Determining the Stationary Barriers to the implementation of Radio Frequency Identification (RFID) technology in an emerging construction industry

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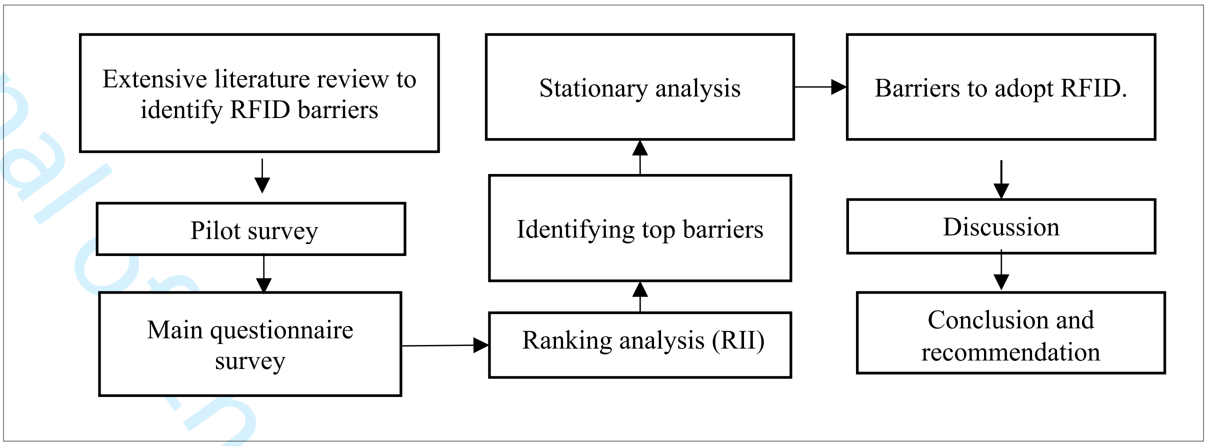

Figure 1. Research framework

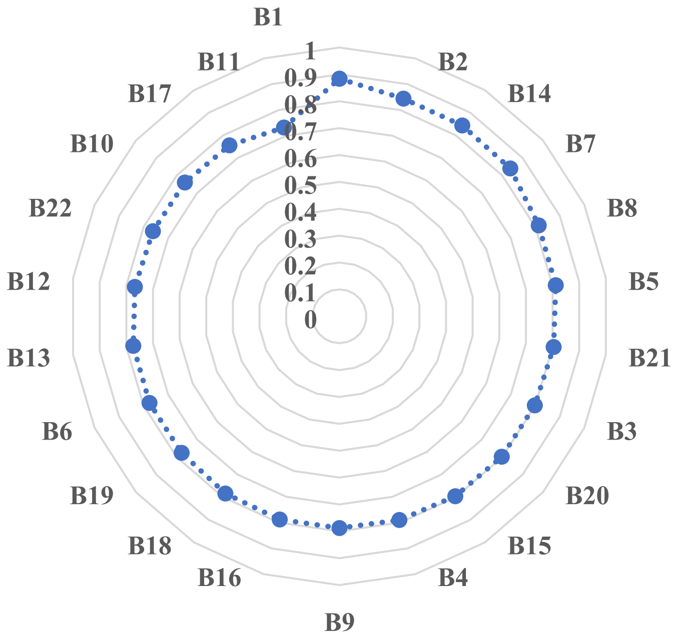

Figure2: RII for RFID barriers

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Abstract

Purpose- To realize full benefits without sacrificing the practicality of such projects, the decision-making process for residential building construction needs to include sustainability principles at every level. Therefore, this paper aims to investigate the applicability of Radio Frequency Identification (RFID) and identify the barriers that impede its successful adoption in construction projects to achieve sustainability.

Design/Methodology-The paper opted for a quantitative approach by using a structured questionnaire survey. A total of 107 responses were collected from Nigerian construction practitioners involved in private and public construction businesses.

Findings- The results showed the high cost of RFID implementation, with a mean score of 4.42 as the top-ranked barrier, followed by lack of security, maintenance, power availability, and inadequate training. The study further deployed Ginni's mean difference measure of dispersion and revealed that the stationary barrier to adopting RFID technology is the lack of demand.

Practical implications – The findings of this research can assist decision-makers in improving the sustainability of all building projects by implementing RFID.

Originality /value - The findings of this study will serve as the basis for comprehension and critically evaluate the numerous barriers preventing the widespread adoption of RFID technology.

Keywords: Radio Frequency Identification, Construction Projects, Project Performance, Sustainability.

1. Introduction

The construction sector is dynamic and intricate. A construction project consists of interdependent components and activities that substantially influence the environment and community during their entire life cycle (Oke et al., 2021, Kineber et al., 2020a). SBCI reports that 30% of net greenhouse gas (GHG) emissions in developed and developing nations are attributable to construction projects, which account for more than 40% of the world's energy production (Sbci, 2009). About 40 % of the United States and Europe's comprehensive resources and energy are utilised in the building industry (DoE, 2008, Atanasiu and Attia, 2011). In third-world countries, the sustainability of a building project is rather alarming (Kineber, 2020, Kineber et al., 2020b). Consequently, there is no doubt that the construction sector plays a key role in ensuring that fundamental living standards are met, despite the fact that these nations have engaged in the fast economic expansion (Durdyev et al., 2018). However, the sector required extensive data processing and exchange throughout the project lifecycle to strengthen the economy and enhance productivity in the building sector.

