Drivers of Carbon Dioxide (CO₂) Emissions in Ghana: A Comparative Analysis on Consumption of Energy by the Industry, Agriculture, Residential and the Transport Sector (2000-2018)

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Abstract

The recent historical increases in energy-related CO2 emissions globally have put the Ghana's transport, industry, residential and agriculture sector in the spotlight, courtesy of the significantly high pollutant emissions from these sectors. Taking a cue from this, this paper investigates into the drivers of carbon dioxide emissions in Ghana by examining the consumption of energy by the industry, agriculture, residential and the transport sector. In doing so, this study employs the Regression model as a statistical method to examine the relations between dependent variable (carbon dioxide emissions) and the four variables of interest (energy consumption by the industry, agriculture, residential and the transport sector). Decomposition Model was applied to identify the driving forces of the emission or resource utilization. From the analysis, the transport sector contributes to more release of carbon dioxide emissions (over 78%) as compared to the other sectors. This was highly driven partly by economic affluence and population. However, technological advancement played a major role in slowing the growth of Domestic Material Consumption (DMC). Among the drivers of DMC increase, the role of population was relatively less yet very significant as compared to affluence, highlighting large resource consumption due to expanding urban and social lifestyles. In general, this current study offers policy insights for the transportation, agriculture, residential and industry sectors of Ghana and other similar economies that replicate the same condition.

Keywords: Carbon dioxide, energy consumption, decomposition analysis, regression analysis, Ghana.

1. Introduction

From a global point of view, the exponential increased in population and the desire of people to enjoy a comfortable lifestyle has necessitated the demand of energy consumption. Fossil fuel as the main source of commercial energy is consumed by most sectors of the economy to run their activities. The combustion of fossil fuel to produce energy amplifies the emission of carbon dioxide gas and other harmful gases in the atmosphere which have negative effect on public health and the environment. Greenhouse gases (GHGs) emissions are also emitted during the combustion process which increases the atmospheric temperature resulting in global warming thus causes change in climatic condition. The carbon dioxide gases causes about 20% of the earth greenhouse effects, water vapor accounts for 50% and clouds account for 25 % [1]. The United Nations estimated that the world's population was growing at the rate of 1.14 % or about 75 million people per year in 2012. By 2050, the world population is projected to be in the range of 7.4–10.6 billion. A global emission of CO2 is seen to be increasing with the population rising from 21.2 to 26.9 billion metric tons [2].There were nearly no increases in North American emissions, and a significant decrease occurred in Europe, whereas CO2 emissions from Asia have doubled. The growing global population demands more energy consumption to maintain the same level of lifestyle; and, for developing countries, the increasing population has a more significant effect as the life quality keeps improving. There is a minimum amount of energy needed to sustain human life. Fuel energy is needed for cooking in houses and restaurants, as well as in heating and/or cooling for houses and buildings. Much more energy than the minimum is consumed in developed countries, providing food, clothing, shelter, transportation, communications, lighting, materials, and numerous services for the entire population. The pursuit of economic growth worldwide by human beings has resulted in rapid urbanization, industrialization and agricultural operations that are responsible for environmental degradation and pollution [3]. Reductions in environmental degradation and pollution are a sine qua non for sustainable development of any economy [4]. Among the greatest challenges facing humanity in the 21st Century is the extensive environmental degradation and pollution induced by increasing greenhouse gas emissions. Existing literature [4-9], suggests that that greenhouse gases (GHG) emissions underpin global warming and climate change. GHGs comprise; carbon dioxide, ozone, methane, nitrous oxide, and water vapour. However, carbon

dioxide emission is the principal GHG and a major cause for climate change and global warming [4]

The increasing rate of population growth and rapid urbanization growth in Ghana calls for increasing demand of energy for consumption. Although the price of energy in Ghana continues to fluctuate, the rate of demand of energy especially the consumption of fossil fuel cannot be underestimated. Ghana's energy sector has evolved over the last two decades. This is due to continuous reforms and stability that allowed for increased investment by private players especially in the electricity sub-sector. In addition, the discovery of oil and gas in commercial quantities in 2007 and subsequent production in 2010 further put the country's energy sector in the path of growth. The country started oil production in 2010 with only one field, but now can boast of a total of three oil producing fields namely; Jubilee, Tweneboa Enyenra Ntomme (TEN) and OCTP Sankofa Gye Nyame [10]. One of Ghana's paramount constraints to economic growth is its unreliable and inadequate supply of electric power. The country has 2,837 mega-watts (MW) of installed generation capacity, including 726 MW of generation from independent power producers (IPPs). Actual availability hardly exceeds 2500 MW on a day to day basis however. This serves a population of 27.4 million that is growing at 2.3% per year. One of Ghana's paramount constraints to economic growth is its unreliable and inadequate supply of electric power. The country has 2,837 mega-watts (MW) of installed generation capacity, including 726 MW of generation from independent power producers (IPPs). Actual availability hardly exceeds 2500 MW on a day to day basis however. This serves a population of 27.4 million that is growing at 2.3% per year (Energy commission, 2016).

The motivation to increase the supply of energy to meet the increasing demand of energy by the sectors of the economy of Ghana leads to a bilateral causal link in the release of carbon dioxide in the atmosphere with its adverse effects on the environment. This paper investigates into the drivers of carbon dioxide emissions in Ghana by examining the consumption of energy by the industry, agriculture, residential and the transport sector. The study will also help policy makers to formulate policies that will help to control the emissions.

2. Literature Review

Numerous studies have been conducted on drivers of carbon dioxide emissions. Different studies have adopted various methods in different locations and in different periods with different conclusions being drawn. A synchronic/thematic review of the literature shows mixed results in different case scenarios of the determinants of carbon dioxide emissions.

