Digitalisation of Property Management

Challenges of Building Management Systems Adoption in Trinidad and Tobago

Olivia Tiku

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Supervisor: Ju Liu
Abstract

There is a growing need in the urban development of developing countries for sustainable buildings. Building management system (BMS) is known for its ability to optimise a building’s sustainability performance. This study examines the challenges of adopting BMS as a digitalised property management tool in public schools in Trinidad and Tobago. It employs case study method with observation and semi-structured interview. It uses Rogers’ diffusion of innovation five-element framework to discover the society’s willingness to adopt BMS, and the challenges associated with its adoption. It is found that there’s a willingness to adopt, however, implementation costs and better understanding of the society’s social system must be considered. This paper concludes by addressing how this can be done and providing recommendations future research.

**Keywords:** Building Management Systems, Developing Countries, Real Estate Prop-tech, Sustainability, Technology Adoption, Digitalisation.
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1. Introduction

Nearly 40% of the global carbon emission is attributed to the real estate sector, which is a critical issue of climate change (Deloitte, 2022). In the real estate industry, Building Management Systems (BMS) are considered the smart technologies of the future. In agglomerated cities it provides an opportunity for businesses to develop solutions that improve operational efficiency, generate new revenue, improve returns, and increase asset values while simultaneously reducing environmental impact caused by climate change.

A BMS is a computer-based control system installed in buildings that manages and monitors the building's mechanical and electrical equipment, such as heating, ventilation, air conditioning, lighting, and security systems. It gathers data on energy consumption, equipment performance, and environmental conditions, among other things.

In addition to optimising equipment performance and detecting and diagnosing equipment faults before they cause significant damage, building managers can also use BMS data to identify areas for energy efficiency improvement. Data can also be used to make informed decisions about replacing or upgrading equipment.

Additionally, building managers can use data analytics to predict equipment failure, reduce maintenance costs, and improve occupant comfort and safety. Building managers can make data-driven decisions that lead to more efficient and sustainable buildings by leveraging data and analytics.

Smart Building Technology (SBTs) includes Building Management Systems. As a bundle of properties that enable non-digital devices to become "smart," SBTs include efficiency, waste reduction, accessibility, comfort, safety, and integration with intelligent networks to make them "smart." Organisations and researchers are increasingly focusing on sustainability as a project goal and as a characteristic of project management processes (Zanello, Fu, Mohnen & Ventresea, 2015), and adopting SBTs in the construction industry is seen as a key step toward sustainability.

Research on SBT adoption such as BMS is needed. This is especially true for developing countries where the construction industry can provide significant benefits in terms of sustainability, efficiency, and comfort. BMS are standard features in modern buildings in
developed countries. The adoption of BMS is still limited in developing countries, and their potential benefits are often overlooked.

1.1 Research problem
Noticably, there is a lack of research on BMS adoption in developing countries. Most of the research on the adoption of digital technology in property management is based on developed countries’ practices.

Developing countries face unique challenges in building management. Rapid urbanisation and industrialisation have increased the demand for energy and resources in these countries. The result is that buildings consume a lot of energy and emit a great deal of greenhouse gases. Furthermore, poor building maintenance and management practices in developing countries often lead to poor indoor air quality, uncomfortable living conditions, and increased health and safety risks. Through providing an integrated and comprehensive approach to building management, BMS can play a crucial role in addressing these challenges.

According to Nikolai Siniak et al (2020), one main concerns of real estate prop-tech implementation is skilled labour. Generally, for developing countries, the inadequate use of these skills can also lead to a brain drain, which advertently can be used to develop the public innovation within the developing country. In this case, the public-school buildings maintenance needs.

1.2 Aim of the research
The aim of this thesis is to explore the situation and challenges of BMS adoption in developing countries. Practically, the thesis expects to generate implications for practitioners to adopt BMS as well as to contribute to the implementation of public innovations through prop-tech in a developing country. Theoretically, it is to contextualise digitalisation of property management in developing countries in order to add new knowledge to innovation management literature.

1.3 Research Questions
The research will focus on case studies of selected school buildings in Trinidad and Tobago and attempt to answer the following research questions:

i. What is the current situation of BMS adoption?

ii. What are the challenges of BMS adoption in Trinidad and Tobago for sustainable school buildings?
iii. What are the implications of implementing BMS for sustainable real estate in developing countries.

1.4 Research Outline
This paper consists of seven chapters. The first chapter describes how BMS can be used to address real estate climate impacts in developing countries as a digital management tool which further goes on to introduce the research problem. The second chapter provides a review of literature on technology adoption, prop-tech and digitalisation, innovations, and eco-systems in developing countries. The third chapter discusses the theoretical background and demonstrates the analytical framework used to generate the interview’s questionnaire. The fourth chapter explores the methods used to design the research of this thesis through its data collection methods, as well as the case study and limitations. Additionally, the participant’s profile and how they were recruited is introduced here. The fifth chapter examines the coded results retrieved from the data collected and provides a critical analysis to answer the research questions. The sixth chapter offers further discussions which align the results to the literature chosen for review. The seventh chapter concludes the thesis with a summary of the results and provides recommendations for future research.

1.5 Context of the study
This paper selects my home country Trinidad and Tobago as the research case. The public-school buildings are the main concern of this study as they provide the best suited case given its maintenance challenges and innovation readiness infrastructure or lack thereof.

A sustainable building benefits not only society and the environment, but also owners and operators. As reported by the U.S. Green Building Council, sustainable buildings can reduce operating costs by 8-9 percent, increase value by 7.5%, and improve employee productivity. Sustainable buildings are essential for creating a more sustainable future (Jhunjhunwala, 2022). As a result of climate change and resource depletion, they are becoming increasingly important.

The United Nations Development Programme (UNDP) in its report (2019) examined various indicators, including digital infrastructure, digital literacy, and policy and regulatory conditions, to assess Trinidad and Tobago’s readiness for the digital age.

In 2022, the Inter-American Development Bank (IDB) published a report about digitalisation investments in Trinidad and Tobago. It emphasizes the potential benefits of digitalisation for
the country's economy, as well as the challenges that must be addressed in order to realise these benefits. It recommends further digitalisation through the development of a national digital strategy, which would serve as a roadmap for the country's digital transformation, as well as measures to promote digital literacy and skills development. The importance of addressing regulatory and policy barriers to digital investment is also stressed, including greater clarity and consistency in regulations related to e-commerce, data protection, and cybersecurity.

1.5.1 Trinidad and Tobago as a Developing Country

Trinidad and Tobago consist twin islands (see Figure 1). Historically, Trinidad was originally inhabited by Arawakan and Cariban-speaking tribes before the Spanish arrived in 1498. The Spanish did not have an effective presence on the island until 1592 when they founded San José of Oruña. Trinidad's development proceeded slowly, and few Spaniards or African slaves immigrated to the island. However, from 1776, the Spanish government encouraged Roman Catholics from other Caribbean islands to settle in Trinidad with their slaves, and this transformed Trinidad's population, economy, and society (Brereton, 2007).

Trinidad became a British colony in 1802, and sugar plantations using slave labour became a significant part of the economy. Slavery was abolished between 1834 and 1838, and indentured workers from India arrived from 1845. Tobago was sighted by Columbus in 1498 but did not have any permanent European settlement until the 18th century. Tobago's sugar production peaked in the 1790s but began to decline after 1807. Tobago was amalgamated with Trinidad in 1889, creating the united colony of Trinidad and Tobago (Brereton, 2007).

Trinidad and Tobago were governed as a crown colony during the British colonial period, but constitutional reforms eventually led to self-government and independence. The People's National Movement (PNM) held power from 1956 to 1986, and the oil boom in 1973-81 brought prosperity to the population. Trinidad and Tobago became a republic within the Commonwealth in 1976 (Brereton, 2007).
Today, Trinidad and Tobago is a small, middle-income developing country with a population of 1.3 million people and rich natural resources. The economy is heavily reliant on oil and gas production, which accounts for a large proportion of GDP and exports. The country has become a major financial centre in the Caribbean. While governance indicators have stagnated in recent years, steps are being taken to improve governance and public service delivery.

The country experienced significant economic growth between 2000 and 2007, but GDP has slowed down since then due to falling oil and gas prices. The economy contracted in 2014-15 and experienced negative growth in 2016. However, the country has a low level of public indebtedness, adequate financial buffers, solid human capital, and political stability, which are expected to facilitate an economic rebound over the medium term (World Bank, 2015).

Almost eight years later, from the World Bank’s last published report on Trinidad and Tobago’s economic development, the Inter-American Development Bank has been actively working with the country towards developing a sustainable environment for the nations’ occupants through financial assistance and promotion of young innovators; investing together with the government of Trinidad and Tobago to produce clean energy and to become digitally ready.
As a natural resource driven economy, most of the country’s advancement has been saturated into the oil and gas, industrialisation sectors. Technological advancement has not managed to fully take its course in the developing economy thus far. However, the Government of Trinidad and Tobago recently, developed a roadmap towards ‘Digital Readiness’. Trinidad and Tobago's new Ministry for Digital Transformation is a positive development that reflects the country's interest in using digital technology for development. The Ministry aims to prioritize a more coordinated approach to digital initiatives in the country.

