Environmental Implications of Transport Infrastructural Development in Warri Metropolis

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Abstract

This study investigated the effects of transport infrastructure on the environment of Warri Metropolis, Delta State, Nigeria. The purpose of the study was to determine the nature of transport infrastructure in Warri metropolis, evaluate the environmental impacts, analyse the available mitigation measures and suggest mitigation measures for the sustainable solutions. A field survey research design was used and structured questionnaires were used to collect data from a sample of 400 respondents in the three existing strata (Udu, Uvwie and Warri South Local Government Areas) with simple random sampling. Descriptive statistics and multiple correlation analysis were used to analyse the 384 valid responses obtained using the SPSS software. It was found that there are various kinds of transport infrastructures like road, rail, port, airport, pipeline etc. in the study area with the highest infrastructure being road. The study found that there was a significant relationship between transport infrastructure and environmental conditions, where the total value of the environmental variations explained by transport infrastructure was 55.2% ($R = 0.743$). The most significant contributor was road networks ($\beta = 0.412$) followed by port/waterways and pipelines. The study also showed a very strong relationship between mitigation strategies and environmental quality ($R = 0.991$; $R^2 = 0.982$), meaning that the implementation of strategies like environmental law enforcement, use of non-motorized transport, noise control and the creation of green spaces have a significant impact on improving the environment. The study suggests that environmental regulations must be implemented, eco-friendly transportation systems must be promoted, public awareness must be raised and environmental issues must be incorporated in the transport planning process, all of which are necessary for the realization of sustainable urban development.

Keywords: Transport Infrastructure; Development; Impact; Environment; Warri Metropolis

1.0. Introduction

The growing importance of sustainable infrastructure development is driven by its comprehensive impact on environmental quality, economic development and social welfare. Transport infrastructure refers to the physical facilities, infrastructure and systems that enable the movement of people and goods. They are roads, bridges, railways, ports and airports. In urban settings, transport infrastructure plays an important role in shaping urban expansion, land-use and accessibility, according to Litman (2017). However, it can also cause environmental damage

in a variety of ways, including through the destruction or alteration of habitats, the discharge of pollutants, and the disturbance of land.

Infrastructure plays an important role in the physical and economic development of cities and towns all over the world. The property value and land price in areas with transportation improvements tend to increase, whereas areas without the improvements grow at a lower rate. In addition, those cities that are seeing economic and population developments in addition to transportation expansion may see significant demand-driven increases in property and land values (Goldberg, 1970).

Transportation is a major determinant of human development at the individual, national, regional and global level, and plays an important role in the economic development of any nation as well as the physical development of the individual. (Oyesiku, 2002). There have been a number of studies demonstrating that transportation systems are correlated with land use (Sajini, 2018; Sun et al., 2019; Sajini, 2022a). Transportation patterns are an integral part of development patterns and are often organized on streets. They are essential to life, to society's development and to civilization. Furthermore, investing in transport infrastructure will improve accessibility and lead to less travel time and better cost-benefit results. These enhancements often result in a wider reach of service and better access to schools, offices, banks, health care centres, shopping centres and recreational centres.

Road transportation is an important contributor to economic growth in the different sectors. It facilitates the access to the rural community and fosters agricultural events, small and big industrial development. Road transport also plays a great role in residential, commercial, educational, and recreational developments (Nwanze, 2002; Oni, 2011). Rail transportation, on the other hand, supports the movement of both passengers and freight. The development of railway systems can promote sustainable urban mobility. The potential of trains to compete with other modes of transport in that they are an effective form of transport can be realised when the infrastructure is adequate and stations are easily accessible (Polom et al., 2018).

While it plays a crucial role in socio-economic development, transportation infrastructure has also been found to have negative impacts on the environment, especially when urbanisation is accelerating (Sajini, 2022b). Zhang et al. (2010) found that the ecological impacts of road construction can be significant on the long-term, such as destruction and fragmentation of habitat, that can lead to the extinction of endemic and indigenous species. Thus, there is an urgent need to implement effective mitigation measures in the planning and implementation of infrastructure projects. This concern formed the foundation of formulation of the objectives of the present study

1.1. Statement of the Problem

Since the Brundtland Report of 1987, the concept of sustainable infrastructure development has become more popular and has been defined as "development that does not compromise the ability of future generations to develop their own" (Lim, 2009).

