World Bank World Development Indicators

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I. Introduction

In this document, we have explored the economic, social and sustainability performance of various countries by analyzing and visualizing data from the "World Bank World Development Indicators" dataset. The given dataset has data from 1960 to 2022.

Columns given in the dataset :

- **country**: The country or geographic region.
- **date**: Date of the measurement. This column along with country can be used as index.
- **agricultural_land%**: Agricultural land as a % of land area of the country/region.
- **forest_land%**: Forest area as the % of land area of the country/region.
- **land_area**: Land area, measured in km^2.
- **avg_precipitation**: Average precipitation in depth, measured in mm per year.
- **trade_in_services%**: Trade in services as a % of GDP.
- **control_of_corruption_estimate**: Index that makes an estimate of the control of corruption.
- **control_of_corruption_std**: Standard error of the estimate of control of corruption.
- **access_to_electricity%**: Percentage of the population that has access to electricity.
- **renewvable_energy_consumption%**: Renewable energy consumption as a % of total final energy consumption.
- **electric_power_consumption**: Electric power consumption, measured in kWh per capita.
- **CO2_emisions**: CO2 emissions measured in kt.
- **other_greenhouse_emisions**: Total greenhouse gas emissions, measured in kt of CO2 equivalent.
- **population_density**: Population density, measured in people per km^2 of land area.
- **inflation_annual%**: Inflation, consumer prices, as annual %.
- **real_interest_rate**: Real interest rate (%).
- **risk_premium_on_lending**: Risk premium on lending (lending rate minus treasury bill rate, %).
- **research_and_development_expenditure%**: Research and development expenditure, as a percentage of GDP.
- **central_goverment_debt%**: Central government debt, total, as a % of GDP.
- **tax_revenue%**: Tax revenue as a % of GDP.
- **expense%**: Expense as a % of GDP.
- **goverment_effectiveness_estimate**: Index that makes an estimate of Government Effectiveness.
- **goverment_effectiveness_std**: Standard error of the estimate of Government Effectiveness.
- **human_capital_index**: Human Capital Index (HCI) (scale 0-1).
- **doing_business**: Ease of doing business score (0 = lowest performance to 100 = best performance).
- **time_to_get_operation_license**: Days required to obtain an operating license.
- **statistical_performance_indicators**: Statistical performance indicators (SPI): Overall score (scale 0-100).
- **individuals_using_internet%**: Percentage of population using the internet.
- **logistic_performance_index**: Logistics performance index: Overall (1=low to 5=high).
- **military_expenditure%**: Military expenditure as a % of GDP.
- **GDP_current_US**: GDP (current US$).
- **political_stability_estimate**: Index that makes an estimate of Political Stability and Absence of Violence/Terrorism.
- **political_stability_std**: Standard error of the estimate of Political Stability and Absence of Violence/Terrorism.
- **rule_of_law_estimate**: Index that makes an estimate of the Rule of Law.
- **rule_of_law_std**: Standard error of the estimate of Rule of Law.
- **regulatory_quality_estimate**: Index that makes an estimate of Regulatory Quality.
- **regulatory_quality_std**: Standard error of the estimate of Regulatory Quality.
- **government_expenditure_on_education%**: Government expenditure on education, total, as a % of GDP.
- **government_health_expenditure%**: Domestic general government health expenditure as a % of GDP.
- **multidimensional_poverty_headcount_ratio%**: Multidimensional poverty headcount ratio (% of total population).
- **gini_index**: Gini index.
- **birth_rate**: Birth rate, crude (per 1,000 people).

- **death_rate**: Death rate, crude (per 1,000 people).
- **life_expectancy_at_birth**: Life expectancy at birth, total (years).
- **population**: Total population.
- **rural_population**: Rural population.
- **voice_and_accountability_estimate**: Index that makes an estimate of Voice and Accountability.
- **voice_and_accountability_std**: Standard error of the estimate of Voice and Accountability.
- **intentional_homicides**: Intentional homicides (per 100,000 people).

Added columns to the dataset for visualisation

- **gdp_per_capita**: The GDP per capita, measured in current US dollars.It is calculated by dividing the total GDP by the population of the country/region.
- **debt_to_gdp%**: Debt to GDP ratio, expressed as a percentage, shows the country's total government debt compared to its GDP.
- **gdp_growth%**: GDP growth percentage measures the rate at which a country's GDP is growing or shrinking compared to the previous year.
- **tax_revenue_gdp%**: Tax revenue as a percentage of GDP shows the portion of a country's economic output that is collected through taxes.
- **rural_population_percentage**: It is calculated by dividing the rural population of the country/region by total population.
- **co$_2$_per_capita**: It is calculated by dividing the total CO_2 emissions of the country/region by total population (in kt).

We have broken down our analysis into the following three tasks :

- T1: Analyzing Trends and Impacts of major economic events across the globe over the years
- T2: Analyzing key social indicators across countries to uncover trends and insights into global social development
- T3: Analyzing trends and relations of environmental and sustainability indicators to evaluate global progress in addressing climate change.

II. Tasks

A. T1: Analyzing Trends and Impacts of major economic events across the globe over the years

In this comprehensive analysis, we aim to delve into a wide range of critical economic indicators across a diverse set of countries, spanning different time periods, economic landscapes, and stages of development. By examining key metrics such as GDP per capita, inflation rates, government debt levels, trade performance, and energy consumption, we can uncover significant patterns that reveal both growth trajectories and underlying vulnerabilities in national economies.

Our approach highlights the economic progression of global leaders like Luxembourg, the USA, and China, alongside countries experiencing notable economic transformations, such as Ukraine and Sri Lanka. Through this exploration, we aim to gain a deeper understanding of how countries with vastly different economic conditions and government policies have managed growth, handled crises, and responded to external pressures like global recessions, financial instability, and geopolitical events.

Luxembourg, with the highest GDP per capita, provides a case study of how smaller economies can leverage high productivity and innovation to maintain sustained growth. The USA and China serve as examples of economic giants that demonstrate different approaches to development—one characterized by long-term stability and high-income status, and the other by rapid industrialization and expansion into global markets.

In contrast, the inclusion of countries like Ukraine and Sri Lanka in the analysis helps illustrate how socio-political instability, conflict, or economic mismanagement can severely hinder a country's ability to achieve sustainable growth. These outliers also provide a deeper context for understanding inflation patterns, government debt dynamics, and economic recovery efforts.

By correlating various economic factors across these countries, we aim to draw inferences about economic resilience, the impact of government policies on growth and stability, and the broader socio-political influences that shape national economies. Ultimately, this analysis provides a holistic view of the interplay between economic indicators and how different economies respond to both challenges and opportunities over time.

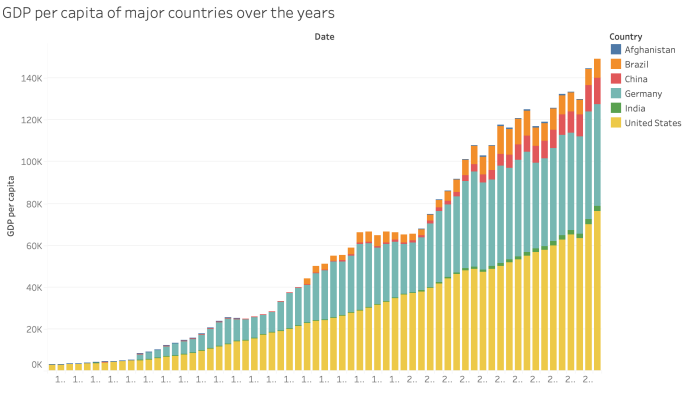

Fig 1. Stacked bar chart for countries such as Afghanistan, Brazil, China, Germany, India and USA representing the trend in GDP per capita over the years from 1960 to 2022

- **United States**: In (Fig 1.) the country shows a consistent and significant increase in GDP per capita, especially from the mid-1980s onwards, reaching its highest point by 2022. This reflects its dominance as one of the world's largest and most developed economies, driven by a stable economy, high productivity, and technological advancements, leading to high living standards.
- **Germany**: In (Fig 1.) the country exhibits a similar trend to the United States with robust economic growth and a high-income status throughout the period from 1960 to 2022, maintaining its position as a leading global economy.
- **China**: In (Fig 1.) the country demonstrates an extraordinary rise in GDP per capita starting in the late 1990s and early 2000s, corresponding to its economic reforms, industrialization, and rapid expansion in global trade. By 2022, China's GDP per capita sees substantial growth, but the gap between China and more developed economies like the US and Germany persists.
- **Brazil**: In (Fig 1.) the country experiences an upward trend in GDP per capita, particularly from the 2000s, benefiting from periods of economic growth in Latin America. However, its progress has been slower compared to China, and it remains behind more developed economies.
- **India**: In (Fig 1.) the country starts seeing significant GDP per capita growth from the early 2000s, driven by rapid industrialization and economic development. India still lags behind major developed countries.
- **Afghanistan**: In (Fig 1.) the country shows little to no significant rise in GDP per capita over the years from 1960 to 2022, primarily due to ongoing political instability, conflict, and lack of substantial economic development or industrialization.

