

Exploring the relationship between greenhouse gas emissions and forest area: Cluster and time series analysis of selected countries

Abstract

This poster investigates the relationship between greenhouse emissions and forest area using data from the World Bank. The data was clustered based on greenhouse emissions vs forest area for the years 1990, 2000, 2010, and 2019. Countries were then selected from each cluster for further analysis by fitting a function to the plots of greenhouse emissions and forest area vs time and predicting their trend for the next 30 years. The poster presents the results and highlights the trends of time for each country.

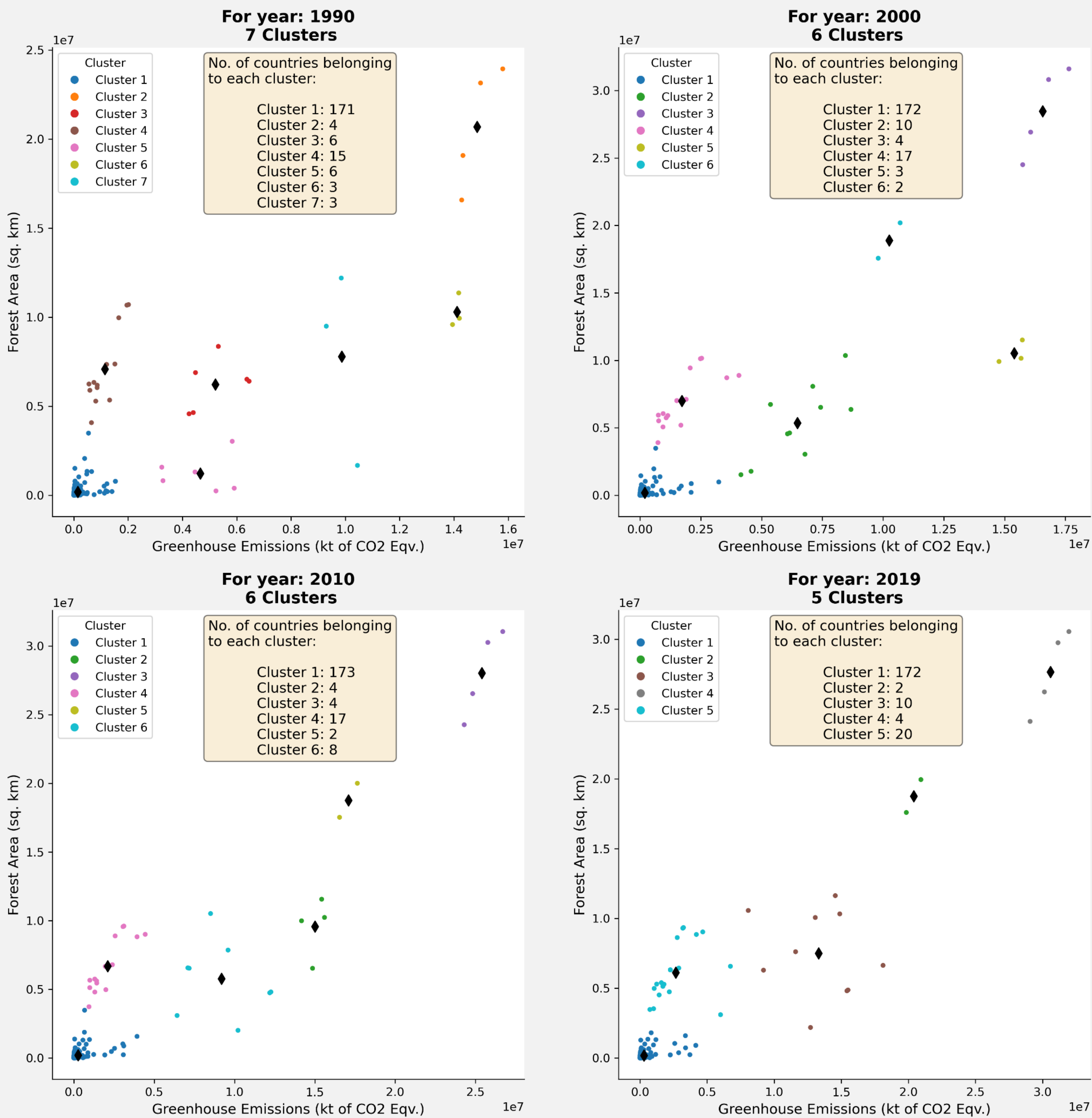
Introduction

- Cluster analysis is performed on greenhouse emissions vs forest area data for 1990, 2000, 2010, and 2019.
- Countries are selected from the clusters for further analysis: China, Australia, UK, and US.
- Suitable functions are fitted to their emissions and forest area over time to predict trends up to 2030, 2040, and 2050 with confidence intervals.
- Results are compared between clusters belonging to the same or different groups.

Cluster analysis of greenhouse emissions vs forest area: Key findings

- The graph of greenhouse emissions vs forest area shows cluster centers and has four subplots for each year.
- Most countries fall into cluster 1 for all years, with emissions in the range up to 5 million kt and 2.5 million sq. km forest land.
- The number of clusters reduces from 7 in 1990 to 5 in 2019, with a reduction in emissions taken place and forest area decreasing slightly for some countries.
- Clusters 1, 3, and 5 have almost all countries, so countries in these clusters are further studied for their similarities and differences to investigate their trends.

