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INFLUENCE OF TRANSPORT OPERATIONS ON THE CHANGING LOCAL CLIMATE IN NIGERIA'S SOUTHWESTERN CITIES

Summary. The activities of transport operations exhibit both positive and negative outcomes. Its negative effects on human health and the sustainability of the environment are of interest in this study. As a result, the study investigated the influence of transport operations on the changing local climate in Nigeria's southwestern cities. It investigated motorists' socioeconomic status (SES) and travel characteristics; the salient components of transport operations contributing to greenhouse gas emissions (GHG emissions); the effect of GHG emissions from transport operations on the local climate; transport externalities contributing to local temperature changes; and the effect of GHG emissions from transport

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operations on human health in the research location. This study employed a cross-sectional research design, utilizing systematic sampling to collect 580 copies of questionnaires administered to commercial motorists found in queues across two randomly selected parks in each capital city within the region. Both descriptive and inferential statistics (ANOVA and Linear Regression) were used to analyze the data. The study found that 60% of the motorists were middle-aged (aged between 36 and 45). The majority (70%) drive an average of 100 to 150 km, and premium motor spirit (PMS) is the primary source of energy for 95% of them. The nature and condition of the fuel in use are the top-ranked components of transport operations contributing to GHG emissions. The result of the ANOVA revealed a significant variation among the components of transport operations contributing to GHG emissions ($F = 28.302$, $p = 0.000<0.05$). Meanwhile, the linear regression results indicate that vehicular GHG emissions have a significant impact on the local climate ($F1/578=30.091$, $p=0.000<0.05$). Traffic congestion and bad road conditions were the top-ranked transport externalities contributing to the changing local climate. The most common effects of GHG emissions on human health were headaches and difficulty breathing. Considering these findings, this study suggests the best tactics to lessen the effects of GHG emissions from transport operations, which adversely affect the local climate and human health in the study area.

Keywords: cities, climate change, greenhouse gas GHG emissions, transport, transport externalities

1. INTRODUCTION

Transport is as old as the existence of man. It is inextricably linked to man's historical development, as accessibility and mobility are unquestionably necessary for achieving and satisfying human needs [18, 21]. Transport is a modern civilization's facilitator; it is a catalyst through which any society develops with the desired momentum, and it has played extensive and pivotal roles in the transformation of any economy over time [2]. Salisu [21] opined that the demand for transport, which is a function of human survival and societal interaction, will no doubt remain an increasing and continuous one so long as the earth continues to rotate in its elliptical orbit. Hence, there is no escape from it, as people and goods must move and basic human needs must be sought for; "it is a demand of all demands" [4, 9]. There is no question that the availability, practicality, functionality, dependability, safety, and quality of transport modes are essential to human existence and survival, as well as the sustainability of their surroundings. As a result, it is imperative that communities maintain an effective transport system that will support their social, economic, and environmental sustainability, especially in cities [2, 3, 17].

The contributing effects of transport on economic growth and development are both positive and negative. Studies on the positive effects of transport systems on economic development both in developed and developing nations have been well discussed and established in the literature [1, 2-4, 7, 9, 11, 17, 20]. Of interest to this study is the impact of transport on the changing local climate due to the operational nature of the available transport system. Transport operations, particularly the popular land-based mode, which is commonly used for both non-discretionary and discretionary urban travel, are characterized by noticeable costs, which include but are not limited to increasing levels of motorization and car ownership, environmental damage, deteriorating air quality, crime activities, and urban stress [17, 20]. The consequential effect of the costs, especially the increasing growth of car ownership and motorization levels, undermines the capacity of transport infrastructure and the overall performance of transport systems as car ownership rates are rapidly increasing in developing countries, including Nigeria. Meanwhile, the growing use of automobiles, particularly in Nigerian cities, is accompanied by the government's gradual withdrawal from providing an efficient public transport system, as well as substandard transport infrastructure facilities, a poor administrative and institutional framework for public transport operations, poor network capacity orientation and safety, inadequate public mobility options and operational situations, and poor conditions of public vehicles, leading to basic challenges that cannot be easily managed, such as terrible traffic congestion, environmental degradation, air and water pollution, urban sprawl, and stress.

Accordingly, Gilbert [7] observed that the increasing demands for mobility options along with the attributed challenges of transport operations in cities are the drawback effects of inadequate transport infrastructural provision and development, which consequently affect the social and economic development of cities and the sustainability of the environment. One of the obvious consequences of transport operations that obviously influence the environment is the greenhouse gas emissions (GHG emissions) from the transport facilities, which are becoming unavoidable in most countries, particularly in emerging nations such as Nigeria, where transport externalities are still very high and alarming. The persistent emission of greenhouse gases (GHGs), which include nitrous oxide, carbon dioxide, ozone, methane, and halocarbons, mainly causes global warming and climate change [13]. The climate continues to change because of global warming, with noticeable effects including altered rainfall patterns, rising sea levels, melting ice and snow, and an increase in the frequency and severity of extreme weather events and temperatures [10]. Undoubtedly, GHG emissions from the transport system are the principal causes of the warming of the planet and the changing climate [8, 23]. Sperling and Cannon [23] opined that the transport sector is a major source of GHG emissions as it contributes about one-fourth of global GHG emissions, causing climate change, and the United States takes the lead amongst all other countries in the world in terms of transport-related GHG emissions. According to Chapman [5], transport-related externalities degrade air, water, and soil through vehicular exhaust, hazardous material spillage, soil, and noise pollution from vehicle operations, causing hearing problems and soil contamination, and igniting accident occurrences that result in fatalities or a risk to the lives of passengers and property [6]. Hence, Chapman [5] observed that the overreliance on land transport and increasing consumption and exhaustion of fossil fuels appear to be responsible for the climate's long-term damage across the globe. Nigeria is not exempt from the latter.

