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ADOPTION AND UTILIZATION OF INFORMATION TECHNOLOGY AND DIGITAL TOOLS IN PROJECT MANAGEMENT IN ROAD CONSTRUCTION IN SOUTH EAST NIGERIA

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Keywords: *Utilization, Adoption, Digital Tools, Management in Road Construction.*

Abstract: *This study focused on the adoption and utilization of it and digital tools in project management in road construction in south East Nigeria. The guiding objective of the study is to determine the level of IT and digital tools adoption in project management in road construction in Southeast Nigeria. To identify the challenges to the adoption of IT and digital tools in project management of road construction projects in Southeast Nigeria. The study adopted Technology Acceptance Model (TAM) and system theory by Ludwig von Bertalanffy. The study employed a survey design method, utilizing a quantitative approach through a meticulously structured questionnaire. The population of this study constituted all relevant registered road construction professionals as obtained from the register of various professional associations in South-East Nigeria. A sample size of 301 was gotten through Taro Yamane formula. The findings of the study reveals that Various IT tools, such as Project Management Software (PMS), Geographic Information Systems (GIS), and Building Information Modeling (BIM), are increasingly utilized to enhance project planning, execution, and monitoring. The study further reveals that The challenges in adopting IT and digitalization in road construction projects in Southeast Nigeria are multifaceted. Financial constraints are a major barrier, as the high costs associated with acquiring and maintaining advanced digital tools are often prohibitive for many construction firms. Additionally, there is a significant skills gap, with many project managers and workers lacking the necessary training to effectively utilize digital tools. The study recommends that Continuous*

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training and IT education are essential to equip professionals with the skills needed to effectively use digital tools in road construction.

1.1 Introduction

Road infrastructure is critical to the economic and social development of any region, serving as the backbone for the transportation of goods, services, and people. In Southeast Nigeria, road construction is particularly vital due to the region's economic activities, which include agriculture, commerce, and manufacturing. Efficient road networks facilitate the movement of goods and people, thereby enhancing economic productivity and regional integration. However, the road infrastructure in Southeast Nigeria is often inadequate, with many roads being poorly maintained and underdeveloped (World Bank, 2019). The state of road infrastructure in this region remains a significant challenge.

The deficiencies in road infrastructure have significant implications for the region's economic development. Poor road conditions often result in increased transportation costs, increased vehicle operating costs, delay the movement of goods, longer travel times, higher accident rates and reduced access to essential services such as healthcare and education. This situation is compounded by the frequent delays and cost overruns that plague road construction projects in the region. All of which negatively impact economic productivity and quality of life (World Bank, 2019). According to the World Bank (2019), improving road infrastructure in Nigeria could enhance economic activities by reducing travel time and costs, thereby facilitating trade and commerce.

Deficiencies in road infrastructure projects are often attributed to a combination of factors, one of which is the over-reliance on traditional project management practices (Verma & Singh, 2019). Traditional project management tools such as Gantt charts, the Critical Path Method (CPM), and paper-based documentation have been integral in managing project timelines and resources. These tools, while reliable, are predominantly manual, leading to inherent inefficiencies and human errors. Moreover, traditional tools are often static and lack the adaptability required to accommodate changes in project scope or unexpected challenges, thus limiting their effectiveness in dynamic project environments (Zhang & Li, 2020). Inadequate planning, poor resource allocation, ineffective communication, and lack of real-time monitoring domicile in traditional project management practices (Burke, 2013). Osei and Amponsah (2021) underscores how traditional methods often fall short in addressing the

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complexities and unique challenges associated with large-scale road construction projects. The authors highlight several limitations, including the lack of adaptability to changing project requirements, inadequate risk management strategies, inefficiencies in project planning, scheduling, and control. and insufficient stakeholder engagement.

These issues often result in project delays, cost overruns, and compromised quality. Oke & Aigbavboa (2017) highlighted that project delays are a significant issue in Nigerian construction projects, often caused by factors such as poor project management practices, funding issues, and delays in material delivery. The lack of effective communication and collaboration among project stakeholders further exacerbates these challenges. Traditional communication methods, such as face-to-face meetings and phone calls, are often inefficient and can lead to misunderstandings and miscommunications. This can result in errors, rework and further delays in project completion.

Information Technology (IT) and digitalization has the potential to address many of the mentioned aforementioned challenges in road construction. The integration of digital tools, software applications, and technological systems improve various stages of road construction projects, from planning and design to execution and maintenance. The adoption of IT and digital tools in road construction can enhance project planning, execution, improved resource management, real-time monitoring and control, effective communication and collaboration leading to improved project outcomes. (Project Management Institute, 2017). Globally, digitalization has brought about a transformative shift leveraging advanced technologies to enhance efficiency, sustainability, and safety across infrastructure projects. Adoption of IT and digital tools enhanced project management effectiveness with respect to time, cost, scope, quality, resource efficiency sustainability, and stakeholder satisfaction of projects (Hallowell, Molenaar & Fortuna, 2013).

Project management software such as Microsoft Project and Primavera P6 can be used to manage schedules, allocate resources, and track progress. These tools help project managers to plan and control project activities more effectively, reducing the likelihood of delays and cost overruns (Ghaffarianhoseini Tookey, Ghaffarianhoseini, Raahemifar & Oluwoye., 2017). Digital communication tools like Slack and Microsoft Teams can improve collaboration among project teams by providing real-time communication and information sharing. This can enhance coordination and reduce the likelihood of misunderstandings and miscommunications. Hallowell, Molenaar & Fortunat (2013) demonstrated the positive impact of digital communication tools on construction project outcomes, including improved efficiency and reduced project timelines. Eastman, Teicholz, Sacks & Liston (2011) highlighted the benefits of BIM in construction project management, including improved accuracy, better coordination, and reduced rework

In the light of the above discourse, it become pertinent to investigate the level of adoption and utilization of IT and digital tools in project management in road construction in South East Nigeria

1.2 Statement of the Problem

Road construction projects in Southeast Nigeria are critical to the region's economic growth and social development. Despite their importance, these projects often face significant challenges that hinder their successful completion. The recurring issues of project delays, cost overruns, and substandard quality have been widely documented in the literature (Oke & Aigbavboa, 2017). These problems are primarily attributed to inefficiencies in traditional project management practices, which include inadequate planning, poor resource allocation, and ineffective communication among stakeholders.