[11],employs the PMD panel and ADRL approach to examine the causal link of economic growth, energy consumption (Fossil fuel), carbon emission and oil price for African countries. The study reveals that for both short and long run, the consumption of energy and the release of carbon are interrelated. The study also reveals that there is a bilateral causal link between energy consumption and economic growth. As the economy is booming, high rate of energy is consumed which lead to high emission of carbon. [12] in a studies to assess the effects of Economic Growth, Trade Openness, and Urbanization on Carbon Dioxide Emissions in Ghana using regression analysis established that for both long-run and short-run periods, the levels of carbon dioxide emissions in Ghana were influenced by trade openness, proportion of population living in urban areas and Gross Domestic Product per capita over the period, 1960 to 2014.Increased trade openness led to decreased total emissions while increasing urbanization and rising Gross domestic product (GDP) per capita increased total emissions. Rising GDP per capita leads to increased average wealth of the country, this then fuels increasing households' consumption demand for luxury goods. [12-13] revealed that carbon dioxide emission could be reduced by increased in trade openness but the study failed to outline the type of trade and requires further research.

EKC postulates that per capita pollution increases with rise of economic growth and after achieving certain limit, it starts decreasing with increase in per capita development. However, this study has limitation as instead of taking overall energy consumption it considers only renewable energy consumption and also lags because of linear modeling. Relationship between economic development, energy use and carbon emission were analyzed by [14] for USA in the time period of 1960–2004. The study conclude that output affects the increase in carbon emission and energy consumption in the long run .Similarly, [15] verified the causality running from economic development to energy use and carbon emissions for France by employing the data of 1960–2000. In another study of Greece for time period 1977–2007 unidirectional causalities were found running from economic growth to energy consumption and from economic growth to carbon emissions while investigating the relationship between energy use, GDP and CO2 emissions [16]. [17], also observed significant positive relationship between carbon emissions and energy use as well as among GDP and energy use for Gulf countries (GCC) both for short run and long run.

[18] use the Kaya identity (equation) to analyze and decompose trends and drivers of African CO2 emissions between 1990 and 2017. Trends and drivers of African fossil fuel CO2 emissions 1990–201grow rapidly, blowing past the climate goals. Energy demand is projected to continue to grow under a business-as-usual policy scenario in most African countries as shown in this study. The findings of the studies indicates that most African countries have been experiencing increased in carbon dioxide emission as there are no effective policies or the policies are not sufficient to mitigate energy related CO2 emissions .

Moreover, the result from the Toda and Yomamoto granger causality test showed a mix of bidirectional,

unidirectional, and neutral relationships for all countries [19].The study also revealed that the variance decomposition analysis revealed that economic growth contributes largely to changes in future carbon dioxide emissions in Senegal and Morocco whilst in Ghana technical efficiency contributes largely to changes in future variations in carbon dioxide emissions. In the same way [20-21] asserted that while the use of biomass energy consumption and real GDP have a negative effect on CO2 emissions in the transportation sector. This was only limited to the transport sector and failed to take into account other sectors of the economy that uses biomass as its energy. The rising fossil fuel energy consumption is associated with increasing the CO2 emissions that are stemming from the transportation sector (Muhammad Umara et al.2020). Correspondingly, these studies did not to compare the energy consumption rate of the transport sector in relation to the other sectors of the economy. Likewise [13, 22] revealed in their study that both CO2 emissions and economic growth positively and significantly affect energy consumption in all the eight panels, including the Belt and Road Initiative panel and the Organization for Economic Co-operation and Development panel. co integration analysis of kaya factors namely CO2, total primary energy consumption, population and GDP was investigated in Ghana using vector error correction model with data spanning from 1980-2012. It follows that increasing consumption of primary product has a direct impact on co2 emission therefore reducing the total consumption. Similarly, in a study that explores the relationship between ecological footprint, urbanization, and energy consumption by applying the ARDL estimation technique reveal that economic growth and financial development deteriorating impact on the environment in the short run. However, the same was not true for both energy use and urbanization. While urbanization and energy use promote environmental quality in the long run, financial development and economic growth degrade it further. Samuel –[23-24] explored the effect of energy consumption and economic growth on CO2 emissions. the pooled OLS regression and fixed effects methods), Granger causality and panel co integration tests. Data from 70 countries from 1994–2013 were analyzed growth) have a bi-directional causal relationship with CO2 emissions, while energy consumption has a uni -directional relationship. Likewise, the outcome of the co integration tests established that a long-run relationship exists among the study variables (energy consumption and economic growth) with CO2 emissions. However, the pooled OLS and fixed methods both showed that energy consumption and economic growth have a significant impact on CO2 emissions. Hence, this study supports the need for a global transition to a low carbon   economy primarily through climate finance, which refers to local, national, or transnational financing that may be drawn from public, private and alternative sources of financing. Alternatively, [25] examines the effect of urbanization and energy on carbon dioxide emission in Ghana within the framework of the Environmental Kuznets Curve (EKC) Hypothesis over the period 1971–2013. Estimation results from Fully Modified OLS confirmed the presence of the EKC hypothesis over the period for Ghana. In addition, combustible renewable and waste consumption, electricity production from hydro and trade openness are found to reduce carbon dioxide emission while fossil fuel consumption, electricity production from fossil fuels, urbanization and industrialization increase carbon dioxide emission for Ghana. The study again revealed that an interaction between urbanization and combustible renewable and waste consumption, however, has a positive effect on CO2 while the interaction between urbanization and fossil fuel consumption has a negative effect.

