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Analyzing the UAE's Carbon Footprint: Strategic Pathways for a Sustainable Future

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Abstract: ***This comprehensive study delves into the environmental challenges and strategies for carbon footprint reduction in Dubai, amidst the backdrop of global climate change concerns. It outlines the significant rise in Earths average temperature over the last century, emphasizing the consequential shifts in weather patterns and ecosystems. Highlighting the concept of planetary boundaries by Rockström et al. and the impact of urbanization on climate change, the study focuses on the United Arab Emirates, particularly Dubai's rapid development and its environmental implications. By utilizing data from CO And Greenhouse Gas Emissions Data Explorer by Our World in Data and Marcus Lu's reports, the research presents an analysis of carbon emissions from various perspectives, aiming to understand the individual contributions to the emissions and discover effective strategies for reducing the environmental footprint. It discusses the importance of precision in measuring the urban carbon footprint, equity in global resource distribution, and the significance of targeted interventions like promoting renewable energy, sustainable building practices, and transportation methods. The study not only underscores Dubai's high per capita emissions but also its ambitious target for achieving net - zero emissions by 2050, navigating through the limitations of data reliability and the dynamic nature of environmental policies.***

Keywords: Climate Change, Carbon Emissions, Dubai, Sustainability, Planetary Boundaries, Carbon reduction strategies, Carbon Footprint

1. Introduction

The Earth's average temperature has risen by 1.0 degrees Celsius over the last century. This seemingly small shift is causing significant changes in weather patterns and ecosystems, impacting our health, communities, and daily lives, emphasizing the urgent need for action to secure a sustainable future.

The study by Rockström et al. introduces the concept of "planetary boundaries" that are crucial to prevent irreparable harm to the environment. It quantifies seven of these boundaries, such as climate change and biodiversity loss, emphasizing the need to stay below an atmospheric CO2 concentration of 350 ppm (Rockström et al., 2009). Furthermore, urbanization's impact on climate change, particularly regarding urban heat islands, needs inclusion in climate models to understand their influence on local and global climates (McCarthy et al., 2010). In the UAE, abiding by these planetary boundaries is imperative to mitigate harm to the environment and sustainably manage the country's rapid development.

This is particularly essential in vibrant cities like Dubai, which is recognized for its towering buildings and rapid development, where a notable issue is at hand: it produces a significant amount of carbon. This is because people rely heavily on air conditioning, the extensive use of private jets, relatively low use of public transportation in comparison to private cars, and significant fuel consumption in relation to UAE's population contribute to this concern (Reuters, 2010). Climate models predict temperatures in the Middle East, including Dubai, which reveal a concerning trend of an approximate 1.4 - degree Celsius increase by mid - century and a 4 - degree Celsius increase by the end of the century for the whole world (Dickie, 2023), emphasizing the urgency for actions to mitigate adverse effects like reduced rain - fed agricultural land and longer dry seasons (Evans, 2008). Therefore, implementation of international standardization of carbon foot - printing is necessary to direct efforts to reduce emissions and managing these emissions effectively (Pandey et al., 2010). The main aim of this study is to find answers to this crucial question: How can Dubai cut down on the energy that harms the environment and inspire its residents to adopt practices that are helpful in reducing their carbon footprint?

Ensuring precision and reliability in measuring the UAE's urban carbon footprint is essential for understanding the city's true environmental impact (Fry et al., 2018). Furthermore, promoting equity in global resource distribution, as suggested by Steffen and Smith, not only fosters fair allocation but also provides opportunities for the UAE to access diverse resources and collaborative initiatives, strengthening its pursuit of a more sustainable path. These strategies can contribute to mitigating environmental challenges while promoting overall development within the city.

This study will explore carbon dioxide emissions from various perspectives, with a focus on per capita emissions. By understanding how individuals contribute to emissions, we aim to discover straightforward and effective strategies for people in the UAE. The goal is to find easy ways that everyone can adopt to lessen their environmental footprint and contribute to making the UAE more sustainable.

2. Methods

To analyze carbon emissions, data was collected from the following sources: "CO_2 And Greenhouse Gas Emissions Data Explorer" by Our World in Data (https: //ourworldindata. org/explorers/co2) and Marcus Lu's reports on carbon emissions, accessed from Visual Capitalist (https: //www.visualcapitalist. com/ranked - per - capita - carbon - emissions - by - country/ and https: //www.visualcapitalist. com/carbon - emissions - by - country - 2022/). Google Sheets served as the primary tool for data organization and graphing. The study focused on visualizing total emissions for the top 5 countries and per capita emissions for the top 15 countries, utilizing Marcus Lu's data to provide a comprehensive overview of global carbon emissions patterns.