Traditional project management methods in road construction have been characterized by a lack of detailed planning and scheduling, leading to unforeseen issues during project execution. Resource allocation issues, such as the inefficient us e of labor, materials, and equipment, further exacerbate these problems. Communication barriers, resulting from reliance on outdated methods like face-to-face meetings and phone calls, contribute to delays in information dissemination and

Misunderstandings among project stakeholders. Additionally, the absence of real-time monitoring and control mechanisms makes it difficult to quickly identify and address issues as they arise, leading to further delays and increased costs (Oke & Aigbavboa, 2017; Project Management Institute, PMI, 2017). In contrast, the adoption of Information Technology (IT) and digital tools in the construction industry has shown promise in addressing these challenges. IT tools such as project management software, Building Information Modelling (BIM), and digital communication platforms can enhance project planning, execution, and monitoring.

Therefore, this study seeks to investigate the current level of IT and digital tool adoption in road construction projects in Southeast Nigeria, evaluate their impact on project timelines, cost efficiency, quality control, and stakeholder communication, and identify the barriers to their adoption. By addressing these issues, the study aims to provide insights that can inform policy and practice, ultimately contributing to the

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successful completion of road construction projects in the region.

1.3 Objectives of the Study

The study focused on the following objectives:

1. To determine the level of IT and digital tools adoption in project management in road construction in Southeast Nigeria.
2. To identify the challenges to the adoption of IT and digital tools in project management of road construction projects in Southeast Nigeria.

1.4 Research Questions

The study sought to answer the following research questions:

1. What is the level of adoption of IT and digital tools in project management of road construction projects in Southeast Nigeria?
2. What are the challenges faced in adoption of IT and digital tools in project management of road construction projects in Southeast Nigeria?

1.5 Statement of Hypotheses

The study was guided by the following null hypotheses

1. There is no significant impact of IT and digital tools adoption on project management in road construction projects in Southeast Nigeria.

1.6 Scope of the Study

The study focuses on road construction projects in Southeast Nigeria, encompassing urban, suburban, and rural areas within the region. It considers projects varying in scale from small-scale local road to larger ones.

The study examined a broad spectrum of IT applications and digital tools relevant to project management in road construction. This includes but not limited to Building Information Modelling (BIM), project management software, GIS applications, and digital communication platforms.

It assesses how the adoption and utilization of IT and digital tools impact various aspects of project management, such as project timelines, cost efficiency, quality control and stakeholder communication. The study included a comparative analysis between different types of road construction projects using IT versus traditional methods with respect to project management effectiveness of the road construction projects.

2.1 Conceptual Review

2.1.1 Information Technology and Digital Tools in Project Management

Information Technology in project management refers to the use of digital tools, software applications, and technological systems to support the planning, coordination, execution, and monitoring of project activities (PMI, 2017). It encompasses a wide range of technologies, including computer software, hardware, networks, and data management systems that collectively enable project managers and teams to manage resources, timelines, budgets, and communications effectively.

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Information Technology and digital tools used in project management in road construction can be organized into several key categories based on their functions and applications. These include surveying and site analysis, design and modelling, project planning and management, construction and automation, monitoring and quality control, safety and risk management, environmental and sustainability, asset and maintenance management, financial and contractual tools. An overview of some of the specific tools is provided as following:

I. Project Management Software

Project management software (PMS) refers to applications designed to aid in planning, organizing and managing project tasks and resources. These tools offer functionalities such as task scheduling, resource allocation, budget management, and risk management. Depending on the sophistication of the software, it can manage estimation and planning, scheduling, cost control and budget management, resource allocation, collaboration, communication, decision-making, quality management, time management, and documentation or administration systems **(**PMI, 2017**).** The basic features of the Project management software are that of scheduling and planning, budget tracking, document management and collaboration tools. Automation, AI and Machine Learning, Virtual and Augmented Reality (VR/AR), Internet of Things (IoT) integration are advanced features in some project management software.

. Popular project management software includes Microsoft Project, Procore, PlanGrid, Autodesk Construction Cloud, Primavera P6, Asana, Trello, Jira, Basecamp and Smartsheet (Verzuh, 2015)**.** The selection criteria for project management software depends on usability, scalability, customization, support and training and cost. Although, project management software is disadvantageous in terms of subscription costs, learning curve, and dependency on internet connectivity, its advantages are overwhelming; as improved efficiency, better collaboration, accurate tracking, informed decision-making and enhanced visibility, streamlined project scheduling and tracking, efficient resource allocation and cost management, real-time progress monitoring and reporting (Verzuh, 2015)

II. Digital Communication Platforms

Digital communication platforms are tools that enable real-time communication, collaboration, and file sharing among team members, regardless of their geographical location. These platforms enhance the flow of information and improve coordination (Duarte & Snyder, 2006). Features like instant messaging, video conferencing and file sharing are common with digital communication platforms. Tools like

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Slack, Microsoft Teams and Zoom facilitate real-time communication and collaboration among project stakeholders, including engineers, architects, contractors, and clients (PMI, 2017). The scope of digital communication platforms is for distributed teams and remote work. They have the advantages of enhanced collaboration and information sharing, documentation, reduced communication delays and misunderstandings, improved stakeholder engagement and decision-making. The disadvantages of digital communication platforms have been reported as security risks, over-reliance and learning curve (PMI, 2017).

III. Building Information Modeling

Building Information Modeling (BIM) is a 3D model-based process that provides detailed insights and tools for the planning, design, construction, and management of infrastructure. It is a digital representation of the physical and functional characteristics of a project. BIM has the features of 3D modelling, integration of various project data (design, construction, operation), clash detection and data visualization (Olugboyega, 2019). Its application in road construction includes visualization, coordination., simulation and analysis. BIM facilitates the planning and design phase by providing detailed 3D models that help in visualizing the project before actual construction begins (Eastman *et al.,* 2011). BIM enhances collaboration, reduces errors, and improves project visualization and efficiency (Olugboyega, 2019).