Traditional disciplines encompass a structure's technique of planning, upgrading, and management (structure, electrical, mechanical, and architecture). There are also a number of occupations in disciplines like waste management and environmental science. The majority of these fields have strict technological requirements. Developing wireless technologies, such as Radio Frequency Identification (RFID), have evolved from remoteness into mainstream applications that improve the processing of produced items and materials (Want, 2006). RFID has existed for decades. However, reduced costs and higher capabilities have only recently prompted firms to examine RFID's benefits closely. RFID permits identification from a distance without requiring line of sight, unlike older bar code technology. RFID has several use cases, including the production and delivery of tangible commodities such as automobiles and transmission assembly (Mintchell, 2002) and pharmaceutical packaging processes (Forcinio, 2002), among others. The Radio Frequency Identification (RFID) system makes use of electromagnetic fields in order to identify and automatically track tags that are affixed to "things"(Domdouzis et al., 2007). An electromagnetic interrogation pulse from a nearby RFID reader device triggers the operation of the RFID system, which consists of a miniature radio transponder, a radio receiver, and a transmitter. The tag then transmits digital data, which is typically an inventory identification number, back to the reader (Marwedel and Engel, 2016).

This number can be used for inventory tracking and management of products. According to Kibert [13], sustainable construction necessitates a sustainably implemented ecosystem considering environmental and operational energy usage. However, it is described as a technique initially and after the construction companies have completed the project (Hill and Bowen, 1997). Moreover, the construction business must be revolutionized by introducing innovative, viable and successful construction techniques (Wolstenholme et al., 2009). Thus, encouragement of actions and components of a building project that are environmentally friendly from the very beginning of the project is one way to monitor its likelihood of being successful. RFID offers considerable potential for improving a variety of processes. In today's construction works, RFID can be used in designing and planning a project (Torrent and Caldas, 2009). It can also serve as a monitoring asset in construction, whereby it can be used to monitor the activities going on and off-site (Wang, 2008). Also, the components of an RFID system are a radio transponder, a radio receiver, and a radio transmitter. When an electromagnetic interrogation pulse comes from a nearby RFID reader device, the tag sends digital data—typically an identification asset number—back to the reader. This causes the reader to recognize the tag (Marwedel and Engel, 2016). This enhances inventory tracking of goods. There are two types of radio frequency identification (RFID) tags: active tags are powered by a battery and may be read at a longer range away from the RFID reader, up to hundreds of meters. Passive tags are powered by the energy from the RFID reader's probing radio waves (Ramkumar et al., 2020).

Despite prior studies on the benefits of RFID in the building industry, and inadequate effort has been made to regulate cloud computing advantages in the construction business in third-world nations. However, in demand for this technology, there have only been a few instances of RFID being used in actual building activities. This was billed as a cutting-edge technology that has not yet seen broad use in the construction sector (Wang, 2008), as there are several probable explanations. Project actors may have been unaware of the possible application of RFID in construction. Various technological, financial, or ethical barriers may potentially limit widespread adoption in this diverse industry (Chin et al., 2008). As a result, by investigating the challenges and barriers with RFID deployment in Nigeria's construction sector, this study will contribute to the existing studies on RFID as a burgeoning research subject. In the most current study, RFID is shown as a burgeoning sector, and the researchers highlight issues about the use of RFID technology in the Nigerian construction industry. Regardless of the difficulties that have been recognized in the sector, there is a need to investigate the perspectives of the principal players in the construction industry.

In this regard, the goal of the current research is to evaluate the implementation of RFID practices in the Nigerian construction industry, using Lagos State as a case study, as well as to evaluate the application areas and determine the factors that inhibit the use of cloud computing in the construction industry. In this regard, the research will also evaluate the application areas and determine the factors that inhibit the use of cloud computing in the construction industry. Leveraging RFID to achieve success in sustainable building initiatives will be made easier for decision-makers to achieve high level of productivity in the built domain. Additionally, this may have an impact on the mode of implementation that is used for the execution of construction projects in the context of Nigeria and other developing nations (Aghimien et al., 2018).

In view of the Global-Local Context methodology adoption, the study worth to the globe is highlighted. It represents and intensifies the issues investigated. Moreover, the value of a study may be determined by showing its significance in local and global contexts (Kineber et al., 2021a, Summers, 2019). Consequently, this clarity may be reached by concentrating on "emerging" nations, such as Nigeria (i.e., establishing the importance). As a result, it is possible to execute a successful construction project in Nigeria and other developing countries by cutting down on needless expenditures and increasing productivity via the use of cloud computing (Aghimien et al., 2018). Thus, this article comprises of the state- of-art, followed by the research method used. Then, the findings of this research are then reviewed against current literature. The conclusion highlights the key findings and future research recommendations.

