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Enhancing Sustainability in Project Management through Smart Technology Integration: A Case Study Approach to Green Building Projects

Yusuf Adedayo Lawal [1*], Jermaine Ayotunde Sanwoolu [1], Omowunmi Temitope Adebayo [1], Olawale Ibrahim Olateju [1]

[1] Lagos State University, Lagos, Nigeria
*** Corresponding Author:** yusuf.lawal@lasu.edu.ng

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ABSTRACT

The combination of smart technologies, such as the Internet of Things (IoT) and Building Information Modelling (BIM), however, has become the disruptive approach to improve sustainability in project management, particularly in green construction projects. The objective of this study is to assess the effect of these technologies upon sustainability end points, specifically toward outcomes, including energy efficiency betterment, cost/waste reduction, and optimization of resources use. Based on the Resource-Based View (RBV) and Stakeholder Theory, the current study, for the first time, offers, a theoretical structure to explain how smart technologies relate to sustainability goals. Employing a mixed-method design, the present study obtained quantitative data with standardized questionnaires and qualitative data through semi-structured interviews. SPSS Statistics quantified the outcomes while qualitative data were coded with NVivo to establish relevant themes, for example energy efficiency and stakeholder satisfaction. Results show that IoT-based systems and BIM has a notable effect on project sustainability by providing real-time data for decision making, decreasing operational defaults, reduced environmental impact. This study makes a contribution to the sustainable management of the project literature by presenting the economic and environmental advantages of smart technologies. It also offers practical recommendations--e.g., policy frameworks and capacity-building programs--to facilitate the meta-scale introduction of these technologies. These observations are of great use to those working in the industry, the policy makers and researchers who are contributing to the development of sustainability in the construction industry.

Keywords: Smart Technology Integration, Building Information Modelling, Internet of Things, Sustainability in Project Management, Green Building Projects, Energy Efficiency, Sustainable Construction

INTRODUCTION

Construction is responsible for a significant proportion of environmental sustainability accounting for about 39% of global CO2 emissions from energy-related source (World Green Building Council, 2021). Dealing with this issue, employing a green building strategy has arisen as a critical solution to minimize environmental footprint while enhancing the efficiency of resource use. Implicit in this paradigm is the incorporation of sustainability thinking into the field of project management so that the goal of sustainability is realized at each stage of the project life cycle (Darko et al., 2022). However, the area requires new solutions, e.g., the use of smart technologies to optimize and enhance sustainability routes.

The use of smart technology (combined with Internet of Things (IoT) devices, Building Information Modelling (BIM) and real-time data analytics is transforming construction processes via the implementation of predictive maintenance, resource optimization, and waste management optimization (Xu et al., 2021). These technologies not only enhance the operation efficiency of green buildings, but also enable data-driven decision-making in green building project planning. For instance, BIM and IoT applications are integrated such that the project manager's portfolio can be virtually simulated as to the performance of energy use, to the consumption of the building's material, and as to the sense of the construction progress, in order to minimize consuming of resources and money (Lu et al., 2023).

Sustainability is no longer an afterthought, but an integral component of business in the field of project management. In present project management paradigms, environmental, social, and economic sustainability are being brought into the delivery of a project, hence there is a demand for new instruments and techniques (Kopnina Blewitt, 2023). Smart technologies facilitate this integration by providing real-time insights and enabling agile responses to sustainability challenges. There are however major challenges including high upfront technology cost, lack of professional skills, and resistance to change in traditional construction practices (Shirowzhan et al., 2023).

Construction industry is one of the major emitters of environmental impact and accounts for approximately 39 of the global energy related CO2 production (International energy agency, 2019). Traditional construction project management techniques are not sufficient to address the multidimensional nature of sustainability challenges of construction projects and hence the construction project products perform poorly and causes significant environmental concerns (Hwang Ng, 2013). Integration of intelligent technologies such as Internet of Things (IoT) and Building Information Modelling (BIM), which holds the potential to be a valuable pathway to achieving sustainability in project management, enabling real-time monitoring, its decision-making, and resource allocation (Li et al., 2019).