Huang and Yeh (2008) noted that sustainable infrastructure development is critical because it has a large impact on the physical environment and socio-economic aspects. It can also affect ecosystems and human activities as construction and renewal of infrastructure is involved, for

instance. Furthermore, there are some difficulties in such development, such as high time demand and high cost, and concerns about long-term sustainability (Lothe, 2006). Previous research has provided different definitions of sustainability. The United Nations ESCAP (2006) defines sustainable infrastructure as that which is designed and maintained to ensure ongoing economic and environmental sustainability, placing emphasis on the conservation of resources over the life of the building or other infrastructure.

Assessing the sustainability of transport infrastructure development is usually done based on the impact of the development on the economy, the environment and overall social benefits, which is often determined by the efficiency and effectiveness of the transport system (Khalid et al., 2012; Jeon & Amekudzi, 2005).

Given the above, this study aimed at further investigating the impact of transport infrastructure on the environment of Warri metropolis.

The specific objectives of the study are as follows: Identify the types of transport infrastructure in Warri metropolis; evaluate the effects of transport infrastructure on the environment; examine the effectiveness of strategies adopted to reduce the impacts of transport infrastructure on the environment and finally, propose solutions to reduce the adverse effects of transport infrastructure on the environment in Warri metropolis.

In the study, two hypotheses were stated and tested:

i. There is no meaningful links between transport infrastructure and environmental condition of Warri metropolis.

ii. The strategies implemented to reduce the impact of transport infrastructure are not significantly correlated with the environmental quality of Warri metropolis.

1.2. Conceptual Framework.

Environmental Impact Assessment (EIA) is a systematic and anticipatory decision-making method that can identify, predict, evaluate and control the potential environmental and social impacts of proposed projects, policies or plans before they are put in action (Morgan, 2012).

EIA originated in the early environmental regulatory regimes, like the U.S. National Environmental Policy Act (NEPA), and it has since been adopted and adapted globally as a planning process and an environmental management tool (Morgan, 2012).

The three main purposes of EIA are to ensure that environmental considerations are taken into account in the planning and decision making of projects, to minimize or avoid adverse effects, as a result of the project design and implementation, and to maximise beneficial impacts, by examining other options and considering environmental issues (Epele, 2021).

2.0. Materials and Methods

2.1. Study Area

Warri is a major oil producing city in Delta State, Nigeria. It is located on 5°31′N latitude and 5°45'E longitude. It is situated close to the Warri River, 30 miles (48 km) upstream from

Forcados. This a port city on the Bight of Benin in the west of the Niger Delta. Warri is also a major urban centre in the State of Delta, having experienced rapid urban expansion over the past few years, as infrastructure has spread out across neighbouring communities like Uvwie, Udu and Okpe. These adjoining areas are now connected with the growing network of roads.

It is a city which has become culturally diverse as a result of its historical function as a port and commercial centre of the country and its population comprises of Itsekeris, Urhobos, Ijaws, Isokos, Nigerians and foreigners. The dominant ethnic groups of the area are the Itsekiris, Ijaws and Urhobos.

Moreover, Warri has experienced a resurgence of economic significance since the discovery of crude oil and natural gas in the area. The city was home to the second refinery of crude oil in Nigeria in 1978. It is connected to the refinery by a network of oil pipelines to Kaduna, in northern Nigeria. Warri is also the site of one of the major seaports of Nigeria and numerous oil companies, both local and international, have offices there. Besides, there is an integrated steel plant in the neighbouring town of Aladja to provide support to the development of the greater Warri area.

