CLIMATE CHANGE ANALYSIS (1961 – 2022)

MINI PROJECT REPORT

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for

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EXAMINER I

EXAMINER II

ABSTRACT

With the growing urgency of climate change, understanding historical temperature trends is essential to predicting future impacts. This analysis aims to provide insights that can support climate policy and global awareness by examining temperature changes from 1961 to 2022 across multiple countries and regions. By analyzing attributes such as country classification, emission levels, and geographic location, this study identifies trends that highlight regions most affected by temperature increases. Over 100 countries fall into high-risk categories for temperature rise, emphasizing the widespread and varied impact of climate change. This analysis supports policymakers and environmental organizations by offering data-driven insights into global warming trends, the influence of regional factors, and the variance between developed and developing nations. Furthermore, identifying consistent temperature increases in high-emission countries and areas without coastal buffers underscores the need for targeted intervention. By improving our understanding of these dynamics, this work contributes to informed decision-making for climate adaptation and resilience strategies globally. In addition to temperature trends, this study investigates the socio-economic ramifications of climate change, particularly how vulnerable populations in developing nations are disproportionately affected. The intersection of poverty, lack of resources, and geographic susceptibility further exacerbates the challenges faced by these communities. This research also highlights the importance of collaboration between nations, advocating for global partnerships that facilitate knowledge-sharing and financial support for climate adaptation initiatives. Ultimately, this comprehensive analysis aims to galvanize action, ensuring that effective climate response measures are informed by historical data and tailored to the unique needs of diverse populations across the globe.

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CHAPTER-1
INTRODUCTION

1.1 Background

Climate change has become one of the most pressing issues of the modern era, with significant warming trends observed across the globe since the mid-20th century. This project focuses on analyzing **temperature changes from 1961 to 20**22 to understand these trends and their implications. Using a comprehensive dataset of **225 records with 72 features**, including country-specific indicators like temperature changes, ISO codes, and relevant climate metadata, this analysis investigates key questions about the patterns of climate change

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1.2 Objective

The primary objective of this analysis is to examine global climate data to uncover patterns in:

- Temperature trends over time (1961–2022)
- Regional variations in warming
- Differences between developed and developing countries
- Impacts of emission levels on temperature changes
- Temperature trends in landlocked vs. coastal regions

This analysis aims to provide insights into historical and regional temperature changes, helping to understand the factors influencing climate shifts and supporting future climate resilience planning.

CHAPTER-2

DATASET OVERVIEW

2.1 Dataset Description

The dataset, sourced from the Food and Agriculture Organization of the United Nations, includes climate indicators for multiple countries, capturing data from 1961 to 2022. The dataset contains 72 columns, including:

- **ObjectId**: A unique identifier for each record.
- **Country**: The name of the country or region for which the data is provided.
- **ISO2**: The two-letter country code following the ISO 3166-1 alpha-2 standard.
- **ISO3**: The three-letter country code following the ISO 3166-1 alpha-3 standard.
- **Indicator**: Describes the climate change indicator, specifically focusing on temperature changes.
- **Unit**: The unit of measurement for the climate indicator (e.g., Degree Celsius).
- **Source**: The organization or entity from which the data was sourced.
- **CTS_Code**: A unique code representing the climate indicator.
- **CTS_Name**: The name of the climate indicator being tracked (e.g., Surface Temperature Change).
- **CTS_Full_Descriptor**: A detailed description of the climate indicator.
- **F1961 to F2022**: Temperature change values for each corresponding year from 1961 to 2022.

2.2 Data Link

The dataset is publicly available on Kaggle:

https://www.kaggle.com/code/rewidashabaanmohamed/climate-change/notebook

CHAPTER-3

DATA PREPARATION AND PREPROCESSING

3.1 Data Cleaning

Before analysis, the dataset was pre-processed to ensure data quality:

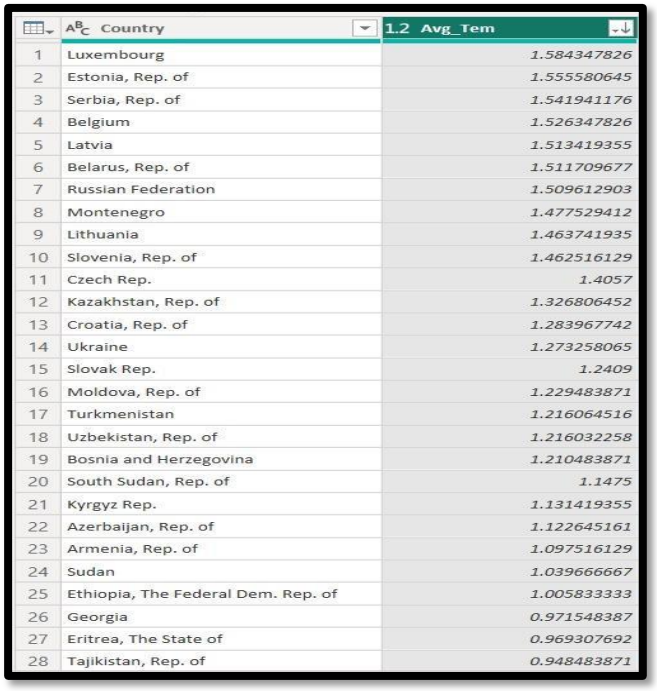
- **Handling Missing Values**: Identify any missing values in the dataset columns, especially for annual temperature data (e.g., F1961 to F2022).
- **Standardizing Units**: Ensure that all temperature data is recorded in the same unit (e.g., Degree Celsius). Convert if necessary and verify consistency.
- **Removing Duplicates**: Check for any duplicate records in country-specific indicators, ISO codes, or other columns. Remove duplicates to avoid biased analysis.

3.2 Data Transformation

- **Yearly Average Calculation:** Create additional columns to calculate average yearly temperature changes per country, making it easier to identify annual trends and observe changes over time.

Year	Avg_Temp
F1961	0.163053191489362
F1962	-0.0134761904761905
F1963	-0.0060425531914895
F1964	-0.0700585106382974
F1965	-0.247026595744681
F1966	0.105505208333333
F1967	-0.110832460732984
F1968	-0.199109947643979
F1969	0.157942105263158
F1970	0.0924867724867726
F1971	-0.200513089005236
F1972	-0.0849062500000004
F1973	0.229367875647668
F1974	-0.16303125
F1975	-0.0234946808510637
F1976	-0.245915343915344
F1977	0.165816216216216

- **Temperature Change by Region:** Create aggregated values by grouping data by continent or other regional classifications. This transformation will facilitate regional trend comparisons and highlight variations across continents.



	Country	Avg_Tem
1	Luxembourg	1.584347826
2	Estonia, Rep. of	1.555580645
3	Serbia, Rep. of	1.541941176
4	Belgium	1.526347826
5	Latvia	1.513419355
6	Belarus, Rep. of	1.511709677
7	Russian Federation	1.509612903
8	Montenegro	1.477529412
9	Lithuania	1.463741935
10	Slovenia, Rep. of	1.462516129
11	Czech Rep.	1.4057
12	Kazakhstan, Rep. of	1.326806452
13	Croatia, Rep. of	1.283967742
14	Ukraine	1.273258065
15	Slovak Rep.	1.2409
16	Moldova, Rep. of	1.229483871
17	Turkmenistan	1.216064516
18	Uzbekistan, Rep. of	1.216032258
19	Bosnia and Herzegovina	1.210483871
20	South Sudan, Rep. of	1.1475
21	Kyrgyz Rep.	1.131419355
22	Azerbaijan, Rep. of	1.122645161
23	Armenia, Rep. of	1.097516129
24	Sudan	1.039666667
25	Ethiopia, The Federal Dem. Rep. of	1.005833333
26	Georgia	0.971548387
27	Eritrea, The State of	0.969307692
28	Tajikistan, Rep. of	0.948483871

- **Risk Classification**: Add a new column to classify each country as "High Risk," "Moderate Risk," or "Low Risk" based on its average temperature increase rate. This can help visualize and assess regional temperature trends and risk levels effectively.

