Innovations

Assessing the Environmental Sustainability of Railway Transportation in Nigeria

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Abstract: *The strategic importance of a nation's transport system to the country's economic growth and the increasing threat that climate change poses to the world necessitates an environmental sustainability analysis of the double standard gauge railway transportation network in the Nigeria. Until recently commuting between Nigeria's major cities, Lagos and Ibadan lacked a functioning rail system however following the revitalizations of rail transportation within these cities, the need arouse to assess the environmental sustainability of the rail transportation within the country. Previous researches on rail sustainability in Nigeria were done using secondary data but this research, adopted a mixed methods research approach to justify the formulated hypothesis that there is no significant difference in environmental sustainability of rail transport across selected rail stations. This was validated using One-way ANOVA and descriptive statistics. The result revealed the mean values of terminal locations, such that Ibadan had the highest value of (M=18.78, SD= 3.49), Lagos, (M=18.21, SD= 3.32) and Abeokuta (16.31, SD=3.65). The ANOVA indicated that railway terminal location had a significant influence on environmental sustainability with [F (2, 388) = 9.10, p < .01] hence confirmed the observed variance in derived mean values. Further Scheffe Post Hoc test showed the mean differences between Abeokuta and Ibadan at (MD=2.47, p < .05) and Abeokuta and Lagos at (MD=1.90, p < .05) were significant however, the mean difference between Ibadan and Lagos was not significant (MD =0.57, p > .05). Result showed that there was a significant difference in the indices of environmental sustainability across the stations [F (2, 388) = 9.10, p < .01] hence the formulated hypothesis is rejected. This study recommended the adoption of a holistic environmental sustainability policy in the construction and management of the ongoing railway revitalization project in the country. It is also advised that the operational efficiency of the rail system should be in line with the best global practices to maintain its competitiveness.*

Keywords: *Railway, Transport, Sustainability, Environmental, Double standard gauge, Key informant interview.*

1. Introduction

Seamless mobility is considered a key factor in the development of any region as various scholars in the past have given empirical evidence of the undeniable linkage of transport to the development of the economy, political and social future of any nation, [7, and 21]. The positive effect of transport in the development of economies were empirically submitted in the works of [5, 11, 12, and 25] to mention a

few. Transport is defined as the movement of person, goods and information from one place to another for higher place, value and preference by [25]. Despite the established positive influence of transport on regional and national development, it also generates negative impacts on societal and human wellness as indicated by [13].

These transport negative externalities are expendable to a holistic societal growth and hampers environmental quality through the unmitigated remittance of Sulphur dioxides (SO2) into the atmosphere. Indubitably, both public and private transport sectors are guilty of wholesome remittance of environmental pollutants into air, [22] Berck and Bruckner in [16] indicated that an emission factor of e = 554.375 for private cars and e = 288.275 for public transport (measured in Kg, Carbon dioxide (CO2) equivalent per megawatt- hour are clear indicators that both means of travel contributes to environmental pollution. It is also an incontrovertible fact that the transport sector has become a prominent contributor to the overall pollution (carbon emission) which accounts for approximately one-quarter of global CO2 emission, [27]. This is as a result of growth in urbanization drive from the late nineteenth century which resulted in increment in urban travel demand across the world [4]. With the economic boom of the late twentieth century and the attendant proliferation of motorized transport led by the Fordist revolution automobile production, the gradual emergence of negative externalities of environmental pollution began in most cities globally [3, 4].

The strategic importance of a nation's transport system to the country's economic growth and the increasing threat that climate change poses to the world necessitates an environmental sustainability analysis of the double standard gauge railway transportation network in the Nigeria. Owing also to the fact that cities around the world are daily seeking to implement more sustainable transport system to mitigate the known transport negative externalities. In Nigeria, railway transportation until recent times suffered crisis and account for insignificant proportion of value added in the transportation sector, [10]however in the last three years, deliberate attempt has been made by the government to introduce double standard gauge rail on the newly constructed Lagos-Ibadan rail tracks for passenger and cargo movement at the intercity level.

