Volume 9, Issue 10, October– 2024 International Journal of Innovative Science and Research Technology
ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT196

The Moderating Effect of Population Growth on the Relationship between Carbon Emission and Economic Development in Surigao Del Norte, Philippines using Predictive Algorithm

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Abstract:- This paper explored the moderating effect of population growth on the relationship between carbon emissions and economic development in Surigao del Norte. The descriptive research design of the study has been complemented by data mining techniques in the analysis of the gathered data. The results revealed that the trend of population growth, economic growth, and carbon emission in Surigao del Norte from 2019-2022 were fluctuating based on pre- and post-pandemic effects as well as increased economic activities, industrial growth, and changes in energy consumption patterns. Moreover, the forecasted trend of population growth, economic development, and carbon emission in the next decade is also fluctuating based on the data but notable increase in the population growth for the province will significantly be seen and since the forecasted trend of population growth, economic growth, and carbon emission is fluctuating, it does have a significant contribution to the Philippines population growth, economic development, and carbon emission in the next decade. Consequently, the economic development in the province of Surigao del Norte poses a significant impact towards the province's carbon emission in the next years and lastly the population growth of Surigao del Norte has a significant and positive influence towards the economic development of the province and its corresponding carbon emissions in the next years.

Keywords:- *Carbon Emission, Population Growth, Economic Development, Forecasting Trend, Predictive Algorithm.*

I. INTRODUCTION

There is a growing concern about the world's rapid population growth as it puts even more strain on essential resources, such as arable land and fresh water, jeopardizing human survival itself. In the Philippines, the country has experienced significant population growth rates in recent decades. According to the Philippine Statistics Authority (2024), the projected population growth rate for the Philippines in 2024 is estimated to be around 1.51%. This steady population growth presents various challenges and implications for the country, including environmental pressures, carbon emissions, and economic concerns. In Surigao Del Norte, a province in the Philippines, population growth has also been observed to grow from 1.4% to 1.7% (PSA, 2024a). This growth rate indicates a significant increase in the number of individuals residing in the province and it comes with a set of problems and challenges that needed to be addressed such as overutilization of natural resources, deforestation, and habitat destruction, leading to environmental degradation and loss of biodiversity (Maja & Ayano, 2021; Zubaidi et al., 2020).

On the other hand, increased carbon emission is one of the results of overpopulation as increased population equals increased demand for fuels extracted from below the Earth's surface, such as coal, oil, and gas, which when burned, release enough carbon dioxide into the atmosphere to trap warm air inside as in a greenhouse (Anser et al., 2020; Chen et al., 2022; Wang, Li, & Li, 2023). This in turn results to severe climatic changes and global warming more quickly than at any other time in recorded history, gradual increases in temperature causing weather patterns to shift, and disrupting the natural equilibrium of the environment (Rehman et al., 2021; Shaari et al., 2021).

Apart from the increased carbon emissions, there were published studies that explored the impact of population growth on the economic development across various countries. Lubbock et al. (2022) examined the impacts of inflation, unemployment including population growth on Philippine economic growth over the period of 1991 to 2020 and revealed that population growth has an impact on economic growth. Consequently, if population growth tends to increase, then economic growth will decline. Moreover, the performance of the Philippine economy has been hindered by the country's bourgeoning population due to its rapid population growth. For the last decade, the Philippines had the highest annual population growth rates in the Southeast Asian region. As a result, economic progress has been diminished and the country's poverty rate has been accelerated (Mapa et al., 2010), coupled with lower standard of living (Jones, 2022), decrease in capital per worker (Wang & Li, 2021), and poverty (Marques, 2023).

On the other hand, it can be gleaned that the cited studies focused on the problems of rapid population growth and its consequences ranging from environmental degradation to economic issues. However, there has been no published studies regarding the relationship between carbon emission and

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT196

economic development in Surigao del Norte, Philippines and how population growth moderates these variables, providing a localized perspective on the global challenge of population growth and its impacts.

Hence, this study determined how population growth affects the relationship between carbon emissions and economic development in Surigao del Norte using multiple linear regression, exponential growth, and symbolic regression analysis, respectively, providing valuable and useful insights in navigating the constructs of this study.

➢ *Statement of the Problem*

This study aimed to determine the moderating effect of population growth on the relationship between carbon emissions and economic development in Surigao del Norte using a predictive algorithm. Specifically, it sought to answer the following questions:

- What is the trend of population growth, economic growth, and carbon emission in Surigao del Norte from 2019-2022? Based on these trends, what accounts for these changes?
- What is the forecasted trend of population growth, economic development, and carbon emission in the next decade?
- If the trend of population growth, economic growth, and carbon emission is increasing, decreasing, or fluctuating, does it have significant contribution to the Philippines population growth, economic development, and carbon emission?
- Is there a significant relationship between the trend of economic development and carbon emission in Surigao del Norte?
- How does the population growth of Surigao del Norte moderates the relationship between economic growth and carbon emission?

➢ *Hypothesis*

While majority of the questions do not require a hypothesis, the fourth and fifth questions however, were hypothesized as follows:

- H1: Economic development significantly and positively influences the carbon emissions in Surigao del Norte.
- H2: Population growth moderates the significant and positive influence between carbon emissions and economic development in Surigao del Norte.

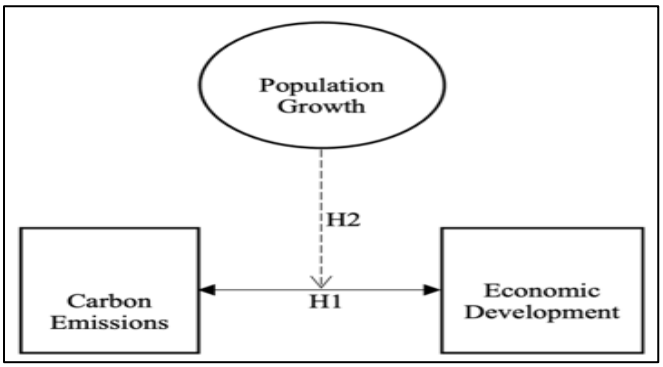

Fig 1 System Architecture of the Study

The figure above shows the interplay of the constructs of study. It showed the connection between carbon emissions and economic development, which were the constructs used to determine their significant relationship. Notably, it is also gleaned in the framework the population growth as a simple moderating variable that moderates the relationship of carbon emissions and economic development.

