Abuja light rail mass transit project: A paradigmatic case study for sustainable railway transportation infrastructure project in Nigeria

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Abstract

This research discusses a study that examined the issue of sustainable railway transport infrastructure project in Nigeria. A case study method was used in the study; several sources were used for data collection. These sources include; primary data collection which used (semi-structured questionnaires, oral interview) and secondary sources from projects, contract documents and government reports. The research results were used to formulate roadmap models for sustainable railway infrastructure projects. The research also discusses the outcomes and makes some recommendations for railway transportation infrastructure projects sustainability.

Keywords: Case Study, Roadmap Models, Sustainability, Railway Infrastructure

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1. Introduction

Railway administration in developed nations like Japan, France and Canada, has become more rational with time. New strategies, such as public- private partnership, and build operate- transfer (BOT) arrangements, as well as old strategies such as privatization, are being adopted to enhance railway safety, punctuality, reliability and sustainability. Furthermore there is increasing interest worldwide in development of transport by expanding high- speed rail networks such as the shrinkansen in Japan and the TGV in France. New non rail technologies like the Japanese MAGLEV are being investigated. The priority for these changes has environmental undertones, and railways are increasingly being seen as environmental friendly (National Research Council, 1987).

In developed countries, transport policy is dynamic and changes responsively according to technological trends in the transport sector. Government policy in respect of rail transport innovation and development are fairly consistent and largely limited to policy making and execution (Odeleye, 2000).

Meanwhile, countries all over the universe are now being challenged with issues that have to do with sustainable infrastructure project delivery. Therefore, railway infrastructure sustainability problem remains active all the time and one of the critical challenges that cut across various transportation infrastructure in Nigeria and some other West African Countries. The problems and challenging issues (Oraegbune et al., 2015; Oraegbune, 2015) manifest in different forms. Identification of and clear understanding of the effects are prerequisites for proffering definite solutions to the puzzling circumstances. A case study has been severally used for such research in the past (Oraegbune et al., 2015; Oraegbune, 2015). Scholars have identified the potency of case study method in scientific inquiries in various disciplines including engineering and construction (Oraegbune, 2015).

This study assessed issues and problems that form obstacle to successful delivery of sustainable railway infrastructure projects in Nigeria. It uses Abuja light rail mass transit as a case project or study with a focus on railway transport projects in Nigeria. The research is built up of distinct parts; it gives a brief over view of the case study research method and highlights its salient features. The next is a discussion of case study selection and structure in which specific features of the case study projects assessed are highlighted. The paper went on to discuss the applications of case study method in the research in specific appropriate levels of details (Oraegbune, 2015). Thus, the paper discusses the results which include; the development matrix of vital sustainability issues for transportation projects and a road map on the vital sustainability issues identified in the research (Oraegbune et al., 2015; Oraegbune, 2015).

The study then compares both the matrix and roadmap to proffer solutions and make recommendations for successful delivery of sustainable railway transportation infrastructure projects in Nigeria. The action above results to brief review of Abuja light rail transit project case study.

2. Review of case study

There are several rigorous, exhaustive and epistemological theorems of case study research (Oraegbune et al., 2015; Mclaughlin and Thomas, 1984), defined case studies as "analysis of persons, events decisions, periods, projects, policies, institutions or other methods".

Although, the main need is that the case conditions of the inquiry will be an instance of a class of phenomena that provides analytical framework – an object within which the study is carried out and which the illuminates and explicated (Oraegbune, 2015; Lim, 2009; Lamneke, 2005), defined case study as a research approach, situated between concrete data taking techniques and methodological paradigms, while Oxford Advance Learner's Dictionary 6th Edition defined a case as detailed amount of the development of a person, a group of people or a situation over a period of time (Oraegbune et al., 2015; Lim, 2009; Hornby and Wehmeler, 2000). There are other similar definitions by Thomas (2011), Corkin (2013) and Yin (2014). In addition to above, there are several gains of case study. These gains include; providing a great amount of description and detail; presenting opportunities that researchers could not otherwise have, developing analytic and problem solving skill, allowing for exploration of solutions for complex issues etc. Although, one main problem of case study is that the results might not be generalized (Oraegbune et al., 2015; Lim, 2015).

