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ASSESSMENT OF THE LEVEL OF AWARENESS OF INTELLIGENT BUILDINGS IN LAGOS STATE, NIGERIA

RESEARCH ARTICLE[1]

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ABSTRACT

The feasibility of achieving sustainable building development, an eco-friendly environment, and building investment conservation by integrating technological intelligence in buildings is highly viable. Intelligence features are, therefore, increasingly being incorporated in new designs and existing buildings to enhance the useful life, productivity and satisfaction of occupants, and a greener environment. This article evaluates the use of intelligent building systems in Nigeria. Primary data were obtained with the use of structured questionnaires that were self-administered to construction professionals in the private and public sectors in Lagos State. Data collected were analysed using descriptive and inferential statistics. Findings established that 90.24% of the respondents were aware of intelligent building systems, while practitioners who have worked or were working on buildings with intelligent features were limited to 51.2%. Approximately 64.60% of the respondents have used intelligent buildings previously, but only thirteen (13) notable buildings were identified to have employed intelligent building systems to a reasonable extent in the study area. The features of intelligent buildings with top level of awareness

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were CCTV system; access control and locks (mean = 3.96); alarms and alerts (mean = 3.92); HVAC system (mean = 3.90), and fire alarm system (mean = 3.89). Features with high level of utilisation include lighting system, which was the most utilised feature (mean = 3.57); fire alarm system (mean = 3.48); access control and lock; CCTV system (mean = 3.45), and HVAC system (mean = 3.43). The results showed that most of the features with a high level of awareness were also those with a high level of utilisation. The study established that the level of awareness and utilisation of intelligent building systems in the study area is high, but full adoption of the system is still low.

ABSTRAK

Die haalbaarheid van die bereiking van volhoubare gebou-ontwikkeling, eko-vriendelike omgewing en die bou van beleggingsbewaring deur die integrasie van tegnologiese intelligensie in geboue is hoogs lewensvatbaar. Hierdie artikel evalueer die gebruik van intelligente geboue-stelsels in Nigerië. Primêre data is verkry deur gestruktureerde vraelyste wat deur die konstruksie professionele persone in private en openbare sektore in Lagos State voltooi is. Data wat ingesamel is, is ontleed met behulp van beskrywende analise. Bevindinge het vasgestel dat 90.24% van die respondente bewus was van intelligente geboue-stelsels, terwyl praktisyns wat gewerk het of aan geboue met intelligente kenmerke gewerk het, tot 51.2% beperk is. Ongeveer 64.60% van die respondente het voorheen intelligente geboue gebruik, maar slegs dertien (13) noemenswaardige geboue is geïdentifiseer wat intelligente geboue-stelsels in die studiegebied gebruik het. Die kenmerke van ’n intelligente gebou met topvlak van bewustheid was CCTV-stelsel; toegangsbeheer en slotte (gemiddeld = 3.96); alarms en waarskuwings (gemiddeld = 3.92); HVAC-stelsel (gemiddeld = 3.90), en brandalarmstelsel (gemiddeld = 3.89). Kenmerke met ’n hoë vlak van benutting sluit in beligtingstelsel wat die mees gebruikte kenmerk was (gemiddeld = 3.57); brandalarmstelsel (gemiddeld = 3.48); toegangsbeheer en slot, en CCTV-stelsel (gemiddeld = 3.45), en HVAC-stelsel (gemiddeld = 3.43). Die resultate het getoon dat die meeste kenmerke met ’n hoë vlak van bewustheid ook dié met ’n hoë vlak van benutting was. Die studie het vasgestel dat die vlak van bewustheid en benutting van intelligente geboue-stelsels in die studiegebied hoog is, maar die volle aanvaarding van die stelsel is steeds laag.

1. INTRODUCTION

As a significant entity among the identified three basic needs of life, building accommodates roughly 80% of daily human activities. Besides the comfort of living, working space, and shelter from harsh environmental conditions that building offers, it creates capital assets and durable consumer good (Seeley, 1997: 10). The conventional good of buildings has revolutionised with the advancement in information communication and technology (ICT) to garner innovative good for users and owners. The emerging technological innovations in building constructs have established the possible interaction between the building and its users and/or occupants for improved thermal comfort, increased human productivity, better morale and satisfaction, improved security and safety, enhanced energy saving, and marketability (Ghaffarianhoseini *et al*., 2015: 1; Wong, Li & Lai, 2008: 284, 287; Wong, Li & Wang, 2005: 144). The ability of buildings to effectively sense and interpret information from its uses, with the aid of installed technological systems to activate mechanical responses, has made buildings more efficient and intelligent, thus, intelligent buildings (IBs).

IB is an option for achieving the global sustainable building development by means of its efficient energy-management potentials. New buildings with the integration of intelligence in their designs are 70% more efficient and smart in capacities and use than conventional buildings (Osama, 2018). Smart and/or IBs are founded as feasible solutions to deficiencies in existing buildings and challenges of construction-related environmental threat (Lilis *et al.*, 2016: 2; Barrie & Paulson, 1992). IBs are a panacea for constraints in economic development because they have over 50% cost-saving potential to address energy and climate change challenges (Ramesh & Khan, 2013; Tomlinson, 2010). Such economic development challenges stem from energy waste from the deteriorating capacity of existing buildings/facilities to accommodate changing future growth, and climatic threats from greenhouse gas emissions.

Developed countries have records of increased provisions of IBs for residential, commercial, and office purposes, owing to the derivable value-added benefits and cost-minimisation potentials of IBs (Clements-Croome, 2015; Braun, 2007: 4374-4375; Flax, 1991: 24). For example, the installation of an energy-management control system (EMCS) in commercial buildings soared by 80% in the USA from 1995 to 1999 (Braun, 2007: 4374). The intelligent office building of Apple company in San Francisco has 70% natural ventilation construct (Lonergan *et al*., 2015, cited in Ghaffarianhoseini *et al*., 2015: 4). The world-class bio-reactive façade in Germany provides shade and a renewable fuel source (Arup 2013, cited in Ghaffarianhoseini *et al*., 2015: 4). The Manitoba Hydro Place in Canada has 70% energy conservation over typical large office towers.

In developing countries, particularly the hot and humid climes, the interventions of technological intelligence have gained increased adaptation in building development designs and existing building retrofits, to improve thermal comfort and conserve energy consumption. For example, the integration of intelligence (*e.g.*, HVAC) in buildings in Nigeria led to an annual cost-saving potential on energy consumption of 46.3% and 3^{o}C improvement on thermal comfort (Onyenokporo & Ochedi, 2018).

The innovative potentials of IBs greatly contribute to the targets for energy efficiency, by alleviating the problem of rising urban growth in the world (Lilis *et al*., 2016: 2). For example, Europe and North America have a 74% and 82% urbanisation growth rate, respectively (Lilis *et al*., 2016: 2). Nigeria has a 212% increased level of built-up area (Onanuga, Eludoyi & Ofoezie, 2022: 592). IB technology is a novel building approach in the Nigerian construction industry. It is highly imperative that the country embraces the system of building intelligence in future policies for new constructions to meet up with its rapid urbanisation growth. There is a seemingly low level of adoption of intelligent systems in the country, and scant empirical research on building intelligence in Nigeria (Iwuagwu & Chioma, 2014; Ahmed, 2009; Owajionyi, 2007). This study attempts to investigate the level of awareness of IB systems (IBSs) and use in the country, with a view to adding to building innovation knowledge base and providing an empirical guide for further research.

2. LITERATURE REVIEW

2.1 Intelligent buildings

The concept of IBs was conceived in the USA in the early 1980s (Frank, 2007: 107). The first ever IB in the world was constructed in Hartford, USA, in 1984 (CIBTIN, 2002: online). Nowadays, IBs are rapidly becoming policy measures for the design and development of new buildings rather than mere conceptual frameworks for representing future buildings (Ghaffarianhoseini *et al*., 2015: 8-9). There is no consensus on the definition of an IB, as there has been no definite end to building technological innovation that is progressing daily. However, the nexus of all definitions centres on the derivable cost-benefit efficiency, energy-use management, and waste-reduction potentials of IBSs (Ghaffarianhoseini *et al*., 2015: 4; Wong *et al*., 2008: 287; Braun, 2007: 4374-4375). According to the USA Intelligent Building Institute, an IB can be defined as providing a profitable and cost-effective condition by enhancing its four fundamental components, including structures, system, services, and management, as well as the interrelationships between them (Osama, 2018; Wong *et al*., 2005: 144). The USA Intelligent Building Institute also described IB as “one which integrates various systems to effectively manage resources in a coordinated mode to maximize technical performance, investment and operating savings flexibility” (Ghaffarianhoseini *et al*., 2015: 1). On the other hand, Flax (1991: 24) described an IB as one that “creates an environment that maximises the efficiency of the occupants of the building, while simultaneously allowing effective management of resources with minimum life-time costs.

An IB has, in general, been described as a technologically induced environment that interacts with and responds to users’ requirements by influencing the well-being, productivity, and satisfaction of its occupants at a more cost-effective rate (Wong *et al*., 2005: 144). IB is a means to an end, as it is able to satisfy the desire of building owners and occupants by offering comfortable, flexible, and energy-efficient living conditions at a minimal cost. This is accomplished by the sustainable design and incorporation of advanced building technologies in new buildings (Chen *et al.,* 2006). The IBS allows for the networking of building services and systems in a unified whole, and for exchanging information between the systems for effective management decision, thus resulting in more time and cost savings in the use of all the facilities (Flax, 1991: 25). According to Flax (1991), IBS, also known as the fourth utility, is an intelligent cabling infrastructure that harnesses the different life of services and systems to be compatible with the life cycle of a building, by integrating the building architecture with migration path for changing old systems and to accommodate technology advancement.

