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Environmental Impacts of the Rural Access and Mobility Project Implementation in Osun State, Nigeria: A Mixed-Method Approach

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About Article

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ABSTRACT

The study explored the environmental impacts of the Access and Mobility project implementation in Osun State, Nigeria using a mixed-method approach. The study was anchored on the Ecological Footprint Theory, while concurrent mixed-method design approach was employed. Four-hundred and fifty respondents residing within the RAMP-2 projects regions comprised Iwo, Ife and Ilesha were sampled using both probability and non-probability sampling procedures. A self-designed instrument was used to obtained information from the participants. Mean, standard deviation, t-test and Analysis of Variance (ANOVA) were used for data analysis, while the responses from the KII were thematically analysed. The findings revealed significant perceived environmental impacts of RAMP implementation, with main concerns comprised air and water pollution (2.94), noise and vibration pollution (2.84), soil and land degradation (2.83), and community health and safety (2.76) with the mean threshold of exceeding 2.50. Conversely, displacement of community members (2.25), increased traffic issues (1.24), and loss of agricultural land (1.14) were perceived as relatively less significant impacts. The findings revealed no statistically significant differences in perceived environmental impacts of RAMP-2 among residents based on sex ($t = 0.305$, $p = 0.760 > 0.05$), age ($F = 11.625$, $p = 0.078 > 0.05$), and primary occupation ($F = 2.542$, $p = 0.081 > 0.05$). This showcases that demographic characteristics do not significantly influence perceptions of environmental impacts of RAMP-2 among rural dwellers in Osun State, Nigeria. The Rural Access and Mobility Project (RAMP) has had significant environmental impacts, with shared concerns among rural dwellers regardless of sex, age, or occupation. Therefore, rural dwellers should participate in environmental impact assessments and collaborate with project implementers to develop mitigation measures to minimize the environmental impacts of rural road projects. The RAMP-2 officials should implement robust environmental impact assessments, develop and enforce effective mitigation measures, and engage with local communities to address concerns and promote sustainable practices throughout the project lifecycle among others.

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1. INTRODUCTION

The rapid expansion of road infrastructure in Sub-Saharan Africa is a major development initiative of the 21st century, profoundly impacting human communities and natural landscapes. By 2050, an estimated 25 million kilometres of new roads will be built globally, with about 60% of this development focused on 79 planned corridors in Africa. This massive infrastructure growth aims to meet rising transportation needs driven by population growth and economic development, particularly in areas where poor connectivity limits access to markets and essential services (Thorn *et al.*, 2022; Adeyemi *et al.*, 2014; Adeyemi & Oladunmoye, 2016; Adeyemi & Muraina, 2015; Aransi, 2022). In economically developing countries, a surge in road construction is expected over the next decade to accommodate growing passenger and freight traffic. If not carried out sustainably, this development will have severe environmental consequences at local, regional, and global levels.

There is no gainsaying that road construction plays a vital role in economic development and connectivity in both developed and developing societies. In spite this, the road construction poses significant environmental challenges on the residents of the community (Aransi, 2020a; Adeyemi, 2006; Adeyemi & Jimoh, 2014; Adeyemi, *et al.*, 2024; Tanveer & Ajay, 2025). According to Hoy *et al.* (2024), the expansion of infrastructure networks has intensified the environmental footprint of the construction industry, primarily due to the high demand for virgin aggregates. Traditional road construction relies heavily on extracting and processing natural resources like crushed rock, sand, and gravel, which leads to environmental degradation, ecosystem disruption, and increased pollution, including air and water pollution and higher greenhouse gas emissions. Changmo *et al.*, (2024) reiterated that emissions from road construction vehicles with internal combustion engines are the major contributor to global warming and climate change. Even dust pollution is predominantly generated during excavation and backfilling stages, which are key components of earthwork construction activities.

