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Atmospheric Emissions in Nigeria in the Aftermath of COVID-19: A Carbon Foot Print Perspective

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Abstract:

Carbon foot print inclusive, life style changes forced by the covid-19 pandemic has both immediate and long-time effect on diverse facet of human endeavors. Towards quantifying this, secondary emission data was relied upon for time series analysis that showing an increasing trend in emission, further, primary data was obtained via survey procedures for correlation analysis, the result indicates that emissions increase do not necessarily imply to an increase in carbon foot print, as most variables understudied returned a p-value showing disagreement with this assertions, for example, working from home has a significant correlation with spending on transportation with an effect size of .288*and a p value of .022, so also is earnings/income at .260*and a p-value of .039, product reuse and recycle at .484** and a p-value of <.001, Willingness to use alternative energy has increased by an effect size of 266 at p .035 level of significance, indicative of a positive decrease in carbon footprint, in contrast the use of charcoal/fuelwood which has increased post covid-19 with an effect size of 470** p <0.001, patronage of processed product has also increased with an effect size of 325 p .009, as Energy savings and management reduced in post covid-19 period at an effect size of 097 and a p .450 level of significance, with reduced patronage of organic products at an effect size of .096 and a p value of .452 significance. Suggesting that advocacy and public enlightenments is needed to reduce carbon footprint through lifestyle changes related to these aspects. In conclusion the carbon foot print in Nigeria post covid-19 is not Business as usual, total emissions by volume might have increased but some life style changes have significantly reduced individuals carbon footprint. Without which the emissions would have compounded.

Keywords: *Business as Usual. Transboundary Emissions. Time Series Analysis. Feedback Effect. Confounders*.

1 Introduction

As at April 2024, Nigeria has recorded a total of 267,188 cases of Corona virus, with 3,115 deaths and 259,593 recoveries (Nigeria Center for Disease Control and Prevention NCDC 2022). While its impact was easily quantifiable in economic terms, quantifying changes in carbon footprint became fuzzy, partly because emission data collection was hampered by the restrictions accompanying these periods, and there are direct and indirect sometimes synergetic relationship between aspects of lifestyle changes relative to energy choice and uses. In this respect, there is a paucity of the post pandemic scientific literatures accounting these changes in Nigeria.

A methodology relying on the energy utilization and consumptions towards the production of finished products is deemed insufficient in defining carbon footprints, rather the cradle to grave approach which includes: the sourcing of raw materials and its transportation to and from the factory, must be accounted for in reference to energy expended in doing so. Hence, carbon footprint is not limited to individuals' patronage of industrial products, rather it entails the entire aspects of individuals livelihood, including domestic energy needs, commercial needs and transportation needs etc. all of which has a direct positive correlation with the economy (Han *et al.*, 2022).

According to Lu *et al.,* (2021) higher carbon footprints are a testament to an increased industrial activities and consequent higher atmospheric emissions. The correlation between economic productivity and atmospheric emission is one of a higher positive direction (Statistics Canada & Wang, 2022). Though it is well documented that the Covid-19 Pandemic was accompanied by a

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clearer and cleaner atmosphere resultant of the abysmally low and often a halt in industrial activities, coupled with plenty travel cancelations resultant of the travel restrictions, all aimed at combatting the spread of the disease (Ronaghi & Scarsone 2023).

The direct impact of poor air quality on human health and the indirect impact on human support system or livelihood through increased foot prints and consequent climate change has been an undisputed fact of the 21st century. The picture in the aftermath of Covid-19 pandemic is still an ongoing debate and there is need to articulate this at the local level in Nigeria. The Twin feedback effect of emission exacerbating climate change and vis-à-vis climate change to emissions is undisputed (Bajzelj & Richards 2014).

For instance, respiratory illnesses were expected to reduce during the Covid-19 pandemic, but it is hard to conclude if this was resultant of a cleaner atmosphere consequent of lower emissions, owing to the nature of the virus having a high affinity towards attacking the respiratory system of humans (Costa & Bortoli, 2022). Obviously, the pandemic took a toll on emission records, blamed on man hour lost, as the record harvesting systems in most developing countries are not automated.

The time series analysis could surface in establishing a useful trend for long time data extrapolation and forecasts, but its inability to factor life style changes related to the Pandemic as it relates to decrease or increase in carbon footprint makes it a fallacy. On the other hand, remote sensing capabilities and satellite imagery techniques for monitoring atmospheric air quality, as commonly used in the aviation and travel industries, is usually very expensive to generate, requiring advanced technical capabilities and expertise, which is inadequate and insufficient in the third world (Tikader *et al*., (2024) Costa & Bortoli, (2022).