ProjectedTemperatureChangeColumn	RiskCategory
1.39435483870968	Low Risk
-1.05591836734694	Low Risk
1.39435483870968	Low Risk
-1.05591836734694	Low Risk
1.39435483870968	Low Risk
1.39435483870968	Low Risk
1.39435483870968	Low Risk
1.39435483870968	Low Risk
-1.05591836734694	Low Risk
1.39435483870968	Low Risk
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1.39435483870968	Low Risk
1.39435483870968	Low Risk
-1.05591836734694	Low Risk
1.39435483870968	Low Risk
-1.05591836734694	Low Risk
1.39435483870968	Low Risk

ProjectedTemperatureChangeColumn	RiskCategory
7.24870967741936	High Risk
7.92806451612903	High Risk
10.9751612903226	High Risk
8.09370967741935	High Risk
11.2264516129032	High Risk
7.37564516129032	High Risk
15.1170967741935	High Risk
15.2634782608696	High Risk
5.05596774193548	High Risk
12.1048387096774	High Risk
5.43709677419355	High Risk
5.0691935483871	High Risk
5.28629032258064	High Risk
5.45032258064516	High Risk
8.16140350877193	High Risk
6.5008064516129	High Risk
6.31222222222222	High Risk
12.8396774193548	High Risk
6.00274193548387	High Risk
14.057	High Risk
7.24854838709677	High Risk
5.5044262295082	High Risk
5.66032258064516	High Risk

ProjectedTemperatureChangeColumn	RiskCategory
3.96229508196721	Moderate Risk
3.96229508196721	Moderate Risk
3.96229508196721	Moderate Risk
3.96229508196721	Moderate Risk
3.96229508196721	Moderate Risk
3.96229508196721	Moderate Risk
3.96229508196721	Moderate Risk
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3.96229508196721	Moderate Risk
3.96229508196721	Moderate Risk

- **Calculating Deviations:** The "YearlyDeviation" column represents the deviation of each year's temperature from a specified baseline or historical mean.

  Formula: YearlyDeviation = Temperature Change − Baseline Temperature

  This highlights significant positive or negative deviations, helping track long-term trends and anomalies.

Year	Temperature_Change	YearlyDeviation	Anomaly
1982	-0.346	-0.829	Normal
1982	0.173	0.524	Normal
1982	0.399	0.184	Normal
1982	0.28	0.101	Normal
1982	1.044	0.866	Normal
1982	0.164	0.235	Normal
1982	0.097	-0.435	Normal
1982	0.162	-0.402	Normal
1982	0.359	-0.019	Normal
1982	0.309	-0.16	Normal
1982	0.186	-0.309	Normal
1982	0.384	0.107	Normal
1982	0.531	0.561	Normal
1982	-0.086	-0.494	Normal
1982	-0.041	0.129	Normal
1982	0.165	-0.139	Normal
1982	0.526	0.594	Normal
1982	0.211	0.05	Normal

- **Country Count by Classification:** Categorize all countries as either Coastal or Landlocked based on geographical attributes such as their proximity to oceans or seas.
    - **Coastal Countries:** Have coastlines.
    - **Landlocked Countries:** Surrounded by land with no sea access.

- **Hemisphere Classification:** Classify each country by its geographical hemisphere:
    - **Northern Hemisphere:** Countries north of the equator.
    - **Southern Hemisphere:** Countries south of the equator.

- **Distribution Analysis:** After categorizing countries by type (Coastal or Landlocked) and hemisphere, count how many countries fall into each category. This transformation provides insights into global trends, such as the ratio of Coastal to Landlocked countries in each hemisphere.

- **List Countries by Category and Hemisphere:** Generate a list or table showing each country's name, its classification (Coastal or Landlocked), and its hemisphere. This allows for easy comparison across regions and types.

Country	Avg_Temp	Classification	Landlocked_Coastal	Year	Index	Hemisphere
Afghanistan, Islamic Rep. of	1.72	Developing	Coastal	2006	45	
Albania	0.345	Developing	Coastal	2006	107	
Algeria	1.395	Developing	Coastal	2006	169	
American Samoa	0.403	Developing	Coastal	2006	229	
Andorra, Principality of	1.485	Developing	Coastal	2006	290	
Angola	0.561	Developing	Coastal	2006	352	
Anguilla	0.691	Developing	Coastal	2006	414	
Antigua and Barbuda	0.659	Developing	Coastal	2006	475	
Argentina	0.596	Developing	Coastal	2006	537	Southern
Armenia, Rep. of	1.621	Developing	Coastal	2006	568	
Aruba, Kingdom of the Netherlands	0.51	Developing	Coastal	2006	619	
Australia	0.721	Developed	Coastal	2006	676	Southern
Austria	0.907	Developed	Landlocked	2006	738	
Azerbaijan, Rep. of	1.488	Developing	Coastal	2006	769	
Bahamas, The	0.385	Developing	Coastal	2006	831	
Bahrain, Kingdom of	1.823	Developing	Coastal	2006	893	
Bangladesh	0.814	Developing	Coastal	2006	955	
Barbados	0.844	Developing	Coastal	2006	1017	
Belarus, Rep. of	0.647	Developing	Coastal	2006	1041	
Belgium	1.404	Developed	Coastal	2006	1064	

- **Temperature Changes by Decades (1980-1990, 2000-2010):**
    - **1980-1990:** A slight warming trend with an overall average of 0.19°C in 1982.
    - **2000-2010:** Increased variability with temperatures ranging from -0.169°C to 2.362°C in 2007.

    This reflects greater climate volatility influenced by natural and human activities.

Year_2000-2010	Avg_Temp
2007	0.675
2007	1.316
2007	1.22
2007	1.032
2007	1.024
2007	0.885
2007	0.957
2007	0.934
2007	-0.169
2007	0.706
2007	0.935
2007	0.929
2007	2.137
2007	0.958
2007	0.937
2007	1.08
2007	0.266
2007	0.679
2007	2.362
2007	1.883
2007	0.85
2007	0.806
2007	0.978
2007	0.537
2007	1.861
2007	0.23
2007	0.969

Year_1980-1990	Avg_Temp
1982	-0.346
1982	0.173
1982	0.399
1982	0.28
1982	1.044
1982	0.164
1982	0.097
1982	0.162
1982	0.359
1982	0.309
1982	0.186
1982	0.384
1982	0.531
1982	-0.086
1982	-0.041
1982	0.165
1982	0.526
1982	0.211
1982	-0.111
1982	0.324
1982	0.31
1982	0.277
1982	0.099
1982	0.186
1982	-0.13
1982	0.18
1982	0.437

- **Highest and Lowest Temperature Changes:** Identify the top 10 countries with the most significant annual increases in temperature and those with minimal changes.

  - **Highest Temperature Change:** Luxembourg, Estonia, Serbia, etc.

  - **Lowest Temperature Changes:** Pitcairn Islands, Falkland Islands, etc

Country	Top_10_Lowest_Temp_Change
Pitcairn Islands	-5.17
Nauru, Rep. of	-0.70
Falkland Islands (Malvinas)	0.17
Tokelau	4.31
Yemen, Rep. of	4.39
Niue	4.70
Rwanda	6.85
Burundi	7.58
Micronesia, Federated States of	8.16
Marshall Islands, Rep. of the	8.33
Cook Islands	8.65
Total	**6,700.63**

Country	Top_10_Highest_Temp_Change
Luxembourg	1.58
Estonia, Rep. of	1.56
Serbia, Rep. of	1.54
Belgium	1.53
Latvia	1.51
Belarus, Rep. of	1.51
Russian Federation	1.51
Montenegro	1.48
Lithuania	1.46
Slovenia, Rep. of	1.46
Czech Rep.	1.41
Total	**0.54**

- **Risk Categories Distribution :** Categorize countries into High, Moderate, and Low-Risk levels based on projected temperature changes.
- **Projected Risk Levels:** To classify countries into risk categories (High, Moderate, Low) and project their average temperature changes to evaluate the potential future impacts of climate change**.**

Country
Algeria
Andorra, Principality of
Armenia, Rep. of
Austria
Azerbaijan, Rep. of
Bahrain, Kingdom of
Belarus, Rep. of
Belgium
Benin
Bosnia and Herzegovina
Brazil
Brunei Darussalam
Bulgaria
Burkina Faso
Cabo Verde
Canada
Cayman Islands
Croatia, Rep. of
Cuba
Czech Rep.
Denmark
Djibouti
Dominican Rep.