Furthermore, Salisu [21] stated that Nigerian cities are seeing a high pace of urbanization, urban expansion, and population growth, together with a rise in the demand for physical mobility and increasing car ownership, without adequate transport institutional framework and administrative capacity to manage the challenges posed by this unprecedented population increase and urbaninsation rate. The consequential effects of unprecedented population increase, unguided urbanization, increasing physical travel demand, and poor transport operations not only pose a serious threat to human health and the sustainability of cities but also exacerbate local climate and degrade environmental resources such as air pollution and heat islands. While unethical and poor transport operational situations, increasing physical travel demand, and human activity primarily through transport, as well as the weak transport institutional framework and administrative capacity, have recently posed a significant threat to climate and environmental sustainability, resulting in environmental stress, increasing the average temperature of the surrounding areas, and further contributing to climate challenges, especially global warming. Regrettably, the accumulation of greenhouse gases in the atmosphere brought on by increasing vehicle combustion and related transport activities is what is responsible for the climatic problems. Several efforts to address climate issues, however, have been of global concern to stakeholders in the transport and environmental management industries, particularly professionals, the government, non-governmental organizations, and others.

Unfortunately, advocacy through empirical studies and measures to address the impact of transport on local climate change in Nigeria is still very low or lagging. Therefore, establishing the influence of transport on the changing local climate and human health, as well as identifying measures to mitigate the negative consequences caused by transport operations in Nigeria's cities, became pertinent and thus formed the focus of this study. Undoubtedly, several studies in the global south have shown much effort (empirical and theoretical) on adaptation of transport infrastructure to the changing climate, mitigation of transport operational risk factors, and strategies for reducing emissions of GHGs, congestion, and crashes through governmental and non-governmental reports and research articles. There is, however, a paucity of empirical investigation into the effect of transport on local climate change in the global north, especially in Nigeria. It is against this backdrop that the study examined the influence of transport on the changing local climate in Nigeria's southwestern cities. To achieve this aim, the following objectives guided the study: examined motorists' socioeconomic status (SES) and travel characteristics; examined motorists' perceptions of the salient components of transport operations contributing to greenhouse gas emissions (GHG emissions); assessed the effect of GHG emissions from transport operations on local temperature or climate; examined the transport externalities contributing to local temperature changes; examined the effect of GHG emissions from transport operations on human health; and examined the measures to reduce GHG emissions from transport operations towards mitigating its devastating effects on our immediate environment and human health. Filling this research gap will advance our understanding of transport and climate change.

2. LITERATURE REVIEW

The intricate relationship between transport operations and the changing local climate in Nigeria's southwestern cities has become a focal point for researchers, given its profound socioeconomic and environmental implications. This literature review, drawing insights from authoritative sources such as ActionAid [24], McCollum and Christopher [12], Nirjar, Jain, and Parida [14], and Ribeiro et al., [19], aims to elucidate the multifaceted impact of transport operations on climate change, encompassing economic, social, and environmental costs, as well as greenhouse gas (GHG) emission reduction, mitigation measures, and climate change adaptation.

Economic, Social, Environmental Impacts of Climate Change:

ActionAid (2006), referenced in [24], sheds light on the economic ramifications of supply and demand fluctuations induced by climate change. Frequent climate-related disasters, like floods, contribute to soil erosion, infrastructure damage, and reduced agricultural output, resulting in food shortages and increased costs for relief, rehabilitation, and pollution management. References [12, 24] underscore the pivotal role consumer behaviour plays in influencing the sustainability of businesses, which is undermined by the effect of climate actions, extending its influence on critical domains such as water availability, ecosystem services, energy supply, and various industries globally. In specific scenarios, climate change can lead to severe environmental consequences, including ecosystem degradation, community devastation, asset loss, disruption of local economies, and mass migrations [10, 24]. Ribeiro et al. [19] highlight that the actions of transport systems significantly contribute to climate change, accounting for 20-25% of global energy consumption and carbon dioxide emissions. Odjugo (2009) cited in reference [15] noted that beyond transport factors, general human factors such as industrialization, technological development, urbanization, deforestation, fossil fuel combustion, etc., and natural factors including solar radiation quality and quantity, the astronomical position of the earth, etc. are significant causes of climate change. The adoption of comprehensive urban planning and the coherent complete street transport model emerge as promising approaches for sustainable urban development, aiming to mitigate GHG emissions, environmental degradation, and social impacts associated with transport-related activities [10, 22].

GHG Emission Reduction, Mitigation Measures, and Climate Change Adaptation:

Studies, such as McCollum and Christopher [12], underscore the role of urban planning in mitigating GHG emissions. Densely populated areas with diverse land uses tend to emit fewer GHG emissions from travel, emphasizing the importance of comprehensive urban planning in reducing environmental impact. Climate challenges persist, with transport-related GHG reductions often deemed more expensive in cities due to factors like low fuel price elasticity, high demand for personal travel, and difficulties in adopting new technologies. Mitigating GHG emissions necessitates strategic interventions, including low-carbon fuels, vehicle efficiency improvements, and travel reduction based on a complete street model [24]. Enhancing vehicle efficiency through incremental vehicle technologies, advanced smart technologies, and improved on-road operating procedures is proposed to achieve comprehensive and rapid reductions [12, 24].

