**Subject:** Enviromental Systems and Societies

**Title:** Investigation into the relation of a country's carbon dioxide emmissions ($CO_2$) per capita over their development levels.

**Research Question**: Is there a meaningful difference between the development levels of countries by the meausure of their Human-Development-Index (HDI) and their carbon dioxide emmissions ($CO_2$) per capita?

**Session:** May 2025

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# 1. Introduction

With increased industrialization and urbanization, global warming is one of the biggest problems which is facing humanity in today's world. Global Warming is caused by the enhanced effect of the greenhouse effect which is caused by the greenhouse gases (GHG). Some examples for greenhouse Gases include carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$)**[1]**. Contaminants such as these gases, cause the heat radiated by the earth to be trapped within the earth's atmosphere. Global warming can also cause a global temperature rise which can in turn result in climate change.

The global warming caused by the bioaccumulation of these greenhouse gases is one of the greatest environmental issues the world is facing with constant urbanization and industrialization. As a result, governments from all over the world have been pushing new directives and rules to combat global warming and climate change. However, it can be seen that the countries that are mainly pushing these directives, are more economically developed countries (MEDCs) rather than less economically developed countries (LEDCs). But many people argue that actually more economically developed countries actually emit more greenhouse gases compared to less economically developed countries because their economies are mainly dependent on industrialized production and they have several industrial factories and facilities which carry global warming potential.

**[1]: European Union. (n.d.). GHG emissions of all world countries. EDGAR.**

**https://edgar.jrc.ec.europa.eu/report_2024**

However, as an opposition to this argument, some people argue that less economically developed countries are more susceptible to emit greenhouse gas emissions compared to MEDCs because they do not have the same techniques, regulations and methods to lower and prevent the emissions of greenhouse gases. So, in order to assess if there is a correlation between a country's development level and its carbon dioxide emissions per capita, an investigation will be conducted upon several countries which will be representing a development level. Together with this, the carbon dioxide emissions of these countries will be compared in relation to their development levels. This study also represents a greater scope of study in this field by investigating and comparing 100 countries. The investigation year being 2024 also signifies that the investigation is up to date with current conditions.

## 2. Background Information

### 2.1. The Greenhouse Effect

Air pollution in core, can be described as the presence of any chemicals that may cause harm to living organisms due to their accumulation within the atmosphere. This is considered a global environmental problem for all living organisms because they cause imbalance in the way that ecosystems interact with each other. However, as a result of air pollutants being emitted to the atmosphere, a phenomenon known as the greenhouse effect increases within the atmosphere. In normal circumstances, greenhouse effect occurs because some of the heat that is radiated by the earth's surface , gets absorbed by various gases in the atmosphere, the so-called greenhouse gases. This means that some of this radiation is received by the earth's surface again, causing additional warming.**[2]**

**[2]: Tsokos, K. A. (2023). Physics for the IB diploma. Coursebook. Cambridge University Press.**

Greenhouse effect is an important phenomenon for living organisms within the earth because it keeps the temperature of the earth within a comfortable temperature range for all living organisms. However when gases such as $CO_2$ (carbon dioxide) gets emitted to the atmosphere, by the means of external agricultural or industrial activity which is caused by humans, the "greenhouse effect" of the atmosphere increases, because, greenhouse gases they are called, starts to trap more of the incident infrared radiation radiated by the earth which causes an increase in the global temperatures of the earth.

## 2.2. Greenhouse gases and its effects on the environment by its emission

Without a doubt our world is ever changing. Human civilization is continuing to thrive day by day. New achievements are being made every day which carry the civilization to new heights. However, with this achievements, humankind also grows its environmental impact on the environment. Over the last years, there has been a growing worry of human's environmental impact on the environment which has led to stringer protocols regarding environmental impact. One of the key area of focus was global emissions, the inorganic gases which are emitted to the environment as the result of human activity. These gases have variety of different effects on the environment. But most popular of this kind of gases are the gases which are referred as the "greenhouse gases"."greenhouse gases" is a term used for referring to the gases which trap the heat inside of the atmosphere. **[3]** The heat absorbing qualities of these gases contribute to the global warming of the planet. Over the last 20 years greenhouse gases have contributed to a 1.5 degree celsius rise in the global temperatures.**[4]**

**[3]: Environmental Protection Agency. (n.d.). EPA. https://www.epa.gov/ghgemissions/overview-greenhouse-gases**

**[4]: United Nations. (n.d.). *What is climate change?*. United Nations. https://www.un.org/en/climatechange/what-is-climate-change**

Greenhouse gases differ by name and their specific qualities but commonly methane and nitrous oxide are referred to as greenhouse gases. But most common gas referred as a greenhouse gas is carbon dioxide (CO2). This is an important greenhouse gas produced by the extraction and burning of fossil fuels such as coal, oil and natural gas. The importance of the impact that carbon dioxide gas makes on the environment is ever increased by Fossil fuels being the primary source of energy for humankind for years. So it has been a vital step for world nations to control the emission of carbon dioxide and other greenhouse gases.

## 2.3. Measures Taken in History to Reduce Global Emissions

After 1980's governments started to introduce environmental emissions protocols and regulations which limited a corporate or country to specific emission standards. In 1997, Kyoto protocol was signed by 192 countries and it set an example as the first internationally recognized climate agreement. Kyoto protocol helped to reduce the global emissions of the world nations by 7% and it set an example for future climate agreements.**[5]** And in 2016, 196 parties were involved in the signing of the Paris Climate Act.