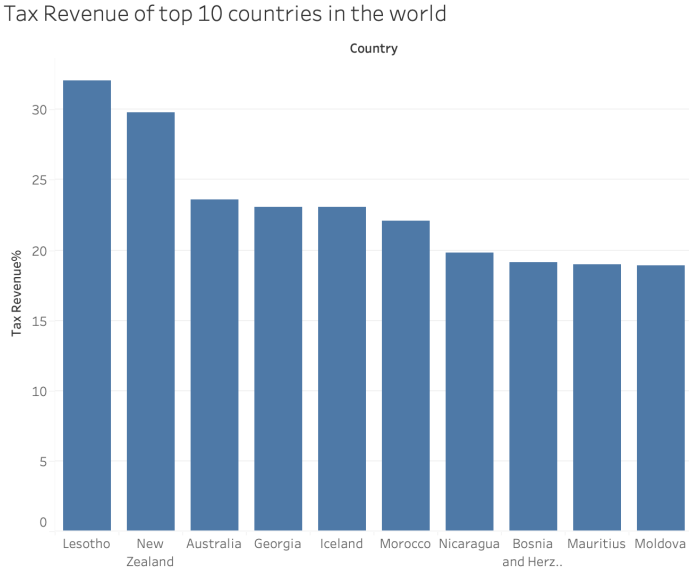

Fig 2. Bar chart representing top 10 countries with the maximum tax revenue from 1960 to 2022

- In (Fig 2.) The bar chart illustrates tax revenues as a percentage of GDP for several countries from 1960 to 2022, emphasizing those with the highest tax collections.
- In (Fig 2.) **Lesotho** stands out with over 30% of its GDP generated through tax revenue, suggesting a strong reliance on taxes due to limited other economic resources.
- In (Fig 2.) **New Zealand** follows closely, just under 30%, reflecting its efficient tax system and reliance on public funding for comprehensive services such as healthcare and education.
- In (Fig 2.) **Australia**, **Georgia**, and **Iceland** demonstrate high tax-to-GDP ratios, ranging between 22% and 25%, indicating robust tax collection frameworks that support government functions and infrastructure.
- In (Fig 2.) **Morocco**'s slightly lower tax revenue, around 21%, suggests a balanced economy with both tax and other income sources contributing to GDP.
- In (Fig 2.) **Nicaragua**, **Bosnia and Herzegovina**, **Mauritius**, and **Moldova**, with tax revenues between 18% and 20%, represent economies where tax collection may be more challenging due to factors such as weaker administrative systems or a larger informal sector.
- The presence of higher tax-to-GDP ratios in developed countries highlights their ability to maintain robust tax systems, which is critical for sustaining public services and infrastructure development.
- Lower tax revenue in some countries can also reflect a higher reliance on foreign aid or non-tax revenue sources, which may not be sustainable for long-term economic growth.
- The data reveals significant variations in tax collection across these countries, underscoring the importance of efficient tax systems in funding public services. It also highlights the struggles of developing nations in collecting substantial tax revenues.

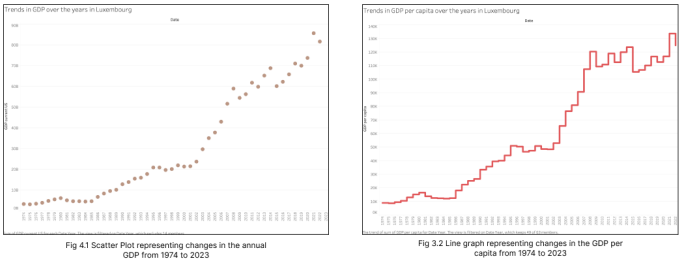

Fig 3. Graphs representing annual GDP and GDP per capita of Luxembourg

- In (Fig 3.) the analysis of Luxembourg highlights several key trends that provide insights into the country's economic and technological evolution.
- In (Fig 3.) Luxembourg, known for having the highest GDP per capita in the world, shows significant progress across various dimensions from 1974 to

2022.

- In (Fig 3.) the GDP, both in current US dollars and per capita, displays a steady increase over the years, reflecting the nation's economic growth, resilience, and its prominent position as a global financial hub.
- In (Fig 3.) the graphs reveal that during major global economic crises, such as the stock market crash and the dot-com bubble burst, Luxembourg experienced a slight dip in its economic performance. Luxembourg's economy also dipped during the 2015-16 period mainly due to changes in EU tax regulations aimed at curbing tax avoidance. These stricter rules led many multinational corporations, which Luxembourg's economy heavily relies on, to restructure their tax arrangements or relocate. The end of favorable tax rulings further contributed to the decline, as it affected corporate tax strategies and reduced economic activity in the country.
- Despite these global crises, Luxembourg's economy quickly rebounded, demonstrating its ability to recover and maintain its growth trajectory.

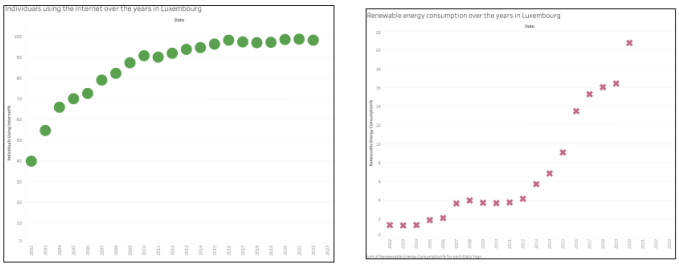

Fig 3.1 Scatter Plot representing Individuals using internet from 2002 to 2023

Fig 3.2 Scatter Plot representing Renewable energy consumption from 2002 to 2023

Fig 3.3 Scatter Plot representing Individuals using internet from 2002 to 2023

Fig 4. Graphs representing different data for Luxembourg

- In (Fig 4.1) The adoption of the internet is a clear indicator of Luxembourg's modernization, with a marked increase in individuals using the internet from 2002 to 2022.
- This growth parallels the global technological boom and shows Luxembourg's commitment to becoming a tech-forward nation.
- In (Fig 4.2) The rising consumption of renewable energy over the same period reflects Luxembourg's emphasis on sustainability, aligning with global efforts to transition to cleaner energy sources.
- In (Fig 4.3) Additionally, trade in services has shown continuous growth, crucial for Luxembourg's status as an international financial and services hub.
- This suggests that Luxembourg has effectively capitalized on globalization and international trade, further boosting its economic prosperity.
- In sum, Luxembourg's economic, technological, and environmental strategies have positioned it as a high-income, progressive nation with sustained growth in key areas over the past few decades.
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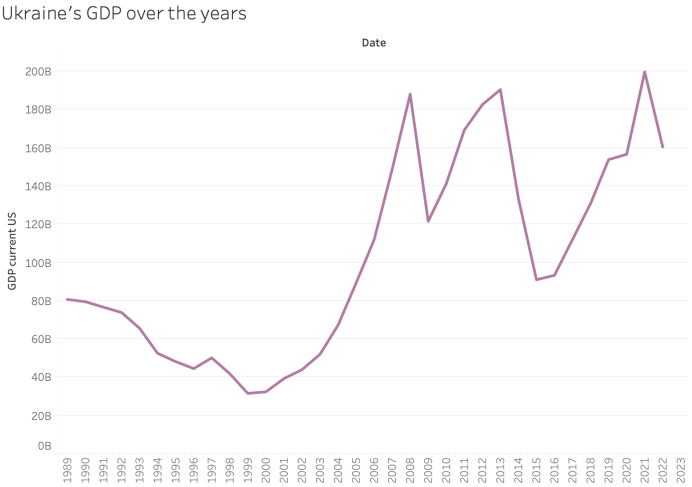

Fig 5. Line graph representing annual GDP for Ukraine from 1989 to 2023

- In (Fig 5.) Ukraine's GDP drop in 2016 and 2017 was largely a consequence of the ongoing geopolitical crisis and its economic fallout.
- The annexation of Crimea by Russia in 2014 and the conflict in the Donbas region severely disrupted key industries and infrastructure, particularly in eastern Ukraine, leading to a sharp decline in industrial output.
- The conflict triggered a severe recession in 2014-2015, which carried over into 2016-2017, slowing recovery efforts.
- The loss of trade with Russia, Ukraine's largest trading partner, further exacerbated the economic downturn.
- The sharp depreciation of the Ukrainian hryvnia led to high inflation and reduced purchasing power.
- Ukraine's structural economic challenges, such as corruption and reliance on heavy industries, worsened the situation.
- Bailout packages from the IMF helped stabilize the economy, but accompanying austerity measures added to short-term economic pain, delaying recov-

ery.

- These factors combined to significantly impact Ukraine's GDP during this period.
- In (Fig 3.) In contrast, Luxembourg's GDP growth displays consistent growth over the past two decades, emphasizing the nation's economic stability and effective governance.
- In (Fig 5.) International sanctions imposed on Russia following the annexation of Crimea had a spillover effect on Ukraine's economy, disrupting regional trade flows.

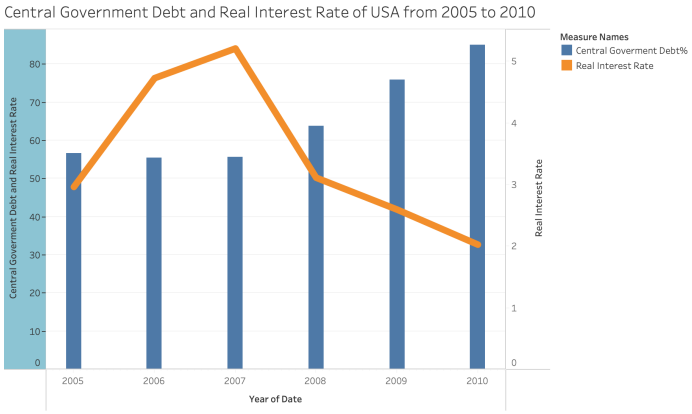

Fig 6. Mixed Line and Bar chart representing the real interest rate and central government debt of USA from 2005 to 2010

- In (Fig 6.) The graph depicts the USA's central government debt percentage alongside the real interest rate from 2005 to 2010, showing key trends during this period.
- Government debt remains relatively steady until 2007, after which there is a sharp rise in 2008, likely due to the global financial crisis.
- The spike in debt reflects increased government spending aimed at stabilizing the economy, including stimulus measures and bailouts.
- Meanwhile, the real interest rate peaks in 2007 before starting a steady decline, a typical response during financial crises.
- Central banks, such as the Federal Reserve, lower interest rates to encourage borrowing, stimulate the economy, and counteract the recession.
- By 2010, government debt remains high while the real interest rate continues to decrease, signaling continued economic strain.
- This divergence between rising debt and falling interest rates underscores the government's reliance on borrowing to fund stimulus measures and infrastructure investments.
- The declining real interest rate reflects the Federal Reserve's efforts to make borrowing cheaper, spurring consumer spending and business investment.
- Despite these measures, the persistently high levels of debt indicate long-term fiscal challenges, which could have implications for future monetary policy and economic growth.
- The sustained rise in government debt post-2008 suggests that recovery efforts, although necessary, may have come at the cost of increased fiscal burden for future generations.
- The continued decrease in real interest rates raises concerns about the potential long-term effects on savings rates and inflation management in the post-crisis recovery phase.
- As the government focused on stimulus, the trade-off between short-term economic recovery and long-term fiscal sustainability became increasingly apparent.