The research reported in this study, the case study project set the foundation of sustainability roadmaps for Nigeria railway transport infrastructure project. The data was primarily qualitative as the study, at this stage sought to understand the measures taken and procedures involved at project – specific to address the issues that impact on railway transportation infrastructure sustainability in Nigeria. For the purpose of this study, the exploratory approach of the case was used to assess specific problems and seek for answers.

i.   In real-life practice, a part from the research problems identified through the previous studies (Lim, 2015; Oraegbune et al., 2015; Oraegbune, 2015), what are the problems that hinders achieving sustainability infrastructure projects (railway) in Nigeria.

ii. How are those problems be addressed and what procedures or methods are needed in order to achieve sustainability in railway transportation infrastructure projects in Nigeria.

iii. The ensuing section discusses case study selection and structure in the study under discourse.

2.1. Case study selections and structure

An average or typical case neither provides the best information, nor clarifies lines of history and causation (Oraegbune et al., 2015; Oraegbune, 2015). The choice of the case study greatly affects the results of the study. It was also noted that the case selection criteria must relate to the problem statements/questions, research aim and objectives, and define what attributes will be most likely to yield relevant information (Oraegbune et al., 2015; Baskarada, 2014, Lim, 2009; Winegardner, 1999). Therefore, the process of selecting cases or case project must be undertaken in a way that maximize what can be learned in the period of time available for the study (Oraegbune et al., 2015; Lim, 2009). In the context of the case study project(s) selected

for the study, certain criteria were set-up to ensure a degree of suitability (John, 2008 and Tellis, 1997)**.** To ensure that meaningful information could be obtained to address vital sustainability problems, very strict criteria were applied to select case study projects.

These include:

  i.   The case project should be a successful railway transportation infrastructure projects with recognized achievements by the industry validation.

 ii.   The railway infrastructure has to consider or bear sustainability direction or its focus as the project targets.

iii.   The railway project has to be completed or ongoing with reasonable completion and sustainability driven motion.

 iv.   The case project site(s) must be located in Nigeria. The projects selected are based on their high profile or quality and success integrating sustainable best practice in railway transportation infrastructure.

Table 1. Illustrate how a selected case project in the study satisfies the basket of selected criteria. The case project is Abuja light Rail mass transit projects/ Lagos – Badagry Railway Project.

S/NO	CASE PROJECT CRITERIA	REMARKS ON CASE PROJECT: ABUJA LIGHT RAIL MASS TRANSSIT POJECT
i.	The case project should be a successful transportation infrastructure project (railway) with recognized achievements by the industry.	The project is ongoing while lots 1 and 3 are nearly completed with high quality job.
ii.	The railway project must bear a sustainability focus as its targets.	Contain various sustainable criteria, indicators and best practices.
iii.	The rail project must have been completed or ongoing with a great percentage of completion.	The projects is subdivided into lots 1, 2, 3, 4, 5 and 6, while 1 and 3 are about to be completed.
iv.	The case project sites should be in Nigeria.	The railway project covered Abuja Capital Metropolitan for now (285km).

Figure 1. Abuja Light rail mass transit with integrated sustainability elements or criteria

Figure 2. Abuja Light rail mass transit with integrated sustainability elements or criteria

2.2. Project history

Abuja, the Federal Capital of Nigeria, is a young city conceived and designed in the late 1970. It is only of the few cities in the world planned before it was built, and planned as a national capital. Its creation was guided by a master plan that set out the design to meet the demands of a growing population. While most of its founder's aspirations have been largely realized, it lacks a rail mass transit system.

The design concept of Abuja is a linear form, curved roughly into a crescent shapes. The city was designed for 1.6m initially however; the current population of the city and satellite towns is of the order of 7m. The average house hold size is 49 with less than 50% of households owning cars. The average percentage of income spent on transport is 30% and the medium monthly household income is N42,000. Currently, a medium of trips cost N250 and current commute time is 40 – 90 minutes with a significant waiting time (Federal Capital Territory Admin, 2010).