1.5.2 School Buildings in Trinidad and Tobago

Most schools in Trinidad and Tobago were built over 50-60 years ago. Some schools have been renovated to meet the needs of a growing capacity demand, or for better accommodation conditions, while few experience more strenuous issues which are beyond repair. In the last 10 years there were 25 primary and 6 secondary schools newly built (Ministry of Education, n.d.). Additionally, there has been continuous repair programmes in place to ensure adequate functionalities for the majority of the schools and its occupants.

In 2017, the former Government Minister of Education promised to start the construction of 10 schools throughout Trinidad and Tobago. “To address the need for new schools and to ensure that parents and students are recipients of quality facilities, new school construction will be done on a phased basis. The first phase will see the construction of ten (10) new schools throughout the island” (Loop News, 2017). The knowledge of whether or not this construction has begun is uncertain.

Often times, there are numerous reports on certain primary or secondary school’s inability to function at its optimum standard due to improper maintenance, outdated systems or simply the age of the building hinders permanent resolution of the building’s issues. This means that, constant repair and rectifications must be conducted, which at times becomes a hazard to the occupant’s health and safety, resulting in lengthy displacement of students and staff from the school’s building.

According to an article written in the local newspaper, after protests for a new building in the year 2019 by students at the Scarborough Secondary School in the isle of Tobago, due to the school’s state of disrepair, the Tobago House of Assembly allocated 50 million Trinidad and Tobago Dollars (TTD) towards a newly constructed building project which was estimated in total 200 million TTD (George, 2020). To date, this project has not begun with its physical construction.
2. Literature Review

This chapter provides a literature review of the literature on technology adoption through the diffusion of innovation, real estate prop-tech and digitalisation, innovations and real estate eco-system, in the context of developing countries.

2.1 Digital Technology Adoption in Developing Countries

Increasing adoption of innovations is challenging due to uncertainty. When an innovation is adopted or rejected, its consequences may create uncertainty, and consequences are the changes that occur in an individual or a social system. Sahin (2006) recommends that individuals be made aware of all the consequences of adopting an innovation in order to reduce the uncertainty.

It is important to consider the innovation's nature since low-tech innovations diffuse more easily than high-tech ones in developing countries. Moreover, low-tech innovations do not require much skill and capital, and they don't rely heavily on channels of transmission. In contrast, advanced innovations may not find local absorptive capacity necessary to diffuse. Therefore, indigenous, and domestic innovations need to be developed.

Sahin (2006) states that there are three communication elements involved in diffusion: an innovation, two individuals or other units of adoption, and a communication channel. To reach mutual understanding, participants create and share information using communication channels.

Communication efficiency is determined by the development of infrastructure and the geographical and cultural distances between participants. As a result of their efficient transport systems, developed countries are able to facilitate the spread of knowledge. Whereas infrastructure in many developing countries is inefficient, making it difficult for the transfer of knowledge to be transported both internationally and internally, thereby inhibiting innovation (Chataway, J., Hanlin, R., & Kaplinsky, R., 2014).

Chatti and Majeed (2022) emphasize the importance of enhancing environmental quality in urban environments by adopting new digital technologies, particularly information and communication technologies (ICTs).

Five significant results were found in their study: (i) ICTs negatively affect the environment; (ii) per capita income negatively impacts environmental preservation; (iii) the interaction between ICTs and urbanisation can reduce carbon emissions; (iv) telephones are particularly
effective at reducing environmental damage, especially in developed countries; (v) the positive environmental impact of ICTs in developing countries is weak.

The social system, according to Rogers (2010), is a set of interrelated units working together to accomplish a common objective. The diffusion of innovations occurs within the social system, so it is influenced by its social structure. According to Rogers, structure is defined as a pattern of arrangements among the units in a system. Furthermore, he claimed that innovation is influenced by the social system, which is the main criterion for categorising adopters.

The time aspect is often ignored in most behavioural research. Rogers (2010) argues that including the time dimension in diffusion research illustrates one of its strengths. There is a time dimension associated with the innovation diffusion process, adopter categorisation, and adoption rate.

Nevertheless, Kotter, J.P. & Cohen (2012) conceptualised behavioural changes in terms of, “People change what they do less because they are given analysis that shifts their thinking than because they are shown a truth that influences their feelings.”

Lowry (2002) successfully applied Rogers’ attributes of innovations framework and discovered 'observability,' did not significantly influence BMS use. According to the study, 'relative advantage' and 'compatibility' are correlated.

A negative correlation was also found between 'voluntariness' and BMS usage. According to the study, a user who felt their use of BMS was obligatory (low voluntariness) would be more likely to use it if it was easy to use, but a voluntary user would be more concerned with its compatibility.

2.2 Real Estate Prop-tech and Digitalisation in Developing Countries

Prop-tech adoption in commercial real estate faces a number of challenges and barriers, as highlighted in the Said Business School (2020). In order to create a seamless user experience, stakeholders need to develop more data standards and interoperability between different platforms and systems. This can make it difficult for stakeholders to integrate different prop-tech solutions. Furthermore, the report points out that the high cost of implementation and the lack of clear return on investment can also prevent adoption.

In addition, the report emphasizes the need for cultural change within the industry, as some stakeholders are reluctant to embrace new technologies or may lack the skills to use them
effectively. The adoption of prop-tech in commercial real estate may also be challenged by regulatory and privacy concerns.

Also highlighted and agreed in other studies, such as PwC Real Estate (2020) report is the need for data standards and interoperability to enable prop-tech adoption. Similarly, the Deloitte prop-tech report (2020) identifies cultural barriers and the high cost of implementation as major industry challenges. To fully realise its transformative potential, several challenges and barriers must be overcome.

Zanello, Fu, Mohnen & Ventresca (2015) analysis of the creation and diffusion of innovation in developing countries to Smart Building Technologies (SBTs) and their integration into building automation systems as a property management tool suggests that there are several challenges to the adoption of SBTs. Construction process technical difficulty, a lack of awareness and understanding of SBTs, a lack of clear benefits and incentives, and a lack of communication and collaboration have been identified as the top five barriers.

SBTs adoption is hindered by the technical difficulties of the construction process. It is a complex and non-repetitive process, making it difficult to adapt to new technologies. It is also difficult to adopt innovative technologies within firms due to lengthy planning and approval processes. Another obstacle is the inability to find sustainable materials and products.

Nikolai Siniak et al (2020) states, “Property is at the heart of a smart territory, and it is time for the real estate industry to take a leading role.” Further suggesting that it is also likely for territorial competition and territorial growth to benefit from the implementation of real estate Prop-Tech solutions.

2.3 Innovation and Real Estate Business Eco-system in Developing Countries

2.3.1 Innovation in Developing Countries

Heeks (2017) explores the potential of digital technologies to help low- and middle-income countries develop economically and socially. Heeks argues that digital technologies can play a crucial role in enabling developing countries to achieve their development goals. However, he accentuates some of the challenges they must overcome.

Digital technologies have the potential to increase efficiency and productivity. Heeks suggests that by reducing transaction costs and increasing market access, technology can facilitate economic growth. In addition, he discusses how digital technologies can be used to improve healthcare and education systems.
Heeks also acknowledges that realising these potential benefits will pose significant challenges. In low- and middle-income countries, one of the biggest challenges is the digital divide, which results in a lack of access to the necessary infrastructure and skills to utilise digital technologies. In order to address this divide, Heeks argues that infrastructure and education must be significantly invested.

Especially in low-skilled sectors, Heeks points out that digital technologies could disrupt existing jobs and industries. According to Heeks, policymakers ought to take steps to reduce negative consequences of digital technologies by carefully considering their potential social and economic impacts.

A key strength of Heeks' study is that it emphasises the importance of a holistic approach to digital development that incorporates social, economic, and political factors. In addition to bridging the digital divide, Datta (2020) considers the digitalisation in the Global South emphasises the importance of intermediaries, including non-profits and private sector organisations, in order to facilitate the adoption of digital technologies in urban areas.

Datta also points out some limitations of Heeks' study, such as its limited focus on issues related to governance, participation, and sustainability, which are critical in the context of urban development. Additionally, Heeks' study does not adequately address the issue of power dynamics, which can shape the adoption and use of digital technologies in development.

Often, firms in developing countries adapt existing technologies to meet the needs of customers and resources available in their region, which is the characteristic of the innovation landscape in these countries. The reason for this is a combination of high costs and risks associated with ground-breaking innovations, as well as a relatively low level of education in many countries with low and middle incomes. Due to this, developing countries are more likely to practice imitation and incremental innovation.