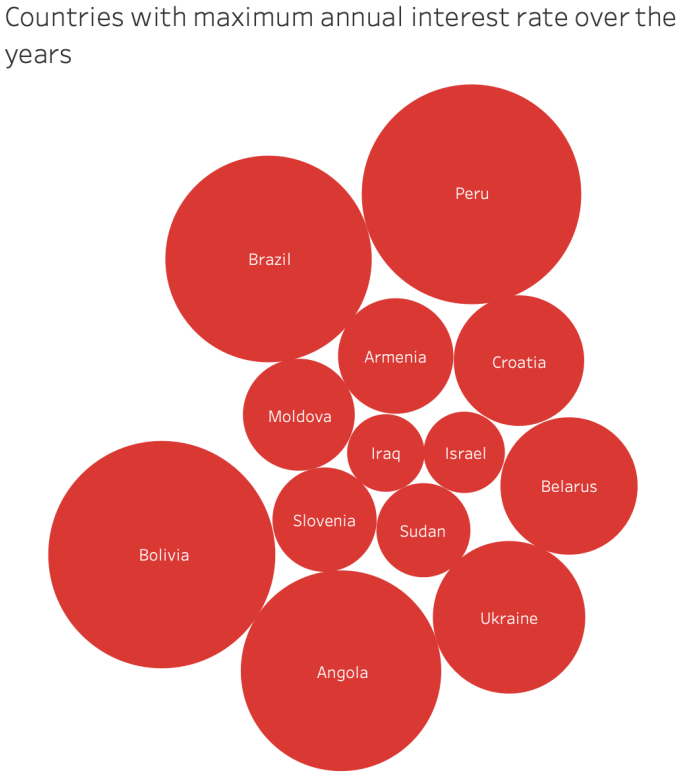

Fig 7.Circle chart to show the countries with maximum annual inflation percentage over the years

- In (Fig 7.) The Bubble chart highlights countries with the highest annual inflation percentages over the years.
- Peru, Bolivia, and Brazil have the largest circles, indicating severe inflationary pressures during this period.
- This likely resulted from economic mismanagement or crises, leading to significant currency devaluation and rising prices.
- Countries like Angola, Ukraine, and Belarus also experienced notable inflation, potentially due to external shocks or economic transitions.

– The inflation levels in these countries disrupted economic stability, affecting overall economic performance and reducing living standards.
– High inflation typically erodes purchasing power, making it harder for populations in these nations to maintain consistent standards of living.
– Inflationary spikes also likely led to economic instability, forcing governments to implement corrective measures, such as monetary tightening or fiscal adjustments.
– Sustained high inflation often triggers a loss of investor confidence, potentially leading to reduced foreign direct investment and slower economic growth.
– Countries with high inflation may face challenges in maintaining stable exchange rates, further contributing to economic volatility.

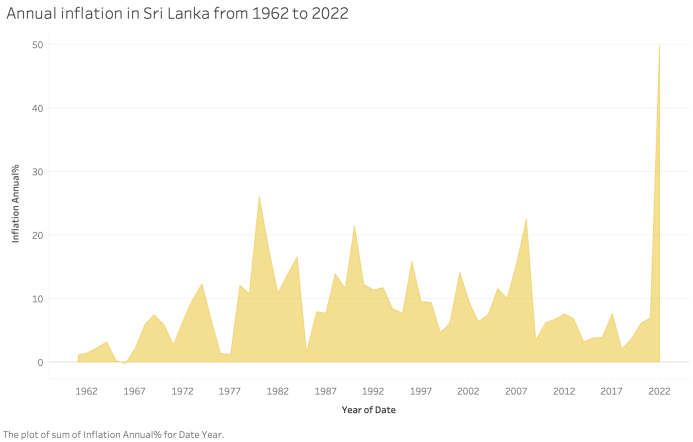

Fig 8. Area graph showing the annual inflation rate in Sri Lanka from 1962 to 2022

– **Inflation Spikes**: In (Fig 8.) These fluctuations have mainly been caused due to the civil war among other factors which ended in 2008. The country heavilty relies on imports, tourism and foreign exchanges as well which have not been very lucrative over the years.
– **Periodicity**: Inflation shows a cyclical behavior with sharp increases and decreases approximately every 10-15 years.
– **Recent Inflation Surge**: The inflation rate in 2022 exceeds 50%, the highest point in the country's modern economic history.
– **Stable Periods**: Between 2000-2007 and 2010-2019, inflation remained relatively stable, ranging from 5% to 10%.
– **Global Events Impact**: Certain peaks, such as the one observed in 2008, align with global economic events like the financial crisis, suggesting external factors may influence domestic inflation.
– **Government Policies and Monetary Decisions**: Changes in government policies and monetary decisions, such as interest rate adjustments or fiscal stimulus measures, have impacted inflation. For example : Aggressive monetary easing during downturns can lead to higher inflation in later years.

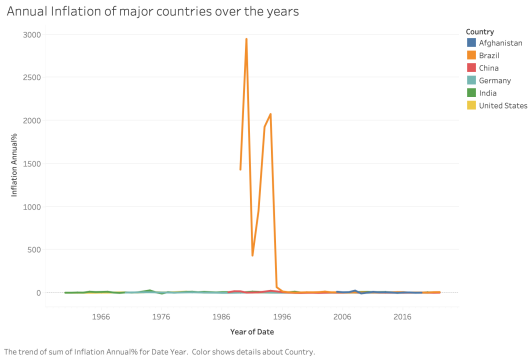

Fig 9. Continuous line graphs for countries such as Afghanistan, Brazil, China, Germany, India and USA

– In (Fig 9.) Brazil exhibits more volatile inflation, influenced by political instability and external market shocks.
– Afghanistan does not show any significant spikes in inflation up to 2020 due to the lack of available data for the year 2021.
– After the Taliban takeover in 2021, Afghanistan's inflation rate spiked, but this is not reflected in the graph because of null values.
– To address the missing data, the average inflation rate was imputed to handle the discrepancies effectively.
– China, despite rapid economic growth, maintains controlled inflation, highlighting a focus on economic stability.
– The USA and Germany show moderate but stable inflation trends, reflecting their mature economies and well-developed fiscal controls.
– This comparison underscores the economic stability of developed nations like the USA and Germany, whereas countries like Afghanistan and Brazil remain vulnerable to inflation spikes due to external and internal pressures.

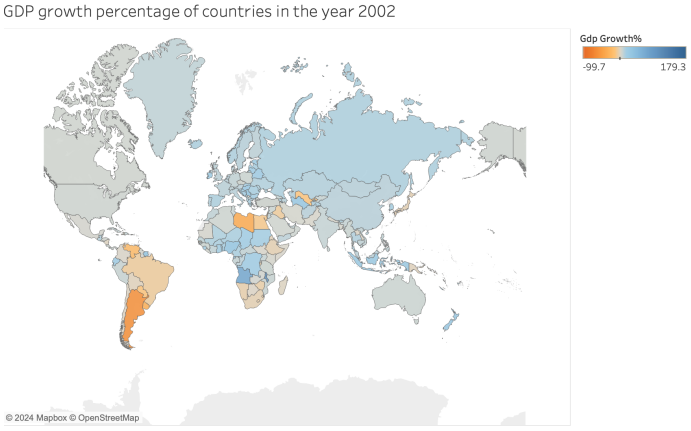

Fig 10. Heatmap for the GDP growth percentage of all the countries in the year 2002

– **Global Economic Impact:** In (Fig 10.) We chose

this particular year so that the heatmap could depict the widespread economic impact of the 2000-2002 recession, following the burst of the dot-com bubble. Many countries in light blue exhibit low or negative GDP growth, reflecting the global slowdown.

- **Severe Decline in Argentina:** In (Fig 10.) Argentina shows a significantly negative GDP growth rate (dark orange), indicating the country's major economic crisis during this period, including its debt default in 2001-2002.
- **Mixed Performance in Africa:** In (Fig 10.) Africa displays varying GDP growth percentages, with some countries experiencing growth (e.g., blue regions in East Africa) while others, such as in Central Africa, have negative growth (orange regions). This suggests the region's diverse economic conditions in response to global events.
- **Stable Growth in China and India:** In (Fig 10.) China and India (light blue) show positive but moderate GDP growth, reflecting their growing economies at the time, somewhat insulated from the dot-com bubble's direct effects.
- **Recovery in North America:** In (Fig 10.) The United States and Canada appear with slight positive growth after recovering from the initial shock of the dot-com bubble burst. The U.S. experienced a mild recession, but recovery was underway by 2002.
- **Resilient Growth in Eastern Europe:** In (Fig 10.) Countries in Eastern Europe show moderate GDP growth rates, potentially reflecting their transition economies benefitting from market reforms and foreign investment during this time.