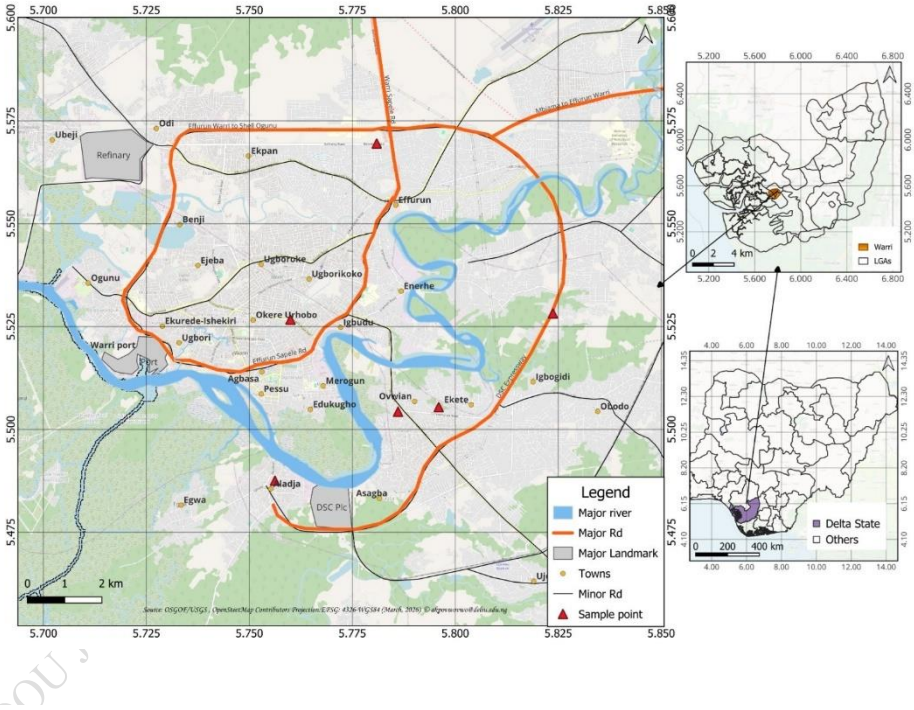

Figure 1. Map showing Warri and environs

SOURCE: OSGOF/VSGS, OPEN MAP CONTRIBUT0RS PROJECTION: EPSG: 4326-WGS84 (March, 2026). (C) Akpovwovwo@delsu.edu.ng

2.2. Methodology

This study used the Cross-sectional survey research design to examine the environmental impact of transport infrastructural development in Warri metropolis of Delta state, Nigeria. The primary data were obtained by structured questionnaires which were administered to the people of the study area. The study population included the residents of the three Local Government Areas which make up the Warri Metropolis that include Udu, Uvwie and Warri South.

The questionnaires were distributed by simple random sampling method to make sure all the eligible respondents have equal chance of selection and 400 questionnaires were distributed. Proportionate sampling was done within the three strata according to their population parameters. The questionnaire was administered to 400 people and 384 (96.0%) questionnaires were retrieved and the completion was correct.

The questionnaire aimed to gather data on their perception of the development of the transport infrastructure, as well as the environmental impacts that have arisen from this development, such as air pollution, noise pollution, traffic congestion, waste generation and changes in land use patterns. The instrument was given to experts for content validity prior to administration.

The collected data from the field surveys were coded and analysed using the statistical package for the social sciences (SPSS) version 25. Data on respondents' characteristics and perceptions were summarized using descriptive statistics which included frequencies, percentages, means and standard deviations. Multiple correlation analysis was used to study the correlations between the transport infrastructural development and selected indicators of environmental impact. The statistical significance was determined at 0.05 level of significance.

3.0. Results

In line with first objective of the study which sought to identify the types of transport infrastructure in Warri metropolis, Table 1 below presents the types of transport infrastructure in the study area.

Table 1 Types of transport infrastructure available in the Warri Metropolis

Types	Frequency	Percentages (%)
Road Network, Railways, Airports, Port and pipe lines	300	78
Road Network, Railways, Airports only	31	8
Airports and Port only	20	5
None of the above	33	9
Total	**384**	**100**

Source: Researcher's Fieldwork (2026)

Table 1. Shows that road network, railways, airports, port and pipe lines (78%) are the predominant transport infrastructure in Warri metropolis.

The second objective which aimed to examine the impact of transport infrastructure on the environment was realised as shown in highlighted responses in Tables 2.

Table 2: Impact of road construction on the city's ecosystem and wildlife

Impact	Frequency	Percentages (%)
Habitat Fragmentation	121	31.5
Wildlife Mortality	76	19.8
Pollution	122	31.8
Changes in spatial behavior	65	16.9
Total	**384**	**100**

Source: Researcher's Fieldwork (2026)

Table 2. shows the impact of road construction or expansion on the city's ecosystem and wildlife. It was observed that 31.8% of the respondents mentioned that pollution is one of the major impacts of road construction or expansion on the city's ecosystem followed by habitat fragmentation (31.5%), wildlife mortality (19.8%), and changes in spatial behaviour (16.9%).

Table 3: How transport system affects water bodies within the metropolis

Effects	Frequency	Percentages (%)
Pollution	217	56.5
Habitat Disruption	88	22.9
Thermal Pollution	48	12.5
Sedimentation	32	8.3
Total	**384**	**100**

Source: Researcher's Fieldwork (2026)

Table 3. shows that 56.5% of the respondents said pollution is the major effects of transport system on water bodies within Warri Metropolis, 22.9% said habitat disruption, thermal pollution (12.5%), and sedimentation (8.3%).

Table 4: contribution of urban transportation to noise pollution in Warri

Option	Frequency	Percentages (%)
Yes	337	87.8
No	47	12.2
Total	**384**	**100**

Source: Researcher's Fieldwork (2026)

Table 4. shows that 87.8% of the respondents agreed that urban transportation has contributed to noise pollution in Warri while 12.2% disagreed.