3. Results

The results of this study aim to shed light on the current state of carbon emissions in Dubai and the United Arab Emirates, and aims to address the research question: How can Dubai reduce its environmental impact and encourage residents to adopt practices that lower their carbon footprint? The following quantitative analyses explore per capita emissions in the UAE and its global standing, providing a comprehensive understanding of the current scenario. In examining the global landscape of carbon emissions, it is crucial to first consider the total emissions of the top five countries: China, the United States, India, Russia, and Japan. Figure 1 illustrates the annual CO2 emissions for each of these nations, offering insights into their emission trends from 1965 to 2022.

China, the world's largest emitter, exhibits a noteworthy pattern of increasing annual CO2 emissions over the years, reaching its peak in 2022. In contrast, the United States has experienced relatively stable emissions with only slight fluctuations, reflecting a consistent output. India's emissions have steadily increased, showcasing a continuous upward trajectory, while Russia has shown a similar upward trend, albeit with a decrease towards 2022. Japan, in contrast, has not experienced major fluctuations, maintaining a more stable emission pattern.

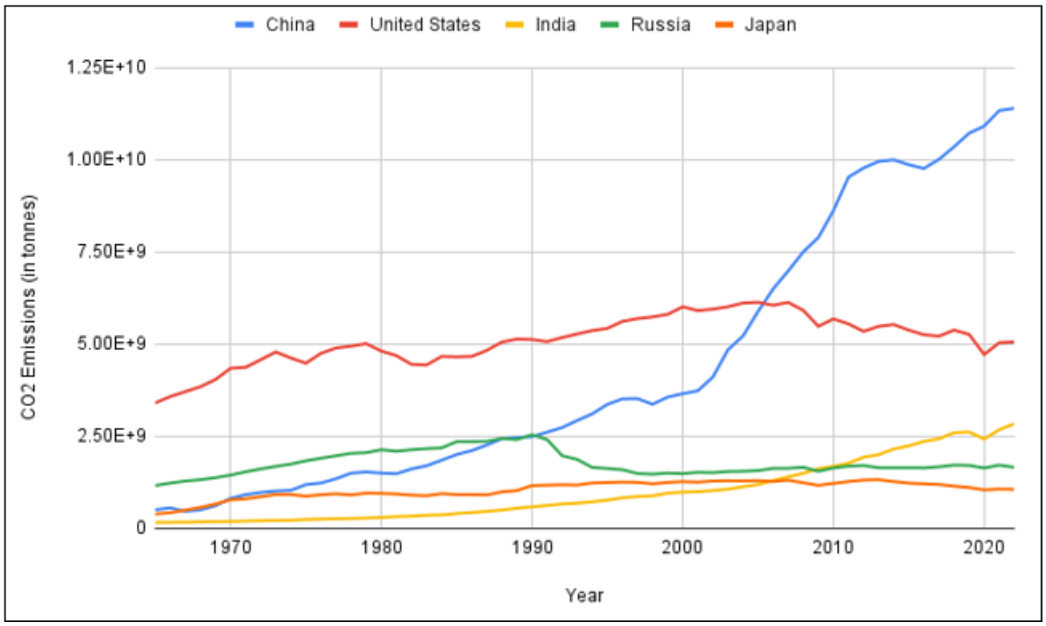

Figure 1: Graph showing the Annual CO2 Emissions for the top five countries from 1965 to 2022.

While total emissions provide an overview of a nation's contribution to global greenhouse gases, per capita emissions offer insights into the individual carbon footprint, considering the population size. This distinction becomes particularly relevant when examining the UAE, as highlighted in Figure 2, which focuses on per capita emissions. Figure 2 illustrates UAE's per capita emissions in tonnes per person, revealing a peculiar scenario. Despite not making it to the top 10 for total annual emissions, the graph demonstrates that the UAE's per capita emissions are notably high, reaching a peak in 1969 of 80.97 tonnes per person and gradually decreasing thereafter with irregular fluctuations. This unusual discrepancy emphasizes the need to consider both total and per capita emissions to comprehensively assess a country's environmental impact.

