



Maintenance and Management Challenges of Public Infrastructural Facilities in Nigeria –Barriers to Modern Technology Approach

Adeyemi, F. O¹, Olaniyi O. A¹

¹: Department of Civil Engineering, Ajayi Crowther University, Oyo, Oyo state, Nigeria.

Corresponding author: fo.adeyemi@acu.edu.ng

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Abstract

Over the past few years, there has been a global growing interest in research dealing with the potential impact of cutting-edge technologies on maintenance and managing infrastructures of civil engineering public infrastructures. This paper focuses on maintenance and management challenges of public civil infrastructural facilities in Nigeria, assesses the current state of infrastructure, identifies the barriers to modern technology approach, and suggests possible ways to improving the maintenance practices in Nigeria. Research questionnaires consisting of closed-ended questions and a few open-ended questions, were administered to various stakeholders in the civil engineering infrastructure industry, and analyzed. Findings show that the current state of public infrastructural facilities maintenance was rated as either poor or very poor, indicating a high level of dissatisfaction. The identified central barrier in the implementation of cutting-edge technologies in Nigeria is corruption, signaling that corruption is perceived as the core barrier to progress. The investment in the use of Artificial Intelligence (AI) and drones was recommended for predictive maintenance and remote inspection solutions. Anti-corruption measures are viewed as more critical than technological solutions, hence, these measures are highly recommended. Human capital development was also seen as equally vital to successful technology integration.

Keywords: Maintenance, Management, Public Infrastructure, Challenges, Modern Technology, Barriers.

1. Introduction

Civil engineering infrastructures such as buildings, highways or roads, bridges, healthcare facilities, schools, water supply systems utility infrastructure, oil and gas and other industrial facilities are critical to the economic and social development of any nation. Globally, these infrastructures play a vital role in supporting daily economic activities, transportation, healthcare, education, governance, promoting business operations, and ensuring the well-being of citizens. Unfortunately, Nigeria, as a nation has continued to struggle with maintaining its public civil engineering infrastructure.

Despite investments in infrastructure projects, numerous policies and interventions, substantial investments in construction and development, maintenance is often overlooked, leading to frequent failures that require costly rehabilitation or complete reconstruction. Many government-built infrastructures in Nigeria namely; buildings, roads, bridges, and other facilities often deteriorate rapidly, and fall into disrepair shortly after construction, leading to increased costs for repairs, reduced service life, and negative socioeconomic impacts. Currently, according to Chima, (2021), Nigeria loses N2.03 trillion from poor infrastructure yearly (about 2% of GDP lost to inadequate infrastructure), report by Chiejina, (2021) also shows that poor infrastructure costing Nigeria \$17.1 billion yearly, (reflecting lost growth from infrastructure deficits).

Several researchers have identified poor planning, inadequate funding, ineffective stakeholder engagement, corruption Manjo, (2023), lack of skilled personnel, or insufficient technical expertise, inadequate technological integration, lack of accountability, inadequate policy enforcement, Uma, (2014); Oladapo *et al.*, (2024), as factors affecting infrastructure maintenance and management in Nigeria. In addition, public perception regarding maintenance responsibility is often misaligned, with many stakeholders assuming that it is solely the government's duty, leading to poor participation and cooperation. This has resulted in the neglect of routine maintenance schedules, leaving public infrastructures prone to rapid deterioration or decay and failure, resulting to frequent failures of essential facilities, higher repair costs and economic losses, safety hazards, reduced economic productivity, wastage of public funds, safety hazards, economic setbacks, and reduced service life. Conventional infrastructure maintenance methods such as reactive, preventive, corrective, routine, periodic, emergency maintenance, and manual inspection are not data-driven, and may not address root causes.

Globally, the stakeholders in civil infrastructure community are currently presented with unprecedented opportunities to ensure the durability, longevity and sustainability of the infrastructures by adopting innovative technologies. As populations continue to grow and infrastructure structures age, there is an urgent need for more cost-effective technologies to build, maintain, monitor and repair these infrastructure structures Costin, *et al* (2018). In recent times, the construction industry has stepped into the usage of modern or cutting-edge technology for the maintenance of and management of infrastructures.

A revolutionary development that is changing the conventional landscape is the incorporation of state-of-the-art technologies into facility management procedures (Teicholz, 2012). Furthermore, according to Enkhjin (2023), using cutting-edge technologies makes a substantial contribution to environmental sustainability. Cutting-edge technologies have opened up new possibilities with the advent of the digital age (Rane, 2023). However, successful technology integration necessitates more than just the implementation of new systems; it also calls for careful planning, a dedication to organizational change, and a deep understanding of current procedures (Enkhjin, 2023).