## 2.4. Human Development Index (HDI)

Human Development Index, HDI for short, is a summary measure of average achievement in key dimensions of human development goals,which is set by the United Nations. The Human Development Index assesses three key areas of human life which can be summarized as, having a long and healthy life, being knowledgeable and having a decent standard of living. Index is calculated by taking the geometric mean of indices for these three metrics.**[6]**

**[5]: Unfccc.int. (n.d.). https://unfccc.int/kyoto_protocol**

**[6]: Nations, U. (2024a, November 27). *Human development index*. Human Development Reports. https://hdr.undp.org/data-center/human-development-index#/indicies/HDI**

The HDI can be used to question national policy choices, in this case carbon dioxide emissions regulations of specific countries. Each country is assigned a value between 0 and 1, and with this value the countries can be classified into four different groups which are set by the United Nations. These groups can be divided into countries with low, medium, high and very high human development. In the investigation these 4 groups of development will be used to group countries with a similar level of development and a conclusion will be reached upon these 4 groups.

## 2.5. Argument on LEDC and MEDC countries Greenhouse Gas Emissions

International treaties such as the Kyoto Protocol and the Paris Climate Act have aimed to lower the greenhouse gas emissions globally. Since, these are international agreements each nation is expected to lower it's emissions by a set amount. But different nations have different levels of development. The world is comprised of many countries which have different populations, economic income and industries. These differences with regard to environmental pollution, affect a country's carbon footprint. As a result, many people argue that a country's development level has a relation with its carbon footprint. Some people argue that more economically (MEDCs) developed nations have a higher carbon footprint per capita due to their possession of industrial factories and their economies being reliant on production of industrialized goods such as heavy machinery, equipment, tools and heavy machinery. However, as an opposition to this argument, some people argue that less economically developed countries (LEDCs), have an bigger carbon footprint compared to MEDCs, because they do not have the same facilities for pollution reduction or prevention. Also LEDCs have a higher population density compared to MEDC's which can have an effect on the carbon footprint of LEDC's.

## 2.6. Research Question

Is there a meaningful difference between the development levels of countries by the measure of their Human-Development-Index (HDI) and their carbon dioxide emissions ($CO_2$) per capita?

## 2.7. Hypothesis

It is expected that countries with lower development, LEDC's, will have lower emissions per capita compared to MEDC's.This argument is hypothesized due to, MEDC's having industrial factories and facilities which increases their global warming potential. Also consumption of goods and services is higher in MEDCs compared to LEDCs due to their wealth and buying power which in turn increases the carbon footprint of the population in MEDCs compared to LEDCs. **[7]**

## 2.8. Aim of The Investigation

The aim of this investigation is to outline and investigate the correlation, if any, between a nation's development level and its carbon emissions per capita. In order to assess and compare specific countries development levels, the Human-Development-Index (HDI for short) will be utilized in the study, which is a metric published by the United Nations and it evaluates a person's quality of life in a nation. Together with carbon emissions and Human-Development-Index a comparative analysis will be conducted in the investigation, which will help us to reach a conclusion about the relation between a nation's development levels and carbon emissions.

**[7]: BBC. (2024, April 17).** ***The development gap - CCEA - BBC bitesize*****. BBC News. https://www.bbc.co.uk/bitesize/articles/zwf63qt#z3h7s82**

# 3. Methodology

The methodology of the investigation was created to determine if a correlation exists between the Development level of world countries and their carbon emissions. To determine if a correlation exists or how it is correlated, data was gathered from official sources which included several statistical values. Each country was assessed with respect to its Human-Development Index value in the year 2024 of between 0 and 1, and also their carbon dioxide gas emissions per capita in 2024. To determine accurate results from the investigation, the carbon emissions of countries were taken into account with respect to per capita, meaning carbon emissions per person.

## 3.1. Method Development

### 3.1.1. Selection of world countries to be assessed and evaluating their suitability for the investigation

Before the world countries were selected for the investigation to be assessed they were researched thoroughly. They were specifically chosen to reflect most of the world population. In order to achieve this, small island or remotely situated countries were eliminated from the scope of the investigation. Also countries with a population count of fewer than 1,000,000 residents were eliminated from the scope of the investigation due to their outlying characteristics such as the population count and scale of their economies.

### 3.1.2. Selection of which index is going to be utilized for the assessment and comparison of world countries development levels

After selection of the countries to be investigated in the experiment, a suitable metric was needed to assess and compare development levels associated with the countries. There are several metrics which are published by United Nations and Various Governmental organizations to assess a country's development levels. During the process of developing the

methodology, 3 key parameters were selected to assess the development level of countries. These parameters include the general population's life expectancy at birth, Educational Level associated with the population and a decent standard of living with respect to Gross-National-Income**[8]**. These 3 key parameters were selected because of their ability to affect the individual's environmental value systems and awareness about environmental topics. From these parameters, it was evaluated that most suitable index to form a relation between development levels was the **Human-Development-Index (HDI).** HDI index is published by the United Nations for 194 world countries every year and it takes into account these key 3 metrics, obtaining a value from 0 to 1 **[9].** Coupled with carbon emission data, the HDI index will help the investigation to investigate and reach a conclusion about the relation between development level and emissions.

