INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 22, No. 2, p. 1-8, 2023
http://www.innspub.net

RESEARCH PAPER | OPEN ACCESS

Unveiling the driving forces affecting carbon dioxide emissions in the Philippines

Jonecis A. Dayap[*1], Gracielle Rose D. Gentallan[2], Ricky B. Villeta[1], Jeanilyn S. Dionsay[1]

[1]*School of Arts and Sciences, University of San Jose, Recoletos, Philippines*

[2]*School of Environmental Science and Management, University of The Philippines, Los Baños, Philippines*

Article published on February 05, 2023

Key words: Regression analysis, Carbon emissions, Population factors

Abstract

Human-induced carbon dioxide emissions are the major cause of climate change. Although the Philippines' contribution to global climate change due to carbon emissions is negligible, the trend of carbon emissions from the energy sector is increasing, with emissions expected to quadruple by 2030. Thus, this paper investigates the population factors affecting per capita carbon dioxide emissions (CO_2E) in the Philippines. Multiple regression analysis was performed to determine and quantify the level of effect of its population factors such as life expectancy at birth (LEB), urban population (UP), population aging (PA), and energy use per capita (EUPC) that significantly influence the CO_2E. The data used for the analysis were retrieved from the World Bank for the period 1985 – 2020. Results showed that LEB, UP, PA, and EUPC are identified as significant factors affecting CO_2E. Among these significant factors, EUPC has the largest effect on CO_2E ($F = 338.81$, $p = 0.000$). Additionally, PA exerts the largest influence as a driving force of CO_2E from EUPC ($F = 40.83$, $p = 0.000$). The regression model based on the identified significant factors is robust and significant ($F = 723.35$, $p = 0.000$), explaining 98.94% of the variation in CO_2 emissions in the Philippines. This suggests that the policymakers must consider these four variables in making actions towards reducing carbon emissions in the country.

***Corresponding Author:** Jonecis A. Dayap ✉ jdayap@usjr.edu.ph

Introduction

The global increase in population has continually put pressure on meeting the demands for energy. Economic growth accompanied by rapid urbanization has also increased the need for energy supply at levels that are out of the ordinary (OECD, 2012). Even in the past, it is evident that population density must take into account both the degree of development of the economy and capacity for energy, however, the maximum population that the current energy limit can support is finite, and if it exceeds, both population growth and economic development will be heavily affected (Xundi *et al*., 2010). Moreover, as demands on energy should be met, the world's current energy production is still mainly dependent on fossil fuels which is a significant contributor to the increasing amount of atmospheric greenhouse gasses (GHGs) (Rahman and Vu, 2021). This would mean that environmental impacts are also one of the issues that should be addressed in the population-and-energy scenario.

The findings of the study by Muzayanah *et al*. (2022) in Indonesia show that a significant relationship between population density and energy utilization is exhibited in which a higher population size would result in a higher demand for energy. They suggest that for every 1% increase in the total population, a 0.36% increase in energy consumption will happen. One of the goals of developing countries is an increase in economic growth. Developing countries, such as the Philippines, may view population growth as a positive factor in an increase in economic growth. However, the relationship between the two could still be seen as negative when an excessive population increase becomes evident, which eventually hinders economic growth (Furuoka, 2010).

Several factors have been observed to have a relationship with the total emissions. The economic aspect of energy utilization and carbon emissions is being driven by a new trend in population, specifically, population aging (Feng *et al*., 2023). Shifts in the age structure among the population are seen to be a vital factor influencing carbon emissions. Aside from this, the continuous expansion of urban areas accounts for about 70% of emissions when fossil fuels are burned (Churkina, 2016). This value is predicted to increase in the years to come as urbanization among the population is continually rising and would dominate the global demographics. Moreover, the increase in carbon emissions induces not only problems with the environment but with human health as well. The study by Murthy *et al.* (2021) depicts that carbon emissions, aside from having a significant relationship, have a negative impact on life expectancy.