BIM software such as Autodesk Revit or Navisworks create detailed 3D models of road construction projects. These models include data on geometry, materials, and other relevant details. The models are shared among stakeholders to facilitate collaboration and coordination

High initial cost, high training and expertise and complexity of integration with existing systems are the limitations of BIM (Azhar, 2011),

IV. Geographic Information Systems

Geographic Information Systems (GIS) are designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data. These systems allow users to visualize, question, analyze, and interpret data to understand relationships, patterns, and trends (Longley, Goodchild, Maguire & Rhind, 2015). The features of GIS include spatial data management, mapping and visualization, spatial analysis and data integration. Generally, GIS is used for site selection and analysis, environmental impact assessment and infrastructure management (Ghaffarianhoseini *et al.*, 2017). The most common GIS are QGIS and ArcGIS. QGIS is an open-source GIS platform that offers advanced capabilities for geospatial analysis and map creation (Chang, 2016). ArcGIS provides

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powerful tools for spatial analysis, mapping, and data visualization. It collects, stores, analyzes, and visualizes geographical data. Layers of spatial data are integrated to provide a comprehensive view of the project area. GIS analyze terrain, plan routes, and assess environmental impacts for road construction projects. GIS has been found to improved decision-making, enhanced data visualization and better resource management. However, its disadvantages include among high cost of implementation, requires skilled personnel and data accuracy issues (Chang, 2016).

V. Internet of Things (IoT) and Sensors

The Internet of Things (IoT) involves connecting physical devices, such as sensors and machines, to the internet to collect and exchange data. The Internet of Things (IoT) enables the deployment of interconnected devices and sensors in road infrastructure to monitor conditions in real-time. The basic features of IoT include real-time monitoring, data collection and analysis, predictive maintenance and remote control (Evans, 2011). IoT applications include traffic management, structural health monitoring, and environmental sensing. IoT devices collect and transmit data for predictive maintenance, optimize traffic flow, and enhance safety by providing early warning systems for potential hazards (Shan, Shen & Ni, 2020). Sensors are installed on equipment and infrastructure to collect data on various parameters like temperature, humidity, and vibrations. They can monitor the health of machinery, track material usage, and ensure safety on construction sites. Sensors and Internet of Things (IoT) have the advantages of increased efficiency, improved safety and better resource management, However, their disadvantages are high implementation cost, data security concerns and complexity of integration (Greengard, 2015).

2.1.2 Global Trend of IT and Digitalization in Road Construction

The adoption of IT and digitalization in road construction follows a global trend. It is accelerated due to several key trends: Integration of technologies, smart infrastructure initiatives and data-driven decision making (Aziz *et al.*, 2021). The North America is a leader in IT adoption in road construction (Wandera & Odongo, 2021). The United States and Canada in particular, are at the forefront of IT adoption in construction. The region's strong technological infrastructure, regulatory support, and investment in innovation have accelerated the integration of IT solutions. BIM, AI, and cloud computing are widely used, and there is a growing interest in adopting emerging technologies like blockchain and 3D printing (Clement, Lee & Motamedi, 2021). Despite the progress, the region faces challenges such as

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cybersecurity risks and the high cost of implementing advanced technologies (Aziz *et al.*, 2021).

Europe has been proactive in adopting IT in road construction, with government mandates and incentives playing a crucial role. The EU's focus on sustainable construction and digitalization has driven the adoption of BIM, IoT, and other digital tools (Wu, Li & Zhang, 2019). The United Kingdom, Germany, and the Nordic countries, have been leaders in adopting IT in construction. The UK's BIM mandate has significantly influenced IT adoption across Europe. The UK's BIM mandate has set a precedent for other countries, while Germany's focus on Industry 4.0 is driving the adoption of IoT and robotics in road construction. The fragmented regulatory environment across different countries and the need for standardized guidelines pose challenges to IT adoption in Europe (Wu *et al.*, 2019).

The Asia-Pacific countries like China, Japan, South Korea, and Singapore are rapidly advancing in IT adoption in construction. China's massive infrastructure projects have driven the need for digital solutions, while Singapore's smart nation initiatives have led to widespread adoption of BIM and IoT in construction (Clement, Lee & Motamedi, 2021). Japan's aging workforce is also pushing the adoption of robotics and automation in construction. The diverse economic landscape across the region means that while some countries are at the forefront of IT adoption, others lag due to infrastructure and investment constraints.

Also, the Middle East is increasingly embracing IT in construction, particularly in countries like the United Arab Emirate and Saudi Arabia where mega-projects such as smart cities and large-scale infrastructure developments are being planned. BIM, drones, and mobile technology are particularly popular in the region (Omar & Mills, 2019). The adoption of BIM, drones, and mobile technology is growing, supported by government initiatives. The significant challenges in the region are the reliance on expatriate labor and the need for skilled professionals to manage IT systems (Shan *et al.*, 2020). Information Technology and digitalization adoption in road construction is growing in Latin America, with countries like Brazil and Mexico leading the way. The focus is primarily on improving project management and communication through cloud-based solutions and mobile technology. However, economic instability, high costs, limited access to advanced technologies, and regulatory hurdles are significant challenges in the region (Wandera & Odongo, 2021).

. In Africa, IT adoption in road construction is still in its nascent stages in many parts of Africa (Abanda, Vidalakis, Oti & Tah,

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2015). However, there is growing interest in adopting digital tools. South Africa is the most advanced in IT adoption within the construction industry on the continent. The country has seen the implementation of BIM, cloud computing, and GIS in various large-scale infrastructure projects. The South African government and private sector are increasingly recognizing the value of IT in improving project delivery and sustainability (Ferreira, Nkosi & Wium, 2021). Among countries in East Africa, Kenya and Ethiopia are emerging as a significant player in the adoption of IT in construction, driven by rapid urbanization and infrastructure development (Macharia, Njoroge, & Mwai, 2019). GIS and mobile technology are commonly used in road construction and urban planning. Kenya, in particular, has made strides in integrating IT into its road construction processes, supported by government initiatives and foreign investment (Abanda *et al.*, 2015). The West Africa region has Nigeria and Ghana been gradually adopting IT in road construction. The use of mobile technology and cloud-based project management tools is becoming more common, particularly in urban development and infrastructure projects. However, the adoption of more advanced technologies like BIM and AMG is still limited.