II. METHOD

A. Research Design

The study utilized a quantitative descriptive research design using data mining technique as the research design appropriate to the study. Data mining is the process of analyzing enormous amounts of information and datasets, extracting useful intelligence to help organizations solve problems, predict trends, mitigate risks, and find new opportunities (Simplilearn, 2023). This study is appropriate for processing the data to analyze information obtained from an educational study. The goal of this research approach is to systematically investigate and analyze the moderating effect of population growth on the relationship between carbon emissions and economic development in Surigao del Norte. Specifically, it includes population growth data, carbon emission cases data, and economic development data to see how these changes affect the carbon emission and economic development in Surigao del Norte. By employing these descriptive methods, the study aims to identify the moderating effect of population growth on the relationship between carbon emissions and economic development in Surigao del Norte.

B. Research Environment

This study is conducted in the province of Surigao del Norte, Philippines. The province had divided into two different districts. The municipalities of Burgos, Dapa, Del Carmen, General Luna, Pilar, San Benito, San Isidro, Santa Monica (Sapao), and Socorro are under District I, while Alegria, Bacuag, Claver, Gigaquit, Mainit, Malimono, Placer, San Francisco (Anao-Aon), Sison, Tagana-an, and Tubod are part of District II. Surigao City is the only city in the province and considered as the main capital of the province. Overall, Surigao del Norte comprises 20 different municipalities, with a total population of 534,636 as of the 2020 Census.

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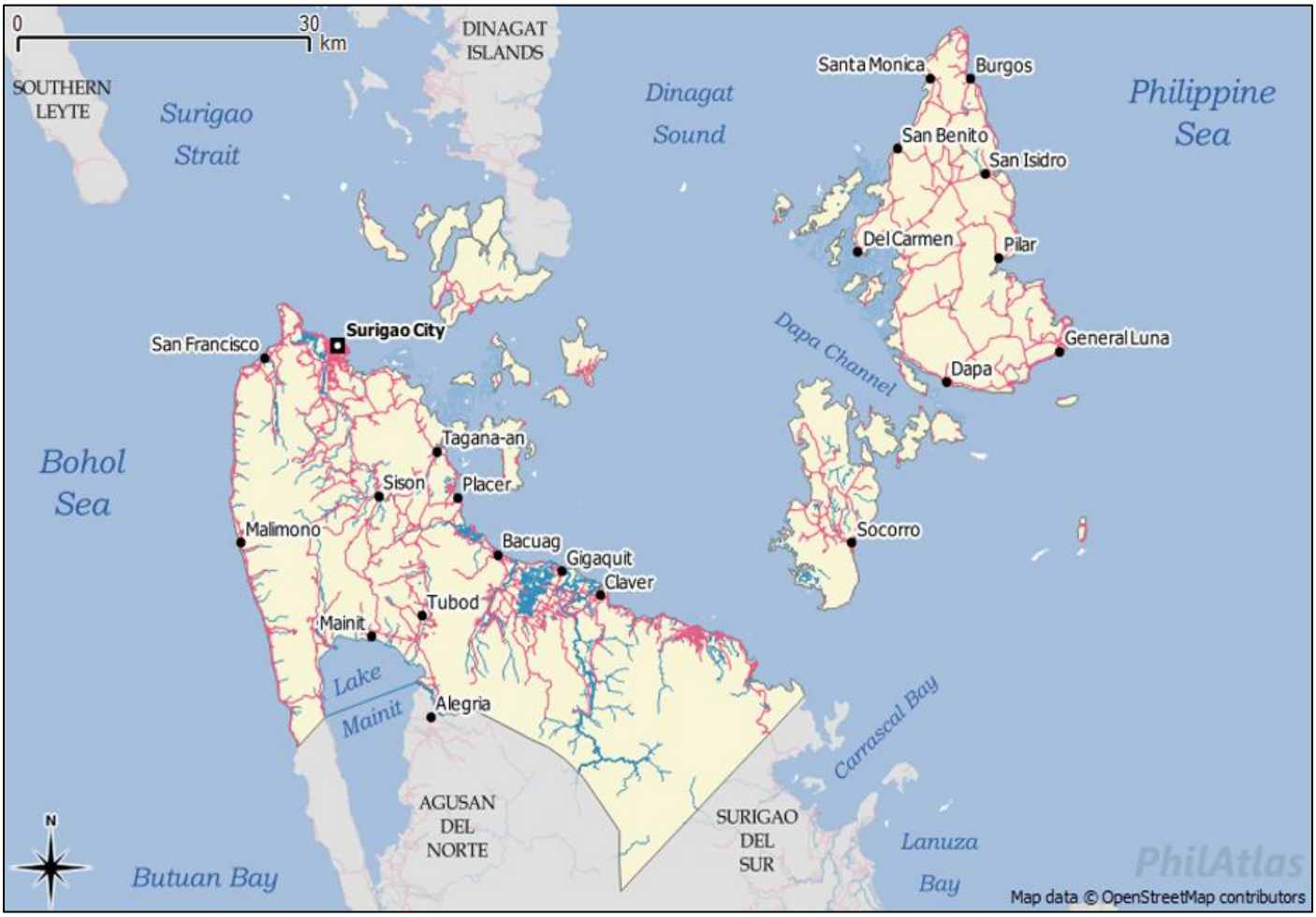

Fig 2 Satellite View of the Research Environment
https://www.philatlas.com/mindanao/caraga/surigao-del norte.html#:~:text=Surigao%20del%20Norte%20is%20a,the%202020%20Census%20was%20534%2C636.

C. *Research Instrument*

The research instrument involves gathering secondary data on Surigao del Norte's population growth, carbon emissions, and economic development indicators from a dependable web source. This includes the Philippine Statistics Authority (2022), Global Forest Watch (2022), and National Economic Development Authority (2022) These data were validated for accuracy and completeness. A comprehensive assessment of the literature was carried out in order to pinpoint important theoretical frameworks and study-related empirical findings.

D. Statistical Data Analysis

➢ *Exponential Growth*

Exponential growth is a process where a quantity increases over time at an ever-increasing rate, with the rate of change proportional to the quantity itself. It is described by an exponential function of time, where the variable representing time is the exponent (Mahato et al., 2024). In this study, the researchers used exponential growth in order to forecast the existing data of population growth in Surigao del Norte for the next decade. It is denoted as:

$$P(t) = P_0 e^{kt} \quad (1)$$

➢ *Symbolic Regression Analysis*

Symbolic regression is a type of analysis for function identification. The objective of symbolic regression is to determine the relationship between input and output variables by identifying the underlying mathematical expression. It is a machine learning-based regression method based on genetic programming principles that integrates strategies to spot profound and clarify complex links that can be generalizable, applicable, explainable, and span across most scientific, technological, economic, and social principles (Angelis et al., 2023). In the study, the researchers utilized symbolic regression analysis to search for mathematical patterns hidden in the data. This develops a genetically programmed algorithm that serves as a model for forecasting data. This algorithm will be used to forecast Economic Development and Carbon Emissions.

