

Evaluation of Global Renewable Energy Adaptation over 2000-2020

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Introduction

The increase in global warming and CO₂ emissions over the past century has led us to adapt and utilize renewable energy and replace the conventional fossil fuels. To understand the effect of the renewable energy adaptation over the fossil fuels, it is crucial to examine the pattern over the last two decades and investigate whether the utilization of renewable energies have led to decrease in CO₂ emission or not and thus, have any effect on the global warming. It is also useful to understand what is the current stage of adaptation of the renewables over fossil fuels in various countries.

This problem will be explored using a global sustainable energy dataset that covers electricity and energy consumption attributes per year for each country from 2000-2022. To investigate the global patterns, this study uses Python, Arcpy module. The pattern will be analyzed using different plots, global maps and correlation graphs between various factors.

Datasets

The dataset used in this project is obtained from Kaggle website [1]. The dataset covers sustainable energy indicators for world countries spanning over 20 years from 2000 to 2020. The relative features used in this dataset include access to electricity, renewable electricity generating capacity per person, percentage of renewable energy in final consumption and many more.

The analyzed data columns include “Electricity from fossil fuels (TWh)”, “Electricity from nuclear (TWh)”, “CO₂ emissions (metrics per person)” and “Renewable energy % in final energy consumption” .

Methods

1. Exploratory Data Analysis using Python:

The correlation between the columns was analyzed using `df.corr()` (-1 indicating negative, 0 - non- and 1 positive correlation between the columns. The missing values, duplicate rows and zero values were analyzed and dropped using `.dropna()` function. There were no duplicate rows detected. Number of unique rows, null values and correlation between the columns were identified using python. Matplotlib, pandas and numpy libraries were imported.

The countries with highest and lowest renewables and fossil consumption were detected. The histograms for the highest and lowest CO2 consumption were plotted as well. A linear correlation graph between the CO2 consumption vs Renewable energy % increase over 20 years in US was also plotted.

2. ArcPy implementation in ArcGIS:

To plot the countries in ArcGIS Pro, I have created a database to store the latitude and longitude values. The values were plotted on ArcGIS Pro to indicate the countries from which data was derived. Using Arcpy functions such as `SearchCursor`, average CO2 emissions per country was calculated and then plotted using matplotlib.

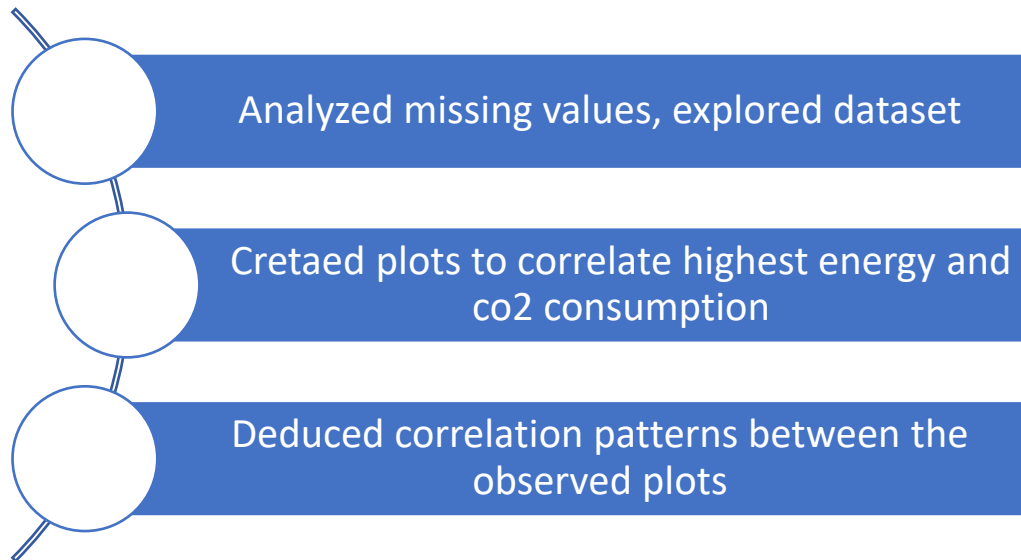


Figure 1. Flowchart of the methodology adapted in this study.