AverageTemperatureChangeColumn	ProjectedTemperatureChangeColumn	RiskCategory
0.724870967741935	7.24870967741936	High Risk
0.792806451612903	7.92806451612903	High Risk
1.09751612903226	10.9751612903226	High Risk
0.809370967741935	8.09370967741935	High Risk
1.12264516129032	11.2264516129032	High Risk
0.737564516129032	7.37564516129032	High Risk
1.51170967741935	15.1170967741935	High Risk
1.52634782608696		
0.505596774193548		
1.21048387096774		
0.543709677419355	5.43709677419355	High Risk
0.50691935483871	5.0691935483871	High Risk
0.528629032258064	5.28629032258064	High Risk
0.545032258064516	5.45032258064516	High Risk
0.816140350877193	8.16140350877193	High Risk
0.65008064516129	6.5008064516129	High Risk
0.631222222222222	6.31222222222222	High Risk
1.28396774193548	12.8396774193548	High Risk
0.600274193548387	6.00274193548387	High Risk
1.4057	14.057	High Risk
0.724854838709677	7.24854838709677	High Risk
0.55044262295082	5.5044262295082	High Risk
0.566032258064516	5.66032258064516	High Risk

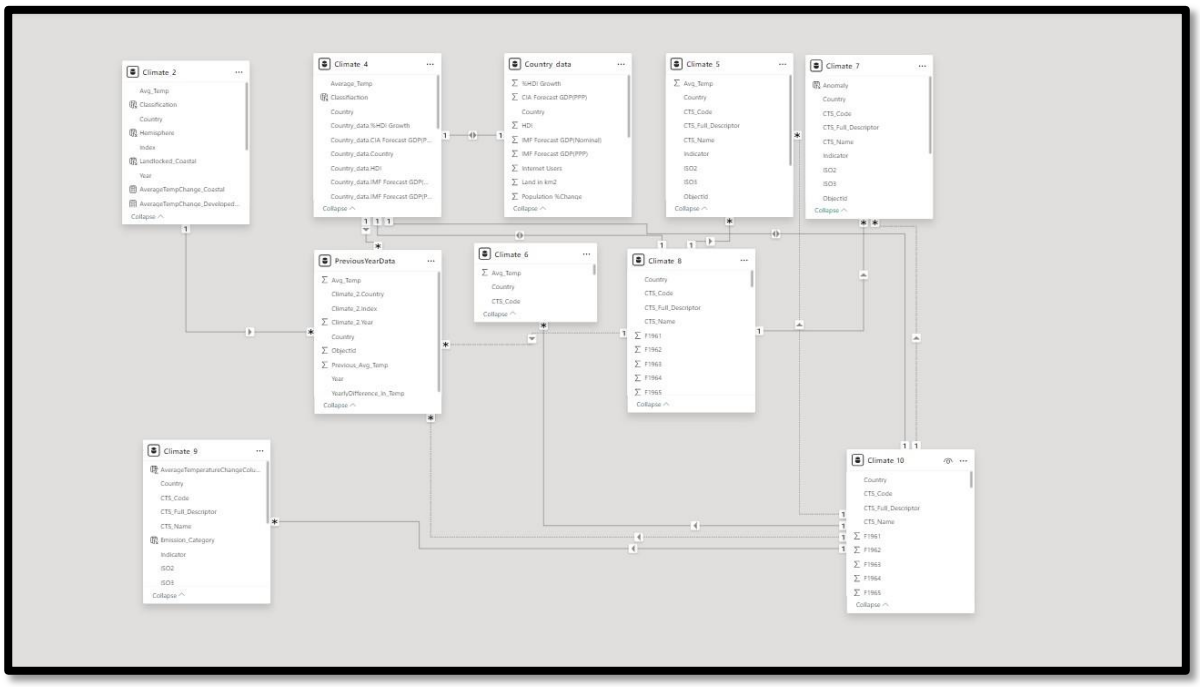
Name 'HighRiskCountries'[ProjectedTemperatureChangeColumn]

3.3 Handling Outliers

Outliers in key climate indicators, such as temperature changes, were identified and addressed. Records with extreme or anomalous temperature values were either corrected based on historical trends or excluded from further analysis to ensure consistency. Special attention was given to unusually high temperature increases in countries like Luxembourg and Estonia, and sudden deviations in regions such as Finland, suggesting sharp temperature rises. These anomalies were reviewed carefully to maintain data integrity and avoid skewing overall trend analysis.

3.4 Data Modeling

Overview of Climate Data Relational Database Schema



Purpose and Objective:

The schema is designed to systematically organize climate and socio-economic data, enabling comprehensive analysis of their interrelations across different countries and time periods.

Core Components:

The schema comprises various tables, including climate metrics, economic indicators, and country-specific data, each serving distinct functions while interconnected through defined relationships.

Relationships and Structures:

It features multiple one-to-many and many-to-many relationships that illustrate how different datasets interact, facilitating detailed queries and analyses.

- **Key Tables:**

  Climate Tables (Climate_2, Climate_4, Climate_5, Climate_6, Climate_7, Climate_8, Climate_9, Climate_10): These tables contain different aspects of climate data, including average temperatures, classifications, indicators, and historical data across various years. Each climate table serves a specific purpose in analyzing temperature changes, anomalies, and other climate-related metrics.

- **Country Data Table:**

  Country_data: This table provides essential socio-economic indicators tied to different countries, such as GDP growth, HDI (Human Development Index), and demographic data. It forms a crucial link between climate data and a country's economic profile.

- **PreviousYearData Table:**

  This table tracks changes in average temperature compared to the previous year, creating a dynamic understanding of climate progression. It links to the climate tables to provide context in temporal analysis.

Relationships

- **Join Relationships:** The schema shows several one-to-many relationships (illustrated by arrows), meaning one record in a parent table (like Climate_4) can relate to multiple records in child tables (like Climate_8 or PreviousYearData).
- This structure allows for detailed analysis of how one variable (e.g., average temperature) corresponds to various aspects (e.g., GDP or HDI) across multiple countries.

Data Integration:

- The integration of climate data with socio-economic indicators through the Country_data table allows researchers to analyze potential correlations between climate trends and economic development. For instance, comparing average temperatures with GDP growth can offer insights into how climate impacts economic conditions.

Temporal Analysis:

- Tables like PreviousYearData and various Climate tables enable the exploration of changes over time, helping to identify trends in climate anomalies and average temperatures across different years, which is critical for climate forecasting and policymaking.

This schema serves as a robust foundation for analyzing complex interrelations between climate data and economic indicators across various countries and years. By leveraging this relational design, researchers can extract meaningful insights that inform climate policy, economic planning, and environmental sustainability efforts. Such an integrated approach emphasizes the importance of understanding how climate dynamics influence, and are influenced by, socio-economic factors globally.