Greenhouse Emissions vs Forest Area showing cluster centers



Investigate Australia from cluster 1

- Emissions followed a logistic curve and increased till 2018 at 0.6M kt, then remained stable.
- Emissions showed an overall increase of 20% over time.
- Forest area followed a bell curve.
- Sharp decrease in forest area from 1990 to 2010, showing a decrease of 34% and similar increase in just 6 years' time till it fizzled out at 1.34M sq. km.
- Forest area is expected to remain the same till 2050 at 1.34M sq. km.

Investigate UK from cluster 1

- Emissions followed a decaying logistic curve. UK showed an excellent 55% reduction in emissions over the period of time.
- It is expected to reduce more by 88% till 2050 reaching to about 50000 kt.
- An upward logistic trend is followed for forest land.
- An increase of 11% is observed for forest land reaching at about 31000 sq. km.
- It is further likely to increase an additional 6% till 2050.

Investigate China from cluster 3

- Emissions show a logistic curve with an increase of 12.5M kt over time, representing a 250% increase in emissions over the period of time.
- Emissions are expected to increase an additional 40% until 2050 before leveling off at 17.5M kt.
- Forest area increases logarithmically upward over time.
- It reaches at 31% to 2.1M sq. km and is expected to increase by an additional 29% to 2.7M sq. km until 2050.

Investigate US from cluster 5

- The greenhouse emissions follow a bell curve.
- It follows a cycle of increase and decrease of 17% till 2019 and is expected to remain constant till 2050 at 5.9M kt
- The forest area of US follows a 3rd degree polynomial curve.
- It increases initially to 3% till 2016, then it started to decline at 3M sq. km till 2019.
- The area is further expected to decrease by 29% till 2050 to as low as 2.2M sq. km.