Railways play major role in the decarbonisation of the economy with its environmental, social and economic advantages as such result in the preservation of the planet. This is the position of International Labour Organisation where they stated that medium and high speed rails are viable options for intercity travels against cars which is noted for increasing congestion and pollution. This research therefore contribute to an existing body of literature that is debating the environmental sustainability of rail transportation with focus on the Lagos-Ibadan axis of the south-western part of the country, Nigeria.[1] summated that Nigeria is currently tottering towards the greatest environmental crisis on how to progressively sustain her over 170millions people in a habitable sustainable environment and that high demand of combustion fossil fuels like oil and gas and carbon has significantly contributed to climate change. The scholar also indicated according to a study commissioned by World Bank in (2007) that Nigeria accounts for roughly one-sixth of the worldwide gas flaring which in turn spews some 400 million tons of carbon dioxide into the atmosphere. Based on the ongoing, this research asked a question to determine the environmental sustainability of rail transportation in Nigeria with reference to the South western region.

2. Literature Review

Sustainability is the capacity to endure as well as survive by [15]. Achieving sustainability will enable the earth to continue to support human life. The United Nations (UN) Stockholm conference on the human

environment in 1992 marked the first significant international meeting on how human activities were harming the environment and putting humans at risk. The UN conference on the Environment and Development (UNCED) also known as the earth summit also held in 1992 in Rio de Janerio, Brazil adapted agenda 21 which calls for reorienting policy towards sustainability. The agenda 21 was a statement of principles by more than 178 governments and a comprehensive plan action to be adapted globally, nationally and locally by organization of UN system and government in areas in which humans impact the environment. The commission on sustainable development (CSD) was then established in 1992 to ensure effective follow up of UNCED. The world summit on sustainable development (WSSD) in Johannesburg, 2002, re-affirmed implementation of Agenda 21, UNESCO National Education Support Strategy, UNESS.

Various studies have summated that rail transport play a significant role in transport sustainability [18, 26]. A sustainable transport is described as transportation where the beneficiaries pay their full social costs including those that should be paid for by future generation while sustainable transport according to, [8] is defined as transport that meets the current transport and mobility needs without compromising the ability of future generation to meet those needs. The railway is globally termed an environmentally friendly mode of travel which encourages green transport, green economy and smart cities. Investments on transport infrastructures have positive impacts both for gross domestic product (GDP) and for job generation. Over the years, many countries have successfully adopted railway for their intra and intercity journeys whilst taking measures to ensure the efficiency and sustainability of the sector. Railway transport has been found to be an efficient and environmentally sound means of intra and inter city transportation means that can move large number of people quickly and clean over short and long distances, [6]. The world summit on sustainable development (WSSD) of September, 2002 in South Africa commended the environmental friendliness of rail transport in mass movement of commuters in cities as well as minimization of urban transportation externalities, [19].

A study on the sustainability of railway investment using triangulation method was conducted by [20] in their bid to develop practical organisational tools for measuring sustainability. They employed the Structural Equation Model (SEM) and Correlation for the purpose. A lacuna howbeit observed in their results showed that the users of rail services were left un-researched hence this research assessed the environmental sustainability of Lagos-Ibadan standard gauge rail through the rail user using One-way ANOVA.Research on the efficiency of rail transport as a sustainable mode of transportation was carried out by [2] in Nigeria using the rail mass transit system in Lagos. He concluded that not much researches have been done on railway sustainability in Nigeria. Furthermore, the trend towards increased use of personal vehicles presents numerous challenges such as noise and air pollution. Pollution is a topic of intense researches at all level because of the increased level of anthropogenic activities and climate changes. Air and noise pollution in the urban centre has rapidly increased due to high population density, increased number of motor vehicles, use of fuels with poor environmental performance, poorly maintained transportation system and above all, ineffective environmental regulation and policies, [17] therefore efforts should be geared towards finding measures to mitigate these observed externalities so as to reduce ozone layer depletion. The revival and the modernization of rail transportation between Nigeria major cities through a world-class, double standard gauge rail therefore provide an imperative to assess the environmental sustainability rail transportation in the country and this studyintends to serve as guide to policy makers in the areas of transport environmental sustainability benchmark and evaluation.