CHAPTER-4

DATA ANALYSIS AND INTERPRETATION

4.1 DATA ANALYSIS

1. **What is the overall global trend in temperature change from 1961 to 2022? This is shown in the Figure 4.1.**

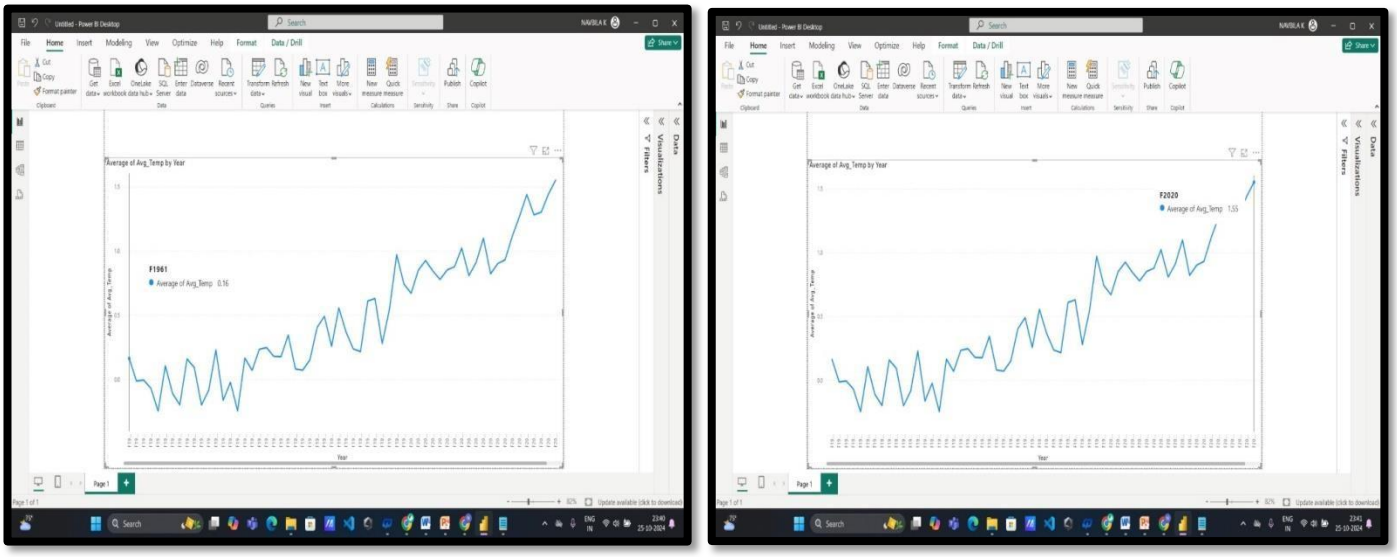


Figure 4.1: Global Temperature Change (1961-2022)

2. **How do temperature changes vary across different regions or continents over the observed period?**
   This is shown in Figure 4.2

3.

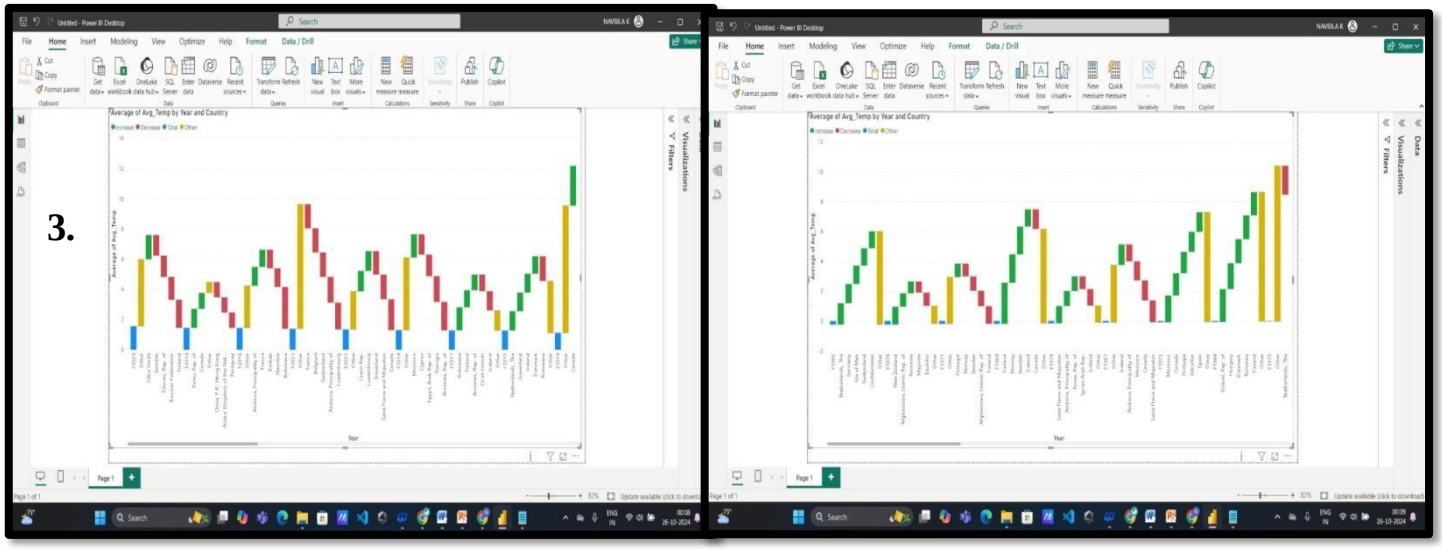


Figure 4.2: Regional Temperature Variations Over Time

3. **Which countries experienced the most significant temperature changes? This is shown in Figure 4.3**

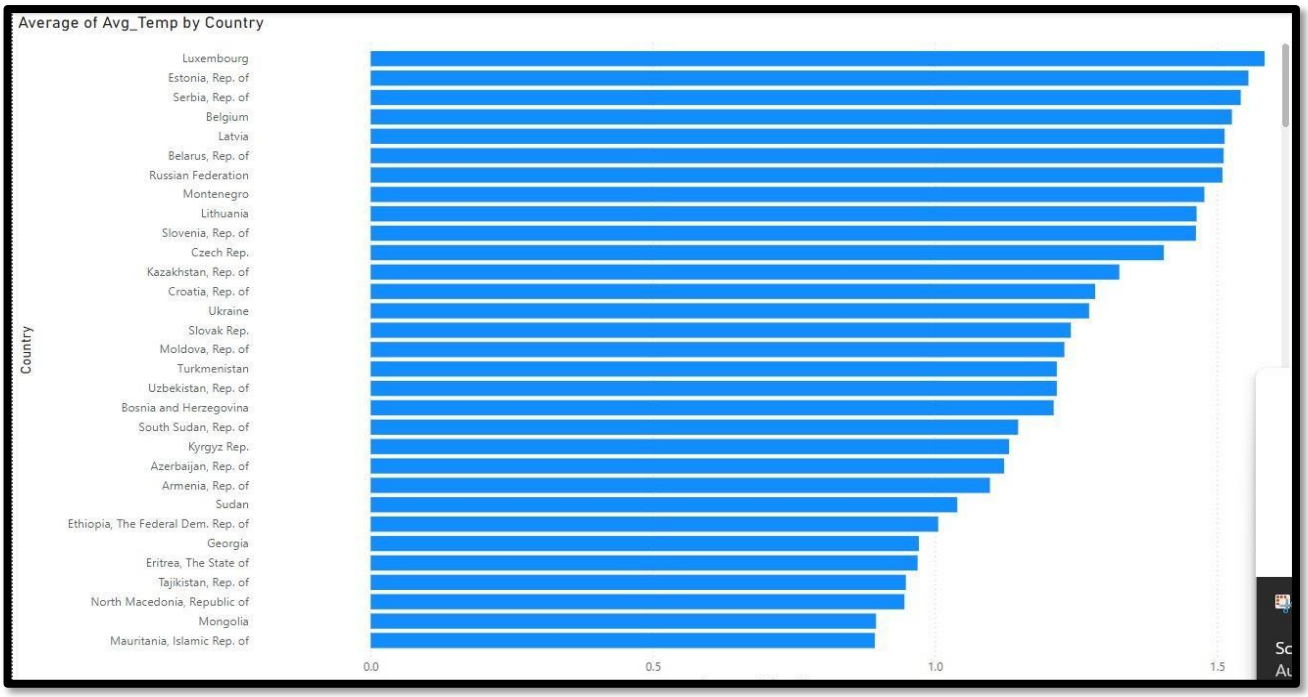


Figure 4.3: Countries with Significant Temperature Changes

4. **How do yearly average temperature changes compare between developed and developing countries?**

   This is shown in Figure 4.4

Figure 4.4: Comparison of Temperature Changes Developed vs. Developing Countries

5. **Are temperature changes more severe in landlocked countries compared to coastal nations?**