Some real-world scenarios explaining trends

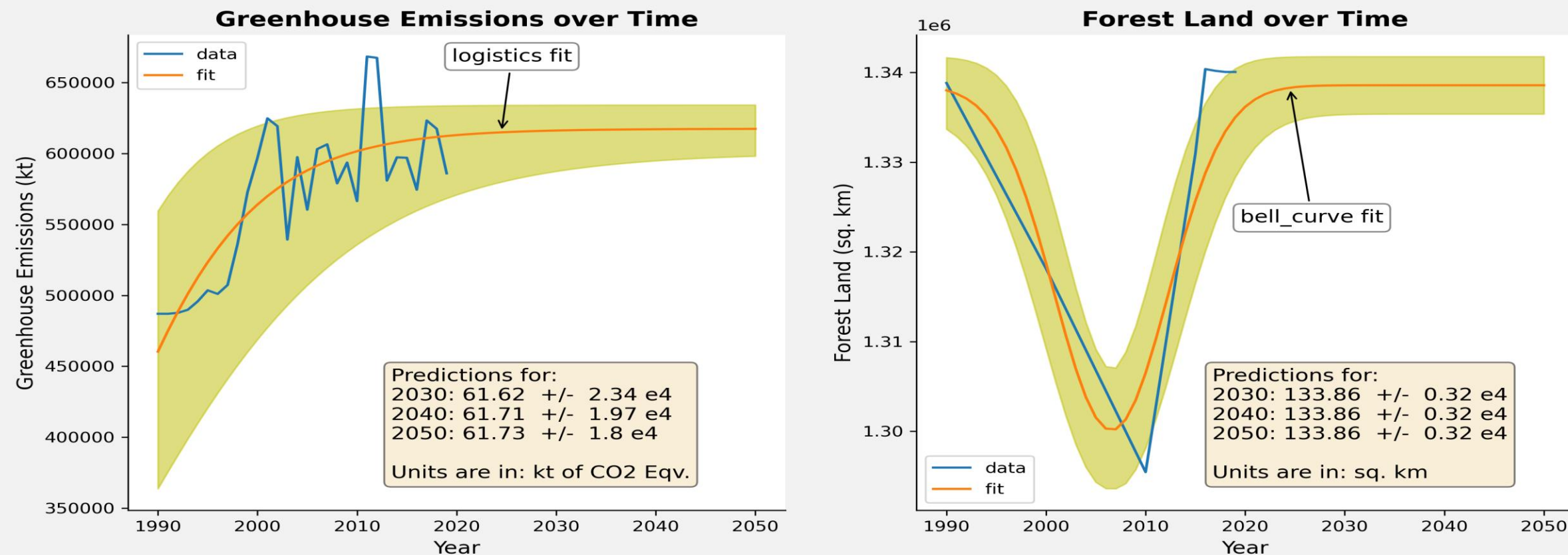
- Australia's emissions reduction policies, including the carbon tax, contributed to a reduction in emissions but did not significantly affect forest cover.
- The UK's Forest Stewardship Council (FSC) certification scheme and Woodland Carbon Code incentivize sustainable forest management and afforestation.
- China's 2020 afforestation target aimed to increase forest cover to 23%, promoting ecological civilization and climate change mitigation.
- The US's reliance on fossil fuels and deforestation for economic growth highlights the need for sustainable development and transitioning to renewable energy sources.
- The impacts of climate change and natural disasters, such as bushfires and hurricanes, have also affected emissions and forest cover trends in these countries.

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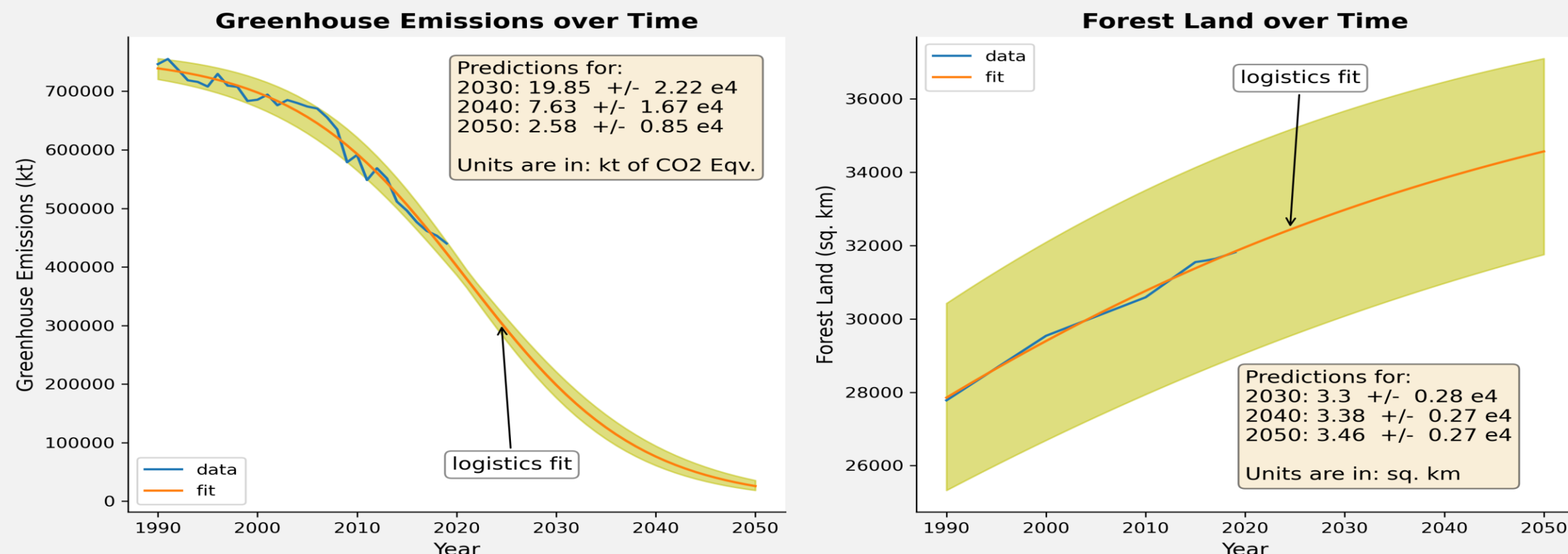
Student ID: 22034204

