildings and Smart Environment [9]; [10]. The prefabrication method of building construction and this concept is taking a trend in Nigeria construction industry as few companies and occupants are embracing the concept. [11] There are different types of BAS, some are simple remote control of lighting and temperature others are complex network of computer/micro controller that have different levels of intelligence and automation [12]. However, an exemplary BAS could be a programmable thermostat able to define the

temperature setting for an air conditioning and heating equipment for each time of the day. When compared to old conventional thermostat with metal coils and mercury switches that start and stop heating and cooling equipment based on manual settings. Programmable thermostats are simple automated system, but cannot provide full sense of scope and complexity that it is possible with BAS. However, household thermostats is a simple illustration of basic principle of BAS when compared to programmable thermostats [13]

2.2. Building Automation Systems (BAS) in Advanced Countries

Technological advancement and inventions all over the world is rapidly increasing as well as building designs and development which has affected the major areas such as structure, system, services and management. A combination of these factors has created the era of automated and intelligent buildings, which have been established to be energy efficient, which is commonly used in now in developed countries. It has codes for proper efficient utilization of energy and in future zero energy consumption. [14]. In Europe, the European commission has set a standard 80% target for all European homes to be equipped with smart meters by the year 2020 while in China, the 12^{th} five-year plan (2011-2015) set very strong targets for energy efficiency. Every building and home is unique in energy consumption levels and therefore building automation systems should be introduced to utilise available resources for maximum energy efficiency at minimum cost [15]. [16][17][18][19] recognize the advantages of concept of Intelligent building as reduction in building preservation and energy costs; enhanced productivity, gains in rent, investments, occupancy rates, retention; and ability to change use of space. The actual cost of an intelligent building is not only its cost of construction but the cost of operation and maintenance of the structure over its life span.

2.3. Building Automation Systems (BAS) in Nigeria

The Nigeria construction industry is undergoing a major set-back because of inadequate knowledge and understanding of the concept of BAS by the professionals.

The major automation systems used in residential homes are the CCTV system and often times plumbing systems. These systems are found mostly in the urban area of the cities in Nigeria. It is therefore important to evaluate the recently adopted systems, its effects in the construction industry and also the integration of these systems in homes, because of global high demand for smart homes and intelligent buildings.

The study is aimed at the integration of various Building automation systems to enhance efficiency and productivity in a residential building. The objectives are to: identify various automation systems adopted in residential buildings; evaluate the benefits of building automation in residential building. This study provides clarity on the whole concept of building automation and its components. It is also creates awareness to the construction professionals on the importance and need for building automation to be adopted in our present day construction of residential buildings and also the various aspects in which automaton can be carried out for better efficiency and productivity of a residential building. This study will breach the gap between building construction and information technology on automation systems and its adoption in residential buildings and provide a platform for further areas of study.

Finally, it provides trending approaches to Building Automation Systems in residential buildings, construction and manufacturing companies with partnership opportunities and also creates a level of awareness to the public on automation products and services. Regularized training for professionals practicing or not, help in professional research and education scheme in universities and lastly provides client with better satisfaction.

3. RESEARCH METHODS

The study area is Lekki Phase 1, Lagos state, Nigeria. It is the urban area where the high class in the society resides and some of their buildings have various automation system integrated in them. This research study is based on field survey, use of structured questionnaires.[11],[20],[21], [22]Primary data were obtained through structured questionnaires to architects, builders, engineers, IT consultants. Secondary data was obtained from literature review of relevant books, journals, and other related sources. The responses in the questionnaires were collated and analyzed with the use of IBM SPSS 20. Relative Importance Index (RII) was used to rank the 5-likert scale with the formula RII=∑W/A*N RII= Relative Importance Index; W= Weight of each attribute; Σw= Summation of all weight of each attribute; A= is highest score e.g. 5

N= total number of respondents i.e. 70

4. DATA ANALYSIS AND PRESENTATION

Descriptive statistical methods were employed to analyze the data while instrument of data presentation includes tables, pie charts, bar charts, histograms and pictures.

Table 1 Detailed response from questionnaires retrieved

Respondents	Questionnaire Distributed	Questionnaire Returned	Response Rate %
Architects	20	15	75
Builders	20	10	50
Engineers	20	15	75
IT Consultants	25	20	80
Occupants	15	10	66.67
TOTAL	100	70	70

Table1 shows that the questionnaires were distributed to five categories of respondents: - Architects, Builders, Engineers (Civil, Mechanical, and Electrical), IT Consultant and Occupants. The average response rate is {(70/100)*100} = 70%.