Nguyen and Aiello (2012: 248) and Wong *et al*. (2005: 145) opined that IBs are best described based on the selection of Quality Environmental Modules (QEMs) that best meet the users' requirements via environmental friendliness (health and energy conservation), space utilisation and flexibility, cost effectiveness (operation and maintenance with the emphasis on effectiveness), human thermal comfort, working efficiency, safety and security measures (fire, earthquake, disaster, and structural damages), culture, image of high technology, construction process and structure, as well as health and sanitation.

The management of IBs is dependent on the collection and processing of information originating from components of controlled engineering systems, represented as an extensive network of sensors and actuators (Pavel, Khomenko & Ternovay, 2019: 1). Wang *et al*. (2004) indicated that, in China, the market pattern of IB is changing and moving to large public buildings such as exhibition centres, libraries, stadiums, culture and art centres, as well as museums. The buildings contain intelligent devices, which are connected and share information through a network (Shah *et al.,* 2019: 11). The intelligent assistant uses artificial intelligence techniques that allow users to communicate with the devices through voice control. These devices communicate through the advanced wireless networks and save data on the cloud. With the increased awareness of integrating intelligent technologies in new buildings, development of smart spaces is conceivable for solving personal and social issues (I-Scoop, 2018: online; Wong *et al*., 2008). The utilisation of edge and fog computing is the other area of IB advancement with respect to decrease response time and delay (Shah *et al.,* 2019: 17).

The concept of IBs has not been exploited in Nigeria to an appreciable extent because of a low degree of cognisance and awareness about the concept among construction professionals. This poses the greatest challenge to its adoption in the Nigerian construction industry (Mohammed, 2015). The awareness level of IBs could be attributed to the adoption of modern, developing computing and technology. The most common components of intelligence in buildings are the sensor-controlled glass doors in numerous public buildings, the close circuit television system, and smart cards in commercial buildings (Mohammed, 2015; Iwuagwu & Iwuagwu, 2014). However, no building in Nigeria is completely intelligent (Owajionyi, 2007: 112).

The advancements in IBs include more comfortable living conditions, more convenience, a bundle of entertainment, and sustainability in their designs (I-Scoop, 2018: online). Emerging IB services include, among others, indoor positioning, occupancy detection, automated environmental monitoring, demand-based and personalised HVAC control, as well as human-building interactions (Jin *et al*., 2018: 6152). While these technologies have been demonstrated in research labs and few selected buildings within the global context, their public access in the majority of real-world buildings is still limited (Jin *et al*., 2018: 6153).

2.2 Intelligent building technologies

Telecommunication technologies are vital components of IBs. Such technologies in buildings are the Building Automation Systems (BAS) for communication, controlling and monitoring energy services and uses, comfort, home activities, and security (Shah *et al*., 2019; AlFaris, Juaidi & Manzano-Agugliaro, 2017: 3). The BAS includes the BACnet (Building Automation and Control network), LonWorks systems, and KNX that have gained popularity in the USA and on European markets over the past decades. The automation can be integrated with field devices such as smart meters, sensors, and actuators on a platform and internet on another platform, in order to enhance the level of intelligence of the building (AlFaris *et al*., 2017: 8-12; Lilis *et al*., 2016: 2-4).

Shah *et al*. (2019) revealed that, in smart home networks, IB devices communicate with each other through specific protocols such as Zigbee, KNX, and Z-Wave. Zigbee is a wireless network that relays signals to another device by strengthening and expanding the network. Zigbee can be built in dimmers, door locks, thermostats, and many other applications. Z-Wave is a mesh network that uses low-energy radio waves to provide wireless connectivity to home devices (Shah *et al*., 2019: 17). KNX is open source and mostly used for automation, and each system in KNX is smart itself. This implies that, if a system fails, the performance of other devices connected to the network is not affected, because it operates on more than one physical layer (Bharathi, 2018). The second choice of the protocol is Ethernet, which is much faster than wireless networks, and in which the IB devices are connected through wires (Shah *et al*., 2019: 17).

Wi-Fi and Bluetooth have also been used in IBs. Wi-Fi is a more convenient network that works within a range of 25m for the connectivity of devices, but Bluetooth is preferred for shorter range communications (Bharathi, 2018). In the IBSs' network, the energy management controller controls the electronic devices (Shah *et al*., 2019: 17). IoT device has also found applicability in IBs because the device is easy to come by and activated by the metrics of sensors (Bradley *et al*., 2018: 24-26). According to Luo, Lin and Su (2009), IB features have been developed in security and fire detection systems that are operated as multi-sensor-based intelligent systems. Braun (2007: 4376-4377) established that embedding intelligence with HVAC and other building services equipment offers incentives such as reduced utility costs, operational costs, maintenance, and service costs, while improving the thermal comfort and satisfaction of occupants. Flax (1991: 24-27) established that IB distribution systems allow building users to benefit from new advances in technology at minimal cost without majorly disrupting existing building uses. Flax (1991) identified fourteen (14) components of IBs: Energy Management Systems (EMSs), Temperature Monitoring Systems (TMSs), Lighting Control and Reduction (LCR), Access and area locate systems, security system, Fire Life Safety (FLS), Telecommunications (including Integrated Services Digital Network [ISDN]), Office Automation (OA), computer systems, Local Area Networks (LAN), Management Information Systems (MISs), cabling schemes and records, maintenance systems, and expert systems.

2.3 Drivers and barriers of intelligent buildings

One major driver of IBs is the attention to users' enhanced well-being (Alessandra, 2018: 11). IBs have relied more on artificial intelligence (AI), which allows for exploiting the information gathered by sensors in a building, understanding the context, choosing the best activities to perform, and effectively modifying the environment. Similarly, the advancement of new techniques with IoT has introduced innovative concepts that revolutionised building uses and opportunities in IB models (Boodi *et al*., 2018; Lilis *et al*., 2016: 5-9).

Factors including energy saving, climate change mitigation, increase in property values, and cost-saving efficiency have been considered as drivers that have made the incorporation of intelligence in new building designs very fashionable (Masia, Kajimo-Shakantu & Opawole, 2020: 619; Boodi *et al*., 2018: 1; Nguyen & Aiello, 2012: 249). The financial incentives generated from the reduced cost of installation through the evolution of the distributed system of BI controls, lower cost of software configuration tools, and cost computing have also influenced the increasing adoption of IBs (Hakkinen & Belloni, 2011; Braun, 2007: 4376). Clements-Croome (2015) established the economic feasibility of IBs as one of the contributory factors for the adoption of intelligence in office buildings in the European Union (EU). Their added value significantly affects the economic conditions of offices through lower costs of healthcare, higher work productivity, higher rental values and staff retention, lower operating costs, and minimised energy consumption.

Flax (1991: 25) described the areas of maximum benefits of IB management in USA office buildings that have influenced the increasing trends of IBs in the USA. These include the investment conservative ability of the IBs network when connected to the building systems, the hedge of the resale and lease values of IBs over conventional buildings, and staff efficiency benefits guaranteed by IBs by fast responses to customers' needs at the lowest reasonable costs. Hakkinen and Belloni (2011: 247) indicated that the drivers of IBs include financial incentives, building regulations, client awareness, client demand, planning policy, taxes/levies, investment, and labelling/measurement. Ang *et al*. (2005) emphasised that the role of the project manager, who represents the client, could significantly influence the choice of IBs in the same way that active involvement in demand specification by the end user could affect the inclusion of IB features in building. Robinson *et al*. (2005) mentioned that knowledge management and sharing among professionals are essential drivers for all innovations, including IBs, in large construction organisations.

On the other hand, barriers to the application of intelligent features in buildings have stemmed from the numerous challenges relating to energy consumption, lack of adequate knowledge of the concepts, over-estimation of capital costs and under-estimation of the potential cost savings, and the absence of a common framework that incorporates the aspects and tasks of IB with construction practices at an operational level (Alessandra, 2018: 10; Johnny & Heng, 2008; Matar *et al*., 2008: 1; Bartlett & Howard, 2000). Managing IBs is also considered a challenging task, especially in the presence of contrasting goals, for example, meeting users' needs and reducing energy consumption (Owajionyi, 2007: 110). Wong *et al*. (2008) opined that the processing of intelligence in buildings constitutes barriers to IBs. These barriers include rules of competition and tendering processes, functioning of value chains, possibilities to apply integrated design processes, lack of knowledge and ignorance of existing efficient IB technologies, lack of demand, and drawbacks in IB marketing processes. The study further noted that difficulties in adopting new processes and working methods, in order to apply new technologies, hinder the adoption of IBs. Zhou and Lowe (2003) identified primary barriers to the implementation of sustainable buildings, namely the misperception of capital costs and the inadequate market value. However, the study did not evaluate the extent to which these factors influence IBSs. Hakkinen and Belloni (2011) indicated that many of the barriers to IBs can be overcome by improved professional education in various new approaches to building delivery systems.