3. Study Area

The construction of the Lagos-Ibadan rail tracks commenced in 2017 and was completed in 2021 after Ajaokuta- Warri in 2020 by Muhammadu Buhari's led administration in Nigeria. The Lagos- Ibadan

standard gauge is the second to be constructed. The modern rail commenced commercial activities on the 10th day of June 2021 on a double-track standard gauge rail with twenty-four (24) coaches. The train terminals along the corridor include Obafemi Awolowo terminals in Moniya, Sam Olagoke Akintola terminals in Omi-Adio, Aremo Segun Osoba terminals in Olodo, Prof. Wole Soyinka terminals in Abeokuta, Funmilayo Ransome-Kuti terminals in Papalantoro, Prof. Yemi Osinbajo terminals in Kajola, Lateef Jakande terminals in Agbado, Babatunde Fashola station at Agege and Mobolaji Johnson terminals in Yaba, indicating that the track cuts across three south-western states namely, Lagos, Ogun and Oyo states in Nigeria. Six (6) out of the nine (9) terminals are presently functional. Data from the NRC indicates that ninety per cent (90%) of the passenger volume that utilizes the transit system uses only three of these stations. Therefore the scope of study span across Mobolaji Johnson terminals in Lagos state, Prof. Wole Soyinka terminals in Ogun state and Obafemi Awolowo terminals in Oyo state.