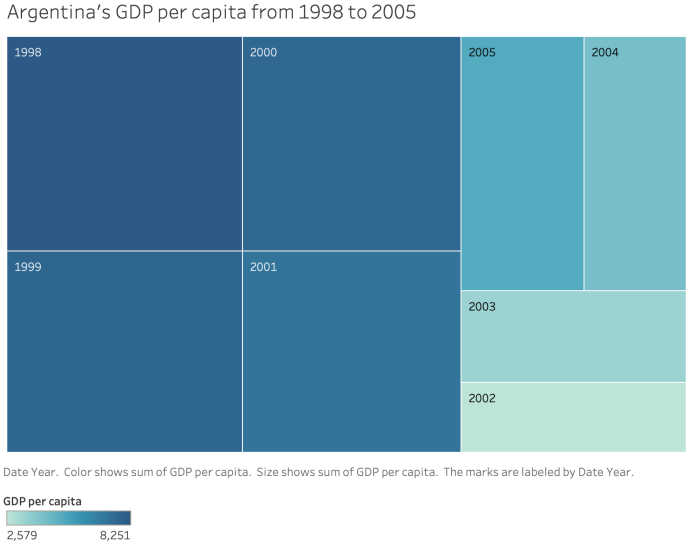

Fig 11. Treemap for the GDP per capita of Argentina from 1998 to 2005

- **Economic Stability Pre-2001:** In (Fig 11.) From 1998 to 2000, Argentina's GDP per capita remained relatively stable, as indicated by the darker blue shades, representing higher GDP per capita values. This suggests relative economic stability during these years.
- **Sharp Decline in 2002:** In (Fig 11.) The year 2002 shows a notable dip in GDP per capita, as indicated by the lighter color in the treemap. This corresponds to Argentina's severe economic crisis and debt default in 2001-2002, which led to a sharp drop in the country's economic output.
- **Gradual Recovery Post-2002:** In (Fig 11.) From 2003 onwards, the GDP per capita shows a slow recovery, with the color transitioning back to a darker shade by 2005. This suggests that Argentina's economy started to rebound after the crisis, although the recovery was gradual.
- **Impact of Argentina's Crisis:** In (Fig 11.) The treemap visually depicts the significant impact of Argentina's financial crisis during this period, with 2002 standing out as a year of severe economic decline.
- **Sustained Growth Post-2005:** In (Fig 11.) From 2006 onwards, Argentina's GDP per capita consistently increased, indicated by the darker and more consistent shades, suggesting a period of sustained economic growth following the recovery phase.

B. T2: Analyzing key social indicators across countries to uncover trends and insights into global social development

In this task , we will analyze a range of social indicators across different countries, focusing on factors that directly or indirectly affect the quality of life for their citizens. By examining social indicators , we aim to identify trends and patterns that highlight the social development and well-being of populations. This analysis will help us understand how these indicators vary across nations and the extent of their impact on people's lives.

Hypothesis 1: Access to Internet and Electricity

Our hypothesis examines the relationship between access to electricity and internet usage, leveraging two key attributes from the dataset: Access to Electricity and Individuals Using the Internet . We analyzed these trends to better understand how internet and electricity accessibility has evolved across countries

We have used the 2 main labels given in the dataset , Access to electricity precentage and INdividuals using internet

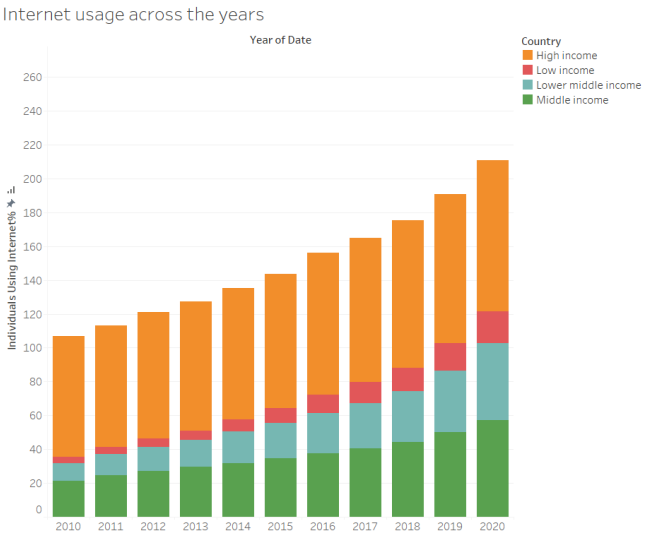

Fig 12. Stack Bar showing Access to electricity across years for different countries

Figure 12 presents a stacked bar chart depicting internet usage percentages for country categories based on income levels: high income, middle income, lower middle income, and low income. The data spans from 2010 to 2020, a period chosen because internet access prior to 2010 was either limited or non-existent in many countries.

The chart shows that by 2010, high-income countries already had widespread internet access, which grew steadily throughout the decade. In contrast, low-income countries had minimal access in 2010 and made gradual progress, though a significant gap remained by 2020. This disparity is due to differences in infrastructure, economic resources, and technological investment.

High-income countries have well-established digital networks, while low-income countries face challenges like limited infrastructure and resources, contributing to the persistent digital divide. Additionally, the availability of affordable internet and technology plays a crucial role in determining access, particularly in low-income regions. Countries in the middle-income group made noticeable strides, bridging the gap slightly but still lagging behind higher-income nations.

The role of government policies, such as investments in digital infrastructure and the promotion of internet access, also shaped the expansion of usage across income groups. By 2020, even lower middle-income countries experienced a significant increase in internet access, signaling progress but still highlighting the persistent inequities. These ongoing disparities have implications not only for digital connectivity but also for education, healthcare, and economic opportunities in the 21st century..

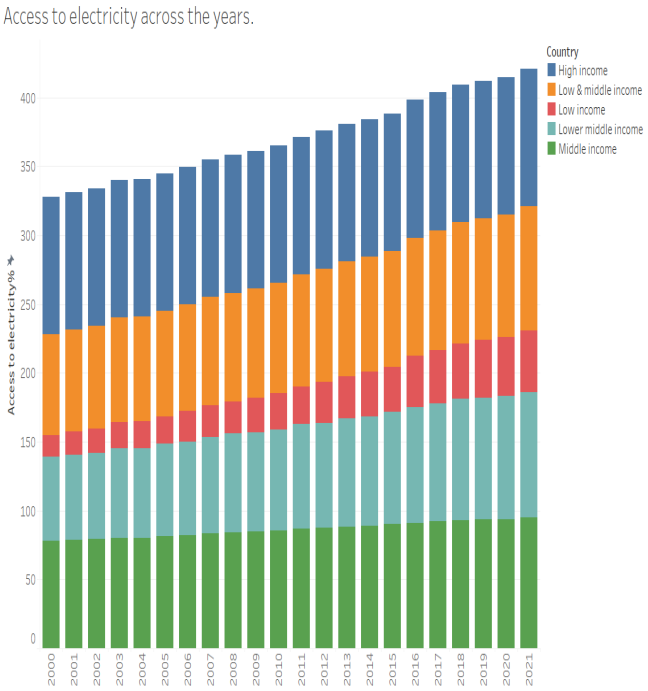

Fig 13. Stack Bar showing Access to electricity across years for different countries

Figure 13 shows the trends in Access to Electricity across high, middle, lower middle, and low-income countries from 2000 to 2020 using a stacked bar chart. High-income countries had near-universal access to electricity by 2000, and this remained consistent over the two decades.

On the other hand, low-income countries, which started with significantly lower access in 2000, showed gradual improvement over time. However, by 2020, the gap between low-income and high-income countries remained significant. This disparity can be attributed to differences in infrastructure investment, economic resources, and policy focus.

High-income countries benefit from longstanding investments in their national electrical grids, while low-income nations face challenges like remote populations and limited resources, slowing their progress in achieving universal electricity access. Additionally, political instability and inadequate government support have also hampered efforts in certain low-income regions. In middle-income countries, access to electricity improved significantly, with several nations on the path

to achieving near-universal access.

Despite the progress, achieving full electrification for low-income countries will require sustained international support, increased funding, and technology transfer to overcome persistent barriers.
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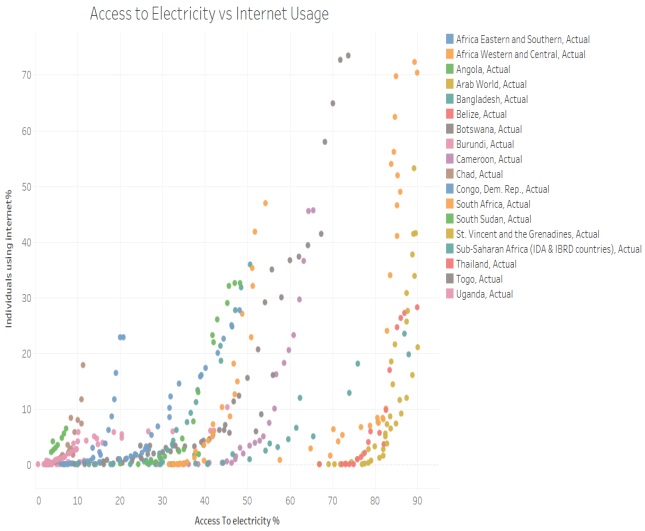

Fig 14. Scatter plot showing relation between Access to electricity and internet usage across the year

Figure 14 shows the correlation between Access to Electricity and Individuals Using the Internet for 20 countries from 1990 to 2020. The scatter plot reveals a clear trend: as electricity access increases, internet usage rises. Countries with widespread electricity in the 1990s saw rapid internet growth, while those with lower access experienced slower progress, improving as they expanded their electrical infrastructure.

The correlation exists because electricity is essential for internet usage. Countries with higher electricity access saw faster growth in internet use, while those with limited access experienced slower progress. Improvements in internet usage closely follow expansions in electricity access. Additionally, countries that invested in both electricity and telecommunications infrastructure simultaneously showed the most rapid advancements in internet connectivity. This highlights the importance of a coordinated approach to development in bridging the digital divide.

Hypothesis 2: Life Expectancy and Birth Rate

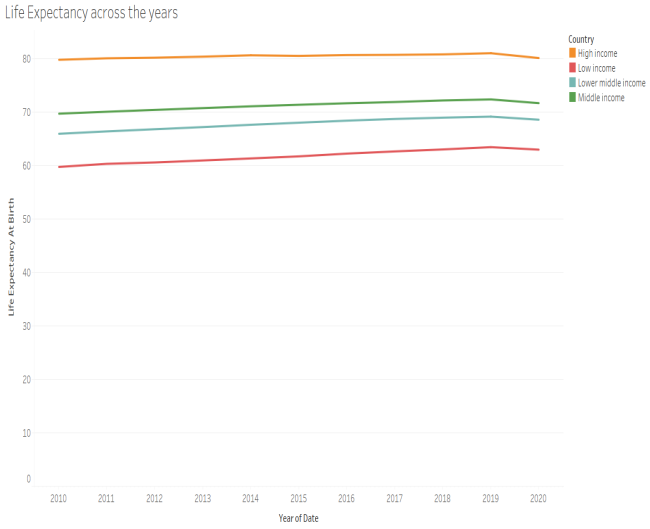

Fig 15. Line graph showing Life expectancy for countries accross the years

Fig 16. Density plot between Govt Health expenditure and Life expectancy

Figure 15 shows life expectancy trends across income categories: high, upper middle, lower middle, and low income. Higher-income countries consistently have the longest life expectancy due to better healthcare infrastructure and resources.