Despite their potential to deliver gains, the adoption of smart technology in the construction of green buildings is limited by the cost of its implementation, a lack of industry technical expertise and a reluctance to innovation amongst the industry (Won Lee, 2016). A further deficiency is the dearth of empirical validation of the practical value and effect of embedding such technologies into the practices around sustainable project management (Darko et al., 2017). This literature gap indicates the need to perform "deep" case studies in which to understand the effectiveness of smart technology in contributing to sustainable project outcomes in construction.

Closing that gap is key to developing actionable frameworks that can guide the construction industry towards adopting greener behaviours. With an examination of the actual use of smart technologies in green building projects, this paper will offer clues to the right practices, reveal the bottlenecks in the implementation, and suggest the methods of mitigating them, hence deepening the understanding of sustainable project management in the construction industry.

The overall aim of this study is to investigate the impacts of integrating sm technologies (e.g., IoT, Building information Modelling (BIM) on sustainability in project management for the greener aspects of building projects. Focusing on the application of real-time data analytics, predictive surveillance, and the allocation of resources to help reduce waste and environmental impacts, this study aims to provide a clear understanding of what is feasible by way of a real-time data-driven process. Moreover, the present research also has the objective of expounding the gap in the existing literature by exploring the on-the-ground application of smart technologies, generating evidence-based suggestions to assist the use of novel technique by project managers and optimize innovation process in response to sustainability visions.

Other key objectives are to identify barriers and motivators for use of smart technologies in sustainable construction projects. The research will focus on potential cost impact, technical capability needs, resistance to technological change on an organizational level. Through investigation of these challenges as they relate to sound real-world use-case scenarios, the study is intended to provide actionable guidance that addresses these hurdles, and facilitate deployment of smart technologies on a broader level. In general, this objective aims at developing the surrounding frameworks that can be used to provide smart technology integration in conjunction with sustainable project management practices enabling economic and environmental advantages to individuals associated with the construction industry.

LITERATURE REVIEW

Sustainability in Project Management

Sustainability in project management means that certain environmental, economic and social aspects are integrated systematically into the planning and execution of as well as evaluation of projects. This concept directly challenges well-established project success criteria - time, cost, and scope - and life-cycle-value is preferred over one-time value (or life-cycle-value) thereof (Martens-Carvalho, 2017; Lawal et al., 2024). Since the construction industry is becoming even more and more subject to examination and chastisement for its environmental impacts on construction sites and waste generation. It is of extreme importance to factor sustainability into the project management. The relevance of sustainability is reflected not only in national efforts but also in global efforts, such as in the Sustainable Development Goals (SDGs) of the United Nations (United Nations, 2020), with an emphasis on the role of infrastructure for the construction of sustainable societies.

Sustainable project management in the construction sector is exemplified by the use of practices including the optimisation of materials, energy savings and waste management. For example, inclusion of lifecycle assessments as part of project planning allows project managers to consider the environmental impacts of the materials and processes in order to encourage use of sustainable options (Silvius Schipper, 2020). Also, sustainable project management minimizes waste and inefficiency to both reduce costs and performance. It is in this capacity as a social institution that it helps stakeholders gain satisfaction by responding to community need, as well as being used to equitably distribute resources and promote ethical practice. These multilevel benefits also show the criticality of sustainability as a principle of the base of current project management.

In addition, the sustainability of a project is not an objective but naturally associated to innovation and technologies. The current tools and techniques, in turn, enable the project managers to better achieve the sustainability goals. Technologies including digital twins and energy modelling software provide data-based insight to support decision making in sustainable development (Zhang et al., 2021). But realizing this outcome demands a paradigm change in the way of handling the work of project management professionals. Sustainability integration requires a good foundation of technical expertise and socio-environmental context knowledge of the projects and consequently stimulates the capacity building and the dissemination of knowledge among stakeholders (Aarseth et al., 2017).