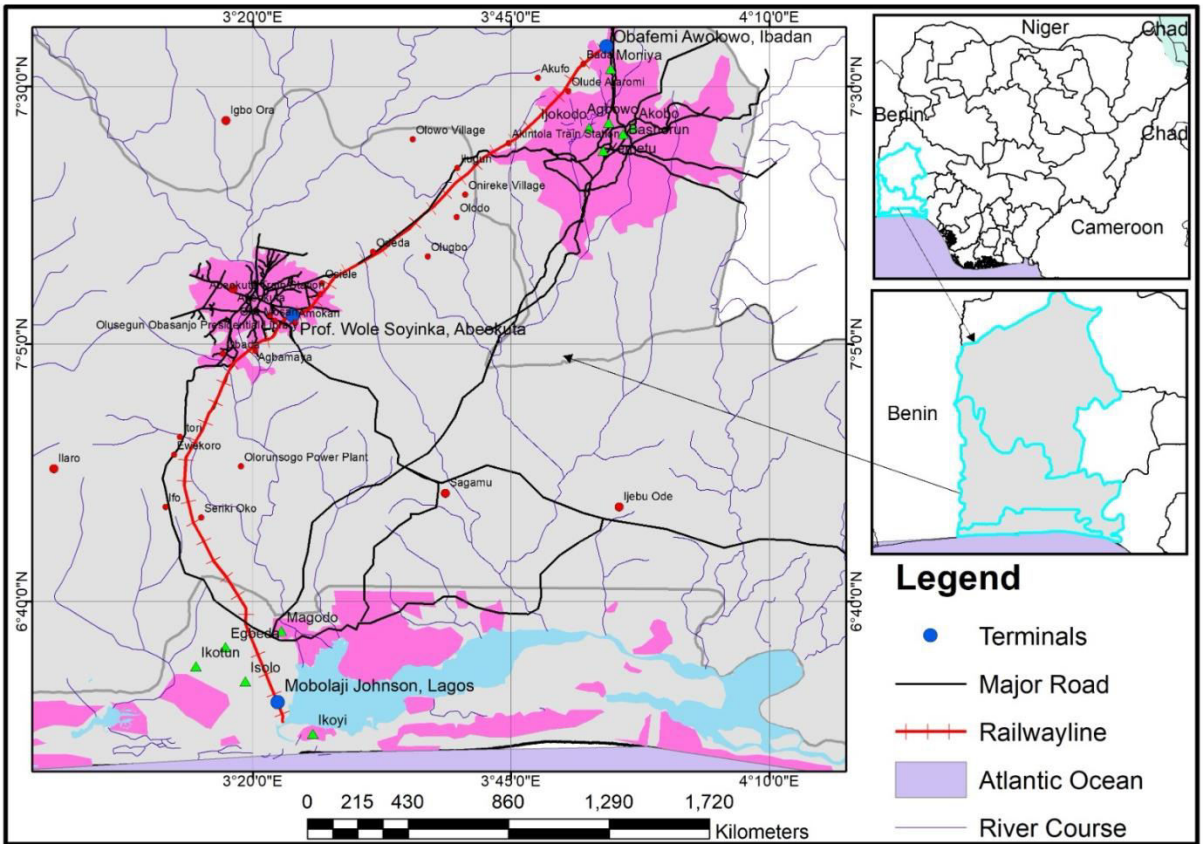

Figure 1.1 Rail Tracks Indicating Major Selected Terminals on the Lagos- Ibadan Modern Rail Corridor

Source: Cooperative Information Network (COPINE), 2023

4. Methodology:

The methodological approach for the study employed mixed methods. Data for the study were sourced through primary and secondary sources. The primary data involved the administering of predetermined set of questionnaires and direct observations to obtain information on rail passengers' perception of the environmental sustainability of the rail operations. Secondary information were sourced from reliable internet source, textbooks, journals and articles. The sampling technique employed in this study is multistage. Stratified techniques was adopted to delineate the rail terminals along the corridor into states.

Systematic sampling techniques used to identify terminal from which respondents were selected from, based on the level of activities currently on-going at the terminals as not all the terminals along the route are presently operational. The random technique was used in administering the questionnaire to passengers as they sit at the terminals.

Available data showed that a total of Twelve thousand, four hundred and seventy-six (12,476) passengers travelled along the Lagos- Ibadan rail corridor on weekly basis (NRC, 2022). Therefore, average monthly passenger is calculated as *12,476 X 4 = 49,904* (Forty-nine thousand, nine hundred and four). Estimated average six months passengers = *49,904 X 6 = 299,424* (Two hundred and ninety-nine thousand, four hundred and twenty four) being the sample population. To this end, the sample size was determined using Taro Yarmane, (1967) sampling formula which is statistically represented as,$n = \frac{N}{1+ N\{e\}^2}$

Where, n= sample size
N= Population
e= the precision level (0.05)
Therefore: $n = \frac{299,424}{1+ 299,424\{0.05\}^2} n = \frac{299,424}{1+ 299,424\{0.0025)}$

$$n = \frac{299,424}{1 + 748.56} n = \frac{299,424}{749.56}$$

n= 399.466, equivalent **400.**

Questionnaires were administered to rail passengers based on the level of activity at each location.

Table 1: Distribution of questionnaire by terminal location Size

S/N	Name of Station	Number of Passenger Sampled (N)	Percentage %
1	Mobolaji Johnson Yaba	224	56
2	Obafemi Awolowo, Moniya	128	*32*
3	Prof Wole Soyinka Abeokuta	48	*12*
	Total	***400`***	***100***

Source: Researcher's Field Survey 2022.

4.2 Scale Development

The objectives of the study to examine the environmental sustainability of rail services across selected sites was analysed using inferential tools of Mean/ standard deviation and One-Way ANOVA cum percentage tables to show the influences of sites on environmental sustainability. Scheffe Post Hoc test was also conducted to validate the mean difference among various sites on environmental sustainability. One-way ANOVA is statically written as:

$$\frac{MST}{MSE}, \text{such that}$$

$MST = \sum_{i=11}^{k} \frac{(T\dot{\iota}^2/n\dot{\iota} - G^2/n)}{K-1}$,…… ……Eqn 1

$MSE = \frac{\Sigma_{i=1}^{k} \Sigma_{j=i}^{ni} \int_{ij}^{2} - \Sigma_{i-1}^{k} (T\dot{\iota}^2/_{n\dot{\iota}})}{n-k}$,…… Eqn 2, where

F = the variance ratio for the overall test

MST = Mean square

MSE = Mean square due to error (within groups, residual mean square0

Y_{ij} = Observation

Tí = Group total

Ní = Number in group

N = Total number of observation

G = Grand total of all observation

Hypothesis:H_0: There is no significant difference in the environmental sustainability of rail transportation across selected sites.

