

**Abstract :** This study compares methane emissions and CO2 footprints in India, China, United States, and Japan. Using World Bank data, we analyze trends from 1990 to 2019 and apply K-means clustering to identify distinct emission patterns. The findings provide valuable insights into the environmental profiles of these countries and inform targeted mitigation strategies for greenhouse gas emissions.

**Introduction:** This study focuses on analyzing methane emissions and CO2 footprints in four major economies: India, China, the United States, and Japan. Methane emissions and CO2 production are critical environmental indicators associated with climate change and sustainability. By comparing these indicators among different countries, we can gain insights into their environmental performance and identify areas for improvement. The World Bank data on methane emissions and CO2 production is utilized to examine the trends and patterns over the years. Through clustering analysis, we aim to identify interesting clusters of data that can provide valuable insights into the comparative environmental performance of these nations. This analysis contributes to a better understanding of the challenges and opportunities in reducing greenhouse gas emissions and promoting sustainable practices.

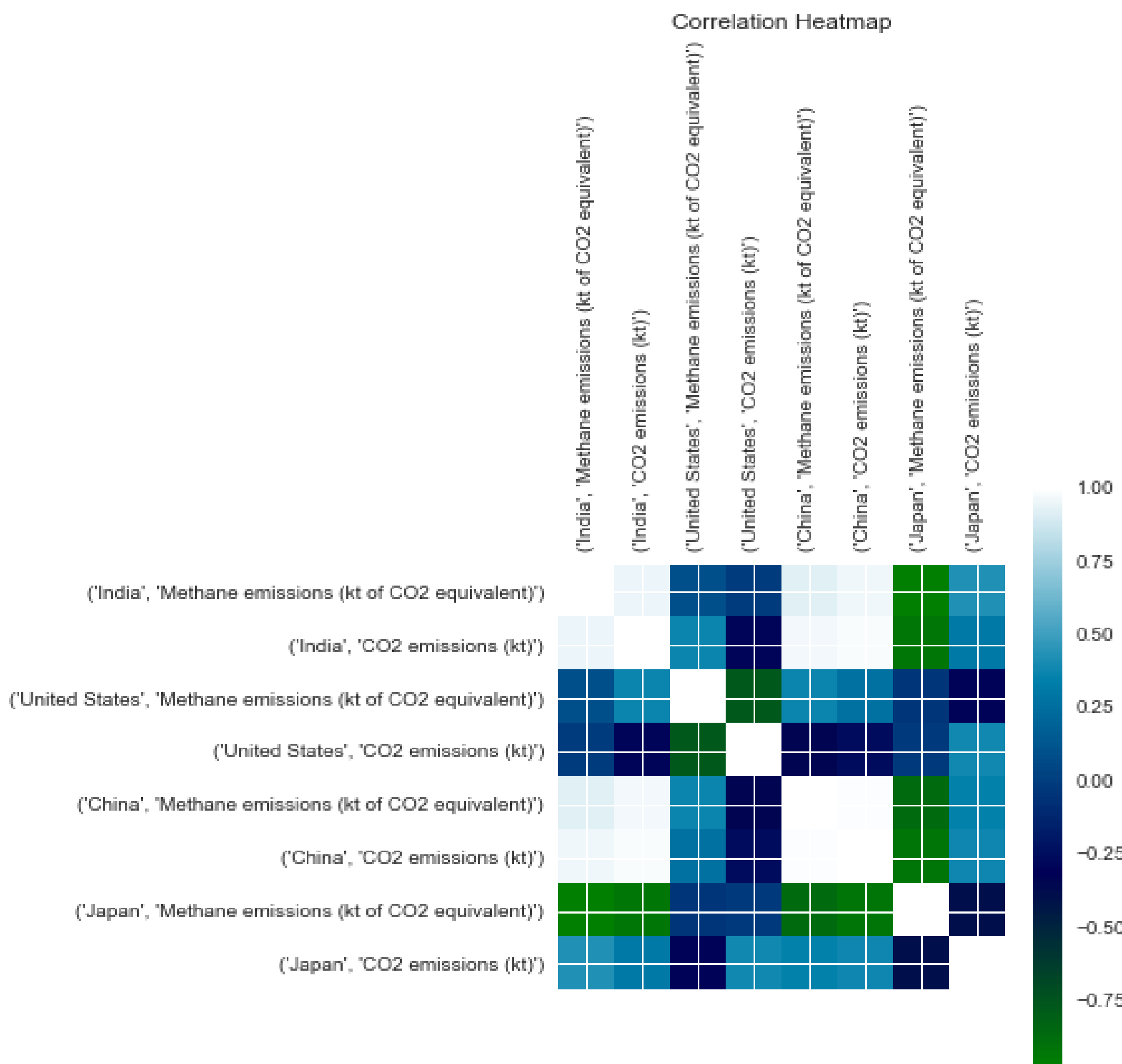
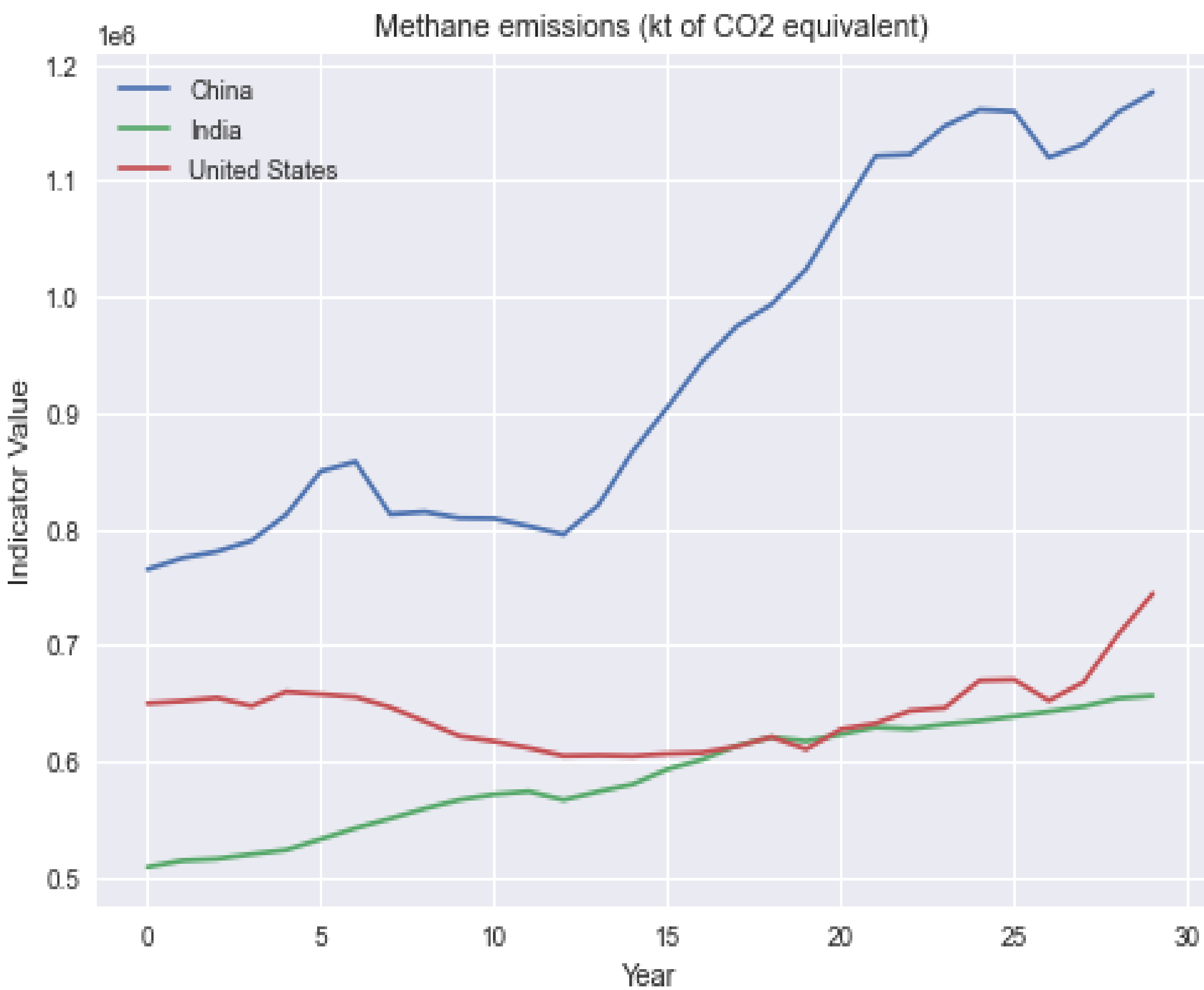
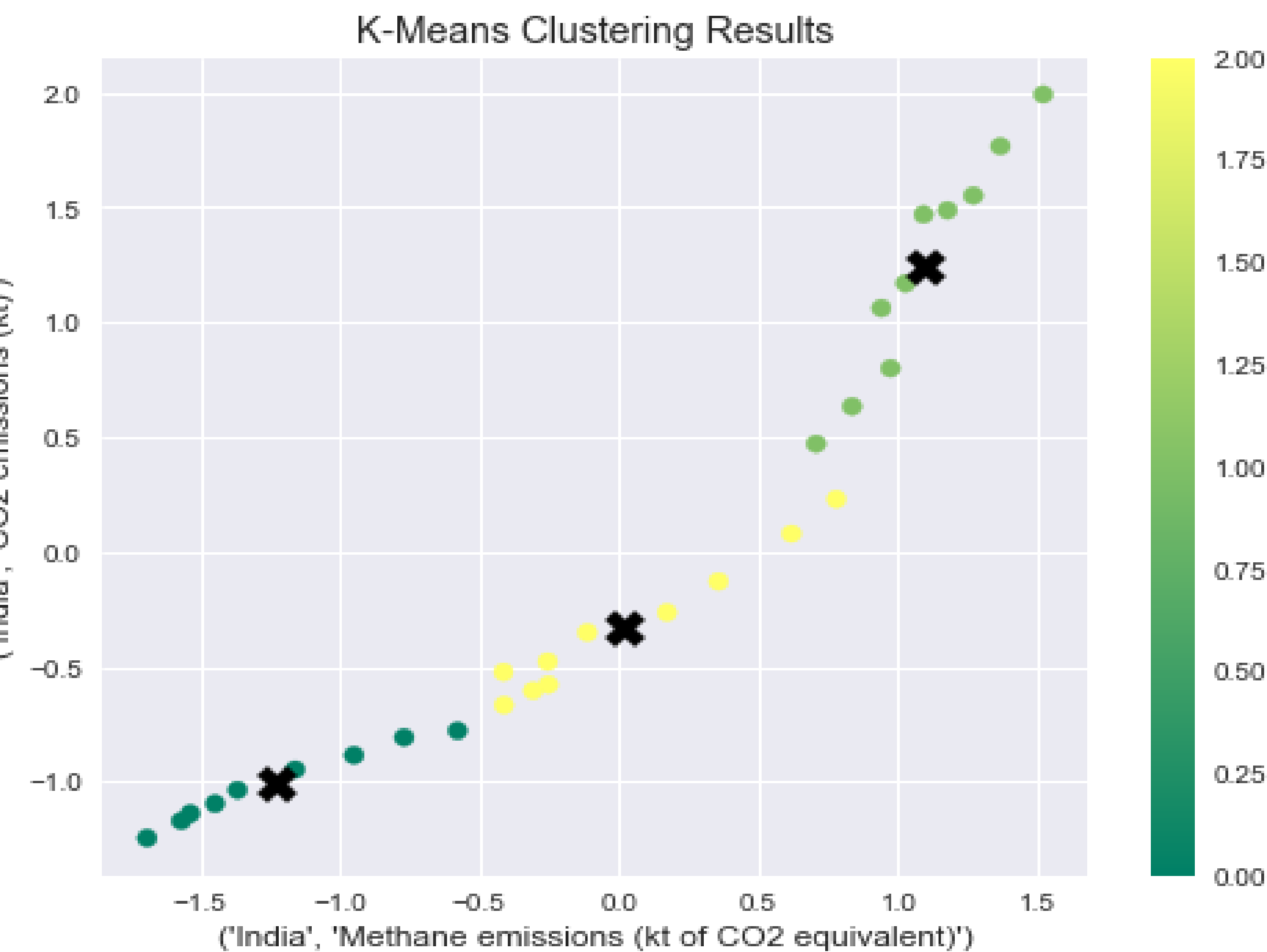
**Results:** **Clustering Analysis:** The clustering analysis was performed on the data related to methane emissions and CO2 footprints for India, China, the United States, and Japan. The analysis grouped these countries into different clusters based on their environmental performance. This allows for a comparative study of the countries' emission levels and footprints, highlighting variations and similarities among them.