### 3.1.3. Selecting the methodology for measuring carbon emissions

To assess a country's carbon emissions, several different methods were considered. This included the total $CO_2$ emissions (in Tons) emitted by the Country, emission of $CO_2$ per capita (in tons), which is the measure of carbon dioxide gas emitted for a single person over a year, and $CO_2$ emissions per GDP. As a result the methodology for assessing the emission of carbon dioxide was selected to be per capita. This choice was made because assessing the total carbon dioxide emissions of a country would bring discrepancy to the total investigation as it would benefit smaller countries. Also assessing carbon emission per GDP would benefit MEDCs over LEDCs due to their significantly higher Gross National Income.

**[8]: Herre, B., & Arriagada, P. (2023, November 1). The human development index and related indices: What they are and what we can learn from them. Our World in Data. https://ourworldindata.org/human-development-index**

**[9]: Nations, U. (2024, November 27). Human development index. Human Development Reports. https://hdr.undp.org/data-center/human-development-index#/indicies/HDI**

### 3.1.4. Risk and Ethical Assesment

The data used in the study was gathered from publicly accessible resources which were from official governmental agency websites. Here it can be considered that each individual country reports its carbon dioxide emissions. So it is up to the EDGAR ,Emissions Database for Global Atmospheric Research, website for it to collect reliable information. Also HDI index values which were obtained for countries were obtained through the United Nations Portal to ensure reliable data.

## 3.2. Variables

To better demonstrate the Variables of the investigation, a graph was constructed which illustrates the independent, dependent and controlled variables for the investigation.

| Named Variable | How it will be controlled/manipulated | Data Sources |
|---|---|---|
| **Independent Variable** | | |
| Countries which have different levels of development | The categories of development levels of Countries will include:<br>● Very High Human Development<br>● High Human Development<br>● Medium Human Development<br>● Low Human Development.<br>From each Category 7 Random Countries will be selected and evaluated with respect to their human development Index. | Data for the Human Development Index will be gathered from official United Nations sources. |

**Table 1:** A graph demonstrating the Independent Variable (Development Level) of the investigation.

| Named Variable | How it will be controlled/manipulated | Data Sources |
|---|---|---|
| **Dependent Variable** | | |
| carbon dioxide gas emissions (per capita) of specific Countries that have different levels of development | The countries specific carbon dioxide gas emissions will be evaluated by making a comparison of each country's gas emissions per capita. The reason for doing the emissions comparison by per capita is to compare the countries carbon dioxide emissions based on the emission for a single individual of a population. Comparing outright emissions can result in a compromised comparison, in turn achieving a misleading conclusion. | The data for the carbon dioxide gas emitted by a specific country per capita, will be gathered from official sources which will be cited in the bibliography. |

**Table 2:** A graph demonstrating the Dependent Variable ($CO_2$ gas emissions) of the investigation.

| Controlled Variable | How will it be Controlled? | How would this variable affect the data if it was not controlled |
|---|---|---|
| The year at which investigation is conducted upon | Only Collecting Data from the Year 2024 | The data scope would be broad, preventing a detailed investigation |
| Data Sources Utilized (EDGAR - Emissions Database for Global Atmospheric Research) and (United Nations) | Gathering data from the same reputable and official sources | Collecting data from multiple and unofficial sources may result in data inconsistency and unreliability |

**Table 3:** A graph demonstrating the Controlled Variables of the investigation.

## 3.3. Materials & Apparatus

- TI-84 Calculator
- *Emissions Database for Global Atmospheric Research* website
- *United Nations Human Development Reports* website
- A Computer with Excel for statistical calculation

## 3.4. Methodology

i) The data is obtained through the website "United Nations Development Reports"

ii) Under the section of Human-Development-Index the values of 2024 is downloaded as an excel file

iii) As a result the spreadsheet is obtained, together with the classification of countries from different development levels and HDI values.

iv) Then the website "Emissions Database for Global Atmospheric Research" can be visited to obtain the emission data for each country.

v) Under the page of "Country Fact Sheet" each specific country's carbon dioxide emissions per capita of the year 2024 can be downloaded.

vi) Once taken note of all the data, data processing can be proceeded.

## 4. Justification of Method

The reason for the investigation's year of scope to be 2024 is due to the investigation to be as closely relevant as today's world demographic. Because from 2010's to now, the public's perception of climate change have been greatly altered. And as the society's awareness about climate change have been increasing, in turn governments have been pushing new directives and measures to combat climate change. In a social demographic, as demonstrated here, it is

crucial to investigate if the MEDC's carbon emissions per capita are higher or lower compared to LEDC's. This investigation as a result will derive a relation between the human development index (HDI) of demonstrated countries and their carbon dioxide emissions per capita through the use of statistical data and data processing measures. The set of countries used for the investigation will be evaluated in four groups. Each group will consist of 25 countries for a grand total of 100 countries. The research interval was selected to be the year 2024 in order to ensure the relevancy of the findings of the investigation.