In conclusion, several studies have been conducted on the subject area but there is no study that compares the industry, agriculture, residential and the transport sectors in response to their contribution to carbon dioxide emissions in Ghana. This study contribute in widen the evaluation vision of the parameters (sectors) effecting CO2 emission and build a correlation equation. IPAT decomposition model was adopted to examine the driving forces of the emission or resource consumptions. This can help decision makers to formulate more effective policies to reduce the emission and impact of CO2 on public health and the environment.

3.   Materials and Methods
3.1 Data Sources
The study implemented the literature review research design, where published documents constituted the main data sources [10].Based on the established tenets and protocols of literature reviews, the study was completed in three stages. Stage one involved identifying relevant documents. With limited access to Elsevier's Scopus and Clarivate Analytics' Web of Science, the study relied on Google Scholar and regular Google searches to identify relevant documents. Given the limited published works on the subject, the study included several document types, including journal articles, conference papers, technical reports, and authoritative policy documents from famous entities and trusted organization. Stage two involved screening and preliminary review of the included documents. During this stage, the study sought to identify the documents containing relevant documents and extracting reported environmental consequences of carbon dioxide emissions. The preliminary evaluation resulted in the inclusion of journal articles, conference papers, technical reports, and authoritative policy documents. Stage three was dedicated to extracted relevant information and collecting data. The data on carbon dioxide emissions from 2000-2018 on Ghana was derived from World Development Indicators website. Imported data on energy consumption by the transport, residential, industry and the agriculture sector was also produced by the Energy Commission of Ghana. Also, socio-economic data including GDP and Population are real data available at World

Bank's Statistical Archives [26].

3.2 Analysis of data
3.2.1 Analysis based on regression model
This study was conducted based on hypothesis that the levels of carbon dioxide (CO_2) emissions are influenced by energy consumption by the industry, agriculture, residential and the transport sector. Regression analysis as a statistical method was used to examine the relations between dependent variable (CO_2 emissions) and the three variables of interest. Regression coefficient of determination is computed for each independent variable respectively to examine the percentage of variation explained by the explanatory variable on the response variable. The final results are compared to determine which of the explanatory variables causes more percentage of carbon dioxide emission from 2000-2018.

3.2.2 Variables measured
Independent Variables = energy consumption by the industry, agriculture and Transport sector.
Dependent Variable = Carbon dioxide emissions
Regression line is given as $y = ax^{\sim} + b^{\sim}$

$$a\sim = \frac{\sum(x)(\sum y) - n(\sum(xy))}{(\sum_x)2 - n(\sum_x)2}$$

$$b\sim = \frac{(\sum(x)\sum(xy)) - (\sum(y)(\sum_{(x)}2)}{(\sum_{(x)}2 - n(\sum_x 2)}$$

Regression Coefficient $(R^2) = (\frac{Standard\ deviation^X}{Standard\ deviation^Y}) \times \sim a$

Where $S_x = \sqrt{\frac{\sum(x)2 - \frac{1}{n}(\sum(x)2}{n-1}}$ and $S_y = \sqrt{\frac{\sum(y)2 - \frac{1}{n}(\sum(y)2}{n-1}}$

$R^2 = (\frac{S_X}{S_Y}) \times \frac{\sum(x)(\sum y) - n(\sum(xy))}{(\sum_x)2 - n(\sum_x)2}$

3.2.3 Hypothesis tested.
H_1 There is a significant relationship between the consumption of energy by the industry sector and carbon dioxide emissions

H_2 There is a significant relationship between the consumption of energy by the agriculture sector and carbon dioxide emissions

H_3 There is a significant relationship between the consumption of energy by the transport sector and carbon dioxide emissions

H_4 There is a significant relationship between the consumption of energy by the residential sector and carbon dioxide emissions

3.3 Decomposition Approach and Analysis on the driving forces
Finally based on the Regression model, decomposition approach was applied to identify the driving forces of the emission or resource utilization. The widely used equation in environmental analysis is the master equation that determines the environmental impacts driven by socio-economic and technological factors and was originally proposed by Ehrlich and[27] as given by the equation(1)

$I = P \times A \times T$

Where I denote environmental Impact, P accounts for population, A is the economic affluence indicator usually represented by GDP per capita, and T is the technological indicator measured in terms of environmental impact per unit of GDP, thus we can re-write the above as equation(2)

$$Env. Impact = Population \times \frac{GDP}{Capita} \times \frac{Env. Impact}{Unit\ of\ GDP}$$

As environmental impacts are influenced by all of the three components in the master equation, this necessitates a need to gain insights into the drivers of environmental impact [28],thus, leading to the decomposition of IPAT equation. Among the two widely used decomposition methods i.e. Laspeyres and Divisia Index, LMDI is often recommended [28] was employed in our analysis to decompose drivers of I in the IPAT master equation, The additive decomposition method has been selected due to its ability to report results in absolute quantity of DMC variations. As per our selected method, drivers of change in DMC can be calculated according Eqs. (3)- (6)

$\Delta I(env. impact) = DMC(tons) = DMC_{t1}(tons) - DMC_{to}(tons)$

$$= \Delta P + \Delta A + \Delta T \qquad\qquad (3)$$

$$\Delta P = \sum \frac{DMC_{t1} - DMC_{t0}}{InDMC_{ti} - InDMC_{to}} \times In\frac{P_{t1}}{P_{t0}} \qquad\qquad (4)$$

$$\Delta A = \sum \frac{DMC_{t1} - DMC_{t0}}{InDMC_{ti} - InDMC_{to}} \times In\frac{A_{t1}}{PA_{t0}} \qquad\qquad (5)$$

$$\Delta T = \sum \frac{DMC_{t1} - DMC_{t0}}{InDMC_{ti} - InDMC_{to}} \times\ In \frac{T}{T_{t0}} \qquad\qquad (6)$$