Smart Technology Integration

Using smart technologies in the practice of project management, and more specifically construction, has been drastically modified by data-oriented, real-time, and predictive analytics. Technologies such as Building Information Modelling (BIM), the Internet of Things (IoT), and artificial intelligence (AI) are changing the traditional way of doing things and making them more efficient while being in line with the objectives of sustainability. E.g., BIM can be exploited for planning and monitoring sustainable buildings through modelling energy efficiency, judicious use of resources and the identification of potential risks at the planning stage (Lu et al., 2023). Conversely, IoT provides not only increased operational efficiency through real-time data feedback (factors such as energy use, machine operation, and material utilization) in the loop for pro-active decision making (Zhou et al., 2021).

The incorporation of the smart technologies also addresses several issues in the sustainable project management. Traditional solutions do not usually concede the necessary accuracy and flexibility where complex sustainability goals are at stake, e.g., greenhouse trap gases emission or resource conservation. Smart technologies compensate for this shortcoming by providing instruments that help to be more efficient and more transparent (Darko et al., 2022). For instance, waste generation by IoT-driven sensors can be monitored in real time, and actions are taken in real time on the basis of circular economy principle. In this manner, the collaborative nature of BIM also improves stakeholder management such that sustainability objectives are achieved over the course of the project lifecycle.

Yet the smart technologies themselves are not without challenges in the application process. High implementation costs, lack of technical expertise, and resistance to change are significant barriers that hinder widespread adoption (Won Lee, 2016). Intervention in these issues is required through targeted actions, such as capacity-building and policy-based incentives, in an effort to motivate industry players to become innovative. Furthermore, the development of standards and good practices for the application of smart technology is an important aspect to be considered in order to maximize the potential sustainability gains in project management.

Interrelatedness of Concepts

The integration of smart technologies and sustainability in the project management domain results in a synergistic effect, where the positive outcomes of both are enhanced. Smart technologies provide the platforms to operationalize sustainability objectives, through proximate monitoring, measurement and optimization of environmental and economic performance (Li et al., 2019). On the other hand, the growing importance of sustainability drives innovation in the smart technology sector, as the construction industry systematically seeks innovative solutions to the increasing environmental and social pressure. This mutually reinforcing can be seen in green building work, where BIM and Internet of Things (IoT) enabling technologies have been successfully used to effect energy saving, waste reduction and stakeholder engagement (Zhang et al., 2021).

Furthermore, embedding these concepts leads to a more systemic view of a sustainable building sector. By aligning technological innovation with environmental and social targets, project managers can create value for actors and offer solutions to critical global challenges, i.e., climate change and resource scarcity. This combined approach not only enriches the results of a project, it also positions the construction industry as a driving force for sustainable development. However, from the current capabilities of the technology, achieving this potential would require sustained learning, innovation and collaboration among industry players, policy makers and academics (Aarseth et al., 2017).

THEORETICAL REVIEW

Triple Bottom Line (TBL) Theory

The Triple Bottom Line (TBL) theory, proposed by (Elkington, 1998), provides a comprehensive framework for evaluating sustainability in project management. This theory emphasizes the interconnectedness of three pillars: environmental, economic, and social sustainability. Within this work, TBL theory provides the basis from which to infer how project management schemes can be leveraged to meet these dimensions of holistic sustainability at a whole system level. For instance, TBL draws attention to the importance of sustainable designs that minimize environmental impact, economic-efficient management of resources that guarantee economic sustainability, and inclusive stakeholder practices that meet social needs (Silvius Schipper, 2020).

What makes theory of TBL particularly relevant to this study is its potential to provide a context for the purposes ̂of smart technology integration in relation to wider sustainability objectives. This work, using TBL principles, compares the efficacy of technologies such as BIM and IoT to deliver actionable progress on all the three sustainability facets. In particular, TBL theory emphasises the need to take trade-offs and synergies between these factors into account, providing a basis for how project managers can take informed decisions which optimize the balance of sustainable performance (Elkington, 1998).