The increasing requirement for agility and resilience highlights the strategic imperative for firms to use cutting-edge technologies. Effective use of this technology will optimize resource use, lower operating expenses, and establish settings that are flexible and change-resistant (Bughin *et al.*, 2019). Decision-makers can make well-informed and data-driven decisions on resource allocation and space utilization by using the ability to gather and analyze data from different facility components (O'Donovan *et al.*, 2015). By remaining ahead of the curve, companies who successfully integrate technology into facility management obtain a competitive advantage (Roper & Payant, 2014).

Using state-of-the-art technologies gives decision-makers new perspectives. Developed nations including the United States, Japan, Germany, Australia, South Korea, China, Sweden, the United Kingdom, the Netherlands, Singapore, and the United Arab Emirates (UAE) have effectively incorporated technology into infrastructure maintenance, increasing its durability and efficiency. Some other countries have effectively used contemporary technology to address comparable issues, and there are also local initiatives or pilot projects in Nigeria (such as Lagos Smart City and the digitalization of the FCT maintenance agency).

According Li, *et al* (2022), the four most frequently used information technologies in civil infrastructure construction, maintenance and management are Wireless Sensor Networks (WSN), Building Information Modeling (BIM), Fiber optic sensing (FOS) and Radio Frequency Identification (RFID). Noel *et al.* (2017) presented an investigation of Structural Health Monitoring (SHM) using Wireless Sensor Networks (WSN), and outlined the algorithms used for pipeline damage detection and localization. WSN has been used to improve the efficiency of maintenance and overhaul of urban pipelines, Zhou, *et al* (2020). Lin, *et al.* (2019) has proposed a buried wireless sensor network (B-WSN) system to detect pipe joint leakage caused by large-scale ground movement.

Imran *et al.* (2020) developed an autonomous water quality monitoring system based on a smart city WSN. Hodge *et al.* (2015) conducted a survey that demonstrated how WSN can be used to monitor transportation infrastructures such as bridges and tracks, and the health of vehicles in real-time. Zhao *et al.* (2019) developed a piezoelectric sensing system for road surfaces to control the adverse effects of vehicle overload on traffic safety. Furkan *et al.* (2020) developed a WSN system derived from wired sensors for the fast, robust measurement of structural deformation on highways. WSN has been widely used in the railway industry. BIM is a decision-making tool that utilizes various digital tools and applications, Hetemi, *et al* (2020). It has been widely used in the construction industry for decades, but its applications in civil infrastructure projects progressing slowly, Chong, *et al* (2016).

In recent times, industry and academia have been collaborating to apply BIM for civil infrastructure projects, such as roads, highways and bridges. It provides construction professionals with new methods to plan, design, build and manage infrastructure more effectively, Akhoundan, *et al* (2018). Other advantages of BIM include 3D Visualization (Boddupalli. *et al* (2019) Chen *et al* (2020), Improve the Efficiency and Accuracy of Information Exchange (Li, & Cao, (2020). Life Cycle Management (Puente *et al* (2016), Costin *et al.*, (2018). It also improves design quality through visualization and increases collaboration among various professionals Shim, *et al* (2011).

With Nigeria's growing population and increasing infrastructural demands, effective maintenance strategies are essential for sustainable development. There exist limited use or absence of modern technology (e.g., IoT, GIS, BIM, maintenance management systems). This study is aimed at describing the current state of infrastructure maintenance, identifying the barriers associated with the implementation of technologies in the area of civil engineering infrastructure in Nigeria, and explores how these technological innovations can improve efficiency, reduce costs, and enhance durability. By studying and applying these technological advancements, Nigeria can reduce maintenance costs, enhance service delivery, and ensure infrastructure longevity.

2. Research Methodology

This research aims to investigate maintenance and management challenges of public infrastructural facilities in Nigeria, identifying the barriers to the implementation of cutting-edge technologies in facility management. The research methodology involves the collection of quantitative data via surveys through structured questionnaires distributed to 200 professionals or stakeholders in the Nigeria's public civil infrastructure sector, who utilize or maintain the public infrastructural facilities, namely Engineers, government officials, private contractors, and facility management practitioners etc., in order to obtain quantitative data related to the effectiveness of cutting-edge technology implementation in Nigeria.

Both closed-ended and some open-ended questions are included in the surveys since they offer a wider range of information. In contrast to closed-ended questions, which feature options that are decided by the researcher, open-ended questions required written responses from the respondents. For clarity and ease of comprehension, the questions were written in straightforward English. The information was gathered over a six-week (42-day) period. To find important links, statistical analysis was used to examine the numerical quantitative data. Bar graphs were used to display the data once frequency tables were created.