Furthermore, a summary of the literature reviewed highlights the inadequacies of developing countries in planning and implementing resilient and adaptive measures to address global climate change. Adaptation efforts such as the use of infrastructure resilience and community-based resilience methods are adjustment strategies capable of addressing the changing precipitation pattern, potential climate change effects, and the vulnerability of people and natural systems [15]. Designing and constructing transport infrastructure (buildings, roads, and bridges) to withstand extreme weather events and changing climate conditions, implementing measures such as elevated structures, flood barriers, and improved drainage systems to reduce vulnerability, and providing climate-smart agricultural practices, early warning systems, and capacity-building initiatives are major adaptation measures to address climate change [15].

Literature Gap:

Despite the comprehensive insights provided by the existing literature, significant research gaps persist. In-depth studies are needed to explore the nuanced relationship between transport operations and local climate change, utilizing a mixed-methodology approach—specifically, a “survey and observational methodology.” This approach will capture subjective insights from motorists through questionnaire responses, allowing a deeper understanding of their travel behaviours, perspectives on specific components of transport operations contributing to GHG emissions, transport externalities influencing local climate changes, and the health impacts of GHG emissions from transport operations. Concurrently, objective data collection from direct sampling of vehicle parameters is essential to scrutinize the direct effects of GHG emissions on local temperature changes. This research aims to provide a comprehensive understanding of the impact of transport operations on local climate change, which is essential for informed policymaking and sustainable development amidst evolving climate challenges in Nigerian cities.

3. STUDY AREA AND METHODOLOGY

3.1. Study area

Nigeria's southwestern region consists of the six capital cities and states, including Ikeja-Lagos, Abeokuta-Ogun, Ibadan-Oyo, Osogbo-Osun, Akure-Ondo, and the Ado-Ekiti-Ekiti States (Fig. 1). The Southwestern region, which is one of the most prominent geopolitical zones in Nigeria, lies between latitudes 6^{o}N and 81/2^{o}N of the equator and longitudes 3^{o}E and 5^{o}E of Greenwich Meridian Time (GMT), with a total area of 79, 048 sq. kilometres (Fig. 1 and Fig. 2). Specifically, several treaties struck with the local population allowed for the region's inclusion into the British Empire during the final decade of the nineteenth century. The purpose of the incorporation was to give the British complete authority over the region's material and human resources, so they could build significant physical infrastructure. This includes the contemporary transport infrastructure that has taken on the role of the area's original, pre-colonial transport systems. The region is full of transport terminals, networks, and operations, most especially the railroad and maritime transport that began in the area [16]. However, the region is the Nigerian transport hub, with freeways linking it with other areas of the country; one international airport in Lagos; and domestic airports in Ibadan and Akure, aside from seaports in Lagos and inland waterways in the coastal parts of the region [2].

Notable expressways in the region include the Lagos-Ibadan highway, the Ibadan-Ife-Ilesa highway, the Lagos-Ore-Benin expressway, the Ibadan-Oyo-Ilorin expressway, the Lagos-Abeokuta highway, and the Apapa-Osodi expressway, among others. Importantly, the Lagos-Ibadan and Lagos-Abeokuta highways act as interstate highways leading to Oyo State and Ogun State, respectively, and are the main thoroughfares connecting the nation's largest cities. Furthermore, the region has the headquarters of the Nigerian Railway Corporation (NRC), which is in Lagos, and a series of pipelines carrying fluids, gases, and petroleum firms in, within, and outside the cities in the region. Moreover, the Southwestern region is blessed with water bodies that allow for inland water transport operations and maritime or sea shipping businesses, as well as being characterized by both international and domestic airports for inter-city passenger and freight flight services.

3.2. Methodology

This study used a mixed-method research methodology consisting of a cross-sectional survey and an observational method. The combination of this mixed methodology allows for both subjective insights from drivers through the questionnaire responses and objective data collection from the direct observation of vehicle and local climate parameters. The cross-sectional survey was adopted to capture subjective insights from motorists through questionnaire responses, allowing a deeper understanding of their travel behaviours, perspectives on specific components of transport operations contributing to GHG emissions, transport externalities influencing local climate changes, and the health impacts of GHG emissions from transport operations. Concurrently, objective data collection from direct sampling of vehicle and local climate parameters was essential to determine the direct effects of GHG emissions on local temperature changes. However, the nature of the research objectives, the interaction of relevant variables in the research, as well as evidence from the literature reviewed, influenced the choice of a mixed-method research methodology. Both primary and secondary data formed the sources of data used in this study. The primary data employed was a questionnaire survey complemented with field observation involving the use of vehicular emission and local temperature test apparatus. The questionnaire survey was administered to commercial motorists at major parks in the selected cities. The thermometer was used to pick the local temperature, while the emission test apparatus, the "carbon meter," helped to determine the rate of carbon emissions from the sampled vehicles. The secondary data was sourced from both published and unpublished materials, including journal articles, reports, and textbooks.

