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RISK MANAGEMENT AND SUSTAINABLE DEVELOPMENT IN ROAD CONSTRUCTION IN SOUTH-EASTERN NIGERIA

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ABSTRACT

Civil engineering projects involve multiple activities, spanning a large area of land, and entailing the possibility of subterranean conditions making them extremely risky. Road construction involves risk from the beginning to the ending and can significantly impact any one of the project's components, such as cost, quality, timeliness, and scope. This study considered selected construction companies within the South East geopolitical zone of Nigeria as a case study to examine sustainable risk management for road construction projects. The methodology comprised the use of a questionnaire survey for primary data gathering and one-sample t-test statistical model for data analysis. From the result, the program evaluation review technique with a mean value of 3.71, is the most successful risk management strategy in Nigeria, according to this study, and it complies with sustainable development principles; while delayed payment challenge is seen as the risk with the highest rating. The study would assist project managers in better estimating risks before any project begins, understanding the risks that are expected in road projects, and creating appropriate mitigation strategies early on in a project.

KEYWORDS: *Sustainable development, Risk management, Road construction, Civil Engineering, Project managers, Projects, Infrastructure*

1.0 INTRODUCTION

The road construction sector is essential to the economic and social advancement of any country because it makes it easier for people, commodities, and services to move about (Oladinrin et al., 2012). The importance of having a well-developed road infrastructure in Nigeria, a nation with a fast-rising economy and population, cannot be underscored. However, there are several issues facing Nigeria's road building sector that affect both its long-term viability and efficient risk management.

In the past, Nigeria's road system has found it difficult to meet the demands of economic expansion and urbanisation. Congestion, higher transportation costs, and decreased economic efficiency have all resulted from inadequate road networks**(Abdul Fattah, et al, 2022).** Furthermore, poor roads exacerbate traffic jams, deterioration, and environmental harm. This situation emphasises the necessity of a thorough strategy that incorporates both sustainable development practices and efficient risk management techniques in order to solve the complex problems associated with road construction.

Risk is determined by the likelihood that an event will occur as well as the extent of the harm that would ensue if it did (EPA, 1996). Risk can be either beneficial or detrimental, and it is described as "the likelihood that an event will happen which will have a consequence on objectives." (ASEE, 2008). One popular definition of risk is the sum of the likelihood and the probability of an event (or exposure's outcome or effect). This is where the commonly accepted idea of risk originates: Probability x Consequence equals risk.

Risk is inherent in all human activities. Any venture's success or failure is determined by the way its managers handle it. (Thompson and Perry, 1992) The construction business is no exception. In comparison to other industries, the construction sector is thought to be more vulnerable to risk. This can be attributed to the intricate and time-consuming design and building process, as well as the tremendous effort required to manage numerous human resources from various institutions with varying backgrounds, interests, and goals. (Othman 2008). Furthermore, reimbursement, security deposit and retention, start and finish dates, variations, delay and delay cost, and liquidated damages are also examples of risk factors. Along with changes in commercial or governmental plans, magnitude can be one of the main sources of risk.

Risk management is a complex fusion of various viewpoints, attitudes, perceptions, and qualitative or quantitative methodologies, rather than being a single procedure. Stakeholder participation, two-way communication, and response are therefore essential elements of effective risk management. In order to effectively manage project risks and uncertainties, risk management is one of the most important processes. Effective risk management implementation is crucial to restoring the construction industry's dismal reputation for project execution. Risk management can be used to eliminate typical issues in construction projects, such as unsafe working conditions, poor product quality, overbudget, and delays in project completion. Therefore, one may say that risk management is crucial, particularly when making risk-related decisions. (Lee Chun and Azlan, 2012).

One essential component of sustainable development is risk management. Sustainable development is typically evaluated in relation to concurrent advancements in its "three pillars": environmental preservation, human development, and economic growth. Construction firms must deal with a complex and frequently interconnected mix of risks and opportunities presented by the three pillars of sustainability—social, economic, and environmental.