   This is shown in Figure 4.5

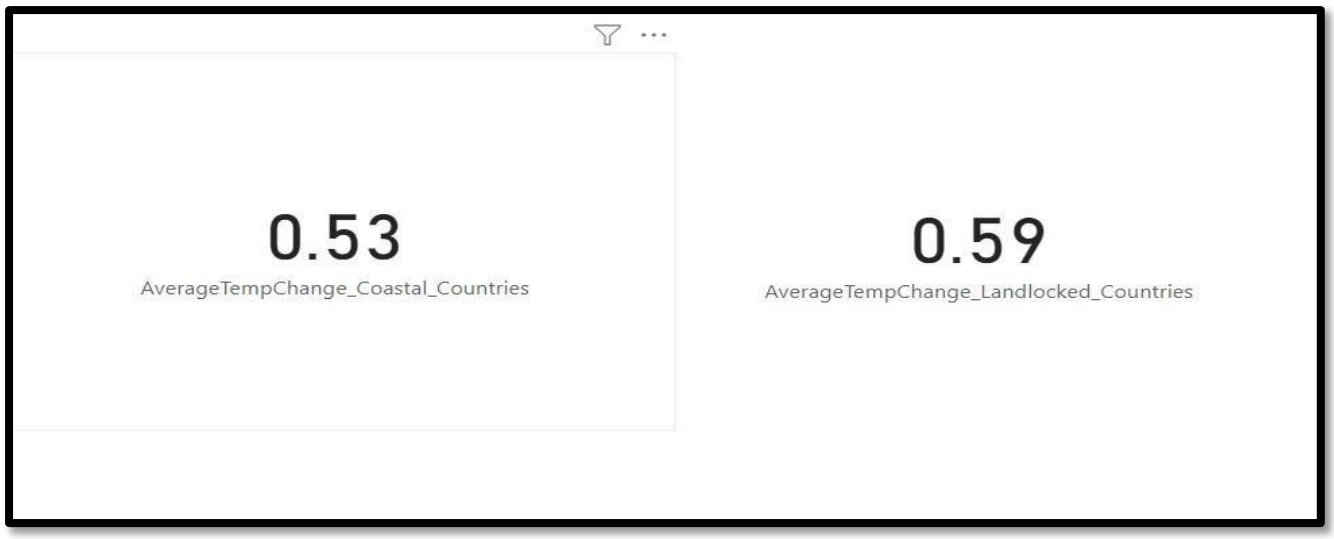


Figure 4.5: Average Temperature Change: Coastal vs. Landlocked Countries

6. **How do temperature changes differ between the Northern and Southern Hemispheres?**

   This is shown in Figure 4.6

Figure 4.6: Northern vs. Southern Hemisphere Temperature Changes

7. **How does the average temperature change vary between high-emission countries and low-emission countries?**

This is shown in Figure 4.7

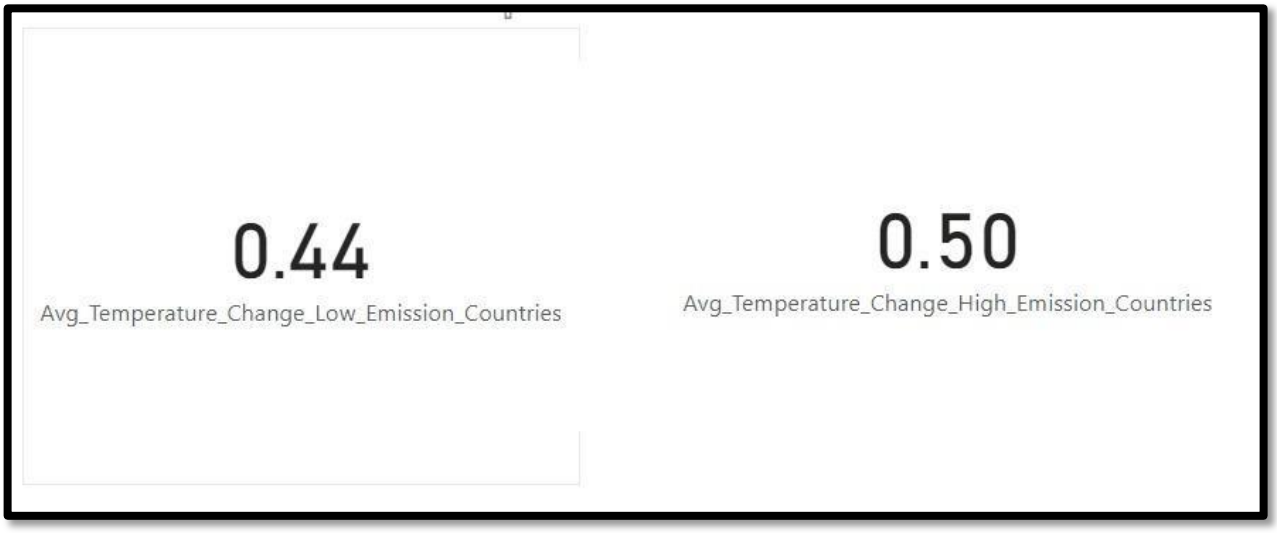


Figure 4.7: Average Temperature Change: High vs. Low Emission Countries

8. **What are the top 10 countries that have shown consistent annual increases in temperature?**

This is shown in Figure 4.8

Country	Top_10_Highest_Temp_Change
Luxembourg	1.58
Estonia, Rep. of	1.56
Serbia, Rep. of	1.54
Belgium	1.53
Latvia	1.51
Belarus, Rep. of	1.51
Russian Federation	1.51
Montenegro	1.48
Lithuania	1.46
Slovenia, Rep. of	1.46
Total	**0.54**

Figure 4.8: Top 10 Countries with the Highest Temperature Increase

9. **What are the top 10 countries that have shown the least change in temperature**

over the observed years?
This is shown in Figure 4.9

Country	Top_10_Lowest_Temp_Change
Pitcairn Islands	-5.17
Nauru, Rep. of	-0.70
Falkland Islands (Malvinas)	0.17
Tokelau	4.31
Yemen, Rep. of	4.39
Niue	4.70
Rwanda	6.85
Burundi	7.58
Micronesia, Federated States of	8.16
Marshall Islands, Rep. of the	8.33
Total	**6,700.63**

Figure 4.9: Top 10 Countries with the Least Temperature Change

10. **Is there any relationship between the size of a country (land area) and its temperature change ?**
    This is shown in Figure 4.10.

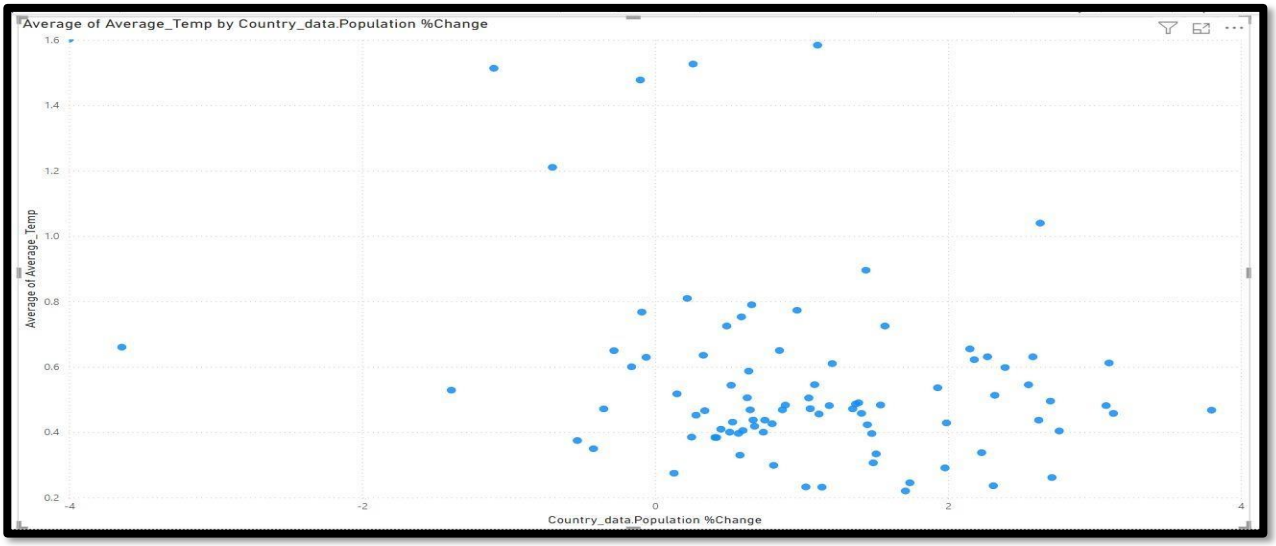


Figure 4.10: Correlation Between Land Area and Temperature Change

11. **How did temperature changes accelerate or decelerate during certain decades (e.g., 1980-1990, 2000-2010)?**