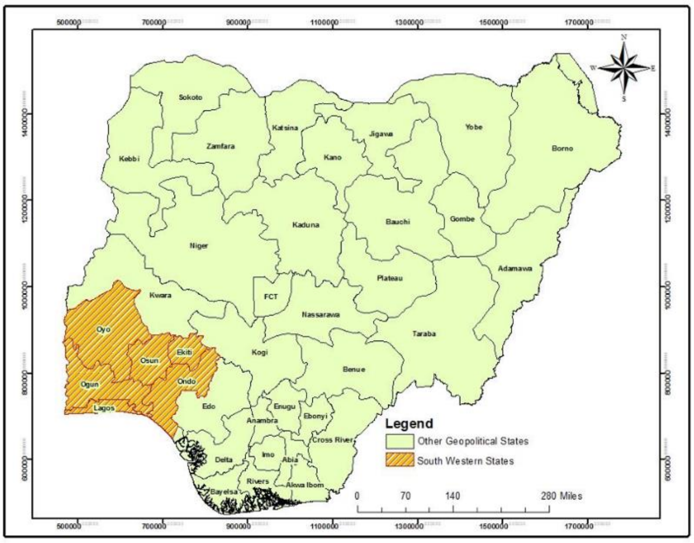

Fig. 1. Nigerian map displaying the Southwestern geopolitical zone (research region)

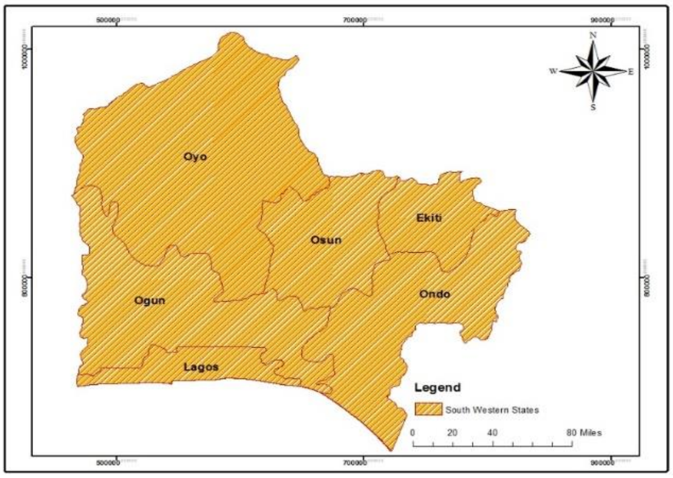

Fig. 2. Map of the Southwestern region

Furthermore, this study adopted a multistage sampling technique comprising random, quota/proportionate, and systematic sampling methods. In the first stage, a random sampling technique was employed to select two major motor parks in each capital city, including Abeokuta, Ado-Ekiti, Akure, Ibadan, Ikeja, and Osogbo. Due to the lack of accurate information on the number of registered commercial motorists with personal vehicles across the selected capital cities, the second stage involved assigning a proportional sample size of fifty (50) to allocate numbers to samples (commercial motorists in their vehicles) in a systematic approach after the selection of the first vehicle and its driver in the queue. In the third stage, a systematic sampling technique was used to select one out of three motorists in their respective vehicles from the queues at the randomly selected motor parks in each capital city based on the allotted numbers. In other words, a total of 600 copies of a questionnaire were administered across the study area, of which 580 copies were completed, representing a 97% response rate (see Table 1). The questionnaire design included both closed-ended and open-ended questions. The Likert scale was majorly considered for the closed-ended questions, while the questions were structured based on the research objectives. Simultaneously, immediately after the completion of the questionnaire administration, emission rates were collected from the 600 vehicles along with local temperature data around the sampled vehicles.

Worthwhile, the gathered data underwent presentation and analysis employing a combination of descriptive and inferential statistical methods. Descriptive statistics utilized frequency and percentage tables along with the Relative Mean Index (RMI). Meanwhile, inferential techniques, including linear regression analysis and Analysis of Variance (ANOVA), were employed to achieve the hypothesized propositions. Linear regression assessed the impact of vehicle emission rates on the fluctuating climate, specifically measured by local temperature. ANOVA was used to determine the statistical variation between the perceived salient factors of transport operations influencing GHG emissions in the selected cities. In other words, the Relative Mean Index (RMI) used for presentation and analysis relies on data collected through Likert's scale using a four-point grading system of Strongly Agree, Agree, Disagree, and Strongly Disagree. The process of estimating the RMI is presented as follows:

i. Each evaluation was given a weighted value of 4, 3, 2, and 1, correspondingly, indicating strong agreement, agreement, disagreement, and strong disagreement.
ii. The addition of the product of the response for each variable rating and its corresponding weight value was used to calculate the weighted value of SWV as a sum. Thus, the mathematical expression is:

$$\mathbf{SWV} = \sum_{i=1}^{4} X_i Y_i \tag{1}$$

Where:
SWV = Summation of Weight Value,
X_i = number of participants rating i to a specific metric
Yi = the weight value that every metric has been allocated (i = 1, 2, 3, 4).

