Examining the correlation between population sizes and CO_2 emissions

Background:
Since the 1970s, the world's population has more than doubled from 3 billion to 7 billion people. The planet is predicted to have to house another 3 billion by 2050. This rapid population growth on a global scale will have obvious negative implications. This includes limited resources, such as food, water and housing, and also a greater impact of pollution of the planet.

At the same time, there has been increasing concern about increasing levels of carbon dioxide in the atmosphere. Scientists tell us that this comes from humans, and that it is causing global warming. This interest in uncovering whether there is a link between population growth and a nation's carbon emission rates was sparked by the growing issue of global warming, as there is a link between atmospheric carbon dioxide levels and climate change.

This investigation will attempt to discover whether there is any link between a nation's population and the amount of carbon emissions that it produces yearly. If there is a link, then countries producing larger quantities of CO_2 should begin to consider finding methods to reduce the amount that they release into the atmosphere by attempting to cut their emissions on an individual level, thereby reducing their overall emissions. If this occurs then, over time, slowing the process of global warming might be successful.

Introduction:
The purpose of this assessment is to gain insight as to whether a nation's population has an effect on the yearly amount of carbon emissions produced. This cannot be done through first-hand experiments, and so data that has already been collected from other sources will be used. In order to make the assessment as accurate as possible, more than one source will be used to obtain data, in order to avoid any biases that the data collector may have had or any inaccuracies that may have appeared in their work.

Through finding connections between a country's CO_2 emissions and its population size it can become easier to predict changes that will occur in the environment over the next several years. This is important as environmental damage may be able to be reduced, and more forms of sustainable energy may be introduced if it becomes clear that population growth leads to greater CO_2 emissions.

The 10 most and the 10 least populous countries have been chosen for the assessment, so it is logical to use the nations that rank as the most and least populous as a basis for the rest of the assessment. Overall, through this assessment it will be possible to establish whether the amount of carbon dioxide released by a country is linked to its population, and so find out if the ways to solve the problem of global warming should be linked to reducing the emissions from each individual.

In order for the assessment to be as accurate as possible, data will be collected from three reliable sources.

- Index Mundi
- NationMaster
- Gapminder

All three hold information on global statistics that have been updated regularly. By comparing three reliable sources and the information that they give on countries' populations and carbon emissions, the most accurate results can be obtained. The data that will be used in the table of results is a

measure of a country's total carbon emissions, and the calculations shown in the next table are measures of carbon emissions per capita.

Research question:
Does a country's population impact on the amount of carbon emissions it produces?

Hypothesis:
A country's population does affect the amount of CO_2 that is released, as each person will be using energy that is produced with the release of carbon dioxide.

Method:
1. Select countries to examine that will make the assessment as wide-ranging as possible. (Use the 10 most populous countries and the 10 least populous countries.)
2. Collect raw data from the countries selected by population size and carbon emissions. (Use the online sources Gapminder, NationMaster and Index Mundi for reliable data.)
3. Collate this raw data into a table for further analysis. Rank countries in order of population size.
4. Create graphs to display information more clearly (for example, Venn diagrams) as the results will be easier to assess.

Variables:
Independent
The population sizes. Data on this will be obtained from more than one source to make the assessment as accurate as possible.

Dependent
The carbon dioxide emissions per annum.

Controlled
1. The sampling strategy—before beginning the assessment, the countries that were to be assessed included the 5 countries with the highest carbon emissions and the 5 with the largest populations. However, it became clear that many of these were the same, so the 10 most and least populous were sampled instead.
2. The year for which the data was collected.

Data table/results:
Rankings

Emissions ranking	
Highest 10	**Lowest 10**
1. China	1. Brunei
2. United States	2. Suriname
3. Russia	3. Iceland
4. Japan	4. Malta
5. India	5. Greenland
6. Brazil	6. Andorra
7. Indonesia	7. Belize
8. Pakistan	8. Liechtenstein
9. Nigeria	9. Monaco
10. Bangladesh	10. Gibraltar

Population size rankings	
Highest 10	**Lowest 10**
1. China	1. Suriname
2. India	2. Malta
3. United States	3. Brunei
4. Indonesia	4. Belize
5. Brazil	5. Iceland
6. Pakistan	6. Andorra
7. Nigeria	7. Greenland
8. Bangladesh	8. Lichtenstein
9. Russia	9. Monaco
10. Japan	10. Gibraltar