2. Research Background

2.1 Overview of Implementation of RFID

RFID has had a long history commencing with its utilization during the second world war to its modern usage (Domdouzis et al., 2007). The basic architecture of RFID itself consists of a tag, reader and middleware to perform advanced analysis on the data which makes it practical for use of many applications with beneficial outcomes. There are several problems which arise when using the passive tags due to the nature of the system, in particular, the amount of unreliable readings in the raw data (Chen and Aini, 2020b). The physical birth of RFID would not come until the fusion of two technologies was achieved approximately around the era of the world wars. The first technology was the continuous wave radio generation which was created in 1906 by Ernst F.W. Alexanderson. The second technology was the Radar device which is thought to have been developed in 1922 and was utilized extensively in world war 2 (Landt and Catlin, 2001). The combination of these two devices resulted in the concept of RFID which was first academically proposed in the theory by Harry stockman in 1948. During this time, RFID was employed to distinguish between enemy and allied aircrafts in the war. Unfortunately, as stockman notes, technology had not progressed to the point that complete potential of RFID technology could be realized (Landt, 2005b).

According to Conway (2001), RFID research continued to be pursued in both academic community and military aircrafts division who were attempting to develop identification friend or foe" (IFF) technology throughout the 1950s. It was not until the late 1960s, that a sensormatic and article surveillance which consisted of a security system incorporating RFID tags that only stored an "on and off" command to prevent theft in stores. RFID's focus throughout the 1970s was in the tracking of animals and vehicles and, also, with the automation of factories. This technology adoption eventually led to the first RFID-integrated road toll, established in Norway in 1978. It was employed later in various other locations worldwide. In 1990, RFID was integrated into people's daily activities. An example of this includes the utilization of RFID key cards for enhanced security to enable a higher level of integrity for secure locations (Wikramanayake et al., 2009).

2.2 *Implementation of RFID for sustainable construction industry*

Many studies have stressed environmental issues' importance (Oke et al., 2015). Business sustainability transformation, objectives, and implementation strategies are difficult jobs (Aarseth et al., 2017). As a result, there is a need to balance environmental, economic, and social sustainability (Martens and Carvalho, 2017, Oke et al., 2015). The implementation of sustainability in the building industry has sought exact strategies to incorporate this notion into present operational circumstances (Abidin and Pasquire, 2007). Companies' desire for environmental improvement and deciding social responsibility ethics might stimulate larger uses of cloud computing as a vital strategic phase. The use of RFID in construction project administration would accelerate the establishment of viable building partners who would be more helpful, cohesive, and capable of working professionally and collaboratively than previous ways. Building partners can save and retrieve storage development data in real-time using RFID technologies.

This technology has been used for a long time, beginning with applications during WWII and progressing to its present applications (Domdouzis et al., 2007). RFID's core architecture consists of a tag, middleware, and reader to do advanced processing on data, making it suitable for usage in a variety of applications with favorable consequences. Because of the nature of the system, there are several challenges that occur when using passive tags, particularly the amount of erroneous readings in the raw data (Chen and Aini, 2020a). RFID would not have emerged until the merging of two technologies occurred around the time of the world wars. The first technique was the continuous wave radio generator, which was developed by Ernst F.W. Alexanderson in 1906. The Rada device, which is said to have been designed in 1922 and was widely utilised during WWII, was the next technology (Landt, 2005a). The combination of these two instruments resulted in the notion of TFIDD, which was first articulated academically in Harry Stockman's 1948 hypothesis.

During the war, the RFIDD was employed to differentiate between ally and hostile aircraft. Regrettably, as Stockman points out, technology has not evolved to the point where the full promise of RFID technology can be realized (Stockman, 1948). According to Conway (2001), RFID research was relentlessly pushed in military and academic aviation units attempting to create identify friend or foe (IFF) technology in the 1960s. During the late 1960s, the creation of a sensor Matic and Article Surveillance, which consisted of a security system integrating RFID tags that can only store on and off command to combat theft in stores, was noticed. RFID reached a tipping point in the 1970s with the tracking of animals and vehicles, as well as with the automation sectors.

In time, the deployment of this technology resulted in the first RFID-enabled road toll, which was established in Norway in 1978. It was later utilised in several areas across the world. RFID has been incorporated into people's daily routines by 1990. One example is the use of RFIDD keycards to strengthen security and provide a higher level of integrity for protected places (Llamas et al., 2014). Furthermore, RFID enables SMEs to focus on their critical sustainable creativity and lucrative business. Factories must achieve effectiveness in business value enhancement over time by developing an operational business model (Jabłoński and Jabłoński, 2016). Typically, a corporation's complete resources, including effort and time, are committed to its IT department and assigned to other essential divisions within the organisation. Small and medium-sized firms whose primary product is not IT-based do not need to be concerned about updating or preserving their information system (IS). Instead, companies must concentrate on their core competencies to improve the performance and competitiveness of their enterprises. However, it might push them to be innovative and discover new ways to do commercial business (Tehrani and Shirazi, 2014). RFID enables businesses to reach their output objectives while conserving resources. It boosts their operational performance and efficiency by focusing on their essential enterprises rather than con-core companies, including monitoring and upgrading structure, making them more cost-effective.