The Mean Index Value [MIV] is calculated by dividing the sum of RIM by the number of variables studied, whereas the Relative Mean Index [RMI] for each variable was determined by dividing the SWV by the total number of replies. Unless stated otherwise, a higher RMI corresponds to a better level of efficacy for the variable being examined. This can be stated quantitatively as:

$$\mathbf{RMI} = \frac{SWV}{\sum_{i=1}^{4} X_i} \tag{2}$$

In other words, to run the inferential statistics analysis, the collected data was transformed into a dichotomous form of binary digits 0 and 1 and presented as "Strongly Agree" or "Agree" =1 and "Strongly Disagree" =0. This transformed data of the indicators of transport externalities (independent variables) was regressed with the local temperature rate (dependent variable) as well as used to transform the salient factors of the transport operation contributing to GHG emissions into dichotomous form and used for the test of the postulated hypotheses. However, version 21 of the Statistical Package for Social Sciences (SPSS) software was used to do both the data presentation and analysis.

Tab. 1

Sample Size and Response Rate of the Respondents (Motorists)

Southwest capital cities	Proportional sample size	Response rate
Abeokuta	100	100
Ado-Ekiti	100	94
Akure	100	96
Ibadan	100	100
Ikeja	100	100
Osogbo	100	90
	600	580 equivalent of 97%

4. RESULTS AND DISCUSSION

4.1. Motorists' Socioeconomic Status (SES) and Travel Characteristics

The results of the data gathered and analyzed on the socioeconomic status of the respondents "motorists" are presented in Table 2. The findings revealed that the respondents were mostly male (96%), while 4% of the respondents were female. The vast majority (60%) are between the ages of 36 and 45; they are a middle-aged and active economic group. In addition, over three-quarters (75%) are married, 90% have a formal education, and the remaining 10% have no formal education. It's worth noting that the vast majority, 75%, are owners of the vehicles used for commercial transport services. The majority (80%) earned between $100,000 and $150,000 monthly from the transport business, while 90% of the respondents indicated that they were full-time commercial drivers. Worthwhile, 60% have between 4 and 6 people living in their household, and a majority of 70% have more than one wife. In other words, most (70%) run intra-city transport services and cover an average of 150 kilometers of trips per day (70%). Significantly, 95% of the respondents use Premium Motor Sprit (PMS) as a type of fuel for commercial transport services, which indicates the dominance of the use of PMS in the study area and obviously may contribute to the GHG vehicular emissions. The majority (80%) of the motorists operating during peak hours consumed over 40 liters of PMS depending on the daily traffic situation. In the categories of vehicles owned and used for commercial services, the majority (70%) of indicted Toyota products include the Liteace, Sienna, Coaster, and Picnic. Findings also revealed that most (75%) of the vehicles owned are secondhand (Tokunbo), meaning the respondents are not the first users. Meanwhile, 70% of the respondents revealed that their vehicles have spent over 5 years with them. Regarding the frequency of maintenance, the majority (70%) indicated they engaged in monthly scheduled service maintenance due to the kilometers traveled.

Tab. 2

Motorists' Socioeconomic Status (SES) and Travel Characteristics

Gender Structure			**Age Classification**		
Nature	Frequency	Percentage	Range	Frequency	Percentage
Female	23	4.0	18-25	52	9.0
Male	557	96.0	26-35	87	15.0
Total	580	100.0	36-45	348	60.0
Marital Status			46-60	93	16.0
Status	Frequency	Percentage	Total	580	100.0
Single	87	15.0	**Educational Attainment**		
Married	435	75.0	Level	Frequency	Percentage
Others	58	10.0	No formal education	58	10.0
Total	580	100.0	Primary	87	15.0
Occupational Status			Secondary	377	65.0
Nature	Frequency	Percentage	Tertiary	58	10.0
Full-time motorist	522	90.0	Total	580	100.0
Part-time motorist	58	10.0	**Average Monthly Income**		
Total	**580**	100.0	Range	Frequency	Percentage
Ownership of the Vehicle			Below #50,000	29	5.0
Ownership	Frequency	Percentage	#50,000-#100,000	58	10.0
Yes, I am the owner	435	75.0	#100,001-#150,000	464	80.0
No, I operate on hire services	145	25.0	#150,001-#200,000	29	5.0
Total	580	100.0	Total	580	100.0
Nature of Transport Services Rendered			**Household Size**		
Number	Frequency	Percentage	Number	Frequency	Percentage
Intra-city	406	70.0	1-3	174	30.0
Inter-city	174	30.0	4-6	348	60.0
Total	580	100.0	Above 6	58	10.0
Daily Travel Distance			Total	580	100.0
Length	Frequency	Percentage	**Number of Spouse**		
Less than 100km	116	20.0	Number	Frequency	Percentage
100 to 150 km	406	70.0	One wife	174	30.0
Above 150km	58	10.0	More than one wife	406	70.0
Total	580	100.0	Total	580	100.0

Rate of Daily Energy Used			**Type of Fuel/Energy Used**		
Volume	Frequency	Percentage	Type	Frequency	Percentage
Less than 20 liters	29	5.0	PMS	551	95.0
20 to 40 litters	87	15.0	Diesel	29	5.0
Above 40 liters	464	80.0	Electricity/Solar	0	0.0
Total	580	100.0	Total	580	100.0
Brand of Vehicle Used for Transport Services			**Category of Vehicle Used for Transport Services**		
Brand	Frequency	Percentage	Category	Frequency	Percentage
Toyota products	406	70.0	Brand-New	29	5.0
Nissan products	70	12.0	Secondhand (Tokunbo)	435	75.0
Mazda products	58	10.0	Third User (Nigeria)	116	20.0
Mercedes products	29	5.0	Total	580	100.0
Others products	17	3.0	Frequency of Vehicle Maintenance		
Total	580	100.0	Period	Frequency	Percentage
Age of Vehicle			Weekly	29	5.0
Age	Frequency	Percentage	Monthly	406	70.0
Less than 5 years	174	30.0	Quarterly	116	20.0
Above 5 years	406	70.0	Twice a year	29	5.0
Total	580	100.0	Total	580	100.0