Results

The results from the python processing of the dataset are given below/ The histograms in figure 2 show the countries that have highest and lowest renewables and CO2 energy consumption. The figure 2 also represents the annual change in the CO2 consumption and utilization of the renewable energies over two decades for United States since it was one of the highest energy consumption countries. Figure 4 shows that there is a positive correlation between the decrease of the CO2 emission and increase in the adaptation of the renewables. Figure 3 shows that the 2 of the top energy utilizing countries show a higher percentage of fossil fuels over renewables. This indicates that the fossil fuels are still being highly used and renewables might not be enough to satisfy the countries needs. The United States, China and India are the top countries in terms of the fossil fuel and renewable energy usage, as well as CO2 consumption. The lowest renewables were identified to be 0% in mainly islandic counties such as Bahamas, Bermuda and so on. The lowest fossil fuel consumption is observed in Nepal and Iceland. The countries with the lowest CO2 emission are Tuvalu and Nauru which are island countries as well.

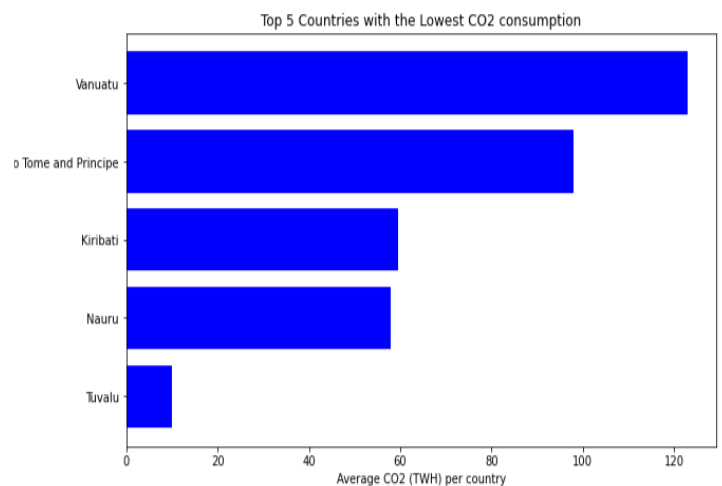
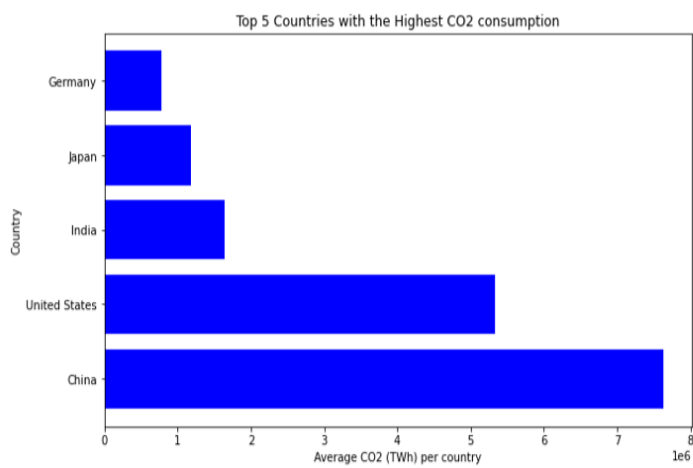
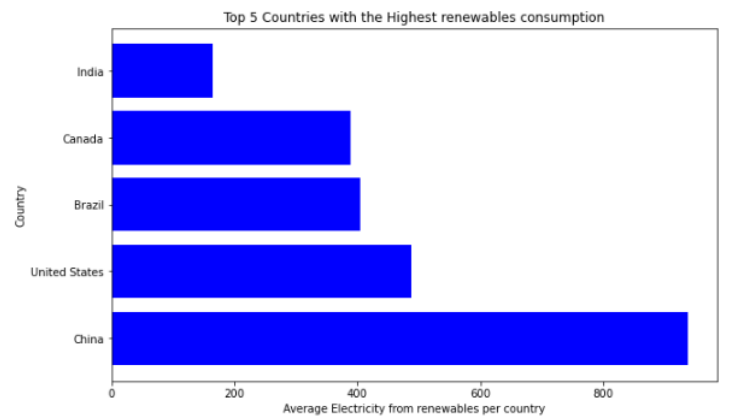
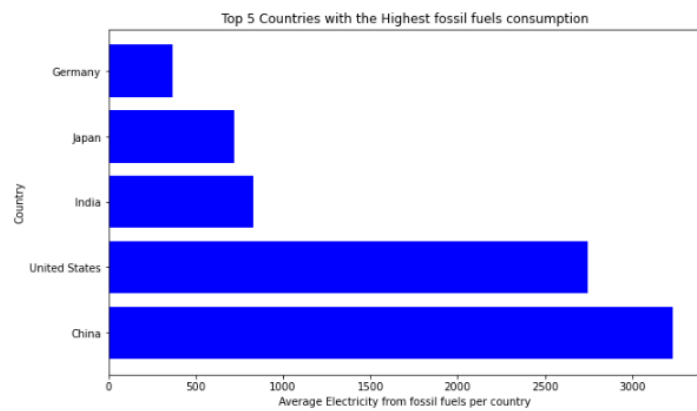
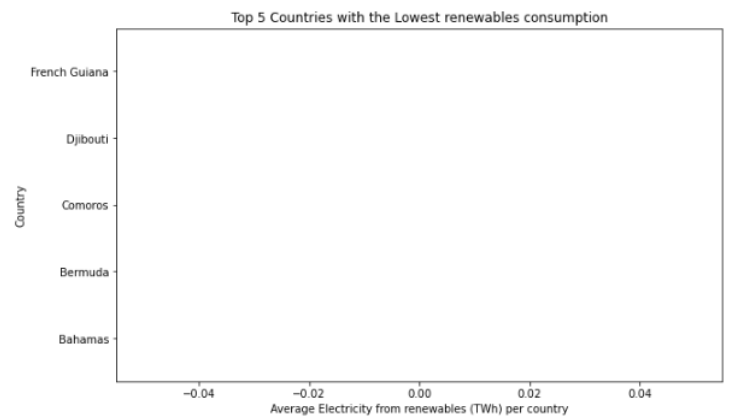
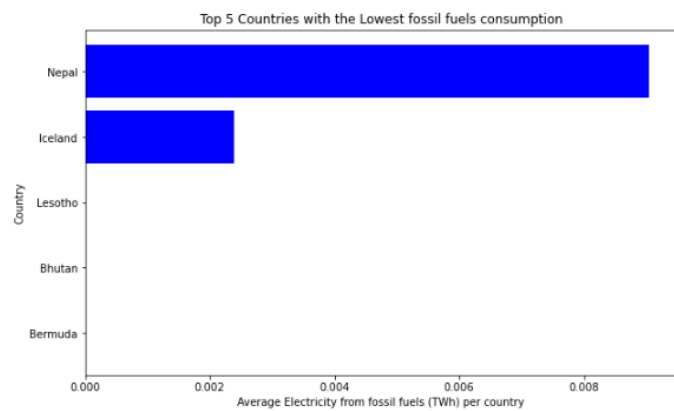


Figure 2. Top 5 countries in terms of the highest and lowest CO2 consumption (TWh), renewable energy and fossil fuel usage.