In the journey to achieving a country's economic growth, a compromise on the increase in energy utilization is needed in the different sectors of the economy. It is believed that population factors such as population aging, urban population, life expectancy, and energy use per capita ultimately impact total carbon emissions, as population variables (e.g., age structure, life span, urban expansion) influence energy consumption (Fig. 1). Therefore, the objectives of this study are 1) to identify significant population factors affecting the carbon dioxide emissions in the Philippines; and 2) to quantify the level of effects of the identified significant factors on the carbon dioxide emissions in the country.

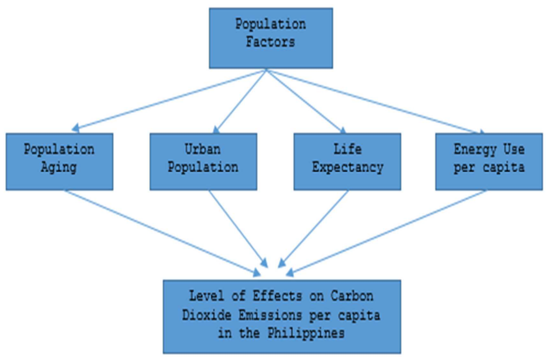

Fig. 1. Population Factors Affecting CO_2 Emissions in the Philippines.

Material and methods

This section discusses the study area, data collection, and data analysis used in the paper.

Study Area

The Philippines is located in Southeast Asia. It is an archipelagic country that is composed of 7,107 islands.

It is characterized by a humid climate, mountainous terrains, and coastal plains. Three distinct seasons are experienced in the country: the dry season which is from March up to May, the wet season from June up to November, and the cool dry season which is experienced from December up to February (ADRC, 2011). With a population of 111,046,910, and a current growth rate in its population of 1.5% (The World Bank, 2022), the Philippines remain one of Southeast Asia's fastest-growing population countries (UN Population Division, 2010). However, the population in 2021 is reported to be the lowest in the past seven decades (Cudis, 2021).

Moreover, the country is susceptible to a number of natural calamities brought about by its geographical location such as earthquakes, droughts, typhoons, and storm surges, among others. Climate change impacts become more intense in the country as experienced through rising sea levels, food insecurity, and weather-related deaths. Extreme climate events in the country resulted in fatalities that amount to 455 annually from 1999-2018, a considerably high number. Moreover, around 4,547 USD is lost annually due to these harsh weather events (Climate Transparency, 2020). Therefore, actions should be urgently taken to avoid further and more intense damages and losses to the country.

The country does not have a clear expression of its carbon tax as well as a trading system for its carbon dioxide emission. Energy taxes and excise taxes on the consumption of electricity and fuels, however, are collected (OECD, 2018). The Climate Transparency Report (2020) reported that the per capita greenhouse gas emissions of the Philippines is 1.18 tCO2e/capita.

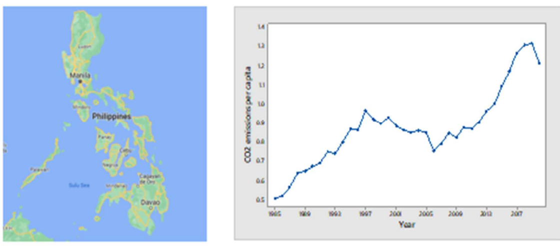

Fig. 2. Map of the Philippines and the country's carbon dioxide emissions per capita (1985 – 2020).

As shown in Fig. 2, the Philippines' carbon dioxide emissions per capita have increased from 1985 to 2020. Although the Philippines contributes insignificantly to global climate change, carbon emissions from the energy sector are projected to quadruple by 2030, with transportation emissions are expected to double (World Bank).

Data Collection

There are five variables used in this paper as being defined in Table 1. Based on the consistency and completeness, the researchers utilized the World Bank's dataset from 1985 to 2020 to investigate the significant factors affecting the carbon dioxide emissions in the Philippines. The emissions include the carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring, but do not include land use change.

Table 1. Definition of variables.