Further, the nature of atmospheric emissions been transboundary as to localized, jeopardizes the possibility of accounting for source, especially for long historic data. Moreover, the risks of changing environmental and social variables acting as confounders also makes it difficult to establish a course effect relationship (Thompson *et al.*, 2014). Consequently, this study obtains a primary data using a survey technique, capturing those changes and effect that preceded the pandemic as it relates to energy consumption pattern and lifestyle changes, towards correlating with the secondary data on emissions, upon determining its growth rate and extrapolating well into the post Covid-19 periods, assuming business as usual.

While some researchers are of the opinion that productivity is accelerated to make up for the losses during these periods, others believe some cutting edge innovation accompanying the Covid-19 era was retained well into the post Covid-19 era, such as: the work from home initiative and the digital/e-learning propagation (Arsad *et al.*, 2023 Verma *et al*., 2021). Whatever the assertion might be, its impact on emissions is certainly one of either a reduction or an increase in emission rates and needs to be resolved Verma *et al*., (2021) & Inegbedion, (2021a).

2 Materials and Methods

2.1 Study Area and Subject Selection

Two States were chosen for the purpose of this study, merited for their high population, industrialization and commerce, namely Lagos in south western Nigeria and Kano in north western Nigeria Inegbedion, (2021b) & Elimian *et al.*, (2022). This Two States have a population of **15,772,884** and **16,253,549** respectively as at 2023 (National Population Commission NPC, 2020). With a corresponding covid-19 incidence rate of 103,931 and 5,333 respectively NCDC (2022). Figure 1, depicts the location of the study area.

2.1.1 MAP OF STUDY AREA

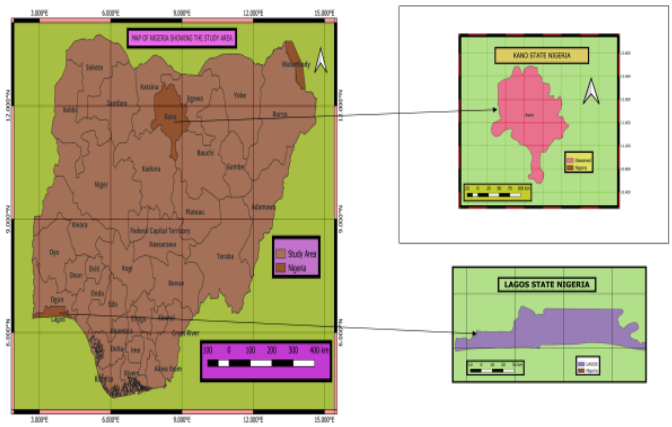

Figure 1: Map of Nigeria Showing Kano and Lagos State.
Source: Digitized by Author using QGIS 3.38 (2024).

2.2 Research Design and Instrument

A longitudinal research design was adopted, both primary and secondary data were used for the study purpose, whereas emission records was obtained from the National Atmospheric Agency website forming our secondary data (Rafferty 2024). Primary data were obtained using a survey technique, relying on a well-structured close ended questionnaire designed in 3 parts, to capture information about socio demographic characteristics, covid-19 induced socio-economic related life style changes, and Covid-19 influenced changes in energy consumption pattern.

A sample size of 384 respondents were administered the questionnaire, relying on Krejcie and Morgan (1970) Sample size table for finite population, specifying that for a population above 100000, a sample size of 384 is adequate.

The questionnaire was designed, administered and retrieved online, the simple random sampling techniques was favored for this. In a pilot study conducted in Gombe State, North Eastern Nigeria, the designed instrument was initially pre-tested in 10% population of the sample size for reliability coefficient, using the Cronbach Alpha test on the Statistical Package for Social Sciences software (SPSS) version 29 for internal consistency, which returned a test value of 78.8 % from Table 1. which is well in range of the acceptable limits as suggested in (George & Mallary, 2003).

A total of 15 questions were asked, 5 for section 1, and 10 for section 2, with 5 questions for parts A and B respectively. The socio-demographic characteristics including gender, age, education, marital status, occupation, and gross monthly income, 5 questions were asked to ascertain the direction of the covid-19 induced socio-economic related life style changes, using a 4-point Likert scale, while 5 questions were also asked to determine the direction of the Covid-19 influenced changes in energy consumption pattern also on a 4-point scale.

Table 1. *Reliability Statistics*

Cronbachs Alpha	N of Items
.787	10

2.3 Data Analysis, Results and Discussion

Emission data needed to undergo a time series analysis as records were limited to 2016 data, A time series analysis was implemented to determine the emission level, assuming the effect of covid-19 didn't matter. While a chi square analysis was implemented on the primary data to determine how the respondent fared on issues associated with carbon footprint change relying on their life style changes.

Result of the time series analysis depicted graphically in figures 2 and 3, as plots of original data and extrapolated otherwise forecasted to the present i.e. 2023 respectively, using SPSS 29, while adhering to the rule that limits extrapolation to exclude the current year in question 2024. Both graphs show an increasing trend in emission levels, but not accounting for the impact of covid-19.