| Countries to be utilized in the experiment | | | |
|---|---|---|---|
| **Countries with Low Human Development** | **Countries with Medium Human Development** | **Countries with High Human Development** | **Countries with Very High Human Development** |
| Nigeria | Venezuela | Bulgaria | Switzerland |
| Rwanda | Bolivia | Egypt | Norway |
| Togo | Morocco | Mauritius | Iceland |
| Mauritania | Kenya | Tunisia | Hong Kong |
| Pakistan | Gabon | Albania | Denmark |
| Côte d'Ivoire | Suriname | China | Sweden |
| Tanzania | Bhutan | Armenia | Germany |
| Lesotho | Tajikistan | Mexico | Ireland |
| Senegal | El Salvador | Iran | Singapore |
| Sudan | Iraq | Sri Lanka | Australia |
| Djibouti | Bangladesh | Bosnia Herzegovina | Netherlands |
| Malawi | Nicaragua | Vietnam | Belgium |
| Benin | Cabo Verde | Dominican Republic | Finland |
| Burundi | Uganda | Ecuador | Liechtenstein |
| Eritrea | Equatorial Guinea | North Macedonia | United Kingdom |
| Ethiopia | India | Cuba | New Zealand |
| Liberia | Nepal | Moldova | United Arab Emirates |
| Madagascar | Guatemala | Indonesia | Canada |
| Guinea-Bissau | Kiribati | Peru | Korea |
| Congo | Honduras | Azerbaijan | Luxembourg |
| Guinea | Lao | Brazil | United States |
| Afghanistan | Vanuatu | Colombia | Austria |
| Mozambique | Sao Tome and | Libya | Slovenia |
| Sierra Leone | Principe | Algeria | Japan |
| Burkina Faso | Eswatini | Turkmenistan | Israel |
| | Namibia | | |

**Table 4:** A graph showing the set of countries that will be assessed in the investigation.

# 5. Results and Analysis

## 5.1. Raw Data

| Countries | Independent Variable (HDI Value) | Dependent Variable ($CO_2$ emissions Per Capita) (in Tons) |
|---|---|---|
| **Countries with Very High Human Development** | | |
| **Switzerland** | 0,967 | 3,87 |
| **Norway** | 0,966 | 7,86 |
| **Iceland** | 0,959 | 8,79 |
| **Hong Kong** | 0,956 | 4,51 |
| **Denmark** | 0,952 | 4,56 |
| **Sweden** | 0,952 | 3,43 |
| **Germany** | 0,950 | 7,06 |
| **Ireland** | 0,950 | 6,5 |
| **Singapore** | 0,949 | 9,38 |
| **Australia** | 0,946 | 14,21 |
| **Netherlands** | 0,946 | 7,09 |
| **Belgium** | 0,942 | 7,18 |
| **Finland** | 0,942 | 5,73 |
| **Liechtenstein** | 0,942 | 3,87 |
| **United Kingdom** | 0,940 | 4,42 |
| **New Zealand** | 0,939 | 7,22 |
| **United Arab Emirates** | 0,937 | 20,22 |
| **Canada** | 0,935 | 14,91 |
| **Korea** | 0,929 | 11,04 |
| **Luxembourg** | 0,927 | 11,18 |
| **United States** | 0,927 | 13,83 |
| **Austria** | 0,926 | 6,65 |
| **Slovenia** | 0,926 | 5,81 |
| **Japan** | 0,920 | 7,54 |
| **Israel** | 0,915 | 4,13 |

**Table 5:** A Raw Data table for countries with Very High Development Levels .(Listed by Decreasing HDI)

| Countries | Independent Variable (HDI Value) | Dependent Variable ($CO_2$ emissions Per Capita) (in Tons) |
|---|---|---|
| **Countries with High Human Development** | | |
| **Bulgaria** | 0,799 | 5,86 |
| **Egypt** | 0,728 | 2,31 |
| **Mauritius** | 0,796 | 3,29 |
| **Tunisia** | 0,732 | 2,57 |
| **Albania** | 0,789 | 1,56 |
| **China** | 0,788 | 9,24 |
| **Armenia** | 0,786 | 2,63 |
| **Mexico** | 0,781 | 3,52 |
| **Iran** | 0,780 | 9,1 |
| **Sri Lanka** | 0,780 | 0,965 |
| **Bosnia and Herzegovina** | 0,779 | 6,33 |
| **Vietnam** | 0,726 | 3,69 |
| **Dominican Republic** | 0,766 | 2,74 |
| **Ecuador** | 0,765 | 2,51 |
| **North Macedonia** | 0,765 | 4,19 |
| **Cuba** | 0,764 | 1,92 |
| **Moldova** | 0,763 | 2,5 |
| **Indonesia** | 0,713 | 2,41 |
| **Peru** | 0,762 | 1,7 |
| **Azerbaijan** | 0,760 | 4,14 |
| **Brazil** | 0,760 | 2,2 |
| **Colombia** | 0,758 | 1,97 |
| **Libya** | 0,746 | 8,88 |
| **Algeria** | 0,745 | 3,99 |
| **Turkmenistan** | 0,744 | 10,51 |

**Table 6:** A Raw Data table for countries with High Development Levels. (Listed by Decreasing HDI)

| Countries | Independent Variable (HDI Value) | Dependent Variable ($CO_2$ emissions Per Capita) (in Tons) |
|---|---|---|
| **Countries with Medium Human Development** | | |
| **Venezuela** | 0,699 | 2,47 |
| **Bolivia** | 0,698 | 1,98 |
| **Morocco** | 0,698 | 1,82 |
| **Kenya** | 0,601 | 0,38 |
| **Gabon** | 0,693 | 2,16 |
| **Suriname** | 0,690 | 4,45 |
| **Bhutan** | 0,681 | 2,31 |
| **Tajikistan** | 0,679 | 0,93 |
| **El Salvador** | 0,674 | 1,27 |
| **Iraq** | 0,673 | 4,3 |
| **Bangladesh** | 0,670 | 0,71 |
| **Nicaragua** | 0,669 | 0,87 |
| **Cabo Verde** | 0,661 | 1,71 |
| **Uganda** | 0,550 | 0,14 |
| **Equatorial Guinea** | 0,650 | 2,44 |
| **India** | 0,644 | 2,07 |
| **Nepal** | 0,601 | 0,58 |
| **Guatemala** | 0,629 | 1,13 |
| **Kiribati** | 0,628 | 0,76 |
| **Honduras** | 0,624 | 1,08 |
| **Lao** | 0,620 | 3,49 |
| **Vanuatu** | 0,614 | 0,92 |
| **Sao Tome and Principe** | 0,613 | 0,92 |
| **Eswatini** | 0,610 | 0,92 |
| **Namibia** | 0,610 | 1,53 |

