CO2 EMISSION AND HEALTH CHALLENGES IN AFRICA: A COMPREHENSIVE ANALYSIS

by Shail Jyala and Eleena.B

Department of School of Professional Studies, Clark University

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Salem B. Othman

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Abstract

Environmental pollution, specifically the rise in carbon dioxide (CO_2) emissions, poses a significant threat to public health globally. In the context of Africa, where economic and population growth have been accompanied by increased industrialization, understanding the impact of CO_2 emissions on health can be useful if not beneficial to a developing continent as this might be helpful in developing effective environmental policies and mitigating the impact of climate change. The pattern of CO_2 emissions from area, population, transportation, energy, and combustion of other fuels, change in forestry, and bunker fuel are all analyzed in this study. After careful analysis, we were able to extract useful information from the data. For example, a correlation between the data and major factors contributing to CO_2 emissions shows that most factors, including area, population, and transportation, have a direct impact on CO_2 emissions. Each row appears to represent a particular combination of year, country, and various factors. Mapping and visualizing CO_2 to major factors contributing to it produced a linear trend.

Introduction

As the global community grapples with the far-reaching consequences of environmental degradation, the issue of escalating carbon dioxide (CO_2) emissions emerges as a paramount concern, significantly impacting public health on a worldwide scale. Within the African continent, where rapid economic and population growth coincides with a surge in industrialization, the intricate interplay between development and environmental sustainability becomes increasingly complex. The imperative to comprehend the implications of CO_2 emissions on health takes on heightened significance for a continent poised at the crossroads of progress and environmental stewardship.

This research undertakes a comprehensive examination of data spanning two decades (2000-2020) from 51 African countries, focusing on key variables such as energy consumption, CO_2 emissions, and related environmental indicators. The dataset, rich and multidimensional, serves as a lens through which we can discern patterns and trends, shedding light on the evolving landscape of energy usage and its environmental consequences. Employing advanced Python tools including NumPy, Seaborn, Geopandas, Matplotlib, and Pandas, we navigate through the intricacies of this expansive dataset to unravel insights that extend beyond mere retrospective analysis.

Our approach extends beyond the confines of historical data interpretation, seeking to contribute meaningfully to the ongoing discourse surrounding future environmental policies. While economic growth and development are crucial, our primary focus lies in understanding the nexus between environmental changes and public health. The escalation of CO_2 emissions correlates with a rise in respiratory illnesses, cardiovascular diseases, and other health challenges. In an era where the need for sustainable practices has never been more pronounced, our study endeavors to inform the dialogue on crafting policies that foster not only economic growth but also safeguard the health of communities, ensuring a future where progress aligns harmoniously with environmental well-being. Through a nuanced exploration of the data, we aspire to provide a foundation for evidencebased decision-making, offering a roadmap towards a healthier and more sustainable future for generations to come.

Methods

The dataset, sourced from Kaggle, underwent a meticulous process of cleaning and preparation. This involved addressing null values, replacing missing data, and eliminating unrelated columns to ensure the dataset was primed for analysis. Leveraging Python libraries such as Pandas, NumPy, Matplotlib.pyplot, Seaborn, and GeoPandas, our analytical journey unfolded in distinct phases. Below are key visualizations accompanying our analysis:

1. Original Dataset Head:

```python
df.head()
```

[3] ✓ 0.0s Python

	Country	Sub-Region	Code	Year	Population	GDP PER CAPITA (USD)	GDP PER CAPITA PPP (USD)	Area (Km2)	Transportation (Mt)	Total CO2 Emission including LUCF (Mt)	Total CO2 Emission excluding LUCF (Mt)	Other Fuel Combustion (Mt)	Manufacturing/Construction (Mt)	Land-Use Change and Forestry (Mt)	Industrial Processes (Mt)	Fugitive Emissions (Mt)	Energy (Mt)
0	Algeria	Northern Africa	DZA	2000	30774621	1780.38	8510.36	2381741	16.85	80.62	80.05	0.0	6.16	0.57	3.79	14.75	76.26
1	Algeria	Northern Africa	DZA	2001	31200985	1754.58	8840.67	2381741	17.04	76.24	78.65	0.0	6.25	-2.41	3.77	11.86	74.88
2	Algeria	Northern Africa	DZA	2002	31624696	1794.81	9354.22	2381741	19.36	80.00	82.40	0.0	6.62	-2.41	4.06	10.20	78.35
3	Algeria	Northern Africa	DZA	2003	32055883	2117.05	10088.09	2381741	21.76	85.78	88.19	0.0	7.01	-2.41	4.03	12.17	84.16
4	Algeria	Northern Africa	DZA	2004	32510186	2624.80	10653.34	2381741	22.03	87.09	89.49	0.0	8.09	-2.41	4.90	11.22	84.60