3. Results and Discussion

a. Questionnaire Administration and Return Rate

Out of 200 questionnaires administered to the respondents, all the 156 questionnaires were duly filled and submitted. The 156 responses were found valid for analysis, and represented a total of 78% response rate as revealed in the result. This response rate is considered satisfactory to make conclusions for the study, and can be related to Mugenda and Mugenda (2003) who said a 50% response rate is adequate, 60% good and above 70% rated very good. This implies that based on this assertion, the response rate in this case of 78% is very good.

b. Demographic Characteristics of the Respondents

From figure 1, it shows that there are more male 148 (94.9%) than female 8 (5.1%). From this it can be deduced that although the study sampled both gender, majority of the respondents were male.

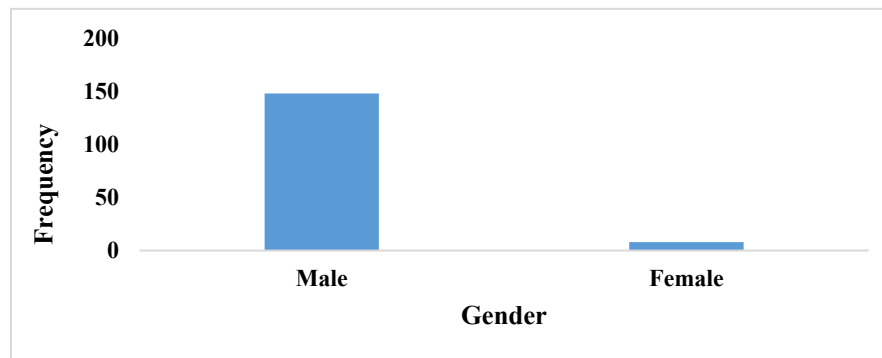


Fig. 1: Distribution of respondents by gender

The ages of the respondents showed that 4 (2.6 %) are between 18-25years, while 20 (12.8%) are between 26-35years. 84 respondents (53.8%) are between 36-45 years, while 36 (23.1%) respondents are between 46-55 years. 12 (7.7%) are 56 years and above. It also shows that all the respondents are above 15years of age which is the minimum legal working age in Nigeria according to the Labour Act of Nigeria, with restrictions on the type of work. Similarly, they are also 18years of age and above, which is the minimum age of standard entry into workforce in Nigeria, full-time without restrictions.

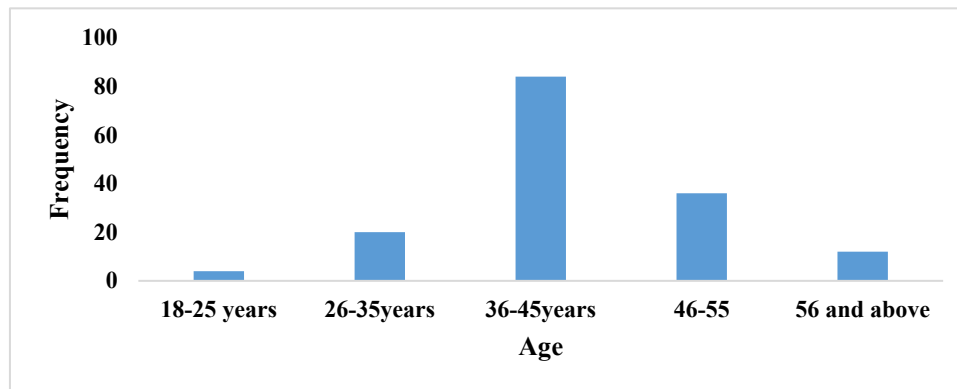


Fig. 2: Distribution of respondents by Age

Figure 2 revealed the category of the respondents. It is shown that 96 (61.5%) of the population are Civil/structural Engineers, Government officials constitute 12 (7.7%), Academic/Researcher 12 (7.7%), Private sector Employee 16 (10.2%), Real estate and developer 4 (2.6%), Architect 4 (2.6%), while 12 (7.7%) did not specify their professions.

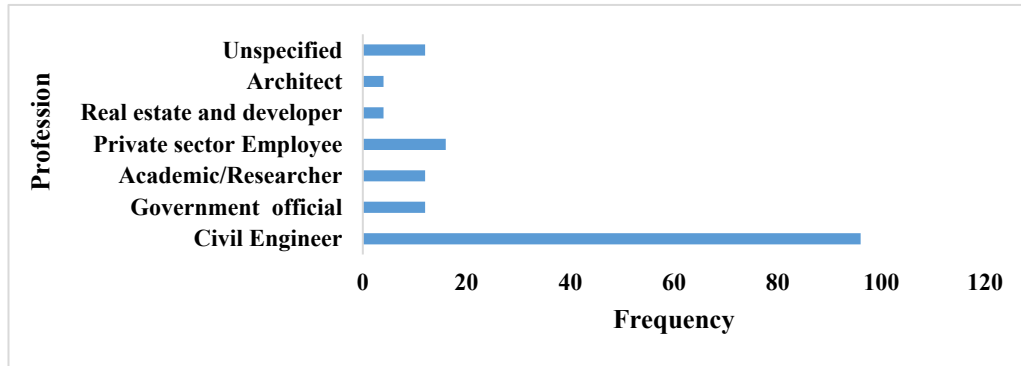


Fig. 3: Distribution of respondents by profession

Based on qualifications, 80 respondents (51.3%) have Bachelor' degree, Diploma 8(5.1%), 48 (30.8%) respondents have Master's degree, while 8 respondents (5.1%) possess PhD. are just 7 (6.5%). Others who did not specify their qualifications are 12 (7.7%).