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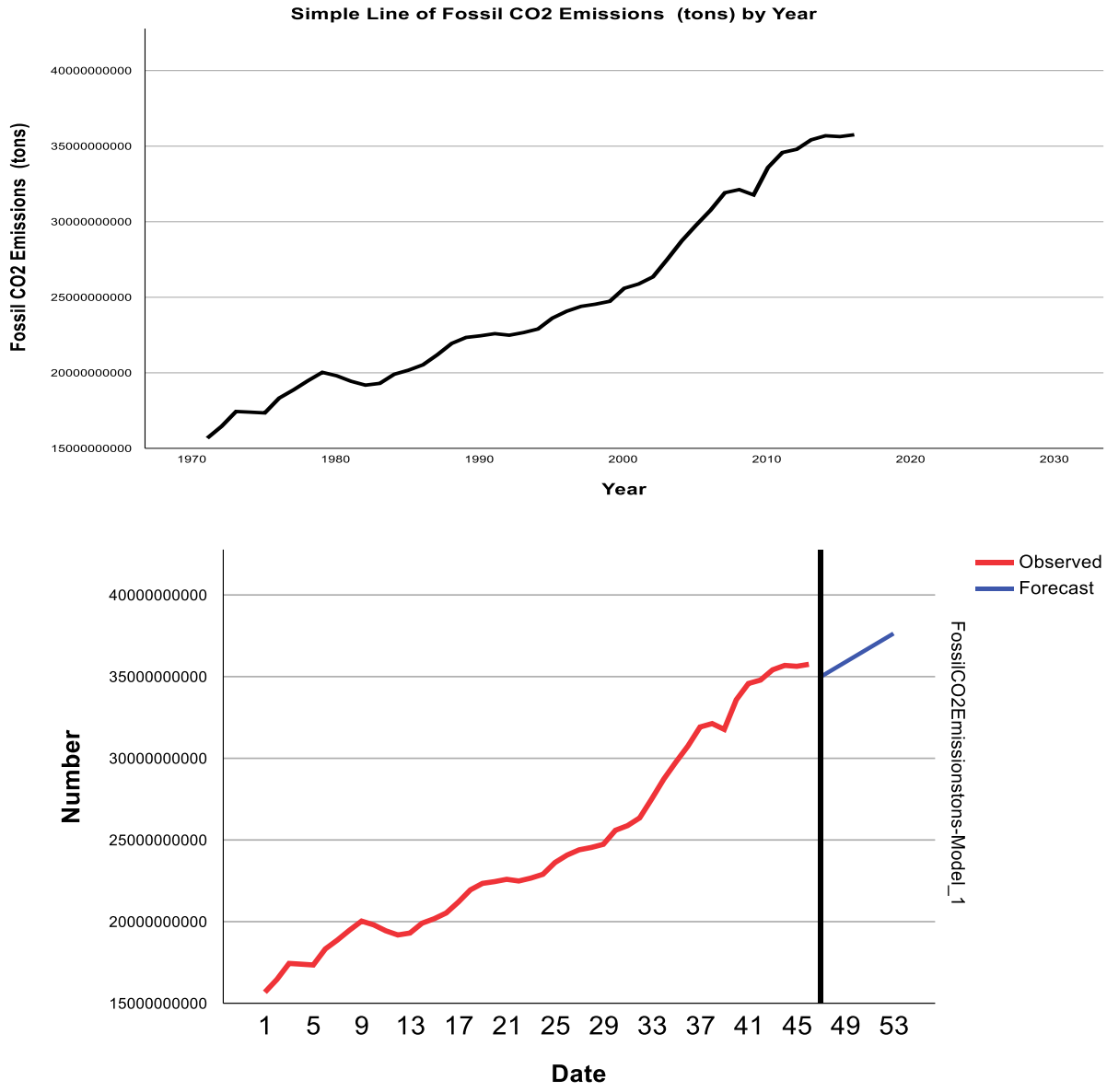

Figure 3: Forecasted Time Series Line Graph 2017-2023

The model summary for the above graphs returned in Table 2, shows an $F_{(1)} = .493$ $P < .001$ $R^2=0.994$. At α .05 confidence level the emission data was able to account for 99.4% rate of change in carbon emission.

Model	Number of	Model Fit statistics	Ljung-Box Q(18)	Number of

	Predictors	Stationary R-squared	R-squared	RMSE	Statistics	DF	Sig.	Outliers
Fossil CO2 Emissions (tons)-Model_1	1	.944	.944	1457175134.493	223.574	18	<.001	<.001

Table 2: Model Statistics

Further, **Tables 3 and 4** is summary output of correlation matrix, towards determining the performance of selected variables of emissions otherwise carbon footprint, against life style changes attributed to the Covid-19 pandemic, like the work from home and transport restrictions, as it affects personal earnings and economic choices related to energy and production.