Where ΔDMC is the environmental impact indicator representing changes in DMC from the starting year t_0 (2000) to the end of the year t_1(2018), ΔP represents the influence of population change, ΔA represents the contribution of economic affluence (in terms of GDP per capita), and ΔT represents the influence of technology(in terms of DMC per GDP), respectively, on changes in DMC.
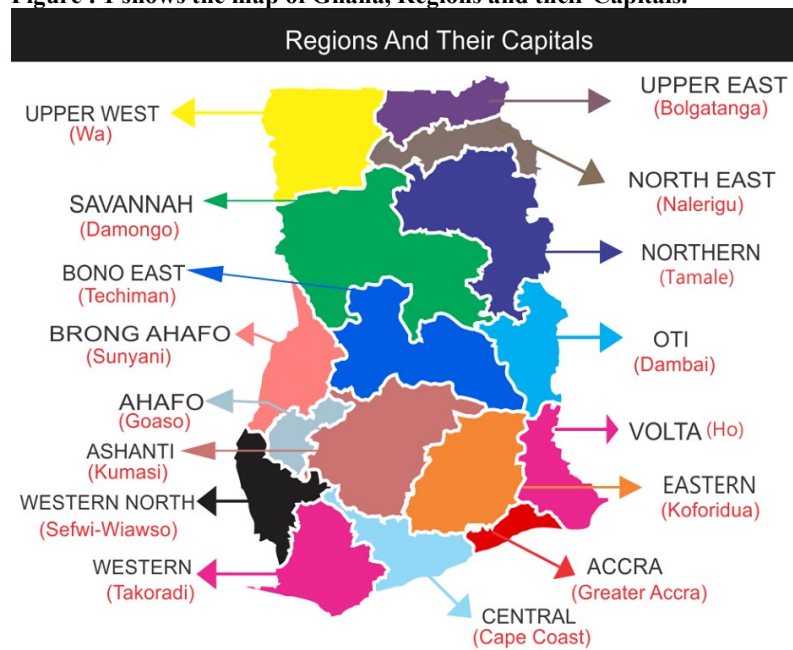
Table: 1 Shows the Final Energy Consumption by sectors, CO2, Population and GDP (2000-2018)

YEARS	CO2	Industrial	Agriculture	Transport	Residential	Population	GDP
2000	730.3	5740	59	1169.1	3473.2	19,278,856	4.98
2001	736.7	6210	55.8	1179.8	3284.9	19,756,928	5.31
2002	694.2	7420	59.1	1242.6	3166.8	20,246,381	6.17
2003	543.1	7130	55.4	1182.6	3026	20,750,299	7.63
2004	556.4	6620	61.5	1365.8	2969.7	21,272,323	8.88
2005	590.8	7020	59.6	1350.6	2921.7	21,814,642	10.74
2006	799.7	8430	57.3	1392.4	2770.8	22,379,055	20.44
2007	797.8	9050	64.2	1603.8	2654.2	22,963,946	24.83
2008	823.8	8560	60.8	1567.5	2596.2	23,563,825	28.68
2009	802.8	9950	71.8	1914.1	2750.2	24,170,940	26.05
2010	767.8	1150	70.4	1877.3	2679.3	24,779,619	32.2
2011	883.2	12210	76.9	2119.4	2841.9	25,387,712	39.34
2012	873.4	14220	88.1	2467.6	2908.3	25,996,450	41.27
2013	899.6	15010	90.9	2611.7	2984.8	26,607,645	62.82
2014	878.4	14370	89.4	2633.8	3067.6	27,224,473	51.72
2015	841.7	15130	92.5	2868.5	3052	27,849,205	47.5
2016	842.5	14110	83	2642.9	3120.7	28,481,945	54.5
2017	845.8	14780	74.6	2504.2	3242.9	29,121,465	58.85
2018	1039.6	16110	99.1	2785.8	3319.2	29,767,102	65.32