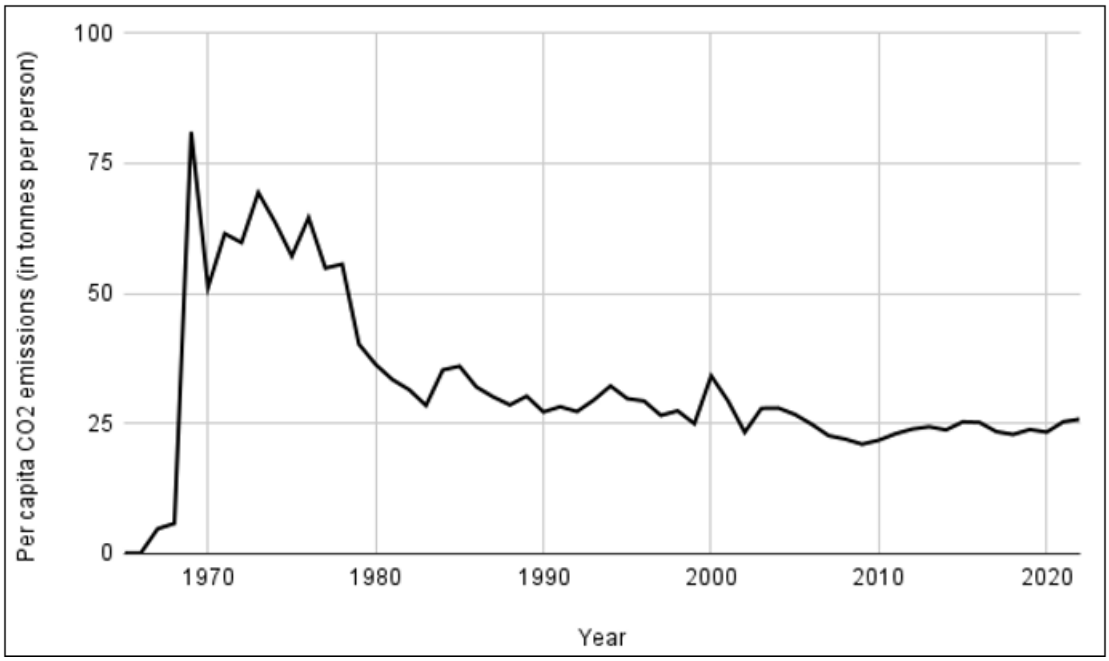

Figure 2: Graph showing UAE's CO2 Emissions per capita from 1965 to 2022

Comparing per capita emissions among the top six countries in 2023—Qatar, Bahrain, Kuwait, Trinidad and Tobago, Brunei, and the United Arab Emirates—reveals the significant carbon footprint of Dubai (Figure 3), but also shows that the United Arab Emirates has decreased its carbon footprint over the years. In figure 3, Kuwait stands out as the highest emitter among the top six countries in 1991 with a per capita emission of 367.92 tonnes per person. However, when considering overall trends and averages, Qatar consistently maintains the highest per capita emissions among the six countries. As we progress towards 2022, all six countries exhibit similar per capita emissions, and importantly, they have collectively decreased their carbon footprints over the years. This observation suggests a positive trend towards environmental sustainability in the regions.