Table 1: Barriers of intelligent building system

Barriers	*Studies*
Need to manage opposite goals (minimising energy consumption, maximising users' wellness and ensuring a low level of intrusiveness)	Alessandra (2018)
Management of IB challenging task, especially in the presence of contrasting goals	Owajionyi (2007)
Rules of competition and tendering processes are complex; functioning of value chains; possibilities to apply integrated design processes; lack of knowledge; ignorance of existing efficient IB technologies; lack of demand and drawbacks in IB marketing processes; difficulty to adopt new processes and working methods so as to apply new technologies; IB solutions are not adequately valued by clients; low public awareness and knowledge about IB and its benefits; rigid normative steering mechanisms; deficient ecological inducements in the taxation system, and the fragmentation of responsibility in the construction and real-estate sectors	Williams & Dair (2007); Johnny & Heng (2008)
Misperception of incurring higher capital costs and inadequate market value; greater expenses originate from the increments in the consultant's fees and unfamiliarity of the design team and contractors with IB methods	Zhou & Lowe (2003); Hydes & Creech (2000)
Lack professional education in the field of IB	Hakkinen & Belloni (2011)
Cost consultants overestimate the capital costs of energy-efficient measures and underestimate the potential cost savings	Bartlett & Howard (2000)
Absence of a common framework that incorporates the aspects and tasks of IB with construction practices at an operational level	Matar, Georgy & Ibrahim (2008)
Network-based technologies are still improving, the correct communication protocol for intelligent buildings is absent, which leads towards security issues in intelligent buildings; flexibility is not accessible in intelligent buildings with respect to appliances from various vendors	Shah et al. (2019)

3. METHODOLOGY

3.1 Research design

This study investigated the level of awareness and adoption of intelligence features in buildings in Lagos State, Nigeria. Lagos is one of the 25 megacities of the world, with the highest records of construction and commercial activities in the country (Ameh & Osegbo, 2011). Lagos is characterised by massive urban drift, accounting for approximately 11% of the country's population in 2016 and an annual temperature range of 27^0C-34^0 C (Ojeh, Balogun & Okhimamhe, 2016). The teeming population coupled with high temperatures led to increased energy consumption in the State. This necessitated the integration of intelligence in existing buildings and in new building developments, in order to improve thermal comforts and conserve energy consumption (Onyenokporo & Ochedi, 2018).

The study adopted a quantitative research methodology through the use of a structured questionnaire to obtain information from a sample of respondents (Creswell, 2003: 5, cited in Nasila & Cloete, 2018). Information on the level of awareness and adoption of features of BI founded the basis of the questionnaire design for the survey to enable the researchers to compare and contrast data generated from different professionals in the study area. Descriptive analysis was employed to summarise the questionnaire data on the respondents' level of awareness and utilisation of IBSs, by using frequencies and percentages (numerical) to reduce the number of responses to a mean score (Woodrow, 2014: 49). Inferential analysis was used to understand the differences in perceptions on the utilisation of IBSs in the study area by building professionals such as architects, builders, engineers, estate surveyors and valuers, quantity surveyors, and procurement managers. The sampled professionals were categorised as those who work with and/or as contractors (contracting firms), consultants (private firms), and government (public organisations). The Kruskal-Wallis test of probability-values (p-values) was extracted to explain the relationship between the three categories of professionals (Bewick, Cheek & Ball, 2003: 452).

3.2 Sampling frame and response rate

The target population for the study was drawn from construction professionals who work with contracting firms, consulting firms, and government establishments in the study area. Statistics obtained from the authors' pilot survey (2020) indicated that there were 125 registered quantity surveying firms, 315 architectural firms, 438 engineering firms, 70 building firms, and one government agency (Ministry of Works) in Lagos State, as shown in Table 2. A percentage range of 10%-30% for a small population and 5% for a large population is deemed adequate for a survey (Trochim, 2007). Therefore, 20% each of quantity surveying firms (25) and building firms (14) and 5% each of architectural firms (16) and engineering firms (22) were selected. This made up a total of 77 firms, including one government agency. The respondents, registered professionals, in each of the categorised work settings, were sampled using random technique. Random sampling affords each member of the subset an equal opportunity of being chosen as part of the sampling process (Kothari, 2004: 15).

Table 2: Sampling frame and size

Respondents' organisation	*Sample frame*	*%*	*Sample size*
Quantity surveying firms	125	20	25
Architectural firms	315	5	15
Engineering firms	438	5	22
Building firms	70	20	14
Government organisation	1	100	1

Source: NIQS (2019); ARCON (2016); COREN (2019); V-Connect (2018)

At least two professionals in the groups (architects, estate surveyors, quantity surveyors, engineers/builders) were selected from the public and private sector organisations for the questionnaire survey. A total of 156 copies of a structured questionnaire were administered to the target respondents. Eight-two (82) copies of the completed questionnaires were retrieved, representing a response rate of 52.56%. The response rate is considered adequate, as asserted by Idrus and Newman (2002) that the response rate of 30.0% is appropriate for construction management studies. The total retrieved questionnaires were stratified in the study sample as 30 quantity surveyors, 11 architects, 23 engineers, 16 builders, 1 procurement officer, and 1 estate surveyor. Respondents who worked in contracting firms represented 24.4%; those who worked in consulting firms represented 47.6%, while 28% of the respondents worked in a government establishment.

3.3 Data collection

The variables extracted from the reviewed literature formed the basis for the constructs that were used for the questionnaire design. The questionnaires were self-administered between October and December 2020. A structured questionnaire is considered an effective data-collection method for measuring respondents' beliefs, attitudes, and opinions (Van Laerhoven, Van der Zaag-Loonen & Derkx, 2004). The survey questionnaire is designed as a close-ended type. According to Kothari (2004), a close-ended questionnaire is easy to handle, simple to answer, and relatively quick to analyse. The questionnaire was divided into three parts. Part one addressed the respondents' profile and obtained information about their academic and professional qualifications, occupation, organisation type, and years of work experience. Part two was designed on the awareness of IBSs and was divided into two sections. Section one included five tick-box questions and section two was designed as a set of eight variables with 59 Likert-scale measurement items. Respondents were required to choose from the tick-box options (see Table 5) and requested to indicate their level of agreement from the scale of measurements, in order to examine their level of awareness of features of IBs (see Table 5). Part 3 was a set of eight variables with 59 Likert-scale measurement items on the construct ‘utilisation’. Respondents were required to indicate their level of agreement, in order to examine the level of utilisation of IBs (see Table 6). The measurement results are used in the descriptive analysis and to test the opinions of different categories of respondents surveyed on the awareness and utilisation of the features of IBs.

3.4 Data analysis and interpretation of the findings

Data analysis was based on descriptive and inferential statistics, including mean, frequency distribution, percentage, and the Kruskal-Wallis test. Descriptive statistics are considered effective tools to describe the characteristics of the respondents and to understand the underlying details of a data set by placing them in a meaningful perspective (Naoum, 2007: 103, cited in Nasila & Cloete, 2018). The validity and reliability tests for the research data were conducted using the Cronbach’s *alpha* (α) test. These ranged as $0.952 \leq \alpha \leq 0.977$. The extracted Cronbach’s *alpha* values were used to analyse the internal consistency of reliability of the variables evaluated. Taber (2018: 1279) stated that an acceptable range of Cronbach’s *alpha* values is from 0.70 to 0.95. However, Field (2009) established the reliability of scales as the *alpha* tends toward 1.000. Hence, the value $0.952 \leq \alpha \leq 0.975$ means that the scale is reliable and can be used to measure the underlying construct for which it was designed. The Kruskal-Wallis test was adopted to analyse the variance of opinions from the independent groups of professionals, having unequal sample sizes (Field 2009: 559-568). This explored the statistically significant differences in the variance of opinion, with $p \leq .05$, from the extracted variables.

3.5 Limitations to the study

Only the responses retrieved from the professionals prior to the imposition of COVID-19 lockdown order (April 2020) were analysed for the purpose of research. The embargo placed on intra- and intercity movement by the Federal Government of Nigeria (FGN) at the designated period of the research survey restricted the administration of the questionnaire and the retrieval of larger samples for the analysis. The respondents were limited to industry practitioners. Case studies involving academics may be considered in future studies.

4. RESULTS

4.1 Background information of the respondents

Table 3 shows the respondents' profile regarding their highest academic qualifications, professional affiliations, years of work experience, and number of projects handled during 2016-2020. The profile shows that nearly half (47.6%) of the participants worked for consulting firms and that the other half worked for either contracting firms (24.4%) or for the Government (28%). The vast majority (97.5%) of the respondents were either quantity surveyors (36.6%), engineers (28%), builders (19.5%), or architects (13.4%), and 73.1% had either a Bachelor of Science/Bachelor of Technology (B.Sc./B.Tech.) (52.4%), or a M.Sc. degree (20.7%). Although a slight majority (68.3%) of the respondents had between 1 to 10 years' work experience, 31.7% had over 11 years' experience and slightly over half (67.1%) of the respondents were involved in more than 10 construction projects, in general, between 2016-2020. This implies that the respondents have adequate tertiary qualifications and experience in the building industry to provide information that could help make useful deductions on the adoption of IBSs in the study area.

The respondents had different professional affiliations, indicating their competence to practise in their various disciplines. This was supported by their membership of the respective discipline regulatory institutions. Over half (61%) of the respondents were affiliated with either the Nigerian Institute of Quantity Surveyors (NIQS) (35.4%), or the Nigeria Society of Engineers (NSE) (25.6%), and the remainder of the respondents were affiliated with the Nigerian Institute of Building (NIOB) (17.1%), and the Nigerian Institute of Architects (NIA) (12.1%).