2.3Barriers to FRID adoption in the construction industry

Consequently, to guarantee that regulation of quality by relevant stakeholders in the construction industry can be properly implemented effectively, it is necessary to remove impediments (Othman et al., 2020a). The absence of a globally accepted standard format is one of the most significant technical challenges facing the use of RFID technology in the construction sector (Erickson et al., 2007). For instance, each retailer uses a different format the implementation cost may be substantial. However, industry associations are in favor of standardization, despite the fact that single retailers might be loath to share their competitive advantage achieved via more efficient inventory tracking or supply chain efficiency. RFID scanners and tags present an additional difficulty. RFID tags generate

UHF waves that are absorbed by water and other liquids; these waves are also reflected by metals, which can result in inaccurate readings. Due to the significant cost- related to setting a precise implementation schedule, additional providers may fail to adhere to it. The Adoption by major merchants such as Wal-Mart and Tesco will reduce the price of tags, an argument that may be used to persuade others of the advantages of investing in new technology. Although RFID has a series of benefits, a large number of companies are still undertaking research and accumulating information on the technology (Vijayaraman and Osyk, 2006). In Sweden, for example, big grocery stores like ICA, Axfood, and Coop have done a few tests, but they don't want to use the technology because it costs a lot to invest and isn't very reliable. Additionally, IKEA has done tests. Firms in other industries, for instance, have partially implemented RFID. For instance, VOLVO Technology (for tracking reasons) and SSAB Oxelo sund are companies (to identify and track material). The adoption of the technology has not been without difficulty, particularly concerning the industrial environment, which has caused issues with tagging and radio wave disturbances. Also, previous research demonstrates that organisations introducing the technology must conduct a fundamental strategic evaluation of their business processes and supplier and distributor relationships (Jones, 2017). Table 1 is a summary of what some writers have said about RFID problems in the construction industry.

(Insert Table1)

3. Study methods and design

This study aims to improve the sustainable construction sector's performance in Nigeria through identifying and exploring the barriers to RFID adoption. For this to happen, exhaustive research of the relevant literature was carried out to identify the obstacles to adopting RFID and a questionnaire survey was utilized to determine the importance of these barriers. This survey was composed of three (3) major sections: the profile of the respondent, the barriers for adopting RFID (Table 1), and the open-ended questions. Three significant stakeholders were contacted: the client contractors and consultants. They could be subdivided by profession or occupation as follows: Quantity surveyors, Builders, Architects, and Engineers. Respondents assessed barriers for adopting RFID technology on an information and experience question, using a 5-point Likert scale, (where 5 = extremely high, 4 = high, 3 = average, 2 = small and 1 = no or very small). This scale was adopted in some previous research (Oke et al., 2022; Kineber et al., 2020b).

The convenience sampling techniques were used in the research. This is to ensure that there is an equal chance of every member being selected. Consequently, the sample size was determined by means of purposive sampling. Due to the nature of the research, which seeks input from building industry actors, this is the case. Furthermore, the sample size employed in this study was determined using a methodological purpose analysis (Badewi, 2016, Kineber et al., 2021b). Consequently, 98 participants out of 119 were addressed in person (self-administered), which corresponds to a response rate of around 82%. This rate of return was deemed acceptable for this sort of investigation (Kothari, 2009, Wahyuni, 2012, A.F. Kineber, 2021). Figure 1. shows the research framework of this study adopted from El-Kholy and Akal (2021).

(Insert Figure1)

3.1 Relative Importance Index (RII)

In addition to examining RFID barriers, this study employed the mean rating and Relative Importance Index (RII)-based characteristics to determine the most important RFID hurdles in the Nigerian construction sector. According to Salleh (2009) RII is a statistical method for determining the ordering of distinct causes, and it is the most popular way for ranking and assessing variables (Yap and Skitmore, 2018, Taiwo et al., 2018, Rahim et al., 2016). 5-point Likert scale and RII shall assess the responses' events' frequency, and intensity shall be assessed by Equation 1(Olomolaiye et al., 1987, Chan and Kumaraswamy, 1997).

$$RII = \frac{\sum w}{A \times N} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5 \times N} \quad (1)$$

Where W is the participant's weighting of each attribute, A is the maximum weight, and N is the total number of participants. Table 2 displays the statistical means, standard deviations, and RII values based on these factors. This rating is then used to cross-compare the relative value of the factors according to the three groupings selected by the respondents (consultants, owners, and contractors). So, this study is able to reveal the most significant barriers to RFID adoption in Nigeria.