Construction activities, including earthmoving, material transportation, off-road machinery operation, asphalt and concrete production, and infrastructure development (such as pavements, bridges, and tunnels), generate air emissions that require prediction, measurement, and mitigation (Aransi, 2019; Giunta, 2022). This indicates that the road construction practices seem to significantly contribute to air quality deterioration and in turn pose a long-term risk to both human health and the natural environment. This further supports that the transport sector is a significant contributor to global greenhouse gas emissions, with a substantial portion attributed to road construction, rehabilitation, maintenance, and usage, respectively. The construction industry is a significant contributor to environmental pollution, posing major challenges to projects due to the substantial pollution generated. Key environmental impact indicators include greenhouse gas (GHG) emissions, eutrophication potential (EP), acidification potential (AP), human health particulates, ozone depletion, and smog formation (Mohamed *et al.*, 2017; Aransi, 2020b).

The widespread use of traditional materials like asphalt and concrete in road construction has significantly contributed to greenhouse gas emissions, resource depletion, urban heat island effects, and water runoff problems (Aryan *et al.*, 2023). Road construction activities can generate significant amounts of waste, leading to soil and water contamination, air pollution, and habitat destruction if not properly managed. Furthermore, the extraction and processing of materials for road construction consume natural resources and energy, exacerbating environmental degradation, while landfills produce methane, a potent greenhouse gas, as organic materials decompose (Akinyooye & Adesokan, 2021; Enobie *et al.*, 2024). Africa's significant road infrastructure deficit, valued between $68 billion and $108 billion, has resulted in a heavy dependence on external financing (Thorn *et al.*, 2022).

The Rural Access and Mobility Project (RAMP) aims to improve rural infrastructure and connectivity in Osun State, Nigeria. However, the project's implementation may have significant environmental implications, including habitat destruction, water pollution, and loss of biodiversity. The increasing demand for road construction and rehabilitation under RAMP may exacerbate these environmental concerns, posing risks to local ecosystems and communities. Road development has far-reaching environmental consequences that go beyond the initial construction phase, triggering secondary development, land-use changes, and resource exploitation that can profoundly alter ecosystems (Ament *et al.*, 2023; Ojo, & Chukwudeh, 2016). Despite the potential environmental impacts of RAMP, there is a dearth of comprehensive studies assessing the project's ecological footprint in Osun State. Existing literature on infrastructure development in Nigeria, especially on rural road infrastructure, often focuses on economic benefits, overlooking the environmental consequences. This study aims to address this knowledge gap by employing a mixed-method approach to investigate the environmental impacts of RAMP implementation in Osun State, providing valuable insights for policymakers and stakeholders to mitigate adverse effects and promote sustainable development.

1.1. Objective of the study

The study's broad objective was to explore the environmental impacts of the Access and Mobility Project (RAMP-2) implementation in Osun State, Nigeria by engaging mixed method lens, while specific objectives are to;

i. examine the environmental impacts of the activities of Rural Access and Mobility Project in the communities of intervention in Osun State, Nigeria; and

ii. investigate if the environmental impacts of the activities of Rural Access and Mobility Project differ base on the residents' demographic characteristics (gender, age, and primary occupation).

1.2. Research questions

The study is guided by the following questions.

i. What are the environmental impacts of the activities of Rural Access and Mobility Project in the communities of intervention in Osun State, Nigeria?

ii. To what extent do the environmental impacts of the activities of Rural Access and Mobility Project differ base on the residents' demographic characteristics (gender, age, and primary occupation)?

2. LITERATURE REVIEW

A recent study by Philipo *et al.* (2025) investigated the socioeconomic and environmental effects of road infrastructure development in Sub-Saharan Africa. The findings revealed a significant link between foreign direct investment (FDI) and environmental degradation, with a standard deviation increase in FDI associated with a 34% rise in adverse environmental road impacts ($\beta = 0.34$, $p < 0.05$). This relationship was particularly pronounced in countries with weaker environmental governance. Conversely, countries with higher Human Development Index (HDI) scores experienced 28% fewer negative environmental impacts, indicating that development status plays a crucial role in determining environmental management capacity.