Variables	Definition	Unit
CO_2E	Per capita carbon dioxide emissions	Metric tons/person
LEB	Life expectancy at birth	Years
UP	Proportion of the urban population to the total population	Percent
PA	Population Aging (proportion of the population ages 65 and above to the total population)	Percent
EUPC	Primary Energy use per capita	kWh/person

Source: World Bank

Data Analysis

Descriptive statistics are used to generate summary statistics for predictor variables (LEB, UP, PA, and EUPC) by determining the mean, standard deviation, minimum and maximum value. To test which of the predictor variables have significant influence on carbon dioxide emissions in the Philippines, the multiple regression model was employed. This model is illustrated below:

$$CO_2E = \beta_0 + \beta_1 LEB + \beta_2 UP + \beta_3 PA + \beta_4 EUPC + \varepsilon$$

where

$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4$ are the parameters to be estimated and ε is the variation in estimate.

Initially, the dataset was subjected to multiple regression model's assumptions such as multicollinearity, and normality test of residuals in order to generate reliable results. In the process of analyzing the data, the researchers used Minitab version 16 statistical software.

Results and discussion

The impact of population pressure on carbon emissions is an issue that needs to be examined. As shown in Table 2, the average LEB in the Philippines is 69 years. Nearly 4% of the total population is aging, and almost 46% of the total population lives in urban areas. On the other hand, the average primary energy use per capita in the country is 3,665 kWh.

Table 2. Summary descriptive statistics of explanatory variables.

Variable	Mean	Standard Deviation	Minimum	Maximum
LEB	69.058	2.432	63.505	72.119
UP	45.945	1.027	42.235	47.408
PA	3.9613	0.5660	3.3277	5.2222
EUPC	3665	664	2445	5098

Table 3 reveals that the variables LEB, UP, PA, and EUPC are significant factors that impact carbon dioxide emissions in the Philippines. Among the significant factors, EUPC has the largest impact on CO_2E based on the F-values that determine the effect size of its significant predictors towards CO_2E ($F = 338.81$, $p = 0.000$). It is followed by PA ($F = 40.83$, $p = 0.000$), UP ($F = 18.57$, $p = 0.000$) and then LEB ($F = 13.33$, $p = 0.001$). From that, it can be deduced that the PA exerts the largest influence as a driving force of CO_2E from EUPC. Table 3 also showed that the regression model based on the identified significant factors is robust and significant ($F = 723.35$, $p = 0.000$) which can explain 98.94% of the variation in CO_2 emissions in the Philippines.

The Department of Energy (2019) reported that the Philippines' total energy consumption is 36.3 million tons in 2019, with transport being the most intensive consumer of energy (accounting for 34.9% of the whole country's energy consumption). Moreover, emissions from the energy sector from 1990-2012 amounted to 43 MtCO2E. It is important to note that the primary source of energy for the country is still from the burning of fossil fuels. Industries and electrical companies are heavily dependent on coal for their energy use. In 2018, non-renewable coal and oil accounted for 61 percent of all power sources (IBON Foundation, 2020).

With regard to population aging, the Commission on Population and Development has declared that there is an increasing volume of senior citizens in the Philippines. It is reported that the country would have an "aging population" between 2030 and 2035. Currently, 5.4 percent or over 5.86 million individuals comprise old dependents in the country (PSA, 2022). With the aging population increasing, the demand for electricity will be affected at a significant level. The paper of Abrigo and Ortiz (2021) concluded that in the Philippines, aging has an influence on the growth of electricity demand as it affects it directly, significantly, and persistently, as older people in the country utilize more electricity compared to other age groups.

Table 3. Effects of population factors on the carbon dioxide emissions in the Philippines.