Table 3: Respondents' profile

Characteristic	*Category*	*Frequency (n = 82)*	*%*
Organisation	Consulting	39	47.6
	Government	23	28
	Contracting	20	24.4
Occupation	Quantity surveyor	30	36.6
	Engineer	23	28
	Builder	16	19.5
	Architect	11	13.4
	Estate manager	1	1.2
	Procurement	1	1.2

Characteristic	*Category*	*Frequency (n = 82)*	*%*
Educational level	Ordinary National Diploma (OND)/ Higher National Diploma (HND)	16	19.5
	Bachelor of Science (B.Sc.)/Bachelor of Technology (B.Tech.)	43	52.4
	Master of Science (M.Sc.)/Master of Technology (M.Tech.)	17	20.7
	Doctor of Philosophy (Ph.D.)	1	1.2
	Postgraduate Diploma (PGD)	3	3.7
	Missing system	2	2.4
Professional affiliation	Nigerian Institute of Quantity Surveyors (NIQS)	29	35.4
	Nigeria Society of Engineers (NSE)	21	25.6
	Nigerian Institute of Architects (NIA)	10	12.2
	Nigerian Institute of Building (NIOB)	14	17.1
	Nigerian Institution of Estate Surveyors and Valuers (NIESV)	1	1.2
	Missing system	7	8.5
Experience (years)	1-10	56	68.3
	11–20	18	22
	21-30	4	4.9
	31-40	4	4.8
Projects handled between 2016 and 2020	1-5	24	29.3
	6-10	31	37.8
	11-15	19	23.2
	16-20	5	6.1
	Missing system	3	3.7

4.2 Awareness of intelligent building systems

The data obtained for the analysis of the level of awareness of IBSs in the study area was generated from responses to questions as to whether the respondents have the knowledge about IBSs, whether they know any building work that is completely intelligent, and specify such, how they learnt about IBs, if they have used an IB before, to what degree a building is considered intelligent, features of IBs, and level of use of IBs.

Findings in Table 4 show that 90.24% of the respondents know what IBs are and over half (64.6%) of the respondents used an IB previously.

Respondents were almost equally distributed in how they obtained their knowledge about IBs from personal experience (25.6%), self-research (25.8%), and group discussions (29.3%). Half of the respondents (51.2%) were involved in the execution of IBs implementation in building work in Lagos State, but the vast majority (82.9%) of the respondents did not know of any building projects that employed the IBs in the study area. This confirms that the level of awareness of IBS is high among construction professionals in the study area. These results also show that IBs are available in the study area and that the respondents had some experience in IB construction projects. Although the knowledge of an IBS is very high among construction professionals in the study area, the adoption of the system in building construction is still low. However, Oke, Aigbavboa & Omole (2020) recommended that seminars and workshops be organised to increase the awareness level of construction professionals.

Table 4 shows that the professionals in the study area identified thirteen (13) notable buildings that employed IBS. This figure is, however, low for a megacity such as Lagos, which is the commercial nerve of Nigeria and one of the top 25 megacities of the world. It is expected that such a city should have several notable buildings that used the IBS, like several other megacities of the world, and particularly in the 21st century, where the usage of modern technologies and innovations are on the rapid increase (Oke *et al.*, 2020; Ahmed, 2009).

Table 5 presents the level of awareness of the professionals about the features of IBs. The Cronbach's *alpha* was greater than 0.70 at .975, indicating acceptable internal reliability, as recommended by Taber (2018: 1279). Respondents were mostly aware of access control and locks (mean = 3.96; SD = 0.94), and CCTV system (mean = 3.96; SD = 1.07). Alarms and alerts ranked third (mean = 3.91), HVAC system ranked fourth (mean = 3.90), fire alarm system ranked fifth (mean = 3.89), camera system ranked sixth (mean = 3.88), lighting system ranked seventh (mean = 3.84), surveillance ranked eighth (mean = 3.80), elevators and escalators ranked ninth (mean = 3.73), and sensors ranked tenth (mean = 3.72). The high ranking of CCTV camera is triggered by its use in many public buildings (malls, supermarkets, hotels, banking halls, etc.) to ensure security. CCTV cameras are usually installed in places that require continuous monitoring (Smith, 2010: online). The usage of CCTV cameras is on the increase in Nigeria perhaps because of the spate of insecurity in the country occasioned by Boko Haram terrorists and various banditry groups. Access control and locks ranked high because they are also a means to ensure security and control access, especially in hotels and public commercial buildings. This agrees with Adejimi (2005) that access control and locks, by way of magnetic cards, are used worldwide and corroborates the assertion by Iwuagwu and Iwuagwu (2014) that the most common aspect about intelligence in buildings is the sensor-controlled glass doors in numerous public buildings. The high ranking of HVAC is expected because it is common in the vast majority of public and commercial buildings as it provides thermal comfort for occupants, thus improving their productivity (Samuel, 2013).

Table 4: Awareness of IBs

Statement/Question	*Category*	*Frequency (n = 82)*	*%*
Awareness of IBs	Yes	74	90.24
	No	8	9.76
Awareness of any building work that is completely intelligent in Lagos State	Yes	42	51.2
	No	40	48.8
Have you used an intelligent building previously?	Yes	53	64.60
	No	29	35.40
Building projects that employed the IBs	No response	68	82.9
	Alliance place, Ikoyi	1	1.2
	Cornerstone capital Alliance project VI	1	1.2
	Eko Atlantic city	1	1.2
	FolorunshoAlakija'sFolorunshoAlakija's mansion	1	1.2
	Kuramo Beach Residence	2	2.4
	Malls and hotels	1	1.2
	Maryland mall	1	1.2
	Nigerian stock exchange	1	1.2
	Residential apartment at Ikoyi	1	1.2
	Seplat	1	1.2
	Sheraton hotel	1	1.2
	Ibis hotel	1	1.2
	Victoria Island	1	1.2
How did you learn about IBs?	Personal experience	21	25.6
	Self-research	22	26.8
	Discussion with other people	24	29.3
	Other means	15	18.3

The professionals have a low level of awareness about health/medical/fitness record vault and paging system (mean = 2.910), health/medical alert system (mean = 2.878), and vending machine (mean = 2.854). The low ranking of these features of IBs may be as a result of the fact that they are more sophisticated than those that ranked very high. Therefore, due to the low adoption of IBs in Nigeria, it is most unlikely to have the more sophisticated features of IBs with high level of awareness. The sophisticated features of IBs will probably have a better level of awareness in developed countries, where IBSs have a better level of adoption. Iwuagwu and Iwuagwu (2014) underscored this, by positing that adoption of modern technology is evolving in Nigeria.

Further analysis was carried out to test the agreement in the opinions of different categories of respondents surveyed on the awareness of the features of IBs, using the Kruskal-Wallis test (Table 5). The test of significant difference is established at $p<0.05$. The findings established that there is no statistically significant difference in the level of awareness of the features by professionals working in contracting, consulting, and government organisations, except for six features. These include HVAC system (heating, ventilation, and air conditioning) ($p=.028$), detector service ($p=.034$), remote audio/video ($p=.043$), fire suppression system (dry, wet) ($p=.046$), parking ($p=.037$), and paging system ($p=.022$). This finding implies that the respondents have varying levels of awareness of the features. This could be as a result of their different levels of exposure and experience in construction projects, especially with respect to IBs.

4.3 Utilisation of intelligent building system

4.3.1 Level of utilisation of intelligent building system

Table 6 shows the utilisation of the identified features of IBS in the study area. Lighting system was the most utilised feature (mean = 3.57), fire alarm system ranked second (mean = 3.48), access control and lock ranked third (mean = 3.45, SD = 1.12), CCTV system ranked fourth (mean = 3.45, SD = 1.13), HVAC system ranked fifth (mean = 3.43), elevators and escalators ranked sixth (mean = 3.41), surveillance; power management ranked seventh (mean = 3.37), alarms and alerts ranked ninth (mean = 3.30), and video surveillance and utility meter ranked tenth (mean = 3.29). The three least utilised features of IBs were Very Early Smoke Detection Apparatus (VESDA) system (mean = 2.62), health/medical alert system (mean = 2.65, SD = 1.08), and zone and climate control (mean = 2.65, SD = 1.02).

Lighting system ranked as the most utilised feature of IBs, probably because it is a basic requirement in any functional modern building. Control of lighting

Table 5: Respondents' awareness of IBs features

Features	*Contracting*			*Consulting*			*Government*			*Overall*			*Cronbach's alpha .975*	
	Mean	*SD*	*R*	*Mean*	*SD*	*R*	*Mean*	*SD*	*R*	*Mean*	*SD*	*R*	*Kruskal-Wallis*	*Sig.*
Access control and locks	4.20	0.83	1	3.87	1.06	5	3.91	0.79	1	3.96	0.94	1	1.526	.466
CCTV system	4.20	0.83	1	4.03	1.01	2	3.65	1.30	5	3.96	1.07	2	1.816	.403
Alarms and alerts	3.95	0.94	7	3.97	0.99	4	3.78	1.20	2	3.91	1.03	3	.259	.879
HVAC system (heating, ventilation and air conditioning)	3.95	0.76	7	4.13	1.03	1	3.48	0.99	15	3.90	0.99	4	7.156	.028*
Fire alarm system	3.90	1.02	10	4.00	0.89	3	3.70	1.15	4	3.89	0.99	5	.985	.611
Camera system	4.15	1.04	4	3.87	0.92	5	3.65	1.11	5	3.88	1.01	6	3.034	.219
Lighting system	3.85	1.14	11	3.87	1.03	5	3.78	1.00	2	3.84	1.04	7	.237	.888
Surveillance	4.20	0.89	1	3.74	0.97	12	3.57	1.27	12	3.80	1.06	8	3.535	.171
Elevators and escalators	4.05	1.00	5	3.62	1.11	20	3.65	1.30	5	3.73	1.14	9	1.987	.370
Sensors	4.05	0.83	5	3.62	0.99	20	3.61	1.16	10	3.72	1.01	10	2.350	.309
Gate automation	3.95	1.00	7	3.62	1.16	20	3.65	1.19	5	3.71	1.13	11	1.009	.604
Wireless	3.50	1.10	24	3.82	1.00	8	3.57	1.16	12	3.67	1.07	12	1.385	.500
Video surveillance	3.45	1.10	25	3.72	0.92	13	3.61	1.12	10	3.62	1.01	13	.706	.703
Utility meter	3.60	0.94	20	3.72	1.07	13	3.48	1.16	15	3.62	1.06	13	.719	.698
Power management	3.65	1.14	17	3.77	0.99	9	3.35	1.11	20	3.62	1.06	13	2.315	.314
Data protection	3.80	0.95	14	3.59	1.14	25	3.48	1.16	15	3.61	1.10	16	.678	.712
Ventilation system	3.60	0.99	20	3.77	0.96	9	3.32	1.04	22	3.60	1.00	17	3.013	.222

