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THE EFFECTS OF ENVIRONMENTAL PECULIARITIES ON TRANSPORTATION INFRASTRUCTURE PERFORMANCE IN LAGOS METROPOLIS, NIGERIA: RESIDENTS' EXPERIENCES

Summary. Efficient transportation infrastructure is pivotal for the seamless functioning of global cities, with coastal cities facing unique challenges due to environmental peculiarities. This study delves into how Lagos' environmental peculiarities impact transportation infrastructure performance, shedding light on both positive and negative implications. A comprehensive survey involving 1284 residents within Lagos Metropolis was conducted using multistage sampling techniques. A combination of descriptive (percentage and mean-weighted analysis) and inferential (Fisher's exact test and Phi Cramer's V Test) statistics was adopted for data analysis. Major findings revealed that the environmental peculiarities in Lagos foster the use of multimodal infrastructure options and concurrently exert adverse effects on various facets of transportation infrastructure performance, including travel cost, commuting time, fare charges, wear and tear of infrastructure, and the overall cost of maintenance and repairs. The results of the Fisher's exact test underscore the undeniable impact of Lagos' environmental peculiarities on transportation infrastructure performance ($p = 0.000 < 0.05$). This study concludes that high water tables, as a representative environmental peculiarity, substantially

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influence transportation infrastructure performance, shaping the mobility needs of residents. In light of these findings, the study advocates for the full implementation of sustainable infrastructure solutions. Recommendations include establishing robust drainage systems, incorporating corrosion-resistant materials, and adopting innovative technologies to mitigate the repercussions of rising sea levels on critical transportation infrastructure, enhancing its resilience in the face of environmental challenges.

Keywords: environmental peculiarities, Lagos Metropolis, residents' perception, transport externalities, transportation infrastructure performance

1. INTRODUCTION

Transportation infrastructure remains a critical component for the effective functioning of cities globally and the performance of transportation infrastructure, no doubt, has a direct impact on the quality of life, economic development, and environmental sustainability of these cities. However, the performance of transportation infrastructure is often constrained by varying degree of environmental peculiarities such as extreme weather events, air pollution, severe weather events (like hurricanes, typhoons, and floods) natural disaster such as earthquakes, tsunamis, and wildfires [14, 22]. The environmental peculiarities which various across global settlements and cities have long-lasting effects on transportation infrastructure, leading to service interruptions and longer travel times in human settlements.

In recent years, the environmental peculiarities, especially of coastal cities, have become an increasingly important topic of discussion. Environmental peculiarities such as extreme weather events, natural disasters, climate change and air pollution according to 10 and 25, have significant effects on transportation infrastructure performance in many cities of the world, while transportation infrastructure is usually vulnerable to these environmental peculiarities, leading to disruptions in transportation services, maintenance costs and reduced productivity. Furthermore, natural disasters such as earthquakes and floods also have significant effects on transportation infrastructure performance in global cities. For instance, the 2011 earthquake and tsunami in Japan caused damage to transportation infrastructure, leading to disruptions in rail and road services [10]. Climate change has also been identified as a significant environmental peculiarity that affects transportation infrastructure performance in global cities. Rising sea levels and flooding caused by climate change can cause significant damage to transportation infrastructure, leading to disruptions in transportation services [19]. Air pollution is another environmental peculiarity that has significant effects on transportation infrastructure performance in global cities and, as such, influences the health of commuters, leading to increased healthcare costs and reduced productivity.

Lagos is known for its unique environmental challenges and transportation infrastructure issues. In other words, the city's rapid urbanization, combined with inadequate infrastructure and poor waste management, has led to various environmental problems, such as air and water pollution, traffic congestion, and flooding resulting in reduced efficiency and increased travel time for commuters [28]. The environmental peculiarities in Lagos, such as intense rainfall, high groundwater table, and tidal variations, have significantly impacted the quality and durability of transportation infrastructure and the challenges posed by these peculiarities include traffic congestion, reduced road safety, and increased transportation costs, among others.

Furthermore, Lagos is surrounded by water bodies, such as the Lagos Lagoon, the Atlantic Ocean, and various other waterways, which made the city to be prone to high level of water table. These environmental factors, coupled with the city's low-lying terrain, make Lagos vulnerable to flooding and other environmental challenges that affect the performance of the transportation systems [1]. Accordingly, Ref. [3] opine that the frequent flooding caused by the city's water bodies and sea level rise has led to road closures, traffic congestion, and delays in commuting, while the high salinity levels in the water bodies have been found to cause significant damage to bridges and other infrastructure, leading to costly repairs and maintenance. The experiences of residents also reflect the challenges posed by these environmental peculiarities on transportation systems operational performance. Residents report frequent traffic congestion and delays due to poor road conditions and flooding, making commuting difficult and time-consuming.