Analysis of Variance					
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	4	1.40809	0.352023	723.35	0.000
LEB	1	0.00649	0.006487	13.33	0.001
UP	1	0.00904	0.009036	18.57	0.000
PA	1	0.01987	0.19873	40.83	0.000
EUPC	1	0.16488	0.164884	338.81	0.000
Error	31	0.01509	0.000487		
Total	35	1.42318			

Legend:

p- value < α = 0.05 - significant at α = 0.05

Model Summary:

S	R-sq	R-sq(adj)
0.0220603	98.94%	98.80%

On the other hand, Table 4 shows that the predictor variables UP, PA, and EUPC (coefficients = 0.02241, 0.0951, 0.000252 respectively) are directly associated with CO_2 emissions in the Philippines while LEB is inversely related to carbon emissions in the country (-0.01266). That is, for every unit increase in UP, PA, and EUPC, a rise of 0.0224 units, 0.0951 unit, and 0.0003 unit of carbon emissions per capita in the

Philippines respectively and for every unit increase in LEB, a decrease of 0.0127 unit of carbon emissions per capita in the country. Table 4 also shows that there is no perfect multicollinearity (VIF < 10) among the independent variables, implying a low correlation between them. The probability plot of residuals as shown in Fig. 3 is normal. This implies that the regression results are reliable.

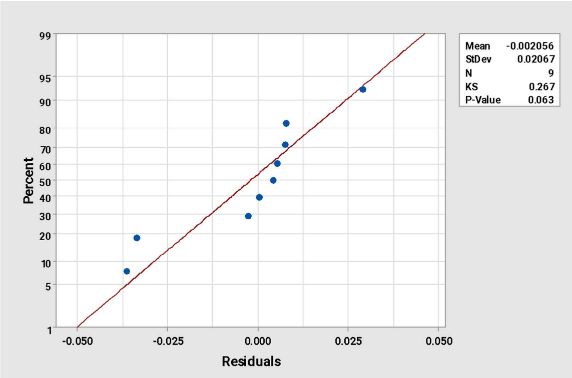

Fig. 3. Probability Plot of Residuals.

Table 4. Effects of population factors on the carbon dioxide emissions in the Philippines.

Coefficients					
Term	Coef	SE Coef	T-value	P-value	VIF
Constant	-0.583	0.263	-2.22	0.034	
LEB	-0.01266	0.00347	-3.65	0.001	5.11
UP	0.02241	0.00520	4.31	0.000	2.05
PA	0.0951	0.0149	6.39	0.000	5.11
EUPC	0.000252	0.000014	18.41	0.000	5.95

Legend: p- value < $\alpha = 0.05$ – significant at $\alpha = 0.05$

Regression Equation Model:

CO_2 emissions per capita = -0.583 – 0.01266 LEB

+ 0.02241 UP

+0.0951 PA

+ 0.000252 EUPC

Life expectancy and Carbon emissions

Achieving economic growth would mean a higher demand for energy to continue at an increasing rate in the different activities in the country (e.g., manufacturing, production, service provision, and different daily household activities). A higher energy demand would result in an increased production of energy, which would later result in increased emissions. This would further put risks to the health of many individuals and other living organisms.

The World Health Organization (WHO, 2022) has reported that indoor air pollution generated by the burning of solid fuel (e.g., charcoal, firewood) was responsible for around 237,000 deaths of children in 2020, while around 6.7 million premature deaths occur annually due to both ambient and household air pollution. The findings of the study by Osabohien *et al.* (2020) in Nigeria revealed that an inverse relationship is seen between life expectancy and carbon dioxide emissions, implying that as carbon emissions increase, life expectancy decreases.

Urbanization and Carbon emissions

Economic growth has always been accompanied by urbanization. As there is always a push for development, environmental degradation cannot be set aside. A growing economy is recognized as one of the leading factors behind the increase in carbon emissions (Li *et al.*, 2022) due to the heavy reliance on fossil fuels for energy supply to reach the demands of the growing population (Li and Ullah, 2022).

Advancements toward a growing economy also accelerate urbanization, which further increases carbon emissions (Chen *et al.*, 2022), enhancing global warming. A study by Jiang *et al.* (2022) in China revealed that urbanization indeed paves way for increased carbon emissions, and it ultimately produces a significant positive influence on both emissions and economic growth. Chen *et al.* (2022) also found in their study that for the majority of OECD countries, an increase in carbon emissions is attributed to accelerated urbanization.