4.2. Salient Components of Transport Operations Contributing to GHG Emissions

Table 3 reveals the results of the analysis on motorist perceptions of the salient components of transport operations that contribute to the GHG emissions and changing local climate across the study area, using the Relative Mean Index (RMI) and Mean Index Value (MIV). Findings revealed that the vehicular energy type, or source of energy, is the predominant component contributing to greenhouse gas emissions (3.9347). This finding is corroborated by the fact that the majority of respondents (95.0%) rely on premium motor spirit (PMS) over other energy sources for commuting services in the study area. The factors that placed second, third, fourth, and fifth, in order of precedence, were journey time (3.6134), vehicle engine condition (3.5206), road condition (3.5223), and travel distance (3.3789). In the research area, vehicle condition was shown to be the least significant contributor to greenhouse gas emissions. Considering this, the findings showed that 50% (5 out of 10) of the transport system's source variables scored higher than the MIV of 2.9387.

Tab. 3

Salient Components of Transport Operations Contributing to GHG Emissions

Transport Sources of Greenhouse Gases Emission	SD	D	N	A	SA	TWV	RIM	MIV	RK
Vehicle engine condition	21	80	408	1540	0	2049	3.5206		4
Nature and condition of engine oil for vehicle servicing	258	298	207	380	55	1198	2.0584		9
Traffic control devices and officers	344	180	33	104	555	1216	2.0893	2.9387	8
Vehicle condition	273	340	237	240	0	1090	1.8729		10
Nature and consumption of energy/fuel in use	67	0	0	1944	145	2290	3.9347		1
Vehicular fuel system	186	232	267	652	140	2049	2.5378		7
Nature of road condition	135	28	843	408	250	1198	3.5223		3
Vehicular engine size/capacity	61	242	162	368	1270	1216	2.8591		6
Travel time	135	290	612	236	195	1090	3.6134		2
Total distance travelled	18	292	357	784	515	2290	3.3789		5

4.2.1. Hypothesis testing

Hypothesis One (*H_0: There is no statistical variation among the salient components of transport operations contributing to GHG emissions*)

Further investigation was conducted using ANOVA to determine whether there is a statistical variation among the salient components of transport operations contributing to GHG emissions. The result of the ANOVA shows that there is a statistically significant variation among the salient components of transport operations that contribute to GHG emissions in the study area.

Tab. 4

Tests of Between-Subjects Effects (where or not there is a statistical variation among the salient components of transport operations contributing to GHG emissions)

Source		Type III Sum of Squares	Df	Mean Square	F	Sig.
1	Intercept	15.255	I	.401	30.091	.000
	Error	16.343	579	.013		
	Total	31.599	580			

4.3. The Effect of the Vehicular Greenhouse Gas Emissions on Local Temperature or Climate

Table 5 presents the result of the vehicle's GHG emissions on the local temperature or climate. Descriptively, the results presented in Table 5 show that 15.0% of the respondents run emission tests on their vehicles annually, 5.0% run emission tests on their vehicles once in the last 5 years, and 80.0% of the respondents have never conducted or run emission tests on their vehicles. By implication, the majority (80.0%) of motorists are carefree about the emission status of their vehicle and thus not worried about the extent to which their vehicle operation affects or pollutes the local climate.

Tab. 5

Frequency of theVehicle Emission Test

Frequency of emission test	Frequency	Percentage
Annually	29	15.0
Once in the last 5 years	87	5.0
Never run emission test	464	80.0
Total	580	100.0

4.3.1 Hypothesis Two *(H_0: Vehicular GHG emissions does not statistically influence local temperature or climate)*

Further investigation was conducted in order to better understand the statistical effect of vehicle GHG emissions on local temperatures or climate. A vehicle emission test was conducted on 580 vehicles and their local temperature was picked simultaneously. The independent variable "the vehicle GHG emission (g)" was achieved through the vehicle emission test conducted on the vehicles, which was done using the carbon meter to track the carbon emitted by a vehicle, which is equivalent to the measure of greenhouse gas. While the dependent variable "changing local climate" was measured by the temperature of the vehicles sampled across the study area, the analysis was conducted using linear regression, and the result is presented in Table 6. The outcomes depicted in Table 6 display the "R" value, serving as the linear regression correlation coefficient, gauging the accuracy of predicting the dependent variable "local temperature change." With a value of 0.795, it indicates a commendable level of prediction. The R square (R2) value, denoting the coefficient of determination, stands at 0.685, implying that 68.5% of the variability in the dependent variable (local temperature or climate) can be elucidated by the independent variables. Simultaneously, the adjusted R square (Adj. R2) is 0.667, signifying that the model's accuracy of prediction accounts for 67%.

Examining the F-Ratio in the ANOVA, which assesses the overall significance of the regression model's fit for the regressed data in Table 4.8, the findings disclose $F^{1}/_{578}$= 30.091, with a significant p-value of 0.000. In comparing the ANOVA results, it is evident that both the observed and calculated p-values are less than the table p-value of 0.05 (p 0.005). Consequently, there is unanimous agreement to accept the alternative hypothesis (H1) and reject the null hypothesis (H0). This implies that the vehicle's GHG emissions statistically influence the local temperature or climate.