Being the commercial, financial and industrial nerve centre of Nigeria and also known for its aquatic splendor, bustling population, diverse economy, and congested transportation system, the Lagos's unique environmental peculiarities, such as flooding and air pollution, coupled with poor transportation infrastructure, have resulted in significant challenges not only for policymakers, urban planners, traffic planners, but also for residents and businesses particularly in the face of its rapid population growth and the increasing demands of socio-economic activities. It is on this basis that this study examines the residents' experiences of the transportation infrastructure performance in the midst of prevailing environmental peculiarities in Lagos Metropolis, Nigeria.

2. LITERATURE REVIEW

Researchers have examined diverse transportation issues at international and national scale over the years due to the crucial role that the sector plays in the economic, social, and environmental development of human settlements and socio-spatial interactions. In fact, the relationship between environmental peculiarities and transportation infrastructure performance is critical to the sustainable development of global cities [17]. However, the performance of transportation infrastructure is affected by various environmental peculiarities such as weather conditions, as extreme weather events, sea-level rise, geological characteristics, ecological factors and air pollution, which are becoming increasingly prevalent due to global climate change. Therefore, the impact of environmental peculiarities, such as extreme weather events, sea-level rise, air pollution, and other natural phenomena, on transportation infrastructure performance in global cities is an area of growing concern in recent times.

The impact of these environmental factors can lead to disruptions in transportation systems, resulting in economic losses, reduced accessibility, and increased travel time. This highlights the need for cities to consider the effects of environmental peculiarities when planning and designing transportation infrastructure. Several studies have examined the impact of environmental peculiarities on transportation infrastructure in global cities. For instance, a study by Ref. [9] investigated the impact of typhoons on the performance of the Hong Kong transportation system, finding that severe typhoons can cause significant disruptions, leading to economic losses and reduced accessibility. Another study by Ref. [30] examined the impact of air pollution on transportation infrastructure in Beijing, finding that high levels of pollution can lead to increased travel time and reduced accessibility, particularly for vulnerable populations.

Climate change and extreme weather events, including hurricanes, floods, and wildfires, pose significant challenges to transportation infrastructure. These events can damage infrastructure, disrupt services, and result in economic losses. For example, Hurricane Sandy in 2012 caused extensive damage to New York City's transportation infrastructure, leading to disruptions in subway and commuter rail services, as well as damage to tunnels and bridges [18]. Air pollution is another environmental factor that affects transportation infrastructure performance. Poor air quality can impact the health of commuters, reduce the efficiency of transportation systems, and increase maintenance expenses. A study by the American Lung Association found that air pollution costs the U.S. economy $131 billion annually in lost productivity and healthcare expenses [6].

The impact of geological characteristics on transportation infrastructure performance has been extensively studied in geotechnical engineering research. For instance, Ref. [13] and [29] opined that the geological characteristics such as soil conditions and topography can also impact transportation infrastructure performance in which soft soils can cause settlements and subsidence, leading to pavement cracking and deformation, while topography can also present challenges for transportation infrastructure development, particularly in mountainous regions where steep slopes and narrow valleys can limit the options for road and railway alignments. Furthermore, ecological factors, such as vegetation and wildlife, can also affect transportation infrastructure performance. Trees and shrubs growing near roads and railways can interfere with overhead lines, block visibility, and damage structures. Wildlife, such as deer and elk, can pose a risk to drivers on highways, causing accidents and fatalities. The impact of ecological factors on transportation infrastructure performance has been studied in the context of environmental impact assessments and wildlife management plans [25, 31].

Cities are responding to the challenges posed by environmental peculiarities by adopting measures to enhance the resilience of transportation infrastructure. For example, New York City has developed a comprehensive climate resiliency plan that includes initiatives to protect transportation infrastructure from climate risks [20]. Similarly, Amsterdam has developed a climate adaptation strategy that includes measures to protect transportation infrastructure from sea-level rise and flooding [12]. Similarly, a study by [11] examined the impacts of extreme weather events on the transportation infrastructure of Taipei City, Taiwan. The study found that extreme weather events, such as typhoons and heavy rainfall, could cause significant damage to the city's transportation infrastructure, resulting in traffic congestion and delays. Moreover, Ref. [32] has shown that transportation infrastructure is vulnerable to extreme weather events, which can cause damage to roads, bridges and tunnels, leading to disruptions in transportation services, while Ref. [15] observed that the 2012 Hurricane Sandy caused widespread damage to transportation infrastructure in New York City, leading to disruptions in subway and rail services. Research studies have shown that air pollution can cause damage to transportation infrastructure such as bridges and tunnels, leading to maintenance expenses and disruptions in transportation services [8]. However, Ref. [16] advocated for improved investment in sustainable transportation infrastructure can lead to economic benefits such as increased productivity and reduced healthcare costs and as such, cities with strong public transport systems tend to have lower carbon emissions and better air quality compared to those with less efficient systems.