4.   Profile of the Study area

Ghana is an English-speaking nation state in West Africa with a population of about 30 million, growing at an annual rate of 2.5% based on projections of the 2010 Population and Housing Census. The country shares borders with Togo in the east, La Cote d'Ivoire in the west, Burkina Faso in the north, and in the south, the Atlantic Ocean. Agriculture is an important economic sector employing about 42% of the population and accounting for about 20% of the country's GDP over the last decade (2010 to 2019). The major export commodities of the country are based on natural resources. These are cocoa, gold and more recently crude oil, starting from 2011. In particular, exports of crude oil and the production of natural gas have helped to accelerate economic growth over the last three years. The expansion of the Ghanaian economy coupled with rapid population growth and urban human settlement pressures, have led to a notable GHG emission increases from road transport, thermal electricity generation, biomass utilization for cooking and deforestation. Carbon dioxide remained the dominant GHG in Ghana and constituted about 66% of the total net emissions levels for 2016 [29].The key drivers of GHG emissions in Ghana are; population growth, carbon-intensive economic growth and diversification, deforestation and road transportation, electricity generation and solid waste disposal. Road transport represents over 95% of all transport services in Ghana [30]. Further, over 70% of Ghana's major roads are occupied by vehicles that produce high amount of exhaust [31] emissions thereby increasing the percentage of CO2 in the air and decreasing the air quality.
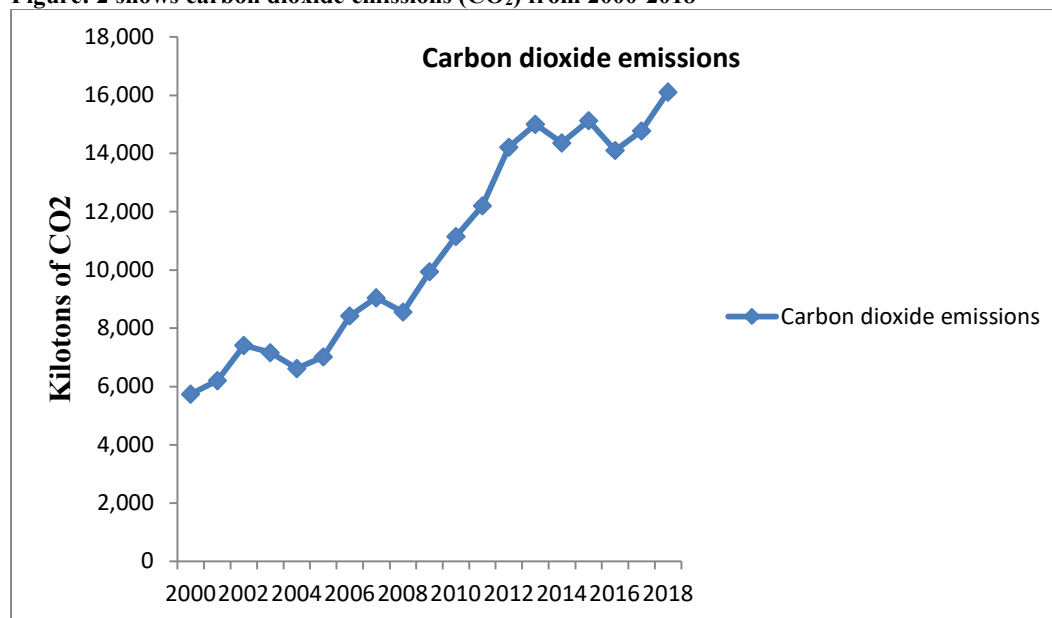
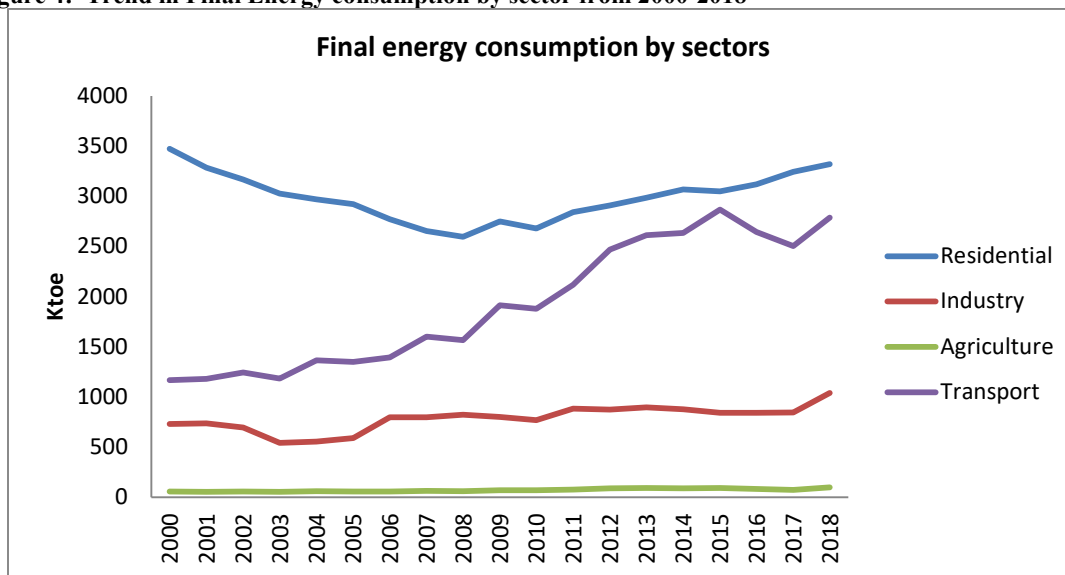**Figure : 1 shows the map of Ghana, Regions and their Capitals.**

5.   Results and discussion
5.1 Results and analysis based on regression model
Figure: 2 shows carbon dioxide emissions (CO_2) from 2000-2018

Figure 4: Trend in Final Energy consumption by sector from 2000-2018


Ghana's energy sector has evolved over the last two decades. This is due to continuous reforms and stability that allowed for increased investment by private players especially in the electricity sub-sector. In addition, the discovery of oil and gas in commercial quantities in 2007 and subsequent production in 2010 further put the country's energy sector in the path of growth. The country started oil production in 2010 with only one field, but now can boast of a total of three oil producing fields namely; Jubilee, Tweneboa Enyenra Ntomme (TEN) and OCTP Sankofa Gye Nyame [10].The final energy consumed by the transport sector on the other hand increased from 1,169 Ktoe in 2000, representing 21.0% of the total energy consumed to 2,952 Ktoe in 2019, representing 37% of the total energy consumed by all sectors of the economy. The final energy consumed by the transport sector has been increasing at an annual average growth rate of 5% between 2000 and 2018. The final energy consumption of the industry sector increased from 730 ktoe in 2000 to 1,039 in the year 2018. Likewise, the final energy consumption by the agriculture sector also increased from 59 Ktoe in 2000 to 99 Ktoe in 2018.

Table 2 Shows regression results of Agriculture, Transport, Industry and the Residential sector of Ghana.