Many of the people living in the satellite towns work within the Abuja Metropolis and require transportation to and from work. Most people rely on private vehicles and minibuses for transportation into the city and a ban on the use of commercial motorcycles has increased the dependency on informal methods of transportation.

The layout of the city was specially designed to accommodate rail mass transit. The transit ways are parallel lines running through about 19 communities. Private vehicles were not planned for these routes. At the centre of Abuja city lies the central business district which is the main government district.

The objective of the Abuja rail mass transit projects is to create a rail mass transit project is to create a rail mass transit system that meets the highest international standards of technical excellence, harnesses the efficient operation and management of the private sector and has broad social and political acceptance.

The ultimate goal is to ensure that Abuja retains its positions as an excellent place to live and work and as a capital that will lead Nigeria in its role as the largest and most dynamic economy in Africa. A reliable rail mass transit will offer many benefits to the city. It will offer a safe and affordable alternative to unsafe public transit. It will offer benefits to the environment by reducing road traffic, gas emission and congestion. It will place Abuja on the world stage as one of the few cities in Africa operating a high railway system. Light railway systems offer through the use of segregated right of way because the transit corridor was planned into the development of the city (Federal Capital Territory Admin., 2010)

2.3. Vital components of the Abuja light rail mass transit project

The Abuja light rail mass transit project consists of six lots (6 lots) covering a distance of appropriately 285km. Lot I (also known as the Blue line) is about 43km long and originates from Ring Road 1 passing through transportation centre in the Central Business District (CBD) to Gwagwa a distance of about 24km. It then joins the commuter rail network in a southwardly direction to the airport, a distance of 8km and

Northwards from Gwagwa to Kubwa, a distance of about 13km. The route traverses the high density areas of Garki, Wuse, Jabbi, Life Camp and Gwagwa. Initial demand is estimated at 136,000 passenger trip daily, growing to 830,000 by year 2030. Lots 2 (known as the red line) covers a distance of about 22km from Nyanya to the transportation centre. Beginning from section D, it will continue for 15km on the transit way through the interchange centre to the Gwarimpa FHA Estate. The line there extends further to reach the blue line. The total length of the line estimated at 54km. The red line will have 16 stations with demand expected to be 136,000 passenger trip daily initially projected to grow to 437,000 by year 2030. Lot 3 (known as the yellow line) runs from transportations centre in the Central Business District (CBD) to the Idu Industrial Area over a length of 18km. It will ultimately connect to the Airport Kuje and Gwagwalada. It will connect with the Blue line at the National Rail Junction east of the Idu Industrial Area, South of Gwagwa. The initial demand is estimated at 68,000 passenger trips per day projected to grow to 121,000 by year 2030. When eventually taken to the Airport, the total length of the line would be about 29.5km. Lot 4 consisting of lots 4A and 4B is an extension of commuter urban rail lane from Kuje to the Satellite town of Karshi passing through Keffi to Linde in Nassarawa State and covering a distance of about 46km, with lot 4B adding a further distance of 46km considering of the southern wing of the transit way. Lot 5 is a commuter urban rail running from Kubwa to Bwari with a connection to Suleja in Niger State, covering a distance of 31km. Lot 6 is an extension of the commuter urban rail line originating from the Airport Cargo Terminal to Kuje and further on to Gwagwalada distance of 43km.

The FCTA is funding the design and build of the fixed infrastructure for lots 1 and 2 and proposes concession its operation to a private operator(s). Lots 2, 4, 5 and 6 are to be conceded to private operators on a design, build, finance, operate and transfer concessions, otherwise known as BOT. Lots 1 and 3 are at finishing stages which may be completed on or before 2015/2016. It is also important to note that these lots1and3 and remaining lots (4, 5, and 6) maintains or contains good number of criteria and indicators for sustainable railway transportation infrastructure. However, the low level of awareness of practice of sustainable best practice has a high quality of job execution in Nigeria (See Figures 1 and 2). The project is being handled by Messrs China Civil Engineering and Construction Company (Federal Capital Territory Admin, 2010).