➢ *Multiple Linear Regression*

This study utilizes multiple linear regression analysis to provide an answer to the moderating effect of population growth on the relationship between carbon emissions and economic development in Surigao del Norte, Philippines. According to Taylor (2023), multiple linear regression is a statistical method that models the relationship between a dependent variable (Y) and two or more independent variables

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT196

(X1, X2, … Xn). This model is useful when there are multiple predictors that may collectively influence the response variables. Further, multiple linear regression can be denoted as:

$$Y = \beta0 + \beta1X1 + \beta2X2 + \ldots + \beta n*Xn + \varepsilon \quad (2)$$

This statistical tool is used to find the moderating effect of population growth on the relationship between carbon emissions and economic growth in Surigao del Norte. The researchers utilized sophisticated methods like multiple regression analysis to estimate the coefficients and generate predictions based on their data.

III. RESULTS AND DISCUSSION

This section presents the results and discussion of the study. It vividly exposes the outcomes of thorough observation, investigation, and analysis.

➢ *Trend of Population Growth in Surigao Del Norte*

The table below show the population growth in Surigao Del Norte in the year of 2019-2022.

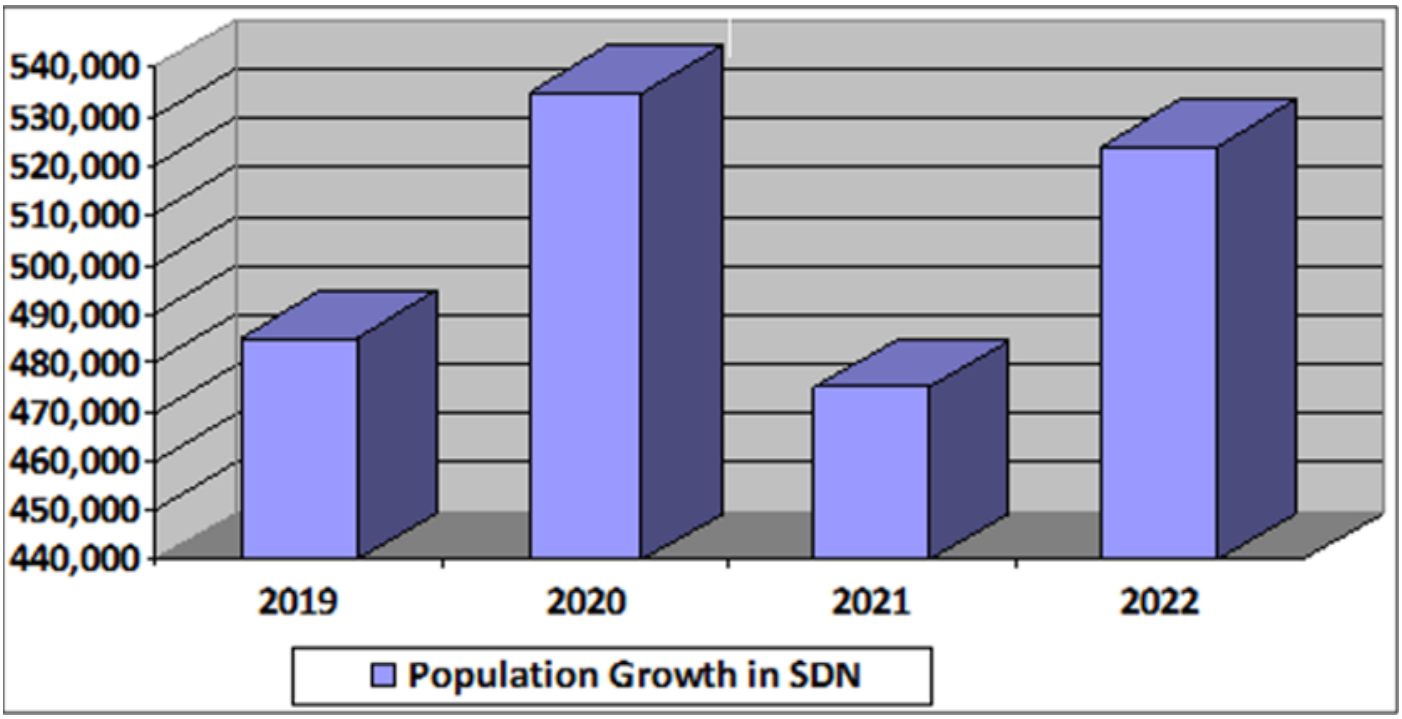

Fig 3 Trend of Population Growth in Surigao del Norte from 2019-2022

The figure above shows the trend of population in Surigao del Norte from 2019 - 2022. In 2019 there is a total of 485,088 population in Surigao del Norte. While the Population Commission (PopCom) predicted that the birthrate would rise under COVID-19, given that access to family planning methods was limited, much the opposite turned out to be the case, due to the anxieties that attended the pandemic (Strangio, 2022). Moreover, the total population in the year 2020 is about 534,636. Even though this year was at the peak of pandemic, wherein people are not allowed to work or else limited to go outside, there has been a notable increase of population in the province.

The growth of the population is due to economic and social change triggered by a pandemic which is also likely to influence childbearing intentions and completed fertility. There is also a claim that the pandemic results in a "baby boom" couple, it is argued that couples spend more time with each other and, as such, they are likely to procreate (Arnstein et al., 2020). In the year 2021 the total population is about 475,028, the civil registration data on births and deaths shows that until August 2021, there were more babies born than people dying. This means that the population is growing due to natural increase (more births than deaths). By September 2021 however, there is a reversal in trend, suggesting a reduction in population growth due to natural decrease (more deaths than births).

The presentation suggested that because of this reversal, depopulation takes place. This decline in natural increase is expected given the unprecedented impact of the COVID-19 pandemic (Grace et al., 2022). Furthermore, the year 2022 has a total population of 523,771. The rise of the population in 2022 is due to the decline and end of the COVID-19 pandemic cases. More people can now carefree do the things that they want in compensation to the effect of the pandemic. This makes sense given that pandemic-era restrictions are ending and people can go out and engage in everyday commercial activities again (Guild J., 2023).

➢ *Trend of Carbon Emission in Surigao Del Norte*

The figure below shows the carbon emission in Surigao Del Norte in the year of 2019-2022.