A second factor that limits innovation capacity for firms in developing countries is the high sunk costs associated with setting up research and development (R&D) facilities and the appropriability issues associated with intellectual property protection. As a result, firms invest more in knowledge acquisition through licensing and technology transfer than in R&D activities.
Moreover, many low-income countries have economies that are less diversified than those in developed economies and rely mostly on agriculture and extractive industries to generate income. Low-income countries operate in the informal sector, which makes collecting data on innovation activities difficult. Due to this, it is difficult to get an accurate picture of their innovation landscape (Chataway, J., Hanlin, R., & Kaplinsky, R., 2014).

Rogers’ diffusion of innovation as explained by Sahin (2006) considers a concept, practice, or project regarded as new by an individual or unit of adoption. It does not matter how long ago an innovation was invented, if it is perceived as new by individuals, then it is still an innovation. Newness is related to the three steps (knowledge, persuasion, and decision) of the innovation-decision process. This concept was heavily criticised by Chataway et al (2014) as it neglected factors that are specific to developing nations.

2.3.2 Real Estate Business Eco-system in Developing Countries

Ecosystems have become increasingly popular in business strategy and as a means of making interdependence more explicit (Moore, 1996; Iansiti & Levien, 2004; Adner, 2006). It is rare for one innovation to constitute a complete innovation. Many innovations require complementary solutions to unlock their full potential (Adner & Kapoor, 2010, p. 313).

Collaboration among diverse stakeholders is key to maximising the benefits of digitalisation and driving continuous improvements in these industries when it comes to innovation from an eco-system perspective. When considering digitalisation and innovation in these sectors, Kytömäki (2020) emphasizes the importance of adopting an ecosystem perspective. It is crucial to drive innovation and value creation by collaborating with diverse stakeholders, such as real estate owners, facility managers, technology providers, and service providers. As a result of digitalisation, data-driven decision-making is enabled, operational efficiency is enhanced, and user experiences are enhanced within buildings.

In an eco-system, collaborative efforts enable the exchange of knowledge, expertise, and resources, allowing stakeholders to learn from each other, foster innovation, and create value collectively. Regulating, enforcing, and supporting an ecosystem for collaboration and innovation requires regulations, policies, and innovation hubs. Innovation hubs can act as a platform for collaboration and co-creation, while regulatory frameworks can promote data sharing, privacy protection, and standardisation (Kytömäki, 2020).

A further investment in skills development and education is needed to equip professionals with the necessary skills. By offering training programs, workshops, and educational
initiatives related to digital technologies, data analytics, and innovation, professionals will be able to embrace digitalisation and contribute effectively to the ecosystem (Kytömäki, 2020).

3. Analytical Framework

This paper uses Rogers' (1962) Diffusion of Innovations (DOI) Five Element Framework as the main analytical framework for understanding the challenges of BMS adoption in the schools throughout Trinidad and Tobago (see Figure 2). Rogers' DOI theory, first introduced by Everett M. Rogers in 1962, is a seminal model that explains how new ideas, technologies, and practices spread within and across social systems.

Rogers' Diffusion of Innovations theory is rooted in various disciplines, including sociology, communication, and marketing. The theory emphasizes the importance of understanding the factors that influence the adoption of new ideas, products, and practices within a social system. The Five Element Framework provides a comprehensive and structured approach to analyse and predict the diffusion of innovations.

Rogers' DOI Five Element Framework consists of five essential elements that work together to determine the adoption and diffusion of an innovation. These elements are:

**Characteristics of Innovation:** An innovation refers to a new idea, product, or practice that offers a perceived advantage over existing alternatives. The characteristics of the innovation, such as relative advantage, compatibility, complexity, trialability, and observability, significantly influence its adoption rate.

**Adopters:** This group relies on the propensity to adopt new ideas and the timing of their adoption. These categories help to understand the dynamics of the diffusion:

**Innovators** are the first to adopt an innovation. Their risk-taking nature often makes them the gatekeepers for introducing new ideas into a social system.

**Early Adopters:** The second group to adopt an innovation. They are more integrated into the local social system, serving as opinion leaders and role models for others.

**Early Majority:** This group adopts innovations just before the average member of a social system. They deliberate for some time before making a decision and often rely on the opinions of early adopters.
**Late Majority:** They adopt innovations after the average member of the social system. They are typically skeptical and cautious, requiring more evidence of the benefits of an innovation. Their adoption often occurs due to peer pressure or economic necessity.

**Laggards:** Laggards are the last to adopt innovations. They are often characterised by their aversion to change, limited social networks, and focus on traditional practices. Their adoption occurs when the innovation has already been widely accepted by the majority of the social system.

**Communication Channels:** Communication channels are the means by which information about an innovation spread among the members of a social system. The channels can be mass media, interpersonal networks, or digital platforms. The choice and effectiveness of communication channels play a crucial role in the diffusion process.

**Time:** The time element in the DOI framework captures the temporal aspects of the diffusion process. The three phases of time - innovation-decision process, adopter categories, and the rate of adoption - help to understand the pace at which an innovation is adopted and the factors that contribute to its rate of adoption.

**Social System:** A social system refers to the interconnected network of individuals, groups, and institutions that share a common culture, values, and norms. The structure, norms, and leadership within a social system can either facilitate or hinder the adoption of an innovation.
Adoption of BMS in School Buildings

Figure 2. Analytical framework for understanding BMS adoption in Trinidad and Tobago

3.2 Roger’s Diffusion of Innovation Framework influence on this study

Roger’s Diffusion of Innovation Framework was considered as an adequate tool for generating the questionnaires for the interviewees chosen in this research. Given that Trinidad and Tobago and its public schools are fairly new to the idea of real estate pro-tech, this framework allowed for the development and understanding of the current circumstances surrounding BMS adoption for public innovation in the school buildings.

4. Methods

This chapter starts with an analysis of the research design, followed by a synopsis of the selected case. The chapter further outlines the thesis’s data collection strategy, analysis, limitations, validity and reliability, and ethical considerations.

4.1 Research Design

This study adopts qualitative research method. Qualitative research was used to generate case studies through interviews with relevant stakeholders because they offer a unique and nuanced perspective into the lived experiences and individual perspectives of the participants. By employing these methods, I was able to delve deep into the human element, capturing the
rich complexity of emotions, thoughts, and motivations that lie beneath the surface of everyday behaviours. The flexibility and adaptability of qualitative research provided a dynamic approach which allowed me to modify my line of inquiry in response to the emerging themes and patterns that I encountered during the interviews.

Furthermore, the qualitative research method prioritizes the establishment of rapport and trust with the participants, fostering an environment where they felt comfortable to share their authentic experiences, thoughts, and feelings. This level of openness and candour is invaluable in revealing the intricate web of connections that link individual cases to broader societal trends and phenomena. By conducting in-depth interviews, I was able to illuminate the context-specific factors that shape participants’ experiences, uncovering the underlying structures and processes that may not be readily apparent in quantitative data.

The narrative and storytelling aspects of this qualitative research, specifically through the case studies, also served to humanise the data, making it more relatable and engaging for diverse audiences. This approach facilitates the communication of research findings in a manner that transcends disciplinary boundaries and fosters empathy and understanding among readers. Ultimately, by utilising qualitative research methods, I aimed to create a more comprehensive and holistic understanding of the phenomena under investigation, thereby contributing to the development of more effective and targeted interventions and solutions.

4.2 Case Selection

The case selection is based on the principle of purposeful sampling and convenience sampling. The sampling strategies were conceptually aligned with the synthesis purpose, that credibly and sufficiently addressed the synthesis purpose (Kemper, Stringfield, and Teddlie, 2003). Purposeful sampling was selected to ensure the data retrieved is reliable, accurate, ethical and trustworthy, considering the portfolios of the interviewees selected to adapt a overall ecosystem approach. Their skillsets and vast experiences within the public-school sector, private sector and ministry of education made them best suited for this research. According to Suri (2011), convenience sampling is often used as its ‘easy to access and inexpensive to study’. Similarly, convenience sampling was used as the accessibility to the interviewees and the data were within my reach as the researcher.

Considering the research requires a knowledge base of the school building’s maintenance strategy, it seemed necessary to gather information from the current occupants and those in charge of its maintenance within the school and from the ministry’s side. When considering,
solutions for the issues which was revealed, the professionals with vast knowledge of BMS and real estate pro-tech by extension, were best suited for those interviews.

Additionally, the case selection of the study deemed substantial as on the one hand, the country selected is a developing country which fits the aim of this study. On the other hand, I have relatively broad access to the data needed for this research which made it possible for this study to conducted.

4.3 Data Collection

The thesis collected two types of data including primary data and secondary data.

The main source of data collection was done through primary data collection of direct observation of the school buildings, and in-depth semi-structural interviews. Six of the interviews approximately lasted one hour and ten minutes, and two were approximately forty-five minutes each, totalling just over 8 hours of interviews.