3.2 Stationary analysis (Ginni's Mean)

"Ginni's Mean Difference Measure of Dispersion and the Weighted Geometric Mean: The present research followed the methodology of Samuel and Samuel and Ovie. Ginni's Mean Difference Measure of Dispersion and the Weighted Geometric Mean"[52] to determine the most critical barriers. These are the steps of this methodology: a) Determining the mean of dispersion of the RII values by applying Ginni's mean difference measure of dispersion, as demonstrated by Equation (2) (E., 2015):

$$G.M = \frac{G}{M} \quad (2)$$

"Where G.M is Ginni's mean difference dispersion measure, G is the sum of the differences between all possible pairs of variables, and M is the total number of differences, where N is the number of variables":

$$M = \frac{N(N-1)}{2} \quad (3)$$

Using Equation to establish a weight for each RII number based on Ginni's mean difference measure of dispersion (4)(El-Kholy and Akal, 2021):

$$Wi = G.M \times \frac{RIIi}{\mathrm{RII1}} \quad (4)$$

Specifying the weighted geometric mean (G.M. (w)) of the RII numbers in order to represent the stationary central value and fit on the RII calibration to reflect the stationary barriers for adopting RFID. Where Wi is the weight of each RII number, RIIi is the relative index number of any cause, and RII1 is the highest relative index number's.) RII1 is the highest relative index number's.) RII1: is the highest relative (El-Kholy and Akal, 2021):

$$G{:}M.(w) = Antilog\frac{\sum \mathrm{w.logRII}}{\sum \mathrm{w}} \quad (5)$$

Where $\sum$w: is the sum of the weights assigned to the RII numbers

4. Results

4.1 Consistency of the collected data

The Cronbach's alpha coefficients were 0.781, which exceeds the 0.70 limit value established by (Nunnally, 1994). As a result, the data obtained from the questionnaires satisfied the internal consistency requirements and were deemed trustworthy and valid for the study.

4.2 Relative Importance Index (RII)

A substantial amount of progress has been made in the implementation of RFID as a result of the various obstacles that have been highlighted in the relevant literature. The choice of construction practitioners to use RFID technology is impacted as a result of these limitations. The research revealed 22 obstacles to RFID implementation. Using the RII Method, the survey data were imported into the SPSS programme and evaluated (Important Relative Index). In this investigation, a technique was applied to determine the relative significance of the factors influencing RFID adoption. The value of the RII range is between 0 and 1, with 0 not inclusive. It is read like this; the higher RII value; the essential criteria are more important and vice versa. According to Chen et al. [72], the resulting matrix is an evaluation of RII with the corresponding level of significance and derived level of importance from RII, which are as follows:

High (H)	0.8 < RII < 1.0
High-Medium (H-M)	0.6 < RII < 0.8
Medium (M)	0.4 < RII < 0.6
Medium-Low (M-L)	0.2 < RII < 0.4
Low (L)	0.0 < RII < 0.2

According to the respondents, High cost was ranked with the mean score of 4.42 followed by lack of security, maintenance, power availability, inadequate training, privacy and low infrastructure with mean score of 4.22, 4.22, 4.20, 4.07, 4.06 and 4.02 respectively. The least barriers of RFID technology in the construction industry are Low investment, complexity, time frame to develop the technology, unclear needs, difficulty in changing the software and lastly immaturity.

(Insert Table2)

(Insert Figure2)

4.3 Stationary Cyber technology success factors

Using the RII number of each barrier as computed by Equation (1) and provided in Table 2, Ginni's coefficient of mean difference may be calculated for these values. In establishing Ginni's coefficient of mean difference (G.M), it is necessary to identify the total differences in the values of all possible variables (G) pairs. The computation of the differences between all possible pairs of RII numbers is illustrated in Table 3. According to Table 3, the sum of the value differences between all feasible pairs of variables (G) is 16.01, and the total number of value differences (M) is 231. Ginni's coefficient of mean difference (G.M) is 0.0693 when Equation (2) is used. Additionally, as indicated in Table 4, ∑w = 1.37and ∑w. Log RII= -0.136, consequently, the weighted geometric mean G.M. (w) is 0.796. This RII calibration result, as stated in Table 4, corresponds to RII number B15. Accordingly, this barrier is considered the stationary barrier for adopting RFID in the Nigerian building industry.

(Insert Table3)

(Insert Table4)

5. Discussion

The building projects have an impact on the socioeconomic dynamics as well as the whole of the social life cycle (Yu et al., 2018). Therefore, sustainable and materials, production processes, and procedures have been executed (Švajlenka and Kozlovská, 2018). From the perspective of sustainability among construction enterprises, it has been observed that as they grow and have a positive economic and social impact, they encounter a number of challenges (Lee and Mwebaza, 2020). The building industry requires considerable sustainable development (Švajlenka et al., 2018). Therefore, RFID methods and tools are important to have a clear view of project execution. Consequently, there is a need to identify the most significs RFID barriers to encourage RFID implementation. However, no study has examined or assessed the methods that promote the deployment of RFID barriers in the building sector of poor nations. This research examines Nigeria as a case study to minimize this gap by highlighting the RFID hurdles to achieving the sustainability of building projects. These obstacles are explored in the following subsections based on the present results of the recommended analysis.