Features	*Contracting*			*Consulting*			*Government*			*Overall*			*Cronbach's alpha .975*	
	Mean	*SD*	*R*	*Mean*	*SD*	*R*	*Mean*	*SD*	*R*	*Mean*	*SD*	*R*	*Kruskal-Wallis*	*Sig.*
Home theatre	3.10	1.07	46	3.77	1.09	9	3.57	1.16	12	3.55	1.12	18	4.879	.087
Perimeter protection	3.85	1.14	11	3.28	0.97	42	3.65	1.15	5	3.52	1.08	19	4.003	.135
Detector service	3.85	0.93	11	3.64	0.93	17	3.04	1.22	37	3.52	1.06	19	6.783	.034*
Remote audio/video	3.75	0.97	15	3.72	0.97	13	3.00	1.31	40	3.52	1.11	19	6.292	.043*
Fire suppression system (dry, wet)	3.75	1.07	15	3.64	0.87	17	3.09	1.00	32	3.51	0.98	22	6.167	.046*
Water management	3.65	0.99	17	3.46	0.97	27	3.26	1.01	24	3.45	0.98	23	1.565	.457
Touch screens	3.15	0.93	44	3.69	0.92	16	3.22	1.35	25	3.43	1.08	24	5.182	.075
Parking	3.60	1.19	20	3.64	1.11	17	2.91	1.12	45	3.43	1.17	24	6.573	.037*
Data network	3.35	1.14	29	3.62	0.94	20	3.13	1.10	28	3.41	1.04	26	3.463	.177
Energy metering	3.35	1.23	29	3.44	1.02	29	3.39	0.89	18	3.40	1.03	27	.253	.881
Intrusion system	3.65	1.04	17	3.28	1.00	42	3.39	1.12	18	3.40	1.04	27	1.449	.485
Multi-room controls/intercoms	3.20	1.06	40	3.62	1.11	20	3.17	1.11	26	3.39	1.11	29	3.255	.196
Audiovisual	3.30	1.08	34	3.38	0.94	34	3.35	1.07	20	3.35	1.00	30	.440	.803
Automated landscaping/Irrigation	3.55	1.05	23	3.37	1.13	36	3.13	1.14	28	3.35	1.11	30	1.373	.503
Alarm monitoring	3.45	1.15	25	3.46	1.02	27	3.09	1.16	32	3.35	1.09	30	1.756	.416
Digital signage	3.35	1.14	29	3.41	1.09	31	3.13	1.10	28	3.32	1.10	33	1.170	.557
Voice network	3.40	1.05	27	3.38	0.96	34	3.13	1.32	28	3.32	1.09	33	.897	.638

SD = Standard Deviation; R = Rating; *Sig. p=<.05

Table 5: Respondents' awareness of IBs features (continued)

Features	*Contracting*			*Consulting*			*Government*			*Overall*			*Cronbach's alpha .975*	
	Mean	*SD*	*R*	*Mean*	*SD*	*R*	*Mean*	*SD*	*R*	*Mean*	*SD*	*R*	*Kruskal-Wallis*	*Sig.*
System control	3.05	1.19	51	3.56	1.07	26	3.09	1.04	32	3.30	1.11	35	4.710	.095
Multi-media room control	3.10	1.21	46	3.44	1.12	29	3.17	1.27	26	3.28	1.18	36	1.297	.523
Notification system	3.30	1.17	34	3.36	0.99	37	3.04	1.19	37	3.26	1.09	37	1.378	.502
Audio and volume control	3.10	1.25	46	3.41	1.12	31	3.09	1.35	32	3.24	1.21	38	1.660	.436
Energy management	2.90	0.97	57	3.36	0.90	37	3.30	1.15	23	3.23	1.00	39	3.856	.145
Game controls	3.10	1.17	46	3.41	0.94	31	3.04	1.11	37	3.23	1.05	39	2.732	.255
DG set monitoring	3.40	1.05	27	3.21	0.86	49	3.09	1.24	32	3.22	1.02	41	1.247	.536
IPTV	3.25	1.12	37	3.36	0.93	37	2.91	1.12	45	3.21	1.04	42	3.626	.163
Appliances control	3.25	1.07	37	3.31	1.00	40	2.96	1.33	44	3.20	1.12	43	1.287	.525
Digital video recorder and set top boxes	3.20	1.15	40	3.23	0.87	48	3.00	0.90	40	3.16	0.95	44	1.398	.497
Chiller management	3.35	1.09	29	3.28	0.89	42	2.78	1.09	51	3.16	1.01	44	4.594	.101
Voice control system	3.20	1.15	40	3.28	1.02	42	2.87	1.14	49	3.15	1.09	46	2.531	.282
Water leak system monitor	3.35	1.09	29	3.15	0.90	51	2.91	1.12	45	3.13	1.02	47	2.042	.360
AV system	3.15	1.27	44	3.28	0.92	42	2.87	1.25	49	3.13	1.11	47	1.626	.444
Remote home	3.25	1.16	37	3.31	1.00	40	2.70	1.18	54	3.12	1.12	48	4.822	.090
Entire house automated control system	3.20	1.28	40	3.26	1.19	47	2.74	1.21	52	3.10	1.22	50	2.658	.265

Features	*Contracting*			*Consulting*			*Government*			*Overall*			*Cronbach's alpha .975*	
	Mean	*SD*	*R*	*Mean*	*SD*	*R*	*Mean*	*SD*	*R*	*Mean*	*SD*	*R*	*Kruskal-Wallis*	*Sig.*
Patient monitoring	3.05	1.28	51	3.21	1.15	49	2.91	1.24	45	3.09	1.20	51	1.296	.523
Leak detection	3.30	0.98	34	3.08	1.01	52	2.74	1.05	52	3.04	1.02	52	3.118	.210
Load-shedding system	3.05	0.94	51	2.95	1.05	58	3.00	1.09	40	2.99	1.02	53	.083	.960
Zone and climate control	3.00	0.92	55	2.90	0.94	59	3.00	1.17	40	2.95	0.99	54	.047	.977
VESDA system	3.10	1.07	46	3.08	1.01	52	2.57	0.95	57	2.94	1.02	55	5.079	.079
Health/medical/fitness record vault	2.95	1.19	56	3.00	1.03	56	2.65	1.19	55	2.89	1.11	56	2.015	.365
Paging system	3.05	1.15	51	3.08	0.93	52	2.43	1.04	59	2.89	1.04	56	7.631	.022*
Health/medical alert system	2.85	1.18	59	3.05	1.12	55	2.61	1.31	56	2.88	1.19	58	2.319	.314
Vending machine	2.90	1.17	57	3.00	1.10	56	2.57	1.27	57	2.85	1.17	59	2.640	.267

SD = Standard Deviation; R = Rating; *Sig. p=<.05

can be done in various ways, the most common method being the use of on/off switches in the vast majority of buildings. This method could waste energy as lights could be left on when not needed. However, IBS uses automatic lighting control system (Ahmed, 2009). The high ranking of fire alarm system is the result of a statutory requirement in building standards. Buildings, depending on their magnitude and purpose, are expected to be equipped with a fire alarm system such as smoke detectors and fire alarms. A fire alarm system plays a vital role in ensuring the safety of lives and properties of occupants allowing occupants to evacuate safely and enabling fire fighters to extinguish fires in time (Samuel, 2013). The high ranking of access control and lock, CCTV camera is justified by the level of insecurity in Nigeria occasioned by banditry and Boko Haram insurgency, where public commercial buildings need to scale up their level of security. The top ranking of elevators and escalators complies with the statutory requirements designed for vertical transportation in high-rise buildings in the State. The low rankings of health/medical alert system, zone and climate control, as well as VESDA system indicate the professionals' low familiarity with innovation in buildings in Nigeria (Iwuagwu & Iwuagwu, 2014). This finding agrees with Onungwa, Uduma-Olugu & Igwe (2017: 25) that the use of modern methods and ICT are not well developed in developing countries such as Nigeria.

Further analysis was carried out to understand the difference in the perception of the three categories of professionals surveyed, using the Kruskal-Wallis test (Table 6). The test of significant difference is established at $p<0.05$. The findings showed that there is no statistically significant difference in the professionals' perception on the utilisation level of the features in contracting, consulting, and government organisations, except for eleven features. These features include access control and locks (p=.02), video surveillance (p=.03), remote audio/video (p=.04), alarm monitoring (p=.04), appliance control (p=.04), leak detector (p=.02), health/ medical alert system (p=.02), CCTV system (p=.07), intrusion system (p=.06), patient monitoring (p=.07), and health/medical/fitness record vault (p=.07).