North Africa, particularly Egypt, is seeing growing IT adoption in construction due to large-scale government-led infrastructure projects. BIM, drones, and GIS are increasingly being used to improve project planning and execution (Kiziltas, Cetiner & Arayici, 2020). Morocco is also beginning to explore these technologies in its urban development projects. Central Africa lags behind other regions in IT adoption in construction due to economic challenges, political instability, and infrastructural deficits. However, there is potential for growth, particularly in the use of mobile technology and GIS for project management and planning. Limited infrastructure, high costs, and a lack of skilled workforce hinder the widespread adoption of IT in construction across the continent.

The future of IT adoption in road construction is promising, with ongoing advancements in technology and growing recognition of the benefits of digitalization. The global road construction industry is expected to continue its digital transformation, focusing on sustainability, smart infrastructure, automation and robotics.

2.1.3 Potentials of IT and Digitalization in Project Management

Researches have been conducted to identify the potential positive impacts of using IT and digital systems on projects. Stewart & Mohamed (2004) identified five performance perspectives of project information management that were

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improved by using web-based project information management systems on large construction projects. These perspectives were operational, benefits, technology/systems, strategic competitiveness, and user orientation.

Weippert, Kajewski &Tilley (2002) surveyed stakeholders on a case study project to rank their satisfaction regarding seven IT implementation perspectives for implementing internet-based construction project management (ICPM) systems on a remote construction project in Australia. Based on their ranking, these perspectives are: (1) information technology (IT), which is also the center of the framework that the other perspectives linked to it, (2) project management, (3) user utility (4) strategic positioning, and (5) value-adding, (6) project organization, and (7) benefits. Similarly, Thorpe (2003) also studied the implementation of ICPM systems (known also as online remote construction management (ORCM)) on a remote construction project in Australia, yet from a user view of ORCM, not a research perspective. Thorpe (2003) reported results, especially ranks of satisfaction regarding seven IT implementation perspectives, similar to Weippert *et al.*, (2002).

Vaughan, Lemingm, Liu & Jaselskis (2013) used a cost-benefit analysis to identify the quantitative and qualitative benefits of using a web-based construction information management system (CIMS), especially with mobile devices, on a university library project. The benefits of implementation were found to include (1) a 11.6% gain in management efficiency; (2) 7.5 hour decrease in total weekly hours worked by each of the studied staff on management activities; (3)1.5 hours of the earlier clerical time returned to the project in form of value-added planning time; and (4) potential savings of 12 to 38 days' worth of travel time to gather documents for each user on a 2-year project. The intangible (qualitative) benefits included (1) increased employee retention and reduced stress, and (2) ability of CIMS to address root causes of rework.

Hasan, Ahn, Rameezdeen & Baroudi, (2019) also studied the implementation of web-based project management by construction organizations, especially with the use of mobile devices, and thus called mobile information and communication technology (Mobile ICT). The study identified five main consequences on project management: four positive and one negative. These consequences include improved communication and work relationship, better management of construction defects, better information management on-site, improved work planning, and distraction and waste of time. Eastman *et al.*, (2011) noted that ICT tools provide comprehensive project models that facilitate real-time monitoring and decision-

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making. In addition, Hallowell *et al.*, (2013) found that ICT tools significantly improve project outcomes by enhancing team communication and collaboration. Enhanced planning and scheduling and improved resource management.

2.2 Theoretical Framework

The theoretical framework for this study draws on established one model and one theory that explain the adoption and impact of Information Technology (IT) and digital tools in project management.

2.2.1 Technology Acceptance Model (TAM) by Fred D. Davis (1989)

The Technology Acceptance Model (TAM), introduced by serves as a vital theoretical framework for understanding the factors that influence the acceptance and use of technology. At the core of TAM are two essential constructs: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). Perceived Usefulness refers to the extent to which a person believes that using a particular technology will enhance their job performance. Perceived Ease of Use deals with the degree to which a person believes that using the technology will be free of effort.

TAM is highly relevant to this study. In the context of road construction in Southeast Nigeria, the Perceived Usefulness could involve the use of project management software, Geographic Information Systems (GIS), or Building Information Modeling (BIM) tools., When project managers perceive that these technologies can improve efficiency, enhance communication, reduce errors, and ultimately lead to successful project completion, their willingness to adopt these tools increases. This, in turn, positively impacts project management effectiveness by enabling better resource allocation, more accurate scheduling, and improved quality control.

Perceived Ease of Use (PEOU), the second core construct of TAM, reflects the degree to which a technology is perceived as user-friendly and requiring minimal effort to use. In regions like Southeast Nigeria, where there may be limited technical expertise and infrastructural challenges, the usability of IT and digital tools is crucial for their successful adoption. Tools that are intuitive and easy to learn are more likely to be embraced by construction professionals.

2.2.2 Systems Theory by Ludwig von Bertalanffy (1968)

Systems Theory, also known as General Systems Theory (GST), posits that systems are composed of interconnected components that interact to form a unified whole. According to Bertalanffy (1968), these components are not merely aggregated but function together in a coordinated manner to achieve systemic goals. Systems Theory revolves around three core elements: Holistic view, interdependencies and

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feedback loops. The holistic view implies organizations are seen as complex systems with interconnected components. Interdependencies centered on synergy, where the collective performance of the system is greater than the sum of its individual parts. The concept of feedback loops refereed to mechanisms through which outputs of a system are fed back into the system as inputs, influencing subsequent actions and decisions (Bertalanffy, 1968).

When applied to this study, Systems Theory encourages a comprehensive examination of how digital tools and technologies integrate into the broader project management system. For instance, the adoption of IT and digital tools is viewed not as standalone solutions but as components that interact with each other and with human elements such as project managers, engineers, and contractors. The effectiveness of these technologies in enhancing project outcomes depends on how well they are integrated into the existing workflows, how they influence decision-making processes, and how they interact with other project components. Also, the synergy between the digital tools, human resources and processes can lead to significant improvements in project management effectiveness.