The interviewees include 8 relevant stakeholders of this research. They are (1) Software Engineer, (1) ICT Director, (3) School Principals, (1) Senior Teacher, (2) Assistant Coordinators, who wishes for their job specifications and location to remain anonymous. The questions which were developed using the Roger’s Diffusion of Innovation analytical framework as the guiding principles in the interview with each of the stakeholders.

Secondary data were used through the analysis of Government published articles and reports which were relevant to the digital transformation initiatives in Trinidad and Tobago as well as news, reports in different local news channels.

4.4 Data Analysis

The thesis conducted a thematic analysis to identify the themes and patterns-based data collected. Firstly, all the interviews were transcribed into full text. Two of the interviews were transcribed manually and six by the AI transcribing software ‘Otter’. Interviews transcribed by Otter were double checked manually to ensure accurate transcription of the audio has occurred.

The data from each interview was then decoded one at a time with constant reflection to each interviewee’s answer to the questions, to search for contradictions or similarities with their answers.
The answers received from the interviews were then organised in a table form with each interviewee’s response to find the relevant information to answer the research questions. The data was then used to identify ideas and concepts which had relation to the literature reviewed.

Thereafter, the concepts were synthesised in order to illustrate themes from them which allowed for the generating of the data through the creation of a visual diagram which assisted with simplifying the information to allow for confirmation of which data was necessary to move forward with in order to answer the research questions.

4.4 Limitations
The number of interviews used in this research was approved as sufficient for this thesis, however its limited number can leave room for opposing views of the results. Additionally, all the interviews conducted were via zoom due to the interviewees high job demands which made their availability of time extremely limited. Also, the lengthy public holiday periods in Trinidad and Tobago fell within this timeframe which made the physical meetings impossible.

The information needed for the research were safeguarded by Government officials and not published for the public’s access which resulted in many red tape processes in order to retrieve information. The difficulty accessing data led to lengthy approval processes, which also contributed to the limited amount of data retrieved.

4.5 Validity and Reliability
In this study, meticulous attention was given to ensure the validity and reliability of the research, which ultimately enhances the trustworthiness of the findings. Despite the hassle to retrieve the internal information needed to conduct reliable research, the receipt of approvals from the Ministry of Education allowed for interviews to be conducted with the requested personnals and gathering of the available data possible.

The data from those interviews were then used in a method of triangulation with observed data and information retrieved from published reports to conclude the similarities of the findings. Additionally, to ensure the reliability of the data, a sampling strategy was used to select the participants of the research. The selection was done in a non-probability sampling strategy as all the participants which preselected to ensure quality data was provided given that the sample amount was limited. The preselected participants were chosen through
purposive sampling based on their ability to provide valuable information due to their experience and knowledge.

By adhering to these standards, this research provides meaningful insights with confidence, contributing significantly to the existing body of knowledge on the topic.

4.6 Ethical considerations
In the collection and handling of its research, this thesis takes ethical consideration based on the European General Data Protection Regulation (GDPR). Interviewees were informed about the research and consents were granted before each interview started. Moreover, personal data of each interviewee is protected against unauthorised use and only the necessary data were collected and utilised as described to them.

5. Results and Critical Analysis
This chapter first presents general information of the case and then the results of critical analysis of the data collected including, 1) the current situation of BMS adoption; 2) the challenges of BMS adoption in the country; 3) the implication of adopting BMS for sustainable real estate in the country.

5.1 The Current Situation of BMS Adoption
The Trinidad and Tobago Green Building Council (TTGBC) is a non-profit organization that aims to promote sustainable building practices in the country. According to the TTGBC, the use of building management systems is gaining popularity in Trinidad and Tobago, particularly in commercial buildings. Building automation and control systems (BACS) are increasingly being used to improve the energy efficiency of buildings and reduce operating costs (TTGBC, 2023).

Private sector organisations and denominational schools in Trinidad and Tobago have demonstrated a proactive approach towards BMS adoption. The software engineer (Informant A) stated that the private sector, driven by economic considerations and competitive advantage, has recognised the potential benefits of BMS in terms of energy efficiency and cost savings. Similarly, the ICT Director (Informant B) stated that the denominational schools, often operating with greater autonomy and financial flexibility, have been more receptive to adopting BMS technologies.
5.1.1 No Current Adoption of BMS in Public Schools

In contrast, BMS adoption in government schools remains considerably low, almost non-existent. Several key factors contribute to this disparity. The allocation of financial resources is often prioritized towards curriculum development, infrastructure maintenance, and other immediate needs, leaving little room for technological advancements such as BMS.

The bureaucratic hurdles and complex decision-making processes within the public sector pose additional challenges as affirmed by Informant A:

“Trinidad government is very open to digitisation of the country and more digital innovations. As far as policies and skills go, I haven't seen any real impact yet to be made and they are not pushing the agenda so far just talks on it, but nothing being done really. In terms of implementing and selecting a company to install such systems, it is a whole other bureaucratic process.”

Government schools often face bureaucratic red tape, which slows down the decision-making process and impedes the implementation of innovative technologies like BMS. The involvement of multiple stakeholders, such as government agencies, ministries, and school boards, can result in delays and administrative complexities, further hindering BMS adoption.

5.1.2 Recent New System for Digital Reporting of Building Management

According to Informant B, although full adoption of BMS has not been implemented in the public schools throughout Trinidad and Tobago, there has been notable steps towards digitalising the reporting system of school’s maintenance needs.

The Ministry of Education has a digital platform called the ‘School Issue Management System (SIMS)’, which allows for real-time reporting of the maintenance needs in the schools. This system replaced the traditional method which took a lengthy period of time to get to the necessary stakeholders which could assist with the resolution of the issues. On the SIMS platform, the issues reported now goes directly to the Ministry’s personnals which transfers the issues to its relevant stakeholder.
**Figure 3: Traditional Maintenance Reporting Method**

As seen in Figure (3), the traditional method of reporting the school’s maintenance needs followed the ritual of the administrator of the particular school would have to detail the issue and send it to their principal. The principal would then take that report and submit it the school’s supervisor in its district, the school supervisor would then submit that to the ‘Division of School Supervision’, followed by the ‘Division of School Supervision’ would have to submit that to \ the ‘Education Facilities Planning and Procurement Division’ (EFPPD). At EFPPD, a surveyor, a quantity surveyor, as well as the coordinator for the particular district, and a project manager would be assigned to investigate the issue. Informant B further explained the process:

“Once it has been investigated, a report is completed for the ministry at that point to issue the ‘Request for Proposals’ to contractors to be able to address the issue. This process is subjected to procurement proceedings, which means that it would have had to go to the Permanent Secretary for approval. The shift and automated reporting system involves the principal to send the issue in real time, by selecting the categorised details, attaching a photo and notes which goes directly to the EFPPD for them to make a decision. When this happens and it is submitted for approval from the Permanent Secretary to begin works, a ‘ticket’ notification is issued back to the school’s Principal.”

The integration of digital reporting systems for maintenance needs represents a significant advancement in technological adoption of the school system, although a complete integration
across all aspects of school operations is yet to be realized. This implementation of digital reporting systems has enabled schools to streamline their maintenance processes and enhance communication between stakeholders involved in maintenance operations. By leveraging digital technologies, schools have transitioned from traditional paper-based reporting to more efficient, sustainable and automated systems.

The adoption of this digital reporting systems allows for real-time tracking and documentation of maintenance requests, ensuring timely responses and reducing administrative burdens. Furthermore, it facilitates data analysis and trend identification, enabling the Ministry of Education to proactively address recurring maintenance issues and allocate resources effectively. While this progress signifies a positive step towards digitisation in schools, it is crucial to acknowledge that comprehensive integration, encompassing all aspects of school administration and operations, is still lacking.

Both assistant coordinators, Informant C and D, reiterated the significant change since the implementation of the SIMS platform, however, they also highlighted the administrative challenges with this system:

“The principals of the schools are the ones in charge of logging the reports, some of them often misreport what are the actual issues and commonly report issues that are not in line with the building’s maintenance needs.”

Despite the recognition of reports through a ticketing system, the principal’s perspective on the school issue management system indicates that it does not guarantee swift resolution to the reported issues. Informant F underlined:

“While the ticketing system serves as a mechanism for capturing and documenting reported problems, it appears to fall short in terms of effectively addressing and resolving these issues in a timely manner.”

The principal's viewpoint suggests that there may be challenges or bottlenecks within the system that hinder the prompt resolution of problems. This may include factors such as limited resources, inadequate prioritization of reported issues, or inefficiencies in the workflow processes associated with issue resolution. The principal's observation highlights the need for a comprehensive evaluation of the school issue management system, with a focus on identifying and rectifying the underlying obstacles that impede the swift resolution of reported problems. By addressing these challenges, schools can ensure that the issue
management system is not only effective in acknowledging issues but also in facilitating its timely and satisfactory resolution.