Changmo *et al.* (2024) developed a framework for determining the fuel use resulting in environmental impacts caused by construction work zones (CWZs) on a range of vehicles and to produce initial calculations of these impacts by modelling traffic closure conditions for highway maintenance and rehabilitation activities. The study included two common highway categories—freeways/multi-lane highways and two-lane highways. The framework was demonstrated using three CWZ operations under different traffic congestion levels. In the simulation results for a freeway with a CWZ and heavy congestion, fuel consumption increased by 85% and the carbon-dioxide equivalent emissions increased by 86%. Changing CWZ traffic congestion from heavy (average speed 5mph) to medium (average speed 25mph for a freeway section) reduced fuel consumption by 40% on a freeway. This study also included use of a pilot car in a CWZ on a two-lane road typical of lower traffic volume state highways and county roads to compare with the drive cycles in MOVES used for the scenarios. The pilot-car operation scenario results indicate that a one-lane closure with pilot-car operation on a two-lane road might consume 13% excess fuel because of idling time and the slow movement of vehicles following the pilot car.

Yakubu and Kawugana (2025) examined the impact of rural road infrastructure on economic activities, food production, market access, and overall welfare in rural communities. Using a mixed-method approach, data was collected from farmers, traders, transport operators, and government officials to assess the significance of rural roads in boosting agricultural productivity and improving rural living standards. The findings indicated that road construction has significantly reduced transportation costs, increased farmers' access to markets, and improved the availability of agricultural inputs such as fertilizers and seeds. Additionally, better road networks have facilitated faster movement of goods, expanded trade opportunities, and enhanced rural employment prospects. Socially, improved roads have led to better access to healthcare, education, and other essential services, thereby contributing to overall rural development.

2.1. Theoretical framework

2.1.1. Ecological footprint theory

This study was anchored on the Ecological Footprint Theory postulated by William Rees and Mathis Wackernage in 1996. The Ecological Footprint Theory, in the context of rural road construction, posits that the development of rural roads has a measurable impact on the environment, which can be quantified in terms of the amount of land, resources, and ecosystems affected. This theory is based on the idea that rural road construction activities, such as land clearing, excavation, and material transportation, have a corresponding ecological footprint that can be calculated and compared to the local ecosystem's biocapacity.

The Ecological Footprint Theory can be applied to the RAMP-2 project to assess the environmental impacts of rural road construction. By calculating the ecological footprint of the project, researchers can quantify the amount of land, resources, and ecosystems affected by the road development. This includes assessing the land disturbance caused by road construction, the resources consumed during the process, and the potential ecosystem disruptions resulting from habitat fragmentation, wildlife disturbance, and water pollution.

The application of the Ecological Footprint Theory to the RAMP-2 project can provide valuable insights into the project's environmental sustainability. By comparing the project's ecological footprint to the local ecosystem's bio capacity, researchers can determine whether the project is operating within the planet's ecological limits or exceeding them. This information can be used to identify areas for improvement and develop strategies to minimize the project's negative environmental impacts. For instance, the project could incorporate environmentally friendly design principles, use locally sourced materials, and implement measures to mitigate habitat fragmentation and wildlife disturbance. By adopting a more sustainable approach, the RAMP-2 project can reduce its ecological footprint and contribute to a more environmentally conscious rural development.

3. METHODOLOGY

3.1. Research design

This study employed a concurrent mixed-method research design, combining quantitative and qualitative data collection and analysis in a single study (Sharma *et al.*, 2023). This design is particularly useful for exploring complex research issues, as it allows researchers to gather insights from multiple perspectives and data sources. By integrating quantitative data (often obtained through questionnaires) with qualitative data (typically collected through in-depth interviews), researchers can gain a more comprehensive understanding of the subject matter.

The mixed-methods approach offers several benefits, including a more complete picture of the research issue, increased confidence in the findings, and the potential for new research directions. By combining open-ended qualitative data with closed-ended quantitative data, researchers can intentionally combine data to provide a more comprehensive understanding of the research problem. This approach enables researchers to tackle complex issues with greater depth and breadth, leveraging the strengths of both qualitative and quantitative methods to gain a richer understanding of the subject matter (Sharma *et al.*, 2023; Akinyooye, 2021).

3.2. Population, sample size and sampling procedures

The study's target population consisted of rural dwellers residing in villages connected by the RAMP-2 project and RAMP officials in Osun State, Nigeria. Yaro Yamane formular was used to determine the sample frame of four-hundred and fifty (450) out of ten-thousand five-hundred and ninety-six (10,596) residents from the six communities. Iwo, Ife and Ilesha regions were purposively sampled. This was because the RAMP-2 project under consideration focused largely on these three regions within the state. Proportionate stratified and simple random sampling procedures were used to select one-hundred and forty-two (142), one-hundred and thirty-five (135) and one-hundred and seventy-three (173) from Iwo, Ife and Ilesha project regions, respectively. An interview guide was prepared and used for KII.