In the context of road construction projects in Southeast Nigeria, feedback loops can manifest in various ways. For example, the use of digital tools for monitoring and reporting project progress provides real-time data that can be used to make informed decisions, adjust plans, and optimize resource allocation. This continuous flow of information and feedback helps in identifying potential issues early, thereby enhancing project management effectiveness by enabling proactive measures and reducing the likelihood of costly delays or errors.

2.3 Empirical Review

2.3.1 Level of IT and Digital Tools Adoption in Road Construction Projects

Studies have revealed the current level of IT and digital tool adoption in road construction projects across the globe. Ali and Karim (2022) report that the road construction industry is increasingly embracing digitalization, particularly in developed countries, where technologies such as Building Information Modeling (BIM), drones, the Internet of Things (IoT), and cloud computing are widely adopted. In contrast, developing countries exhibit slower adoption rates, primarily due to challenges such as high costs, lack of skilled labor, and resistance to change.

Bello and Wang (2023) examine the impact of digital tools on project management in road construction, noting a considerable variation in adoption levels across different regions. In their analysis, they find that developed regions, including parts of Europe and North America, exhibit high levels of digital tool adoption, with technologies like project management software, document management systems, and collaboration platforms being widely used. These tools have significantly improved project coordination, reduced delays, and enhanced cost management. However, in developing regions such as Africa and Southeast Asia, the level of adoption is notably lower due to factors such as inadequate infrastructure, limited workforce training, and regulatory challenges.

Chukwu and Adeola (2023) focus on the adoption and application of Geographic Information Systems (GIS) in road construction, highlighting significant regional disparities. Their study reveals that GIS is widely adopted in developed countries, such as the United States and China, where it plays a critical role in project planning, route optimization, environmental impact assessment, and resource management. However, in developing countries like Nigeria, the adoption of GIS is still limited, primarily due to high costs, lack of technical expertise, and insufficient infrastructure.

Davidson and Samuel (2022) explore the global barriers to IT adoption in road construction, identifying significant challenges that vary across regions. Their research shows that IT adoption is generally higher in developed countries, where the infrastructure and resources necessary to implement these technologies are more readily available. These regions benefit from higher levels of IT integration in project management, which leads to improved efficiency and project outcomes. In contrast, developing countries face substantial barriers to IT adoption, including lack of infrastructure, resistance to change, insufficient training, and high initial costs.

Eriksson and Martins (2023) investigate the adoption of cloud computing in road construction, highlighting its positive impact on project performance, especially in developed regions. Their study finds that cloud computing is increasingly being adopted in countries like the United States and Brazil, where it is used to enhance data management, facilitate real-time collaboration, and provide remote access to project information. However, the authors report that adoption in developing regions remains limited due to concerns about data security, the need for reliable internet access, and resistance to change from traditional project management practices.

Femi and Yusuf (2023) explore the integration of smart sensors in road construction, focusing on their adoption and effectiveness in enhancing project efficiency and quality control. Their study shows that the adoption of smart sensors is more advanced in North America and Europe, where these technologies are used extensively for real-time monitoring, data collection, and compliance with project specifications. These regions benefit from the enhanced accuracy, reduced labor costs, and improved safety that smart sensors provide. However, the authors report that adoption in developing regions, particularly in Africa, is still limited due to high costs, lack of technical expertise, and concerns about data privacy.

Gonzalez and Lee (2023) examine the use of drones in road construction, highlighting the varying levels of adoption across different regions. Their research indicates that drones are widely adopted in developed regions, such as North America and Europe. However, the authors report that in some regions, particularly in Southeast Asia, drone adoption is hindered by challenges such as regulatory restrictions, high initial costs, and the need for specialized training.

Hassan and Okafor (2023) present findings from a global survey on the adoption of 3D printing in road construction, noting that while the technology offers considerable advantages, its adoption is still in its early stages worldwide. The authors report that both developed and developing regions have been slow to adopt 3D printing in road construction due to high equipment costs, lack of technical expertise, and regulatory barriers.

2.3.2 Barriers to Adoption of IT and Digital Tools in Road Construction Projects

Davidson and Samuel (2022) explore the global barriers to IT adoption in road construction, with a particular focus on Nigeria. Their research highlights that while IT adoption is generally higher in developed countries, Nigeria faces significant challenges that hinder the widespread use of IT in its road construction projects. These challenges include inadequate infrastructure, resistance to change, lack of training, and high initial costs. Olugboyega (2019) explored the adoption of Building Information Modeling (BIM) in Nigeria's construction industry, focusing on the challenges and benefits experienced by practitioners. The study highlighted substantial barriers, including high initial costs, lack of skilled personnel, and resistance to change.

Simpeh & Ndihokubwayo (2020) examined the implementation of Building Information Modeling (BIM) in South African construction projects, focusing on its impact and the barriers to its widespread adoption. Data were collected through surveys and interviews with industry professionals. Findings reveal that BIM enhances project coordination, reduces costs, and improves communication among stakeholders. Despite these advantages, the study identified challenges such as high adoption costs, inadequate training, and resistance from traditional construction practices.

Mphigalale, (2021) conducted a research on the application of Geographic Information Systems (GIS) in road construction projects in Kenya, emphasizing its role in route planning and environmental impact assessments. The findings indicated that GIS improves decision-making and resource management. However, challenges such as high costs and technical expertise requirements are noted. The study recommends enhancing GIS training and increasing investment to fully leverage its potential in road construction projects in Kenya

A study by Tessema (2018). Explores the role of Geographic Information Systems (GIS) in road construction projects in Ethiopia, focusing on its benefits and implementation challenges. The findings show that GIS improves project planning and decision-making processes. However, barriers such as high implementation costs and the need for skilled personnel are identified. The study concludes with recommendations for enhancing GIS adoption through targeted training programs and increased investment in GIS technologies.

Oke & Aghimien, (2019) studied the adoption of drone technology in road construction projects in Nigeria, focusing on its benefits, challenges, and practical applications. Surveys and case studies revealed that drones significantly reduce the time and cost associated with traditional surveying methods while providing accurate and real-time data. The research highlights the advantages of drones in site monitoring and inspection of hard-to-reach areas. However, challenges such as regulatory restrictions and data processing requirements are also identified. The study suggests that addressing these barriers through regulatory reforms and investment in data processing capabilities could enhance drone adoption in Nigeria's construction industry.