For the building business, the problem of sustainable development offers a range of opportunities and challenges. Given the social, environmental, and financial hazards to all parties involved in building—local communities, governments, investors and shareholders, indigenous groups, construction corporations, and so forth—these must be taken into account. Understanding risks and how they relate to one another depends on these sustainability pillars. Therefore, the following are the objectives of the study:

i) Identify particular risks associated with Nigerian road development.
ii) Assess the effectiveness of the various risk management techniques used in Nigeria's construction sector.
iii) Assess how well risk management practices in Nigeria's road construction industry align with the idea of sustainable development.

2.0 LITERATURE REVIEW

A comprehensive strategy that aims to strike a balance between social well-being, environmental preservation, and economic growth is known as sustainable development in the road construction sector **(Mensah, 2019).** It entails implementing procedures and tactics that guarantee the building and upkeep of road infrastructure favourably impact society's needs both now and in the future. By incorporating sustainable concepts into road construction, the negative effects of conventional construction techniques are lessened, and a more long-term and responsible approach is encouraged **(Mensah, 2019).**

"No construction venture is completely risk-free. Latham (1994) opined that there are several ways to manage, reduce, distribute, transmit, or accept risk, which cannot be overlooked. Furthermore, Flanagan and Norman (1993) compared the construction sectorto other industries, and concluded that the construction sector is perhaps the most sensitive to risk and uncertainty. In addition, Flanagan and Norman (1993) further subdivided it into more specific concerns, the risks might be classified as geotechnical, financial, or environmental. Numerous stakeholders are involved, the manufacturing process is open, and there is a great deal of interaction between the internal and external environments. Considerable hazards are created by such organisational and technological complexity (Zou et al. 2007).

Environmental effects of road construction projects can be severe and include pollution and disturbance of natural habitats **(Ihuoma, et al, 2021)**. In order to minimise damage to ecosystems and guarantee sustainable growth, it is imperative that these risks be mitigated. Effective mitigation techniques can be used by the road building sector to strike a balance between environmental preservation and infrastructural requirements. These environmental hazards include, but are not restricted to, waste production, habitat upheaval and degradation, noise and vibration, soil erosion and sedimentation, and contamination of the air and water **(Ihuoma, et al, 2021)**.

One of the first attempts to examine the necessity of organising project risks and using a methodical approach that incorporates many tools and techniques, such as PERT, decision trees, and probability distributions, was described by Chapman and Cooper (1983). Cooper et al. (1985) also describe a technique for assessing project cost risk in a follow-up study. They structure the risks as "risk breakdown structures" (RBS), with project cost risk at the top of the hierarchy. A variation distribution of the basic estimate of cost is used to model risk. The first attempt to apply fuzzy sets theory (FST) to address subjectivity difficulties in construction risk assessment was made by Kangari and Riggs (1989), who provide examples of how to use FST as a tool for risk assessment **(**Kangari and Riggs, 1989**)**.

Tavares et al. (1998) designed a stochastic model that incorporates both the duration of a project activity and the randomisation of the cost. The likelihood of not achieving the project's goals—cost and duration—was used to model project risk; no other goals were taken into account. Mulholland and Christian (1999) create a project duration distribution using the PERT approach. Schedule risk is measured by the variance of a project's duration distribution; the greater the variance, the higher the risk related to the project's duration.

The present application of risk management approaches in the construction industry was discovered by Raftery (1994) and Akintoye and Macleod (1997). These consist of the following: subjective probability, risk premium, risk-adjusted discount rate, Monte Carlo simulation, stochastic dominance, Casper, and intuition. According to Odeyinka (1987), transferring to insurance firms is one of the main ways that the Nigerian construction sector manages construction risk.

The probable causes of insurable construction risks that are thought to arise in the Nigerian construction industry, as well as the kinds of insurance policies used to manage them, were investigated by Odeyinka (2000). According to the report, site security, construction risks, and health and welfare standards are given a lot of weighting among the many insurable risks.