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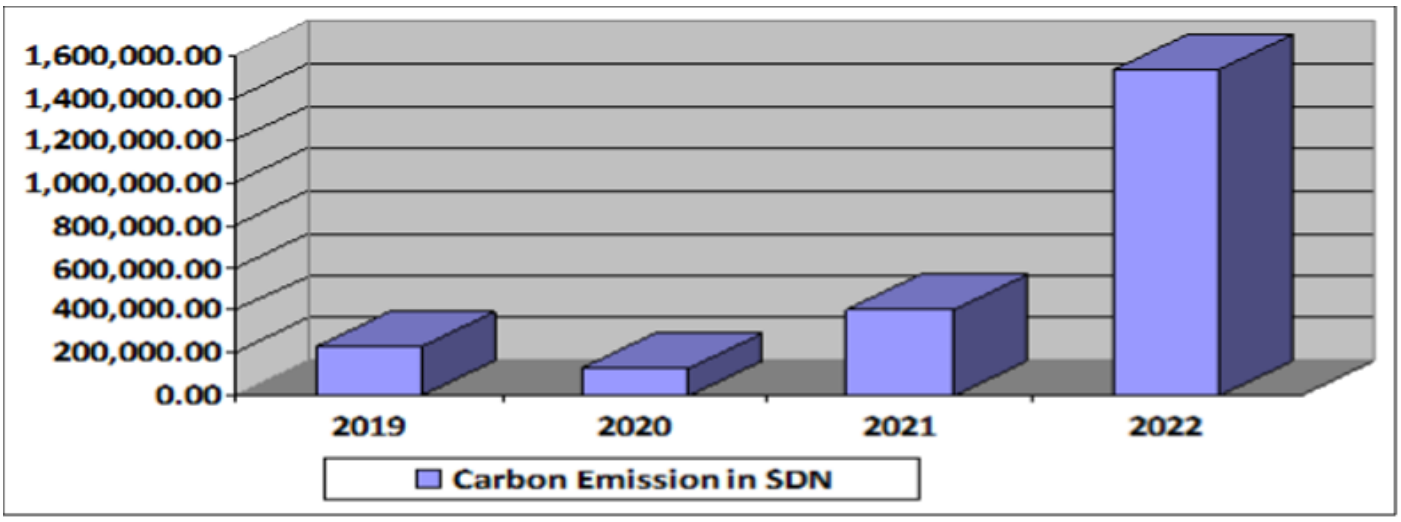

Fig 4 Trend of Carbon Emission in Surigao del Norte from 2019-2022

The figure above shows the trend of carbon emissions in Surigao Del Norte from 2019- 2022. In 2019, carbon emissions were recorded at 231,886 units, indicating the release of greenhouse gases into the atmosphere (Yi et al. 2022). This provided a comprehensive analysis of carbon emissions in Surigao Del Norte, examining emission sources, contributing sectors, and potential environmental impacts. This is the only baseline data that the researchers have and this is where the study is going to start their comprehensive analysis of the current trend of the carbon emission in Surigao del Norte. Through this, the researchers can pr

In 2020, there was a significant decrease in carbon emissions, with a recorded value of 129,917 units. This reduction could be attributed to various factors, including the implementation of environmental policies, changes in industrial practices, and the impact of the COVID-19 pandemic on economic activities (Ray et al. 2022). Hence, the pandemic showed the impact of environmental changes and industrial shift on carbon emissions, highlighting the effectiveness of specific measures in reducing emissions. Because of this, there were no people going outside doing their usual business, for example traveling, going to work every day, especially activities involving transportation.

However, in 2021, there was a sharp increase in carbon emissions, reaching 406,662 units. This surge could be attributed to increased economic activities, industrial growth, and changes in energy consumption patterns (Liu et al. 2022). This also examined the socio-economic factors influencing carbon emissions in Surigao Del Norte, providing insights into the drivers of the observed increase. The trend continued in 2022, with carbon emissions skyrocketing to 1,533,129 units. This significant rise could be attributed to increased industrial production, population growth, and changes in energy sources after the pandemic. Choudhury et al. (2023) conducted a comprehensive study on the drivers of carbon emissions in Surigao Del Norte, exploring the relationship between industrial activities, population dynamics, and energy sources in the region. It was found out that because of the leniency of the province after the pandemic, people were able to go outside, perform basic jobs, and freely travel within the province, contributed to the amount of carbon emissions in the province.

- *Trend of Economic Development in Surigao Del Norte*

The figure below shows the trend of economic development in Surigao Del Norte in the year of 2019-2022.