5.1 Critical barriers for adopting RFID

5.1.1 High cost

Expensive acquisition and upkeep of technology implementation of new technology is hindered by the fragmented character of the building sector (Baradan et al., 2019). High cost of RFID implementation, especially ongoing tag costs. As RFID technology evolves and the demand for smart chips climbs by the millions, the price of each tag will continue to decline. RFID tags cannot now compete efficiently with bar codes, but there will soon come a time when the benefits of RFID tags outweigh their costs (Tzeng et al., 2008). Investors and companies won't invest in a technology they are not literally familiar with due to the risk allocated to the technology invested at that will bring little or no result (Baradan et al., 2019). The low investment of this technology is one of the barriers faced in realizing RFID technology in the construction sector. Professionals do not really trust in the technology, they prefer to go for the manual and traditional approach of tracking and monitoring site activities, thus, bringing about the low investment in the technology (Tzeng et al., 2008).

5.1.2 Lack of security

The concept of "lack of security" is the subject of the third primary component. RFID presents a number of challenges, the most significant of which are related to privacy concerns about the data that is gathered and the inherent qualities of the technology (Loosemore and Lim, 2017). Once they have left the construction site, employees who have been implanted with RFID tags should not be monitored to protect the workers' right to privacy. The problems that are linked with RFID Security, also known as Intrusion Detection, pertain to the identification of outside assaults against the system, most often employing the tags, which hamper the general integrity of the data. These problems may also be referred to as "intrusions" (Mitrokotsa et al., 2010). On the scale of RFID barriers, "'lack of security" comes in second place. The customer serves as both the project's general manager and its owner while the project is being carried out. He oversees the money and makes all of the decisions. He enlists the assistance of other qualified experts to bring the idea to fruition. The specialists who are going to be engaged in the process will be the ones to decide which technology will be employed.

According to Hinkka and Tätilä (2013), RFID is rapidly altering the course of construction processes since it has the ability to monitor and track activities on site despite the fact that no one is physically present on site. It is possible that, apart from the experts who are experienced with this technology, other people will not necessarily commit to using the technology that is utilized in most projects. This act as a barrier when trying to deploy the technology. In addition, the production of RFID technology requires a significant amount of time as well as a great deal of patience to prevent the production of counterfeits. One of the most significant obstacles to overcome in order to successfully adopt RFID technology is a lack of available time (Dziadak et al., 2009a). In comparison to other tracking technologies, it requires a significant amount of time to make true RFID technology. On the other hand, it is simple to manufacture fake RFID technology. However, manufacturing actual RFID technology and putting it to use will need some time. According to Huang et al. (2008), the genuine RFID technology will have a greater storage capacity when compared to the false one; as a result, its production of it would require more time. RFID must. However, because the people who work in the field are not very familiar with the operation of the technology and unaware that it exists, this presents one of the challenges that must be overcome to successfully implement the technology, as it prevents the technology from being used efficiently and effectively (Steynberg and Veldsman, 2011)

5.1.3 Maintenance

The ability to maintain RFID technology is a key barrier to implementing this technology in the construction industry. Maintenance of RFID technology will help to reduce the cost of purchasing new wireless technologies, and it will help to prolong the use of the technology in the construction industry (Osunsanmi et al., 2019). But RFID cannot be adequately maintained due to the professionals who are unfamiliar with it and doesn't know how it works. Also, money will be needed to maintain it, which might be an additional cost to a project, thus, making use of the manual approach (Dziadak et al., 2009b).

5.1.4 Power availability

Lack of power supply or insufficient power supply will affect the adoption of RFID technology. RFID technology uses power directly and indirectly because if the power of the tag is low, it goes off automatically (Osunsanmi et al., 2018). Power supply is not constant, and since RFID technology makes use of power before it can operate, there must be a steady and good current power supply for the technology to work perfectly well and bring out the desired result (Dziadak et al., 2009a).

5.1.5 Inadequate training

Lack of training on the usage of RFID Technology will affect the implementation of the technology. Any professional unfamiliar with how the technology works and functions will surely get it wrong operating it (Osunsanmi et al., 2018). Since there are not many professionals in the construction industry that can use the technology or even train others on how to use it, it becomes a barrier to the adoption of the technology in the construction industry (Dziadak et al., 2009a).

5.2 Stationary barriers for adopting RFID technology

5.2.1 Lack of demand

In the construction industry today, since not all professionals are familiar with RFID technology, the demand for the technology is low. Only professionals that are familiar with the technology will make use of it and demand it, thereby reducing the demand (Hinkka and Tätilä, 2013). RFID technology is not that common, especially in the building industry. A technology most professionals don't know about will not be successful in the field of use (kay, 2003). According to Garfinkel et al. (2005) currently, there are no regulations concerning the usage of tags, and legislation may also be necessary to protect the public. Meanwhile, early adopters like Walmart and Tesco might help allay worries by openly adopting a similar concept. RFID is often utilised in the construction sector to address the increased need for speed and efficiency in material management since building projects are increasingly complex and distinctive, necessitating more granular administration. (Hinkka and Tätilä, 2013).