Sustainable development, as defined by Sage (2009), is the achievement of human requirements while preserving the planet's natural systems and advancing socioeconomically and technologically. Continued advancement in the fields of economics, society, culture, and technology is essential to sustainable global progress. In order to accomplish this, the protection of the planet's natural resources must also get serious consideration. The phrase "sustainable development" refers to the attainment of both enhanced technological and economic growth and the conservation of natural capital, which includes natural resources and the environment. For intergenerational and intergenerational equity to be ensured, as well as for the ability of earth's natural systems to serve humanity to be preserved, enlightened institutions and infrastructure must be developed, and risks, uncertainties, and information and knowledge imperfections must be appropriately managed (Sage, 2009).

3.0 MATERIALS AND METHODS

The study was conducted in Nigeria's southeast geopolitical zone. Staff members and ad hoc employees of designated construction companies where selected by random sampling procedure as study sample. A questionnaire created by the researchers was the tool utilised to collect the primary data. The total of fifty-two (52) questionnaires were distributed and retrieved from selected construction companies and their staff within Enugu state and Anambra state of the South East region. The survey is divided into two parts. The first part includes demographic information about the respondents, and the second part has questions in four clusters: A, B, C, and D. The questions are based on a five-point rating systemviz: Very Great Extent (VGE), Great Extent (GE), Some Extent (SE), Little Extent (LE), and No Extent (NE) receiving scores of 5, 4, 3, 2, and 1 respectively.

Cluster A aimed to address the particular hazards associated with road development in Nigeria. Cluster B offered responses regarding the efficacy of risk management techniques used in the building sector. Cluster C looked for responses on the best way to manage risk in Nigeria, while Cluster D offered answers on how well risk management in Nigeria's road building industry adheres to the idea of Sustainable development.

The researchers and five research assistants, with whom the researchers had received a day of training, administered the questionnaires to the participants and retrieved the data from them. This ensured that the questionnaires were disseminated and retrieved within two weeks with the fewest possible errors. The formulated hypotheses were tested at the 0.05 level of significance using one

sample t-test statistics, while the research questions were evaluated using mean (x) and standard deviation (SD).

3.1 One-sample t-test

The **one-sample t-test** is a statistical method used to determine whether the mean of a single sample significantly differs from a known or hypothesized population mean. The t test is a commonly used hypothesis test in statistics that allows us to compare the mean value of a group of sampled data with some hypothesized value, usually a population mean value (from the same population or a different population). Since the test compares means, the variable of interest should be continuous (McClenaghan, 2024).

4.0 RESULTS

The questionnaires were analysed using SPSS 17.0 software.The results obtained are presented in clusters and have been summarized in the tables below. To analyze the results, values greater than or equal to 3.0 have been chosen as a benchmark for large extent while values below 3.0 will imply a low extent.

4.1 Cluster A: "To what extent are the following risks in construction business in south east Nigeria?"

Table1: Response to Cluster A

S/No	Item	X	SD	Rank	Decision
1.	Flood	3.75	**0.916**	**5th**	Large Extent
2	Equipment Productivity Risk	3.69	**0.875**	**6th**	Large Extent
3.	Financial Risk	4.19	**0.768**	**2nd**	Large Extent
4.	Design Risk	4.08	**1.026**	**3rd**	Large Extent
5.	Security Risk	3.50	**0.939**	**7th**	Large Extent
6.	Kidnapping	3.40	**1.241**	**8th**	Large Extent
7.	Community Unrest	3.33	**1.004**	**9th**	Large Extent
8.	Material Supply Challenges	4.06	**0.860**	**4th**	Large Extent
9.	Volcanic Eruption	2.44	**1.392**	**11th**	Not Risk
10.	Landslides	2.69	**1.351**	**10th**	Not Risk
11.	Delayed Payment Challenge	4.50	**0.642**	**1st**	Large Extent

Table 1 illustrates the responses provided by respondents regarding the seriousness of particular risks in the construction industry. According to the results, the top three risks for the road building industry in the southeast region of Nigeria include delayed payment challenges, financial risk, and design risk.