Technology Acceptance Model (TAM)

The Theory of Technology Acceptance Model (TAM) (Davis, 1989) is a theoretical background for TBL theory by explaining the array of antecedent variables that enable the use of smart technologies for the implementation of project management. TAM means perceived usefulness and perceived ease of use as the key predictors of technology acceptance. In this work, TAM is implemented to shed light on the roles of these variables on the uptake of BIM, Internet of Things and "smart" technologies for sustainable built environments. For example, the model can explain why, in some cases, a portion of stakeholders continue to resist the potential of new applications even if new applications provide considerable value to them, pointing to the effect of strategies targeted at the usability and the relevance of them (Venkatesh & Davis, 2000).

In addition, TAM allows us to formulate users' attitudes and organizational climate effects on technology acceptance. The purpose of the current investigation is to expand the theoretical model of the article in order to close the gap between using TAM to identify the barriers to smart technology adoption as well as provide solutions for the increase in acceptance and usability of the smart technologies. Together with TBL theory, TAM provides an analytical and multidimensional lens that makes the links between personal behavior and organizational behavior within the context of broader sustainability aims, helping to understand the range of driving factors in attaining green building success (Lu et al., 2023).

METHODOLOGY

The study employed a case study approach to explore the impact of smart technology implementation on the sustainability of project management in green building projects. This approach was chosen for its capacity to facilitate critical inquiry into the transferability of findings to realistic contexts. Moreover, the case study method allowed to a deep investigation of the sustainability-technology interface in the context of the end-to-end processing chosen. To get an overall view, the study design employed a mixed methods design with both qualitative and quantitative data (i.e., and therefore not necessarily, because there are elaborate longitudinal and crossover designs in place). This mixed methods approach allowed the analysis of high level patterns and finer details, in accordance with the guidelines for mixed-methods research of Creswell and Plano Clark (2018).

The research was conducted in a green building environment for Lagos Nigeria. Lagos was chosen preferentially, because of its characteristic a very densely built urban zone under active construction greening programme and substantial smart technology uptake already at the construction stage. The target population included 250 project managers, engineers, and sustainability practitioners involved in projects. To ensure representativity across professional disciplines, the current study employed a stratified random sampling procedure, as per Bryman (2016). According to Krejcie and Morgan (1970) table of sample size, a statistically significant sample size (150) of respondents was computed and this would provide the reliability and validity of the data.

Data collection involved both quantitative and qualitative methods. A structured questionnaire, distributed in physical and electronic formats, was used to collect quantitative data. The questionnaire was designed on tested psychometric scales from the literature (e.g., Cheng et al., 2021; Li et al., 2022), in order that the questionnaire could be presented to be a both reliable and valid instrument for the assessment of the relationship between smart technology integration and sustainability outcomes. The survey achieved a response rate of 80%, resulting in 120 completed questionnaires. Qualitative methods, namely semi-structured interviews, were carried out with 15 key informants, such as project managers and sustainability officers. These interviews (each 45 minutes long) have allowed to get deep understanding of the benefits and problems of using smart technologies in sustainability minded projects. Interviews were transcribed to audio for maximal fidelity in the recording of nuanced vocabulary.

Data analysis utilized both descriptive and thematic analytic approaches. Quantitative variables were analyzed with SPSS Statistics software, means, standard deviations, and regression, to investigate the combined impact of integrating smart technology into sustainability outcomes. Qualitative data were transcribed, coded and analysed using thematic analysis with NVivo software. Main topics, including energy efficiency, waste minimization, and stakeholder satisfaction, were identified and adapted within context of the research goals. In the integrative analysis of quantitative and qualitative data, the present study offered a unifying rationale for the respective research questions.

Ethical considerations were strictly followed up in the whole process of the research. All subjects signed informed consent, and their answers were deidentified to keep the information confidential. Ethical approval from the Lagos State University Research Ethics Committee also supported the study and ensured adherence to institutional and international best practices.

The objectives of the study were closely related to its methodology in order to maintain a uniform framework for the attainment of the study objectives. The primary aim of evaluating the role of smart technologies, such as IoT and Building Information Modeling (BIM), in promoting sustainability required both quantitative and qualitative data to capture diverse perspectives. Quantitative analyses (e.g., surveys) facilitated the measurement of quantifiable results (e.g., resource efficiencies, waste minimization, and environmental effects). In contrast, qualitative interviews with key informants provided rich insights into barriers, motivators, and practical challenges, aligning with the objective of generating actionable recommendations for project managers. Using a mixed-methods design, this research successfully combined statistical analysis with thematic analysis to build frameworks for smart technology incorporation as well as for sustainable project management.