Several scholars in Nigeria have also examined environmental peculiarities and its implications on Nigerian transportation infrastructure performance. Specifically, Lagos, Nigeria however, is one of the fastest-growing cities in Africa is faced with numerous environmental challenges that affect transportation infrastructure performance with spread adverse effects on the residents [4]. For instance, flooding is one of the major environmental

peculiarities that influences transportation infrastructure performance in Lagos, Nigeria, with many roads becoming flooded during the rainy season, leading to traffic congestion, delays, and damage to roads and bridges. The study by Ref. [22] found that flooding in Lagos results in the closure of many roads and bridges, which affects the movement of people and goods, aside from damaging the road pavement, causing potholes and making the road surface uneven, which leads to accidents and damages to vehicles. Furthermore, the rapid growth in the population and economy of Lagos has led to an increase in the number of vehicles on the road, which has resulted in severe traffic congestion.

Accordingly, Ref. [23] found that traffic congestion in Lagos leads to delays and increased travel time, which impacts the productivity of people and the economy of the city in addition to increasing air pollution, which affects the health of the residents of Lagos. Regarding poor drainage, 23 found that poor drainage systems in Lagos led to the accumulation of water on roads, which modifies the movement of vehicles, causes accidents and leads to soil erosion, which impacts the stability of bridges and the durability of roads. Like other coastal cities in the world, the study by [7] found that climate change leads to sea-level rise, which affects the stability of bridges and the durability of roads in Lagos, Nigeria, in addition to an increase in the frequency and intensity of rainfall, which leads to flooding and damages to roads and bridges. Based on the foregoing, previous research and literature have only addressed other environmental issues, such as transportation systems and infrastructure, leaving behind, an empirical vacuum on residents' experiences of the impact of environmental peculiarities, particularly salinity, high water volume, and water table, on transportation infrastructure performance; thus, the need for this study.

3. STUDY AREA AND METHODOLOGY

3.1. Study area

Lagos Metropolis is located within the geographical area of Lagos State in the Southwestern part of Nigeria, comprising an area of 1,178.28 square kilometers and is bounded in the North by Ogun State, in the East by the Lagoon, in the West by Badagry Local Government and in the South by the Atlantic Ocean. It is located on 445.05 mile north of the equator and longitude 3.410 E and latitude 6.470 N. The Metropolis comprises 16 Local Government Areas out of the 20 Local Government Areas that make up Lagos State [4]. Lagos, Nigeria's economic capital, is notorious for its traffic congestion and inadequate transportation infrastructure spreading across roadways, waterways, airways, railways etc. and complex transportation operations which is heavily influenced by unprecedented population density, urban land use activities and environmental characteristics of Lagos Island and Lagos Mainland.

3.2. Methodology

A cross-sectional survey research design was employed to investigate residents' experiences regarding the impact of environmental peculiarities on transportation performance in Lagos. Both primary and secondary data were sourced and utilized for this study. The primary data collection involved a questionnaire survey instrument complemented by field observation. The questionnaire was administered to 1284 residents, representing a 0.0001% sample frame of the projected 2021 population of 12,030,141 in Lagos Metropolis. Field observation utilized water-

table and soil salinity test instruments to determine the water-table level and soil salinity in the two regional categories of Lagos Metropolis, namely Mainland and Island.