This image provides a glimpse of the initial state of the dataset, showcasing the first few rows of raw data.

2. Data Cleaning:

```
df_final.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1134 entries, 0 to 1133
Data columns (total 15 columns):
 #   Column                               Non-Null Count  Dtype
---  ------                               --------------  -----
 0   Area (Km2)                           1134 non-null   int64
 1   Building (Mt)                        1134 non-null   float64
 2   Bunker Fuels (Mt)                    1134 non-null   float64
 3   Country                              1134 non-null   object
 4   Electricity/Heat (Mt)                1134 non-null   float64
 5   Energy (Mt)                          1134 non-null   float64
 6   Industrial Processes (Mt)            1134 non-null   float64
 7   Land-Use Change and Forestry (Mt)    1134 non-null   float64
 8   Manufacturing/Construction (Mt)      1134 non-null   float64
 9   Other Fuel Combustion (Mt)           1134 non-null   float64
 10  Population                           1134 non-null   int64
 11  Total CO2 Emission excluding LUCF (Mt)  1134 non-null   float64
 12  Total CO2 Emission including LUCF (Mt)  1134 non-null   float64
 13  Transportation (Mt)                  1134 non-null   float64
 14  Year                                 1134 non-null   int64
dtypes: float64(11), int64(3), object(1)
memory usage: 133.0+ KB
```

We show a screenshot of the dataset cleaning procedure, highlighting what was done to fix missing values and guarantee data integrity.

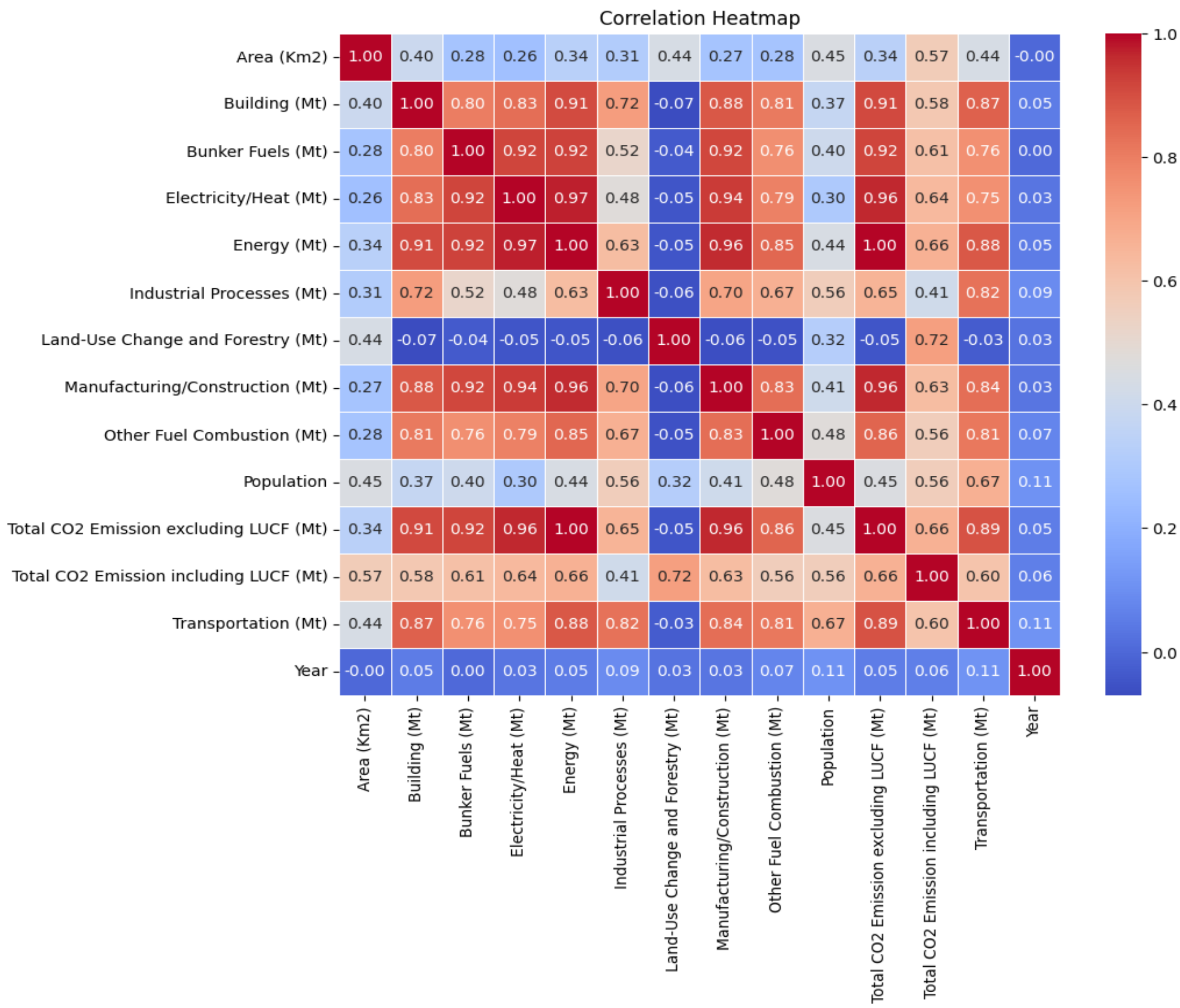
3. Final Dataset Head:

```
df_final.head()
```