It is significant to note that other researchers (Sambasivan and Soon, 2007; Koushki et al. 2005) have conducted comparable studies in other nations and have also discovered that, among other dangers related to the Nigerian construction industry, money difficulties or delayed payments rank highest. Sambasivan and Soon (2007) also noted the following additional risks: design

modifications, material and labour shortages, equipment availability and failure, inexperienced and poor site management by contractors, issues with subcontractors, and equipment availability and failure.

Additionally, Koushki et al. (2005) concluded that the owner's budgetary limitations and evolving designs were the main hazards in Kuwait. These results are comparable to what is available in Nigeria's southeast geopolitical zone, which may not vary throughout the country. According to the benchmark mean value of 3.0, it is significant to note that all of the characteristics listed in table 1 (with the exception of landslides and volcanic eruptions, which have values below 3.0) were acknowledged by respondents as dangers affecting the Nigerian building industry. It is not unexpected that the respondents do not perceive the study location as a risk because landslides and volcanic eruptions are not known to occur there.

4.2 Cluster B: "To what extent are the following risk management practices in construction industries in south east Nigeria effective?"

Table 2: Response to Cluster B

S/No	Item	X	SD	Rank	Decision
1.	Probability Impact Method	3.52	**0.852**	**2nd**	Large Extent
2.	Analytical Hierarchy Process	3.39	**0.929**	**3rd**	Large Extent
3	Decision Trees Analysis Method	3.29	**0.871**	**5th**	Large Extent
4	Fuzzy Ste Theory	3.31	**1.094**	**4th**	Large Extent
5	Program Evaluation Review Technique	3.71	**0.848**	**1st**	Large Extent
6	Transfer to Insurance Companies	3.19	**0.886**	**6th**	fairly effective

Table 2 shows the levels of agreement of respondents on the effectiveness of the itemized risk management practices in Construction industries in Nigeria. The results show that the Program Evaluation Review Technique is the most effective, followed by the Analytical Hierarchy Process and the Probability Impact Method. Additionally, based on the study's predetermined values, it is evident that transfers to insurance companies are unsuccessful and the least effective in Nigeria.

4.3 Cluster C: "To what extent is Insurance business the most suitable method of handling road construction risks in south east Nigeria?"

Table 3: Response to Cluster C

S/No	Item	X	SD	Rank	Decision
1	Transfer to Insurance Companies	3.33	**1.264**	2ND	Highly suitable
2	Probability Impact Method	3.37	**1.030**	1ST	Highly suitable
3	Analytical Hierarchy Process	3.29	**1.035**	3RD	Highly suitable
4	Decision Trees Analysis Method	3.21	**1.091**	5TH	Highly suitable
5	Fuzzy Ste Theory	3.02	**1.057**	6TH	Fairly suitable
6	Program Evaluation Review Technique	3.25	**1.169**	4TH	Highly suitable

Table 3 shows respondents' level of agreement on the extent transfer of risks to insurance businesses, is the most suitable method for handling road construction risks in Nigeria. As discovered, it isn't functioning at the moment. Risk transfer is widely acknowledged to be a cost-effective risk management strategy (Surminski and Oramas-Dorta, 2014), yet it has drawbacks that render it ineffective in certain nations. Although insurance is one tool used in Sri Lanka's construction industry to manage risks, Arooz & Halwatura (2015) noted that insurers occasionally reject insurance claims and refuse payments because of technical exclusions in the policy or just because the insured contractor has not adhered to the policy's conditions and procedures. Similar to the findings of Arooz & Halwatura (2015), insured parties are refused claims in the conventional Nigerian system.

Cluster D: To what extent do risk management practices in road construction conform to the concept of sustainable development?

Table 4: Response to Cluster D

S/No	Item	X	SD	Rank	Decision
1	Environmental Impact	4.04	**0.949**	**1st**	Large Extent
2	Waste Generation	3.44	**1.056**	**5th**	Large Extent
3	Negative Impact on Ecosystem	3.38	**1.105**	**6th**	Large Extent
4	Material Recycling	3.33	**1.080**	**7th**	Large Extent
5	Pollution Control	3.46	**1.212**	**4th**	Large Extent
6	Design	3.71	**1.073**	**2nd**	Large Extent
7	Sustainable Construction	3.62	**0.932**	**3rd**	Large Extent

Table 4 shows respondents' agreement on the extent itemized risk management practices conform to the concept of sustainable development. It is generally accepted that they all conform to the concept of sustainable development to a large extent.