3.1 Research Design

The study employed a survey design method, utilizing a quantitative approach through a meticulously structured questionnaire. The survey design method facilitates the gathering of quantitative data, enabling statistical analysis to provide a comprehensive understanding of IT's impact on project management effectiveness.

3.2 Population of Study

The population of this study constituted all relevant registered road construction professionals as obtained from the register of various professional associations in South-East Nigeria. The major road construction professionals studied were project managers, engineers, architects, surveyors, contractors and site supervisors. Thus, a total of 1389 professionals was involved.

3.3 Determination of Sample size

The sample size for this study was determined by the use of Cochran’s sample size calculation procedure for large population (equation 1).

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Where n_o is the sample size, t = value for selected alpha level of 0.025 in each tail = 1.96 (the alpha level of 0.05 indicates the level of risk the researcher is willing to take that true margin of error may exceed the acceptable margin of error), (p)(q) = estimate of variance = 0.25 (maximum possible proportion (0.5) x 1-maximum possible proportion (0.5) produces maximum possible sample size), d = acceptable margin of error for proportion being estimated = 0.05 (error estimate).

$$n_0 = \frac{(t^2)x\,(p)(q)}{d^2} \qquad (1)$$

$$n_1 = \frac{n_0}{1+\frac{n_0}{population}} \qquad (2)$$

The sample size, $no = \frac{(1.96)^2\ x\ (0.5)(0.5)}{(0.05)^2} = 385$

Since n_o (385) > 5% of 1389

Survey sample sign, $n_1 = \frac{385}{1+\frac{385}{1389}} = \frac{256}{2} = 301$

3.4 Sampling Techniques

The study employed a multi-stage sampling procedure that comprised of cluster sampling technique and stratified sampling technique to ensure different categories of road construction stakeholders were involved in the study. Using cluster sampling technique, the sample was proportionally divided into five clusters representing the five states in the study area (geographical spread). Each cluster (state) was stratified into six strata corresponding with key stakeholders such as project managers, engineers, architects, surveyors, contractors and site supervisors. From each stratum, respondents were randomly selected. Stratified random sampling is relevant in instances where cases in the population belong to different strata to ensure that all sections are equally represented.

3.5 Methods of Data Analysis

The data generated from the survey were subjected to both descriptive and inferential statistics analysis. Simple percentage and mean item score were used to identified and ranked the IT and digital tools as well as challenges in their adoption in road construction in Southeast Nigeria. The mean item score was equally used to determine the extent and level of IT/ digital tools

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adoption in road construction. The analyses were done with Statistical Package for Social Science (SPSS) version 21 software.

DATA PRESENTATION AND ANALYSIS

4.1 Adoption and Usage of IT and Digital Tools in Project Management in Road Construction in Southeast Nigeria

Table 4.1.2a depicts the IT and digital tools deployed by the road professionals in project management of road infrastructure projects in Southeast Nigeria. Topmost on the list of the tools was Mobile Application (26.2%), closely followed by Communication and Collaboration Platforms (23.9%). Others project management tools include Geographic Information System (15.6%), Project Management Software (10.9%), Document Management System (8.6%), Construction Management Software (7.6%), Smart Sensor (2.7%), Building Information Modelling (1.9%), Data Analytics and Business Intelligence (1.3%) and Internet of Things (0.9%) respectively.

In Table 4.1.2b, the project management tools were used occasionally (62.9%) and up-dated occasionally (56.6%). Overall, the level of usage was reported as very low (67.4%). As shown in FIG 2, the project management tools were used in all the categories of road construction projects. The tools were mostly (62.9%) used for large-scale road infrastructure projects.

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Table 4.1. 2a: IT and Digital Tools used by Road Construction Professional in Southeast Nigeria (N=301)

S/N	IT and Digital Tools	n (%)		MIS	Rank
1.	Project Management Software (PMS)	33(10.9)		1.83	4th
2.	Communication and Collaboration Platform	72(23.9)		4,00	2nd
3.	Building Information Modelling (BIM)	6(1.9)		0.33	8th
4.	Document Management System (DMS)	26(8.6)		1.44	5th
5.	Construction Management Software (CMS)	23(7.6)		1.28	6th
6.	Geographic Information System (GIS)	47(15.6)		2.61	3rd
7.	Mobile Application	79(26.2)		4.39	1st
8.	Cloud Computing	0(0.0)		0.00	12th
9.	Internet of Thing (IoT)	3(0.9)		0.17	10th
10.	Drones and Aerial Imaging	0(0.0)		0.00	11th
11.	Smart Sensors	8(2.7)		0.44	7th
12.	Artificial Intelligence (AI) and Machine Learning (ML)	0(0.0)		0.00	11th
13.	3D Printing	0(0.0)		0.00	11th
14.	Augmented Reality (AR) and Virtual Reality (VR)	0(0.0)	0.00	11th	
15.	Autonomous Vehicle	0(0.0)	0.00	11th	
16.	Data Analytics and Business Intelligence	4(1.3)	0.22	9th	
17.	Automation and Robotics	0(0.0)	0.00	11th	
18.	Blocking Chain	0(0.0)	0.00	11th	
	Total	301(100.0)			

Note: MIS = Mean Score Item;