	Area (Km2)	Building (Mt)	Bunker Fuels (Mt)	Country	Electricity/Heat (Mt)	Energy (Mt)	Fugitive Emissions (Mt)	Industrial Processes (Mt)	Land-Use Change and Forestry (Mt)	Manufacturing/Construction (Mt)	Other Fuel Combustion (Mt)	Population	Total CO2 Emission excluding LUCF (Mt)	Total CO2 Emission including LUCF (Mt)	Transportation (Mt)	Year
0	2381741	9.33	1.96	Algeria	29.17	76.26	14.75	3.79	0.57	6.16	0.0	30774621	80.05	80.62	16.85	2000
1	2381741	9.53	1.98	Algeria	30.20	74.88	11.86	3.77	-2.41	6.25	0.0	31200985	78.65	76.24	17.04	2001
2	2381741	9.89	2.17	Algeria	32.28	78.35	10.20	4.06	-2.41	6.62	0.0	31624696	82.40	80.00	19.36	2002
3	2381741	10.68	1.89	Algeria	32.53	84.16	12.17	4.03	-2.41	7.01	0.0	32055883	88.19	85.78	21.76	2003
4	2381741	11.52	2.19	Algeria	31.75	84.60	11.22	4.90	-2.41	8.09	0.0	32510186	89.49	87.09	22.03	2004

Here, we showcase the head of the final dataset post-cleaning, demonstrating the refined and prepared state for analysis.