Population aging and Carbon emissions

Different socio-demographic factors also influence carbon emissions. Aside from population and urbanization, population aging can also be regarded as a driving factor for environmental quality. It is regarded that older people's behavior is much different compared to younger age groups. Since they prefer to stay at home for longer times, they need either heating or cooling systems to regulate their health. This would imply that increased energy consumption is exhibited and would further lead to increased emissions (Tonn and Eisenberg, 2007).

In contrast to this, despite staying at home longer, older people are generally less active which would mean that they would not really heavily use appliances, and they would not be using much transportation services. This would imply then that their energy consumption is low (Ota *et al.*, 2018, Brounen *et al.*, 2012). Either way, emissions and population aging have a significant relationship with each other. A study by Kim *et al.* (2020) in Korea revealed that older people tend to have lower carbon emissions as compared to younger people and that as the aging population and lower fertility become widespread, the youth would dominate the responsibility for higher emissions.

Energy use and Carbon emissions

The changing climate in recent years is primarily attributed to anthropogenic activities such as energy consumption (IPCC, 2018). The pursuit of economic growth has been an issue for some since with economic growth comes higher energy consumption and therefore higher emissions, which further means more intense damage to the environment (Stern, 2004; Chontanawat *et al.*, 2008).

The findings of the study by Chontanawat (2020) with a focus on ASEAN countries reported that there is a significant association between the consumption of energy, economic activity, and emissions. In the short run, emissions brought about by energy consumption are evident, which means that higher energy consumption would result in higher emissions.

Conclusions

The trend of carbon dioxide emissions in the Philippines is increasing. Identifying the factors that influence carbon emissions is critical for developing a sustainable solution to the country's carbon emissions reduction. Population factors such as life expectancy at birth (LEB), population aging (PA), urban population (UP), and energy use per capita (EUPC) have all been shown to have significant impacts on the country's carbon emissions per capita (CO_2E). PA, UP, and EUPC have direct effects on CO_2E, whereas LEB has an inverse effect on CO_2E. It has been identified that EUPC has the largest impact on CO_2E, following PA. This suggests that in order to reduce the country's carbon emissions, policymakers must improve the utilization of renewable energy sources and transition to a low-carbon economy.

References

Abrigo MR, Ortiz M. 2021. Residential Electricity Consumption over the Demographic Transition in the Philippines. ASOG Working Paper Series.

Asian Disaster Reduction Center ADRC. 2011. Philippines' Country Profile. Available online at https://www.adrc.asia/countryreport/PHL/2011/FY2011A_PHL_CR.pdf

Brounen D, Kok N, Quigley JM. 2012. Residential energy use and conservation: Economics and demographics. European Economic Review **56,** 931-945.

Chen F, Liu A, Lu X, Zhe R, Tong J, Akram R. 2022. Evaluation of the effects of urbanization on carbon emissions: The transformative role of government effectiveness. Frontiers in Energy Research **115**.

Chontanawat J, Hunt LC, Pierse R. 2008. Does energy consumption cause economic growth?: Evidence from a systematic study of over 100 countries. Journal of policy modeling **30,** 209-220.

Chontanawat J. 2020. Relationship between energy consumption, CO2 emission and economic growth in ASEAN: Cointegration and causality model. Energy Reports **6,** 660-665.

Churkina G. 2016. The role of urbanization in the global carbon cycle. Frontiers in Ecology and Evolution **3**.

Climate Transparency. 2020. Philippines Climate Transparency Report. Available online at https://www.climate-transparency.org/wp-content/uploads/2021/01/Philippines-CT-2020.pdf

Cudis C. 2021. PH 2021 population growth lowest in 7 decades. Philippine News Agency. https:// www.pna.gov.ph/articles/1163852

Department of Energy. 2019. 2019 Philippine Energy Situationer and Key Energy Statistics. https://www.doe.gov.ph/sites/default/files/pdf/energy_statistics/2019-energysituationer.pdf? withshiel

Feng Y, Wu H, Jin Y, Wang L, Zeng B. 2023. How does population aging affect carbon emissions?—analysis based on the multiple mediation effect model. Environmental Science and Pollution Research 1-16.