**Table 7:** A Raw Data table for countries with Medium Human Development Levels. (Listed by Decreasing HDI)

| Countries | Independent Variable (HDI Value) | Dependent Variable ($CO_2$ emissions Per Capita) (in Tons) |
|---|---|---|
| **Countries with Low Human Development** | | |
| **Nigeria** | 0,548 | 0,58 |
| **Rwanda** | 0,548 | 0,12 |
| **Togo** | 0,547 | 0,28 |
| **Mauritania** | 0,540 | 0,9 |
| **Pakistan** | 0,540 | 0,91 |
| **Côte d'Ivoire** | 0,534 | 0,51 |
| **Tanzania** | 0,532 | 0,28 |
| **Lesotho** | 0,521 | 0,37 |
| **Senegal** | 0,517 | 0,65 |
| **Sudan** | 0,516 | 0,34 |
| **Djibouti** | 0,515 | 0,72 |
| **Malawi** | 0,508 | 0,29 |
| **Benin** | 0,504 | 0,49 |
| **Burundi** | 0,420 | 0,07 |
| **Eritrea** | 0,493 | 0,12 |
| **Ethiopia** | 0,492 | 0,14 |
| **Liberia** | 0,487 | 0,3 |
| **Madagascar** | 0,487 | 0,14 |
| **Guinea-Bissau** | 0,483 | 0,16 |
| **Congo (Democratic Republic of the)** | 0,481 | 1,18 |
| **Guinea** | 0,471 | 0,25 |
| **Afghanistan** | 0,462 | 0,21 |
| **Mozambique** | 0,461 | 0,28 |
| **Sierra Leone** | 0,458 | 0,13 |
| **Burkina Faso** | 0,438 | 0,26 |

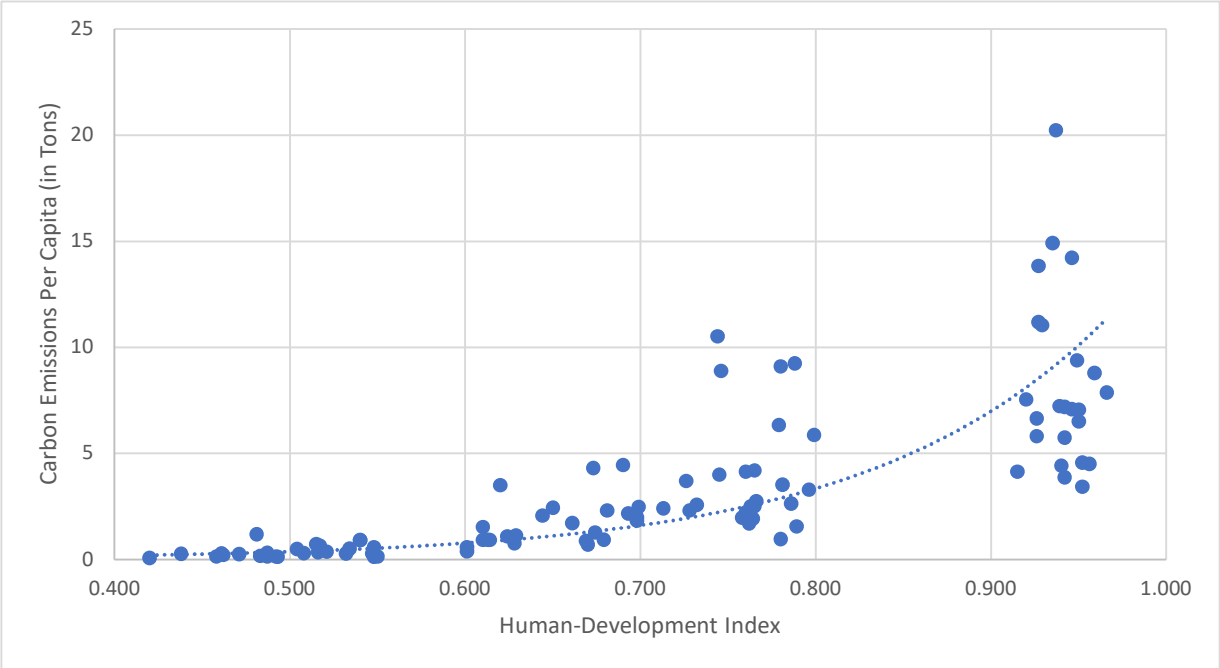
**Table 8:** A Raw Data table for countries with Low Human Development Levels. (Listed by Decreasing HDI)

This table shows the results obtained from the data resources. However in order to investigate if a correlation actually exists between the development levels and $CO_2$ emissions of countries, statistical processing of the data is needed.

