Achieving Sustainability in Transportation Infrastructure Projects (Roads): A Nigeria Case Study

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Abstract: This paper reports a research that investigated various challenging issues militate against successful delivery of sustainable transportation infrastructure projects in Nigeria focusing on roads. The case study method was used. In the research and several sources were used for data collection. These sources for primary data include case study based semi-structured, while secondary data sources projects, contract documents, industry publications and government reports. The research findings were used to formulate matrix of 13 vital challenging issues, and the development of a framework/roadmap and models for sustainable road infrastructure projects. The paper discusses the findings and makes some recommendations for transportation infrastructure projects sustainability.

Keywords: Case study projects, case study research method, Sustainability, transportation infrastructure.

1. INTRODUCTION

Countries all over the world are faced with various challenging issues that militate against sustainable infrastructure project delivery. Thus, infrastructure sustainability remains a perennial problem and one of the global challenges that cut across different sectors. The problems and challenging issues manifest in different forms. Identification and unambiguous understanding of the militating issues are prerequisites for proffering solutions to the problems. Several research methods can be used for such investigation. One of the methods is case study, which has been applied in social science research. Scholars have identified the potency of case study method in scientific inquiries in various disciplines including engineering.

This paper discusses research that investigated issues and problems that militate successful delivery of sustainable infrastructure projects. It uses Nigeria as a case study with a focus on transportation projects (roads). The paper is structured as follows. It gives a brief overview of case study research method and highlights its salient features. This is followed by a discussion of case study selection and structure in which specific features of the case study projects investigated are highlighted. The paper then discusses the application of the case study method in the research in specific appropriate levels of details. Thereafter, the paper discusses the results which include; the development of matrix of vital sustainability issues for transportation projects, and a roadmap on the vital sustainability issues identified in the research. The paper then juxtaposes both the matrix and roadmap to proffer solutions and make recommendations for successful delivery of sustainable road transportation infrastructure projects. The ensuing section gives a brief review of case study research method.

2. REVIEW OF CASE STUDY RESEARCH

There are several ontological and epistemological dimensions of case study research. [1], defined case studies as "…analysis of persons, events decisions, periods, projects, policies, institutions or other systems that are studied holistically by one more methods". However, a major requirement is that the case that is the subject of the inquiry will be an instance of a class of phenomena that provides an analytical framework - an object within which the study is conducted and which the case illuminates and explicates. [2], 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 [3]. There are other similar dentitions [4-6]. There are several advantages of case study. These 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. However, one major disadvantage of case study is that the results mighty not be generalized.

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In the specific context of the research reported in this paper, the case study projects set the foundation upon which sustainability roadmaps for Nigerian transportation infrastructure projects (roads) was established. The data was primarily qualitative as the study, at this stage sought to understand the measures taken and procedures involved at project level to address the problems that impinge on transportation infrastructure sustainability. For this research, the exploratory approach of the case was used to investigate specific problems and seek for solutions. The case studies specifically answered the following research questions.

(i) In real-life practice, apart from the research problems identified through the previous studies, what are the problems that hinder achieving sustainability infrastructure projects (roads) in Nigeria?

(ii) How can those problems be addressed and what procedures or processes are needed in order to achieve sustainability in transportation infrastructure projects (roads) in Nigeria.

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

3. CASE STUDY SELECTIONS AND STRUCTURE

An average or typical case neither provides the best information, nor clarifies lines of history and causation. The choice of the case study greatly affects the results of the study. [7, 8, 9], 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 data. Thus the process of selecting cases or case projects must be undertaken in a way that maximizes what can be learned in the period of time available for the study [10, 8, 11, 12]. In the context of the case study projects selected for the study, certain criteria were set-up to ensure a degree of suitability. To ensure that meaningful data 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 transportation infrastructure project with recognized achievements by the industry or organization/stakeholders.

(ii) It has to consider or bear sustainability direction or focus as the project targets.

(iii) It has to be a completed or ongoing sustainability-driven project.

(iv) The case project site/sites should be in Nigeria. Projects chosen are based on their visibility/high profile or quality and success incorporating sustainable best practice in transportation infrastructure.

Table **1** illustrates how a selected case project in the study satisfies the basket of selected criteria. The case project is 67km 10-Lane Lagos – Badagry Expressway. See Table **1** and Figures **1a** and **1b**.