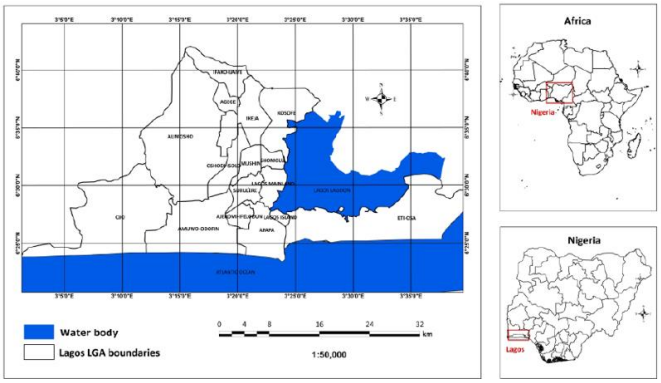

Fig. 1. Lagos Metropolis in the Context of Nigeria and Africa

A probability sampling technique, comprising multistage sampling techniques involving stratified, simple random, and systematic sampling, was adopted in selecting residents, specifically household heads or their representatives across both Mainland and Island regions of Lagos Metropolis. Stratified sampling divided Lagos Metropolis into two major clusters of Lagos Mainland and Lagos Island regions based on government approved political wards, followed by a simple random sampling technique to select 50% of the political wards (minor clusters) in each region. Subsequently, a systematic sampling technique was used to select every tenth residential building after random selection of the first building in each minor clusters, where the household head or representative became the sample unit. Representatives aged 18 and above, irrespective of their status, participated in the study.

Simultaneously, water-table and soil salinity tests were conducted at 10th intervals in randomly selected wards in both Lagos Island and Lagos Mainland. The collected data were analyzed descriptively using frequency tables and mean-weighted analysis. The evaluation of the influence of environmental characteristics on accessibility and mobility requirements involved analyzing cumulative weighted values based on a 5-point Likert scale. This scale ranged from Very Low (VL=1) to Very High (VH=5). The index for each variable was determined by dividing the Summation of Weighted Values (SWV) by the total number of responses. The analysis involved the summation of the product of the number of responses for each aspect and the corresponding weight value associated with each rating, as detailed in Table 3, formulated mathematically as follows:

$$SWV = \sum_{l=1}^{5} X_i\, Y_i \tag{1}$$

Where:
SWV = Summation of Weight Value,
X_i = number of respondents to rating i
Yi = the weight assigned a value (i = 1, 2, 3, 4, 5).

Therefore, the higher the RMI, the higher the level of effectiveness for the variable under consideration is and this is expressed quantitatively as:

$$RMI = \frac{SWV}{\sum_{i=1}^{5} {}^{i=} X_i} \quad (2)$$

The study involved the use of aggregate descriptive analysis. Meanwhile, Fisher's Exact Test was used to test the hypothesis whether or not the environmental peculiarities statistical significantly influence transport infrastructure performance in Lagos Metropolis.

4. RESULTS AND DISCUSSION

4.1. Socio-economic characteristics of residents

This section discusses the findings on the socioeconomic characteristics of sampled residents in Lagos Metropolis. According to the gender classification results in Table 1, more than half (58.7%) of respondents are male, with the remaining 41.3% being female. This is possible because males in a typical cosmopolitan city like Lagos are more mobile than females. According to the results of the marital status data analysis, the Metropolis has less than one-third of respondents who are single (28.3%), close to two-thirds (61.6%) who are married, and one-tenth (10.0%) who belong to other unclassified groups such as widows, widowers, and single parents. Based on this result, it can be deduced that a significant number of respondents are married, with associated marital duties and responsibilities necessitating transportation infrastructure for the convenience of their families' livelihood.

Furthermore, Table 1 revealed that 2.0% of respondents are between the ages of 15 and 20, while more than one-tenth (14.1%) are between the ages of 21 and 30, and less than one-quarter (18.4%) are between the ages of 31 and 40. Furthermore, slightly more than a quarter (27.9%) are between the ages of 41 and 50, while less than one-quarter (19.6%) are between the ages of 51 and 60, and the remaining 18.0% are older than 60. As a result of the age classification results, a significant proportion of respondents in Lagos Metropolis are within the working age range, as only 2.0% and 18.0% are in the school-going age and retirement age, respectively; thus, they are bound to be mobile for varying socioeconomic and cultural engagements that require mobility and transportation infrastructure to make a living in the metropolis.