Github Repo Link: https://github.com/ameerhamza95/ADS_Assignment_3.git

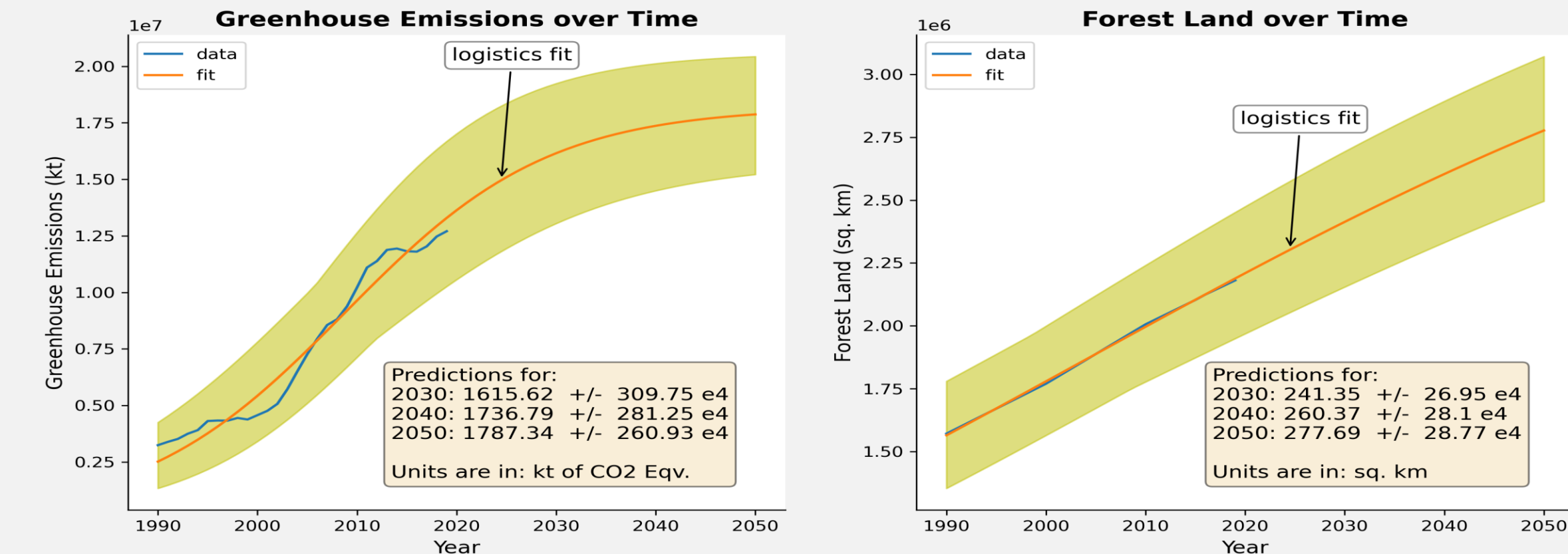
Australia: Cluster # 1 Trends with Time



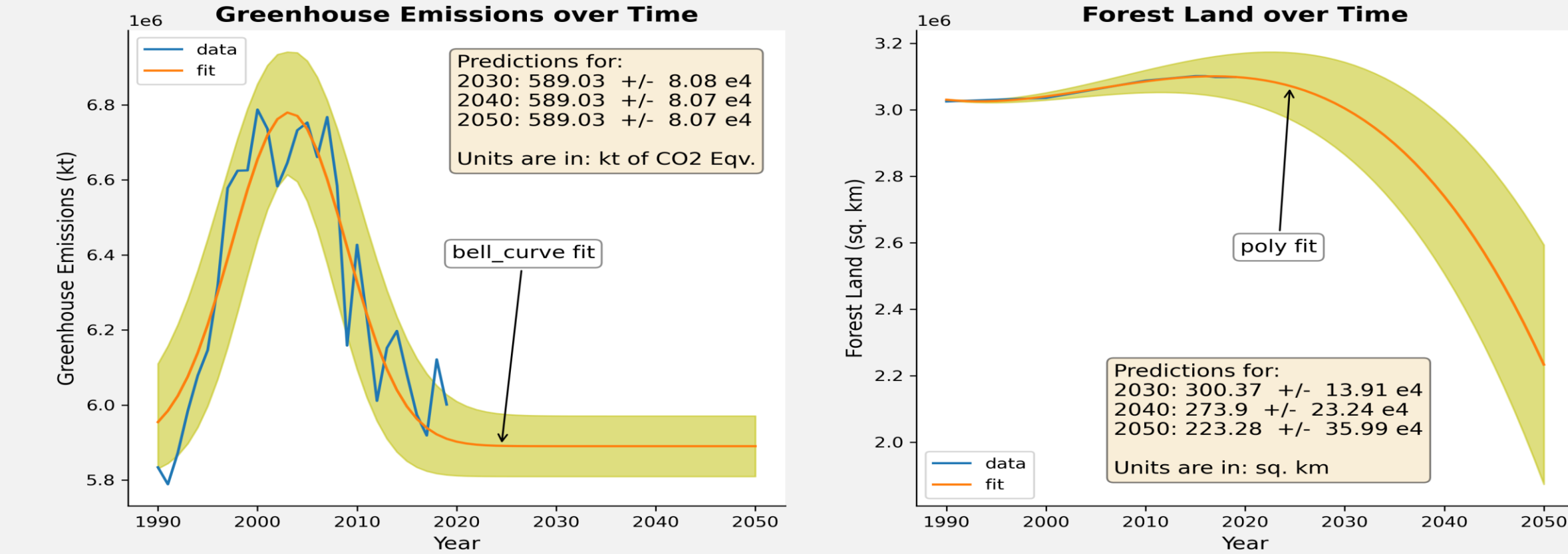
United Kingdom: Cluster # 1 Trends with Time



China: Cluster # 3 Trends with Time



United States: Cluster # 5 Trends with Time



Conclusion

- Cluster analysis revealed that most countries fall into cluster 1, with emissions up to 5 million kt and 2.5 million sq. km forest land. Emissions and forest area have a complex relationship with various trends and curves observed across different countries and clusters.
- The UK in cluster 1 showed a significant reduction in emissions and an increase in forest land due to effective policies and initiatives. China in cluster 3 showed a significant increase in emissions and forest area due to rapid economic growth and government initiatives. The US in cluster 5 showed a cyclic pattern in emissions and a decline in forest area due to reliance on fossil fuels and deforestation.
- Comparison between countries in the same and different clusters suggests that environmental policies and socio-economic factors play a significant role in their emissions and forest cover trends.