4. Correlation Heatmap:



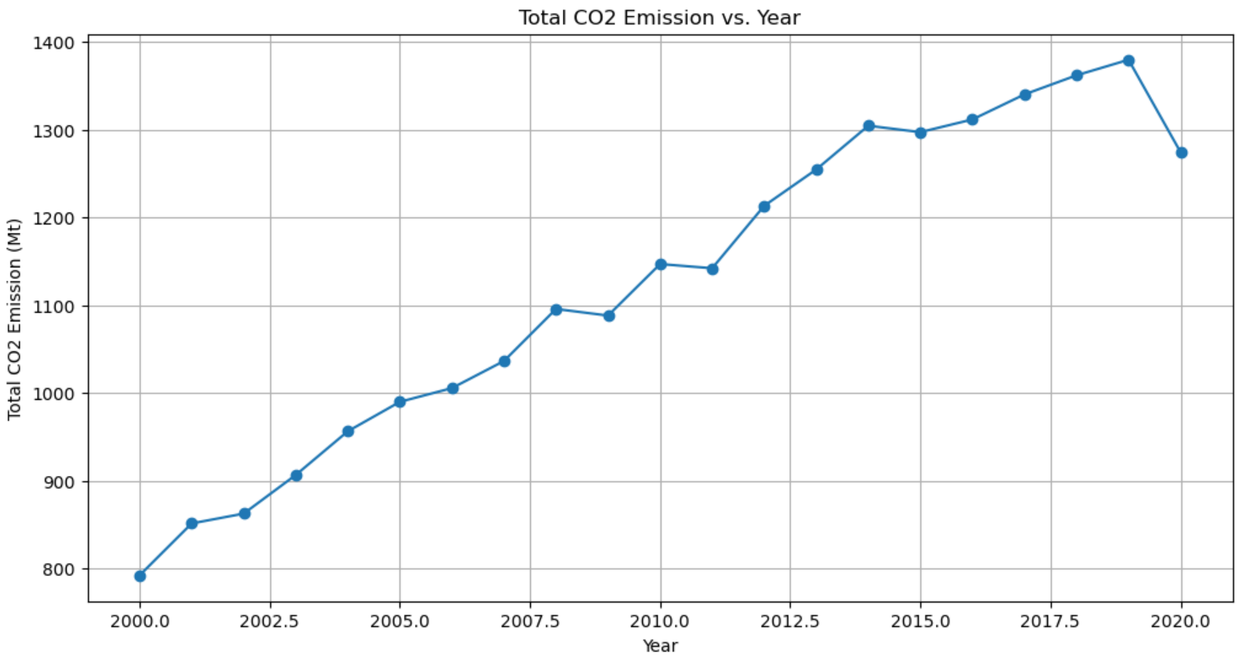
The correlation heatmap visually unveils intricate relationships among variables, providing profound insights into the interconnected nature of different factors within our dataset. Upon scrutinizing the data through a correlation map, several notable inferences emerge. Firstly, Energy and Total CO2 emissions exhibit a perfect correlation (score of 1.0), indicating a direct and proportional relationship with the highest likelihood of mutual influence, suggesting a potential continuation of a rising trend in the future. Similarly, Manufacturing/Construction, Heat/Electricity, Building, and Bunker Fuels all demonstrate direct correlations with Total CO2 emissions (scores ranging from 0.91 to 0.96), suggesting parallel increases and potential continued influence on each other. Conversely, the least correlated factor with CO2 emissions is Land and Forestry. These findings underscore the intricate web of associations among key variables, shedding light on potential drivers of CO2 emissions and their interplay within the dataset.

These images collectively offer a transparent view of our methodology, from the raw dataset to the refined version, and the correlation analysis, providing a comprehensive understanding of the analytical process.

Results & Discussion

The outcomes of our study reveal a multifaceted relationship between CO2 emissions in Africa and key influencers such as population, geographical area, and transportation. This analysis supports our initial hypothesis, demonstrating a discernible upward trend in CO2 levels associated with factors like area, population density, and transportation networks across the continent. The figures and graphs provided offer valuable insights into these relationships, underscoring the significance of our data cleaning and preparation processes in the study.