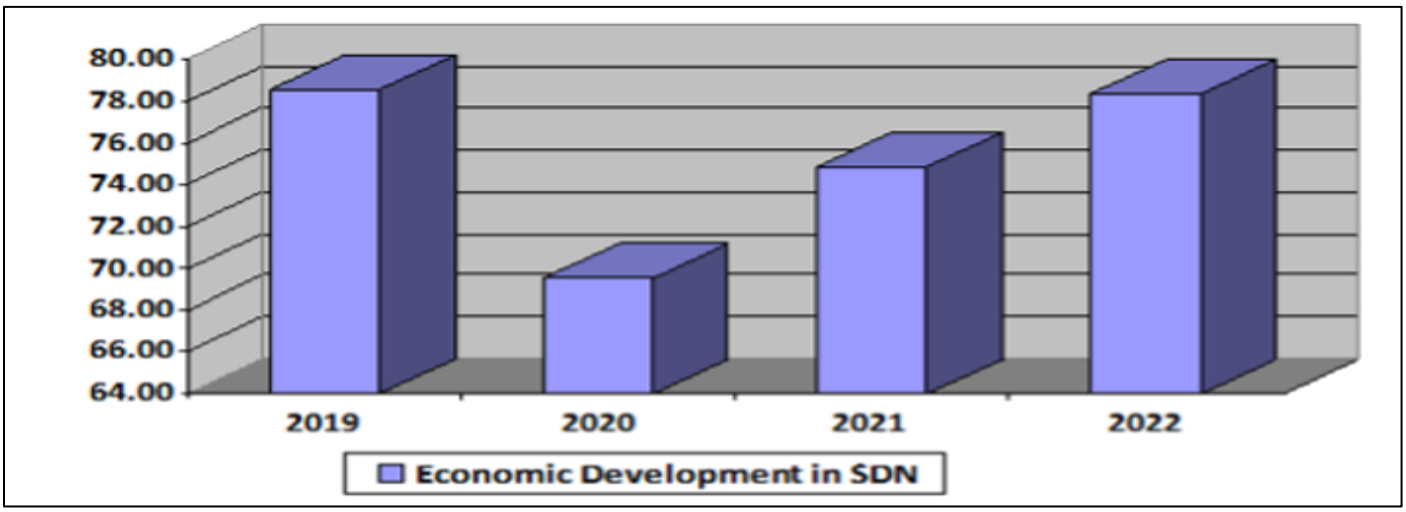

Fig 5 Trend of Economic Development in Surigao del Norte from 2019-2022

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The figure above shows the trend of economic development in Surigao Del Norte from 2019- 2022. In 2019, this year has the highest level of economic development among the four years, indicating a strong pre-pandemic economy. This could be attributed to stable global conditions, tourism, agriculture, or mining activities in the province, sectors which are traditionally strong in Surigao del Norte. This provided a comprehensive analysis of carbon emissions in Surigao Del Norte, which is supported by Yi et al. (2022) who examined emission sources, contributing sectors, and potential environmental impacts in Taiwan. Moreover, the pandemic happened in 2020 in which there is a noticeable decline with the start of the COVID-19 pandemic. This loss has caused by travel restrictions, lockdowns, supply chain interruptions, and decreased tourism. The pandemic had a negative influence on a number of businesses, including the transportation and service sectors, which may have contributed to the decline (Ahmed, 2021). For 2021, this year appears to be showing signs of recovery. The economic development is better than in 2020, however not as good as in 2019. This improvement may be the result of government recovery initiatives being put into place, companies reopening, pandemic restrictions being loosened, and industry adaptations to the "new normal" environment. People are were to go outside and do basic work in order to cope with the loss in the emergence of the pandemic. Lastly, the rate of economic development in the province in the year 2022 is rising and is almost at 2019 levels. This may be explained by a post-pandemic recovery period in which companies have returned to full capacity, tourism has surged, government infrastructure spending has restarted, and people have returned to jobs in mining and agriculture, among other industries. Furthermore, government initiatives to promote recovery, such infrastructure spending and assistance for regional companies, were other drivers of the province's economic growth. During difficult times, remittances from OFWs have also supported local investments and household spending. Economic growth has resulted from both domestic and international investments in important sectors including mining, tourism, and agriculture. These industries were vital to the province's growth and recovery during the post-pandemic contributing to the rising trend shown in 2021 and 2022.

- *Forecasted Trend of Population Growth in Surigao Del Norte*

In the context of this research, the commencement involves the investigation by developing an exponential function to effectively simulate population growth. This function, written as $P(t) = P_0e^{kt}$, incorporates crucial variables necessary for understanding population dynamics across time. Here, P(t) represents the population size after a set period (t) measured in years, and P_0 represents the beginning population at the starting point (time (t=0). The parameter *k* represents the exponential growth rate, which defines the rate at which the population grows over time. By adding this exponential function, we want to create a strong framework for systematically capturing and forecasting population fluctuations, providing significant insights into long-term demographic trends.

$P(t) = P_0e^{kt}$

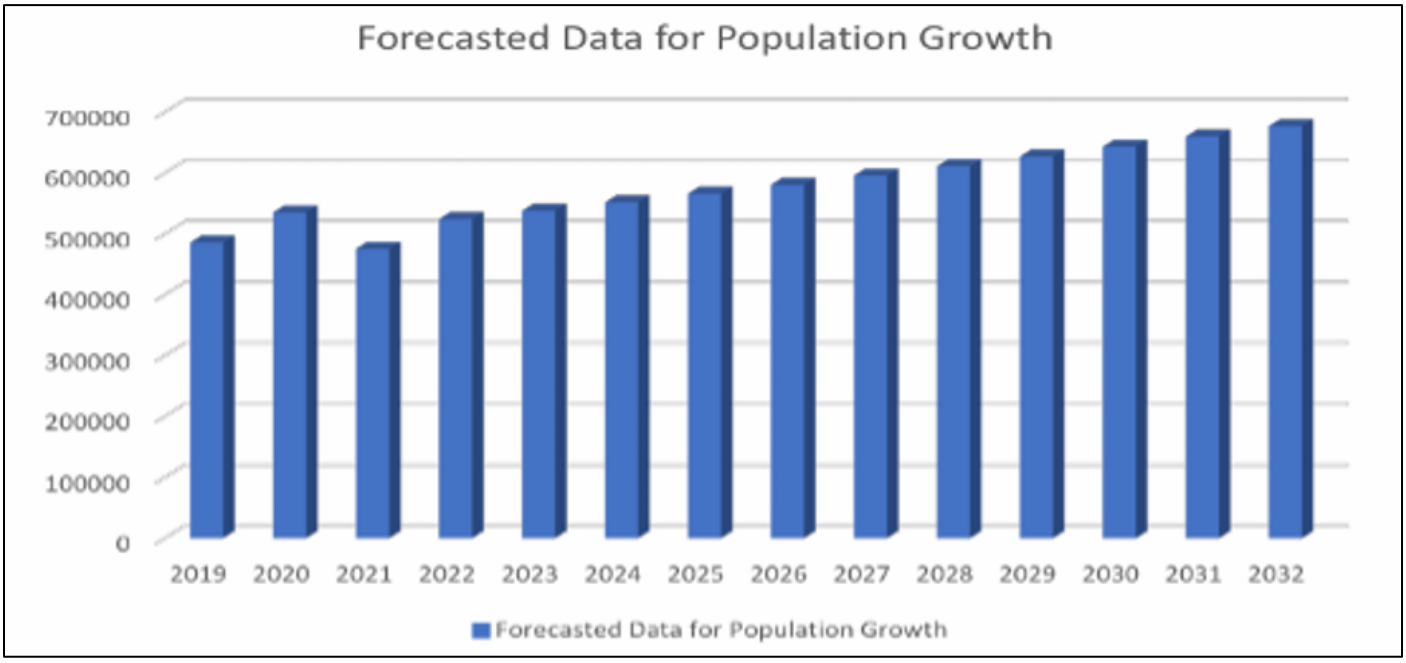

Fig 6 Forecasted Trend of Population Growth in Surigao del Norte from 2019-2032

Over the next decade, population growth is expected to show a steady rising trend driven mostly by a number of reasons. These include the natural rise in population that occurs when birth rates consistently outpace death rates as a result of improvements in healthcare and living conditions. Furthermore, migration is important because social and economic causes draw people from various parts of the world. Population growth is attributed to higher fertility rates as well as economic development that creates job opportunities and better living conditions. Population increase is further

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT196

accelerated by urbanization, which is fueled by migration to metropolitan areas. Immigration and family planning policies, taken together, influence population dynamics and are a major factor in the population growth anticipated in the upcoming years. (Lesson Plans on Human Population and Demographic Studies, n.d.)