## 5.2. Qualitative observations

- Initially, from the data it is observed that there is a direct relation with the countries HDI values and their $CO_2$ gas emissions per capita. As it is observed, generally, as the HDI value for a specific country increases, the $CO_2$ gas emissions per capita increases.
- Countries which have oil dependent industries such as USA or UAE, have a significantly higher $CO_2$ gas emission value per capita with respect to other countries.
- Countries which are situated in the central african continent generally have a lower HDI value, and they have fewer $CO_2$ emissions per capita compared to other world countries while countries situated in Europe and North & South America have a higher HDI value and have more $CO_2$ emissions per capita compared to other world countries.

To better observe the relation between development level of countries and their $CO_2$ gas emissions, a scatter plot graph was constructed.




**Graph 1:** The Scatter Plot Graph showing the correlation between the Human-Development-Index which is situated in the X-Axis as the Independent Variable and carbon Emissions Per Capita (in Tons) which is situated in the Y-Axis as the Dependent Variable. A Trendline was also constructed to show the General Relation.

From **Graph 1** and the trendline which was constructed it can be seen that there is a direct relation between the HDI value and $CO_2$ emissions per Capita. Moreover it can also be deduced from the trendline that as HDI value increases the $CO_2$ emissions per Capita decreases. Countries with a Low HDI value are distributed at the lower end of the spectra of the graph while countries with a relatively High HDI value are distributed at the higher end of the spectra of the graph.

## 5.3. Statistical Analysis

| | HDI Value | $\boldsymbol{CO_2}$ Emissions per Capita (in Tons) |
|---|---|---|
| Mean | 0,71297 | 3,52735 |
| Standard Error | 0,016498873 | 0,38596542 |
| Median | 0,706 | 2,255 |
| Mode | 0,942 | 0,14 |
| Standard Deviation | 0,164988733 | 3,859654199 |
| Sample Variance | 0,027221282 | 14,89693053 |
| Kurtosis | -1,183518819 | 3,559360795 |
| Skewness | 0,070476109 | 1,760726975 |
| Range | 0,547 | 20,15 |
| Minimum | 0,42 | 0,07 |
| Maximum | 0,967 | 20,22 |
| Sum | 71,297 | 352,735 |
| Count | 100 | 100 |

**Table 9:** Descriptive Statistics of the Data Given in Tables 5,6,7 and 8.

**ANOVA: Single Factor**

SUMMARY

| *Groups* | *Count* | *Sum* | *Mean* | *Variance* |
|---|---|---|---|---|
| $CO_2$ emissions (per capita) | 100 | 71,297 | 0,71297 | 0,02722 |
| HDI Value | 100 | 352,735 | 3,52735 | 14,8969 |

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | ***F*** | ***P-value*** | ***F critical*** |
|---|---|---|---|---|---|---|
| Between Groups | 396,037 | 1 | 396,037 | **53,0733** | **7,45368E-12** | **3,88885** |
| Within Groups | 1477,49 | 198 | 7,46208 | | | |
| Sum | 1873,53 | 199 | | | | |

**Table 10:** ANOVA test applied on results given in Tables 5,6,7 and 8.

To better analyze and interpret the results of the investigation, an ANOVA test was conducted **(See Table 10)**. ANOVA test can be utilized to investigate if there is a statistical difference between the means of the two research groups. The Null hypothesis $(H_0)$ and alternative Hypothesis $(H_1)$ is stated below.

$(H_0)$**:** A country's Development Level is not correlated with its $CO_2$ emissions per Capita.

$(H_1)$**:** A country's Development Level will cause a difference in its $CO_2$ emissions per Capita

## 6. Conclusion

The aim of this investigation was to find if a correlation exists between the development levels of countries and their $CO_2$ emissions per Capita and if it exists was it inversely or directly related.

The investigation was conducted over a total of 4 groups. The Groups of classification were countries with low, medium, high and very high levels of human development. To have a clear and enough data to conduct a statistical analysis, each group had 25 countries which were representing their respective development level. Each country had its carbon emissions per capita evaluated over its Human-Development-Index value.

To sum up the results, the average HDI for the 100 country data set was 0,713 and average carbon emissions per capita for the research set was 3,53. The minimum HDI value was 0,42 which belonged to Burundi and the highest HDI value in the research set was 0,967 which belonged to Switzerland. The country with the lowest carbon emissions per capita was Burundi with 0,07 tons of carbon emissions per capita per year. The country with the highest carbon emissions per capita was the United Arab Emirates with 20,22 tons of carbon emissions per capita per year. **(See tables 5,6,7 and 8)**

ANOVA test results indicate that the P-value, which is 7.45E-12, is smaller than the alpha value which was set for the investigation at 0.05. The test results also indicate that F value of 53.07 is significantly higher than the F critical value 3.89. Together these findings from the ANOVA test indicate that there is a statistically significant difference between HDI value of countries and their carbon emissions per capita. As a result, the null hypothesis "$H_0$**:** A country's Development Level is not correlated with its $CO_2$ emissions per Capita." is rejected. The alternative hypothesis "$H_1$**:** A country's Development Level will cause a difference in its $CO_2$ emissions per Capita." is accepted.