One principal (Informant G) explained:

“Although the system allows for direct reporting, for some reason repairs which are not necessary have been conducted instead of what has been reported. It is open for interpretation that the end user of this system is not correctly identifying the real issues or fixing them properly. This is a problem because it wastes time, money, and resources.”

Informant G suggests that close attention should be given to the reported problems, how well the maintenance staff is trained, and how well everyone communicates. By improving these things, they can make sure that the system works better and that repairs are only done when they are really needed. This will save the Ministry money and make the operations of the schools run more smoothly.

In conclusion, the SIM system is a start to the adoption of digitalised property management as the system acts as an introduction to digitalised reporting and logging of maintenance needs. The full adoption of BMS in public schools throughout Trinidad and Tobago is not yet widespread, and there is a need for greater awareness and education on the benefits of these systems. The TTGBC continues to promote the use of sustainable building practices and technologies, including building management systems, through advocacy, training, and certification programs.

5.2 The Challenges of BMS Adoption in Trinidad and Tobago for Sustainable School Buildings

5.2.1 Older School Buildings Specific Challenges

Adopting BMS for sustainable school buildings presents a myriad of challenges, particularly in relation to compatibility with older buildings. Informant A explains that the existing educational infrastructures, especially those constructed prior to the introduction of sustainable building technologies, can present a multitude of integration obstacles, the resolution of which is critical to the successful adoption of BMS.

One primary issue is the inherent design and technological discrepancies between older buildings and modern BMS. Older structures often possess architectural characteristics and systems, such as HVAC, lighting, and energy systems, that may not seamlessly integrate with
BMS technology. This dissonance can engender operational inefficiencies and compromise the potential environmental and economic benefits associated with sustainable building management systems. As explained by Informant A (Software Engineer):

“Most schools in Trinidad and Tobago, being built over 50-60 years ago does not have a central air conditioning system which means that the system has to be compatible with split units which would be newly implemented in each room of the building. In addition, older buildings typically lack the necessary data infrastructure to support the implementation of BMS, which heavily rely on digital connectivity and real-time data gathering for optimal performance. Upgrading the data infrastructure can be time-consuming and costly, particularly in structures that were not designed with such needs in mind.”

Moreover, structural adjustments required for BMS implementation can be extensive and could potentially compromise the historical and cultural significance of the older buildings. Balancing the demand for sustainability and the preservation of heritage value is a recurring challenge in the modernisation of these buildings.

The legal and regulatory constraints tied to building modification also pose a challenge. Many schools in Trinidad and Tobago which falls within the aged or historical building category are often subject to strict rules regarding its alteration, thereby restricting the extent to which BMS can be implemented. Overcoming these regulatory hurdles necessitates a careful and context-sensitive approach, highlighting the complexity of integrating BMS into older educational facilities.

While BMS offers promising advantages for enhancing the sustainability of school buildings, the path towards broad adoption in older buildings is fraught with challenges.

5.3.2. New School Buildings Specific Challenges

In contrast, the newer school buildings in Trinidad and Tobago faces unique challenges with the adoption of BMS for a sustainable building. A senior teacher (Informant E) described:

“Our school is one of the fairly newer school structures in the country, however the challenges faced are endless. These challenges arrived from poorly maintained facilities and the lack of understanding of the functionalities of this modern building.”
These challenges emanate not only from the structural and systemic defects that result from inadequate maintenance, but also from the broader implications these defects have on BMS adoption and overall building sustainability.

A crucial challenge lies in the underperformance and breakdown of existing systems within these poorly maintained buildings. Modern schools often house complex electrical, HVAC, and energy systems, the health of which is pivotal for effective BMS operation. Due to lack of maintenance, these systems may operate below optimal efficiency or may have systemic faults, rendering the adoption of a BMS problematic. Informant E (Senior Teacher) vividly described the maintenance inadequacy at their school:

“The ministry contracted Chinese labour to build the school and when they left the continued support, knowledge, repairs and parts left with them. So, we have 60 Split units plus 60 plus air conditioning units, the water system, the pump system which all fails regularly. A PA system, which was throughout the entire school with speaker systems wired throughout the entire school, but one by one, the children interfered with the speakers so it started to disappear in some rooms, and then after a while I think the system itself failed.”

All four of the schools that were used in this research were either reconstructed or newly built less than 15 years ago. All schools of these schools were previously equipped with central air conditioning systems which had to be phased out due to improper maintenance and the lack of knowledge of its building’s plan. This results in the inefficiencies which undermined the potential sustainability benefits, necessitating extensive and potentially costly repairs before the BMS can be effectively deployed.

The diminished life expectancy of the newer buildings and its systems are hazardous for the adoption of BMS. BMS are typically designed with longevity in mind, intended to manage and optimise building operations over an extended lifespan. However, poorly maintained buildings may significantly shorten life expectancies, which can limit the return on investment for a BMS and may demand more frequent replacements or upgrades of building systems than initially planned. Two principals (Informants F and G) highlighted the psychological impact on their school’s community due to improper maintenance of the school buildings. Poor building conditions negatively affects the perceptions and attitudes of the staff and students.

Successful BMS adoption requires the engagement and cooperation of the building's occupants, emphasising the need to address the social dimensions of BMS implementation in
poorly maintained buildings. In the poorly maintained school buildings, a host of complex challenges, ranging from systemic inefficiencies and structural problems to management issues and occupant perceptions is a reality. Addressing these challenges forces a comprehensive and multidimensional approach to building maintenance and management, with an emphasis on long-term sustainability and occupant engagement.

5.2.3 Collaboration and Financial Support
The adoption of BMS into sustainable school buildings, despite the presence of stakeholder collaboration, is fraught with challenges, particularly when government financial support is limited. These hurdles can be observed in areas such as financial feasibility, system selection and installation, stakeholder alignment, system management, and performance measurement.

A fundamental challenge is the financial feasibility of BMS implementation. The research discovered that there is a vast interest and willingness to adopt BMS into school buildings. However, to adopt such a capital-intensive system, a substantial upfront investment in hardware, software, installation, and staff training is needed. In the context of public school, to secure government support for sufficient funding becomes a significant challenge. Schools may need to explore alternative financing methods, such as public-private partnerships or community fundraising, which can be complex and time-consuming. Informant E explained:

“To my knowledge government schools are we heavily dependent on the government for funding. If we are lucky, we would be fortunate to get funds from one of these international lending agencies, that willing to fund new technologies or advance technologies, especially in schools, but very rarely, might be a one of a kind thing, and it would be for a handful of schools, not for the entire country.”

Due to limited funding, schools may be forced to opt for less advanced or less comprehensive systems, which might not deliver the same level of performance or sustainability benefits as higher-end systems. The installation process may also be complicated by financial restrictions, potentially leading to compromises in the quality of work or the speed of implementation.

Even with stakeholder collaboration, alignment on BMS adoption can be difficult. With limited funds, the decision-making process may become contentious as stakeholders may have differing views on priorities. Informants F and G (Principals) both stated:
“One of the methods we use for acquiring funds is from the school’s fund-raising strategies which is not a substantial amount to implement such a system.”

Non-public schools which in most cases, has students from better economic backgrounds, are usually able acquire funds or collaborations with their ‘Past Pupils Associations’ which benefits those schools drastically in comparison to the fully Government funded public schools, which mostly have students whose families have limited resources. This makes the public schools heavily reliant on the Government’s financial resources for the adoption of BMS in its school.

The ongoing operation and management of BMS also present significant challenges, particularly in a context of limited financial support. BMS require continuous monitoring, maintenance, and occasional upgrades to ensure optimal performance. Without sufficient funding, these operational needs may be inadequately addressed, undermining the effectiveness of the BMS and its contribution to building sustainability.

Lastly, performance measurement and validation pose challenges. With the pressure of limited resources, demonstrating the effectiveness and return on investment of the BMS becomes paramount. However, measuring the performance of BMS can be complex, involving multiple parameters such as energy savings, operational efficiency, and occupant comfort. This complexity can make it difficult to conclusively demonstrate the value of the BMS, potentially leading to scepticism or disappointment among stakeholders.

5.2.4 ICT Connectivity and Skilled Labour

The research conducted alongside the school’s stakeholders discovered that the availability of high-speed and reliable internet connectivity in the buildings were either pending installation, limited connectivity, or in the process of connectivity.

Limited ICT connectivity in schools presents a significant challenge for the integration and operation of BMS, which rely heavily on digital infrastructure. BMS generally require robust and reliable ICT connectivity to function optimally. They depend on sensors, control systems, and real-time data analytics, all of which demands a high level of network reliability. Schools with poor ICT connectivity may face difficulties in implementing BMS, potentially leading to sub-optimal performance, frequent system errors, and overall reduced effectiveness. These technological challenges may compound the financial and logistical hurdles inherent in BMS adoption.
Informant E vividly described the nonfunctional ICT connectivity at their school which has been pending activation:

“They wired and added modems and hotspots throughout the entire school compound. So, the actual infrastructure for Wi-Fi connectivity is in the school. For some reason there is problems with having it up and running for a number of years.”