2.4. Basic Information on Abuja Rail Mass Transit Project

- Revised Contract sum   =   US $8.23, 540,587.87
- Total length   =   45.2KM (Lot 1A + Lot 3)
- Estimated completion period = December 2015/2016
- Lot 1A = Length 18KM
- Stations = 4Nos.

Traffic Handling Capacity:

- Short term (2015)   =   152,720 trips per day
- Medium term (2022)   =   199,495 trips per day
- Long term (2037)   =   306,031 trips per day

Lot 3:

- Length = 27.24km
- Stations = 8Nos.

Traffic Handling Capacity:

- Short term (2015) = 151,635 trips per day

- Medium term (2022) = 119,104 trips per day

- Long term (2037) = 190,436 trips per day

The Invest Opportunities Include:

1- Concession of Lot1A and 3 (i.e. provision and management of rolling stock and operation and maintenance).
2- Lot1B and 2 for concession (final engineering design and construction, provision and management of rolling stock, operation and maintenance) (Federal Capital Territory Admin., 2010).

3. Case study method

The case study involved two main data sources: These are semi-structured interviews and secondary source involving review of previous studies, projects, contractual documents, industry publications and government reports.

Some researchers have suggested that the interviewing method only be used when people's self reports of their opinions are the best source of information, when the desired information is complex or probing or when it is necessary to clarify previously collected information (Lim, 2009; Sproul ,1995; Oraegbune et al., 2015).

In this case, semi-structured interviews were employed to probe into the problems and identify solutions. The importance of case study is that it tries to enlighten a decision or set of decision. In this study, it elicited several aspects including: why they were taken, how they were implemented and the results obtained (Oraegbune, 2015; Lim, 2009; Schram, 1971).

Thus, the main focus of this research was to derive decisions after probing into each vital challenge of sustainability in railway infrastructure transportation. These decisions served to enlighten the way in which

each problem could be solved. In order to deduct useful information which directly contributed to roadmaps formation in this study, for each of the problem, the interviewees were requested to answer the following questions based on their project experience either in Abuja light rail mass transit project or elsewhere.

i.   What are the factors causing problems in the rail project?
ii. What are the problems arising from the challenging issues?
iii. How can the challenging problems be solved
iv. What are the final results of the action taken?

Because they are exemplary and the railway project is ongoing, their implementation measure represents the best practices. Too, the project has integrated strategies to address the critical/vital problems.

Nonetheless, the selection was made using most distinctive measures of the project as input in identifying decision-making patterns. The data gathered from the case study underpinned the development of railway transportation infrastructure sustainability roadmaps and identification of critical sustainability criteria for Nigerian railway transportation infrastructure projects.

3.1. Importance of the case study to the Abuja Light Rail mass transit project

Because of difficulties associated with the project, the case project was seriously considered. This however, opened various challenging issues including evolving strategies for the problem solution. The research identified some vital/critical sustainability challenging issues. This also led the development of solution framework or model for appraisal of railway infrastructure project (Oraegbune et al., 2015; Oraegbune, 2015).

Table 2 recapitulates project level specific upon which the vital criteria could be based on and correctly examined.

Table 2. Connecting some vital sustainability issues with railway infrastructure project level specifics

S/NO	PROJECT LEVEL SPECIFICS	VITAL SUSTAINBILITY ISSUES INVOLVED IN THE RAIL
i.	Project is designed to meet the high traffic congestions and delays in Abuja capital territory and the satellite towns or to create a rail mass transit system that meets the highest international standards of technical excellence.	• Community and society responsibility by the Federal Government and FCT Development Authority. • Inter-satellite communities and mobility transport.
ii.	Large financial commitment was involved in the project development and building implementation.	• Integrating whole life cost/life cycle cost.
iii.	Community interrelationship and business	• Community participation, general

	activities, harness efficient operation and management of the private sector.	consultation before, during and after project completion. • Broad social and political acceptance.
iv.	Consultation with urban planning, law and regulatory authority.	• Maintaining contract project specification in construction area/sites.
v.	Construction activities and environmental issues in the case project area (Abuja).	• Soil erosion control and sedimentation. • Construction noise and vibration impacts. • Air pollution in construction area (Abuja). • Solid waste management. • Road user's safety in the construction sites. • Engineering/Technical performance and material innovation. • Healthy and safety schedule for the project and workers. • Contract method/type and project administration or management.