6. Theoretical and managerial and implications

While the theory of establishing a sustainable concept is not new (Baldassarre et al., 2020), It appears to play an increasingly important function in various of businesses (Broccardo and Zicari, 2020). The proposed approach to prioritisation is a significant barrier to RFID implementation, particularly in sustainable building. This study employs the proposed approach to identify the barriers to RFID deployment. In light of these findings, the gap between RFID theory and practise has been reduced. However, no quantitative study has yet been done to analyse the impact of removing barriers to RFID deployment in the Nigerian construction industry. This study begins with an empirical analysis of the primary RFID hurdles that may hinder RFID implementation in the building industry. This result establishes the framework for future research on the barriers to RFID use in poor nations, particularly in construction management. Therefore, this study gives a means for intern representatives to impartially implement RFID. Nonetheless, this study provides major contributions in the following areas, all of which have significant implications for the building industry:

- It presents a list of RFID hurdles to estimate their weight and how to overcome these constraints to adopt RFID.

- It helps clients, consultants, and contractors analyse and eliminate RFID application hurdles to improve the planning and accuracy of construction projects.
- It provides methodological information that might aid poor nations in using RFID by removing existing obstacles.
- The majority of RFID research has been conducted in developed nations. Consequently, there have been few studies conducted on RFID adoption in underdeveloped nations, notably in the Nigerian construction industry. Therefore, this study effectively established a connection between RFID and the Nigerian construction business. Thus, a strong basis was established for addressing the use of RFID to improve the sustainability of local building projects and close the knowledge gap.
- The results of this study can facilitate the use of RFID in Nigerian building projects. Our findings give a basis for establishing objectives for adopting RFID, such as avoiding wasteful expenses and giving enough resources to each project. Therefore, by developing and implementing the desired strategies, all stakeholders may focus on the project's financial, schedule, and productivity objectives. In the end, having a high level of sustainability in a project has a beneficial influence.

7. Conclusion

The low quality of building projects provided in underdeveloped nations across the world has been boldly proclaimed. Despite the widespread dependence on RFID in construction in many nations, its use in emerging economies is limited. Like other emerging nations, Nigeria is afflicted with abnormalities and inconsistencies in building quality, especially in the case of large-scale projects. This highlights the necessity to implement RFID principles to mitigate this problem. To achieve sustainability in construction, this article aims to explore the application of RFID and identify the challenges that limit its successful use in building projects. Data were acquired from the previous research that had been published, in addition to a quantitative method that involved the use of a questionnaire that was sent out to 107 respondents, the majority of whom were Nigerian construction experts. According to the survey's findings, the, the most significant barrier is the high cost, which received a mean score of 4.42. These barriers include lack of training, privacy concerns, poor maintenance, power availability, and inadequate infrastructure. In addition, According to Ginni's mean difference measure of dispersion, lack of demand is the greatest barrier to RFID technology implementation. Using RFID, this study's findings can offer decision-makers vital information to improve the processes and sustainability of all construction projects. The findings of this study project will give a strong platform upon which to critically evaluate and appreciate the many obstacles that are impacting the adoption of RFID technology.

This work has made a substantial contribution, but it also has several shortcomings that should be acknowledged for future research areas. First off, the study's geographic restrictions prevent the results from being extrapolated. Only those who worked in the field of construction in Lagos, Nigeria, received the questionnaires. For enhanced generalizability of the research findings, future studies should take into account broadening the scope of this study to include other states in Nigeria and more nations. Second, because it is cross-sectional, the research is unable to account for organizational factors or historical circumstances related to RFID installation. In order to fully understand the connection between RFID implementation hurdles and RFID acceptance across the project lifecycle, future research should be longitudinal. In order for RFID technology to be known in the construction industry, the level of awareness must be high and there should be more collaboration between big companies who are familiar with the technology. In addition, there should be empowerment programs for small industries to make use of RFID technology.

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Table 1: RFID barriers in the construction industry

Code	Barriers factors	References
B1	High Cost	
B2	lack of security	
B3	Lack of industry standard	
B4	Lack of maturity	
B5	Privacy	
B6	Low technical ability	
B7	Power availability	
B8	Inadequate training	
B9	Lack of knowledge about the technology	
B10	Time frame to develop the technology	
B11	Immaturity	
B12	Low investment	
B13	Commitment from other project participants	
B14	Maintenance	(Landt, 2005, Thomas et al., 1989, Su et al., 2008, Durfee and Goodrum, 2002, Liard, 2003, Srivastava, 2005, Hassan and Chatterjee, 2006, Goodrum et al., 2006, Juels, 2006)
B15	Lack of demand	
B16	Human issues	
B17	Unclear needs	
B18	Lack of communication in remote areas	
B19	Virus threats	
B20	Inefficient use of software	
B21	Low infrastructure	
B22	Complexity and difficulty in changing the software	

Table 2: Barriers for adopting RFID technology in building construction

	Rank	RII	Mean	Level of Importance
B1	1	0.884	4.42	H
B2	2	0.844	4.22	H
B14	3	0.844	4.22	H
B7	4	0.84	4.20	H
B8	5	0.814	4.07	H
B5	6	0.812	4.06	H
B21	7	0.804	4.02	H
B3	8	0.798	3.99	H-M
B20	9	0.798	3.99	H-M
B15	10	0.796	3.98	H-M
B4	11	0.79	3.95	H-M
B9	12	0.788	3.94	H-M
B16	13	0.788	3.94	H-M
B18	14	0.784	3.92	H-M
B19	15	0.776	3.88	H-M
B6	16	0.776	3.88	H-M
B13	17	0.774	3.87	H-M
B12	18	0.768	3.84	H-M
B22	19	0.762	3.81	H-M
B10	20	0.76	3.80	H-M
B17	21	0.756	3.78	H-M
B11	23	0.732	3.66	H-M

Table3: Differences around each pair of RII numbers.