Table 6: Utilisation of IBs features

Features	Contracting			Consulting			Government			Overall			Cronbach's alpha .977	
	Mean	SD	R	Mean	SD	R	Mean	SD	R	Mean	SD	R	Kruskal-Wallis	Sig.
Lighting system	3.35	0.99	2	3.74	1.07	2	3.48	1.04	2	3.57	1.04	1	2.40	0.30
Fire alarm system	3.45	0.83	1	3.56	1.07	5	3.35	1.23	4	3.48	1.06	2	0.57	0.75
Access control and locks	3.10	1.02	8	3.79	1.13	1	3.17	1.07	19	3.45	1.12	3	7.67	0.02*
CCTV system	3.05	1.05	11	3.72	1.10	3	3.35	1.19	4	3.45	1.13	4	5.46	0.07
HVAC system (heating, ventilation and air conditioning)	3.35	1.23	2	3.64	1.06	4	3.13	1.25	21	3.43	1.17	5	2.70	0.26
Elevators and escalators	3.20	1.06	6	3.49	1.25	7	3.48	1.16	2	3.41	1.18	6	0.91	0.63
Surveillance	3.20	0.95	6	3.46	1.05	9	3.35	1.11	4	3.37	1.04	7	0.96	0.62
Power management	3.35	1.09	2	3.38	1.14	14	3.35	1.03	4	3.37	1.08	8	0.15	0.93
Alarms and alerts	3.05	1.10	11	3.51	1.14	6	3.17	0.98	19	3.30	1.10	9	3.04	0.22
Video surveillance	2.80	0.77	35	3.38	1.02	14	3.57	1.20	1	3.29	1.05	10	7.10	0.03*
Utility meter	3.00	1.21	15	3.41	1.27	13	3.35	1.11	4	3.29	1.21	11	1.55	0.46
Home theatre	3.10	1.21	8	3.33	1.18	16	3.30	1.33	9	3.27	1.22	12	0.57	0.75
Ventilation system	3.05	0.94	11	3.49	1.05	7	3.04	0.98	27	3.26	1.02	13	4.31	0.12
Camera system	3.05	1.36	11	3.46	1.02	9	3.09	1.24	24	3.26	1.17	14	2.10	0.35
Sensors	2.90	1.02	24	3.44	1.10	12	3.13	1.06	21	3.22	1.08	15	3.35	0.19
Fire suppression system (dry, wet)	3.10	0.72	8	3.26	1.07	23	3.22	1.24	13	3.21	1.04	16	0.40	0.82
Water management	2.95	0.76	18	3.31	1.10	18	3.22	0.74	13	3.20	0.94	17	2.49	0.29

Features	Contracting			Consulting			Government			Overall			Cronbach's alpha .977	
	Mean	SD	R	Mean	SD	R	Mean	SD	R	Mean	SD	R	Kruskal-Wallis	Sig.
Wireless	2.95	0.89	18	3.23	1.06	25	3.30	1.22	9	3.18	1.07	18	1.24	0.54
Gate automation	2.70	0.92	45	3.33	1.08	16	3.30	1.06	9	3.17	1.06	19	5.96	0.05
Remote audio/video	2.95	1.36	18	3.46	1.07	9	2.78	1.09	39	3.15	1.18	20	6.37	0.04*
Touch screens	2.70	1.17	45	3.31	1.08	18	3.26	1.32	12	3.15	1.19	21	3.93	0.14
System control	3.00	1.03	15	3.13	1.08	35	3.22	1.20	13	3.12	1.09	22	0.47	0.79
Data protection	2.85	0.93	28	3.18	1.07	30	3.22	1.04	13	3.11	1.03	23	1.56	0.46
Energy management	2.85	1.04	28	3.28	0.89	21	3.04	0.88	27	3.11	0.93	23	3.41	0.18
Detector service	3.25	0.91	5	3.13	1.06	35	2.91	1.12	32	3.10	1.04	24	1.13	0.57
Parking	2.95	1.05	18	3.28	1.26	21	2.91	1.38	32	3.10	1.24	25	1.70	0.43
Audiovisual	2.70	0.92	45	3.21	1.15	27	3.22	0.90	13	3.09	1.04	27	4.11	0.13
Audio and volume control	3.00	1.26	15	3.21	1.13	27	2.96	1.07	31	3.09	1.14	28	0.89	0.64
Perimeter protection	2.80	0.89	35	3.26	1.23	23	3.00	1.17	29	3.07	1.14	30	1.94	0.38
Voice network	2.90	0.85	24	3.31	1.06	18	2.83	1.19	37	3.07	1.06	29	3.28	0.19
Alarm monitoring	2.55	0.83	56	3.21	1.06	27	3.22	1.17	13	3.05	1.06	31	6.41	0.04*
Energy metering	2.70	1.03	45	3.18	1.14	30	3.13	1.06	21	3.05	1.10	32	2.89	0.24
Multi-media room control	2.95	1.19	18	3.08	1.11	37	3.09	1.12	24	3.05	1.12	33	0.13	0.94

Table 6: Utilisation of IBs features (continued)

Features	*Contracting*			*Consulting*			*Government*			*Overall*			*Cronbach's alpha .977*	
	Mean	*SD*	*R*	*Mean*	*SD*	*R*	*Mean*	*SD*	*R*	*Mean*	*SD*	*R*	*Kruskal-Wallis*	*Sig.*
Data network	2.65	0.75	54	3.18	1.07	30	3.09	1.24	24	3.02	1.07	34	3.75	0.15
DG set monitoring	2.90	0.91	24	3.08	0.96	37	2.87	1.06	36	2.98	0.97	35	0.71	0.70
Multi-room controls/intercoms	2.70	1.13	45	3.08	1.04	37	3.00	1.17	29	2.96	1.09	36	1.48	0.48
Notification system	2.75	1.12	41	3.15	1.18	34	2.78	0.95	39	2.95	1.11	37	2.55	0.28
Intrusion system	2.70	0.80	45	3.23	1.16	25	2.70	1.18	43	2.95	1.11	37	5.64	0.06
Digital signage	2.75	0.91	41	3.08	1.13	37	2.78	1.04	39	2.91	1.06	39	2.14	0.34
Chiller management	2.85	1.14	28	2.92	1.09	49	2.83	0.94	37	2.88	1.05	40	0.18	0.92
Water leak system monitor	2.95	0.94	18	3.00	1.08	42	2.57	0.99	48	2.87	1.03	41	3.19	0.20
Appliances control	2.80	1.28	35	3.18	1.10	30	2.39	1.16	52	2.87	1.19	42	6.55	0.04*
Automated landscaping/ Irrigation	2.90	0.64	24	2.95	1.02	47	2.65	1.15	46	2.85	0.98	43	1.26	0.53
Game controls	2.85	0.99	28	2.79	1.06	56	2.91	1.08	32	2.84	1.04	44	0.06	0.97
Voice control system	2.85	1.23	28	3.05	1.17	41	2.48	1.20	51	2.84	1.20	45	3.46	0.18
AV system	2.85	0.93	28	3.00	1.15	42	2.52	1.04	49	2.83	1.08	46	2.56	0.28
Digital video recorder and set top boxes	2.65	0.75	54	2.97	0.87	45	2.70	1.15	43	2.82	0.93	47	2.76	0.25
Remote home	2.70	1.08	45	2.87	0.98	52	2.74	1.14	42	2.79	1.04	48	0.70	0.71
Vending machine	2.80	0.83	35	2.90	1.10	51	2.52	1.31	49	2.77	1.10	49	2.30	0.32

Features	*Contracting*			*Consulting*			*Government*			*Overall*			*Cronbach's alpha .977*	
	Mean	*SD*	*R*	*Mean*	*SD*	*R*	*Mean*	*SD*	*R*	*Mean*	*SD*	*R*	*Kruskal-Wallis*	*Sig.*
IPTV	2.50	0.95	57	2.79	0.92	56	2.91	1.20	32	2.76	1.01	50	1.41	0.49
Leak detection	2.85	1.04	28	2.97	0.99	45	2.26	0.75	58	2.74	0.98	51	7.72	0.02*
Patient monitoring	2.70	1.03	45	3.00	1.21	42	2.35	1.11	53	2.74	1.16	52	5.27	0.07
Entire house automated control system	2.75	0.97	41	2.95	1.12	47	2.30	0.88	55	2.72	1.05	53	5.86	0.05*
Load-shedding system	2.50	1.24	57	2.82	1.00	53	2.65	1.07	46	2.70	1.07	54	1.67	0.43
Health/medical/fitness record vault	2.70	0.86	45	2.92	1.13	49	2.30	1.22	55	2.70	1.12	55	5.34	0.07
Paging system	2.80	1.20	35	2.82	1.10	53	2.30	0.82	55	2.67	1.07	56	3.36	0.19
Zone and climate control	2.50	1.32	57	2.69	0.92	59	2.70	0.93	43	2.65	1.02	57	1.28	0.53
Health/medical alert system	2.80	0.95	35	2.82	0.97	53	2.22	1.28	59	2.65	1.08	58	7.44	0.02*
VESDA system	2.75	1.07	41	2.72	1.15	58	2.35	0.78	53	2.62	1.04	59	1.88	0.39

SD = Standard Deviation; R = Rating; *Sig. p=<0.05

4.3.2 Percentage of utilisation of intelligent building features

Table 7 shows the percentage of utilisation of IB features among the respondents' organisations in the study area. CCTV system had the highest percentage (73.5%), lighting system ranked second (71.75%), HVAC system (heating, ventilation, and air conditioning) ranked third (71.5%), camera system ranked fourth (70.5%), and ventilation system ranked fifth (70.05%). The features with the least level of utilisation were vending machines (37.75%), game controls (39.5%), digital video recorder, and set top boxes (42.25%). The varying levels of utilisation of IB features reflect the different levels at which these features are used in Nigeria. This could also be as a result of the difference in the respondents' level of exposure and experience in construction projects, especially with respect to IBs.