Respondents' levels of education varied, ranging from no formal education to a higher degree of education. According to the findings, slightly more than one-tenth (11.5%) of the population has no formal education, nearly one-tenth (10.7%) has adult literacy education, and 10.4% have a primary level of education. However, less than a quarter (21.8%) have a secondary level of education, nearly one-third (31.2%) have a first degree or its equivalent, and the remaining 14.3% have a higher degree level of education. This analysis shows that the respondents have a high level of literacy and education, as only 11.5% have no formal education. This demonstrates that respondents are familiar with mobility and transportation infrastructure in the Metropolis, and thus their opinions can be trusted. Table 1 shows the results of an analysis of respondents' employment status, which revealed that only 5.7% were unemployed at the time of the survey, while more than one-tenth (19.3%) were students or apprentices, and more than a quarter (27.5%) were in personal or self-employment. Furthermore, slightly less than one-quarter (20.0%) work in the public sector, 22.9% in the private sector, and 4.4% are retirees. In this regard, the findings revealed that the majority of respondents engage in economic activities that necessitate a change in spatial position over a specific distance via transportation infrastructure and mobility options; thus, they are engaged in the act of mobility and accessibility options domiciled in the Metropolis in order to earn livelihoods and sustenance. This clarifies the rationale for residents of Lagos's typical transiting positions.

According to the data analysis results presented in Table 1, respondents' average monthly income ranges from less than ₦30,000 to more than ₦180,000. Only 5.8% earn less than the national minimum wage of ₦30,000 per month, while more than one-tenth (15.3%) earns between ₦30,000 and ₦90,000 and slightly less than one-tenth (9.7%) earns between ₦90,001 and ₦120,000. In addition, nearly one-quarter (18.8%) earn between ₦120,000 and ₦150,000 per month, slightly more than one-third (32.7%) earn between ₦150,000 and ₦180,000 per month, and the remaining 17.8% earn more than ₦180,000 per month on average. This demonstrates that a significant proportion of Lagos residents earn more than the national minimum wage of ₦30,000 per month from various sources of economic engagement. The income range of respondents in particular and residents of Lagos Metropolis reflects the state's gross domestic product, which is widely regarded as the highest in the country, Nigeria.

Given the findings in Table 1, it is interesting to note that respondents' religious affiliations and practices in Lagos Metropolis have no negative impact on mobility and accessibility. In this regard, nearly half of respondents (46.4%) engage in and practice Islam, while slightly less than half equally practice Christianity. Furthermore, those practicing traditional religion account for 9.1%, while the remaining 3.6% practice other unclassified religions. According to the findings of the analysis, there is no religious dichotomy in access to transportation infrastructure and mobility options in the metropolis, implying the presence of respondents practicing and engaging in various religious practices and beliefs. The results of the socioeconomic characteristics of residents attest to Lagos' cosmopolitan and global nature, which is reflected in the extent to which residents use transportation infrastructure for spatial interaction rather than trip-making.

Tab. 1

Socioeconomic characteristics of respondents

Type	Variables	Frequency	% population
Marital Status	Single	358	28.3
	Married	779	61.6
	Others	127	10.0
Gender Classification	Male	742	58.7
	Female	522	41.3
Age Classification	Between 15 & 20 years	25	2.0
	Between 21 & 30 years	178	14.1
	Between 31 & 40 years	232	18.4
	Between 41 & 50 years	353	27.9
	Between 51 & 60 years	248	19.6
	More than 60 years	228	18.0
Level of Education	No formal education	145	11.5
	Adult literacy	135	10.7
	Primary school	132	10.4
	Secondary school	276	21.8
	First Degree/equivalent	395	31.2
	Higher degree	181	14.3

Employment Status	Unemployed	74	5.9
	Students	244	19.3
	Personal/self-employment	247	27.5
	Public service	253	20.0
	Private employment	290	22.9
	Retiree	56	4,4
Average Monthly Income	Less than ₦30,000	73	5.8
	₦30,000 - ₦90,000	193	15.3
	₦90,001 - ₦120,000	122	9.7
	₦120,001 - ₦150,000	238	18.8
	₦150,001 - ₦180,000	413	32.7
	Above ₦180,000	227	17.8

4.2. Residents' average daily distance travel

In terms of the average distance traveled to work, school, and other non-discretionary trips, Table 2 shows that less than one-quarter (20.6%) travels less than 5 km, one-tenth (10.0%) travels between 5 km and 10 km daily, and more than one-tenth (14.2%) travels between 11 km and 15 km. Furthermore, one-third (31.2%) travels between 16 and 20 kilometers to work each day, while the remaining 24.1% travel more than 20 kilometers. Importantly, this demonstrates that respondents travel varying distances and near mileages to their workplaces on a daily basis and, as a result, can travel to any length to engage in productive socioeconomic endeavors. The daily distance traveled for shopping and market, on the other hand, varies slightly. Specifically, less than one-third (286%) travels less than 5 km per day, 13.1% travel between 5 and 10 km per day, and slightly more than one-quarter (261%) travels between 11 and 15 km per day. Furthermore, those who travel between 16 and 20 kilometers account for 19.9% of all trips, while the remaining 28.6% typically travel more than 20 kilometers in their daily shopping trips.