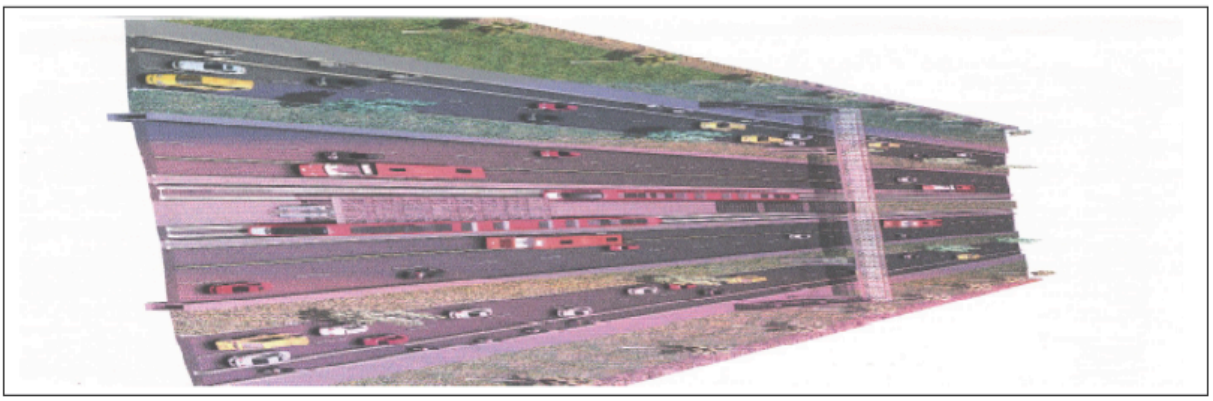
See Figure **1a** and **1b** below: Lagos–Badagary 10 Lane Expressways with incorporated sustainability elements.

3.1. Project History

The Lagos–Badagry dual carriage way is 67km long. It was originally constructed in 1974 by the Lagos State Government and it was later taken over by the Federal Government in 1977 to serve as the Nigerian

Table 1: Case Study Project Criteria (Source: [10])

S/No.	Case Project Criterion	Remarks on case project: Lagos-Badagry 10 Lane Expressways
1.	The case project should be a successful transportation infrastructure project with recognized achievements by the organizational industry.	Project is ongoing with more than fifty percent (50%) completed with high quality control.
2.	Bear a sustainability direction or agenda as its project goals	The project design and contract document addresses various sustainable indicators and sustainable construction including best practices.
3.	It might have been completed or on going.	The project has different work packages, segmented into Lots: 1, 2 and 3. Each, work package is further subdivided into A, B and C and each is at least about 50% completed.
4.	The case project site/sites should be in Nigeria.	Project covered Lagos–Badagry Expressways 67km.



a

Figure 1: a: Prototype of Lagos–Badagry 10 Lane Expressways. **b:** Lagos–Badagry 10 Lane Expressways with wooden/concrete sleepers (Work in progress) below.

Segment of West Africa sub- regional link road. It extends to Seme border and covers a substantial distance inside Benin Republic.

3.2. Socio-Economic Importance

In view of the determination of the present Administration of Governor Babatunde Raji Fashola (2007–2015) to positively transform and/or affect the living conditions of Lagos state residents. The reconstruction/expansion of Lagos–Badagry dual carriage way was conceived as a solution to the physical development and huge increase in population along the corridor over a period of thirty four years. However, its use without adequate maintenance, resulted in severe structural deterioration and inadequacy of road lanes. These cumulatively led to the prevailing chaotic traffic situation on the route.

3.3. Vital Components of the Highway

Some of the vital milestones and major events achieved and/or to be achieved by this project are:

- 4 Nos. of dedicated toll lanes
- 4 Nos. of service lanes
- 2 Nos. of Bus Rapid Transit (BRT) lanes
- 23 Nos. of BRT Bus stop
- 7 Nos. of Toll Link interchanges
- 5 Nos. of Bridges
- 14 Nos. of Deck-on-piles
- 14 Nos. of flyovers
- 21 Nos. of pedestrian bridges
- 72 Nos. of on-line toll booths
- 17 Nos. of off-line toll booths
- 10 Nos. of 10 main carriage ways.