5. Results and Discussion

Table 2: Mean and Standard Deviation Showing the Differences in Environmental Sustainability across Sites

Dependent Factors	Sites	N	Mean	Std. Deviation
Environmental Sustainability	Abeokuta	48	16.31	3.65
	Ibadan	126	18.78	3.49
	Lagos	217	18.21	3.32
	Total	391	18.16	3.49

Source: Researcher's Field Survey 2022.

The influences of rail sites on environmental sustainability of rail transportation were tested. Descriptive statistics (Mean and standard deviation) was first conducted to explain the rail site with the highest level of sustainability. Based on the findings among passengers, it was noted in Table 2 that Ibadan rail site had the highest level of environmental sustainability (M=18.78, SD= 3.49). This was followed closely by the environmental sustainability level in Lagos (M=18.21, SD= 3.32), while the least was that of Abeokuta with a value of (M 16.31, SD=3.65). In order to confirm the observed variances, the One-way ANOVA was conducted and presented in Table 3

Table 3: One-Way ANOVA Showing the Influence of Sites on Sustainability

Dependent Factors	Sources	SS	df	MS	F	P
Environmental Sustainability	Between Groups	212.41	2	106.21	9.10	< .01
	Within Groups	4529.76	388	11.68		
	Total	4742.17	390			

Source: Researcher's Field Survey 2022.

The result in table 1.3 indicated that railway terminal location had a significant influence on environmental sustainability [F (2, 388) = 9.10, p < .01]. This implied that the site where the rail

terminalsis located had influence on the environmental sustainability. In other words, the observed mean values in Table 2 were confirmed and thus, Ibadan had the highest environmental sustainability, while the least was Abeokuta. Further test was conducted since there are more than 2 sites and there is need to understand the mean difference that led to the significant influence of rail site on environmental sustainability. Post hoc Scheffe test was used and presented in Table 4

Table 4: Scheffe Post Hoc Test Showing the Mean Differences between Sites on Environmental Sustainability

	Sites	N	1	2	3
Environmental Sustainability	1. Abeokuta	48	-		
	2. Ibadan	126	2.47*	-	
	3. Lagos	217	1.90*	.57	-

Source: Source: Researcher's Field Survey 2022.

Table 4 shows that the mean difference between Abeokuta and Ibadan was significant (MD=2.47, $p < .05$). Also, the mean difference between Abeokuta and Lagos was significant (MD=1.90, $p < .05$). However, the mean difference between Ibadan and Lagos was not significant (MD =0.57, $p > .05$). This implied that the significant influence of rail site on environmental sustainability was attributed to the significant difference identified. The finding negates the formulated H_0 that there is no significant difference in the environmental sustainability of rail services across selected sites. The environmental sustainability of rail services across selected site was also done using the descriptive analytical tools to measure variables such as" Responder's perception on traffic quality through traffic noise and air disturbances because the key indicator of environmental sustainability is the level of green gas emission per kilometre. This is to justify the outcome of the hypothesis test earlier conducted

Table 5: Response on the Number of Population Exposed to Traffic Noise

Factors	**Options**	**Abeokuta**		**Ibadan**		**Lagos**		**Total**	
		F	**%**	**F**	**%**	**F**	**%**	**F**	**%**
Are you bothered by noise from the train?	Yes	6	12.5	19	15.1	24	11.1	49	12.5
	No	38	79.2	93	73.8	176	81.1	307	78.5
	Indifferent	4	8.3	14	11.1	17	7.8	35	9.0
	Total	**48**	**100**	**126**	**100**	**217**	**100**	**391**	**100**
Extent to which noise pollution is worrisome	Not Applicable	43	89.6	107	84.9	184	84.8	334	85.4
	Very great extent	2	4.2	4	3.2	10	4.6	16	4.1
	Great extent	2	4.2	6	4.8	9	4.1	17	4.3
	Low extent	0	0.0	5	4.0	13	6.0	18	4.6
	Very low extent	1	2.1	4	3.2	1	0.5	6	1.5
	Total	**48**	**100**	**126**	**100**	**217**	**100**	**391**	**100**

Source: Source: Researcher's Field Survey 2022.