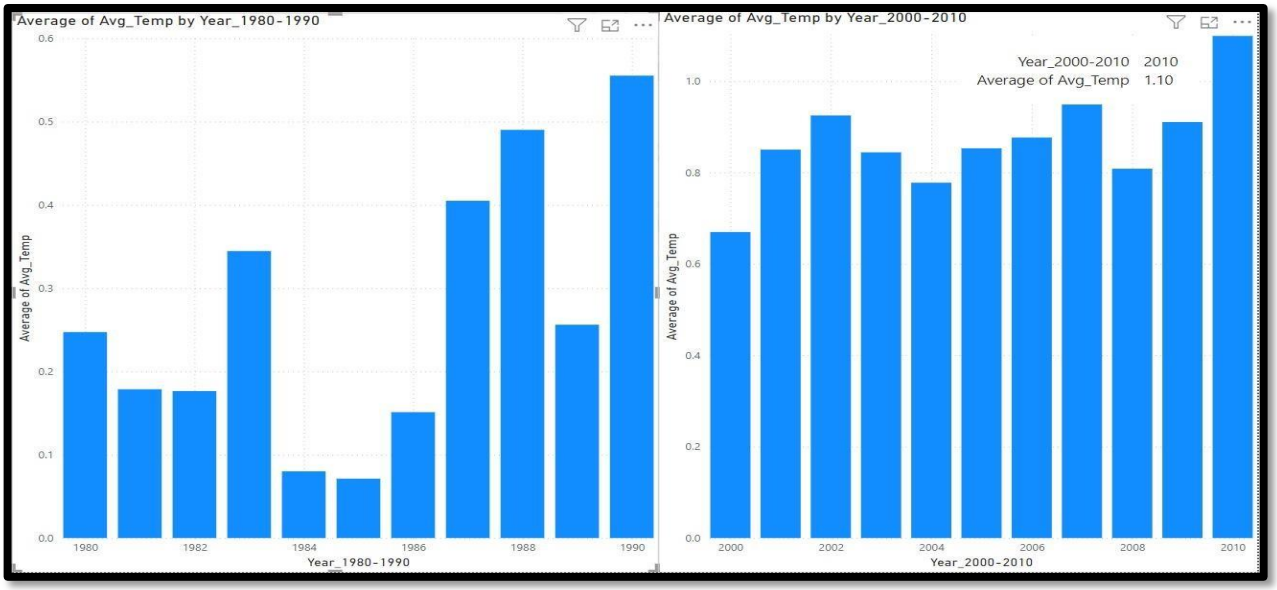


Figure 4.11: Decadal Temperature Change Acceleration: 1980-2010

12. Are there any notable anomalies where a country's temperature suddenly deviates from its previous trend?

This is shown in Figure 4.12

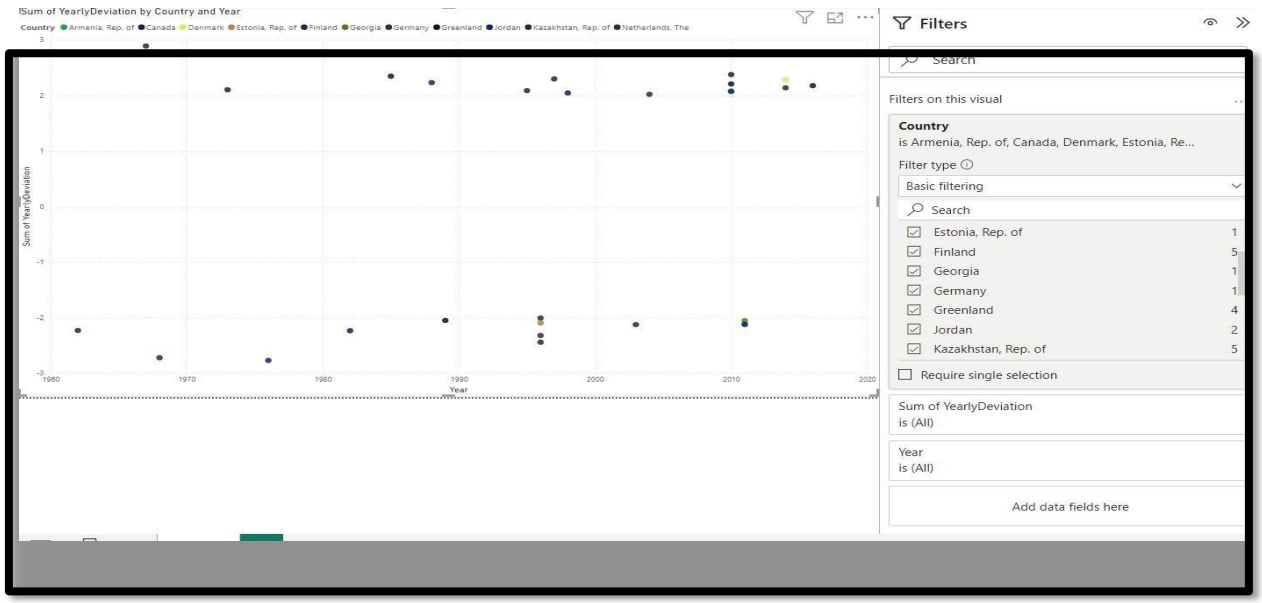


Figure 4.12: Annual Temperature Anomalies by Country (1950-2010)

13. How do temperature trends vary across different continents and what regional factors contribute to these differences?

This is shown in Figure 4.13.