It is generally observed that respondents who cover less than 5 km cover the shortest distance for visiting relatives and social gatherings, and those who cover between 5 and 10 km for social trips account for 36.5% and 35.9%, respectively, while less than a quarter (22.4%) covers between 11 and 15 km for social engagement. However, only 5.1% and 0.1% cover between 16 and 20 km, respectively, and more than 20 km for social trips. Table 2 shows that more than one-third (38.1%) of people travel less than 5 kilometers to visit friends, relatives, and families, while nearly half (47.5%) travel between 5 and 10 kilometers, and more than one-third (13.8%) travel between 11 and 15 kilometers. This indicates that visits covering a long distance receive special attention, and because it is discretionary, a significant number of respondents have limited the distance covered to more than 10 km for such trips to friends and relatives. Furthermore, the analysis of data on the distance traveled to medical facilities revealed that respondents could travel any spatial distance for medical treatment. Similarly, respondents could travel any desired spatial distance for leisure and recreation.

Tab. 2

Distance travel to key spatial locations

Range of distance	Place of work/ School		Shopping/ market		Relatives/social visits		Recreation		Medical facility	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
< 5km	260	20.6	153	12.1	482	38.1	253	20.0	349	27.6
5-10 km	125	10.0	168	13.3	601	47.5	175	13.8	383	30.3
11-15 km	179	14.2	330	26.1	176	13.8	134	10.6	243	19.2
16-20 km	394	31.2	252	19.9	6	0.5	454	35.9	235	18.6
> than 20 km	306	24.1	362	28.6	0	0.0	249	19.6	55	4.3
Total	1264	100.0	1264	100.0	1264	100.0	1264	100.0	1264	100.0

4.3. Perceived impact of environmental peculiarities on transportation infrastructure

The data obtained on the nature of the perceived impact of Lagos' environmental peculiarities on respondents' accessibility and mobility requirements as measure of transportation infrastructure performance was assessed using a developed scale known as the environmental peculiarity impact index (EPII), which used the sum of a weighted value on a five-point Likert scale. The identified impacts ranged from Very Low (VL = 1) to Low (L = 2), Moderate (M = 3), High (H = 4), and Very High (VH = 5). The results of the analysis based on the Equation 1 and Equation 2 produced a total of 31.3854 weighted values and a mean index value of 3.4873 with nine (9) indicators. Meanwhile, the findings revealed that commuting stress (4.5522) is the most notable impact of Lagos's environmental peculiarities, as shown in Table 3. This is not surprising given the well-documented medical impact of Lagos Metropolis' traffic quagmire, which is usually exacerbated by related environmental scenarios such as rain downpours. Disruptions in traffic flow (3.8272) are another distinct impact expressed by respondents as a result of the environmental anomaly. The vehicle maintenance/cost of transportation fare (3.7413) is ranked third, as motorists frequently increase transportation astronomically during any minor downpour in the city, causing commuters to groan for the duration of the downpour.

Moreover, the results revealed that wear and tear (3.6930) and increased commuting time (3.6432) are closely related to disruptions in traffic flow and increased journey duration (3.5316), which occupy the sixth position in the analysis. Respondents rate the remaining indicators, which include threat to life (3.3441) and traffic disruptions (3.0303), as having less severe consequences. However, among the indicators, modal choice and capacity are rated the lowest, with a RIM of (2.0222) denoting less severe implications and being attributed by respondents to the city's unique environmental characteristics.

Tab. 3

Perceived impact of environmental peculiarities on transportation infrastructure performance

Nature of impacts	VL	L	M	H	VH	TWV	RIM	MIV	Rank
Travel/commuting time	160	200	480	1820	1985	4605	3.6432		5
Cost of vehicle maintenance/transport fare	125	192	531	1796	2085	4729	3.7413		3
Wear and tear	104	412	447	1280	2425	4668	3.6930	31.3854/9	4

Modal choice and capacity	437	110 4	342	288	295	2556	2.0222	= 3.4873	9
Disruption of traffic flow	71	318	363	1916	2170	4838	3.8275		2
Journey duration	107	422	537	1748	1650	4464	3.5316		6
Trip disruptions	227	566	474	1616	960	3843	3.0303		8
Threats to life	85	378	1344	1160	1260	4227	3.3441		7
Commuting stress	0	0	24	1560	3830	5754	4.5522		1