Sector	Hypothesis	Regression weight	Beta coefficient	R^2	F	P-value	Hypothesis supported
Agriculture	H_1	AS→CE	.708	.501	17.044	.001	Yes
Transport	H_2	TS→CE	.781	.610	26.545	.000	Yes
Industry	H_3	IS→CE	.778	.606	26.112	.000	Yes
Residential	H4	RS→CE	.048	.002	0.039	.073	Yes

*Sig < 0.05, Agriculture sector (AS), carbon dioxide emissions (CE).

a) Transport	b) Industry

c) Agriculture	Residential
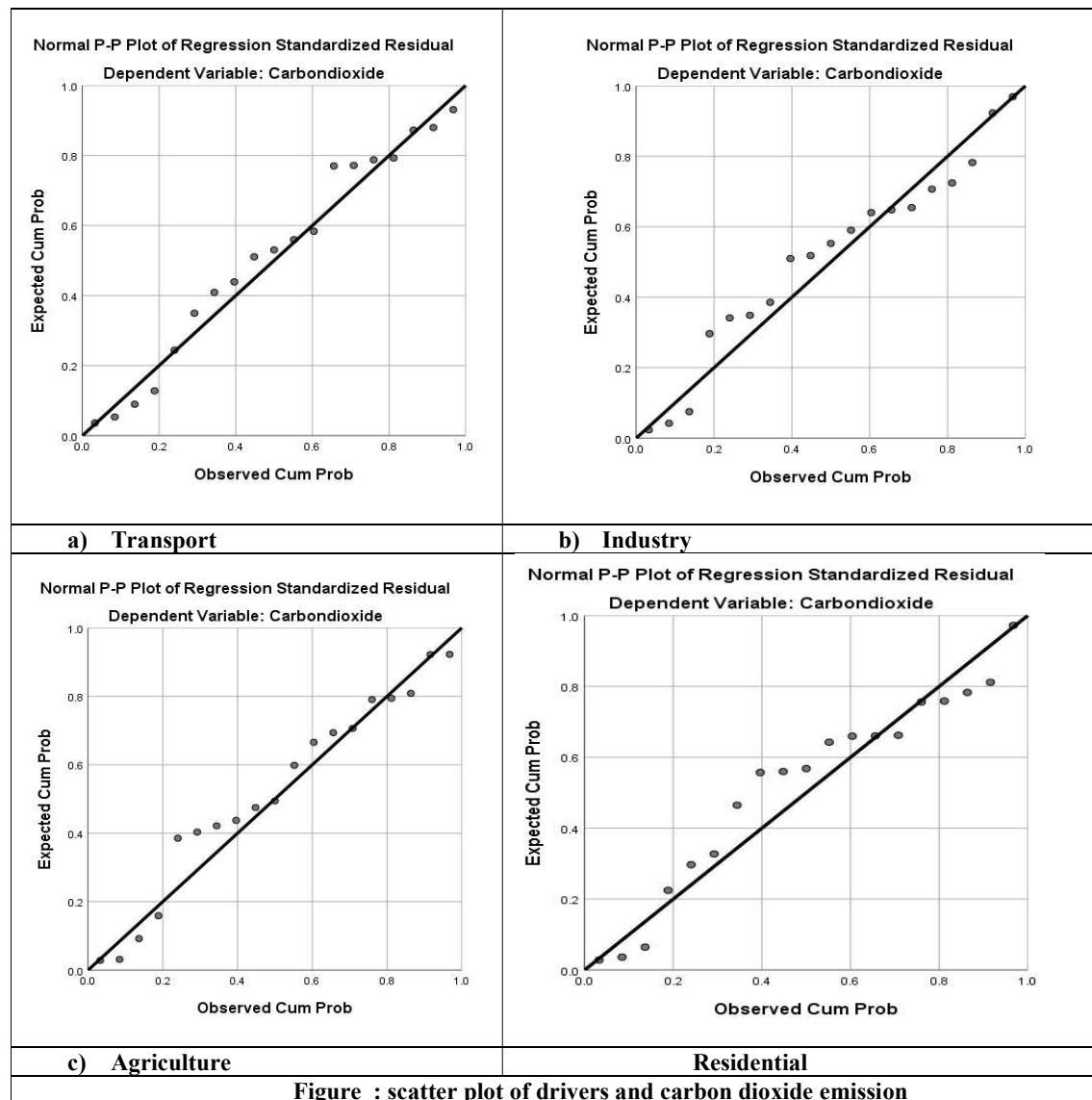
Figure : scatter plot of drivers and carbon dioxide emission

5.2 Hypothesis testing

5.2.1 H_1: *There is a significant relationship between of energy consumption by the agriculture sector and carbon dioxide emissions*

The hypothesis test if energy consumption by the agriculture sector carries a significant impact on carbon dioxide emissions. The independent variable (consumption of energy) was regressed on predicting the dependent variable (Carbon dioxide emissions) to test the hypothesis H_1. Energy consumption significantly predicted carbon dioxide emissions, $F (1, 139606.153) = 17.044$, $P < .001$, which indicates that energy consumption plays a significant role in carbon dioxide emissions in the atmosphere (b=.708(18), p < .001). These results clearly direct the results of the positive effects of energy consumption. Moreover, the $R^2= .501$ depicts that the model explains 50.1% of the variance in carbon dioxide emissions.