A table showing the populations and carbon dioxide emissions of 20 countries

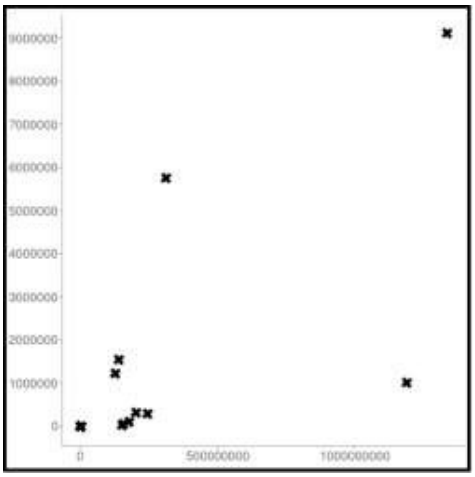
Countries	**Population (total)**	**CO_2 emissions (yearly tonnes)**
China	1,336,718,015	9110978.801
India	1,189,172,906	1007980
United States	311,705,000	5762050
Indonesia	245,613,043	286027
Brazil	203,429,773	327858
Pakistan	176,554,000	105983
Nigeria	155,215,573	48145.7
Bangladesh	150,863,000	29874.1
Russia	138,739,892	1540360
Japan	126,475,664	1224740
Suriname	491,989	2243.8
Malta	408,333	2140.1
Brunei	401,890	10594.0
Belize	321,115	425.4
Iceland	311,058	2229.5
Andorra	84,825	546.4
Greenland	57,670	575.60
Liechtenstein	35,236	273.246
Monaco	30,539	89.276
Gibraltar	28,956	No data available

Calculations:

CO_2 emissions per person—sample calculation
Monaco: 89.276 ÷ 30,539 = 0.0029
China: 9110978.801 ÷ 1,336,718,015 = 0.00681

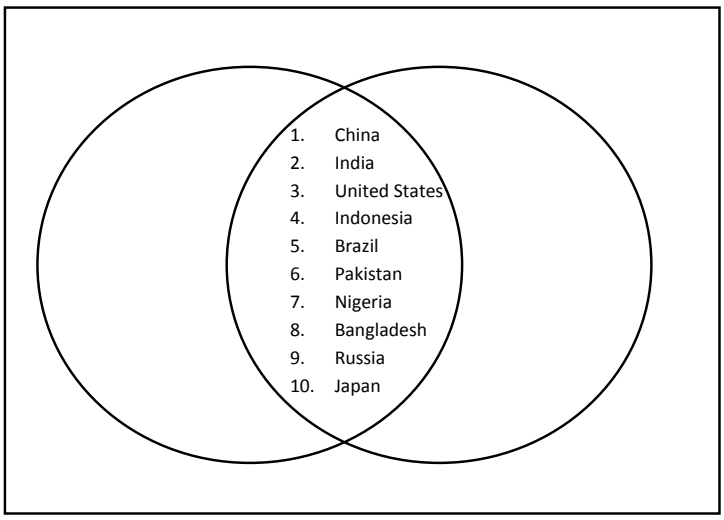
Country	**CO_2 emissions per capita**
India	0.0084
America	0.0184
Indonesia	0.0011
Brazil	0.0016
Pakistan	0.0006
Nigeria	0.0003
Bangladesh	0.0001
Russia	0.0111
Japan	0.0096
Suriname	0.0045
Malta	0.0052
Brunei	0.0263
Belize	0.0013
Iceland	0.0071
Andorra	0.0064
Greenland	0.0099
Liechtenstein	0.0077
Monaco	0.0029
Gibraltar	No data available

A scatter diagram summarizing the results that were found.



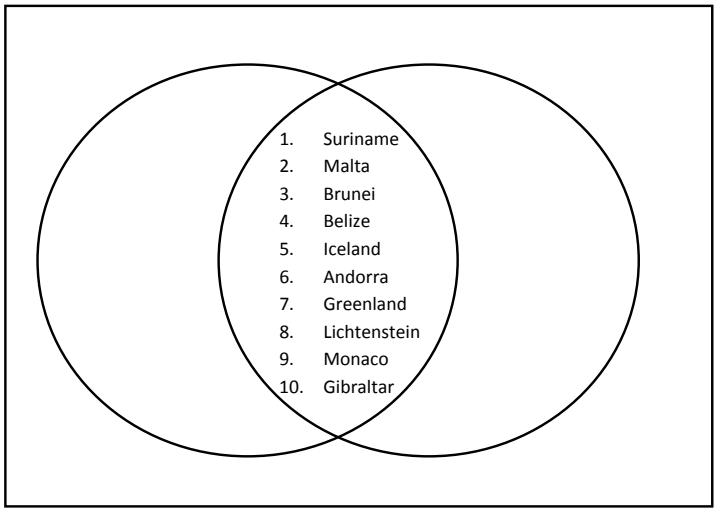
In the diagram above, the *x* axis is population size and the *y* axis is the level of CO_2 emissions.