As the feature with the highest percentage of utilisation among the respondents in the study area, the CCTV system is the result of its high usage mainly for security in Nigeria. CCTV system is one of the simplest forms of ensuring security in buildings (Smith, 2010: online; Mohammed, 2015). It is used in several hotels, factories, corporate organisations, public organisations, banking halls, supermarkets, business environments, and even in religious buildings and individual residential facilities. The growing need for security and monitoring coupled with its affordability greatly influenced its high utilisation in Nigeria. The high percentage utilisation of the lighting system is as expected. Besides being a primary requirement in modern buildings, an energy-efficient lighting system enhances both the design and the performance of buildings. Modern lighting systems are known to be energy efficient, even while accentuating an attractive environment (Ahmed, 2009). Due to the introduction of prepaid metering systems for electricity consumption, energy-efficient lighting is rapidly being embraced in Nigeria. The HVAC system also recorded a high level of utilisation. The reason for this is that, in Nigeria, air-conditioning systems are now common features in many residential facilities, supermarkets, event centres, religious buildings, banking halls, hotels/motels, as well as in other commercial and public buildings. Air-conditioning cooling systems are very important in African countries such as Nigeria, which are characterised by hot climate and where thermal comfort of building occupants is a matter of priority to ensure comfortable and satisfactory environment for occupants.

Vending machines, game controls, digital video recorders, and set top boxes, which are well utilised in developed countries, were the features with the least percentages of utilisation among the respondents in the study area. The reason for this is that Nigeria is a developing country, where the use of modern methods, techniques, innovations, and technology is still in its infancy. This is supported by Onungwa *et al*. (2017: 25) that Nigeria is lagging behind in the use of innovative tools in its construction industry, and

Table 7: Percentage of utilisation of intelligent building features

Components	*Mean (%)*	*Components*	*Mean (%)*
CCTV system	73.5	Water management	57
Lighting system	71.75	Fire suppression system (dry, wet)	56.75
HVAC system (heating, ventilation, and air conditioning)	71.5	Entire house automated control system	56.5
Camera system	70.5	Energy metering	56
Ventilation system	70.05	Detector service	55.55
Surveillance	69	Digital signage	55.5
Gate automation	68.25	Leak detection	55
Alarms and alerts	68.25	Appliances control	54.75
Access control and locks	67.5	Load-shedding system	54.44
Elevators and escalators	65.3	Water leak system monitor	53.75
Sensors	64.75	Health/medical/fitness record vault	53.25
Remote audio/video	63.75	DG set monitoring	53
Perimeter protection	63.65	Audio and volume control	53
Data protection	63.25	Patient monitoring	52.75
Power management	63.15	Alarm monitoring	52.5
Wireless	62.5	Multi-media room control	52.25
Utility meter	61.5	Intrusion system	52
Video surveillance	61.25	Automated landscaping/ Irrigation	52
Data network	60.75	System control	51.95
Touch screens	59.85	VESDA system	51.5
Parking	59.75	Home theatre	51.15
AV system	59.1	Zone and climate control	50.25
Audiovisual	58.9	Health/medical alert system	50
Voice control system	58.5	Paging system	48.5
Voice network	58.25	Remote home	45
Multi-room controls/intercoms	57.9	IPTV	44.55
Notification system	57.7	Digital video recorder and set top boxes	42.25
Chiller management	57.5	Game controls	39.5
Fire alarm system	57.5	Vending machine	37.75
Energy management	57.35		

that it is slow in adopting modern techniques. There are several features of IBs not yet in use in Nigeria and, if some are in use, they have not gained wide coverage. This accounts for the low percentage in utilisation ranking of IB features such as vending machines, game controls, digital video recorder and set top boxes, remote home, paging system, health/medical alert system, zone and climate control.

5. CONCLUSION

This article examined the level of awareness and utilisation of features of IBS in the Nigerian construction industry. The study established that the level of awareness of IB features has risen higher among construction professionals (90.24%) in the study area. However, only 13 buildings employed IBS, despite the high number of ongoing construction projects and commercial activities in the study area. This study established that the adoption of the system is still low. The IB features with the top ranked level of awareness are CCTV system, access control and locks, alarms and alerts, HVAC system, and fire alarm systems. Among these, those with a high level of utilisation include lighting system, which was the most utilised feature, fire alarm system, access control and lock, CCTV system, and HVAC system. The study revealed that most of the features with a high level of awareness also have a high level of utilisation. The features of intelligence with hi-tech and high sophistication such as health/medical/fitness record vault and paging system, health/medical alert system, vending machines, game controls, digital video recorder, and set top boxes have a low level of usage. This indicates the evolving state of adoption of IBs in the Nigerian construction industry. This study concluded that the awareness of the IBS and its features and the utilisation of its features are prevalent among construction professionals in Nigeria. However, the overall adoption of the system is still in its infancy. The study indicated the implications for enlightenment of construction stakeholders and retraining of the professionals for an improved adoption of IBs. Further study in this domain may adopt a mixed methodology with a larger sample size.

REFERENCES

Adejimi, A. 2005. Intelligent building and relevance of design professionals in the global age. In: Fadare, W. & Ajayi, A. (Eds). *Proceedings of the Conference on Globalization, Culture and the Nigerian Built Environment*, vol. II, 6 April. Obafemi Awolowo University, Ile-Ife, Nigeria, pp.142-146.

Ahmed, M.G. 2009. Intelligent buildings: Challenges and benefits of implementation in Nigeria. Unpublished B.Sc. thesis, Ahmadu Bello University, Zaria.

Alessandra, D. 2018. Intelligent systems for smart building management. Networking and Distributed Systems. Available at: <http://www.diid.unipa.it/networks> [Accessed: 12 September 2020].

AlFaris, F., Juaidi, A. & Manzano-Agugliaro, F. 2017. Intelligent homes' technologies to optimize the energy performance for the net zero energy home. *Energy and Buildings*, 153, pp. 262-274. https://doi.org/10.1016/j.enbuild.2017.07.089

Ameh, O.J. & Osegbo, E.E. 2011. Study of relationship between time overrun and productivity on construction sites. *International Journal of Construction Supply Chain Management*, 1(1), pp. 56-67. https://doi.org/10.14424/ijcscm101011-56-67

Ang, K.H., Chong, G.C.Y. & Li, Y. 2005. PID control system analysis, design, and technology. *IEEE Transactions on Control SystemsTechnology*, 13(4), pp. 559-576. https://doi.org/10.1109/TCST.2005.847331

Barrie, D.S. & Paulson, B.C. 1992. *Professional construction management*. London: McGraw-Hill, Inc.

Bartlett, E. & Howard, N. 2000. Informing the decision makers on the cost and value of green building. *Building Research and Information*, 28(5-6), pp. 315-324. https://doi.org/10.1080/096132100418474

Bewick, V., Cheek, L. & Ball, J. 2003. Statistics review 7: Correlation and regression. *Critical Care*, 7(6), pp. 451-459. https://doi.org/10.1186/cc2401

Bharathi, N.G. 2018. Communication trends in internet of things. In: Sugumaran, V. (Ed.). *Developments and trends in intelligent technologies and smart systems*. London: IGI Global, pp. 284-305. https://doi.org/10.4018/978-1-5225-3686-4.ch014

Boodi, A., Beddiar, K., Benamour, M., Amirat, Y. & Benbouzi, M. 2018. Intelligent systems for building energy and occupant comfort optimization: A state of the art review and recommendations. *Energies*, 11(10), article nr 2604. https://doi.org/10.3390/en11102604

Bradley, J., Tomlin, P. & Mathews, B. 2018. Building intelligent infrastructures: Steps toward designing IoT-enabled library facilities. *Library Technology Report*, 54(1), pp. 23-27.

Braun, J.E. 2007. Intelligent building system – Past, present, and future. In: *Proceedings of the 2007 American Control Conference*, 11-13 July, Marrriot Marquis Hostel, Times Square, New York, USA, pp. 4371-4384. https://doi.org/10.1109/ACC.2007.4282463

Chen, Z., Clements-Croome, D., Hong, J., Li, H. & Xu, Q. 2006. A multicriteria lifespan energy efficiency approach to intelligent building assessment. *Energy and Building,* 38(5), pp. 393-409. https://doi.org/10.1016/j.enbuild.2005.08.001

CIBTIN (China Intelligent Building Technology Information Network). 2002. Available at: <http ://www. ib-china.com/> [Accessed: 4 November 2019].

Clements-Croome, D. 2015. Creative and productive workplaces: A review. *Intelligent Buildings International,* 7(4), pp.164-183. https://doi.org/10.1080/17508975.2015.1019698

Climate World (2006): Intelligent ("smart") building at to "Climate World" Exhibition. http://www.climatexpo.com/topics/smart/

Climate World (2006): Intelligent ("smart") building at to "Climate World" Exhibition. http://www.climatexpo.co m/topics/smart/

Field, A. 2009. *Discovering statistics using SPSS.* Third edition. London: Sage.