**Cluster Centers:** Each cluster obtained from the clustering analysis has an associated cluster center. These cluster centers represent the average values of methane emissions and CO2 footprints for the countries within each cluster. By examining the cluster centers, we can gain insights into the typical emission levels and footprints of the countries in each group.

**Future Growth Rates:** The growth rates of methane emissions were predicted for India, China, and the United States. This provides an estimation of how their emission levels may change in the future. By analyzing the growth rates, we can understand the potential trajectories of methane emissions for these countries, which is crucial for environmental planning and policy-making.

**Correlation Analysis:** A correlation heat map was created to explore the relationships between methane emissions, CO2 footprints, and other factors. The heat map helps identify any significant correlations or associations between these variables. By understanding the connections between methane emissions, CO2 footprints, and other factors, we can gain valuable insights into the complex dynamics of greenhouse gas emissions.

**Normalized Data Analysis:** The data related to methane emissions and CO2 footprints were normalized for better comparability. Boxplots were then generated to visualize the distribution of emissions and footprints across the countries. This analysis allows us to identify variations, potential outliers, and overall patterns in the emission and footprint levels of India, China, the United States, and Japan.



**Conclusion:** The analysis of methane emissions and CO2 footprints for India, China, the United States, and Japan yielded several key findings. Firstly, the clustering analysis grouped the countries into distinct clusters based on their environmental performance, highlighting variations in emission levels and footprints. Secondly, the cluster centers provided insights into the average values within each cluster, offering a glimpse into the typical emission levels and footprints for countries in each group. Additionally, the predicted growth rates of methane emissions indicated potential future trajectories for India, China, and the United States. The correlation analysis revealed relationships between emissions, footprints, and other factors. Overall, this study provides valuable insights into the environmental profiles of these countries and aids in understanding their emissions patterns and future trends.