5.0 CONCLUSION and RECOMMENDATION

5.1. Conclusion

There are opportunities and challenges at the nexus of risk management and sustainable development in Nigeria's road construction sector, with important ramifications for the country's social cohesion, environmental conservation, and economic development. The necessity of combining sustainable practices with efficient risk management techniques to guarantee road construction projects' success while reducing negative effects has been highlighted by this investigation.

This study has painstakingly investigated risk management practices and its sustainability in construction industries in south east geopolitical zone of Nigeria. It therefore established the following:

1. Delayed payment challenge, financial risk, design risk, security risk, equipment productivity risk, kidnapping, community unrest, material supply challenges, and flood are all risks in construction industries in south east geopolitical zone of Nigeria.

2. Flood and volcanic eruptions are not risks in the construction industry in the study area.
3. Program Evaluation Review Technique is the most effective risk management practice in Nigeria.

4. Program Evaluation Review Technique, Analytical Hierarchy and Probability Impact Methods of risk management conform to sustainable development practices and hence they are recommended for use in management of risk in Nigeria.

5.2 Recommendations

The following recommendations emerged from these findings, which are approaches to sustainable development and risk management in road constructions, they include:

1. Holistic Approach: Sustainable Road construction requires a holistic approach that considers economic, environmental, and social factors. Balancing the needs of infrastructure development with environmental stewardship and community engagement is paramount.

2. Environmental Responsibility: The road construction industry must adopt sustainable practices to mitigate its environmental footprint. From materials selection to construction techniques, embracing eco-friendly alternatives can significantly reduce negative impacts.

3. Stakeholder Engagement: Engaging with local communities, indigenous groups, and other stakeholders is crucial for addressing concerns, respecting cultural heritage, and gaining support for road projects.

4. Risk Anticipation: Effective risk management is essential to navigate the uncertainties inherent in road construction. From financial risks to geotechnical challenges, proactive planning and mitigation strategies can minimize disruptions.
5. Innovation and Technology: Embracing technological advancements, such as green design solutions and digital project management tools, can enhance efficiency, reduce risks, and contribute to sustainability goals.

6. Regulatory Compliance: Adhering to local regulations and obtaining the necessary permits are fundamental to successful road construction. Compliance ensures projects proceed smoothly and avoid legal complications.

7. Continuous Learning: The field of road construction is evolving, and there's a need for continuous learning and adaptation. Staying updated on best practices, emerging technologies, and regulatory changes is essential for sustained success.

8. Collaborative Efforts: Sustainable development and effective risk management require collaboration among various stakeholders, including government agencies, construction companies, environmental experts, and local communities.

9. Long-Term Perspective: A long-term perspective is essential for both sustainable development and risk management. Considering the entire lifecycle of projects and planning for maintenance and eventual decommissioning ensures the long-lasting benefits of road infrastructure.

10. National Development: Achieving sustainable road construction aligns with Nigeria's broader goals of economic development, environmental protection, and improved quality of life for its citizens.

Finally, the road construction industry in Nigeria has the opportunity to make significant strides toward sustainability by integrating best practices, leveraging technology, and prioritizing risk management. By doing so, the industry can build a network of roads that not only connect regions but also contribute positively to the environment, society, and the nation's overall prosperity. Through collaboration, innovation, and commitment, Nigeria can pave the way for a more sustainable and resilient road infrastructure future.

****Authorship Contribution Statement**

Urokor, M. was involved in writing the initial draft, administering questionnaires and analysis.
Onyekweredike, K. was involved in analysis and research conceptualisation.
Odumade, A.O was involved in analysis, literature review and final draft

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****Statements and Declarations**

We make to declare that the work is original and has not been published elsewhere, except for a preprint version of the results that is online.

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