3.3. Instrument, validity and reliability

The study employed a self-designed instrument. This instrument two sections. The demographic part which is the section A contained sex, age and primary occupation of the respondents. The section B had a 9-item subscale to assess the environmental challenges posed by RAMP implementation in the sample zones. This measures the impact on residents and the community. The respondents were rated on the extent of these challenges using a 5-point Likert scale: 1 (Not at All), 2 (Low Extent), 3 (Moderate Extent), 4 (High Extent), and 5 (Very High Extent).

The instrument's validity was ensured through face and content validation. The items were presented in clear and straightforward language to ensure understandability. The instrument was reviewed by experts at the Institute of Global Affairs and Sustainable Development (GASDI) at Osun State University, and all suggested corrections and observations were incorporated. The instrument's reliability was tested using Cronbach's Alpha method, with 20 respondents from farming communities outside the study area. The Cronbach's Alpha reliability coefficient produced 0.87 which confirmed its reliability for the study.

3.4. Methods of data administration and analysis

The researcher, assisted by four trained research assistants familiar with the study area, administered the instruments. Key Informant Interviews (KII) were also conducted with 15 participants, comprising 4 RAMP officials, 9 rural dwellers, and 2 commercial transporters, with the researcher facilitating the sessions. Data analysis was conducted using SPSS version 26. The descriptive statistics (mean, standard deviation) and inferential statistics (t-test, analysis of variance) were used. Additionally, Key Informant Interview (KII) responses were analysed thematically.

4. RESULTS AND DISCUSSION

4.1. Results based on research questions

Research question 1: What are the environmental impacts of the activities of Rural Access and Mobility Project in the communities of intervention in Osun State, Nigeria?

Table 1. Environmental impacts of the rural access and mobility project in the communities of intervention.

Items	Mean($\bar{x}$)	S. D	Rank
Air and water pollution	2.94	1.16	1st
Noise pollution and vibration	2.84	1.47	2nd
Soil and land degradation	2.83	1.34	3rd
Community health and safety	2.76	1.15	4th
Climate change	2.62	1.34	5th
Natural resource depletion	2.59	1.13	6th
Displacement of local communities	2.25	1.32	7th
Transportation and traffic issues	1.24	1.16	8th
Loss of agricultural land	1.14	1.47	9th

4.2. Interpretation and discussion

Table 1 contained the empirical findings on the environmental impacts of the Rural Access and Mobility Project in the communities of intervention. The empirical findings revealed that air and water pollution ($\bar{x}$=2.94), noise and vibration pollution ($\bar{x}$=2.84), soil and land degradation ($\bar{x}$=2.83), community health and safety ($\bar{x}$=2.76), climate change ($\bar{x}$=2.62), and natural resource depletion ($\bar{x}$=2.59) all exceeded the mean threshold of 2.50, indicating significant perceived environmental impacts. While, displacement of community members ($\bar{x}$=2.25), increased traffic issues ($\bar{x}$=1.24), and loss of agricultural land ($\bar{x}$=1.14) were perceived as less significant impacts. The responses from the interview granted corroborated the empirical findings by submitting as thus:

Since the project's inception, our once-pristine streams and rivers have become polluted with sediment and chemicals from the construction process, harming aquatic life and affecting our irrigation systems (*Female/Iwo Axis/Rural Dweller/Osun/KII/2024*).

The increased traffic and road construction have also led to soil erosion, landslides, and loss of fertile land, reducing our crop yields and threatening our livelihoods. Moreover, the noise and air pollution from the traffic have disrupted the natural habitats of local wildlife, causing a decline in biodiversity (*Male/Iwo Axis/Rural Dweller/Osun/KII/2024*).

One of the significant environmental challenges of road construction is the destruction of natural habitats and ecosystems, leading to loss of biodiversity and disruption of wildlife corridors (*Female/Ife Axis/Rural Dweller/Osun/KII/2024*).