Figure 16 reinforces this, highlighting a positive correlation between government health expenditure (as a percentage of GDP) and life expectancy. Countries investing more in healthcare tend to see longer lifespans, as increased spending improves medical access and quality of care.

However, while more spending generally leads to longer life expectancy, other factors like healthcare

efficiency, lifestyle, and socioeconomic conditions also play significant roles in determining outcomes.

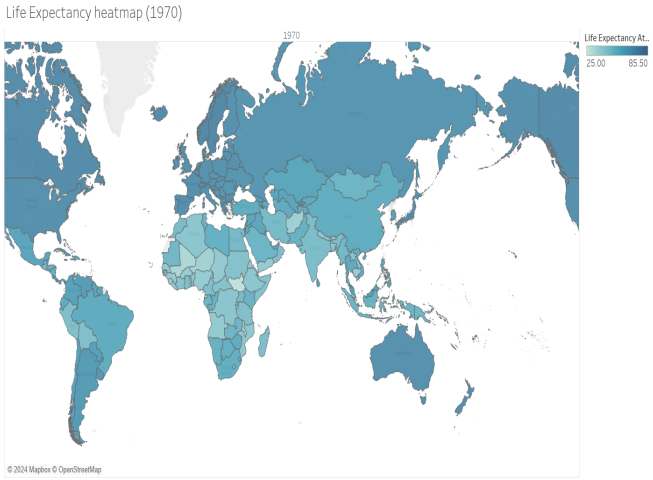

Fig 17.Life Expectancy in 1970

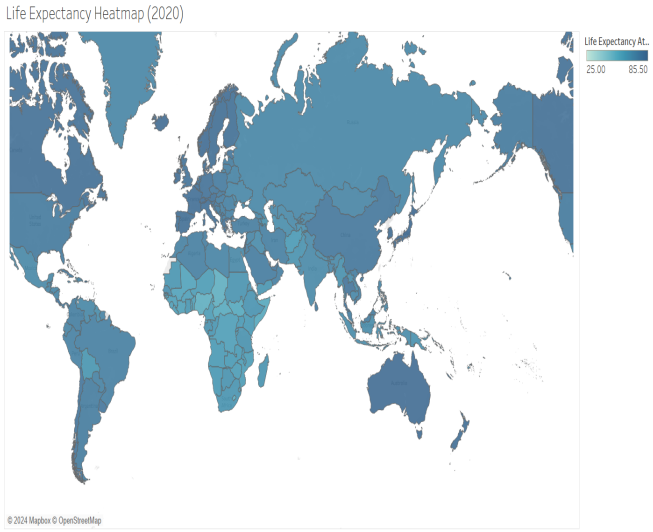

Fig 18. Life Expectancy in 2020

Figure 17 and Figure 18 compares global life expectancy in 1970 and 2020 through heatmaps, showcasing significant improvements over five decades.

Key Trends:

- In 1970, regions like Africa, South Asia, and Latin America had life expectancies below 50-60 years, while North America, Europe, and East Asia were higher. By 2020, most countries, including those in Africa, saw life expectancy rise above 70 years.

- In 1970, developed regions had life expectancies over 70 years, while many other regions lagged far behind. By 2020, global disparities in life expectancy narrowed as healthcare improved worldwide.
.

This progress is largely attributable to advances in healthcare, sanitation, and nutrition, alongside economic growth that enabled greater investments in public health systems. The widespread adoption of vaccines and treatments for diseases played a crucial role in increasing life expectancy in developing countries. Global initiatives such as the eradication of smallpox and efforts to reduce infant mortality have also contributed significantly to the overall rise in life expectancy.
However, despite these advances, some regions continue to face challenges. Issues like political instability, economic inequality, and poor healthcare infrastructure in certain countries have hindered progress, particularly in parts of sub-Saharan Africa and conflict-prone areas. As a result, while the global gap in life expectancy has narrowed, disparities still persist, and ongoing efforts are required to ensure further improvements in health and longevity across all regions.

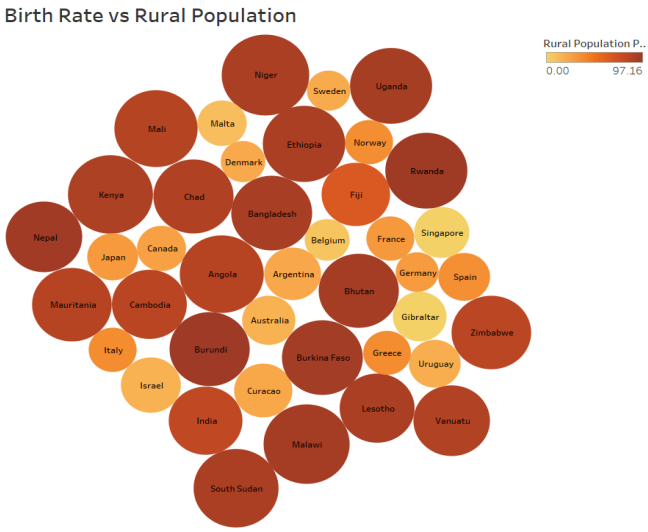

Fig 19. . Bubble chart with color channel highlighting Rural Population Percentage and size channel highlighting Birth rate of different countries

In Fig 19, we have used a bubble chart to visualize birth rates for the top 20 and bottom 20 countries as per the dataset, with bubble size indicating birth rates and color representing rural population percentages.The chart clearly shows that larger bubbles (higher birth rates) are often darker (higher rural populations), highlighting how urban and rural conditions impact demographic trends.

Urbanization, which involves higher living costs and a focus on careers and education, generally leads to lower birth rates. Conversely, rural areas, with less access to family planning and healthcare, tend to have higher birth rates.

Fig 20. Line chart showing Rural population percentage vs Birth rate across the years for Bangladesh and Burundi

To support this observation, we have used dual axis line plot illustrating the trend with two specific examples: Bangladesh and Burundi , which can be seen in figure 20. In 1960, Bangladesh had a rural population percentage of 94.44 and a birth rate of 49.5 per 1,000 people. Burundi's figures were nearly comparable, with a rural population of 97 and a birth rate of 46.52.

However, over the years, the trends diverged significantly. By 2020, Bangladesh had substantially reduced its rural population to 61 and saw a corresponding sharp decrease in its birth rate, which fell to 18 per 1,000 people. In contrast, Burundi did not achieve a similar reduction in its rural population, which remained high at 85 in 2020. As a result, Burundi's birth rate remained relatively high at 35 per 1,000 people.This clear divergence in the trends between the two countries highlights the strong relationship between rural population reduction and declining birth rates.

Bangladesh's successful reduction in rural population correlates with a dramatic drop in birth rates, while Burundi's persistent high rural population is associated with a higher birth rate.

This demonstrates that countries with lower rural populations tend to experience lower birth rates, reinforcing the observed trend.. While urbanization is a major factor contributing to this trend, it is important to recognize that other factors may also influence birth rates.

Hypothesis 3: Human Capital Index.

In Fig 21, the scatter plot shows a clear positive correlation between GDP per capita and the Human Capital Index (HCI) for the years 2010, 2017, 2018, and 2020

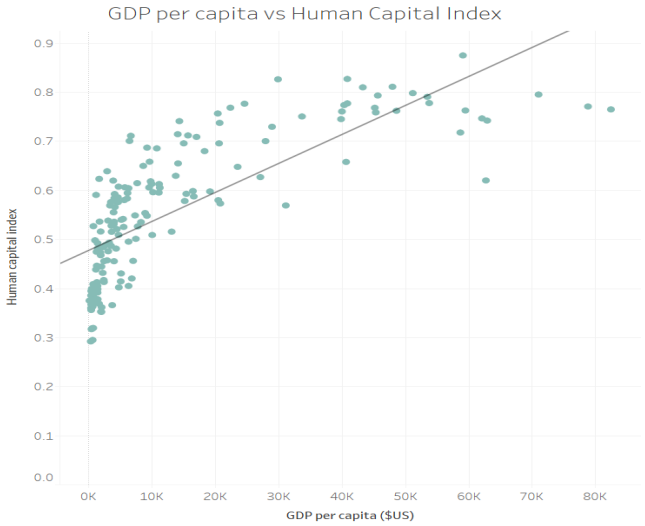

Fig 21. Scatter plot between Human Capital index and GDP per Capita

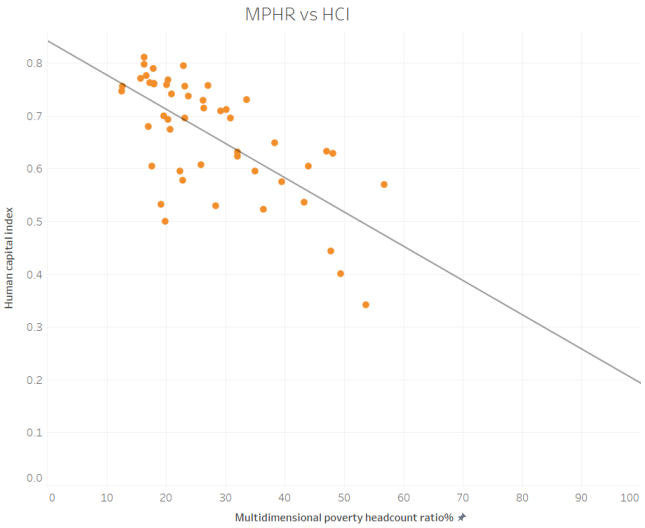

Fig 22. Scatter plot between Human Capital index and Multidimensional poverty headcount ratio

(the years for which we had HCI data). Wealthier countries generally have higher HCI scores due to better education, health, and resources. European countries, with high GDP per capita, benefit from advanced systems, while many African countries, with lower GDP per capita, struggle with lower HCI scores due to limited resources.

In Fig 22, the scatter plot of HCI versus the Multidimensional Poverty Headcount Ratio (MPHR)

shows that HCI decreases as MPHR increases. This indicates that higher levels of poverty are associated with lower human capital outcomes.