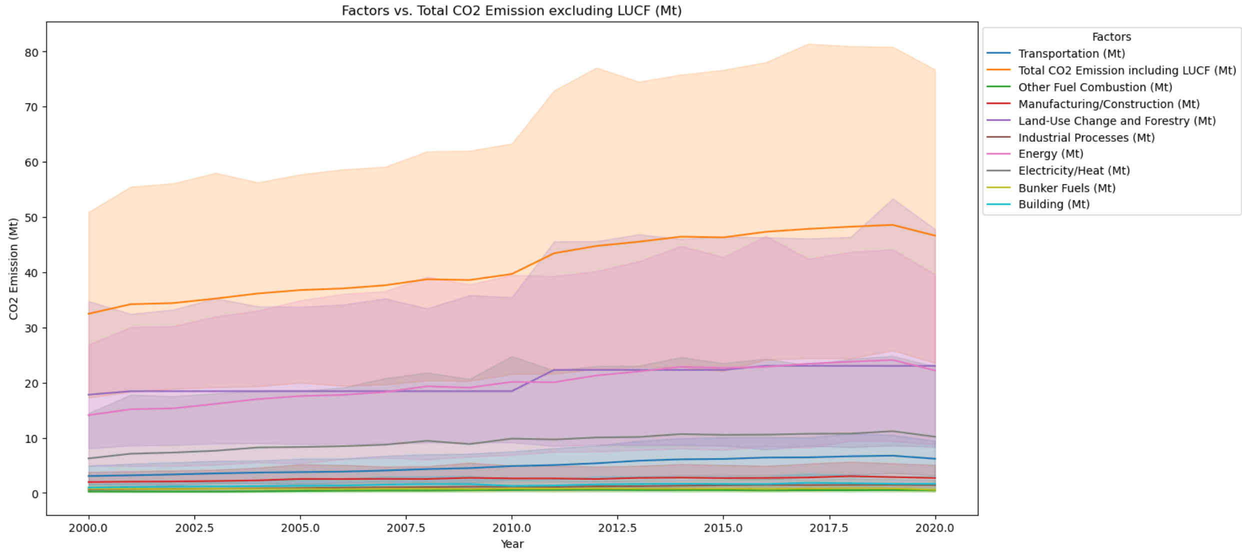
- **CO2 Emission Trends Over the Years**



The graph depicting CO2 emission trends over the two decades (2000-2020) reveals a discernible upward trajectory in carbon dioxide levels. Peaks and troughs indicate variations over time, suggesting potential recurring patterns or external factors influencing the overall trend. The observed increases underscore the challenges posed by growing industrialization and population expansion during this period.

Understanding the temporal dynamics of CO2 emissions is crucial for informed environmental decision-making. Peaks in emissions may align with periods of rapidly increased energy demand, emphasizing the need for targeted interventions during such phases. Conversely, troughs may indicate successful mitigation strategies or external factors influencing emission reduction. Identifying inflection points in the trend provides opportunities for effective policy interventions and underscores the urgency of addressing climate change concerns.