Table 5*:* impacts of traffic congestion in urban environment of Warri

Response	Frequency	Percentages (%)
Causing pot holes	132	34.4
Increasing air pollution due to emissions	91	23.7
Impeding free movement	59	15.4
Noise nuisance	102	26.6
Total	**384**	**100**

Source: Researcher's Fieldwork (2026)

The third objective the sought to examine the policy adopted in the ameliorating the impact of transport infrastructure on the environment of Warri Metropolis, the figure below reflects the strategies.

Policies/measures adopted by the government or local authorities to reduce the environmental impact of transport infrastructure in a chart.

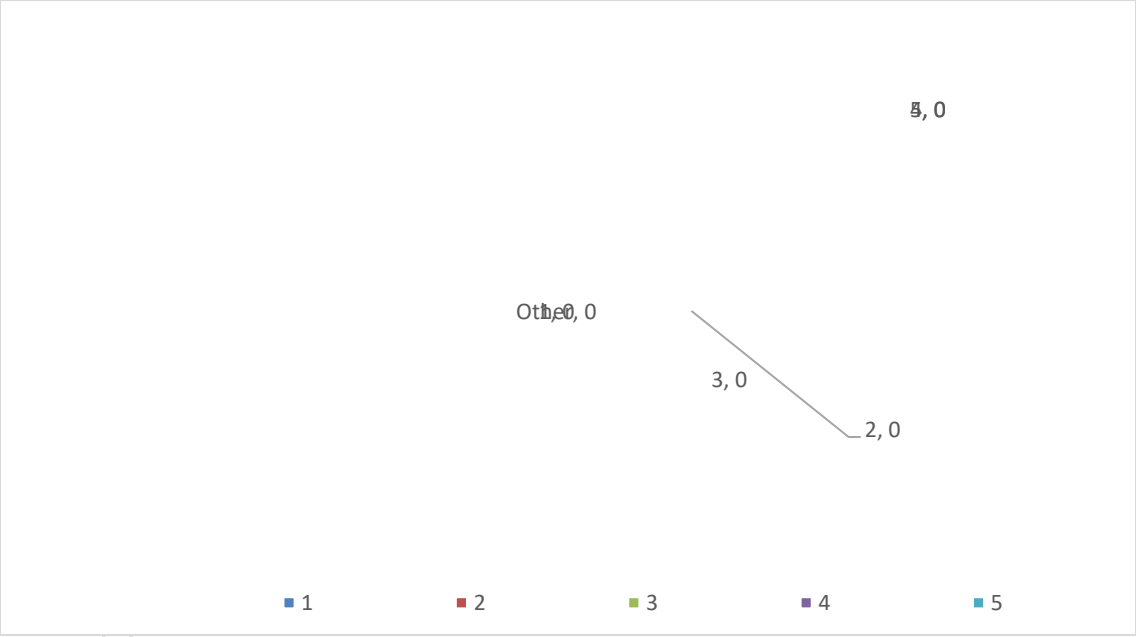

Figure 2: Policies/measures adopted

Source: Researcher's Fieldwork (2026)

Figure 2, shows that environmental laws (41.7%), encouraging non-motorized transportation, land allocation policy (6.3%) are the policies/measures adopted by the government or local authorities to reduce the environmental impact of transport infrastructure (See Fig 4.5).

Hypothesis One: There is no significant relationship between transport infrastructure and the environment of Warri Metropolis.

Table 6: Model Summary – Transport Infrastructure Types vs Environment

Model	R	R Square	Adjusted R Square	Std. Error of Estimate
1	0.743	0.552	0.546	0.712

Source: Researcher's Fieldwork (2026)

Table 7: ANOVA – Transport Infrastructure Types vs Environment

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	229.67	5	45.93	90.58	< 0.001
Residual	186.33	378	0.493		
Total	416.00	383			

Source: Researcher's Fieldwork (2026)

Table 8: Coefficients – Transport Infrastructure Types vs Environment

Predictor	Unstandardized B	Std. Error	Standardized Beta (β)	t	Sig.
(Constant)	1.12	0.15		7.47	< 0.001
Road network	0.42	0.05	0.412	8.40	< 0.001
Railway	0.18	0.06	0.152	3.00	0.003
Port/waterway	0.25	0.06	0.208	4.17	< 0.001
Airport	0.11	0.05	0.098	2.20	0.028
Pipeline	0.20	0.06	0.167	3.33	0.001

Source: Researcher's Fieldwork (2026)

Multiple correlation coefficient is R = 0.743 which is good as a combined relationship. R^2 = 0.552 indicates that the 55.2% of the variance in environmental impact can be explained by the five types of transport infrastructure. The ANOVA shows the model is highly significant (F = 90.58, p < 0.001). So, the null hypothesis is rejected.