Moreover, the dearth of skilled labour to operate BMS poses a substantial obstacle. BMS are complex systems that demand specialised knowledge and skills for installation, operation, maintenance, and troubleshooting. Informant G believes that such a system would be great but if it’s not maintained it will be useless:

“In Trinidad we have seen maintenance is our biggest issue, we get new things, and they talk, and they publish it, but the maintenance of the system may fall by the wayside. So, although they may implement them, we have to consider maintenance of the system and experts to maintain the system to ensure that there is longevity.”

Without adequately trained staff, schools may struggle to properly operate and maintain the BMS, thus limiting its effectiveness in enhancing building sustainability. Furthermore, the lack of skilled personnel can lead to improper usage or overlooked maintenance needs, both of which can result in system damage, shortened lifespan, and increased costs over time. Luckily, the willingness to be trained and acquire the necessary knowledge to operate such a system is existent in the schools. Even when there is motivation and interest in adopting such systems, this cycle can obstruct the path towards more sustainable and efficient school buildings.

In order to interpret and apply the data needed for BMS, it requires both reliable ICT connectivity and staff with the necessary technical expertise. Without these elements, the potential value offered by this data might be unrealistic, diminishing the return on investment for the BMS. Overcoming these hurdles will require targeted investment in ICT, comprehensive training programs, and a long-term commitment to building capacity and improving system reliability.

5.3 Implications of Implementing BMS for Sustainable Real Estate in Developing Countries

Introducing Building Management Systems (BMS) to promote sustainable real estate in developing nations requires rigorous assessment of multiple factors. Through their extensive
use of locally available resources, developing countries exhibit a distinctive character in terms of sustainable real estate. In addition to labour and building materials, these resources also include traditional construction methods and prevalent cultural elements.

5.3.1 Cost of Implementation

Obtaining financing for transformative initiatives constitutes a primary issue for many developing nations and BMS are no exception. Developed countries possess a plethora of funding avenues dedicated to the erection of sustainable structures, thereby enabling the availability of fiscal resources. On the other hand, developing nations often don't have the same resources. In particular, public sector construction endeavours and the selection of materials used are frequently restricted by fiscal constraints and limited financing resources. Developing countries are heavily reliant on foreign investment to adopt digital transformative management systems such as BMS.

For developing countries such as Trinidad and Tobago, which produces natural gas and uses it for most of its energy production, they already have relatively low gas prices compared to the developed world. Although this resource is readily available, the power supply and maintenance of electricity in some districts are often affected by improper maintenance. While the use of natural gas still provides lowered energy rates for consumers, the carbon impact its emissions have on the environment is tremendous. Through implementation of BMS, emissions would be reduced, and adequate evaluation of electricity supply would be conducted to ensure its sufficiency. BMS have increasingly been incorporated into the sustainable real estate paradigm initiatives, particularly within developing nations, as a response to increasing concerns about environmental sustainability and energy efficiency.

BMS generally has a positive rate of return on investment (ROI) over the lifecycle of a building, despite the initial capital outlay, based on factors such as reduced energy use, lower maintenance costs, and an increase in property value, according to empirical data and econometric modelling. In addition to influencing the investment strategy in the real estate sector, this promising ROI can also have a significant impact on sustainable urbanisation in developing countries. BMS is a cost-effective tool for promoting energy efficiency and sustainability, thereby influencing policymaking, investor decisions, and regulatory frameworks within these economies. BMS adoption can therefore be viewed as a strategic investment in the pursuit of economic profitability and environmental sustainability in the real estate sector of the developing world.
5.3.2 Skilled Labour Force

In the economic landscape of developing nations, it is commonplace to engage foreign labour for specialised projects. This practice may be motivated by factors such as cost-effectiveness, access to specific skills, or a combination of both. However, the pursuit of cost-saving labour strategies does not necessarily lead to durable labour outcomes. When outsourced labour forces close their contracts and return to their countries of origin, this conundrum often results in increased long-term maintenance expenditures as the local workforce assumes the responsibilities without the necessary skills or knowledge.

A manifestation of this phenomenon can be observed in the case of Trinidad and Tobago, where recent educational building projects have faced significant maintenance and repair challenges. These edifices, built by an international workforce, now face severe upkeep issues after their departure. In return for their home countries after completing their contracts, the foreign labourers took with them the valuable technical knowledge and experiential knowledge they acquired. The absence of formal handover procedures or instructional training to acquaint local workers with the maintenance needs of these newly erected structures has left a glaring knowledge gap.

As a result of this deficiency, the local workforce has been unable to adequately maintain these structures, resulting in higher maintenance costs. Inadequate maintenance has resulted in substantial structural and functional issues at these schools because of the lack of understanding about the necessary upkeep measures. Thus, the initial labour savings have been offset by spiralling costs of reactive maintenance and remediation, underscoring the unintended consequences of labour outsourcing.

The successful deployment of BMS in this context of sustainable real estate within developing economies underscores the urgent need for skilled labour and long-term relationships with the labour force. Managing the complexity inherent in these technologically sophisticated systems requires a cadre of workers with specialised skills and knowledge. Implementation requires competencies not only in system installation, but also in the understanding of the broader integration of these systems with existing building infrastructure, operating protocols, and maintenance procedures.

In addition, a skilled labour force is required for ongoing maintenance, operation, and upgrading of BMS. Unlike traditional building systems that often rely on reactive maintenance strategies, technologically advanced building management systems require
proactive engagement, including regular system checks, data analysis, and timely software and hardware upgrades. Therefore, establishing enduring relationships with skilled labour is crucial to the sustainability of BMS.

Nevertheless, many developing economies face significant challenges due to a lack of such specialised skills. BMS implementation and operation may be hindered by a pervasive skills gap, undermining the sector's efforts to achieve energy efficiency and sustainability. Therefore, addressing this skills gap becomes imperative. A comprehensive training program and continuous professional development could equip local labour forces with the necessary expertise and facilitate their engagement with BMS.

Moreover, promoting long-term labour force relationships requires attention not only to skills training but also to creating conducive working conditions and supportive organisational structures. As part of this initiative, workers are encouraged to contribute to problem-solving and continuous system improvement by creating a culture of learning and innovation. It is this type of environment that can foster a sense of ownership among the workers, promoting their long-term commitment to the success of BMS.

The cultivation of a durable labour force relationships is also dependent on building strong relationships between a variety of stakeholder groups, including system manufacturers, building owners, facility managers, and workers. By fostering such relationships, knowledge can be exchanged, mutually learned, and problems can be solved collaboratively, enhancing the collective ability to implement and operate BMS efficiently.

Multi-stakeholder efforts are needed to address the socio-technical challenges of implementing BMS, including policy interventions, investments in education and training, organisational innovation, and partnership-building. Through such efforts, BMS can be effectively implemented while contributing to the broader socio-economic development goals of these economies by creating quality jobs, improving skill levels, and promoting technological innovation. As well as contributing to the sustainability and development objectives in these countries, this approach has potential benefits across many layers of urbanisation.

5.3.3 Understanding the Social System

The development of sustainable real estate in developing countries involves more than simply deploying technology; it involves a complex matrix of social systems as well. BMS
implementation success or failure is influenced by a comprehensive understanding of government roles, stakeholder collaborations, cultural norms, and values.

It is commendable that Trinidad and Tobago's government is interested in technology adoption. Although there is little publicity about the organisation, the Inter-American Development Bank is working with it to implement important technology initiatives and improve society's sustainability. This roadmap has given society hope for the future, even though commendable progress has already taken form in the digitisation of various Government ministries processes. The sustainable real estate industry has yet to take full effect.

Developing nations can contribute to the transition towards sustainable buildings by establishing regulatory standards for energy efficiency. The government's role in advancing BMS for sustainable real estate is crucial. In addition, they can provide financial support for their adoption. A government-led effort can also facilitate multi-stakeholder collaborations among policymakers, building industry professionals, BMS manufacturers, building owners, and users by leveraging its influence. In order to integrate BMS into sustainable real estate, such partnerships can promote knowledge exchange, foster shared understanding, and promote collective action.

Multi-stakeholder collaborations involving internal and external stakeholders, can mitigate bureaucratic processes commonly found in developing countries by involving each stakeholder in an essential role. Legislative and policy support can be provided by policymakers, technical expertise can be provided by industry professionals, product knowledge and training can be provided by manufacturers, and practical considerations of BMS operation and maintenance can be provided by building owners and users. Collaboration and active engagement between these stakeholders can enhance the effectiveness of BMS implementation and operation, contributing to the sustainable development goals.