Hypothesis 4: Intentional Homicides

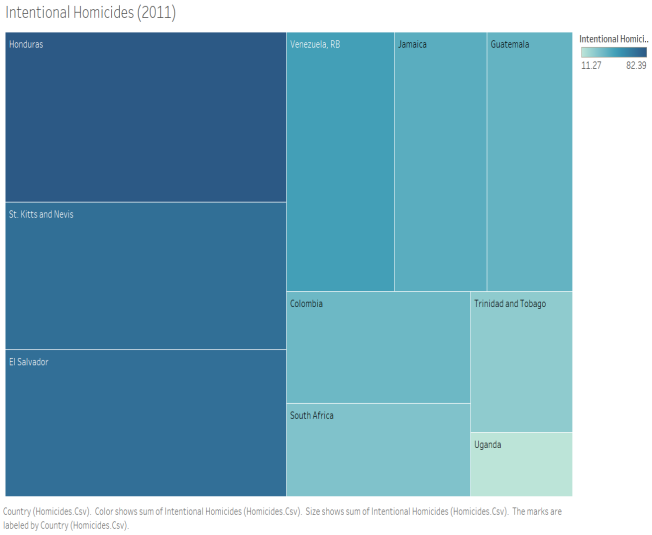

Fig 23. Treemap representing intentional homicides in 2011

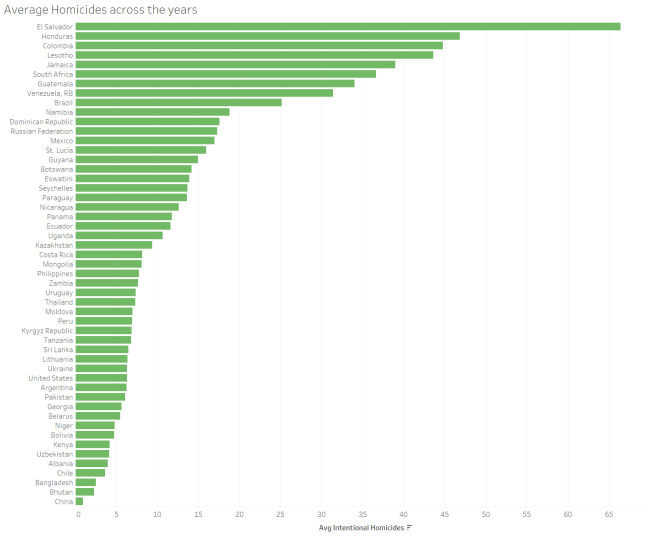

Fig 24. Bar graph representing average intentional homicides for each country

In our analysis on fig 23, we used data from 2011 . The data reveals that homicide rates are particularly high in Latin America and the Caribbean, as well as Sub-Saharan Africa. These regions experience elevated death tolls not only from homicides but also from armed conflicts.

According to the Geneva Declaration on Armed Violence and Development , a quarter of all violent deaths occur in just 15 countries which are shown in treemap (Data of the remaining countries are not available in dataset), averaging over 30 violent deaths per 100,000 people annually. Half of these are in Latin America and the Caribbean. In many of these countries, homicides, rather than armed conflicts, account for the majority of violent deaths.

The relationship between violent death rates and socioeconomic development shows that higher homicide rates are often linked to high levels of income disparity, extreme poverty, and hunger. Conversely, countries that have improved their rule of law have seen a decline in homicide rates, suggesting that stronger legal frameworks and socioeconomic development contribute to reducing violent deaths.

In fig24, we have used bar chart to analyze average intentional homicides for each country across all the years(as per the available data). Again , the same trend was followed.Homicide rates are particularly high in Latin America and the Caribbean, as well as Sub-Saharan Africa.

C. T3: Assessing environmental and sustainability indicators to evaluate global progress in addressing climate change, resource management, and ecological preservation.

In this task, we will analyze a variety of environmental and sustainability indicators across different countries, focusing on the factors that influence ecological balance, resource management, and environmental preservation. By examining key metrics such as carbon emissions, greenhouse emissions, forest and agricultural land area percentage, energy consumption and renewable resource usage, we aim to uncover trends that shed light on global progress towards sustainability. This analysis will provide insights into how countries are managing their environmental responsibilities and the impact of these actions on long-term ecological and human well-being.

Hypothesis 1: Rural Population and Agricultural Land Area

Our hypothesis examines the relationship between rural population percentage and agricultural land area percentage, leveraging two key attributes from the dataset: Rural Population (% of total population) and Agricultural Land

(% of land area). By analyzing these trends, we aim to explore how the proportion of rural populations and agricultural land usage varies across countries, particularly when divided according to income categories. This analysis will help us better understand the dependency of rural populations on agriculture and how these factors are linked across different economic contexts.

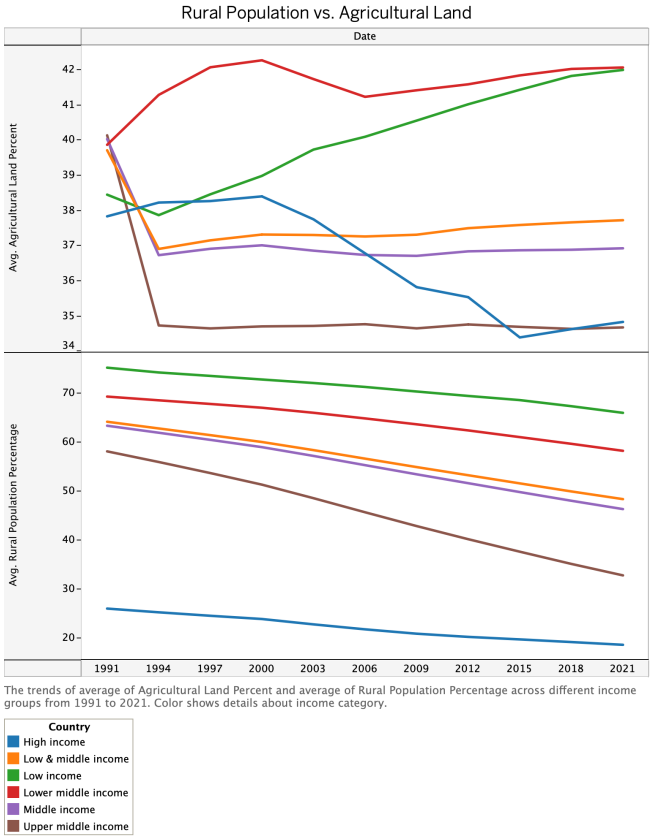

Fig 25. Line Charts showing the relationship between Rural Population Percentage and Agricultural Land Percentage across income groups (1991–2021)

Figure 25 presents 2 line charts depicting trends in percentages of population living in rural areas and percentages of agricultural land out of total land for country categories based on income levels: high income, middle income, lower middle income, and low income. The data spans from 1991 to 2021, a period chosen because agricultural land percentage prior to 1991 was either limited or non-existent in many countries.

Rural Population Trends: The rural population has decreased across all income groups due to urbanization and economic shifts.
Agricultural Land Area:

- Low-income and lower-middle-income countries: These countries have seen an increase in agricultural land area as they rely heavily on agriculture for sustenance and economic growth.
- Middle-income countries: Consistent agricultural land usage is observed due to balanced rural-to-urban migration and stable agricultural needs.
- High-income countries: Agricultural land has decreased, reflecting technological advancements, a shift towards imports, and efforts toward environmental preservation.

The sudden drop in agricultural land area around initial 1990s can be attributed to several factors. One key reason is land reclassification, where land previously categorized as agricultural was redefined for urban development or conservation purposes. Additionally, increased environmental regulations during this period, driven by international agreements and policies aimed at reducing deforestation and preserving biodiversity, led to a decrease in agricultural land. Lastly, a global shift toward industrialization and urbanization contributed to less reliance on domestic agricultural land, particularly in high-income countries, as economies moved toward service and industrial sectors and agricultural imports increased.

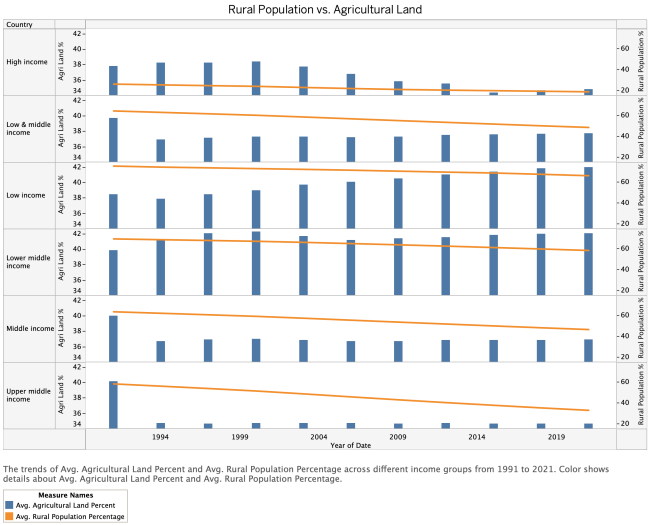

Fig 26. Dual combination showing the relationship between Rural Population Percentage and Agricultural Land Percentage across income groups over the years (1991–2021)

Figure 26 presents a similar analysis of the relationship between rural population percentage and agricultural land area across different income groups, extending the insights observed in Figure 25. The trends depicted in Figure 26 reinforce the conclusions drawn earlier: while rural populations depicted by the orange line across the years continue to decline across all income groups, the changes in agricultural land area depicted by the bars follow comparable patterns. Low-income and lower-middle-income countries continue to see an increase in agricultural land, reflecting their reliance on agriculture. In contrast, middle-income countries show stable land

use, while high-income countries experience a further decrease in agricultural land. These trends reinforce the global patterns in rural land use and agricultural dependence. Also, the general global drop in agricultural land area percentage in early 1990s can also be seen here.

Hypothesis 2: Analyzing Per Capita CO_2 Emissions and Power Consumption Trends Across Different Income Groups

In this hypothesis, we explore the differences in resource utilization and the environmental impact of individuals across various income groups. By examining these differences, we aim to understand how varying levels of income influence the per capita consumption of resources and the associated CO_2 emissions. The analysis also investigates whether increased electric power consumption correlates with higher CO_2 emissions and how this relationship varies based on the economic status of countries.