5.2.2 H_2: There is a significant relationship between energy consumption by the transport sector and carbon dioxide emissions

The hypothesis test if energy consumption by the transport sector carries a significant impact on carbon dioxide emissions. The independent variable (consumption of energy) was regressed on predicting the dependent variable (Carbon dioxide emissions) to test the hypothesis H_2. Energy consumption significantly predicted carbon dioxide emissions, $F (1, 169987.070) = 26.545$, $P < .001$, which indicates that energy consumption plays a significant role in carbon dioxide emissions in the atmosphere (b=.781(18), p < .001). These results clearly direct the results of the positive effects of energy consumption. Moreover, the $R^2= .610$ depicts that the model explains 61% of the

variance in carbon dioxide emissions. .

5.2.3 H₃: There is a significant relationship between energy consumption by the Industry sector and carbon dioxide emissions

The hypothesis test if energy consumption by the Industry sector carries a significant impact on carbon dioxide emissions. The independent variable (consumption of energy) was regressed on predicting the dependent variable (Carbon dioxide emissions) to test the hypothesis H_3. Energy consumption significantly predicted carbon dioxide emissions, $F (1, 168893.806) = 26.112$, $P < .000$, which indicates that energy consumption plays a significant role in carbon dioxide emissions in the atmosphere (b=.778(18), p < .000). These results clearly direct the results of the positive effects of energy consumption. Moreover, the $R^2= .606$ depicts that the model explains over 60.6% of the variance in carbon dioxide emissions.

5.2.4 H₄: There is a significant relationship between energy consumption by the residential sector and carbon dioxide emissions

The hypothesis test if energy consumption by the Residential sector carries a significant impact on carbon dioxide emissions. The independent variable (consumption of energy by residential sector) was regressed on predicting the dependent variable (Carbon dioxide emissions) to test the hypothesis H_4. Energy consumption by the residential sector insignificantly predicted carbon dioxide emissions, $F (1, 631.187) = 0.039$, $P (0.847)$, which indicates that energy consumption by the residential sector plays no significant role in carbon dioxide emissions in the atmosphere (b=.048(18), p above .05 (.073). These results clearly direct the results of the weak positive effects of energy consumption. Moreover, the $R^2= .002$ depicts that the model explains 0.2% of the variance in carbon dioxide emissions.

5.3 Results based on IPAT decomposition model
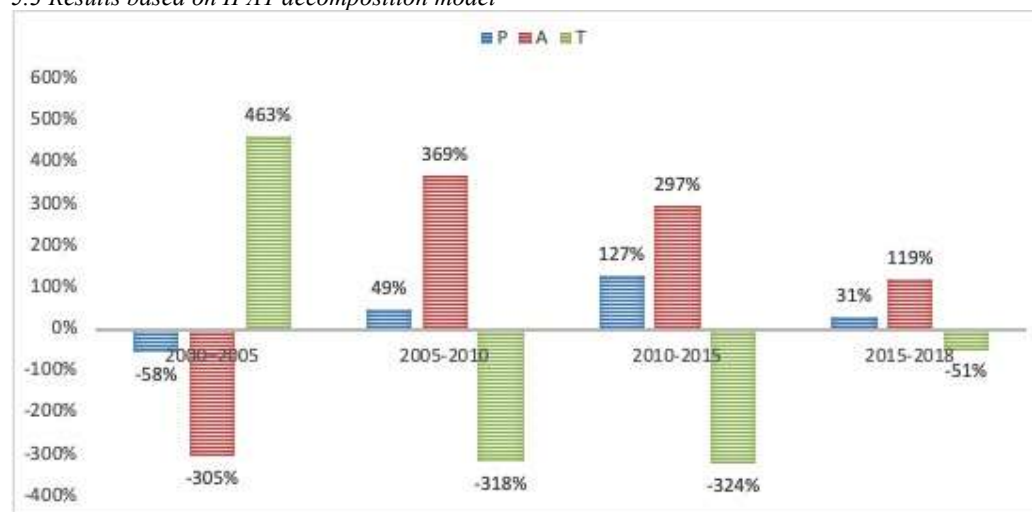
With the help of the IPAT Framework drivers of change in CO2 emissions by the residential, industry, agriculture and the transport sectors were investigated. The environmental impact (ΔDMC) was decomposed into population, affluence (GDP/capita) and technology (DMC/GDP). In Ghana, rising DMC was driven partly by economic affluence and population. However, technological advancement played a major role in slowing the growth of DMC. Among the drivers of DMC increase, the role of population was relatively less yet very significant as compared to affluence, highlighting large resource consumption due to expanding urban and social lifestyles. To minimize the impacts of population on ΔDMC in Ghana, efforts should be directed towards discouraging extravagant consumption of resource use in modern-day lifestyles and controlling rapid population growth in the country. In Ghana, contribution from technological development in reducing DMC was lower than the impact of affluence in increasing DMC, yet it was able to offset partially offset growth in energy consumption driven by the other two factors. ΔDMC was significantly higher during the period 2005-2010 and 2010-2015 as compared to 2015-2018 in accordance with large urban and infrastructure development in Ghana.

Table 3*: Compares energy consumption by sector of Ghana, Nigeria and U.S.A (2000-2018)

SECTORS	GHANA	NIGERIA	U.S.A
Residential	56830	90709	22987
Agriculture	1369	2176	2242
Industry	193220	10148	34987
Transport	36479	8736	29948

Source World Bank data (2021)

Table 3 above compares Ghana's data on energy consumption by sectors with other developing country (Nigeria) and developed country U.S. Much energy is consumed by the residential sector in both Ghana and Nigeria whereas in U.S, the industry sector consumes much energy among the sectors. The agriculture sector among all the three countries recorded the lowest consumption of energy. Ghana has similar economic condition as Nigeria and considering the consumption of energy by the transport sector of the two countries, much energy is consumed by Ghana compared to Nigeria regardless of high population growth in Nigeria. This can be attributed to economic growth and the desire of people to enjoy a comfortable lifestyle.