The environmental challenge of road construction is increased soil erosion and water pollution due to deforestation, excavation, and altered drainage patterns (*Female/Ife Axis/Rural Dweller/Osun/KII/2024*).

Road construction leads to environmental degradation through fragmentation of forests, disruption of water flows, and increased noise pollution, affecting both wildlife and local communities (*Male/Ife Axis/Rural Dweller/Osun/KII/2024*).

The construction of roads exacerbates climate change by releasing stored carbon into the atmosphere through deforestation and land degradation, while also facilitating increased greenhouse gas emissions from vehicular traffic (*Female/Ilesha Axis/Dweller/Osun/KII/2024*).

The noise pollution from the increased traffic has become a persistent issue, disrupting the peaceful environment of our village (*Male/Ilesha Axis/Dweller/Osun/KII/2024*).

The road construction process has resulted in soil erosion, landslides, and the destruction of natural habitats, causing harm to local wildlife (*Male/Ilesha Axis/Dweller/Osun/KII/2024*).

Road construction leads to the degradation of air quality due to the release of particulate matter, nitrogen oxides, and volatile organic compounds from construction activities and subsequent vehicular emissions (*Male/Ilesa Axis/Transporter/Osun/KII/2024*).

While the improved roads have increased the efficiency and safety of my transportation business, I've also witnessed the environmental costs. The increased traffic volume has led to a significant rise in air pollution, with exhaust fumes and particulate matter affecting not only my health but also that of the local community (*Male/Ife Axis/Transporter/Osun/KII/2024*).

Environmental challenges of RAMP projects in the communities where it was implemented may include issues such as inadequate waste management, water pollution, and habitat disruption due to infrastructure development, as well as potential environmental degradation resulting from increased human activity and resource extraction, which can negatively impact local ecosystems and community health if not properly mitigated (*Male/Osogbo/Ramp Official/Osun/KII/2024*).

Environmental challenges may arise from unsustainable practices, such as deforestation, soil erosion, and loss of biodiversity, potentially exacerbated by RAMP projects' infrastructure development, resource utilization, or community engagement activities, highlighting the need for environmentally conscious planning and implementation to minimize ecological footprints (*Male/Osogbo/Ramp Official/Osun/KII/2024*).

In contrary to the empirical findings, participant submitted that:

The project's focus on road construction has also led to the destruction of traditional farming practices and the loss of agricultural land, forcing many farmers like to adapt to new and challenging circumstances (*Male/Iwo Axis/Rural Dweller/Osun/KII/2024*).

The findings revealed that the project's implementation has resulted in significant adverse effects on the environment and communities. Notably, increased air and water pollution are threatening the health and well-being of residents, while heightened noise and vibration levels are disrupting the peace. Soil quality is being degraded, which could impact land productivity and ecosystem balance. Community health and safety concerns are emerging, posing risks to residents' physical and mental well-being. Furthermore, the project's contribution to climate change and depletion of natural resources underscores the need for sustainable practices and resource management to mitigate these pressing environmental issues.

The results further indicated that displacement of community members, increased cost of living, traffic issues, and loss of agricultural land were perceived as less significant impacts by the respondents. To ameliorate the post environmental impact of rural roads infrastructural facilities, Yan *et al.* (2025) identify the potential of smart traffic systems, flexible fuel substitution programs, and urban planning reforms as a way of optimising both economic and environmental impact of rural roads projects. Yan *et al.* (2025) underscore the significance of technological advancements, efficient management practices, and a transition to renewable energy to meet Nigeria's growing transport and rural roads construction demands sustainably.

Research question 2: To what extent do the environmental impacts of the activities of Rural Access and Mobility Project differ base on the residents' demographic characteristics (gender, age, and primary occupation)?

Table 2 Differences in environmental impacts of the activities of Rural Access and Mobility Project on the basis of sex, age, and primary occupation.