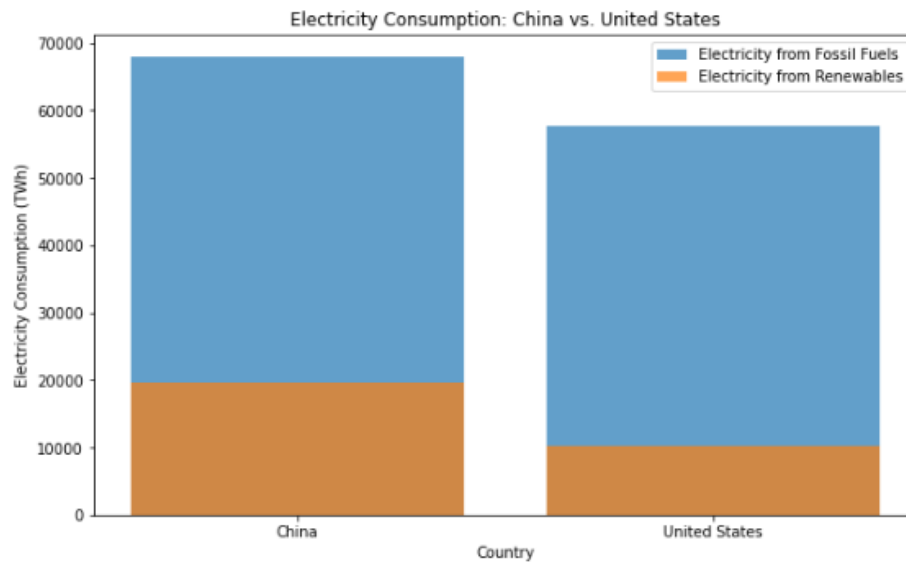


Figure 3. The highest energy consumption countries (Chian and United States) and their respective percentage of fossil and renewables driven electricity usage

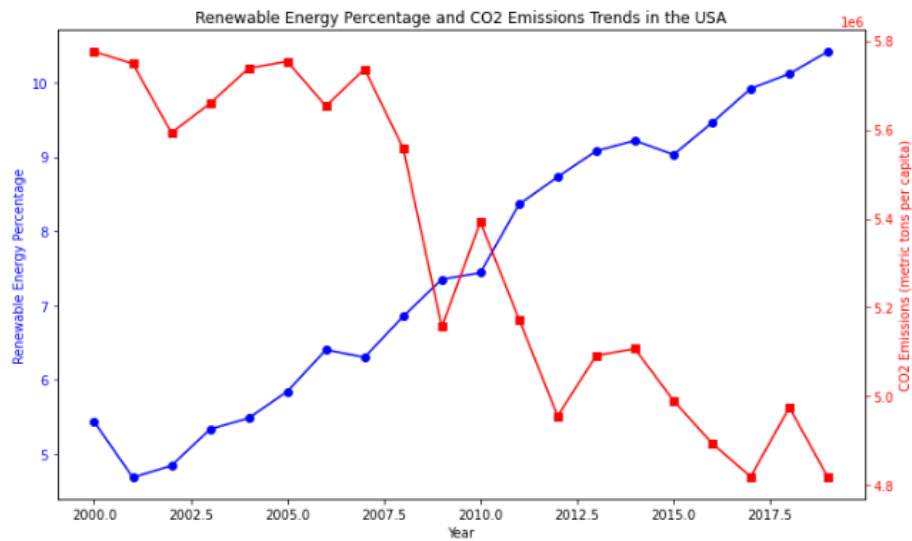


Figure 4. The change in the CO2 consumption and Renewable energy percentage in United States over 2000-2020



Figure 5. The latitude and Longitude values of the countries converted into FeatureClass in Arcpy

Conclusion

This study analyzed global energy patterns over 20 years and identified countries with maximum and minimum energy utilization. The results show a positive correlation between the adaptation of renewable energies of highly populated and larger countries such as United States, India and China and decrease in their respective CO2 emissions. As a conclusion, we can say that even though renewables are being utilized all over the world, fossil fuels still occupy a high percentage of the overall energy consumption in majority of the countries.

References

1. <https://www.kaggle.com/datasets/anshtanwar/global-data-on-sustainable-energy/data>
2. <https://pro.arcgis.com/en/pro-app/latest/arcpy/data-access/insertcursor-class.htm>
3. <https://pro.arcgis.com/en/pro-app/latest/arcpy/data-access/searchcursor-class.htm>
4. <https://matplotlib.org/stable/gallery/statistics/hist.html>