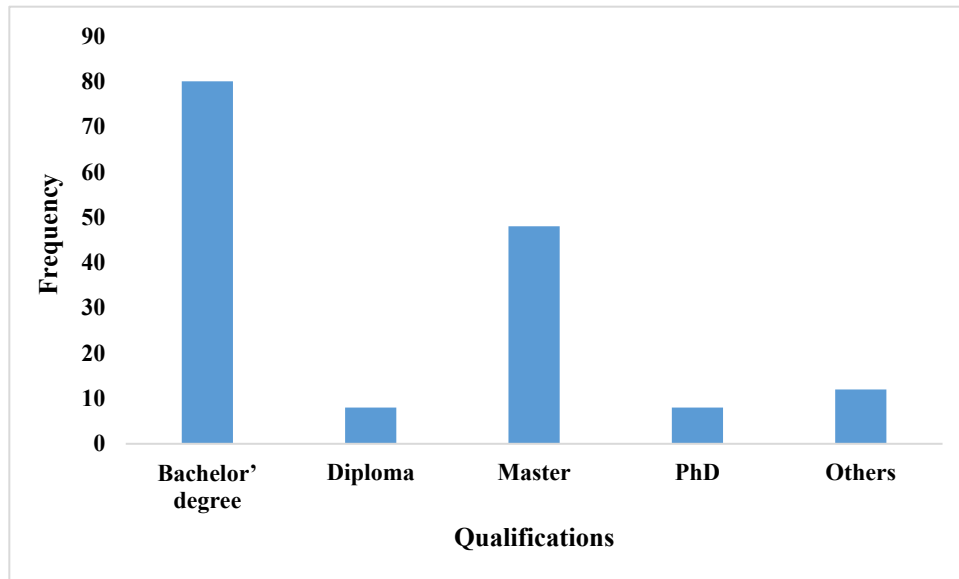


Fig. 4: Distribution of respondents by Qualifications

The years of experience is another factor considered in this research 16 (10.3%) has less than a year experience, implying that they are new employees. Similarly, 16 (10.3%) have between 1 to 5 years of work experience. 28 (17.9%) have between 5 to 10years working experience while the majority of the respondents, 96 (61.5%) have above 10 years working experience.

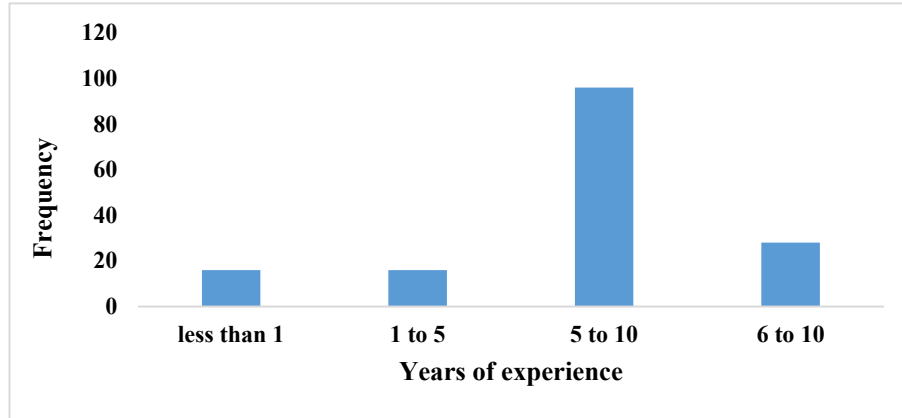


Fig. 5: Distribution of respondents by Years of Experience

c. Assessment of the current condition of civil engineering infrastructure in Nigeria

The deterioration of civil infrastructure in Nigeria represents a critical barrier to economic development and public safety. The overall perception of infrastructure condition is summarized below in Table 1.

Table 1. Frequency Distribution of Infrastructure maintenance Ratings

Rating	Count	Percentage
Very Poor	32	20.5%
Poor	52	33.3%
Average	64	41.0%
Good	8	5.11%
Total	156	100%

A substantial 53.8% of respondents representing 36–45 age group, the largest cohort, is the most critical, rated the infrastructure maintenance as either poor or very poor, indicating a high level of dissatisfaction. In contrast, only 5.11%, represented by 8 respondents, rated it as Good, reflecting a notably low level of approval.