BMS adoption and operation are also heavily influenced by cultural norms and values prevalent in developing countries. As an example, attitudes toward technology, building operation and maintenance norms, and values related to energy conservation and environmental sustainability can influence how people respond to BMS and how they behave. In order to facilitate BMS adoption and effective use, it is crucial to understand and address these cultural factors.
For example, in Trinidad and Tobago, scepticism or resistance towards technology is mainly found among the older demographic in the sense of fear. The local idiom "If it's not broken, don't fix it" is common among this group. It is possible to demystify BMS and cultivate positive attitudes toward its use through educational programs and awareness-raising initiatives. It is possible to instil new routines and practices that align with the requirements of BMS operation through training programs where building operations and maintenance are proactive rather than reactive. Luckily, the younger generation is eager for these old systems to be abolished.

Furthermore, advocacy and sensitisation efforts can encourage the recognition and alignment of BMS with environmental sustainability and energy conservation values where they are not well established. In order for BMS to be successful, these socio-cultural factors must be addressed. In addition to overcoming challenges, this task offers an opportunity to foster new norms and values that are compatible with sustainable real estate development goals.

6. Discussion

This chapter further discuss the results and findings that are presented in the previous chapter. Its purpose is to generate a deeper understanding of the current situation and challenges of BMS adoption in Trinidad and Tobago as a developing country.

6.1 BMS Adoption in Trinidad and Tobago

The findings of this study align with those of Lowry (2002) regarding user acceptance in the context of Trinidad and Tobago when examining the adoption of BMS as a digitalised property management tool. According to Rogers' diffusion of innovation framework (2003), adopters in this society place a high value on perceived ‘relative advantage’ and ‘compatibility’ with the BMS. Users are primarily concerned with improving their comfort levels and managing their tasks, rather than prioritising ‘time’ constraints.

As a result of adopting a particular innovation, a ‘relative advantage’ is perceived as superior to existing alternatives. The advantages offered by the BMS are prioritised by ‘the users’ (in this case, the principals and senior teacher) when adopting the system, including improved comfort, efficient operations, and better task management. As a result of these perceived advantages, the users are willing to adopt the BMS since they align with their specific needs and expectations.
Once implementation is phased in on a phase-by-phase basis, the users explained that the time of implementation does not interfere with their day-to-day operations. Moreover, they expressed that due to the constant hiccups that occur currently during time of maintenance, if building technology is able to eradicate this issue, they would be willing to accept it.

Compatibility also plays a significant role in the adoption process. Compatibility refers to the degree of fit between an innovation and the existing values, needs, and practices of the users. In this study, the BMS is perceived as compatible with the users' requirements and preferences. With its alignment with their objectives of maintaining comfort and streamlining their job responsibilities, the system makes a good choice.

### 6.1.1 Feeling of uncertainty

A key finding of this study is in alignment with Sahin's (2006) research, in which the importance of knowledge sharing is stressed as a means of mitigating the feeling of uncertainty associated with technology adoption, particularly in developing countries. Sahin's study indicates that individuals may exhibit hesitancy towards adopting new due to a lack of information about the potential consequences and outcomes of adoption.

In the case of the adoption of BMS in the public schools in Trinidad and Tobago, the users prioritise relative advantage and compatibility, suggesting that they seek clarity on the benefits and consequences of adopting the system. They also revealed that they have limited knowledge of a BMS existence, much less for what the system entails. This aligns with Sahin's assertion that addressing uncertainty through knowledge sharing is crucial for successful technology adoption in developing countries.

As revealed in this study, users are seeking detailed information about how the BMS will improve their daily tasks and overall work experience, based on their focus on comfort and job manageability. Any uncertainty or hesitation among adopters can be reduced by providing comprehensive information about the potential benefits of BMS adoption, such as improved comfort levels, streamlined operations, and enhanced task management.

It is important that individuals have access to accurate and transparent information about the consequences of technology adoption, as advocated by Sahin (2006). By understanding how the innovation aligns with their specific needs and objectives, they can make informed decisions. Considering the uncertainty and limited information that influence technology adoption in Trinidad and Tobago, knowledge sharing plays a crucial role in clarifying the benefits and addressing any reservations.
According to this study, knowledge sharing in developing countries is a critical mechanism to reduce uncertainty and facilitate technology adoption. To enable users to make informed decisions and embrace the innovation with confidence, comprehensive information about the implications and benefits of implementing the BMS is essential.

6.1.2 ICT Connectivity and Behaviour to New Technologies
Previous empirical studies by Chatti and Majeed (2022) have shown that infrastructure constraints in developing countries hinder knowledge exchange. Among these limitations are the lack of adequate infrastructure for data transmission, poor internet connectivity, and insufficient hardware and software. The research discovered that although ICT penetration in school buildings is either limited or non-existent, however, ICT connectivity throughout Trinidad and Tobago has a high penetration (IDB, 2020). Without adequate ICT connectivity the implementation of BMS would be impossible. The hinderance of knowledge exchange in this context differs from that stated by authors Chatti and Majeed. The knowledge exchange is affected by poor communication channels, attitudes to changes, awareness.

While ICT is vital for BMS adoption, it is also important for how users perceive technology. Cohen et. al (2012) highlighted that people’s behavioural patterns are adjusted based on truth that influences their feelings. This BMS implementation is perceived positively by the users based on how it affects their current working conditions. According to the users, the change acceptance to teaching online and the lack of adequate ICT connectivity affected not only them, but also the students who did not have adequate ICT facilities during the COVID-19 outbreak. In spite of being unfamiliar with this method of teaching, they adapted and became familiar with it.

Despite the challenges associated with the digital technology adoption of BMS in developing countries, the users are prepared and willing to make the necessary changes to foster a more sustainable building environment.

6.2 Prop-tech Challenges in Developing Countries
The findings of this research align and confirms four out of the five key hindrances the study conducted by Zanello, Fu, Mohnen, and Ventressa (2015), which identified five key hindrances to Sustainable Building Technologies (SBTs) in developing countries.

According to Zanello et al. (2015), one of the biggest hindrances is the lack of knowledge and awareness about sustainable building technologies. The hindrance relates to stakeholders’ limited understanding and knowledge of sustainable building technologies’ features, benefits,
and applications. As the results of this research confirms, a significant obstacle to the adoption of sustainable technologies in developing countries is indeed a lack of awareness and knowledge, which impacts stakeholders’ decision-making and their ability to recognise the potential benefits.

Secondly, Zanello et al. (2015) highlight the shortage of technical expertise and skilled professionals in developing countries. SBTs are often difficult to design, implement, and maintain due to a lack of professionals with the necessary skills and expertise. A major hindrance to SBT adoption is the lack of qualified personnel who can effectively handle them, as highlighted by the findings of the present study.

The third hindrance outlined by Zanello et al. (2015) is the high upfront costs of SBTs. Due to their high initial costs, sustainable building technologies may deter stakeholders in developing countries who may have limited resources or prioritise immediate savings. According to the current study, the high upfront costs of SBTs are indeed a significant challenge to their adoption in developing countries, which supports this hypothesis.

Fourth, Zanello et al. (2015) identified a lack of supportive policies and regulations that could hinder the integration of SBTs into the construction industry. SBT adoption is hindered in developing countries by an uncertain and unfavourable environment created by the lack of supportive policies and regulations.

Lastly, Zanello et al. (2015) concluded that the scarcity of locally sourced and affordable sustainable building materials hinders SBT adoption in developing countries. SBT implementation is constrained by the scarcity of locally sourced and affordable sustainable materials. This factor cannot be confirmed or denied based on the findings of this research as the data generated does not provide information on affordability of sustainable building materials.

According to Said Business School (2020), creating a seamless user experience requires developing data standards and interoperability between different platforms and systems. In line with the findings of this study, prop-tech is hampered by high implementation costs and unclear benefits. Before data standards can be establishes in developing countries, support must be given to the data collection to determine the data landscape within its society. (Lundvallet al., 2010). In addition to supporting these findings, PWC's Real Estate (2020) report also underscores the challenges facing stakeholders in the prop-tech industry. The Deloitte (2020) report presents a new perspective by emphasising the need for a deeper
understanding of cultural barriers to prop-tech adoption, which is in line with our research results.

The PWC Real Estate (2020) report corroborates the challenges identified in this study. The study highlights the barriers posed by high implementation costs and the lack of clear benefits associated with prop-tech adoption. It is important to address cost-related concerns and provide stakeholders with an understanding of how prop-tech solutions can benefit them. It is evident from both the report and the research that the real estate industry along with relevant stakeholders must work together to overcome these barriers and promote wider adoption of prop-tech.

In addition to the aforementioned reports, the Deloitte (2020) report offers a fresh perspective by emphasising the importance of understanding cultural barriers to prop-tech adoption. As a result of the present research, it is clear that contextual factors, including cultural norms, preferences, and practices, play a significant role in the adoption of prop-tech solutions. For prop-tech innovations to be implemented and leveraged effectively in diverse contexts, cultural barriers must be identified and addressed.