An objective of the transport environmental sustainability goal is to minimize noise. Transport environmental impacts include various types of air, noise and water pollution, depletion of non-renewable resources, landscape degradation including pavement or damage to ecologically productive lands, habitat fragmentation or wildlife displacement while constructing the travel paths, [14, 16, 23, 24]

indicated that less noise pollution is required for a system to be sustainable. A study of table 4.3.2 above showed that 87.5% of respondents said they were not bothered by noise generated from the train. This therefore indicated that noise pollution form the double standard gauge is less thereby accepted as an environmentally sustainable transport.

Table 6: Response on the Number of Population Exposed to Air Pollution

Factors	Options	Abeokuta		Ibadan		Lagos		Total	
		F	%	F	%	F	%	F	%
Bothered by train air pollution	Yes	5	10.4	23	18.3	27	12.4	55	14.1
	No	43	89.6	103	81.7	190	87.6	336	85.9
	Total	48	100	126	100	217	100	391	100
Extent to which air pollution is worrisome	Not Applicable	43	89.6	107	84.9	182	83.9	332	84.9
	Very great extent	2	4.2	7	5.6	14	6.5	23	5.9
	Great extent	0	0.0	6	4.8	12	5.5	18	4.6
	Low extent	2	4.2	3	2.4	7	3.2	12	3.1
	Very low extent	1	2.1	3	2.4	2	0.9	6	1.5
	Total	48	100	126	100	217	100	391	100

Source: Source: Researcher's Field Survey 2022.

The release of pollutants into air is often considered as the most negative environmental impacts of transport. This emission is classified as having mainly global impacts, such as greenhouse gases and local impacts known as air pollutants. The transport environmental sustainability indicators provide early warning to prevent environmental damage. Sustainability requires limiting motorized trips to protect habitat and fossil fuel use to minimize greenhouse gases. The directional guide on environmental indices shows that less of the specified indicator is better, [24]. An analysis of the number of rail passengers' exposed to air pollution is presented in table 6 above, result showed that the standard gauge train does not generate high air pollution which the narrow gauge trains are noted for. Available data from survey stated that 85.9% of total respondent were not bothered by the rate of emission from the train. The train is therefore considered environmentally sustainable.

6. Implication for Managerial Decision Making

Based on the outcome of this finding, the study recommended the adoption of a holistic environmental sustainability policy in the construction and management of the on going railway revitalization project in the country. It is also advised that the operational efficiency of the rail system should be in line with the best global practices to maintain its competitiveness. Sustainable practises such as an efficient waste management be employed at the terminals and on board the train to manage the waste generated on board and at terminal be employed.

7. Conclusion

Findings from the study revealed that terminal locations had significant influence on the environmental sustainability of rail transportation though the level of variance differs across the terminal. The witnessed variance in the environmental sustainability can be owing to several factors such as climatic condition, human population, economic activities, waste management, technological innovation to mention a few. Abeokuta terminal (Prof. W. Soyinka terminal) had the lowest level of environmental sustainability. This outcome is linked to the possible level of economic activity in the area and human population density since this location has the lowest number of people based on the rate of passenger movement derived from the Nigeria railway corporation. Also based on landmass, Lagos state has the lowest volume of land as shown in the Nigeria map but the state has high human population density more than Abeokuta hence

the result of the finding is justified. It is hereby concluded that the usage of renewable materials, to minimize the train operation negative impact on the environment should also be employed while also working towards the eventual adoption of gas powered rail on the Lagos-Ibadan rail corridor to minimally reduce the generated air pollutant from the rail services. The study has contributed to knowledge by providing an empirical evidence on the environmental sustainability status of the Lagos-Ibadan modern rail and adds to the existing body of knowledge on global rail transportation and sustainability.

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