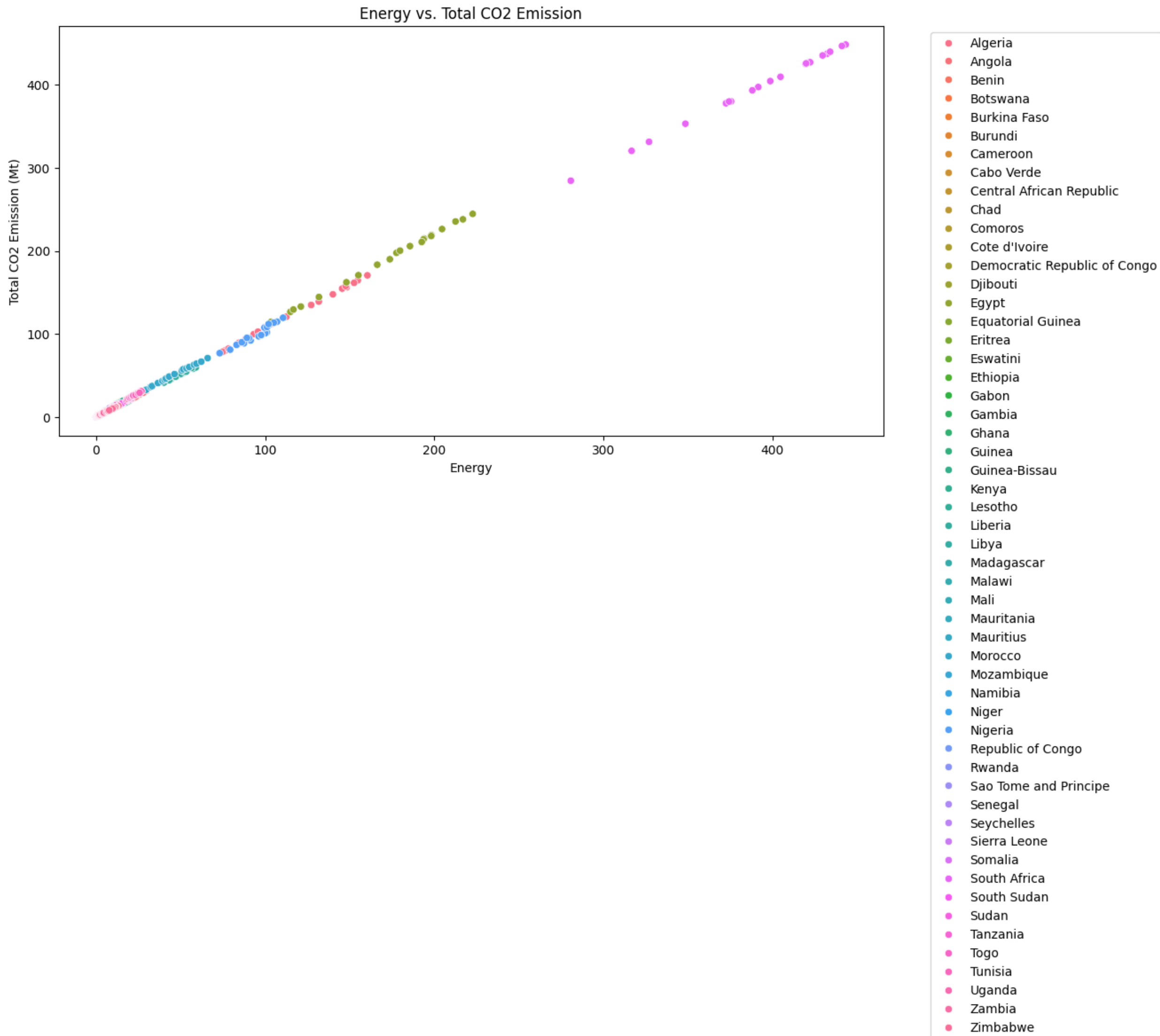
➢ CO2 Emission Factors Over the Years



This graph focuses on CO2 emission factors, providing insights into the changing intensity of emissions concerning various contributing factors. Peaks in emission factors may indicate periods where specific activities or sectors significantly contribute to carbon emissions. Understanding these variations helps pinpoint key drivers of emissions intensity over time.

Identifying factors influencing emission intensity, such as population growth and transportation-related spikes, is crucial for targeted interventions like sustainable urban development and green technology advancements. The combined analysis of graphs offers a comprehensive understanding of CO2 emission dynamics, aiding the crafting of effective environmental policies for sustainable development and climate change mitigation.