4.1. Adoption of BAS in Nigeria

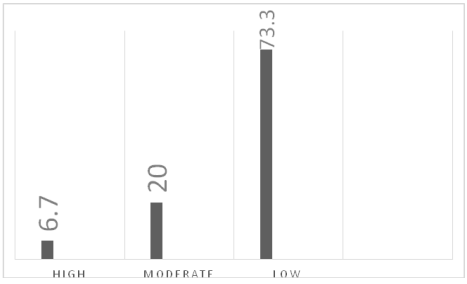

Figure 1 Bar chart for Adoption for BAS in Nigeria

Fig. 1 shows that response rate of 73.3% agreed that the rate of adoption of BAS in Nigeria was low, 20.0% rated the adoption of BAS in Nigeria as moderate while 6.7% rated the adoption rate to be high. This response indicates that there is need for more public awareness on the adoption of BAS in residential buildings in Nigeria.

4.2. Effect of BAS on the Value of the Building

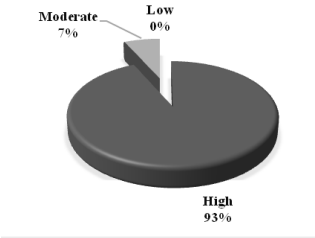

Figure 2 Pie chart for the effect of BAS to the value of the building

Fig. 2 shows that 93% of the professionals chose high that is BAS increases the value of a building while 7% stated the value will be moderate. This indicates that the market price of the building increases because of the various automation systems integrated in the building.

4.3. Need for a Shift in Buildings

Fig.3 shows 93.3% of the professionals said yes stating that the BAS has many benefits such as operational efficiency in terms of cost and energy, monitoring of a building system in real time and reduces need for human intervention thereby ensuring comfort to its users. This necessitates Nigeria to follow the trends and adopt the system.

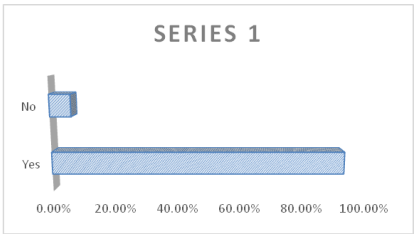

Figure 3 Bar chart for need for shift

6.7% of the professionals responded no stating that there is no need for a shift as the process of construction is very expensive which will give rise to higher rental cost to tenant as owners or developer will look to recover the money invested in the construction and maintenance of such systems.

4.4. Efficiency of BAS in a Residential Building

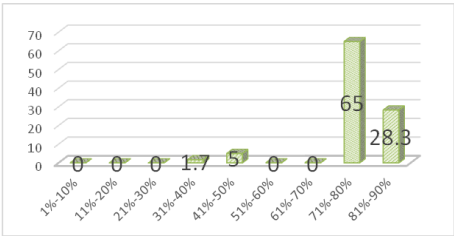

Figure 4 Bar chart for efficiency of BAS in a building

Fig. 4 shows the evaluation of BAS efficiency by the professionals. The most rated percentage was 71%-80% which was ranked 65% by the professionals, 1.7% of professionals rated the efficiency of BAS between 31%-40%, 5% of the professionals rated the efficiency at 41%-50%, while 28.3% of the professionals rated the efficiency of BAS at 81%-90%. This indicates that Building Automation Systems are very effective in building as they make the building more productive and efficient.[23]

4.5. Consideration of BAS in a Building

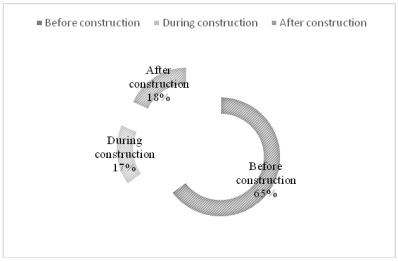

Figure 5 Pie chart for consideration of BAS

Fig.5 shows that 65% of the professionals chose before construction, 18% chose after construction while 17% chose during construction. This implies that automation can be integrated at any time in a building but before construction is most preferred.

4.6. Descriptive Mean Statistics Analysis and Ranking

The descriptive mean statistical analysis and ranking for this research was produced using IBM SPSS statistical tool. The mean was derived from each item treated in the questionnaire distributed. The response varies from "0-5", minimum response rate is "0" that is; no variable was selected by respondent while the maximum variable that can be selected by respondent is "5".