Further, **Tables 3 and 4** is summary output of correlation matrix, towards determining the performance of selected variables of emissions otherwise carbon footprint, against life style changes attributed to the Covid-19 pandemic, like the work from home and transport restrictions, as it affects personal earnings and economic choices related to energy and production.

At rho .288*and a p-value of .022 there exist a significant high positive relationship between working from home and spending on transportation, but the spending is today higher in comparison to the pre-pandemic periods, earnings/income at .260*and a p-value of .039 are lesser, product reuse and recycle at .484** and a p-value of <.001 is greater, with reduced use of charcoal/fuelwood at .470** p-<0.001. but the effect size wouldn't count for purchase of processed goods with a p-value greater than the test value returned as .324, also patronage of processed product is more in comparison to the post covid-19 period, also more energy saving practice is implemented now as to the pandemic period returning a p-value of .349, willingness to use alternative energy has also increased having a p-value of .146, while patronage of organic products is lesser in comparison to the post covid-19 era with a p-value of .093.

It was concluded that with reduced income, lesser use of fuel wood, reduced rate of recycling, greater willingness for green energy, the carbon footprint will be reduced due to reduced associated emissions. While increase in purchase of process goods and decrease in that of organic products should increase emissions, it is insufficient to counter the very many emission decreases. Though transportations spending's might be higher the removal of subsidy and increase cost of fuel is to be blamed, not necessary translating to increase transportation activities that do the actual emissions.

Table 3. Summary Correlation Matrix: for respaces of how Working from home against some Determinants understudied Carbon Footprint Post-Covid-19 vs Between Pre Covid-19

	Spearman's rho	Sig (2-tailed)	Decision
Spending's on transportation	.288	.022	Accepted H_0
Income/earning	.260	.039	Rejected H_0
Product Re-use and recycling	.484	.001	Accepted H_0
Processed goods	.126	.324	Rejected H_0
Domestic use of Charcoal/fuelwood	.470	.001	Accepted H_0
Energy Savings/Management	.120	.349	Rejected H_0
Willingness towards alternative solar energy	.184	.146	Rejected H_0
More use of organic	.214	.093	Rejected H_0

It is evident from Table 4. That reduced earnings have not affected spending on transportation now than before with p-.129, reduced earnings have affected learning from home with p-.012 translating to reduced emissions from transportation, product reuse/recycle has not improved better in comparison to the pre covid-19 era, as reduced earnings have not affected it with a p-value of .075. patronage of process goods has reduced with lesser earnings in comparison with the pre-pandemic period, meaning lesser emissions, domestic use of charcoal/fuel wood, energy

savings and purchase of organic products is not influenced by the shortfall in earnings, but willingness towards alternative energy source is been influenced by shortfall in earnings.

Table. 4. Summary Correlation Matrix: for respaces on how the understudied Carbon Footprint Determinants Performed in relation to Income/Earnings between Pre Covid-19 and Post-Covid-19 periods.

	Spearman's rho	Sig (2-tailed)	Decision
Spending's on transportation	.193	.129	Reject H_0
Learning from home	.314	.012	Accept H_0
Product Re-use and recycling	.226	.075	Reject H_0
Processed goods	.325	.009	Accept H_0
Domestic use of Charcoal/fuelwood	.243	.055	Reject H_0
Energy Savings/Management	.097	.450	Reject H_0
Willingness towards alternative solar energy	.266	.035	Accept H_0
More use of organic	.096	.452	Reject H_0

3 Conclusion and Recommendations

The study reveals that where data about an event stagnates, time series analysis can be employed to extrapolate and forecast for the lost periods from historic data. Though this information is scientifically insufficient in accounting or justifying for the outcome, irrespective of whether it's a decline or appreciation of the phenomenon. As such the use of survey to obtain primary data, by recounting events of determinants relative to the phenomenon is necessary.

It was hence concluded that, though atmospheric emissions in volume compared between pre and post covid-19 periods is on the increasing trajectory, carbon footprint on the other hand is on a decreasing trajectory, as the variables of energy determinant and behavior, choice and affordability, has been hampered by the measures taken to curb the spread of the pandemic.

The following recommendations emanated from the study:

I. Carbon footprint could be reduced without necessarily affecting the economy, as individuals could make life style choices that will cutdown carbon foot prints, by encouraging the work from home, learning from home initiatives and shifting from heavily industrially processed products to more organic ones.

II. Through education, enlightenments and awareness campaigns, better energy choices could be advocated, together with life style changes that includes increased reuse and recycling of products towards emission reduction. Stating their obvious gains in economic terms to the individual.

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