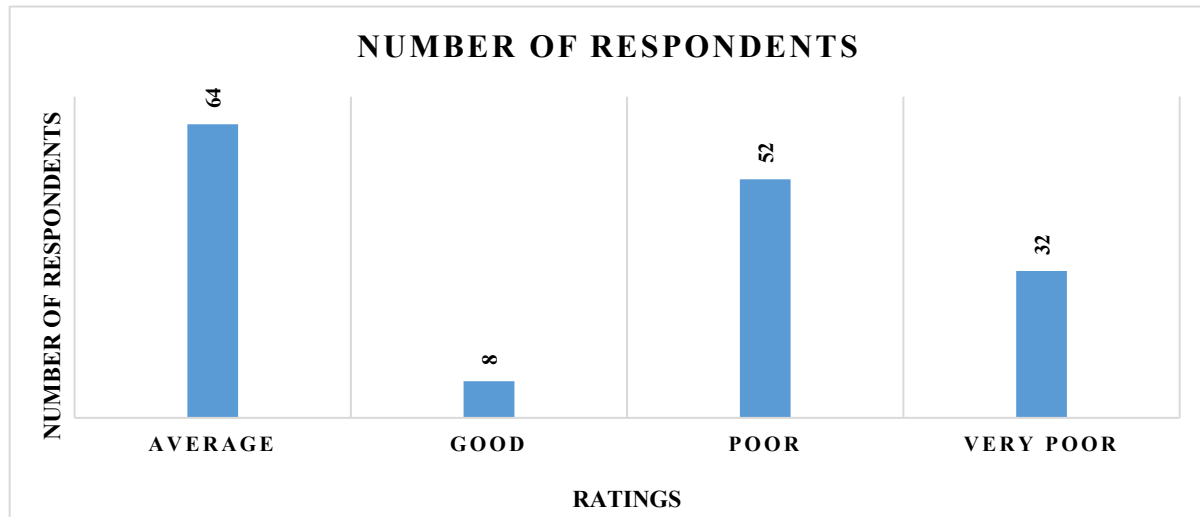


Fig. 6: Bar chart showing ratings by number of respondents

Correlation Between Variables

In order to assess the relationship among multiple variables; infrastructure rating, education, maintenance frequency and tech awareness, and the need to detect the multi-collinearity between the variables, the heatmap correlation matrix was used. The correlation analysis (Figure 7) provides valuable insights into the interactions that exist between the variables.