Over the following decade, Surigao del Norte's population is forecasted to grow steadily. The population is naturally growing as a result of better living and healthcare conditions. Significant influence is also played by migration, which is driven by social and economic causes. The predicted population rise of Surigao del Norte is attributed to a number of factors, including higher fertility rates, economic development that produces jobs and better living circumstances, urbanization, and government policies on immigration and family planning.

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- *Forecasted Trend of Carbon Emission in Surigao Del Norte*

The variable y in the equation represents the predicted carbon emissions or the level of carbon emissions at a given time. The variable t represents time, typically measured in years or periods. The table provided in the search results shows the forecasted values of carbon emissions for the years 2019 to 2032, based on the given equation.

$$y = 476749.204655589 - 754989.041460257*\sin(t) - 1166506.11199222*\sin(t)*\cos(t) - 186.73460087048*t*\cos(t)^2$$

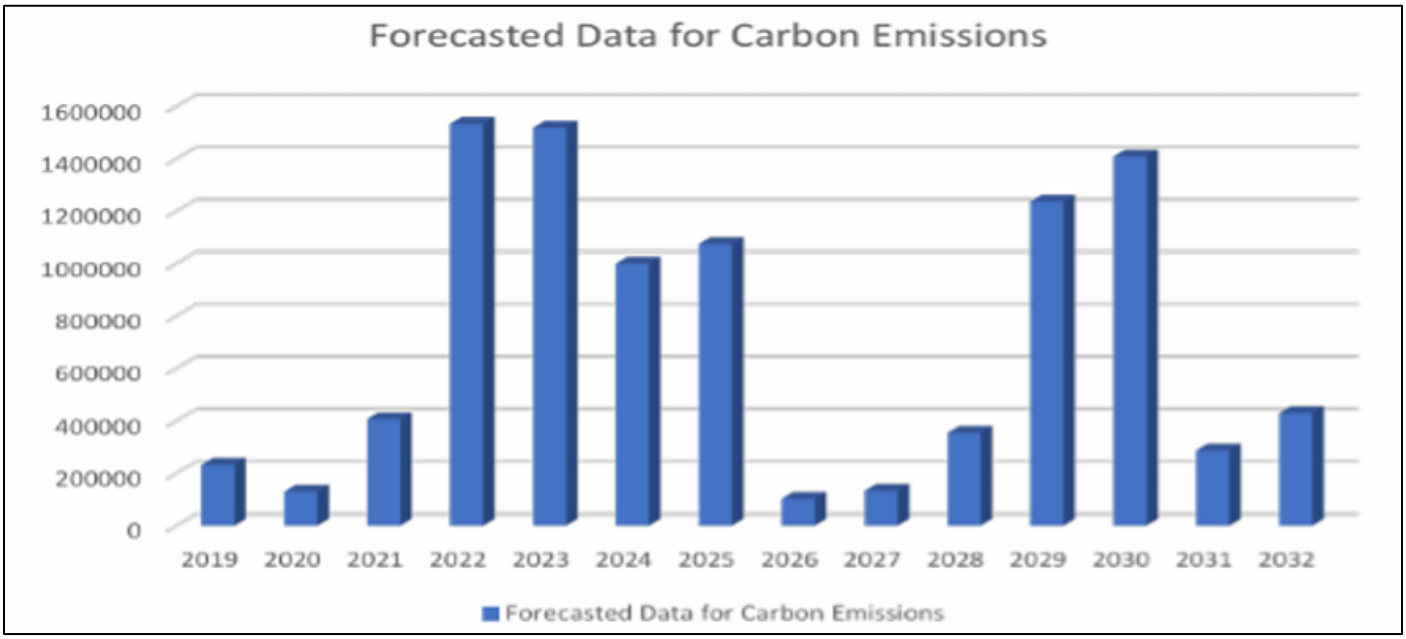

Fig 7 Forecasted Trend of Carbon Emission in Surigao del Norte from 2019-2032

Over the next decade, carbon emissions are expected to show fluctuating trend driven mostly by a number of reasons. These include Technological advancements in renewable energy and transportation could lead to a decrease in emissions as societies transition away from fossil fuels. However, population growth, industrialization in developing countries, and unpredictable geopolitical events might contribute to an increase in emissions if not mitigated effectively.

Furthermore, it is widely recognized that the growth of CO_2 concentration in the atmosphere during the 20th century was a result of increased industrialization and the continued reliance on fossil fuels as the main source of energy. As energy consumption rose, the emission of CO_2 into the atmosphere followed, causing a steady increase in atmospheric CO_2 levels. The proliferation of automobiles and the growth of the transportation sector also contributed to the rise in CO_2

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT196

emissions. The effectiveness of implemented measures to reduce greenhouse gas emissions depends on the country and sector, and some nations' lack of cooperation and commitment hinders progress on a global scale. Further measures, including developing green technologies and stricter policies, can improve ongoing efforts (Nunes, L.J.R., 2023).

Over the following decade, Surigao del Norte's carbon emission production is forecasted to fluctuate. The predicted carbon emission fluctuation in Surigao del Norte is attributed to a number of factors, including the expansion of industrial activities, changes in energy consumption patterns, and the implementation of environmental policies. Additionally, natural disasters and socioeconomic developments could also impact carbon emission levels in the Surigao del Norte. Efforts to promote renewable energy adoption and improve energy efficiency could help mitigate the potential increase in emissions, while proactive measures to address industrial emissions and enforce environmental regulations may contribute to emission reductions.