Flax, B.M. 1991. Intelligent building. *IEEE Communication Magazine*, April, pp. 24-27. https://doi.org/10.1109/35.76555

Frank, O.L. 2007. Intelligent building concept: The challenges for building practitioners in the 21st century. *Journal of the Association of Architectural Educators in Nigeria*, 6(3), pp. 107-114.

Ghaffarianhoseini, A., Berardi, U., AlWaer, H., Chang, S., Halawa, E., Ghaffarianhoseini, A. & Clement-Croome, D. 2015. What is an intelligent building? Analysis of recent interpretations from an international perspective. *Architectural Science Review*, 59(5), pp. 338-357. https://doi.org/10.1080/00038628.2015.1079164

Hakkinen, T. & Belloni, K. 2011. Barriers and drivers for sustainable building. *Building Research and Information*, 39(3), pp. 239-255. https://doi.org/10.1080/09613218.2011.561948

Hydes, K.R. & Creech, L. 2000. Reducing mechanical equipment cost: The economics of green design. *Building Research & Information*, 28(5-6), pp. 403-407. https://doi.org/10.1080/096132100418555

Idrus, A.B. & Newman, J.B. 2002. Construction-related factors influencing the choice of concrete floor systems. *Construction Management Economics*, 20(1), pp.13-19. https://doi.org/10.1080/01446190110101218

I-Scoop. 2018. Smart homes automation. Available at: <https://www.i-scoop.eu/smart-home-home-automation/> [Accessed: 7 November 2019].

Iwuagwu, B.I. & Chioma, M. 2014. Adopting intelligent buildings in Nigeria: The hopes and fears. In: *Proceedings of the 2nd International Conference* *on Emerging Trends in Engineering and Technology* (ICETET'2014), 30-31 May, London, pp.160-163.

Johnny, K.W. & Heng, L. 2008. Application of the analytic hierarchy process (AHP) in multi-criteria analysis of the selection of intelligent building systems. *Building and Environment*, 43(1), pp. 108-125. https://doi.org/10.1016/j.buildenv.2006.11.019

Jin, M., Jia, R., Das, H.P., Feng, W. & Spanos, C. 2018. BISCUIT: Building Intelligent System Customer Investment Tools. In: Yan, J. (Ed.). *Tenth International Conference on Applied Energy (ICAE2018), 22-25 August, HongKong, China*. New York: Curran Associates, Inc., pp. 6152-6157. https://doi.org/10.1016/j.egypro.2019.01.495

Kothari, C.R. 2004. *Research methodology: Methods and technique*. Second revised edition. New Delhi: New Age International (P) Limited Publishers.

Lilis, G., Conus, G., Asadi, N. & Kayal, M. 2016. Towards the next generation of intelligent buildings: An assessment study of current automation and future IoT-based systems with a proposal for transitional design. *Sustainable Cities and Society*, 28(1), pp. 473-481. https://doi.org/10.1016/j.scs.2016.08.019

Luo, R.C., Lin, T.Y. & Su, K.L. 2009. Multi sensor-based security robot system for intelligent building. *Robotics and Autonomous Systems*, 57(3), pp. 330-338. https://doi.org/10.1016/j.robot.2008.10.025

Masia, T., Kajimo-Shakantu, K. & Opawole, A. 2020. A case study on the implementation of green building construction in Gauteng Province, South Africa. *Management of Environmental Quality*, 31(3), pp. 602-623. https://doi.org/10.1108/MEQ-04-2019-0085

Matar, M.M., Georgy, M.E. & Ibrahim, M.E. 2008. Sustainable construction management: Introduction of the operational context space (OCS). *Construction Management and Economics,* 26(2008), pp. 261-275. https://doi.org/10.1080/01446190701842972

Mohammed, Z.M. 2015. An assessment of the level of awareness of intelligent buildings amongst Nigerian architects. Unpublished B.Sc. thesis, Ahmadu Bello University, Zaria, Nigeria.

Nasila, M. & Cloete, C. 2018. Adoption of building information modelling in the construction industry in Kenya. *Acta Structilia*, 25(2), pp. 1-38. https://doi.org/10.18820/24150487/as25i2.1

Nguyen, T.A. & Aiello, M. 2012. Energy intelligent buildings based on user activity: A survey. *Energy Building*, 56, pp. 244-257. https://doi.org/10.1016/j.enbuild.2012.09.005

Ojeh, V., Balogun, A. & Okhimamhe, A. 2016. Urban-rural temperature differences in Lagos. *Climate*, 4(29), pp. 1-18. https://doi.org/10.3390/cli4020029

Oke, A.E., Aigbavboa, C. & Omole, O. 2020. Benefits of adopting intelligent building system. FIG Working Week, 10-14 May. Smart surveyors for land and water management, Amsterdam, The Netherlands.

Onanuga, M., Eludoyi, A.O. & Ofoezie, E.I. 2022. Urbanization and its effects on land and water resources in Ijebuland, southwestern Nigeria. *Environment Development and Sustainability*, 24(5), pp. 592-616. https://doi.org/10.1007/s10668-021-01458-1

Onungwa, I.O., Uduma-Olugu, N. & Igwe, J.M. 2017. Building information modelling as a construction management tool in Nigeria. *WIT Transactions on The Built Environment*, 169(1), pp. 25-33. https://doi.org/10.2495/BIM170031

Onyenokporo, N.C. & Ochedi, E.T. 2018. Low-cost retrofit packages for residential buildings in hot-humid Lagos, Nigeria. *International Journal of Building Pathology and Adaptation*, 37(3), pp. 250-272. https://doi.org/10.1108/IJBPA-01-2018-0010

Osama, O. 2018. Intelligent building, definitions, factors, and evaluation criteria of selection. *Alexandria Engineering Journal*, 57, pp. 2903-2910. https://doi.org/10.1016/j.aej.2018.07.004

Owajionyi, L.F. 2007. Intelligent building concept: The challenges for building practitioners in the 21st century. *Journal of Association of Architecture Educators Niger*, 6(3), pp. 107-113.

Pavel, S., Khomenko, T. & Ternovay, G. 2019. Numerical optimization of the transfer function of the intelligent building management system. *E3S Web of Conferences, 97*, article nr 01008. DOI: https://doi.org/10.1051/e3sconf/20199701008

Ramesh, S. & Emran Khan, M. 2013. Energy efficiency in green buildings – Indian concept. *International Journal of Emerging Technology and Advanced Engineering*, 3(3), pp. 329-336.

Robinson, H.S., Carrillo, P.M., Anumba, C.J. & Al-Ghassani, A.M. 2005. Knowledge management practices in large construction organisations. *Engineering, Construction and Architectural Management*, 12(5), pp. 431-445. https://doi.org/10.1108/09699980510627135

Samuel, H.N. 2013. Assessment of intelligent building and its prospects in Zaria. Unpublished B.Sc. thesis, Ahmadu Bello University, Zaria, Nigeria.

Shah, A., Nasir, H., Fayaz, M., Lajis, A. & Shah, A. 2019. A review on energy consumption optimization techniques in IoT-based smart building environments. *Information*, 10(3), article nr 108. https://doi.org/10.3390/info10030108

Seeley, I.H. 1997. *Quantity surveying practice*. Second edition. London: Macmillan Press. https://doi.org/10.1007/978-1-349-14402-0

Smith, T. 2010. Advantages and disadvantages of smart buildings. Available at: <www.edn.com> [Accessed: 17 December 2020].

Taber, K.S. 2018. The use of Cronbach's *alpha* when developing and reporting research instruments in science education. *Research in Science Education*, 48(6), pp. 1273-1296. DOI: https://doi.org/10.1007/s11165-016-9602-2

Tomlinson, B. 2010. Greening through IT. *Journal Information Technology for Environmental Sustainability*. Cambridge, UK: MIT Press. https://doi.org/10.7551/mitpress/8261.001.0001

Trochim, W.M.K. 2007. *The research method knowledge based.* Third edition. Cincinnati, Ohio: Atomic Dog Publishing.

Van Laerhoven, H., Van der Zaag-Loonen, H.J. & Derkx, B.H.F. 2004. A comparison of Likert scale and visual dialogue scales as response options in children's questionnaires, *Acta Paediatric*, 93(1), pp. 830-835. https://doi.org/10.1111/j.1651-2227.2004.tb03026.x

Williams, K. & Dair, C. 2007. What is stopping sustainable building in England? Barriers experienced by stakeholders in delivering sustainable developments. *Sustainable Development*, 15(3), pp. 135-147. https://doi.org/10.1002/sd.308

Wong, J., Li, H. & Lai, J. 2008. Evaluating the system intelligence of the intelligent building systems. Part 1: Development of key intelligent indicators and conceptual analytical framework. *Automation in Construction*, 17, pp. 284-302. https://doi.org/10.1016/j.autcon.2007.06.002

Wong, J., Li, H. & Wang, S. 2005. Intelligent building research: A review. *Automation in Construction*, 14(1), pp. 143-159. https://doi.org/10.1016/j.autcon.2004.06.001

Woodrow, L. 2014. Presenting descriptive statistics. In: Woodrow, L. (Ed.). *Writing about quantitative research in Applied Linguistics*. London: Palgrave Macmillan, pp. 49-60. https://doi.org/10.1057/9780230369955_5

Zhou, L. & Lowe, D.J. 2003. Economic challenges of sustainable construction. In: Proverbs, D. (Ed.). *Proceedings of the RICS Foundation Construction and Building Research Conference*, 1-2 September, School of Engineering and the Built Environment, University of Wolverhampton. RICS Foundation, pp. 113-126.