5.4 Comparative analysis based on regression results based on decomposition approach
From the results, the regression coefficient of energy consumption by the Transport sector and carbon dioxide emission in the atmosphere was (b=.778(18), $p < .000$). This indicates a strong positive linear relationship between the two variables. Similarly, there was a strong positive relationship between the consumption of energy by the agriculture sector and carbon dioxide (b=.708(18), $p < .001$) and the industry sector (b=.778(18), $p < .000$). In Ghana, rising DMC was driven partly by economic affluence and population. However, technological advancement played a major role in slowing the growth of DMC. Among the drivers of DMC increase, the role of population was relatively less yet very significant as compared to affluence, highlighting large resource consumption due to expanding urban and social lifestyles. This could be concluded that, the transport sector contributes to more release of carbon dioxide emissions as compared to the other sectors. Large urban and infrastructure development in Ghana and the desire for people to enjoy a better lifestyle and living increased the consumption of energy. Although, much energy is consumed by the residential sector but the result of the regression model indicates insignificant relationship.

6.   Conclusion, policy suggestions, limitations and future prospective
6.1 Main findings and conclusion
This study examined the four major sectors of energy consumption of the Ghanaian economy namely the agriculture, transport, residential and the sector industry for the period 2000-2018 that contributes to carbon emission. The energy consumption of the sectors were analyzed using regression model and as per the results, the transport sector contributed to much emission of carbon dioxide representing over 78% whereas the residential sector recorded the least(48%). The driving forces that contributed to the carbon emission were decomposed into population, affluence (GDP/capita) and technology (DMC/GDP). The per capita GDP levels have risen uniformly with Ghana showing fastest growth. With income levels, the expansion of urban centers, agricultural output, transport infrastructure, industrial facilities, residential buildings, population etc. have led to a steady increase in the Domestic Material Consumption (DMC). . However, technological advancement played a major role in slowing the growth of DMC. Among the drivers of DMC increase, the role of population was relatively less yet very significant as compared to affluence, highlighting large resource consumption due to expanding urban and social lifestyles. In Ghana, contribution from technological development in reducing DMC was lower than the impact of affluence in increasing DMC, yet it was able to offset partially offset growth in energy consumption driven by the other two factors. ΔDMC was significantly higher during the period 2005-2010 and 2010-2015 as compared to 2015-2018 in accordance with large urban and infrastructure development in Ghana.

6.2 Policy suggestions
The results of this study indicate that policymakers should set aims and objectives for the introduction of different sustainable transportation option
- Proactive measures should be taken to improve biomass energy consumption in the transportation sector, such as adopting more efficient processes, making better use of by-products, and changing energy usage. The production and use of biomass energy for transportation is an alternative to fossil fuels and can help solve several environmental problems. It can help reduce the accumulation of CO_2 emissions and establish a safe, clean, and sustainable alternative to petroleum.
- Biomass energy consumption can provide a way to reduce oil dependence and promote decarbonization in the transportation sector without changing vehicle inventory and distribution infrastructure. They will play an important role in replacing fossil fuels suitable for aircraft, ships, and heavy road transportation.

- Fuel taxes will help to bring a positive change in the transportation sector. In the short-run, vehicle drivers may change their discretionary habits of driving, for example, in order to save fuel, they may prefer to drive slower or may also increase fuel efficiency by increasing the tire pressure. Moreover, at the point of purchase, tax payments or tax benefits tend to have a more substantial impact on the consumers' choice. Buyers who prefer low-emission, private cars can significantly reduce tax payments at the time of registration, while buyers of high emission vehicles have to pay higher taxes. This measure can be ensured by exempting value-added tax from low-emission vehicles. Levying a carbon tax can also encourage lower CO_2 emissions, and if implemented, it will add to the low carbon direction of the transportation sector. Successful implementation by using financial instruments to address environmental awareness and lessons that will help boost worldwide sustainability.

- The basic aim of the trading programs is to work towards setting up environmental goals, at national or regional levels, in order to define a maximum limit on the volume of pollution that sources are permitted to emit into the environment. In the case of the transportation sector, the economic importance and scale should be measured so as to help determine the costs that are to be incurred in order to change the characteristics of the vehicle fleet and to influence the eventual decision to drive. The regulatory policies that already exist in the transportation sector might be unified in a GHG cap-and-trade structures. This may aid in estimating the implications of this choice for an increased efficiency of the economy, especially when considering this as an effort to achieve an overall mitigation effects.

6.3 Limitations of the current study and future perspectives

The current study is novel from the perspective that it offers an environmental quality insight of the Ghana transportation, agriculture and the industry sector. In spite of this novel approach, this study contains some limitations, and there are potential pathways to improve the study in the future consideration.

- The study only compares three sectors of the economy of Ghana as the major drivers of carbon dioxide emissions. It failed to compare other sectors such as the service, residential sectors. Future studies can be done to compare energy consumption by all the sectors of the economy to determine the sectors that contribute to more emissions of carbon dioxide.

- The study adopted regression analysis to determine the sectors which influenced carbon dioxide emissions. Other models can be implemented especially the input-output model since all the sectors in an economy are interrelated or interdependent.

- The study also suffered some limitations worth noting included limited access to Elsevier's Scopus and Clarivate Analytics' Web of Science.

- While this study was undertaken in the Ghanaian context, it can also be taken in other African countries to compare which sectors contributes to more emissions of carbon **dioxide.**

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