## 7. Discussion and Evaluation

From **Graph 1** and the ANOVA Test it can be deduced that as the HDI value of a country increases the carbon emissions per capita also increases. Therefore my Hypothesis about the investigation is correct. This finding can be related to the fact that more developed countries such as MEDCs have a bigger global warming potential because they operate in an industrialized economy where the economy is dependent on production and import of goods. As a result, MEDCs contain more factories and industrial facilities compared to LEDCs which increase their global warming potential. Also the population in more developed countries have more resources to purchase goods and services which increases the global warming potential. This can be attributed to metrics such as buying power or even motorcar usage. For example the country with the highest carbon emissions per capita in the research data set (United Arab Emirates) has 376 vehicles per 1000 people while the country with the lowest carbon emissions per capita in the research data set (Burundi) has just 10 vehicles per 1000 people.**[10]**

**[10]: Our World in Data. (2024, May 20). *Registered vehicles per 1,000 people*. Our World in Data. https://ourworldindata.org/grapher/registered-vehicles-per-1000-people?tab=chart&country=BDI~ARE**

For the most part, the methodology and the research procedure of this investigation helped it to reach an accurate conclusion with statistical data analysis to back up the results of the investigation. The Data which was utilized in the study, has been gathered from respected environmental agencies in order to ensure it's reliability. However, there is still some uncertainty surrounding the number of countries in the dataset which have provided reliable data about their carbon dioxide emissions to these environmental agencies. Because individual countries which report to these environmental organizations could report falsified or incorrect carbon dioxide emissions data. In order to mitigate this, a deeper inspection into each country's data collection techniques could be utilized. Also there were some outlier countries in the data which possessed a substantial amount of heavy industries but had a lower HDI score due to the income inequality. Perhaps for future investigations, the investigation could be repeated with more countries in the data set for an even more sound conclusion.

The investigation could also be repeated with assessing emission of different air pollutants made by countries such as ammonia, carbon monoxide or even nitrogen oxides in relation with their development levels to research if a correlation exists between toxic air pollutants and the development level of a country.

Moreover the investigation could be repeated by assessing countries' carbon emissions in relation to their geographical position such as the continent which they are situated in . This in turn can be beneficial in understanding how geographical position affects a country's carbon emissions. Assessment with respect to annual intervals can also be conducted to investigate the change in carbon dioxide emissions of countries over the years.

Overall, from this investigation we could see how the development level of a country affects its carbon emissions per capita. This investigation has helped me to understand that global warming potential that more developed countries have over developing and less developed countries has an effect on their carbon emissions per capita.

Also, these results of this investigation could be utilized to compare a specific country's environmental and economic agenda with respect to their carbon dioxide emissions. Also the results obtained from the investigation could be presented at international climate hearings in order to put pressure on some MEDCs which have been pushing more eco friendly regulations in all sectors, however not complying with themselves.

All in all, this investigation investigates the research question "To what extent development levels of countries by the measure of their Human-Development-Index (HDI) affect their carbon dioxide emissions ($CO_2$) per capita?". Through the multiple methodologies, research and statistical analysis methods in this study, we were able to observe and identify a relation between carbon emissions per capita of a country and its respective development level. Over the extensive data set, the countries which were representing their respective development level were evaluated by their carbon emissions per capita in relation to their HDI value. At the end of the investigation it was concluded that HDI value of a country was directly related with its carbon emissions per capita.