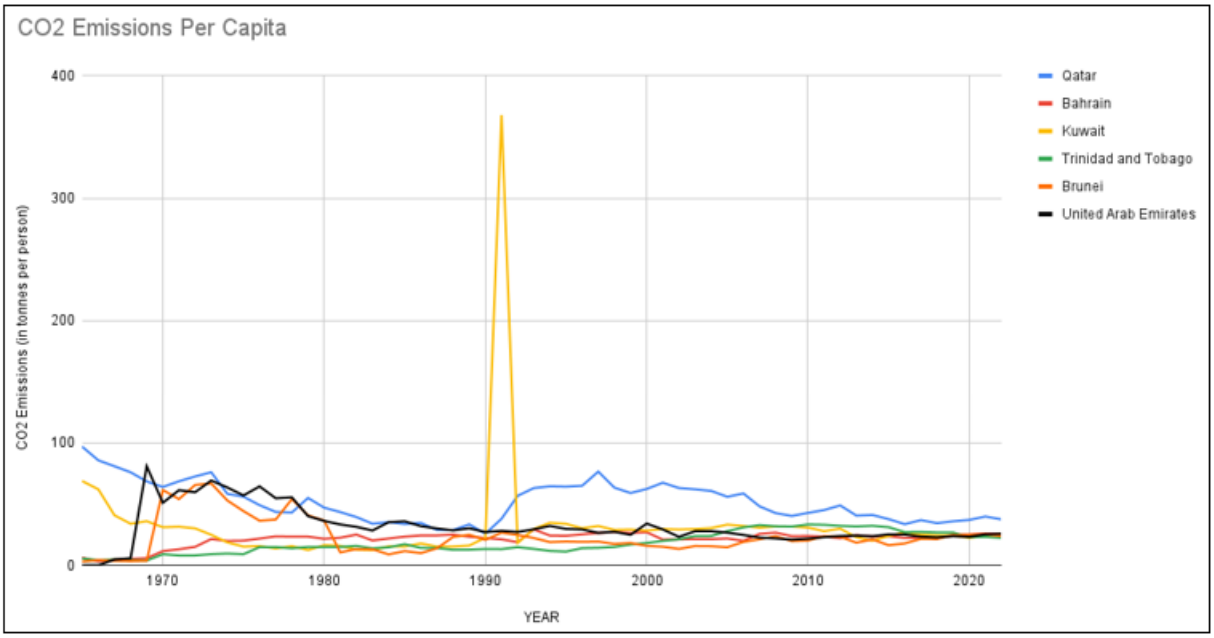

Figure 3: Graph showing CO2 Emissions Per Capita for the top six countries from 1965 to 2022

Contrasting Dubai's per capita emissions with those of the bottom five high - emission countries—United Arab Emirates, Saudi Arabia, Oman, Australia, and the United States—offers additional insights into the city's carbon footprint relative to global trends (Figure 4). When examining the emissions of the bottom six countries, including the United Arab Emirates, it becomes evident that the UAE consistently maintains higher emissions than the other nations. Notably, in 1969, the UAE reached a peak of 80.97 per capita emissions, signaling a significant point in its carbon output. Over the years, Oman has experienced a slight increase in per capita emissions, while Saudi Arabia has seen an overall increase with a marginal decrease towards 2022. In the case of the United States, emissions have mostly remained constant, with a slight decrease observed towards 2022. Australia, on the other hand, has maintained a more or less

constant emission pattern, experiencing slight increases and decreases over the years. This analysis of the bottom five high - emission countries provides an understanding of the variations in their carbon footprints, offering valuable insights into the global context of emissions trends.

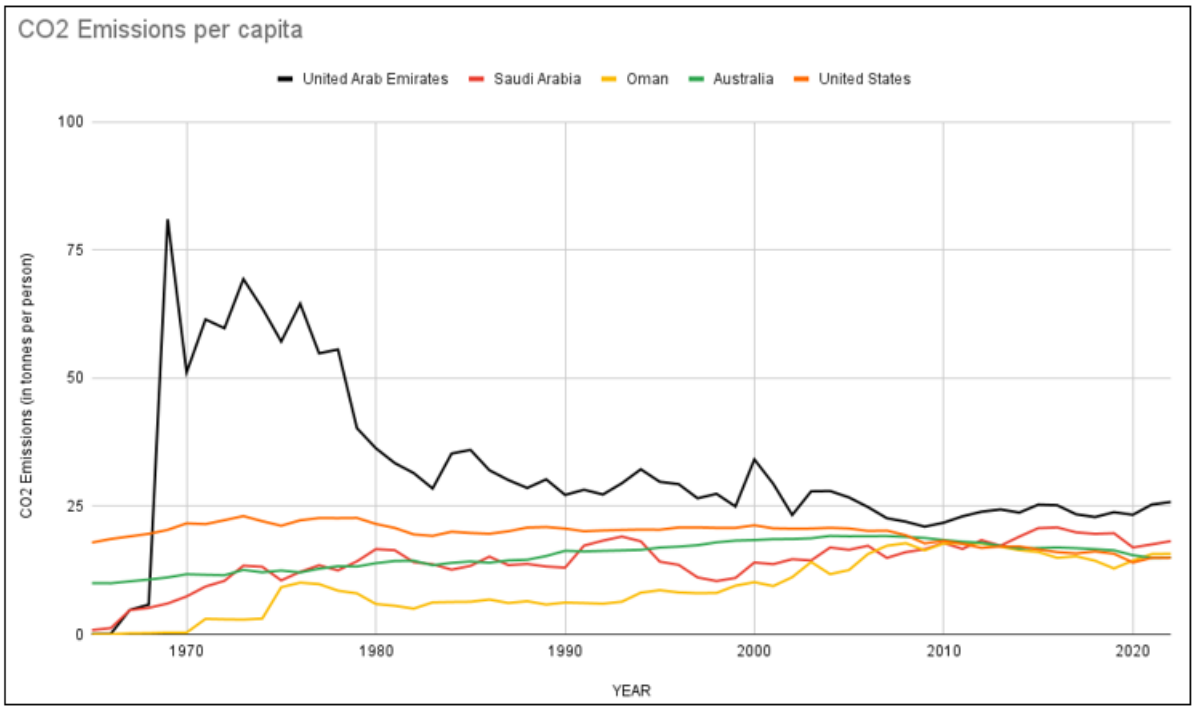

Figure 4: Graph showing CO2 Emissions Per Capita for the bottom five countries from 1965 to 2022