Tab. 6

Model summary of the linear regression
(effect of vehicle GHG emissions on the local temperature or climate)

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.795[a]	.683	.667	.11550

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	15.255	1	.401	30.091	.000[b]
	Residual	16.343	578	.013		
	Total	31.599	579			

4.4. Transport Externalities Contributing to Changing Local Climate/ GHG Emissions

Significantly, transport operations are accompanied by several externalities that contribute to the changing local climate and GHG emissions. In a bid to comprehend the impact of transport externalities on greenhouse gas (GHG) emissions in the research area, Table 7 elucidates the specific external factors associated with global warming and GHG emissions. It is notable that respondents assessed twelve identified transport externalities, and the resulting analysis is presented. Notably, the analysis disclosed that 75% (9 out of 12) of the transport externalities scored above the Mean Importance Value (MIV) of 2.926. Traffic congestion (3.5670), poor road conditions (3.4038), suboptimal energy/fuel and engine oil conditions (3.3213), inadequate vehicle maintenance (3.2285), unregulated logistics functions (3.2268), and insufficient road capacity (3.2285) emerged as the predominant contributors to greenhouse gas emissions in the research area. In other words, the weak institutional framework and performance of the transport administrators ranked the least.

Tab. 7

Transportation Externalities Contributing to Changing Local Climate/ GHG Emissions

Externalities	N	R	S	A	TWV	RIM	MIV	RK
Unguided logistics functions	4	208	690	976	1878	3.2268	2.9465	6
Over-dependency on automobile usage	27	920	189	128	1264	2.1718		12
Poor condition of energy/fuel and engine oil in use	11	168	582	1172	1933	3.3213		3
Traffic congestion	0	118	402	1556	2076	3.5670		1
Weak institutional framework for transport management	43	186	171	15	1956	2.2608		11
Poor condition of the vehicle in use	14	266	423	1176	1879	3.2285		4
Weak traffic and transport policy implementation	187	156	0	1276	1617	2.7784		8
Bad road situation	18	128	495	1340	1981	3.4038		2

Absence of non-motorized transport facilities	17	742	135	596	1490	2.5601		10
Unguided traffic operation and trip distance	4	208	690	976	1878	3.2268		4
Poor road capacity	14	266	423	1176	1879	3.2285		6
Excesses by traffic officers and poor traffic control devices	187	156	0	1276	1617	2.7784		8

4.5. Effect of GHG Emissions from Transport Operations on Human Health

It is worth knowing that the externalities from transport operations, particularly the GHG emissions, have been found to have a negative impact on human and public health. The concern in this study is the effect of GHG emissions from transport operations on human health. Table 8 presents various health-related issues that are perceived to be caused by GHG emissions, such as headaches, body aches, difficulty breathing, asthmatic attacks, heavy eyes, a runny nose, difficulty sleeping at night due to underlying health conditions, and other internal medical diseases or health problems such as congestive heart failure, anxiety, etc. Findings revealed that a majority of over 60% (5 of 8) of the health issues ranked above the Mean Index Value (MIV) of 3.3926. This indicates that five (5), including headache (3.7629), difficulty breathing (3.6426), body ache (3.6065), asthmatic attack (3.4605), and heavy eyes (3.4605), which ranked first, second, third, and fourth, respectively, are the most experienced health problems impacted by GHG emissions from transport operations. In other words, GHG emissions had the least impact on running noses and other internal medical diseases.

Tab. 8

Effect of GHG Emissions from Transport Operations on Human Health

Nature of consequences	SD	D	A	SA	TWV	RIM	MIV	RK
Headache	14	38	174	1964	2190	3.7629	3.3926	1
Body ache/ tiredness	35	76	144	1844	2099	3.6065		3
Asthmatic attack	34	80	396	1504	2014	3.4605		4
Difficulty breathing	12	16	468	1624	2120	3.6426		2
Heavy Eyes	34	80	396	1504	2014	3.4605		4
Runny nose	36	174	807	760	1595	2.7405		7
Difficulty sleeping at night due to an underlying health condition	24	324	309	1172	1829	3.1426		6
Other internal medical problems such as congestive heart failure, anxiety, etc.	36	174	807	760	1595	2.7405		7

4.5.1. Frequency of Medical Treatment due to Exposure to GHG Emissions and Percentage of Income Spent on Medical Treatment

Respondents' views on the frequency of medical checkups and treatment at medical facilities due to exposure to GHG emissions from transport operations were also sought in this study. Table 9 reveals the varied periods as indicated by respondents based on their involvement in transport operations, particularly the hours spent while driving. The majority (52%) of the respondents indicate that it is difficult to estimate the frequency, hence opting for it whenever they feel like it or there is a need for it. Those who indicated quarterly accounted for the least percentage (2.8%).

Tab. 9

Frequency of Medical Treatment due to Exposure to GHGs Emission

Frequency	**Frequency**	**Percent**
Daily	121	21.9
Weekly	90	15.5
Monthly	51	8.8
Quarterly	16	2.8
Whenever I feel like	302	52.0
Total	580	100.0

Similarly, the study also sought from the respondent the percentage of monthly income spent on medical treatment due to the exposure to GHG emissions from transport operations. It is worth knowing that Table 10 revealed that the majority (50.0%) of the respondents do spend between 10 and 20 per cent of their monthly income on medical treatment. This is followed by 21 to 30 per cent (20.0%), while three per cent (3%) of the respondents do spend above 50%. This may be the result of an underlying health condition.