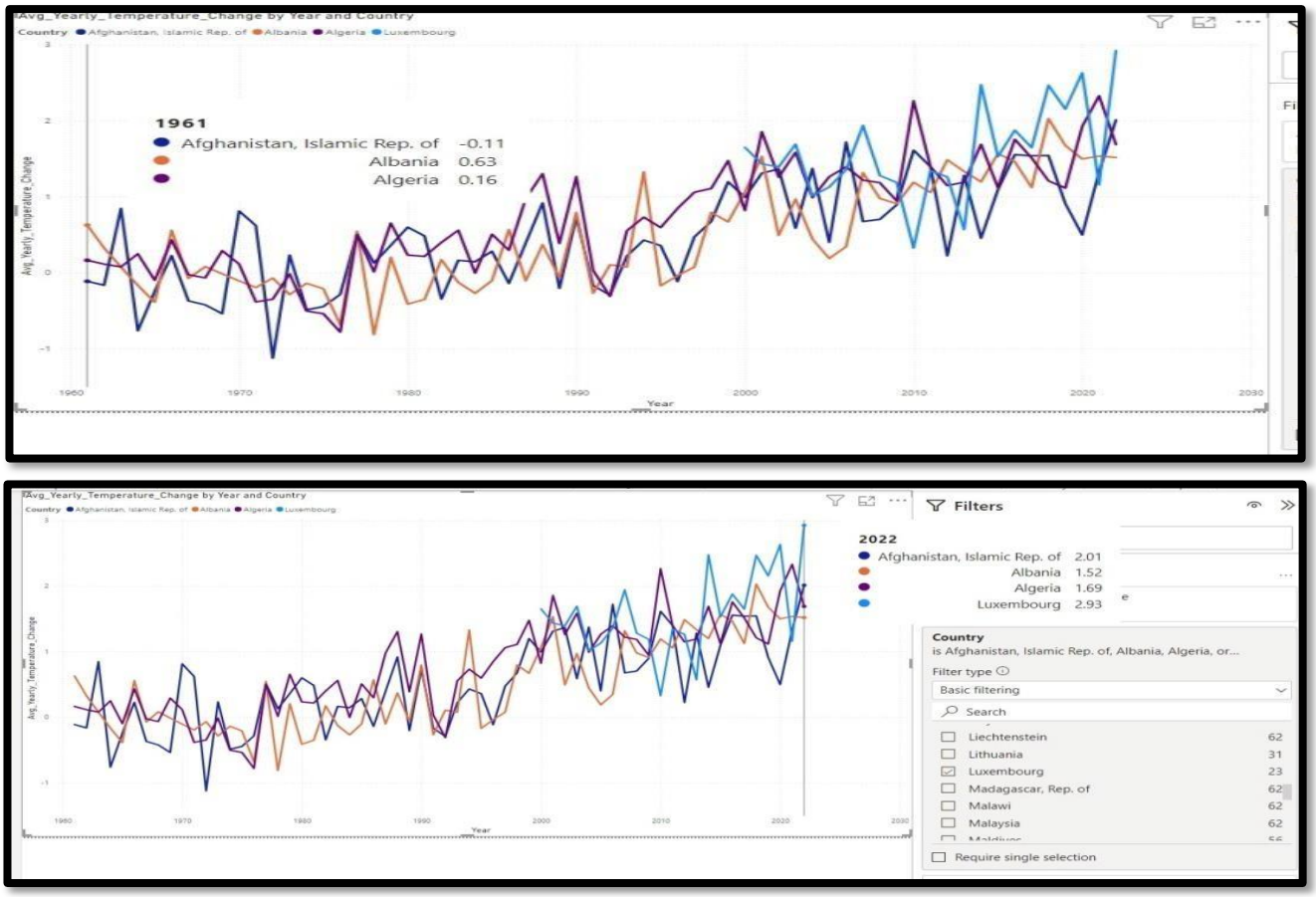


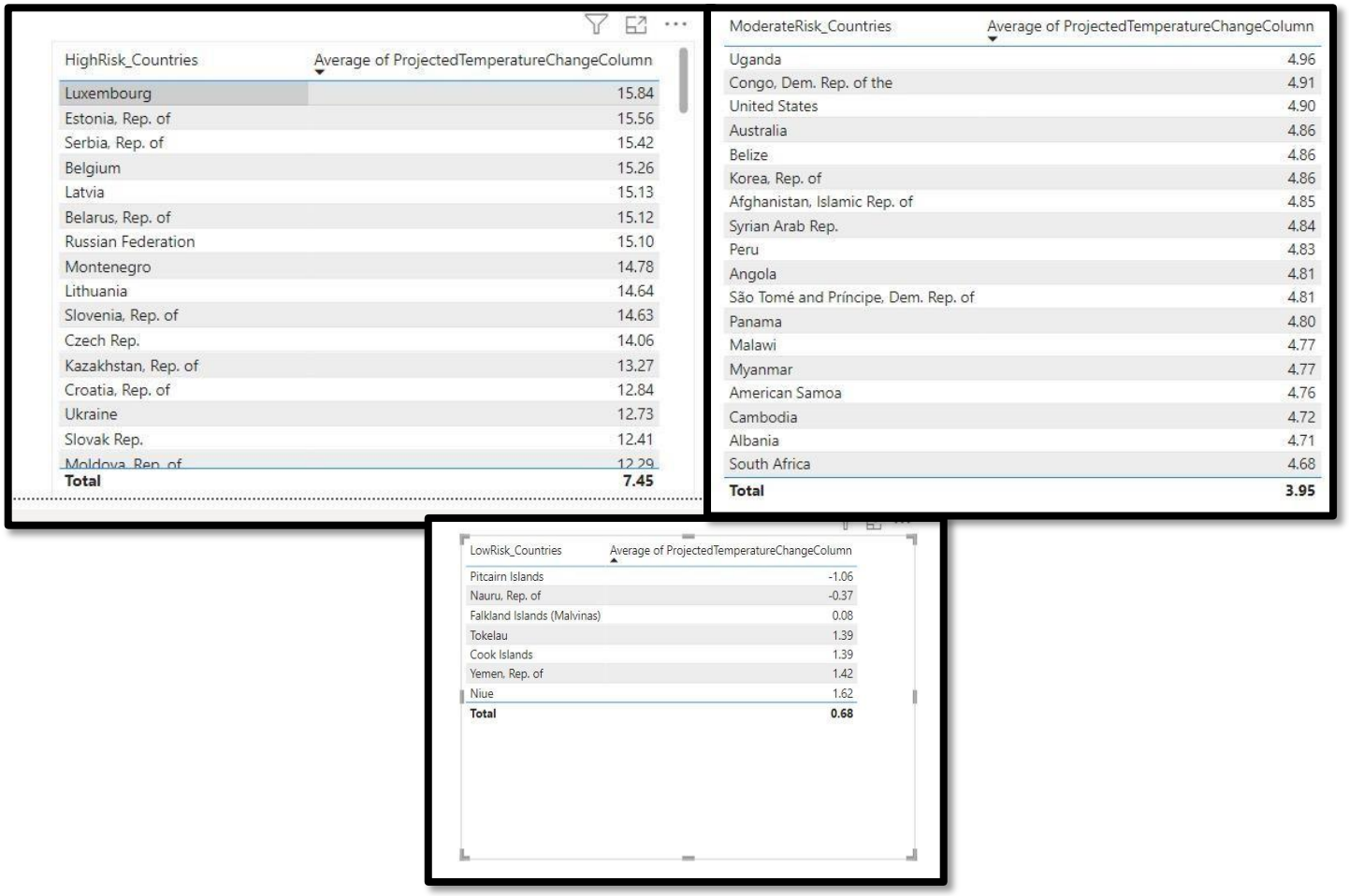
Figure 4.13: Temperature Trends Across Continents: 1961 vs. 2022

14. **How many countries are high, moderate and low risk categories? This is shown in Figure 4.14**

Figure 4.14: Distribution of Countries by Risk Categories

15. **What are the average projected temperature changes for low, moderate, and high-risk countries?**

This is shown in Figure 4.15



HighRisk_Countries	Average of ProjectedTemperatureChangeColumn
Luxembourg	15.84
Estonia, Rep. of	15.56
Serbia, Rep. of	15.42
Belgium	15.26
Latvia	15.13
Belarus, Rep. of	15.12
Russian Federation	15.10
Montenegro	14.78
Lithuania	14.64
Slovenia, Rep. of	14.63
Czech Rep.	14.06
Kazakhstan, Rep. of	13.27
Croatia, Rep. of	12.84
Ukraine	12.73
Slovak Rep.	12.41
Moldova, Rep. of	12.29
Total	**7.45**

ModerateRisk_Countries	Average of ProjectedTemperatureChangeColumn
Uganda	4.96
Congo, Dem. Rep. of the	4.91
United States	4.90
Australia	4.86
Belize	4.86
Korea, Rep. of	4.86
Afghanistan, Islamic Rep. of	4.85
Syrian Arab Rep.	4.84
Peru	4.83
Angola	4.81
São Tomé and Príncipe, Dem. Rep. of	4.81
Panama	4.80
Malawi	4.77
Myanmar	4.77
American Samoa	4.76
Cambodia	4.72
Albania	4.71
South Africa	4.68
Total	**3.95**

LowRisk_Countries	Average of ProjectedTemperatureChangeColumn
Pitcairn Islands	-1.06
Nauru, Rep. of	-0.37
Falkland Islands (Malvinas)	0.08
Tokelau	1.39
Cook Islands	1.39
Yemen, Rep. of	1.42
Niue	1.62
Total	**0.68**

Figure 4.15: Average Projected Temperature Changes for Risk Categories

4.2 PUBLISHING DASHBOARDS

Two dashboards were created to visualize key metrics:

- **Surface Temperature Change Comparison Dashboard:** This dashboard visualizes average yearly temperature changes across countries, highlighting risk categories and comparing impacts between developed and developing nations.
- **Surface Temperature Change Risk Analysis Dashboard:** This dashboard categorizes countries by temperature change risk, focusing on the top 10 countries most and least affected, facilitating targeted climate action and risk assessment.

Dashboard 1: Surface Temperature Change Comparison Dashboard

Figure-1 Surface Temperature Change Comparison Dashboard

This dashboard presents comparative data on average yearly temperature changes across multiple countries. It includes metrics like the number of high-risk, moderate-risk, and low-risk countries based on projected temperature changes. Key highlights include the distribution of average temperature change in developed vs. developing countries, coastal vs. landlocked regions, and emission-based country categories (high vs. low emission). These insights allow stakeholders to monitor climate change impacts across diverse geographic and economic classifications.