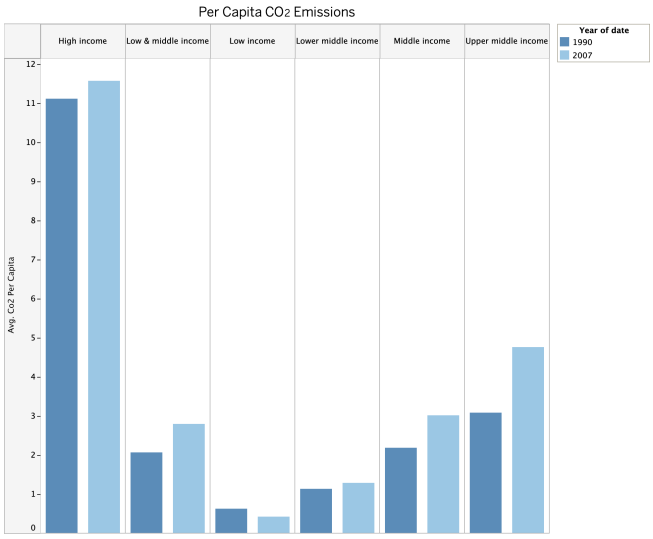

Fig 27. Double bar chart representing the per capita CO_2 emissions for individuals across different income groups (1990 and 2007)

Figure 27 and 28 present two double bar charts illustrating per capita CO_2 emissions and electrical power consumption across different income groups for the years 1990 and 2007. The first chart shows CO_2 emissions per capita for individuals categorized by income levels: high income, middle income, lower middle income, and low income. The second chart depicts per capita electrical power consumption for the same income categories and years. The year 1990 was selected as emission data was not able for years preceding 1990 and 2007 was chosen to provide a comparative view of trends over a significant period, highlighting changes and patterns in resource utilization and environmental impact across different income levels.

It can be seen that per capita CO_2 emissions and electric power consumption have generally increased across all income groups from 1990 to 2007. This trend indicates a strong relationship between higher per capita power consumption and increased CO_2 emissions across all groups apart from the exception of low-income countries experiencing a decrease in per capita CO_2 emissions despite some increase in power consumption.

One possible reason for this exception could be rapid population growth in these countries, which may have mitigated the per capita impact of increased power consumption. Additionally, the limited industrial development in low-income countries may result in lower CO_2 emissions despite rising power consumption, as fewer industrial activities typically contribute less to overall emissions.

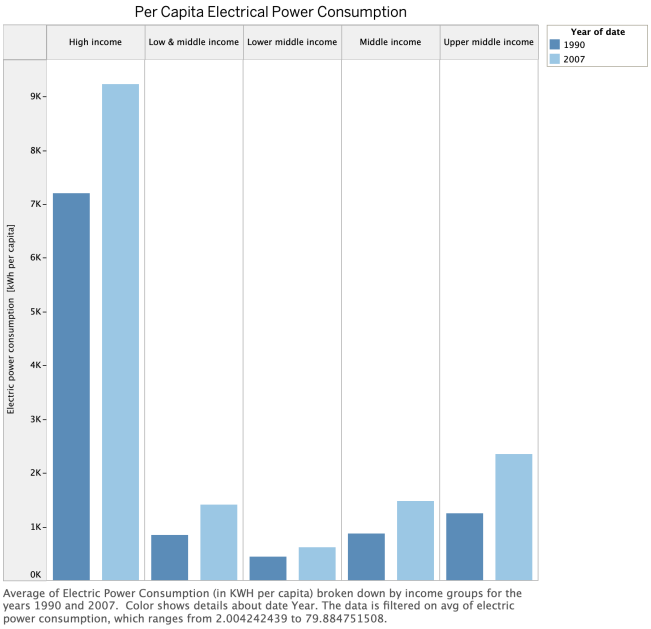

Fig 28. Double bar chart representing the per capita electrical power consumption for individuals across different income groups (1990 and 2007)

A comparative study shows that individuals in high-income countries consume significantly more electricity per capita compared to those in low-income countries. However, this increased consumption is associated with higher CO_2 emissions. In contrast, while individuals in low-income countries consume less electricity, their CO_2 emissions per capita have decreased, reflecting differing levels of environmental impact and resource utilization between high-income and low-income individuals.In high-income countries, urbanization often leads to increased energy use per capita, with more energy-

consuming infrastructure and higher living standards. In contrast, low-income countries may still be in stages of development where energy consumption is lower and spread across less energy-intensive activities.
A person in a high-income economy uses more than 12 times as much energy on average as a person in a low-income economy

Hypothesis 3: Geospatial Analysis of CO_2 and Greenhouse Gas Emissions and Electrical Power Consumption Across Countries

In this hypothesis, we conduct a geospatial analysis to explore global patterns in CO_2 emissions, greenhouse gas emissions, and electrical power consumption. By visualizing these variables on symbol maps, we aim to examine potential correlations between different types of environmental emissions, such as CO_2 and greenhouse gases, and to investigate any direct relationships with electrical power consumption. This analysis will reveal how these environmental and energy factors vary across regions and highlight any notable geographic trends.

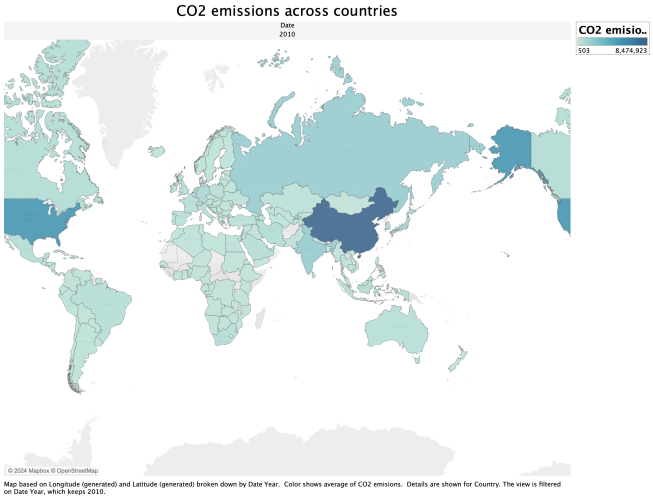

Fig 29. Map representing CO_2 emissions across countries (2010)

Figure 29 and 30 present two maps illustrating CO2 emissions and other greenhouse gas emissions across different countries for the year 2010. The year 2010 was selected arbitrarily. The CO2 emissions represented on the map are measured in kilotonnes (kt). By visualizing these emissions in kilotonnes, the map provides a clear perspective on the scale and distribution of CO2 emissions across different regions, making it easier to compare the environmental impact of various countries.From the symbol maps depicting CO2 emissions and greenhouse gas emissions, we observe a similar trend in both datasets.

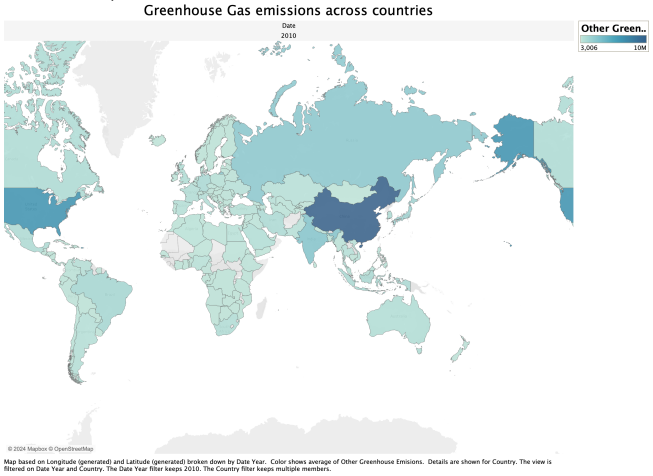

Fig 30. Map representing other greenhouse gas emissions across countries (2010)

This parallel trend suggests that countries exhibiting higher CO2 emissions also tend to have higher levels of greenhouse gas emissions. The analysis indicates that both types of emissions are closely correlated, likely reflecting common underlying factors such as industrial activity, energy consumption patterns, and economic development. Furthermore, the maps highlight that larger economies and more industrialized nations tend to be the largest contributors to global emissions. Countries with lower emissions, on the other hand, are often those with less industrialization and smaller populations, pointing to the ongoing global challenge of balancing development with sustainability..

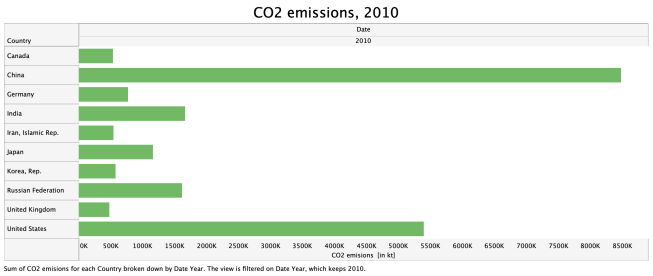

Fig 31. Top 10 largest contributing countries to CO_2 emissions (2010)

Figure 31 presents a horizontal bar chart illustrating top 10 countries with the highest CO_2 emissions for the year 2010. This visual representation highlights the dominant contributors to global carbon dioxide emissions, providing a clear comparison among the top emitters. The symbol map depicting CO_2 emissions across countries for the year 2010 and the bar chart showing the top 10 largest contributing countries to CO_2 emissions provide a complementary view of global emission patterns. The map reveals that darker countries, which signify higher levels

of CO_2 emissions, align closely with those highlighted in the bar chart as the top emitters.
The top 4 darkest countries in the map which are also represented by top 4 longest bars in the horizontal bar chart in their decreasing order of emission for the year 2010 are :
China, United States of America, India and Russian Federation.