It is imperative to develop data standards, interoperability, reduce implementation costs, clarify the benefits of prop-tech, and overcome cultural barriers. Through these insights, stakeholders will be able to gain a comprehensive understanding of the challenges and opportunities associated with prop-tech adoption, enabling them to leverage the potential of prop-tech in the real estate sector of developing countries.

6.3 Digital technology adoption and business ecosystem in Developing Countries

6.3.1 Digital technology adoption in developing countries

The results of this research suggest that although Heeks et. al (2013) suggests that digital technologies disrupt existing industries and jobs in developing countries, this may not necessarily be true for Trinidad and Tobago.

In disagreement with Heeks (2017) analysis, digital technologies can be seen as a tool to make existing jobs and industries more reliable and efficient in developing countries. As a result of the low technology labour force, especially in novel innovations, this opens up opportunities for economic growth through the development of technological industries which clearly broaden the employment pool for skilled individuals.
According to Sahin (2006), one of the main reasons why developing countries haven't fully adopted innovations in their industries is the high cost of conducting research and development of this nature, which leads to the adoption of ‘incremental’ and ‘imitation’ innovations instead.

The need to invest in technology hubs in developing countries is widely acknowledged. Besides creating jobs, this also eliminates the problem developing countries face when implementing ‘incremental’ and ‘imitation’ innovations. Those interested in this industry would be given the opportunity to enhance their skills in their own country as a result of this initiative, which would eliminate the issues of a lack of training and development, outsourcing of skilled labour and brain drain.

Sahin (2006) indicates that innovations are still new to individuals regardless of how long they have been invented, once they are themselves unfamiliar with them. As a result of this ideology, companies tend to rip-off consumers by charging novel innovation prices for old inventions, which can be dangerous in developing countries. When policies and government restrictions on innovation are limited, this can be done easily in developing countries.

Additionally, Heeks' (2017) research has limitations concerning government participation in policymaking, finance interventions, and assistance in shaping power dynamics associated with innovation adoption.

Governments need to play a significant role in the restrictions and policymaking process in order to mitigate the complexity of adopting innovations in developing countries. In this way, ‘imitation’ usage is eliminated while imposing restrictions on innovation age, implementation methods, technology certifications (only from certified institutions), and price ceilings based on criteria are put in place.

6.3.1 Real Estate Business Eco-system

The research at hand supports Kytömäki's (2020) study which argues that real estate business should be conducted alongside real estate owners, facility managers, technology providers, and service providers to collaborate as part of an ecosystem to enhance collaboration. Additionally, collaboration between universities and businesses should be encouraged to ensure that the workforce is equipped with the necessary skills. In an ecosystem of this type, knowledge, expertise, and resources are exchanged, as well as a learning environment is created where stakeholders can learn from each other and create value together.
Considering Adner & Kapoor (2010) study on value creation, it is important to note that in order for developing countries to adopt sustainable real estate procedures, they must be able to fully grasp the value created by its implementation. One stakeholder in this economy would not be able to shift an entire culture. This explains the importance of utilising an ecosystem approach as real estate does not only affect the user or implementor, but it affects the entire environment. Its interdependency allows for sustainable business strategies and practices.

The real estate industry has a diverse set of stakeholders, and Kytömäki (2020) emphasizes the importance of collaboration and partnership. As a result, collaboration has become increasingly important for driving innovation and value creation, as confirmed by the current research. In developing countries, knowledge-sharing ecosystem allows stakeholders to take advantage of the collective wisdom and experience of others, enabling them to make informed decisions and drive the real estate industry in a sustainable direction.

As Kytömäki (2020) describes, the real estate ecosystem creates an environment for collaborative learning, facilitating the exchange of best practices, insights, and innovative ideas among stakeholders. It is through these interactions that stakeholders can learn from each other and gain valuable knowledge. As shown in this research, stakeholders of sustainable buildings implementation need to collaborate not only for the exchange of knowledge, but constructing, financing, training and maintenance.

A holistic approach is necessary for sustainable real estate development in developing countries. As part of the real estate ecosystem, the exchange of resources, including financial, technological, and human resources, is a crucial factor for consideration. The industry’s stakeholders can create value and drive positive change by leveraging the collective intelligence of the ecosystem.

The research discovered that close consideration of developing country’s social system plays a crucial role in BMS adoption. Through thorough analysis of the social system, a real estate ecosystem can lay the foundation for better understanding of the power dynamics from successful adoption. Clear indication of the power dynamics can creative greater innovative solutions, improve operational efficiency, and create new opportunities through the combination of their strengths, knowledge, and resources.
7. Conclusion

In summary, the data collection and accessibility in developing countries needs extreme improvement in order for technology adoption to take advancement in the society. Where the data landscape in developing countries are unknown, prop-tech developers may encounter challenges with developing the best solutions suitable for its environment.

Additionally, Prop-tech already faces challenges of adoption in developed countries with better economic standing and data availability than those of developing countries. This means that the approach and system designs required for adoption in those societies needs a full assessment of the environments capabilities, economic standing, institutional arrangements, and societal acceptance to technology.

Digitalisation of property management in developing countries means the nature of a building’s design, construction, materials, and maintenance practices must be considered. Knowledge of this would also provide a scope into the financial feasibility of an investment into digitalised property management. The rate of return on this investment would be vital for implementation of this in developing countries. Although digitalised property management would foster a more sustainable and precise method of property management long-term, the complexities of implementation would be the most influential factor for adoption feasibility.

While BMS adoption in public schools throughout Trinidad and Tobago is a promising sustainable property management tool, it would require much more than the user’s willingness to adopt. A holistic approach from all actors of property development in this sector must be on board.

A real estate business ecosystem with the much-needed government financial government support would provide the necessary knowledge and expertise for successful implementation. While currently the skillset for maintenance of such systems may be limited in society, the initiative of training and development can take a starting point with the support of the ecosystem.

Based on the review of literature and the data retrieved in this research, it is recommended that further research should be conducted on ‘real estate business eco-system for value creation in developing countries.’ As well as the understanding of the social system in
developing countries for clearer understanding of how technology can be adopted in the urban development plans.

This research is significantly important as developing countries standpoint of advancement differs drastically from those of developed countries. Where many sustainability initiatives start and ends on different ends of the spectrum between these societies.
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## Appendices

### Appendix 1: Presentation of Data Collected and Generated into Theme

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>What is the current situation of BMS adoption in Trinidad and Tobago?</th>
<th>What are the challenges of BMS adoption in Trinidad and Tobago for sustainable school buildings?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informant A (Software Engineer)</td>
<td>“The private sector is more advanced with its adoption.”</td>
<td>“Most schools are quite old, and it depends on if the government wants to fund such a system.”</td>
</tr>
<tr>
<td>Informant B (ICT Director)</td>
<td>“In terms of schools, a full integration is non-existent but the advancement to digital reporting of maintenance needs has been implemented.”</td>
<td>“The willingness to adopt is there but financial support is a major problem.”</td>
</tr>
<tr>
<td>Informant C (Asst. Coordinator)</td>
<td>“At this time, they receive maintenance reports digitally.”</td>
<td>“Apart from BMS not being fully compatible with older buildings, I do not believe the ministry has the money for the system.”</td>
</tr>
<tr>
<td>Informant D (Asst. Coordinator)</td>
<td>“A full system has not been implemented but the reporting is digital.”</td>
<td>“The skilled personnel to operate that system may be few and wide within our ministry. We would have to hire skilled labour which is another cost.”</td>
</tr>
<tr>
<td>Informant E (Senior Teacher)</td>
<td>“This system is needed but it is non-existent at this school.”</td>
<td>“We do not have ICT connectivity at our school. Our building is new but poor structure and maintenance.”</td>
</tr>
<tr>
<td>Informant F (Principal)</td>
<td>“Never heard of it but believes that it would be useful.”</td>
<td>“The school is awaiting ICT Connectivity. Although our building is one of the newer ones, we would have a lot of repairs before we can implement the system.”</td>
</tr>
<tr>
<td>Informant G (Principal)</td>
<td>“The system is non-existent at this school but believes that it is needed.”</td>
<td>“There is internet in the school, but the connection is poor. There are several structural challenges that would have to be addressed first.”</td>
</tr>
<tr>
<td>Informant H (Principal)</td>
<td>“Never heard of BMS.”</td>
<td>“They might have to give us a new school to implement that system.”</td>
</tr>
</tbody>
</table>

| Notes | In the private sector and at the ministry level, there is early adoption rate of BMS. In the schools, it has not been adopted beyond reporting. | Old and new schools have their unique challenges with the adoption. Financial support is a major factor. ICT Connectivity is another major cause for concern when adopting BMS. The skills and training to utilise such a system would also need investment. |