Although, several sustainability criteria standards and sustainable construction has the best practices and have now been enforced in the case project. They were consistently assessed and documented for use as benchmarks for good practice in Nigeria construction industry (Oraegbune et al., 2015). The next section/part highlights details of the interview method.

Table 3. Showing the list of (5) interviewees who participated in Abuja case project study

S/NO.	INTERVIEWEE POSITION ON ABUJA LIGHT RAIL MASS TRANSIT	INTERVIEW DATES	INTERVIEW LOCATION	AVERAGE INTERVIEW DURATION
1.	Deputy Director Rail (Transport)	24/04/2012	Abuja	45 minutes average
2.	Construction Manager (Civil Eng.)	24/04/2013	Abuja	45 minutes average
3.	Chief Civil Engineer	24/04/2012	Abuja	45 minutes average
4.	Environmentalist	25/04/2012	Abuja	45 minutes average
5.	Consulting Engineer (Civil)	25/04/2012	Abuja	45 minutes average.

3.2. Interviewees profiles

Table 3 gives detail summaries of the interviews. The interviewees held different views in various organizations. They too played different roles in the case project, such as construction/operation, design and survey, environmentalists/planners, public relation officer and community development representatives etc. The broad range and extent of their responsibilities and experiences on the project contributed to upgrade the case study findings and provided holistic views of the project dimension(s). On the average, the time of interviews lasted for about 45 minutes each.

3.3. Method used in case assessment questions

Table 4 used here is base on (Oraegbune et al., 2015; Oraegbune ,2015) studies. It shows process used to elicit the sustainability goals and challenges were addressed in practice. This process resulted into the formulation of decision-making model and roadmap to sustainable railway transportation infrastructure project. Before the interviews, each interview was asked to choose as many vital challenging issues as he/she would like to focus upon and to share their experience based on their practical involvement in the project (Oraegbune et al., 2015; Lim, 2009). In addition, some of them made references to previous projects that had similar challenging issues. These contributed to enhance the study findings. Furthermore, for each challenging issue under discourse, probing questions were asked in other to obtain continual data and information for the verification or confirmation of decision-making rule for the answer criteria in Nigeria railway transportation infrastructure study.

Table 4. Looking for best practices for the vital sustainability issues through case projects

Vital sustainability challenging issues.		Best Practices/Action Taken		
CASE INQUISITORY QUESTIONS				
1.	Community and society responsibility by the government or client in Nigeria environment.	1.	What are the factors causing the challenging issue?	Data Analysis
2.	Inter-regional and modality of transport in Nigeria environment.	2.	What are the problems arising from the challenging issue.	Distinctive decision-making rule formula.

3.	Whole-life cost/life cycle cost in Nigeria environment.	3	How can these problems be solved?		↓ Road map formulation
4.	Community participation and General consultation in Nigerian environment.	4.	What are the results/findings from the action taken.		
5.	Maintaining contract and project specifications in Nigeria environment.				
6.	Soil erosion and sedimentation control at project sites.				
7.	Construction Noise and vibration.				
8.	Air quality in construction environment.				
9.	Solid waste management, re-use and re-cycling.				
10.	Road and Railway user's safety in the construction site(s).				
11.	Engineering/Technical performance and material innovation.				
12.	Health and safety plan for the project workers.				
13.	Contract type and project administration.				

4. Results and discussion

This paper discusses the best practice answers and also present findings from case study in the form of roadmap on the vital sustainability criteria for Nigeria railway transport infrastructure projects. Other findings include; minimization in transport (railway) fatality, general public acceptance and no man hour lost time injuries.

4.1. Matrix of vital sustainability challenging issues for transportation infrastructure project (railway)

The roadmap consists of two components, these include:

  i.   A matrix of vital challenging issues in transportation sustainability.
  ii. The roadmaps themselves.

As state previously no challenging issues can be treated separately. The main aim of the matrix present in this study is for its uses as reference tool by stakeholders to enable them achieve or address sustainability more appropriately. Table 5 shows the matrix.