The Venn diagrams below have been used to illustrate whether there is a connection between population size and a country's carbon emissions, as a Venn diagram is the clearest method with which to observe the ranked data. The left circle represents countries with a large population, the right those with high carbon emissions. The countries found in the intersection have both.



As the diagram above suggests, the 10 countries that have the largest carbon emission rates also have the largest populations. This is evident as there are no countries in the diagram that are not in the intersection, implying that there is not one without the other.

The second diagram is similar to the first; the variables, however, are based upon the countries with the smallest populations and lowest carbon dioxide emissions. The left once again represents populations, but this time of the 10 countries with the lowest populations. The circle on the right represents the countries with the lowest carbon emissions. The intersection represents the countries with both low carbon emission rates and populations.



As predicted, all countries fall into the intersection, implying once again that the nations with the lowest carbon emission rates also have smaller populations. Note that information could not be found on Gibraltar's carbon emission rates, and so it cannot be predicted where they will appear on the Venn diagram. If Gibraltar has a high level of carbon emissions it would be the only outlier, as the other countries that were assessed all fit into the intersection of the Venn diagram. Without the data on this country the results are not as complete as they could be.

Conclusion:
The data collected and analysed in the Venn diagrams above would suggest that a country's population size has an impact on the amount of carbon emissions it releases, as all of the countries (from which data could be found) that were studied fit into the intersection of the Venn diagrams. When the data was put into a scatter graph it was not easy to see a direct link between population and carbon dioxide emissions. The most obvious setback to using the scatter graph is that the numbers are so large that information cannot be read very clearly on it but the hypothesis still seems to be correct.

The most obvious reason for this is that the more people there are, the more energy is required because the production of energy from fossil fuels is a major cause of carbon dioxide release. There are other factors that may influence a nation's carbon emission rate aside from population, such as whether there are a larger amount of factories, as international trade may require them to specialize in commodities that need to be produced in large factories.

Discussion:
This study showed that there is a link between population size and carbon dioxide emissions, but I noticed that the amount of carbon emissions people emit on an individual level were also generally higher among the countries that are more urbanized. This applies to India and Bangladesh in particular, as they are still in the process of becoming developed countries and so have an increasing rate of urbanization. They are also nations that are responsible for the mass production of certain goods in factories, and therefore also release copious amounts of carbon dioxide. As they are still in the developmental process, laws may be less strict on issues that encourage factories to use environmentally friendly materials in their production processes.

Despite population size impacting CO_2 emissions greatly, there are other factors that should be considered. The developed countries in the first diagram that have both a large population and are responsible for releasing copious amounts of CO_2 into the atmosphere may do so as the people are more likely to have a larger

income and so can afford to spend more on things such as petrol, heating and electricity, all of which depend on fossil fuels and can add to the amount of carbon dioxide emissions a person produces.

With the first Venn diagram, there is a combination of developed and developing countries and this is also seen in the second Venn diagram. This can also imply that population is not the only factor impacting CO_2 emissions on a national scale. Countries such as Iceland and Greenland have access to hydroelectric power, which does not release CO_2, and so regardless of their population size, the amount of CO_2 they emit tends to be very low.

However this is not the case in areas such as Andorra or Suriname, whose low level of CO_2 emissions may be a result of the high rural populations. Such countries generally have less household use of fossil fuels being burned through electricity, which reduces the level of carbon dioxide emissions overall.

Evaluation:
The investigation used data from different sources, with the Venn diagrams showing strong evidence that supports my hypothesis, but the scatter graph was less clear. This might be because the number of countries included on the scatter graph was too small to see if there was a good link. Because I chose only the highest and lowest populated countries, I did not have any points in the middle of the graph, which would have helped to show if there was a best-fit line. There were also two outliers, and it is not clear if these made a difference to the conclusion.

As mentioned in the discussion, there are other factors that influence carbon dioxide emissions, such as levels of urbanization and industrialization. To help make the investigation clearer, I could have created separate Venn diagrams for developed and undeveloped countries to see if there were the same patterns when similar types of countries are compared. This would make the investigation a fairer test.

Solutions:
In order to prevent further negative consequences of global warming, certain measures have to be taken to reduce the amount of CO_2 a country emits. My study has shown that there is a link with population size, and so countries have to try to reduce the amount of carbon dioxide released by each person. This can be done in the form of environmental laws and with taxes being put on certain activities. If, for example, a limit is put on household energy use or the tonnes of carbon dioxide that their cars can dump into the atmosphere, then emissions might decrease significantly. These methods could prove highly successful, as prices can be paid on any amount of carbon dioxide being dumped that is above the given limit. This will encourage people to decrease the amount of carbon dioxide their cars emit.

Word count: 2244

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