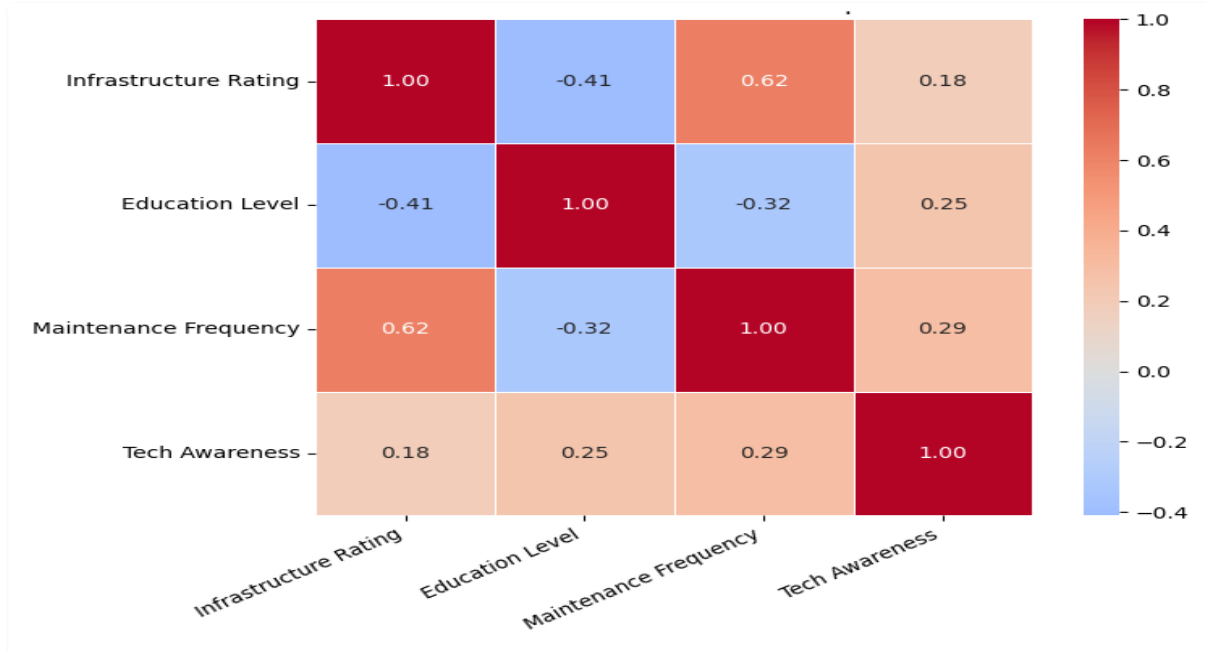


Fig. 7: Heatmap Correlation Matrix

The results show that maintenance frequency exhibits the strongest positive correlation with infrastructure rating ($r = 0.62$). This implies that consistent and effective maintenance directly improves the condition and performance of infrastructure. This also suggests that as maintenance frequency increases, infrastructure ratings tend to improve significantly. It highlights that regular maintenance is a major driver of better infrastructure conditions. This finding aligns with earlier research emphasizing that preventive and corrective maintenance significantly extend the service life of infrastructure systems (Adenuga, 2013; Oke *et al.*, 2017).

Meanwhile, education level demonstrated a moderate negative correlation with infrastructure rating ($r = -0.41$), with 85 percent of PhD holders rating it as poor or very poor. This suggests that individuals with higher levels of education tend to rate infrastructure more critically, possibly due to higher expectations, better awareness of international standards, or the fact that educated populations are concentrated in urban centers where infrastructure is often overstretched. This perspective is consistent with studies highlighting how socio-economic and educational factors influence infrastructure perception (Ebohon & Rwelamila, 2011).

The relationship between infrastructure rating and technology awareness was positive but weak ($r = 0.18$), indicating that digital adoption or awareness alone does not significantly influence infrastructure quality. The relationship between education level against maintenance frequency shows a moderate negative correlation ($r = -0.32$). Higher education levels are linked with less frequent maintenance, possibly because better-educated groups may reside in urban zones with overstretched maintenance schedules. This reflects systemic inequalities in service delivery, where highly educated populations experience inadequate maintenance despite higher awareness and demand. This finding underscores the need for targeted maintenance policies and technology-driven infrastructure management to bridge the gap between public expectations and actual service delivery (Oke *et al.*, 2017).

Education Level against Tech Awareness ($r = 0.25$, weak positive correlation), Educated individuals tend to have slightly higher technology awareness, but the relationship is not very strong. Maintenance frequency and technology awareness showed a weak-to-moderate positive relationship ($r = 0.29$), suggesting that the integration of technology into maintenance practices—such as digital monitoring systems, smart sensors, or mobile-based reporting—may enhance efficiency and indirectly improve infrastructure performance (Aigbavboa & Thwala, 2014). Areas with more frequent maintenance also show slightly better tech awareness, maybe because maintenance systems incorporate digital tracking or reporting.

d. Assessing the barriers to effective infrastructure maintenance

Several factors were identified as barriers to effective implementation of cutting-edge technologies in Nigeria. In this research, the identified central barrier in the implementation of cutting-edge technologies is corruption. Corruption emerges as the most cited challenge, reported by 69 percent of professionals, and carries the highest severity impact with an average score of 3.22. Poor funding and inadequate use of technology follow closely, both registering high severity scores above 3.1, highlighting their interconnected role in undermining infrastructure performance. Notably, all leading challenges have severity ratings exceeding 3.0, indicating persistent and systemic weaknesses in the infrastructure maintenance in Nigeria.

Table 2: Infrastructure Issues by Frequency and Impact

Challenge	Frequency	Avg. Severity
Corruption	108(69.2%)	3.22
Poor Funding	80 (51.3%)	3.15
Inadequate Use of Technology	56 (35.9%)	3.14
Bureaucratic Inefficiencies	40 (25.6%)	3.10
Lack of Skilled Personnel	36 (23.1%)	3.11