Table 5. Matrix of vital transportation sustainability

SUSTAINABILITY CHALLENGING CRITERIA																
NO	ISSUES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	Air quality in construction environment.	■						√			√					
2.	Contract type and Project Admin.		■				√			√						
3.	Community and society responsibility by the government or client in Nigeria.			■	√				√							
4.	Community participation and general consultation in Nigeria environment.			√	■	√			√		√					
5.	Construction noise and vibration.				√	■		√			√					

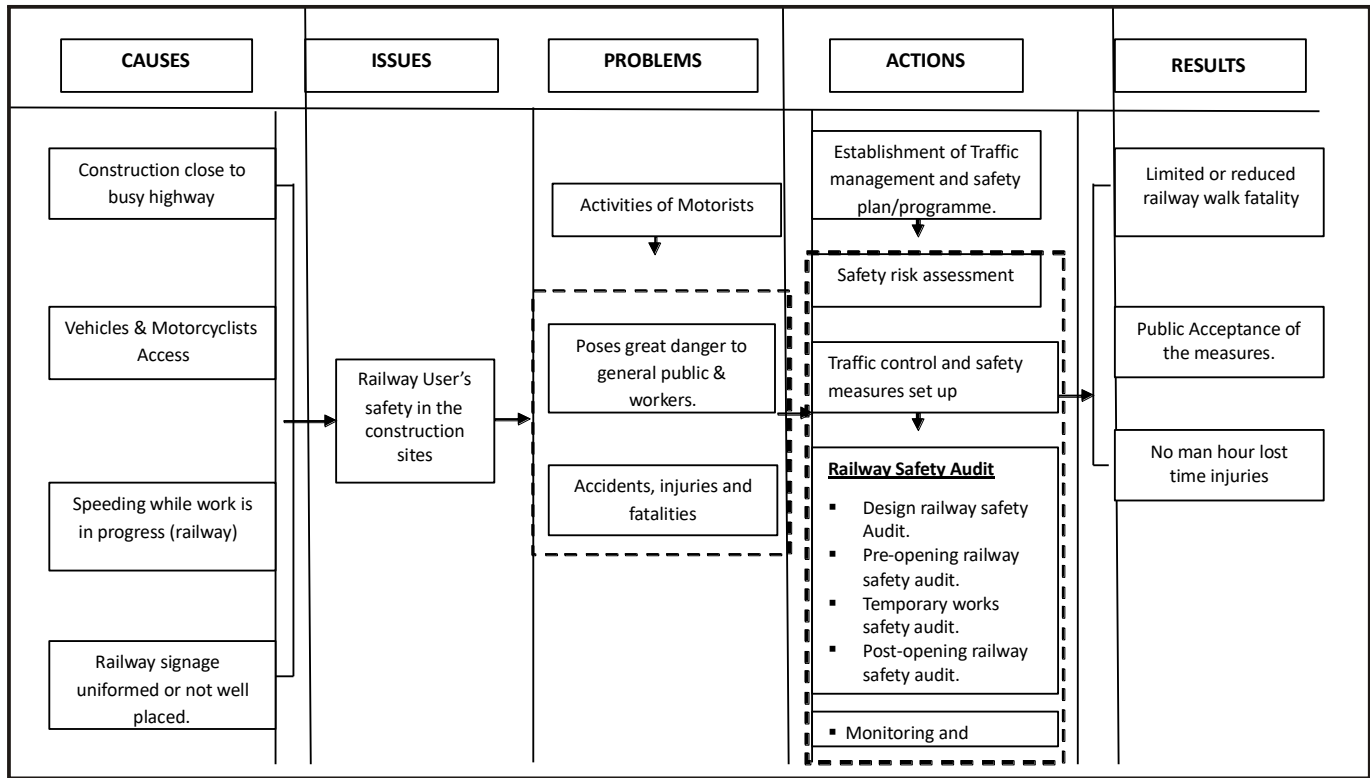| No.		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
6.	Engineering/ Technical Performance and material innovation.		√				■		√	√					
7.	Health and safety plan for the project workers.					√		■		√					
8.	Inter-regional and modality of transport in Nigeria.				√		√		■						
9.	Maintaining contract and project specifications in Nigeria		√				√			■					
10.	Railway users safety in the construction sites.					√		√			■				
11.	Soil erosion and sedimentation control at project sites.											■			
12.	Solid waste management, reuse and recycling.						√						■		
13.	Whole-life, cost/life cycle cost in Nigeria.		√				√							■	