Table 1 presents average emissions from 1965 to 2022 for the top 10 countries. Qatar leads with an average of 51.83 tonnes per person, followed by Kuwait at 32.23 and the United Arab Emirates at 31.82. Other notable contributors include Brunei, Bahrain, and the United States. Trinidad and Tobago, Australia, Saudi Arabia, and Oman complete the list, each with varying average emissions. This analysis offers crucial context for evaluating the effectiveness of past mitigation efforts and identifying areas for improvement in Dubai's carbon reduction strategy.

Table 1: Average per capita emissions of the top 10 countries from 1965 to 2022

Country	Average
Qatar	51.83 tonnes per person
Kuwait	32.23 tonnes per person
United Arab Emirates	31.82 tonnes per person
Brunei	23.54 tonnes per person
Bahrain	21.37 tonnes per person
United States	19.65 tonnes per person
Trinidad and Tobago	18.16 tonnes per person
Australia	15.41 tonnes per person
Saudi Arabia	14.16 tonnes per person
Oman	9.27 tonnes per person

4. Discussion

Dubai, despite not ranking in the top 10 for total annual emissions, demonstrates notably high per capita emissions. This deviation underscores the importance of evaluating a country's environmental impact from multiple angles. While total emissions offer a broader overview of a nation's contribution to global greenhouse gases, per capita emissions delve into the individual carbon footprint, considering population size. The disparity between Dubai's total and per capita emissions highlights the nuanced nature of the city's carbon output, urging a comprehensive assessment for effective environmental policies.

To reduce carbon footprints in Dubai, targeted interventions are essential. Strategies should include initiatives such as promoting renewable energy adoption, advocating for eco - friendly building practices, and encouraging sustainable transportation methods. Promoting the widespread use of solar panels, backed by government incentives, can drive a swift transition toward cleaner energy sources. Strengthening green building standards and introducing regulations for sustainable construction can also contribute to eco - friendly building practices. Finally, encouraging sustainable transportation which involves expanding public transit options, developing cycling infrastructure, and promoting electric vehicles, align with the global efforts to transition to cleaner transportation alternatives.

These strategies align with the findings from various research papers, such as Pandey et al. (2010), which emphasizes the urgency of standardized carbon foot - printing methods for effective emission reduction. Al - Dabbagh (2018) acknowledges UAE's efforts in renewable energy adoption and eco - friendly building practices, suggesting these initiatives, along with improved energy use in buildings, can significantly impact carbon footprints.

It's crucial to acknowledge that the Dubai government has set an ambitious target of achieving net - zero emissions by 2050. The government is actively and proactively implementing measures to rapidly reduce carbon footprints as part of this goal. However, several limitations impact the comprehensive understanding of carbon emissions in Dubai. One notable

concern is the potential presence of reporting bias in the available data. Variations in reporting practices and accuracy among different sources may introduce discrepancies, leading to an incomplete representation of the true per capita emissions. This limitation is closely connected to the completeness and reliability of the data. Gaps in the dataset or inconsistencies in the methods of measurement could affect the accuracy of the findings, preventing a precise measurement of per capita emissions. Additionally, predicting future carbon trajectories faces challenges due to the dynamic nature of environmental policies and the evolving commitment to net - zero by 2050. Rapid changes in policies or technological advancements could influence future emissions in ways that can be difficult to predict.

While external studies broaden our view and provide valuable insights into global trends and best practices, relying on local data specifically tailored to Dubai can significantly enhance the accuracy and relevance of future assessments. Utilizing data directly sourced from Dubai ensures a more nuanced understanding of the local context, considering factors such as specific industries, energy sources, and cultural practices that might influence carbon emissions.

In summary, our study highlights a challenge and opportunity for Dubai due to the difference between total and per capita emissions. Tackling this challenge requires targeted actions involving both national policies and individual behaviors. The commitment to reach net - zero emissions by 2050 is a positive step, emphasizing the need to align research with sustainability efforts. Our findings contribute to understanding Dubai's carbon emissions and the path to a more sustainable future.

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