4. CASE STUDY METHOD

The case studies involved two major data sources. These include semi- structured interviews and secondary sources including review of project and 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 clarity previously collected information [8, 13].

In this case, semi-structured interviews were employed to probe into the problems and to identify solutions or answers. The importance of a case study is that it tries to enlighten a decision or set of decision. In this research, it elicited several aspects including: why they were taken, how they were implemented and the results obtained [14]. Therefore, the major focus of this study was to derive decisions after probing into each vital challenge of sustainability. These decisions served to enlighten the way in which each challenge or problem could be solved. In order to deduct useful data/information which directly contributed to roadmaps formulation at a later stage for each challenge or problem, the interviewees were requested to answer the following questions based on their project experience either in Lagos–Badagry project or elsewhere.

(i) What are the factors causing problems?

(ii) What are the problems arising from the challenging issues?

(iii) How can the problems be solved?

(iv) What are the end result of the action taken?

Since, they are exemplary and on going projects, their implementation measures, represents the best practices. In addition, the project has incorporated strategies to address the vital challenges.

Nevertheless, the selection was made using most distinctive measures of the project as input in identifying or assessing decision-making patterns. The data collected from the case underpinned the development of sustainability roadmaps and identification of vital sustainability criteria for Nigerian transportation infrastructure road projects.

5.1. Importance of the Case Projects to the Research

Because of the composite nature and difficulties, the case project was carefully looked at. This however opened various challenges including evolving strategies for the problem resolution. The study identified 13 vital sustainability challenging issues. This logically led to the development of framework for assessment of transportation projects [10].

Table **2** summarizes project level specifics (constituents and features) upon which the vital criteria could be based on and meaningfully examined.

Table 2: Linking 13 Vital Sustainability Challenging Issues with Project–Level Specifics

S/No.	Project Level Specific	Vital Sustainability Challenging Issues Involved in the Case Projects
(i)	Project targeted to mitigate high traffic congestions and delays in Lagos-Badagary highway.	• Community and Society responsibility by the government or client. • Inter-regional and modality of transport.
(ii)	Vast financial commitment identified in the project.	• Whole life cost/Life cycle cost
(iii)	Community relationship and business activity.	• Community participation and general consultation.
(iv)	Consultation with urban planning, laws and regulation authorities.	• Maintaining contract project specifications in Nigeria environment.
(v)	Construction activities/processes and environmental challenging issues or matters in the case project in Nigeria.	• Soil erosion control and sedimentation. • Construction noise and vibration. • Solid waste management re-use and recycling. • Air quality/pollution in construction environment. • Road users safety in the construction site. • Engineering/Technical performance and material innovation. • Health and safety plan for the project workers. • Contract type and project administration.

Table 3: Showing the List of (5) Interviewees Who Participated in the Case Project Studies

S/No.	Interviewee Position on Lagos–Badagary Project	Interview Dates	Interview Location	Average Interview Duration (mins)
1.	Technical Director (Structures)	15-06-2012	Lagos	45
2.	Project Manager (Civil/Highways)	18-06-2012	Lagos	45
3.	Senior Civil Engineer	18-06-2012	Lagos	45
4.	E. I. A officer (Environmental regulator/Officer)	18-06-2012	Lagos	45
5.	Public relation manager (Community)	18-06-2012	Lagos	45

However, several sustainability criteria standards and sustainable construction best practices had been enforced in the case project. They were consistently assessed and documented for use as benchmarks for good practice in Nigeria construction industry/ environment. The next section highlights details of the interview process.

5.2. Interviewees Profiles

Table **3** gives demographic summaries of the interviews. The interviewees held different positions in various organizations/departments. They also played different roles in the case project. such as construction/operation, design and survey, environmental planning, public relation and community development departments etc. The broad range and extent of their functions and the experiences on the project contributed to enrich the case study findings and provided holistic views from different project dimensions. On the average the time of interviews lasted for about 45 minutes each.

5.3. Method Used in Case Investigation Questions

Figure **2** shows process used to elicit the sustainability goals and challenges were addressed in practice. This resulted in the formulation of decision-making model and roadmap for sustainable transportation infrastructure projects. Before the interviews, each interviewee 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. 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 order to obtain contextual data and information for the verification or confirmation of decision-making rule for the answer criteria in Nigeria environment.