Furuoka F. 2010. Population Growth and Economic Development: Empirical Evidence from the Philippines. Philippine Journal of Development **37**.

IBON Foundation. 2018. Sources of Energy in the Philippines for 2018. https://www.ibon.org/sources-of-energy-in-the-philippines-for-2018/

Jiang J, Zhu S, Wang W. 2022. Carbon Emissions, Economic Growth, Urbanization, and Foreign Trade in China: Empirical Evidence from ARDL Models. Sustainability **14**.

Kim J, Lim H, Jo HH. 2020. Do aging and low fertility reduce carbon emissions in Korea? Evidence from IPAT augmented EKC analysis. International Journal of Environmental Research and Public Health **17**.

Li X, Ozturk I, Majeed MT, Hafeez M, Ullah S. 2022. Considering the asymmetric effect of financial deepening on environmental quality in BRICS economies: Policy options for the green economy. Journal of Cleaner Production **331**.

Li X, Ullah S. 2022. Caring for the environment: how CO2 emissions respond to human capital in BRICS economies?. Environmental Science and Pollution Research **29,** 18036-18046.

Masson-Delmotte V, Zhai P, Pörtner HO, Roberts D, Skea J, Shukla PR. 2022. Global Warming of 1.5° C: IPCC Special Report on Impacts of Global Warming of 1.5° C above Pre-industrial Levels in Context of Strengthening Response to Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. Cambridge University Press.

Murthy U, Shaari MS, Mariadas PA, Abidin NZ. 2021. The relationships between CO2 emissions, economic growth and life Expectancy. The Journal of Asian Finance, Economics and Business **8,** 801-808.

Muzayanah IFU, Lean HH, Hartono D, Indraswari KD, Partama R. 2022. Population density and energy consumption: A study in Indonesian provinces. Heliyon **8**.

Organization for Economic Cooperation and Development (OECD). 2012. OECD green growth studies. In: OECD Green Growth Studies. Available at: https://www.oecd-ilibrary.org/environment/oecd- green-growth-studies_22229523

Organization for Economic Cooperation and Development (OECD). 2018. Taxing energy use for sustainable development, Country notes, Philippines. https://www.oecd.org/tax/tax-policy/taxing-energy-use-philippines.pdf

Osabohien R, Aderemi T, Akindele DB, Okoh JI. 2020. Carbon Emissions and Life Expectancy in Nigeria.

Ota T, Kakinaka M, Kotani K. 2018. Demographic effects on residential electricity and city gas consumption in the aging society of Japan. Energy Policy **115,** 503-513.

Population Divisions of the Department of Economic and Social Affairs of the United Nations Secretariat. 2010. World Population Prospects: The 2008 Revision [Online]. Available from http://esa.un.org/unpp

Rahman MM, Vu XB. 2021. Are energy consumption, population density and exports causing environmental damage in China? autoregressive distributed lag and vector error correction model approaches. Sustainability **13,** 3749.

Stern DI. 2004. Economic growth and energy. Encyclopedia of energy **2,** 35-51.

The World Bank. 2022. Population growth (annual %) Philippines. https://data.worldbank.org/ indicator /SP.POP.GROW?locations=PH

Tonn B, Eisenberg J. 2007. The aging US population and residential energy demand. Energy policy **35**, 743-745.

World Health Organization (WHO). 2022. Household air pollution. Available from: https://www.who.int/news-room/fact-sheets/ detail/household-air-pollution-and-health

Xundi D, Liyin S, Saixing Z, Jorge OJ, Xiaoling Z. 2010. Relationship between energy consumption and economic development in construction industry. Journal of Engineering, Design and Technology.