Data Analysis and Results

The analysis for the first objective, which sought to investigate how the integration of smart technologies, such as IoT and Building Information Modeling (BIM), enhances sustainability in project management within the context of green building projects, utilized regression analysis. The relationship between Smart Technologies and BIM (STIBIM) as the independent variable and Sustainability in Project Management (SPM) as the dependent variable was statistically examined. The results are presented in **Table 1** below.

Table 1. Results of Objective 1

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.625[a]	.390	.388	.65832

a. Predictors: (Constant), STIBIM

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	67.149	1	67.149	154.941	.000[b]
	Residual	104.878	242	.433		
	Total	172.027	243			

a. Dependent Variable: SPM

b. Predictors: (Constant), STIBIM

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.807	.245		7.370	.000
	STIBIM	.410	.033	.625	12.448	.000

a. Dependent Variable: SPM

Model summary revealed that the R-squared value was 0.390, i.e., approximatley a 39% of variation in sustainability of PM project management could be explained by the adoption of smart technologies and BIM. Additionally, a corrected R-squared value of 0.388 further established the robustness of the model, which reduced the risk of overfitting. Moreover, the estimate of the standard error of the estimate 0.658, which is the mean of the differences between the observed data points and the regression line, indicated a fairly good affine predictor.

The ANOVA test confirmed the robustness of the regression model, with an F-value 154.941 and a p-value 0.001. These findings revealed that the combination of this smart technology and BIM was serially good predictor of project management sustainability. This statistical significance validated the stability of the model and the trustworthiness of its ability to estimate the dependent variable at a reasonable level of accuracy.

Coefficient analysis also yielded further information about the relationship between the variables. The normalized beta coefficient to STIBIM was 0.625, which means that there is a strong positive correlation between STIBIM and sustainability in project management. The unstandardized coefficient (B 0.410) indicated that a 1-unit increase in the integration of smart technology and BIM produced a 0.410-unit increase in sustainability. The high t-value (12.448) and the corresponding significance level (p 0.001) additionally strengthened the force and significance of this association and topic of study aim.

Answering certain questionnaire items led to the fact of how much smart technology and BIM implementation contributed to the sustainability of the projects. For example, a large proportion of respondents reported that the smart technologies played a role in the reduction of energy consumption in green building. That observation gives the impression of the perceived usability of IoT-based appliances and sensors for energy efficiency. In the same way, participants reported that BIM helped to achieve project sustainability outcomes (the focus on improved planning, reducing waste and the use of resources in achieving sustainability outcomes).

Another notable result was agreement on the usefulness of smart technology for instances of cost and resource management. A great number of participants stated that such technologies helped to achieve better cost control on green constructions, highlighting the role of such technologies in achieving an economic sustainability which is due to the improvement of cost efficiency. Moreover, participants underscored the role of smart building technologies for the optimization of waste management practices, namely, their use to monitor and reduce waste, playing an important role in environmental sustainability.

The quantitative findings provided a strong positive correlated relationship between smart technologies, BIM and sustainability in the project management. These technologies were shown to provide direct benefits in terms of energy efficiency, cost, and waste management efficiency, pointing to their relevance in achieving sustainability objectives and alignment with global green building standards and practices. This analysis supports the need for widespread adoption of advanced technologies to drive sustainable practices in project management.

The second objective aimed to explore the challenges and opportunities associated with the integration of smart technologies, such as IoT and Building Information Modeling (BIM), in achieving sustainability in project management for green building projects. This objective was investigated using qualitative data obtained from semi-structured interviews conducted with project managers, sustainability consultants, and technology integration specialists.