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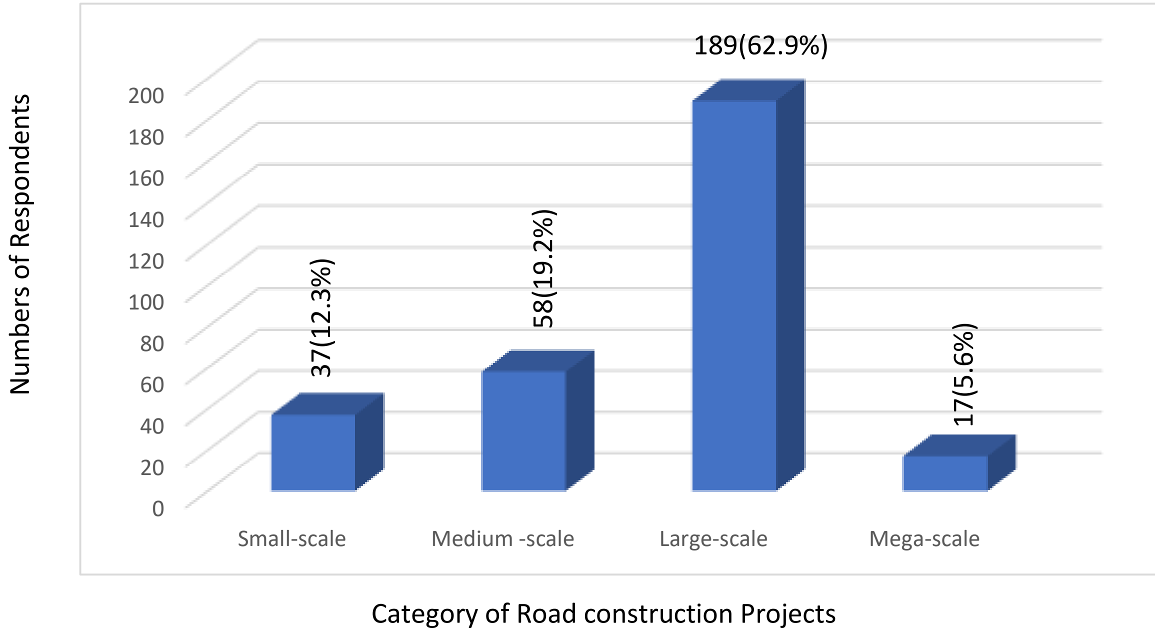

FIG.2: Adoption and usage of IT / Digital tools in project management of different categories of Road Construction Projects in Southeast Nigeria

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Table 4.1. 2b: Frequency of Usage, Up-datedness and Level of IT and Digital Tools Adoption in Road Construction in Southeast Nigeria (N=301)

Category	Sub-category	n(%)
Frequency of usage	Never	0(0.0)
	Rarely	15(4.9)
	Occasionally	189(62.9)
	Frequently	78(25.9)
	Very Frequently	19(6.3)
	Total	301(100.0)
Frequency of Up - datedness	Never	21(6.9)
	Rarely	49(16.3)
	Occasionally	170(56.6)
	Frequently	35(11.6)
	Very Frequently	26(8.6)
	Total	301(100.00
Level of Usage	Very low	67(22.3)
	Low	203(67.4)
	Moderate	31(10.3)
	High	0(0.0)
	Very high	0(0.0)
	Total	301(100.0)

Source: Researcher's field work (2024)

4.2 Challenges in Adoption and Usage of IT and Digital Tools in Project Management

The road construction professionals reported to have faced challenges in the course of the adoption and usage of IT and Digital tools (Table 4.1.4). The major challenge was high implementation cost (28.9%). Other challenges include lack of technical expertise (15.8%), limited training and support (10.6%), insufficient budget (10.3%), technological complexity (8.6%), inadequate infrastructure (6.6%), poor internet connectivity (5.9%) and incompatibility with existing system (4.7%). The

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least (3.7%) challenge faced by the professionals was reported as resistance to change.

To address the diverse challenges, the road construction professionals proffered different measures (FIG.3). The commonest measure to most of the professionals was training programme (29.0%). Other measures include increasing budget allocation (16.6%), enhancing security measures (15.6%), upgrading infrastructure (14.4%), improving internet connectivity (10.3%), hiring expert (7.6%) and engaging external consultants (5.9%) respectively.

Table 4.1.4: Challenges faced in Adoption and usage of IT and Digital Tools in Road Construction in Southeast Nigeria.

S/N	Challenges	n (%)
1.	High Implementation cost	87(28.9)
2.	Lack of Technical Expertise	47(15.8)
3.	Resistance to Change	11(3.7)
4.	Inadequate Infrastructure	20(6.6)
5.	Security concerns	15(4.9)
6.	Limited Training and Support	32(10.6)
7.	Insufficient Budget	31(10.3)
8.	Poor Internet Connectivity	18(5.9)
9.	Technological Complexity	26(8.6)
10.	Incompatibility with Existing System	14(4.7)
	Total	301(100.0)

Source: Researcher's field work (2024)

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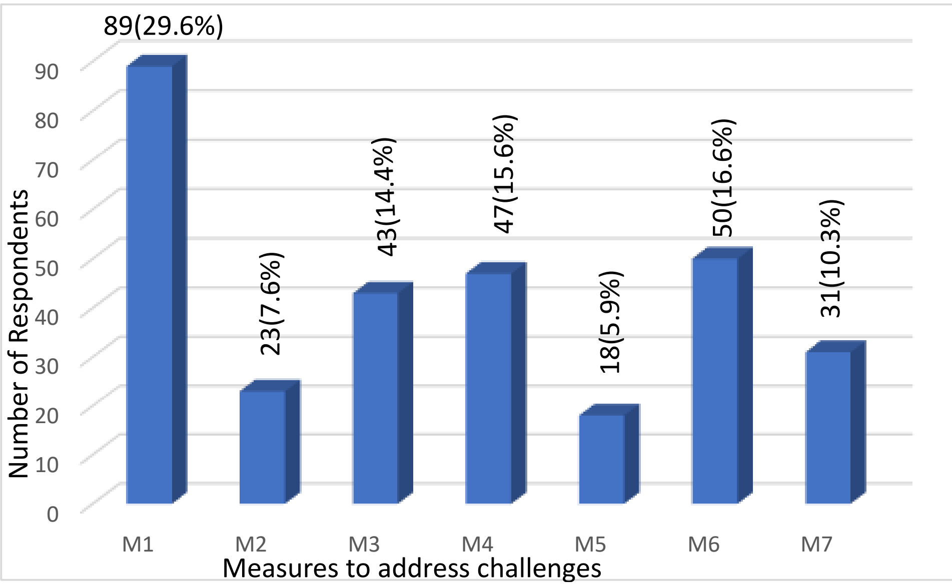

Key: M1: Training Programme; M2: Hiring Expert; M3: Upgrading Infrastructure
M4: Enhancing Security Measures; M5: Engaging External Consultants;
M6: Increasing Budget Allocation; M7: Improving Internet Connectivity.