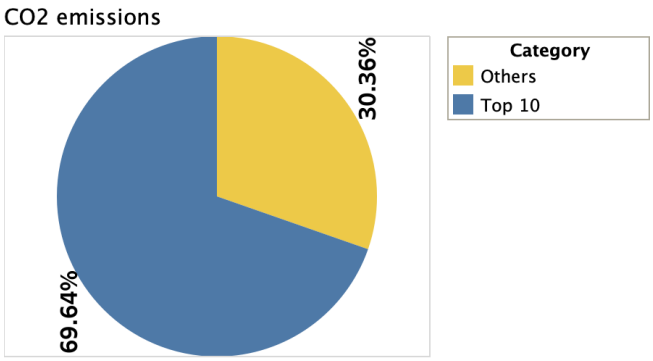

Fig 32. Share of global CO emissions by the top 10 emitting countries compared to the rest of the world (2010)

Figure 32 presents a pie chart showing the percentage share of top 10 CO_2 emitting countries as a part of total CO_2 emissions for the year 2010.These countries are China, USA, India, Russia, Japan, Germany, Canada, Korea, Iran and UK.

The 10 largest contributors to CO emissions account for approximately 70% of the global total, underscoring the significant concentration of emissions within a relatively small number of countries. This disproportionate share of global emissions highlights the crucial role these nations play in shaping the trajectory of global climate change.

By emitting the majority of CO_2, these countries are pivotal in driving global warming and environmental degradation. Addressing climate issues, therefore, hinges on the ability of these top emitters to implement more sustainable practices, adopt cleaner technologies, and commit to substantial emissions reductions. Their actions will be critical in the global effort to mitigate the adverse effects of climate change.

Figure 33 presents a pie chart depicting the percentage share of other greenhouse gas emissions contributed by the top 10 CO_2 emitting countries as part of the total global emissions for 2010. These same 10 countries also account for approximately 64% of total other greenhouse gas emissions, further reinforcing the patterns observed in the maps showing CO_2 and greenhouse gas emissions across all countries. This correlation highlights the significant contribution of the top CO_2 emitters to overall global greenhouse gas emissions, extending the insights gained from the map visualizations.

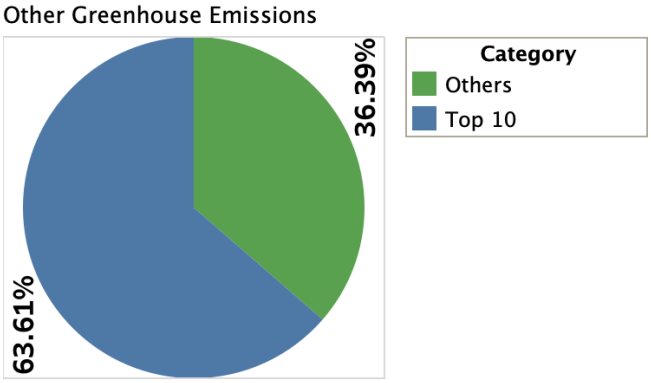

Fig 33. Share of global other greenhouse gas emissions by the top 10 CO_2 emitting countries compared to the rest of the world (2010)

Building on the general increase in per capita CO_2 emissions and per capita electrical power consumption observed across different income groups in Hypothesis 2, we now aim to examine this relationship across individual countries. This will be achieved through geospatial mapping of electrical power consumption, allowing us to explore the correlation between power consumption and CO_2 emissions on a global scale.

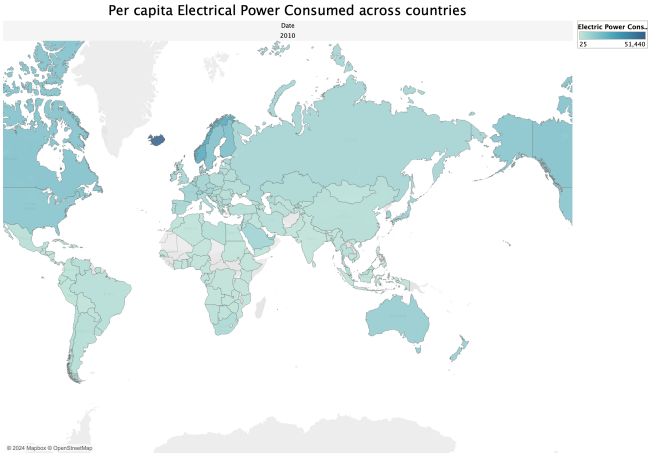

Fig 34. Map representing per capita electrical power consumed across countries (2010)

Figure 34 presents a map illustrating per capita electrical power consumption across countries for the year 2010. Contrary to initial expectations, this map does not directly correlate with the maps depicted in Figures 29 and 30, which show CO_2 and greenhouse gas emissions. This suggests that countries with higher per capita electrical power consumption do not necessarily contribute propor-

tionally to higher per capita greenhouse gas emissions. Notably, regions like Iceland, Norway, and Canada are shaded darker, indicating much higher per capita power consumption. This trend suggests that countries with abundant energy resources, such as geothermal energy in Iceland or hydroelectric power in Norway and Canada, consume much more electricity on an individual basis compared to others. These nations often rely on clean and renewable energy sources, which explains their high energy usage but relatively lower greenhouse gas emissions, a trend that contrasts with the expected correlation between higher energy consumption and emissions.

In contrast, countries in Africa and parts of South Asia, such as Nigeria and India, display much lighter shades, indicating lower per capita power consumption. This reflects the limited access to electricity or lower overall energy usage in these regions due to slower industrial development or less extensive energy infrastructure. However, while these countries consume less electricity per person, some, like India, still contribute significantly to global CO_2 and greenhouse gas emissions due to their reliance on coal and other non-renewable energy sources for power generation.

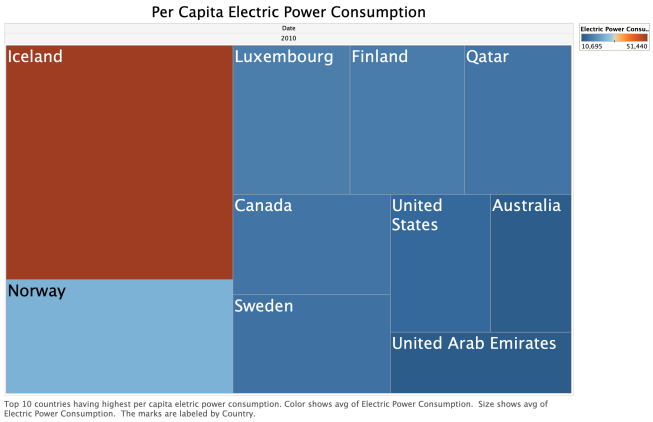

Fig 35. Tree Map displaying the top 10 countries with the highest per capita electrical power consumption (2010)

Figure 35 presents a tree map representing the top 10 countries by per capita electrical power consumption in 2010. The size of each block reflects the relative contribution of each country, with larger blocks signifying higher per capita consumption. Notably, the color gradient difference between Iceland, represented in brown, and Norway, shaded in blue, underscores a significant disparity — Iceland's per capita consumption is nearly double that of Norway, the second-highest consumer. This visualization highlights stark contrasts in energy usage among the top consumers, emphasizing the global imbalance in power consumption levels.

Several factors may contribute to Iceland's exceptionally high per capita electricity consumption:

- Abundant renewable energy sources: Iceland's electricity production is almost entirely powered by renewable sources, specifically geothermal and hydropower. This abundance of low-cost, sustainable energy likely encourages higher consumption levels across various sectors.
- Presence of energy-intensive industries: The country's economic structure includes several energy-intensive industries. Aluminum smelting, in particular, is a major electricity consumer. Additionally, Iceland hosts other sectors such as silica mining, pumice extraction, and extensive geothermal resource utilization. These industries benefit from the country's low-cost renewable energy, driving up overall electricity demand.
- Small population base: Iceland's relatively small population may also inflate its per capita electricity consumption figures. A large total consumption, driven by industrial use, when divided by a small population, results in a disproportionately high per capita consumption.
- Heating requirements: Due to Iceland's cold climate, electricity is heavily utilized for heating, including space heating and hot water systems. This further contributes to the high electricity consumption per person.
- Economic development and structure: In addition to aluminum smelting, other sectors such as data centers, which require vast amounts of electricity, take advantage of Iceland's inexpensive energy supply. This combination of economic activities focused on energy-intensive industries amplifies the overall electricity demand.

Major Challenges: A major challenge was the absence of data for many critical attributes, with several key columns filled with Null or missing values. This incomplete data, especially across various regions, complicated efforts to draw meaningful conclusions. Analyzing trends often required multiple variables, but for many countries, essential data points were lacking, making it even more difficult to identify clear patterns.

III. AUTHORS' CONTRIBUTIONS

Ayush Arya Kashyap: (Task 1: Analyzing Trends and Impacts of major economic events across the globe over the years)

- Conducted data analysis using Jupyter Notebook, Python, and libraries like pandas, datetime, os, among others to identify trends in economic activities in and around the world over the years.

- Visualizations Used : bar chart, stacked bar chart, treemaps, heatmaps area chart, line chart, and bubble diagram to represent the data effectively.
- Interpreted the visualizations and drew conclusions about the overall trends in economic activities.
- Wrote the narrative and descriptions for Task 1, providing context and insights.

Uttam Hamsaraj: (T2: Analyzing key social indicators across countries to uncover trends and insights into global social development)

- Preprocessed the data using tableau prep and analyzed data on social indicators.
- Analyzed and visualized 4 hypotheses with inferences.
- Visualizations Used : Stacked bar chart , Bubble chart , Bar chart , Scatter plot, Density plot, Treemap , Line plot , Heatmap , Dual-axis line graphs.
- Wrote the narrative and descriptions for Task 2, providing context and insights.

Pranav Laddhad: (Task 3: Analyzing trends and relations of environmental and sustainability indicators to evaluate global progress in addressing climate change)

- Preprocessed and analyzed data on environmental indicators using python libraries and tabeau prep.
- Analyzed and visualized 3 hypotheses with inferences.
- Visualizations Used : lines charts, dual combinations chart, double bar charts, cartographic charts, horizontal bar chart, pie charts and tree map to represent the data effectively.
- Interpreted the visualizations and drew conclusions
- Wrote the narrative and descriptions for Task 3, providing context and insights.

IV. REFERENCES

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4) https://tradingeconomics.com/indicators
5) https://documents.worldbank.org/en/publication/documents-reports