Table 2. difference on the basis of sex

RAMP-2 Environmental impacts			
Equal variances assumed			**Equal variances not assumed**
Levene's Test for Equality of Variances	F	3.975	
	Sig.	.058	
t-test for Equality of Means	t	-.305	-.291
	df	449	125.124
	Sig. (2-tailed)	.760	.772
	Mean Difference	-.720	-.720
	Std. Error Difference	2.357	2.475
95% Confidence Interval of the Difference	Lower	-5.367	-5.617
	Upper	3.928	4.178

Table 3. Difference on the basis of age

	Sum of Squares	df	Mean Square	F	Sig
Between Groups	7638.711	3	2546.237	11.625	0.078
Between Groups	43147.508	447	219.023		
Total	50786.219	4500			

Table 4. Difference on the basis of primary occupation

	Sum of Squares	df	Mean Square	F	Sig
Between Groups	1271.377	2	635.688	2.542	0.081
Within Groups	49514.842	448	250.075		
Total	50786.219	450			

4.3. Interpretation and discussion

Table 2 shows that there is no statistically significant difference in the environmental impacts of RAMP-2 project among residents of the regions on the basis of sex (t449 = 0.305; 0.760 > 0.05). This is because the significance level of 0.760 is higher than the probability value of.05. The study found that male and female residents have similar views on the environmental impacts of the RAMP-2 project, with no significant difference between their perceptions. This suggests that both men and women are equally affected or concerned about the project's environmental impacts.

Table 3 indicated that there is no statistically significant difference in environmental impacts of RAMP-2 among residents on the basis of age. This is because the significance level of 0.078 is higher than the probability value of.05 (F (3, 447) = 11.625; (p 0.78 > 0.05). The study found that residents' perceptions of the RAMP-2 project's environmental impacts do not vary significantly across different age groups, suggesting that age does not play a significant role in shaping their views on the project's environmental effects.

Table 4 indicated that the environmental impact of RAMP-2 project did not vary statistically significantly based on their primary occupation of the rural dwellers (F 2, 448 = 2.542; p 0.081> 0.05). The probability value of.05. was less than the sig. value of 0.081. The results in Table 4 show that the environmental impact of the RAMP-2 project is not significantly influenced by the primary occupation of rural dwellers. The F-statistic (F 2, 448 = 2.542) and p-value (p = 0.081) indicate that the differences in perceived environmental impact across occupations are not statistically significant at the 0.05 level. This suggests that residents' perceptions of the project's environmental effects are similar regardless of their occupation.

In agreement, Aransi *et al.* (2025) and Aransi (2018) found that employees' ability to adopt innovative work behaviours, including addressing environmental challenges, is not influenced by demographic characteristics such as gender and age. This finding is consistent with the study by Ranjan *et al.* (2023), which found no significant difference in environmental awareness and concerns among different age groups, suggesting that environmental issues are a universal concern that transcends age.

5. CONCLUSION

The study concluded that the Rural Access and Mobility Project has had significant environmental impacts on the communities of intervention. These environmental impacts include air and water pollution, noise pollution, soil degradation, and negative effects on community health and natural resources among others. The study concluded that the environmental impact perceptions of the RAMP-2 project among rural dwellers do not significantly differ based on demographic characteristics such as sex, age and primary occupation. Sex is not a determining factor in shaping residents' perceptions of the environmental impacts of the RAMP-2 project, as both males and females share similar views on the issue. Age does not significantly influence residents' perceptions of the environmental impacts of the RAMP-2 project.

RECOMMENDATIONS

The following recommendations are suggested for concerned stakeholders.

i. Rural dwellers should participate in environmental impact assessments and collaborate with project implementers to develop mitigation measures to minimize the environmental impacts of rural road projects.

ii. The RAMP-2 officials should implement robust environmental impact assessments, develop and enforce effective mitigation measures, and engage with local communities to address concerns and promote sustainable practices throughout the project lifecycle.

iii. Policy makers should develop and enforce stringent environmental regulations and guidelines for rural road projects, ensuring that environmental impact assessments are conducted and mitigation measures are implemented to minimize harm to local ecosystems and communities.

iv. Project implementers should adopt inclusive engagement strategies that equally consider the concerns and views of both male and female residents, ensuring that their environmental impact mitigation measures address the shared concerns of the entire community.

v. Project implementers should adopt age-inclusive strategies to address environmental concerns, as residents across different age groups share similar perceptions of the project's environmental impacts.

vi. The RAMP-2 project's environmental impact mitigation strategies should be designed to be inclusive and address the concerns of all rural dwellers, regardless of their occupation.

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