NB: Very Low (VL), Low (L), Moderate (M), High (H), Very High (VH), Total Weighted Value (TWV), Relative Index Mean (RIM) and Mean Index Value (MIV)

4.3.1. Hypothesis Testing

Hypothesis 1 (H_0): *Environmental peculiarities does not significantly influence transportation infrastructure performance in Lagos Metropolis*

In a bid to understand the statistical influence of the environmental peculiarities on transportation infrastructure performance, further studies were conducted on the association between the environmental peculiarities and the transportation infrastructure performance using Fisher's Exact Test under cross-tabulation analysis. The cross-tabulation analysis equivocally uses the Fisher's Exact Test to explain the relationship between the categorical variable (environmental peculiarities) which was measured by the water level or water table of the respondents' respective locations which ranges between 0m-5m for those within Lagos Island and 35m-40m for location within the Lagos mainland) and a group of independent variables which include travel commuting time, cost of travel/transportation fare, wear and tear/cost of vehicle maintenance, modal choice capacity, traffic flow, journey duration, trip disruption/cancellation, threats of life and commuting stress, all of which were used to measure the transportation infrastructure performance.

Based on the cross-tabulation results presented in Table 4, it can be deduced that the impact of environmental peculiarities on transportation infrastructure performance is mostly high and very high across the study area with six (6) out of the nine (9) independent variables used to measure transportation infrastructure performance scored high percentage, above 60%. These include travel time (66%), cost of travel (69%), wear and tear (69%), traffic flow (72%), journey time (61%) and commuting stress (93%), while the remaining three which include impact of modal choice capacity, trip disruption and cancellation and threats to life scored low or very low-impact level of environmental peculiarities. The observed higher percentage score is experienced both in the areas with 5m and 38m water level across the metropolis. By implication, regardless of the respondents' location in the study area, the environmental peculiarities of Lagos affect or influence the transportation infrastructure performance. In other words, the correspondent analysis revealed that the impact of environmental peculiarities of travel or commuting time of respondents is high (44%) on Lagos Island and very high (36%) on Lagos Mainland; the cost of travel is very high (42%) in Lagos Island and high (38%) on the Mainland. On the cost of maintenance, the impact of environmental peculiarities is very high (42%) and (37%) on Lagos Island and Lagos Mainland, respectively.

Furthermore, the test of statistical relationship between the categorical variable (environmental peculiarities) and the distribution of another group of variables (transportation infrastructure performance) through the Fisher's Exact Test and Phi. Cramer's V revealed that all the nine (9) examined transportation infrastructure performance variables, significantly influenced by environmental peculiarities with adverse experiences of the residents. These have

their calculated significant values (p-values) for the three tests of significance level at 0.05; hence, the decision to accept the alternative hypothesis (H1) and reject the null hypothesis (H0). This implies that the observed environmental peculiarities significantly influence transportation infrastructure performance in the Lagos Metropolis and as such, affects the residents' mobility and accessibility experiences. By implication of this analysis, the regional disparity between Lagos Island and Lagos Mainland undoubtedly manifests in adverse effects of environmental peculiarities in the Metropolis and impactful severely on transportation infrastructure across the Lagos Metropolis. Positively, it creates opportunities for enhancing modal options (water mode) on the island and other coastal areas of the Metropolis towards improving travel time, traffic flow, and journey time. Meanwhile, the environmental peculiarities influenced the cost of travel, threats to life, commuting stress, trip disruptions and cancellations, as well as cost of maintenance and repairs, especially in Lagos Island than the Island areas, while there is longer commuting distance and time in the Lagos Mainland than the Island, hence, the need to revisit transportation infrastructure vis-à-vis environmental peculiarities of Lagos Metropolis. This is as consistent to the findings of 20 and 21on the need for government investment on road infrastructure.

Tab. 4.

Fisher's exact test of environmental peculiarities and transportation infrastructure performance

Transportation infrastructure performance	Ranking	Environmental peculiarities			Fisher's Exact Test		Phi Cramer'V Test	
		5m	38m	Total	Value	Sig.	Val.	Sig.
Travel/commuting time	Very low	51	109	160	49.950	0.000	0.194	0.000
	Low	42	58	100				
	Moderate	48	112	160				
	High	158	297	455				
	Very high	63	326	389				
	Total	362	902	1264				
Cost of travel	Very low	46	79	125	34.123	0.000	0.163	0.000
	Low	13	83	96				
	Moderate	42	135	177				
	High	109	340	449				
	Very high	152	265	417				
	Total	362	902	1264				
Cost of maintenance/ Wear and tear	Very low	48	56	104	27.629	0.000	0.149	0.000
	Low	51	155	206				
	Moderate	26	123	149				
	High	86	234	320				
	Very high	151	334	485				
	Total	362	902	1264				
Disruption of traffic flow	Very low	21	50	71	13.105	0.011	0.099	0.015
	Low	28	131	159				
	Moderate	39	82	121				
	High	136	343	479				
	Very high	138	296	434				
	Total	362	902	1264				