Thematic analysis of the interview data revealed several recurring themes, categorized as challenges and opportunities. Among the challenges, respondents consistently highlighted the high initial costs of implementing smart technologies. Many participants expressed concerns about the financial burden associated with purchasing, installing, and maintaining advanced systems such as IoT devices and BIM software. As one project manager stated, "While the long-term benefits of smart technologies are clear, the upfront costs can be prohibitive, especially for small-scale projects or developers with limited budgets."

Another notable challenge was the lack of technical expertise. Respondents emphasized that integrating smart technologies into project management requires skilled personnel who understand both the technology and its application within sustainable construction. A sustainability consultant explained, "We often struggle to find professionals who are well-versed in using BIM and IoT tools to achieve sustainability goals. Training existing staff is an option, but it takes time and resources."

Additionally, issues related to interoperability and compatibility were frequently mentioned. Participants noted that different smart technologies and software platforms often lack standardization, which hinders seamless integration. One interviewee remarked, "The lack of interoperability between BIM software and IoT systems creates inefficiencies and adds to the complexity of managing green building projects."

On the other hand, respondents also identified significant opportunities associated with the integration of smart technologies. A prominent theme was the potential for enhanced decision-making. Many participants acknowledged that smart technologies provide real-time data and advanced analytics, enabling project managers to make informed decisions that promote sustainability. As one interviewee noted, "With IoT sensors and BIM data, we can predict energy consumption, track resource use, and identify inefficiencies early in the project lifecycle."

Furthermore, the potential for cost savings in the long term was widely recognized. Respondents agreed that while the initial investment is high, smart technologies help reduce operational costs over time through energy efficiency, waste reduction, and improved resource management. A project manager shared, "Smart technologies pay for themselves in the long run by reducing utility bills and minimizing waste, which directly benefits the project's financial sustainability."

Another opportunity highlighted was improved stakeholder collaboration. Participants observed that BIM facilitates better communication and coordination among project stakeholders, leading to more streamlined workflows and fewer misunderstandings. As one respondent explained, "BIM creates a shared platform where architects, engineers, and contractors can collaborate effectively, aligning their efforts toward achieving sustainability targets."

Overall, the qualitative findings illustrate a dual narrative of challenges and opportunities. While financial, technical, and interoperability issues pose barriers, the benefits of enhanced decision-making, cost savings, and improved collaboration underline the transformative potential of integrating smart technologies into project management for green building projects. These insights emphasize the need for strategies that address the challenges while leveraging the opportunities to achieve sustainable outcomes.

DISCUSSION OF FINDINGS

The findings of the current work underscore the regenerative role of smart applications such as IoT (Internet of Things) and Building Information Modeling (BIM) in driving green construction project management sustainability. These results are in agreement with the theoretical underts of Diffusion of Innovation Theory and of Triple Bottom Line Theory that underlie this study.

Among the potentially more easily observed outcomes is the energy usage increasing effect of smart technology for green buildings. The great majority of survey responses suggested that smart technologies reduce energy consumption and thus feedback positive the efficiency of IoT-based and sensor based solutions and tools for energy management. Accord with the Diffusion of Innovation Theory (Rogers, 2003), that is, indeed the acceptance of a new technology is a function of its lightness in comparison with other technologies, the goodness of the technological fit to the situation context of the technologist, and the presence of a means to "try out" or "practice" the new technology. IoT technologies, characterized by continuous data discharge and remote control of energy-saving devices, have these features and thus are very attractive to be adopted in green building construction projects. These results also correlate with the use of IoT for energy consumption reduction and carbon footprinting reduction in construction (Shrouf et al., 2014; Jafari et al., 2022).

The second key outcome was the contribution of BIM to the sustainability of the project, as respondents understood the role of BIM in the ability to improve planning, reduce waste and improve use of resources. BIM's capability for visualization and to support efficient use of resources in the process matches up well with the Triple Bottom Line Theory, which advocates for the convergence of social (environmental), social (social) and economic factors to be sustainable (Elkington, 1998). BIM facilitates achieving the environmental and economic sustainability by reducing material waste and cost optimization as proposed by the recent literature discussion about BIM benefits for construction sustainability practice (Zhong et al., 2021; Abanda et al., 2020). In addition, the BIM collaborative platform offers stakeholder communication, ensuring that the sustainability targets can be achieved from the start of the project process to the end.