Table 2 Descriptive Mean Statistics for various BAS

Bas systems	N	Minimum	Maximum	Mean	Index	Rank
Surveillance system	60	4	5	4.97	0.9966	1st
Security systems	60	4	5	4.98	0.9967	2nd
Fire and safety systems	60	3	5	4.92	0.9833	3rd
Access control system	60	3	5	3.82	0.7633	4th
Mobile remote control	60	1	5	2.97	0.5933	5th
Lighting control	60	2	5	2.93	0.5867	6th
Heat, ventilation and air conditioning	60	1	5	2.80	0.56	7th
Building management systems	60	1	5	2.65	0.53	8th
Plumbing system	60	1	5	2.47	0.4933	9th

Table 2 shows that between the various BAS identified, Plumbing system has the least mean of 2.47 and security system and surveillance system has the highest mean of 4.98. The BAS mostly used are the Surveillance system and Security system with RII of 0.9967 and ranked 1st and 2nd respectively, fire and safety ranked 3rd with a relative importance index of 0.9833, access control ranked 4th with RII of 0.7633, mobile remote control ranked 5th with RII of 0.5933, lighting control ranked 6th with RII of 0.5867, HVAC ranked 7th with RII of 0.56, Building management system ranked 8th with RII of 0.53, plumbing system ranked 9th with RII of 0.4933. This implies that surveillance, security, fire and safety systems are the commonly used automation systems found in residential buildings.

Table 3 Descriptive Mean Statistics for Challenges encountered in BAS

Challenges encountered	N	Minimum	Maximum	Mean	Index	Rank
High cost of purchasing devices	60	4	5	4.98	0.9967	1st
High maintenance cost	60	4	5	4.97	0.9935	2nd
Lack of adequate power supply	60	4	5	4.97	0.9934	3nd
Lack of technical knowhow	60	3	5	4.93	0.9867	4th
Lack of maintenance practice	60	3	5	4.92	0.9833	5th
Lack of experience making it a risky venture	60	3	5	4.90	0.98	6th
Lack of awareness of benefits of bas	60	3	5	4.83	0.9667	7th
Change in customers taste, style and preference	60	3	5	4.80	0.96	8th
Lack of regulatory body/ framework	60	3	5	4.80	0.9567	9th
Future upgrade of bas	60	3	5	4.62	0.9233	10th

Table3 shows that High cost of purchasing devices ranked 1st with RII of 0.9967and high maintenance cost ranked 2nd with RII of 0.9935, lack of adequate power supply ranked 3rd with RII of 0.9933, lack of technical knowhow ranked 4rd with RII of 0.9867, lack of maintenance practice ranked 5th with RII of 0.9833, lack of experience ranked 6th with RII of 0.98, lack of awareness of the benefits ranked 7th with RII of 0.9667, change in customers taste ranked 8th with RII of 0.96, lack of regulatory body ranked 9th with RII of.0.9567, future upgrade ranked 10th with RII of 0.9233. This indicates that all challenges faced are relevant as they all ranked at 0.9 which implies that the challenges are pressing needs faced in the use of BAS in residential homes.

Table 4 Descriptive Mean Statistics for Benefits of BAS

Benefits	N	Minimum	Maximum	Mean	index	Rank
Higher energy management	60	4	5	4.98	0.9967	1st
Improved security in building	60	4	5	4.98	0.9967	1st
Improved safety in building	60	3	5	4.90	0.9967	1st
Improves interaction between bas and users	60	2	5	4.87	0.98	4th
Enhance property value	60	3	5	4.87	0.9767	5th
Better occupant comfort and productivity	60	3	5	4.87	0.9733	6th
Increased productivity	60	3	5	4.85	0.97	7th
Simplifies building operations	60	2	5	4.80	0.96	8th
Reduces maintenance cost	60	3	5	4.77	0.9533	9th
Avoids business interruption	60	1	5	4.73	0.95	10th
Reduces occupant complaint	60	4	5	4.72	0.9467	11th
Help the disabled	60	4	5	4.71	0.9233	12th

Table 4 shows that between the various benefits of BAS, help the disabled ranked the least at 4.73, while higher energy management, and improve security in buildings ranked the most at 4.98.

High energy management, improved security, improved safety in buildings ranked 1st with a RII of 0.9967, improved interaction between BAS and user ranked 4th with a RII of 0.98, enhances property value ranked 5th with RII of 0.9767, better occupancy comfort ranked 6th with RII of 0.9733, increased productivity ranked 7th with RII of 0.97, simplifies building operation ranked 8th RII of 0.96, reduces maintenance cost ranked 9th with RII of 0.9533,

avoid business interruption ranked 10th with RII of 0.95, reduces occupants complaint ranked 11th with RII of 0.9467, help the disabled ranked 12th with RII of 0.9233. This indicates that all the above benefits of BAS are relevant to the users as they assist them in their daily activities and also help to save energy consumed by the building.

5. CONCLUSION

There is lack of awareness of BAS by professionals and the public at large. Though the benefits of BAS are relevant to the users as they assist them in their daily activities and also help to save energy consumed by the building It is therefore concluded that there is in need for awareness and training by the construction professionals and occupants on the importance and need for building automation to be adopted in our present day construction of residential buildings for better efficiency and productivity.

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