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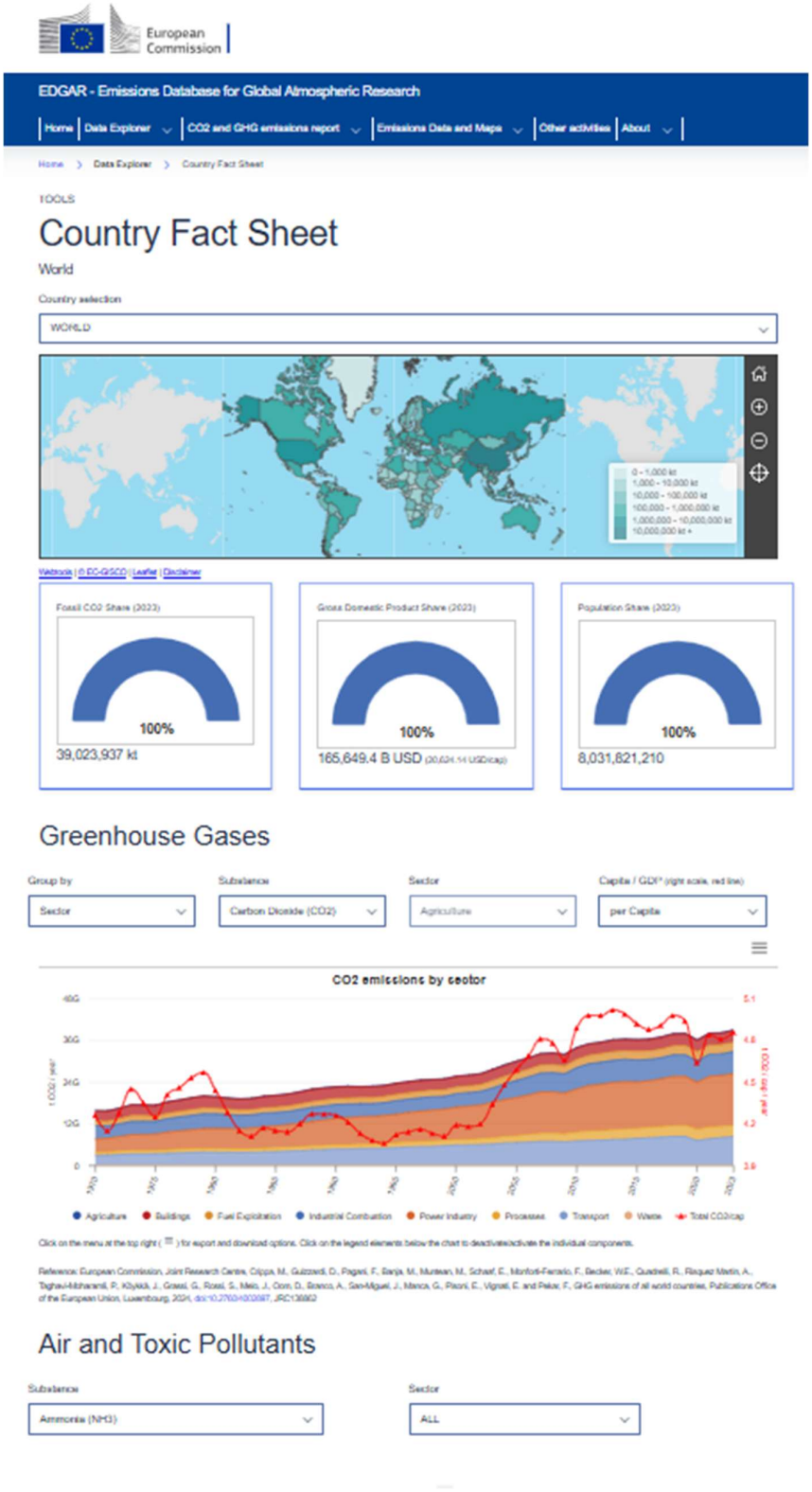
# 9. Appendix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per Capita
CO2 emissions by sector
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Substance
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Sector
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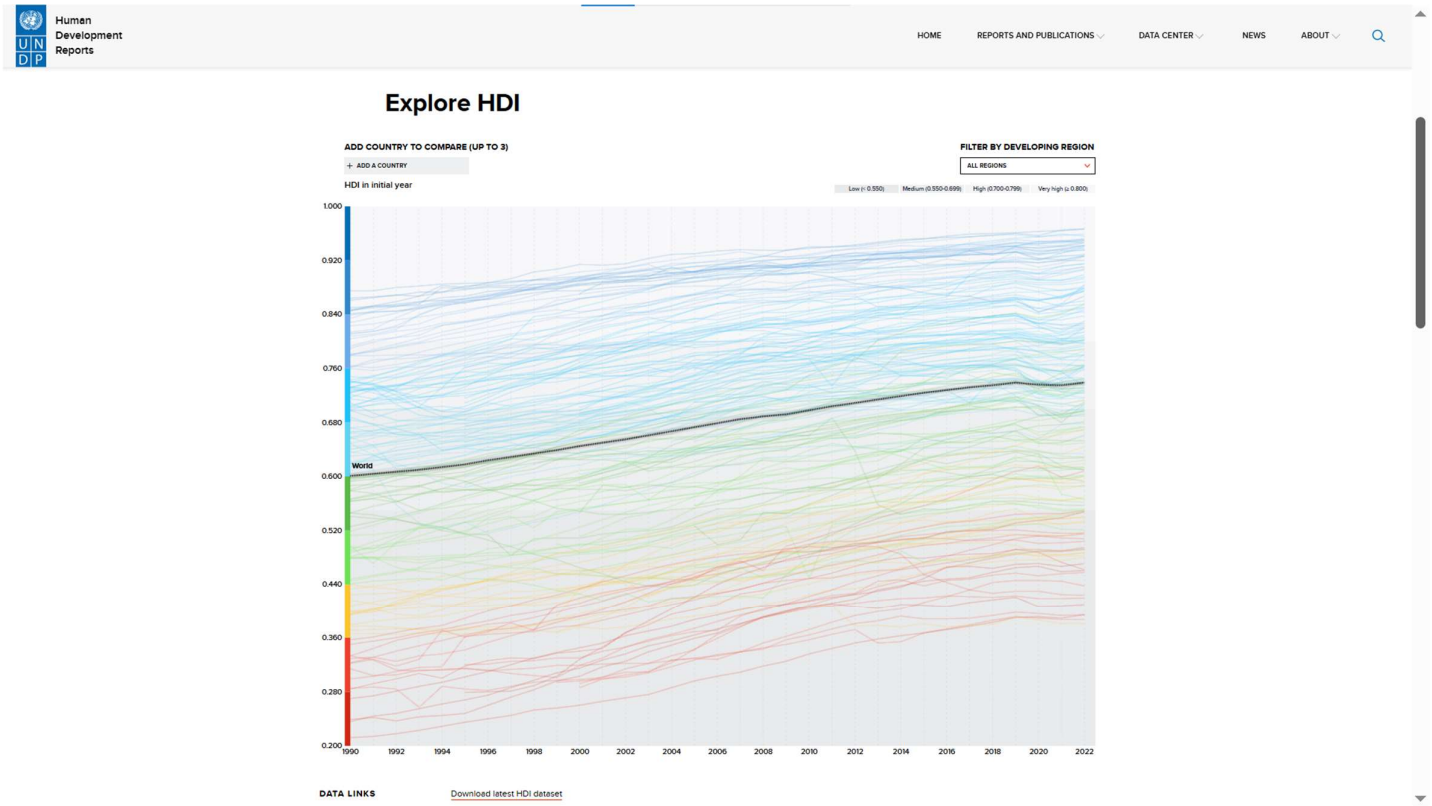
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Very high (≥ 0.800)
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0.840
0.760
0.680
0.600
0.520
0.440
0.360
0.280
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