- *Forecasting Trend of Economic Development in Surigao Del Norte*

The economic development index, or an indicator of economic growth, is represented by the variable y in the formula. Time, expressed in years or intervals, is represented by the variable t. Based on the specified equation, the table in the search results presents the forecasted values of the economic development index for the years 2019 to 2032.

$$y = 77.660704709668 + 9.29242930306588*\cos(t) + 8.56075085495509*\cos(t)^2 - 5.59477035526472*\cos(2+t)$$

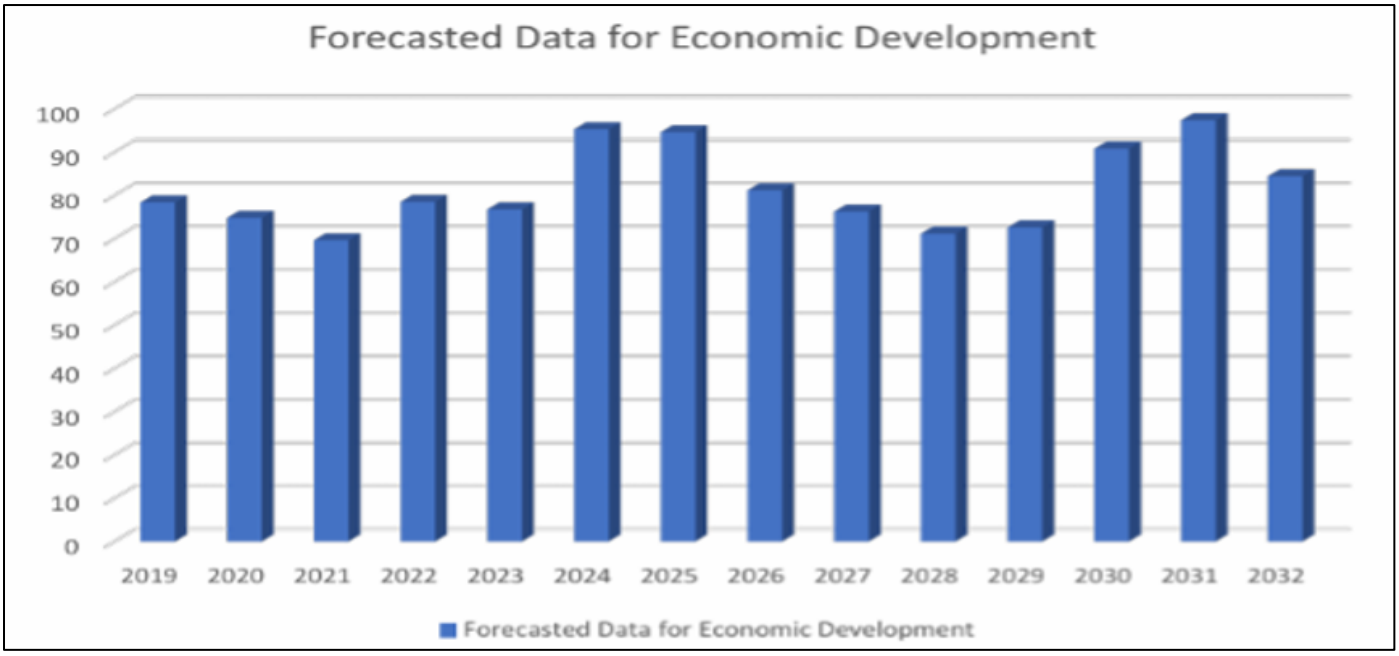

Fig 8 Forecasted Trend of Economic Development in Surigao del Norte from 2019-2032

The forecasted numbers exhibit a shifting pattern due to the interaction of multiple factors influencing economic development. The equation's trigonometric terms represent the economic development's short- and long-term patterns, as well as its cyclical patterns. These can be brought about by a number of variables, including shifts in governmental regulations, economic cycles, advances in technology, and world events. (Zhou et al., 2020)

For instance, the short-term fluctuations are represented by the expression 9.29242930306588*cos(t), which can be brought on by shifts in governmental regulations, business cycles, and world events. Long-term trends are represented by the phrase 8.56075085495509*cos(t)^2, which can be impacted by variables like population shifts, economic development strategies, and technology improvements. The cyclical patterns are represented by the term -5.59477035526472*cos(2+t), which can be brought on by both global events like financial crises and economic cycles like boom-and-bust cycles.

The Economic Development Index (EDI) in Surigao del Norte varies as a result of cyclical economic cycles, long-term growth patterns, and short-term changes. These variations are caused by a number of variables, including local laws, international market trends, and the dynamics of the mining, agricultural, tourism, and fishing industries. Seasonal variations and swings in market demand are the causes of short-term changes, whereas investment and technological advancement are the causes of long-term trends. The data forecasted in Surigao del Norte's economic development index are further influenced by cyclical patterns, such as cycles in the mining or tourism industries.

Significant Contribution of the Trend of Population Growth, Economic Growth, and Carbon in the Case of Philippine Population, Economic Development, and Carbon Emission

The data for economic development (ED) forecasts suggests a cyclical trend; from 2019 to 2032, the index ranges from 69.65 to 97.39. With emissions ranging from -429,204 to

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT196

1,533,129 between 2019 and 2032, the predicted data for carbon emissions (CE) likewise demonstrates a cyclical trend. With the population expected to expand from 485,088 in 2019 to 676,414 in 2032, the population growth (PG) forecast data indicates a generally growing trend.