Journey duration	Very low	46	61	107	29.170	0.000	0.152	0.000
	Low	44	167	211				
	Moderate	35	144	179				
	High	124	313	437				
	Very high	113	217	330				
	Total	362	902	1264				
Trip disruption or cancellation	Very low	63	164	227	15.572	0.004	0.109	0.005
	Low	80	203	283				
	Moderate	52	106	158				
	High	132	272	404				
	Very high	35	157	192				
	Total	362	902	1264				
Modal choice capacity	Very low	124	313	437	26.724	0.000	0.147	0.000
	Low	154	398	552				
	Moderate	25	119	144				
	High	35	37	72				
	Very high	24	35	59				
	Total	362	902	1264				
Threats to life	Very low	9	76	85	31.551	0.000	0.153	0.000
	Low	40	149	189				
	Moderate	137	311	448				
	High	81	209	290				
	Very high	95	157	252				
	Total	362	902	1264				
Commuting stress	Very low	0	0	0	21.881	0.000	0.128	0.000
	Low	0	0	0				
	Moderate	11	77	88				
	High	138	252	390				
	Very high	213	573	786				
	Total	362	902	1264				

5. CONCLUSION AND RECOMMENDATIONS

Lagos is facing significant environmental and transportation infrastructure challenges, while the transportation infrastructure performance in Lagos has been a major concern for the residents who have been experiencing various environmental peculiarities, including salinity, large water bodies, and sea level and high-water table, which have greatly impacted their daily lives in all ramifications. For instance, the presence of water bodies and sea level rise has led to flooding, erosion, and early destruction of transportation infrastructure with adverse impacts on the mobility, accessibility and spatial interactions of residents. It is on this basis that this study examined residents' experiences with Lagos' environmental peculiarities and transportation infrastructure performance.

The study, however, observed that the regional uniqueness of Lagos between the Island and Mainland is characterized by its small landmass and aquatic nature as well as other underlying environmental attributes which are associated with coastal settlements across the globe. As a result, the study established that high water table and salinity are salient environmental peculiarities in Lagos Metropolis that significantly affect, influence, and shape residents'

commuting and spatial interaction experiences. These environmental peculiarities have caused damage to transportation infrastructure, disruptions of modal choice operation, commuting stress and a threat to the livelihoods. Therefore, transportation infrastructure performance in Lagos has been subpar, leading to traffic congestion, delays, and accidents leading to the deterioration of the living conditions in Lagos.

Considering the above, the study concludes that environmental peculiarities of Lagos compound commuting stress, speed up the rate of wear and tear of transportation infrastructure, and exacerbate transportation infrastructure performance. As a result, the government, both the Federal and Lagos State Government needs to take urgent action to address these environmental challenges and improve the transportation infrastructure performance in the commercial and industrial nerve center of the country to ensure that residents' needs are met in making Lagos a sustainable and livable city. As such, the government must take action to address environmental peculiarities of the city and also, involve the residents in the decision-making process.

Therefore, the implementation of policies and programmes that promote sustainable transportation infrastructure development, especially intensification of the construction of sea walls to mitigate the effects of sea-level rise, developing new water sources, and improving the public transportation system in the city become indispensable. Moreover, sustenance of collaborations with international organizations and private sectors to fund sustainable transportation infrastructure projects, and the involvement of the residents in decision-making processes are indispensable at improving the environment and transportation infrastructure performance in Lagos.

In other words, relevant stakeholders have to prioritize the development of sustainable environmental and transportation policies and strategies to mitigate the impact of environmental peculiarities such as high water table, salinity, and sea level rise, and also, improving the transportation infrastructure performance in the city through provision of robust drainage systems, incorporating corrosion-resistant materials in transportation infrastructure deployment, and adopting innovative technologies to mitigate the repercussions of rising sea levels on critical transportation infrastructure which enhances its resilience in the face of environmental challenges, provision of more efficient public transportation systems, increased investment in alternative transportation modes such as cycling and walking, and encourage community involvement and response strategies to address the environmental peculiarity induced challenges faced by the residents especially during commuting.

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