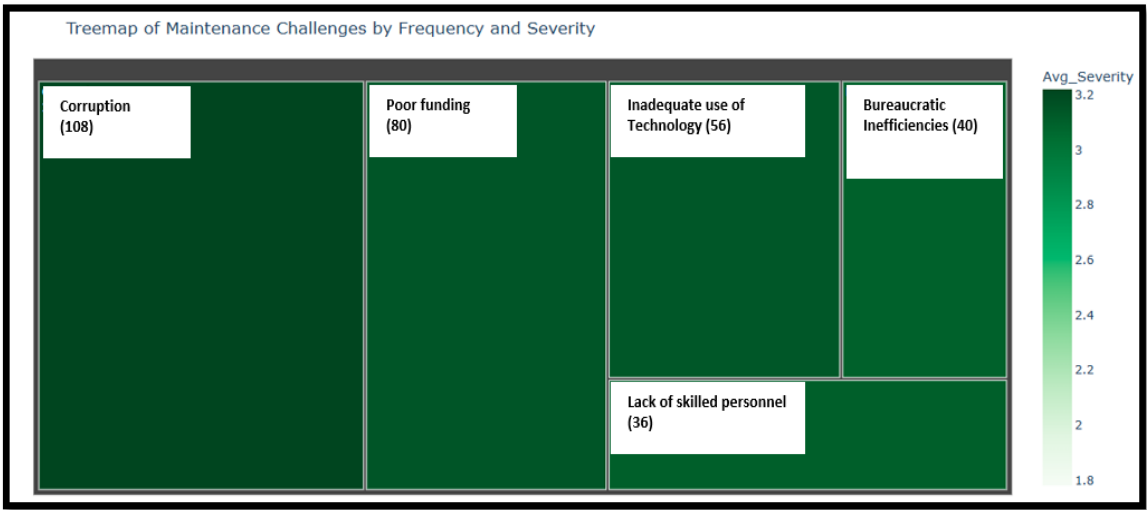


Fig. 8: Tree map Visualization

Table 3: Network Matrix

Challenge Pair	Co-occurrence	Strength
Corruption + Poor Funding	72	(Strongest)
Corruption + Inadequate Technology	48	
Poor Funding + Inadequate Technology	44	
Corruption + Bureaucracy	36	
Funding + Skilled Personnel Gap	28	

The corruption–funding–technology triad dominates failure patterns, with corruption and funding co-occurring in 67 percent of cases and 80 percent of funding issues involving either corruption or tech gaps. Bureaucracy reinforces this loop, linking with corruption in 90 percent and funding in 80 percent of cases. Though the skill gap is least connected, it carries high severity (3.11) when present.

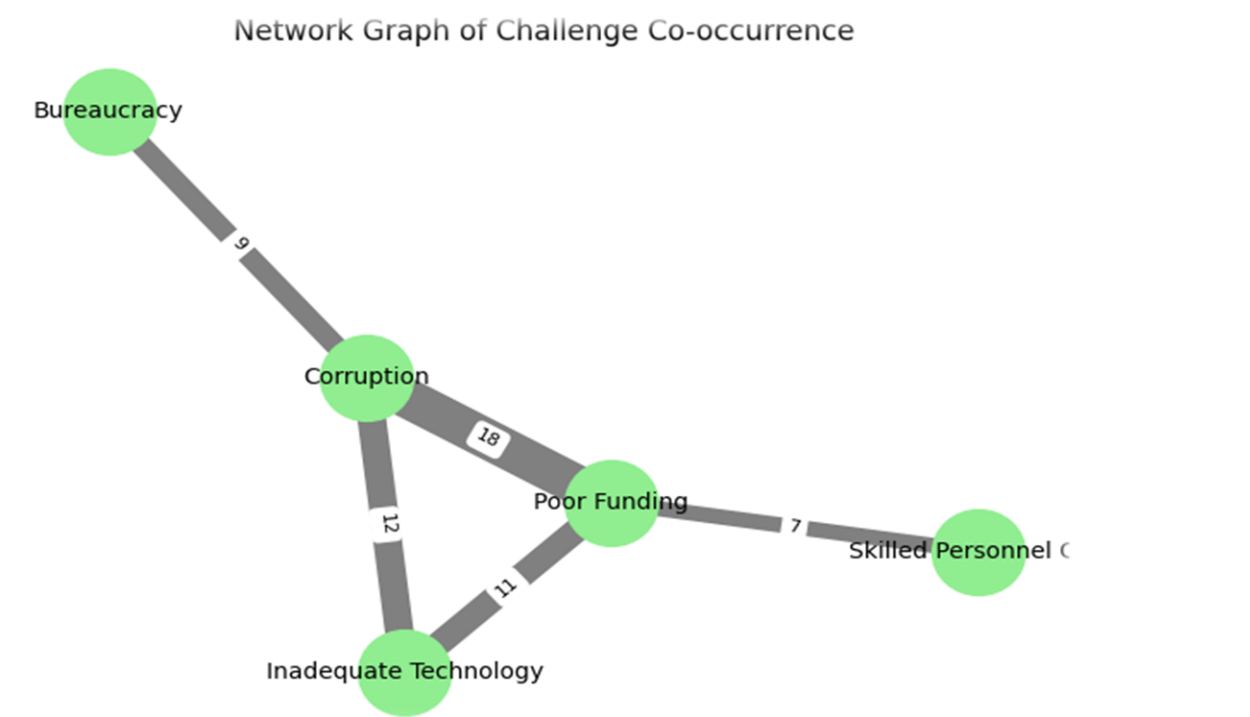


Fig. 9: Network Graph of Challenge Co-occurrence

e. Possible ways of improving the maintenance practices in Nigeria using Modern Technology approach

Artificial Intelligence (AI) (61.3%) and drones (58.1%) emerged as the most recommended technologies, reflecting a strong preference for predictive maintenance and remote inspection solutions. Notably, all technologies received over 45% endorsement, underscoring broad support for integrated, multi-technology adoption.