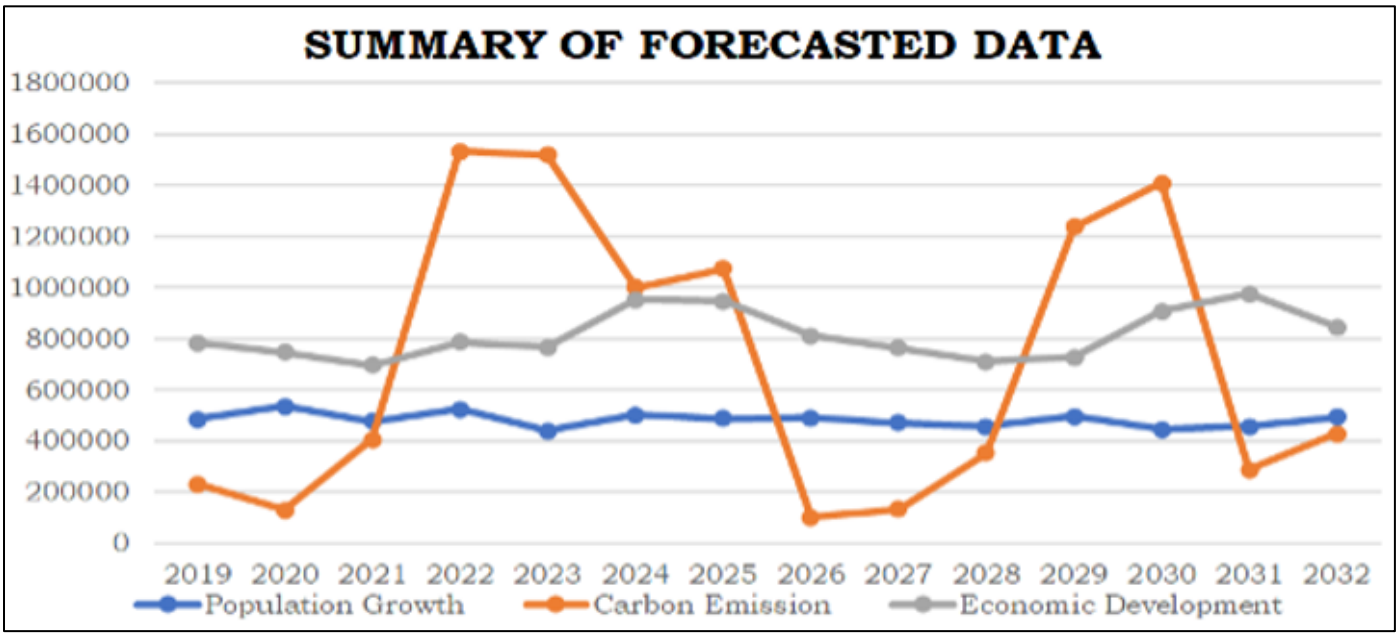

Fig 9 Summary of the Forecasted Trends in Population Growth, Carbon Emissions, and Economic Development in Surigao Del Norte from 2022-2032

The Philippines' erratic economic development pattern can affect trade, investment, and job prospects in addition to the government's ability to implement policies and draw in foreign capital. Global economic development also accompanied with another incidence called inequality through distributional bias and limited opportunities in last few decades. When national income is not distributed proportionately to non-economic sectors, the economic success fails to benefit sustained development in a country (Islam et al., 2015). Fluctuating economic development on a nation depends on various factors, including government policies, market conditions, and external shocks. Effective economic management and policy responses are essential to mitigate the adverse effects and promote sustainable growth and stability in the economic growth of a nation.

Furthermore, fluctuations in carbon emissions make it more difficult to cut greenhouse gas emissions, impeding the nation's goal of a 70% reduction by 2030. Fluctuating carbon emissions production in the next decade can have far-reaching implications for a nation's environment, public health, and even the economy. Emissions from human industry represent a key factor in climate change and exhibit one of the world's most pressing challenges. Year by year increase the concentration of carbon dioxide in the atmosphere and even if energy is a fundamental engine of economic development, the evolution of demand at different stages of economic development requires a viable solution for environmental problems (Onofrei et al., 2022).

Moreover, the tendency of population growth puts additional strain on infrastructure, services, and resources, making it more difficult for the government to properly address social, economic, and environmental concerns. Studies have also been conducted on the supporting capabilities and protection levels of the resources and environment for each region's population and economy, pointing out that the increased vulnerability of the environmental system caused by the increase in human activities has become the main obstacle to the sustainable development of the regional ecological environment and social economy (Huo et al., 2020) while population growth can bring opportunities for economic development and cultural enrichment, it also poses challenges that require careful planning, resource management, and policy interventions to ensure sustainable and inclusive growth.

Significant Relationship Between the Trend of Economic Growth and Carbon Emission in Surigao Del Norte

The table below shows the significant relationship between the trend of carbon emission and economic development in Surigao del Norte.

Table 1 Significant Relationship between the Trend of Economic Growth and Carbon Emission in Surigao Del Norte

Variables	r - value	p - value	Decision on H_0	Interpretation
ED ↔ CE	.452	.000	Significant	Supported

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24OCT196

Table above showed the significant relationship between the carbon emission and economic development in Surigao del Norte. Moreover, results revealed that the computed p-value for the significant relationship between the carbon emission and economic development ($p<0.05=.000$) is less than 0.05 and thus, the null hypothesis is rejected. This implies that economic development significantly and positively influences the carbon emission of Surigao del Norte. Meaning, when there is a progress in the economic trend of the province like consumer behavior, there is an effect towards the carbon emission in the province. According to Nugent and Barone (2021), emissions and economic growth have been "absolutely decoupled" in 32 countries, which means that economic expansion continues apace while emissions increase. The study shows that there is a significant connection between the two variables.

Moderating Effect of Population Growth in the Relationship Between Economic Growth and Carbon Emission in Surigao del Norte

The figure below shows moderating effect of population growth in the relationship between economic growth and carbon emission in Surigao del Norte.

Table 2 Moderating Effect of Population Growth in the Relationship between Economic Growth and Carbon Emission in Surigao Del Norte

Hypothesis	Path Coefficient	t-ratio	p-value	Decision
PG→ED→ CE	-0.090	-.315	.000	Supported

Table above showed moderating effect of population growth in the relationship between economic growth and carbon emission in Surigao del Norte. Moreover, results revealed that the computed t-ratio for the hypothesis is less than the critical t-ratio and thus, the decision for the hypothesis is supported. This implies that the trend of population growth in Surigao del Norte significantly and positively impacts the economic development as well as the carbon emissions in the province. Meaning, when the population of the province increases, the likelihood of a booming economy surges creating more revenue for the region but it also produces significant amount of carbon emissions that contribute to the atmospheric pollution.

According to the Population Media Center (2022), increasing human population significantly impacts the economy in such a way that when there is an increase number of people in a certain area, the chain of supply and demand is affected because a lot of people are in dire need of demands for foods and services, and the rising of prices causes less saving for families to make the working and middle class vulnerable to economic distress. On the other hand, the United Nations Population (2009) said that population growth impacts the trend of increasing carbon emission leading to climatic changes. They further revealed that more people mean more demand for oil, gas, coal, which are examples of fossil fuels that are mined or drilled beneath the surface of the Earth. When these fossil fuels are burned, they emit large amounts of carbon dioxide into the atmosphere that traps warm air like a greenhouse. Hence, the increasing population poses a great threat to both economic development and carbon emissions in the country, specifically, in the province of Surigao del Norte.

IV. CONCLUSIONS

Based on the findings of the study, the following conclusions were drawn: (1) the trend of population growth, economic growth, and carbon emission in Surigao del Norte from 2019-2022 were fluctuating based on pre and post-pandemic effects, economic and social changes, as well as to increased economic activities, industrial growth, and changes in energy consumption patterns; (2) the forecasted trend of population growth, economic development, and carbon emission in the next decade is also fluctuating based on the data but notable increase in the population growth for the province will significantly be seen; (3) since the forecasted trend of population growth, economic growth, and carbon emission is fluctuating, it does have a significant contribution to the Philippines population growth, economic development, and carbon emission in the next decade; (4) moreover, the economic development in the province of Surigao del Norte poses a significant impact towards the province's carbon emission in the next years; and lastly (5) the population growth of Surigao del Norte has a significant and positive influence towards the economic development of the province and its corresponding carbon emissions in the next years.

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