Rank	Barriers	RII	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Sum
1	B1	0.884	0.152																					0.152
2	B2	0.844	0.128	0.112																				0.24
3	B14	0.844	0.124	0.088	0.112																			0.324
4	B7	0.84	0.122	0.084	0.088	0.108																		0.402
5	B8	0.814	0.116	0.082	0.084	0.084	0.082																	0.448
6	B5	0.812	0.11	0.076	0.082	0.08	0.058	0.08																0.486
7	B21	0.804	0.108	0.07	0.076	0.078	0.054	0.056	0.072															0.514
8	B3	0.798	0.108	0.068	0.07	0.072	0.052	0.052	0.048	0.066														0.536
9	B20	0.798	0.1	0.068	0.068	0.066	0.046	0.05	0.044	0.042	0.066													0.55
10	**B15**	**0.796**	0.096	0.06	0.068	0.064	0.04	0.044	0.042	0.038	0.042	0.064												0.558
11	B4	0.79	0.096	0.056	0.06	0.064	0.038	0.038	0.036	0.036	0.038	0.04	0.058											0.56
12	B9	0.788	0.094	0.056	0.056	0.056	0.038	0.036	0.03	0.03	0.036	0.036	0.034	0.056										0.558
13	B16	0.788	0.088	0.054	0.056	0.052	0.03	0.036	0.028	0.024	0.03	0.034	0.03	0.032	0.056									0.55
14	B18	0.784	0.086	0.048	0.054	0.052	0.026	0.028	0.028	0.022	0.024	0.028	0.028	0.028	0.032	0.052								0.536
15	B19	0.776	0.086	0.046	0.048	0.05	0.026	0.024	0.02	0.022	0.022	0.022	0.022	0.026	0.028	0.028	0.044							0.514
16	B6	0.776	0.08	0.046	0.046	0.044	0.024	0.024	0.016	0.014	0.022	0.02	0.016	0.02	0.026	0.024	0.02	0.044						0.486
17	B13	0.774	0.072	0.04	0.046	0.042	0.018	0.022	0.016	0.01	0.014	0.02	0.014	0.014	0.02	0.022	0.016	0.02	0.042					0.448
18	B12	0.768	0.07	0.032	0.04	0.042	0.016	0.016	0.014	0.01	0.01	0.012	0.014	0.012	0.014	0.016	0.014	0.016	0.018	0.036				0.402
19	B22	0.762	0.044	0.03	0.032	0.036	0.016	0.014	0.008	0.008	0.01	0.008	0.006	0.012	0.012	0.01	0.008	0.014	0.014	0.012	0.03			0.324
20	B10	0.76	0.04	0.004	0.03	0.028	0.01	0.014	0.006	0.002	0.008	0.008	0.002	0.004	0.012	0.008	0.002	0.008	0.012	0.008	0.006	0.028		0.24
21	B17	0.756	0.04	0	0.004	0.026	0.002	0.008	0.006	0	0.002	0.006	0.002	0	0.004	0.008	0	0.002	0.006	0.006	0.002	0.004	0.024	0.152
22	B11	0.732	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum			1.96	1.12	1.12	1.044	0.576	0.542	0.414	0.324	0.324	0.298	0.226	0.204	0.204	0.168	0.104	0.104	0.092	0.062	0.038	0.032	0.024	16.012

Table4: Calculations of the weighted geometric mean.

Barriers	RII	Wi	Log RII	Wi. Log RII
B1	0.884	0.0693	-0.0535	-0.0037
B2	0.844	0.0662	-0.0737	-0.0049
B14	0.844	0.0662	-0.0737	-0.0049
B7	0.84	0.0659	-0.0757	-0.0050
B8	0.814	0.0638	-0.0894	-0.0057
B5	0.812	0.0637	-0.0904	-0.0058
B21	0.804	0.063	-0.0947	-0.0060
B3	0.798	0.0626	-0.098	-0.0061
B20	0.798	0.0626	-0.098	-0.0061
B15	0.796	0.0624	-0.0991	-0.0062
B4	0.79	0.0619	-0.1024	-0.0063
B9	0.788	0.0618	-0.1035	-0.0064
B16	0.788	0.0618	-0.1035	-0.0064
B18	0.784	0.0615	-0.1057	-0.0065
B19	0.776	0.0608	-0.1101	-0.0067
B6	0.776	0.0608	-0.1101	-0.0067
B13	0.774	0.0607	-0.1113	-0.0068
B12	0.768	0.0602	-0.1146	-0.0069
B22	0.762	0.0597	-0.118	-0.0071
B10	0.76	0.0596	-0.1192	-0.0071
B17	0.756	0.0593	-0.1215	-0.0072
B11	0.732	0.0574	-0.1355	-0.0078
Sum		1.3713		-0.1362