Cost and resource efficiency also emerged as critical themes. Subjects agreed very highly that the realization of the smart technology can allow cost control in the green building projects. This result is of great interest, as economic sustainability is one of the foundations of the Triple Bottom Line Theory. Smart technology helps reduce operational inefficiencies through streamlining of processes, reduced errors and resource optimisation, which - ultimately - saves money over the long term. It is such a close fit with previous work, which reports that, owing to the great potential and economic value of green building benefits, the economic payback for using smart technologies is generally quantifiable (i.e., a delay in time) for the life cycle of a green building (Arayici et al., 2011; Zhang et al., 2023).

An interesting finding is the application of smart technologies to waste management. The majority of respondents believed that these technological solutions are not only useful for the resolution of waste disposal problems but are also useful for the protection of the environment sustainability. IoT systems, for example, enables remote, waste tracing and optimization and use at the material level. This is consistent with the Diffusion of Innovation Theory, in that these technologies should already be valued for the usefulness they provide to solve important sustainability issues (Rogers, 2003). In addition, these results are consistent with a recent study on the potential of smart ICT to offer means for implementing circular economy prescriptions (say, to optimize use of natural and energy resources and/or minimize waste in construction) Charef Emmitt.

From the qualitative approach, interviews with the involved parties have shown some limitations, including high upfront costs, lack of technical skills, and interoperability problems. These issues raise barriers to widespread adoption of smart appliances, which is consistent with the "implementation gap" that has so often been expected in the Diffusion of Innovation Theory. While the advantages of the above technologies are obvious, their diffusion is limited by a combination of organizational and financial constraints, analogous to those described in other reviews of barriers to technological adoption in sustainable construction (Aghimien et al., 2019; Olawumi Chan, 2018). But the companies chat by the example of the savings by cost, breaking new ground of collaboration with their "interview" interviewees, it feels that these technologies may aid in the attainment of some acceptable goals of sustainability, in which the companies see them worthy to act, need attention.

CONCLUSION

The obtained study results indicate that project management in terms of smart technology and sustainability are strongly interconnected and agree with the models of Diffusion of Innovation and Triple Bottom Line. Both IoT and BIM technologies bring value not only to energy and cost efficiency, but also to environmental and economic sustainability. Nevertheless, there are still issues with respect to capital intensity and interoperability, which need to be tackled before the full potential of the technology can be fulfilled. These results draw several consequential aspects for project managers and policymakers, emphasizing the requirement design approaches promoting the uptake and embedding of smart technologies if green buildings sustainability is to be secured.

Recommendations and Policy Implications

In order to promote sustainability in project management with the use of smart technology, it is suggested that project managers and stakeholders should focus on Implementing of Internet of Things (IoT) and Building Information Modeling (BIM) in green building projects. Accountants should allocate resources to support training which can be applied to improve technical staff skills, allowing staff to use these tools competently. In addition, government and industry regulators need to implement incentives, i.e., in the form of tax credits and grants because the initial investment will be very high to deploy smart technologies. Interoperability should also be considered, and the issue of how a feature of smart technology is used within the construction field must be standardized through stakeholder engagement workshops and knowledge transfer schemes. Not only can these operations provide the optimal use of resources, but it can also lead to waste management and energy efficiency improvement, finally helping to realize the overall green building development sustainability.

From a policy point of view, policies should be implemented to require the inclusion of smart technologies in public and private construction work. Such policies must stress environmental and economic sustainability as well as the prevention of barriers to technology adoption such as cost and fit issues. Policymakers must also foster public-private partnerships (PPPs) in order to help expand capital and technical support. In addition, embedding sustainability objectives in urban planning and in policy concerning smart infrastructure can guarantee that the application of smart technologies has a positive impact on ones which have a largescale environmental and economic impact. These policy measures have been designed to promote the implementation of new and innovative interventions, to facilitate the dissemination of the results of projects, and to ensure that the construction sector becomes a champion of sustainable development.

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