Tab. 10

Percentage of Income Spent on Medical Treatment due to Exposure to GHG Emissions

Frequency	**Frequency**	**Percent**
Less than 10%	58	10.0
10% -20%	290	50.0
21% - 30%	116	20.0
31% - 40%	41	7.0
41% -50%	29	5.0
Above 50%	17	3.0
Total	580	100.0

4.5.2. Measures to Reduce GHG Emissions from Transport Operations

Transport operations in developing countries, particularly Nigeria, are characterized by a number of externalities, including GHG emissions, as a result of underlying issues such as poor administrative functional configuration, institutional framework, and policy implementation. This has a general impact on the performance of the transportation system as well as its unprecedentedly high contribution to public health pollution; as a result, efforts to minimize or eliminate this menace should be accelerated across Nigerian cities, particularly the capital cities. In a bid to understand the measures possible to address this identified menace, this subsection investigated the effective measures to reduce the GHG emissions associated with transport operations in the study area (Table 11). Results in Table 11 show that a majority of over 70% (5 of 7) of the measures ranked above the MIV of 3.3926, indicating effective ways of reducing GHG emissions from the poorly regulated transport operations in the study area. Specifically, measures such as the need to strengthen the awareness campaign (3.7629), the establishment of a periodic advocacy programme (3.6426), strengthening vehicle service maintenance and strengthening the implementation of transport policy (3.6065), and strengthening the implementation of standards for automobile industries (3.4605) were ranked first, second, third, fourth, and fifty-first, respectively.

Tab. 11

Measures to Reduce GHG Emissions from Transport Operations

Measures	SD	D	A	SA	TWV	RIM	MIV	RK
Strengthening the awareness campaign	12	38	174	1964	2190	3.7629	3.3926	1
Establish a periodic advocacy programme	10	16	468	1624	2120	3.6426		2
Strengthening vehicle service maintenance	33	76	144	1844	2099	3.6065		3
Strengthening the implementation of standards for automobile industries	32	80	396	1504	2014	3.4605		4
Provision of test facility centers with affordable corrections materials	22	324	309	1172	1829	3.1426		5
Implementation of the transport policy	33	76	144	1844	2099	3.6065		3
Strengthening the provision and use of alternative energy vehicles, e.g., electric cars and buses	34	174	807	760	1595	2.7405		6

5. CONCLUSION AND RECOMMENDATIONS

The prevalent surge in accessibility and mobility needs for both individuals and freight, coupled with the inadequate state of technologically advanced transport infrastructure and the government's lackluster approach at federal, state, and local levels to provide consistent and quality public transport systems, has resulted in increasing car ownership, the widespread use of vehicles dependent solely on fossil fuels, and excessive reliance on road modes in Nigerian cities. This dependence, during operations, leads to the release of greenhouse gases (GHGs) into the environment, exerting adverse effects on the climate. The lifestyle and behavioral patterns of motorists, particularly in the utilization of personal vehicles for daily transport and logistics, significantly contribute to the excessive release of CO_2 into the environment. This, in turn, manifests in noticeable variations in temperature, precipitation, radiation, and wind speed in urban areas.

Given the indispensable role of transport operations in socio-economic activities and national development, it is imperative to ensure that these operations align with environmental norms to mitigate the adverse impacts that have contributed to recent climate change. The urgent need to mitigate the existing global warming and address climate challenges resulting from escalating transport activities, along with the quest to reduce excess CO_2 in Nigerian cities, underscores the importance of continuing advocacy and strategic planning of the transport system. In light of these considerations, the study investigates the influence of transport on the evolving local climate in Nigeria's southwestern capital cities. The findings reveal that the impact of the local climate changes induced by transport operations is extensive and obvious across the sampled capital cities, adversely affecting the quality of life, socio-economic functions, and overall sustainability of the cities. To curtail the contribution of transport operations to greenhouse gas emissions and mitigate their adverse effects on local climate and health in the study area, the study proposes the following recommendations:

- The need to strengthen the awareness campaign through the establishment of a periodic advocacy programme for motorists not only in the capital cities but across all urban areas within the southwestern part of Nigeria.
- The need to strengthen vehicle maintenance services and the implementation of transport policy. Motorists need to be educated on the importance of periodic and regular vehicle maintenance services, particularly for their health. Meanwhile, there should be provisional test centers with strict policy implementation.
- In the automobile transport industry, there should be strict adherence to standards in facility provisions and operations.
- There is a crucial need to strengthen the adoption and provision of conventional mass public transport systems, particularly electric or solar-powered vehicles like trolleybuses, trams, and light rails, especially for intercity operations.
- Simultaneously, there is a pressing need for an effective and formidable transport institutional and administrative framework with policies to effectively regulate transport operations and curb greenhouse gas emissions from transport operations. These mitigation strategies encompass demand-side initiatives aimed at minimizing physical movement through thoughtful complete street models and inclusive land use planning, implementing user fees for parking, and enforcing fuel taxes. These complementing supply-side initiatives that involve deploying energy-efficient and dedicated mass transit systems for the public and coordinating land use with transport services will lessen environmental degradation and climate challenges and promote sustainable development in the study area and areas with similar challenges.

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