Dashboard 2: Surface Temperature Change Risk Analysis Dashboard

Figure-2 Surface Temperature Change Risk Analysis Dashboard

Focused on risk categorization, this dashboard breaks down countries into high, moderate, and low risk based on projected temperature changes. It provides an analysis of the top 10 countries with the highest and lowest temperature change, thus allowing for targeted risk assessment and prioritization for climate action. Average temperature by country, yearly temperature change, and regional categorization offer a detailed view of the nations most susceptible to climate risks.

4.3 INFERENCES

1. **Global Temperature Trend (1961-2022):** The average temperature increased from approximately 0.16 in 1961 to 1.55 in 2020, indicating significant warming over the decades. This trend highlights the potential impact of climate change and warrants further investigation.

2. **Regional Temperature Variation:** The temperature data across various countries reveals a notable upward trend in average temperatures, especially since 2020. Northern and Southern Europe, along with Canada, demonstrate significant warming, while Africa and the Middle East exhibit more variable patterns.

3. **Most Significant Temperature Changes by Country:** Countries such as Luxembourg, Estonia, Serbia, Belgium, and Latvia have the most significant temperature changes, with Luxembourg showing the highest average temperature increase. These notable rises in average temperatures indicate a pronounced warming trend, highlighting the impact of climate change across these regions.

4. **Developed vs. Developing Countries:** Developed countries have a higher average temperature change of 0.63°C compared to 0.53°C in developing countries, showing a difference of 0.10°C.

5. **Landlocked vs. Coastal Countries:** Temperature changes are more severe in landlocked countries, with an average increase of **0.59°C**, compared to **0.53°C** in coastal nations. This indicates that landlocked countries experience greater temperature fluctuations. The difference of **0.06°C** suggests

that geographical factors may influence climate impacts, potentially due to limited access to moderating oceanic influences.

6. **Northern vs. Southern Hemisphere:** Northern Hemisphere countries have an average temperature increase of 0.56°C, while Southern Hemisphere countries show a lower increase of 0.46°C. This indicates that the Northern Hemisphere is experiencing more significant warming.

7. **High-Emission vs. Low-Emission Countries:** Low-emission countries exhibit an average temperature change of 0.44°C, while high-emission countries show a slightly higher change of 0.50°C. This indicates a potential link between emissions and temperature change trends.

8. **Consistent Annual Increases in Temperature:** The average temperature change for low emission countries is 0.44°C, while high emission countries show a slightly higher change of 0.50°C. This indicates that high emission countries experience marginally greater temperature increases compared to their low emission counterparts. The difference suggests a potential link between emissions and temperature change trends. Overall, both categories exhibit relatively low temperature changes.

9. **Least Change in Temperature Over Time:** Based on the provided data, the top 10 countries that have shown consistent annual increases in temperature are Luxembourg, Estonia, Serbia, Belgium, Latvia, Belarus, the Russian Federation, Montenegro, Lithuania, and Slovenia. These countries exhibit the highest average temperatures, indicating a significant trend in rising temperatures over the years.

10. **Land Area vs. Temperature Change Correlation**: The table lists the top 10 countries with the least change in temperature over the observed years. Pitcairn Islands shows the largest decrease at -5.17°C, while the Falkland Islands has a minimal increase of 0.17°C. The remaining countries, including Yemen and Niue, exhibit slight increases in temperature. Overall, these countries demonstrate relatively stable temperature trends compared to others.

11. **Decade-Based Temperature Trends (1980-1990, 2000-2010**): From the scatter plot analysis, it is evident that there is no strong correlation between population percentage change and average temperature change, as the points are widely dispersed without a clear pattern.

12. **Temperature Anomalies:** The scatter plot reveals notable anomalies in temperature deviations for several countries. For instance, Finland shows a significant upward deviation in recent years, indicating a sharp increase in temperature compared to previous trends. Estonia also exhibits a sudden spike, suggesting an unusual temperature fluctuation. Overall, these deviations highlight specific countries experiencing unexpected changes in their temperature patterns.

13. **Temperature Trends by Continent:** Temperature trends across different countries show varying patterns, with Luxembourg experiencing the highest average temperature change at 2.93°C by 2022. In contrast, Afghanistan and Albania show lower increases, at 2.01°C and 1.52°C, respectively. Regional factors such as geographic location, urbanization, and climate policies likely contribute to these differences. Overall, the data indicates that European countries may be experiencing more significant temperature changes compared to some North African and Middle Eastern nations.

14. **High, Moderate, and Low Risk Categories:** The data indicates significant surface temperature changes across different risk categories, with 103 countries categorized as high risk, 115 as moderate risk, and only 7 as low risk. This distribution shows that the majority of countries experience high and moderate temperature changes, highlighting a concerning trend in temperature increases, while a minimal number of countries fall into the low-risk category. This trend underscores the widespread impact of rising temperatures globally.

15. **Average Projected Temperature Changes by Risk:** The data reveals that low-risk countries have an average projected temperature change of 0.68°C, with notable examples like Pitcairn Islands showing a decrease of -1.06°C. Moderate-risk countries have a higher average of 3.95°C, with Uganda leading at 4.96°C. In contrast, high-risk countries exhibit the most significant average change at 7.45°C, with Luxembourg experiencing the highest increase at 15.84°C. This indicates a clear trend where high-risk countries are projected to face more severe temperature changes compared to moderate and low-risk countries.

CHAPTER-5

KEY INSIGHTS AND FINDINGS

5.1 Temperature Change Trends Over Time

The analysis shows a notable increase in global temperature change post-2000, reflecting accelerated climate change impacts. Temperature changes from 2000 to 2022 represent more than half of the total observed increase, highlighting recent and severe climate shifts.

5.2 Regional Temperature Variability

Countries in Northern Europe and North America experience the highest temperature increases, while Africa and Southeast Asia exhibit more variable trends. This regional discrepancy suggests a need for targeted climate response strategies to address unique geographical challenges.

5.3 Climate Impact Categories

Countries are classified into high, moderate, and low-risk categories based on temperature change rates. High-risk countries predominantly consist of those with limited moderating influences from large bodies of water, indicating that geographical factors play a critical role in climate severity.

5.4 Emerging Climate Concerns by Region

While Europe and North America exhibit the largest overall temperature increases, developing regions like Africa show inconsistent but notable warming patterns. To effectively mitigate climate impacts, emphasis could be placed on adaptation strategies tailored for these emerging and diverse climate patterns

CHAPTER-6

RECOMMENDATIONS

6.1 Prioritizing High-Risk Regions for Climate Action

To address the immediate climate threats, policymakers should prioritize intervention and adaptation measures in high-risk regions, such as Luxembourg, Estonia, and Serbia. These areas exhibit significant temperature changes, indicating a heightened vulnerability to climate impacts.

6.2 Enhancing Monitoring in Moderate-Risk Countries

Countries with moderate risk, such as Uganda, Congo, and Afghanistan, should establish enhanced climate monitoring systems. Continuous tracking of temperature deviations and population vulnerability metrics will allow for timely responses to emerging climate threats.

6.3 Supporting Low-Risk Countries in Sustainable Practices

While low-risk countries like Pitcairn Islands and Nauru have experienced minimal temperature changes, promoting sustainable practices in these regions is essential to maintain their low-risk status. Encouraging renewable energy adoption and low-emission policies can prevent future climate vulnerabilities.

CHAPTER-7

CONCLUSION AND FUTURE WORK

7.1 Conclusion

The analysis of global temperature changes provides critical insights into the varied climate risks across countries. High-risk regions show clear signs of warming trends, and timely intervention can help mitigate potential impacts. Moderate-risk regions require robust monitoring, while low-risk areas should focus on maintaining their resilience through sustainable practices. By targeting these regions with tailored strategies, stakeholders can effectively address climate risks and promote global climate resilience.

7.2 Future Work

Future analysis could include:

- Population Vulnerability Studies: Assessing how population density and demographic factors influence climate risk.
- Real-Time Temperature Monitoring: Integrating real-time data feeds to track climate changes as they happen.
- Cont Predictive Climate Modeling: Developing machine learning models to forecast climate changes and proactively identify potential high-risk regions.

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