6. RESULTS AND DISCUSSION

This section discusses the best practice solution for the vital challenging issues, which were identified from exemplary case projects. It also presents the findings from case study in the form of "roadmap on vital sustainability criteria for Nigerian transport infrastructure projects in road" as the final outcome of the research.

6.1. Matrix of Vital Sustainability Challenging Issues for Transportation Infrastructure Project (Road)

There roadmap consists of are two components. These include;

(i) A matrix of vital challenging issues in transportation sustainability and

(ii) The roadmaps themselves.

As stated previously no challenging issues can be treated individually or separately. The main aim of the matrix presented in this section is for its uses as reference tool by project stakeholders to enable them address sustainability more appropriately. Table **4** shows the matrix.

6.2. Roadmaps on Vital Sustainability Criteria (VSC) for Nigerian Transport Infrastructure Projects (Roads)

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. Figure **3** shows the roadmap model.

7. CONCLUSION AND RECOMMENDATION

This paper discussed transportation infrastructure sustainability challenging issues. Some of the issues

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	2.	What are the problems arising from the challenging issue.		Distinctive decision-making rule formula.
3.	Project Whole-life cost/life cycle cost	3	How can these problems be solved?		↓ Road map formulation
4.	Community participation and General consultation	4.	What are the results/findings from the action taken.		
5.	Maintaining contract and project specifications				
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.				

Figure 2: Infrastructure knowledge acquisition.

Table 4: 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 pollution/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.				√			√			√					
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.	Road and 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.		√				√									

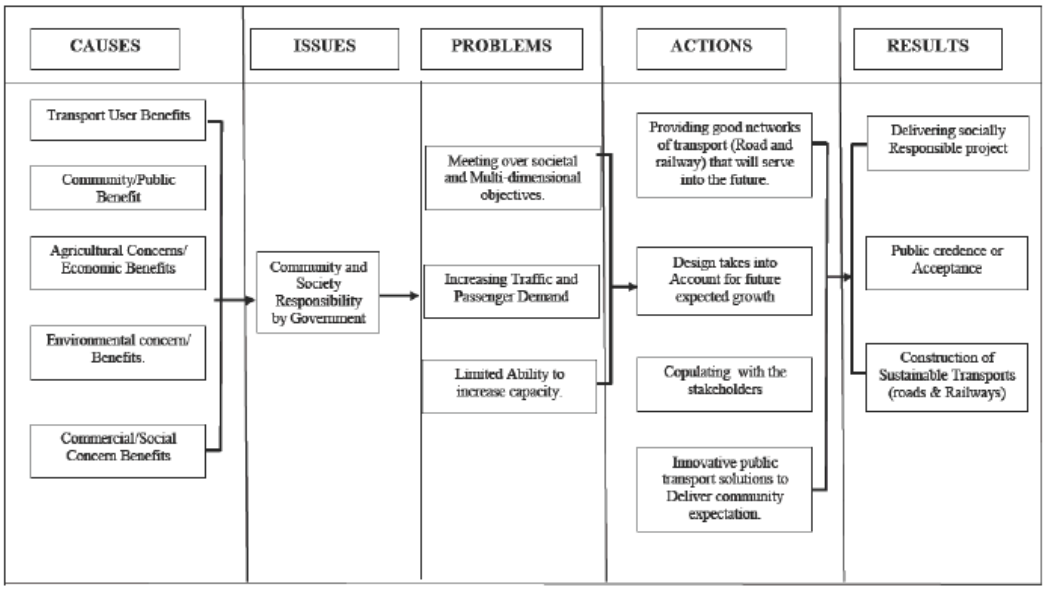


Figure 3: Decision-making model for issue: community and society responsibility by the government or client in Nigeria environment.

and sustainability criteria identified include: air pollution, contract type, community and society, solid and liquid waste management etc. It proposed roadmap and decision-making models to address the identified vital sustainability challenging issues in transportation infrastructure in Nigeria. The decision making models discussed in this paper could form a basis for the solid foundation in the wider context of sustainability appraisal and organizational knowledge management in transport infrastructure projects. The following recommendations are given for successful delivery of sustainable infrastructure projects.

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