Figure 3. Decision-making model for railway user's safety in the construction sites

RAILWAY USERS SAFETY IN THE CONSTRUCTION SITES	
CAUSES	**PROBLEMS**
- Construction close to busy highway. - Vehicles & Motorcyclists Access - Speeding where railway works are in progress. - Railway signage uniformed or not well placed.	- Activities of motorists, motor bikes, cyclists, poses great danger to workers and general public. - Accidents, injuries and fatalities occur.

Recommendations
o   Establishment of Traffic management plan/program
o   To conduct safety risk assessment from the perspectives of public transport, cyclist, pedestrian and construction workers/staff (This is done before detailing traffic control and safety measures).
o   To separate and provide adequate road block between construction work area and traffic; undertake construction during less traffic hours or volumes, provide clear signage, no surprise in rail design & traffic control, speed humps or bumps, etc.
o   To provide notice or information on traffic changes or diversions to the public through community notices, consultations with authorities, providing an advance warning signs, printed materials, advertisements and through media announcements and information centers and communities town criers.
o   Have a railway safety audit in stages to ensure road and railway information or schemes are constructed and operated safely.
o   To reform systematic monitoring and measuring (e.g. Daily implementation records, daily visual and weekly documentation or documented workplace inspections by the supervisor).
o   Contractors to present a monthly statistical safety report.
o   To evaluate and review the reports and records (i.e. identified deficiencies to be rectified immediately).
Results
✓   Minimization in transport (railway) fatality ✓   General public acceptance and awareness ✓   No man hour lost time injuries.

4.2. Roadmaps on Vital Sustainability Criteria/Elements (VSC) for Nigerian transport infrastructure projects (Railways)

This section presents the roadmap on vital criteria for Nigerian transport infrastructure projects encapsulate the 13 vital sustainability challenging issues. Each roadmap is preceded with the decision-making model before recommendations are presented (Oraegbune et al., 2015; Oraegbune, 2015).

4.3. Vital sustainability challenges issues

This section discusses the roadmaps proposed for sustainable transport infrastructure projects. It encapsulates the 13 vital sustainability challenging issues above. Each roadmap is proceeded with the decision making logic or model (Oraegbune, 2015).

Issue 1:   Air pollution

Issue 2:   Contract type and project administration

Issue 3:   Responsibility of community and society by the government or client in Nigeria

Issue 4:   Participation of the community and general consultation in Nigeria environment

Issue 5:   Construction noise and vibration

Issue 6:   Engineering/Technical Performance and material innovation

Issue 7:   Health and Safety plan for the project workers

Issue 8:   Inter-satellite towns and modality of transport in Nigeria.

Issue 9:   Maintaining contract and project specifications in Nigeria

Issue 10:   Railwayuser's safety in the construction sites

Issue 11:   Soil erosionand sedimentation control at the project sites.

Issue 12:   Solidwaste management, reuse and recycling in Nigeria

Issue 13:   Whole-life cost/life cycle cost in Nigeria

5. Conclusion and recommendations

This study dealt with light rail mass transit project (transportation infrastructure sustainability) issues and sustainability elements identified which include: Railway users safety in the construction sites, health and safety plan for the project workers, engineering/technical performance and material innovation, air pollution, construction noise and vibration, whole life cost/life cycle cost in Nigeria etc. The study also proposed roadmap and decision-making models to address the vital challenging issues in railway infrastructure in Nigeria. The decision-making models discussed in Oraegbune et al. (2015) and Oraegbune (2015) study could form a base for the solid foundation in the wider context of sustainability assessment and organizational knowledge management in railway infrastructure projects in Nigeria. The study in addition recommended integration and institutionalization of sustainability best practices (design, construction and operation in our transport infrastructure projects).

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