FIG.3: Measures to address the challenges in adoption and utilization of IT and Digital Tools in Project Management in Road Construction in Southeast Nigeria.

4.3 Future Prospect of IT and Digital Tool Adoption in Southeast Nigeria

Table 4.1.5 shows the future outlook of IT and digitalization in project management in road construction in Southeast Nigeria. Majority (69.3%) of the respondents reported that their organizations are likely to upgrade the existing IT and digital tools in the next 5 years. Also, the organizations will likely (62.2%) invest in new IT and digital tools in the next 5 years.

The professionals identified emerging IT and digital tools that can be used in the future. These new or emerging IT and digital tools include Blockchain Technology (17.9%), Drones and UAVs (7.9%), Augmented Reality (AR) and Visual Reality (VR) (6.3%), Artificial Intelligence (AI) and Machine Learning (ML) (2.0%). The already adopted IT and digital tools that may take a new look include Advanced Project Management Software (24.3%), Increased

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adoption of IoT (15.0%), Enhanced BIM **c**apabilities (13.6%) and Expanded use of GIS (12.0%)

The professionals foresaw potential benefits from increased IT and digital tools usage. Most (24.1 %) foresaw reduced project duration (24.1%), followed by increased cost saving (22.2%), improved efficiency (14.6%), enhanced safety (10.9%), better quality control (10.3%) and increased transparency and accountability (8.9%).

4.4 Hypothesis Testing

The two hypotheses were tested separately. The results are presented in Tables 4.2a and 4.2b respectively. Tables 4.2a shows the descriptive statistics and one-way ANOVA of impact of IT and digitalization on project management effectiveness in road construction in Southeast Nigeria. The result showed that the calculated F-value of 3.56 was significant at p-value of 0.029, 0.05 level of significant with 9 and 291 degrees of freedom. With this result, the null hypothesis was rejected. This implies that there is significant impact of IT and digitalization on project management effectiveness in road construction in Southeast Nigeria.

Tables 4.2b depicts the independent t-test analysis of mean rating of impact of IT/digital tools and traditional tools on project management effectiveness in road construction in Southeast Nigeria. The result showed that the calculated t-value of 5.117 was greater than the critical t-value of 1.965 at $p<0.05$. Therefore, the null hypothesis was rejected. This signifies that there is significant difference between project management effectiveness of road projects using IT/digital tools and traditional tools in Southeast Nigeria.

4.5 Discussion of Findings

The extent of IT and digitalization adoption in road construction projects in Southeast Nigeria is moderate compared to global standards. Various IT tools, such as Project Management Software (PMS), Geographic Information Systems (GIS), and Building Information Modeling (BIM), are increasingly utilized to enhance project planning, execution, and monitoring. The usage of Data Analytics and Business Intelligence, and Internet of Things (IoT) is still at the nascent stage. However, the integration of advanced digital tools like Artificial Intelligence (AI) and Machine Learning (ML), Cloud Computing, 3D printing, Digital Twins, Automation and Robotics, Augmented Reality (AR) and Virtual Reality (VR), Drones and Aerial Imaging and Blockchain are yet to be done. This level of adoption mirrors trends observed in other developing regions where infrastructural challenges, lack of digital literacy, and limited access to cutting-edge technologies have slowed the pace of digital transformation in

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the construction sector (Osei & Amponsah, 2021).

The challenges in adopting IT and digitalization in road construction projects in Southeast Nigeria are multifaceted. Financial constraints are a major barrier, as the high costs associated with acquiring and maintaining advanced digital tools are often prohibitive for many construction firms. Additionally, there is a significant skills gap, with many project managers and workers lacking the necessary training to effectively utilize digital tools. Resistance to change is another challenge, as traditional project management practices are deeply entrenched in the industry, and there is often reluctance to adopt new technologies (Ndikumana & Uwimana, 2022). Furthermore, inadequate infrastructure, such as unreliable internet connectivity, hinders the seamless integration of digital tools in project management processes (Zhang & Li, 2020).

4.6 Conclusion

The findings of this study underscore the transformative impact of Information Technology (IT) and digitalization on project management effectiveness in road construction in Southeast Nigeria. Through an extensive analysis of various IT and digital tools, it is evident that their integration into project management processes has significantly enhanced several dimensions of effectiveness, including time management, cost control, quality assurance, and stakeholder communication. These advancements have not only streamlined project workflows but also mitigated traditional challenges associated with road construction projects in the region. The comparative analysis with traditional project management tools further reveals that IT and digitalization offer superior adaptability to the complex and dynamic nature of contemporary road construction projects, particularly in the context of Southeast Nigeria's unique environmental and infrastructural challenges.

The frequency, level, and pattern of usage of these tools vary significantly, reflecting the diverse needs and capacities of road construction stakeholders in the region. While some tools, such as Geographic Information Systems (GIS) and Building Information Modelling (BIM), are increasingly adopted for their precision and efficiency, others like mobile applications are leveraged for their real-time data sharing and collaboration capabilities. The up-datedness and relevance of these tools also play a crucial role in their effectiveness, emphasizing the need for continuous learning and adaptation among project managers and teams.

However, despite the clear benefits, the study also brings to light several challenges associated with the adoption and implementation of IT and digitalization in road construction. Issues such as

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the high cost of technology, the need for skilled personnel, resistance to change, and inadequate infrastructure pose significant barriers to the widespread use of these tools. Additionally, the study discusses the future outlook of IT and digitalization in road construction, suggesting that as these technologies evolve, they will increasingly shape the strategies and methodologies employed in project management. The potential for advancements in artificial intelligence, machine learning, and automation to further revolutionize the industry cannot be understated, especially as road construction projects in Southeast Nigeria become more complex and demanding.

Recommendations

In the light of the findings, the following recommendations are made:

i. Continuous training and IT education are essential to equip professionals with the skills needed to effectively use digital tools in road construction.

ii. Investing in reliable IT infrastructure is crucial for enabling seamless communication and data sharing in construction projects.

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