Table 4: Technology Recommendations Frequency Analysis

Technology	Frequency	Percentage
Artificial Intelligence (AI)	76	61.3%
Drones	72	58.1%
Geographic Information Systems (GIS)	68	54.8%
Internet of Things (IoT)	60	48.4%
Automation & Robotics	56	45.2%

Table 5: Improvement Strategies Frequency Analysis

Strategy	Frequency	Percentage
Strengthening anti-corruption measures	92	74.2%
Training/capacity building	88	71.0%
Encouraging public-private partnerships	84	67.7%

Adoption of modern technology	80	64.5%
Increased government funding	76	61.3%

Anti-corruption measures (74.2%) are viewed as more critical than technological solutions (64.5%), signaling that corruption is perceived as the core barrier to progress. Human capital development (71.0%) is also highly valued, seen as equally vital to successful technology integration.

Table 6: Association between the awareness and current state rating

	Negative Rating (Poor/Very Poor)	Non-Negative Rating	Total
Aware of Tech	64 (59.3%)	44 (40.7%)	108
Not Aware of Tech	16 (100%)	0 (0%)	16

Fisher's Exact Test: $p = 0.147$

All technology-unaware respondents provided negative ratings, indicating that awareness may influence more balanced opinions. However, the absence of a statistically significant association ($p > 0.05$) suggests that other factors likely play a larger role in shaping satisfaction levels.

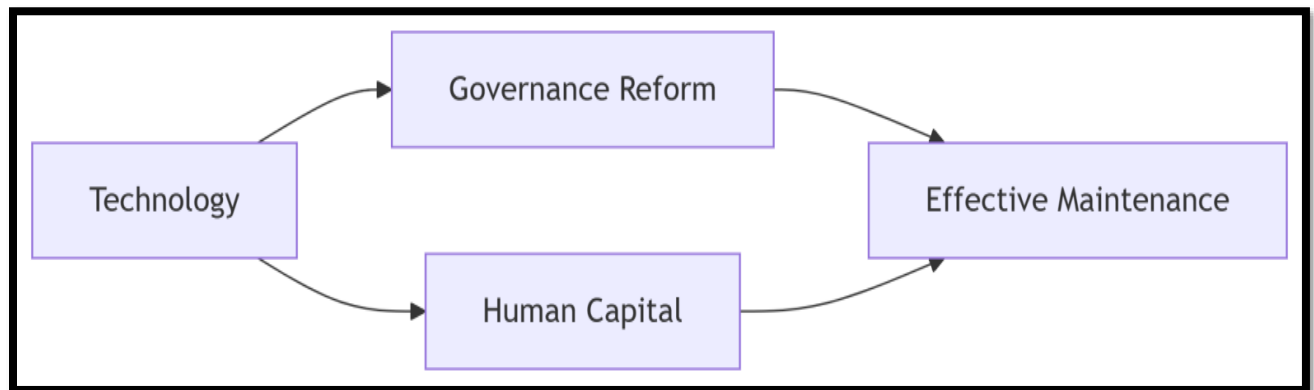


Fig. 10: Strategic Framework for Enhancing Maintenance Practices in Nigeria Using Modern Technology

4. Conclusion and Recommendations

Conclusion

The integration of cutting-edge technologies in infrastructure maintenance and management in Nigeria is confronted with numerous challenges despite the promising benefits. The data presented highlight the current maintenance state of civil engineering public infrastructural facilities in Nigeria, the challenges facing the maintenance practices and suggestions for possible ways of improving the maintenance practices in Nigeria using modern technology approach. It can therefore be concluded that;

1. The response rate in this case of 70% is very good.
2. Majority of the respondents were male professionals, and they are above 15 years of age which is the minimum legal working age in Nigeria according to the Labour Act of Nigeria, with restrictions on the type of work. Similarly, they are also 18 years of age and above, which is the minimum age of standard entry into workforce in Nigeria, full-time without restrictions.
3. Majority of the respondents, 96 (61.5%) have above 10 years working experience.
4. The current state of public infrastructure maintenance in Nigeria is rated as either Poor or Very Poor, indicating a high level of dissatisfaction. Maintenance frequency has a strong effect on the durability of the public civil engineering infrastructural facilities in Nigeria, while education and technology awareness act indirectly by shaping perceptions and enhancing maintenance strategies.

5. Corruption emerges as the most cited challenge, reported by 69 percent of professionals, and carries the highest severity impact. Poor funding and inadequate use of technology follow closely, highlighting their interconnected role in undermining infrastructure performance.
6. AI and drones emerged as the most recommended technologies, reflecting a strong preference for predictive maintenance and remote inspection solutions.

Recommendations

As corruption was perceived as the core barrier to progress, anti-corruption measures are viewed as more critical than technological solutions, and therefore recommended. Human capital development was also seen as equally vital to successful technology integration, and this is also recommended.

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