- **Energy vs Total CO2 Emission Correlation**

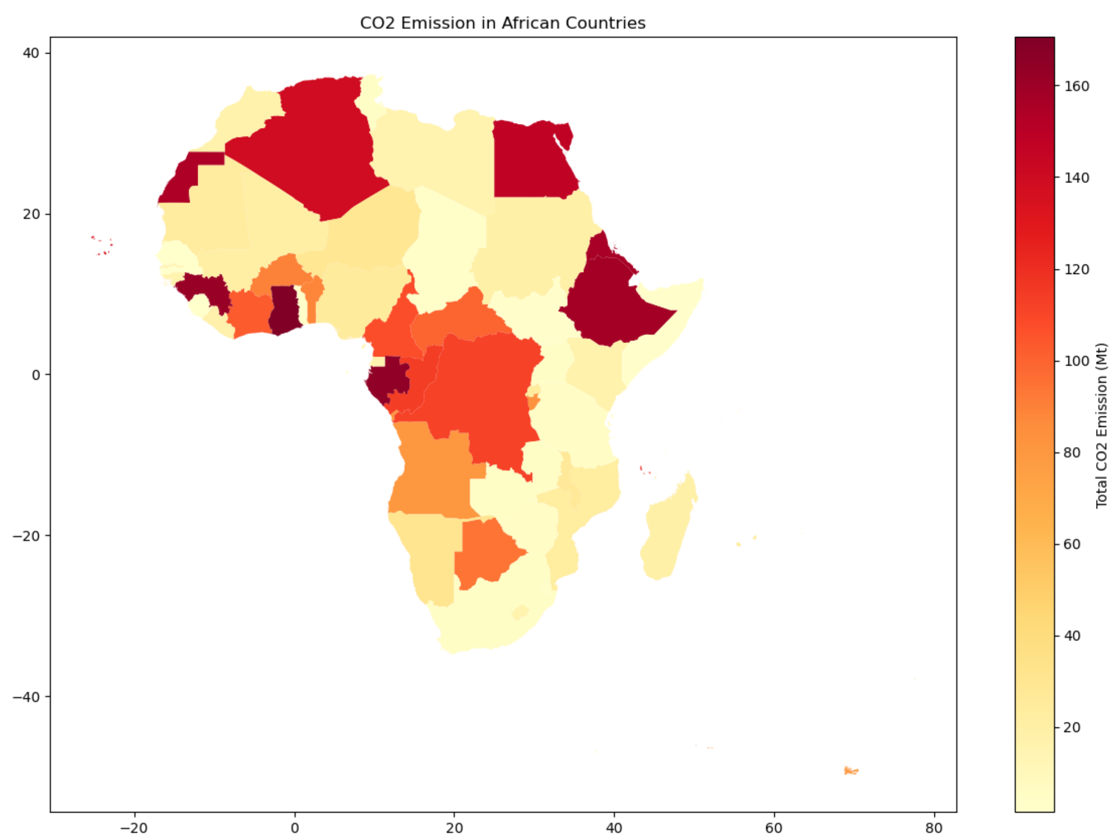


The graph illustrates the correlation between energy consumption and total CO2 emissions, revealing a compelling pattern of a perfect correlation, as indicated by the correlation heatmap. The upward trend suggests a direct relationship between energy usage and carbon emissions. The significance of this correlation prompts a deeper investigation into the impact of energy consumption on total CO2 emissions across the studied timeframe (2000-2020).

The perfect correlation observed between energy consumption and total CO2 emissions underscores the critical role of energy use in driving carbon emissions. This relationship is multifaceted, influenced by factors such as industrialization, urbanization, and economic growth. As nations strive for development, the demand for energy inevitably rises, contributing to a parallel increase in carbon emissions.

However, the impact of this correlation manifests differently in various countries. Developed nations, with established infrastructure and advanced technologies, may exhibit a more efficient use of energy, potentially decoupling economic growth from a proportional increase in emissions. On the other hand, developing countries, undergoing rapid industrialization, might experience a more direct correlation, where increased energy consumption is closely tied to heightened emissions.

- **Map Visualization: CO2 Emissions Across Africa**



The map visualization provides a comprehensive overview of CO_2 emissions across African countries, arranged in ascending order from least to most emissions. The color gradient offers a visual representation of the carbon footprint, allowing for a quick assessment of the environmental impact of each nation within the region.

The map visualization serves as a powerful tool for understanding the spatial distribution of CO_2 emissions across Africa. It provides a basis for informed decision-making, encouraging collaborative efforts to address environmental challenges and promoting sustainable practices within the region.

Conclusion

In summary, our extensive analysis of CO_2 emissions across 51 African countries over two decades reveals crucial insights into the relationship between environmental factors and carbon dioxide levels. The study underscores the impact of population density, geographical area, and transportation networks on CO_2 emissions, emphasizing the urgent need to address environmental challenges in the region.

Moreover, our analysis brings to the forefront the role of increased energy consumption as a significant contributor to CO_2 emissions. The correlation observed between energy consumption and total CO_2 emissions emphasizes the interconnectedness of these factors. As nations undergo rapid industrialization and economic growth, the demand for energy rises, often met by fossil fuels, leading to a proportional increase in carbon emissions.

This surge in energy consumption indirectly contributes to health issues within the population. The combustion of fossil fuels not only releases CO2 but also introduces pollutants such as particulate matter and nitrogen oxides. These pollutants have known adverse effects on respiratory health, contributing to conditions like asthma and other respiratory diseases. Additionally, the overall degradation of air quality associated with increased energy consumption can exacerbate cardiovascular problems.

Recognizing this intricate relationship between increased energy consumption, CO2 emissions, and health issues is imperative for developing comprehensive policies. Addressing environmental challenges necessitates not only a focus on reducing carbon emissions but also a transition to cleaner and more sustainable energy sources. The study thus serves as a compelling call to action, urging further investigation and policy development to mitigate the impact of CO2 emissions on public health while fostering sustainable energy practices in the region. The insights gained contribute to the formulation of holistic, health-conscious environmental policies in Africa.

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