So, there is a strong correlation between transport infrastructure and environment of Warri metropolis. Road networks (β = 0.412) make the largest unique contribution followed by port/waterway (β = 0.208) and pipelines (β = 0.167).

Hypothesis Two: The strategies used for ameliorating the impact of transport infrastructure have no significant relationship with the quality of the environment of Warri metropolis.

Table 9: Model Summary – Mitigation Strategies vs Environmental Quality

Model	R	R Square	Adjusted R Square	Std. Error of Estimate
1	0.991	0.982	0.982	0.142

Source: Researcher's Fieldwork (2026)

Table 10: ANOVA – Mitigation Strategies vs Environmental Quality

Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	457.34	4	114.34	5678.90	< 0.001
Residual	8.60	379	0.020		
Total	465.94	383			

Source: Researcher's Fieldwork (2026)

Table 11: Coefficients – Mitigation Strategies vs Environmental Quality

Predictor	**Unstandardized B**	**Std. Error**	**Standardized Beta (β)**	**T**	**Sig.**
(Constant)	0.98	0.04		24.50	< 0.001
Environmental laws	0.35	0.03	0.380	11.67	< 0.001
Non-motorized transport	0.28	0.03	0.305	9.33	< 0.001
Noise control	0.22	0.03	0.240	7.33	< 0.001
Green Spaces	0.19	0.03	0.207	6.33	< 0.001

Source: Researcher's Fieldwork (2026)

The combined (multiple) correlation coefficient is R = 0.991, which is a very strong combined relationship. The R^2 value of 0.982 means that 98.2% of the variance in environmental quality is explained by the four mitigation strategies. The ANOVA is highly significant ($F = 5678.90$, $p < 0.001$). Thus, the null hypothesis is rejected.

However, the strategies adopted for alleviating impacts of transport infrastructure is significantly related with the perceived environmental quality in Warri Metropolis. The influence of strategies is highest for environmental laws ($\beta = 0.380$) and non-motorized transport ($\beta = 0.305$).

4.0. Discussion of Findings

The result shows that the five types of infrastructures have a combined environmental impact variance of 55.2% (R = 0.743). This is in line with previous research. Polzin (2004) pointed out that there was a high degree of mutual dependency among transportation and land use systems. Furthermore, Button and Rothengatter (2015) discovered that the development of roads, rails and ports has an additive effect on environmental destruction. Our result indicates that road networks are the biggest contributor (β = 0.412) as this is the case in Warri with 93.5% of the most commonly used mode of transport being road. As part of the oil and gas epicentre, infrastructure for port/waterway and pipelines also plays a significant role.

Also, deriving from the multiple correlation between mitigation strategies and environmental quality. the near-perfect multiple correlation (R = 0.991) indicates that the four mitigation strategies are together extremely effective in explaining environmental quality. This is in line with that of Agbaitoro and Ekhator (2025); Sajini (2024); and Sun et al. (2019) which also support the assertion that integrated policy packages are more appropriate than single policies to achieve desired environmental quality. Environmental laws (β = 0.380) and non-motorized transport (β = 0.305) were the two most powerful predictors. Significantly, but somewhat surprisingly, noise control (β = 0.240) and green spaces (β = 0.207) also play an important role. This is relevant as described earlier, noise control (45.8%) and green spaces (47.4%) were reported as having low implementation rates. The level of the multiple correlation is high and indicates that if these strategies are fully applied, environmental quality can be significantly improved.

4.1. Policy Implications of the findings.

Multiple correlation analysis shows that none of the infrastructure types or mitigating measures is a standalone solution. This will need a comprehensive and multi-layered strategy. The key to addressing the environmental burden is to invest in road network improvements and to invest in ports, railways and pipelines to distribute the burden. Similarly, a set of environmental laws, non-motorized transport, noise control and green space planning should be applied simultaneously to produce the best results.

5.0 Conclusion

Transport is an important aspect of urban development in the studied area. It is clear that the use of transport strategies as leverage point in societal development is relevant because of its linkages with other sectors like education, healthcare, agriculture, Trades/Businesses, artisan/crafts and its integration and active participation in these sectors. In this respect, transport infrastructure has evolved as a specific sector which is essential to address the broad spectrum of public issues in a global system. This research has created a novel relationship between transportation infrastructure and environment, and has thus set the pace to introduce environmental aspects into transport infrastructure planning for sustainable goals.

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