

Global Climate Change Dynamics: A Multidimensional Study on the Top Five Economies in The World

Samriddhi Jadhav
IPS Academy, IBMR

ABSTRACT

Global climate change looms as a pressing concern that affects every country worldwide. This research aims to delve into the dynamics of climate change in the top five economies in the world i.e., the United States, China, Japan, Germany, and India. The study will adopt a multidimensional approach to comprehend the nature of climate change in these countries.

The research will involve analyzing a wide range of data which includes records of climate change patterns, greenhouse gases emissions, economic indicators, and policy frameworks. By examining these factors, the study will also help to inform future response planning to climate change and to better anticipate and mitigate the potential consequences of climate change on sustainable development goals and the world.

Moreover, the research will explore the comparison between the top 5 countries CO₂ emission from 1970s to 2022, CO₂ emissions per unit of GDP, waste-to-wealth conversion rate and the progress of these countries in reducing CO₂ emissions.

In conclusion, this research on the dynamics of global climate change in the five economies will contribute to our existing knowledge on the subject while providing a comprehensive understanding of the issue. By identifying this analysis, the study aims to provide a comprehensive and in-depth understanding of the intricate and interconnected nature of climate change in the top five economies in the world.

INTRODUCTION

Climate change is one of the most critical challenges of the 21st century, which affects nations, economies, and ecosystems all around the world. Its far-reaching consequences demand comprehensive, multidimensional analysis to comprehend the complex dynamics at play. As the world struggles with the urgent need for climate action, this research paper undertakes a journey to unravel the multifaceted aspects of climate change dynamics by emphasizing on the top five

economies in the world.

The unfolding story of global climate change is characterized by rising global temperatures, changing weather patterns, more frequent extreme events, and accelerating sea-level rise. These changes are pushed by human activities, primarily the emission of greenhouse gases into the atmosphere, driven primarily by industrialization, urbanization, and energy consumption. As the world's top economic powerhouses i.e., the United States, China, Japan, Germany bear significant responsibility for the greenhouse gas emissions that are causing these climate changes.

India, on the other hand, is a rapidly developing nation with its unique challenges and opportunities. With a burgeoning population and economic growth aspirations, India faces the dual challenge of meeting its energy needs and development goals while mitigating and adapting to the adverse impacts of climate change. It is essential to comprehend how India navigates this challenging environment not only for the country itself but also for the global climate agenda.

This research paper aims to connect the divide in our understanding of the intricate and interconnected climate change dynamics that unfold on the worldwide platform. By contrasting India's climate journey with that of the top five economies, I aim to share insights into the diverse strategies, policies, and experiences that emerge from different national contexts.

Through a multidimensional perspective, I examine factors such as greenhouse gas emissions, renewable energy adoption, climate change policies, vulnerability to climate-related risks, and progress in mitigating climate change in these countries.

Furthermore, this research paper delves into the changing narratives surrounding climate change governance, international cooperation. It also explores the role of these key players on the world stage. My goal is to shed light on how global dynamics of climate change are influenced by national agendas, interests and commitments.

Through promoting a comprehension of the dimensions of climate change dynamics my aim is to encourage cooperative and well-informed measures that go beyond national boundaries and lead us towards a future that is both sustainable and resilient, for our planet.

BACKGROUND OF TOP 5 ECONOMIES

Before delving into details of discussion about the measurement indices and comparison of top five economies in the world with primary focus on India I would like to discuss about the history of climate change in these countries over the years of their development to provide a base of assessments in the study.

UNITED STATES OF AMERICA

The United States boasts a rich legacy of industrialization and economic development, tracing back to the early 19th century. The surge in CO2 emissions has seen a remarkable upsurge along with this development.

- **1800-1900:** The United States underwent rapid industrialization during this period, leading to a significant increase in CO2 emissions. In 1800, the United States' CO2 emissions stood at approximately 10 million tonnes annually. By 1900, emissions had increased to around 200 million tonnes per year.
- **1900-1950:** The United States persisted in industrialization and economic growth, resulting in further spikes in CO2 emissions.
- **1950-2000:** The United States emerged as a global economic powerhouse during this period, and its CO2 emissions persisted to increase. By 1950, emissions had increased to approximately 1 billion tonnes per year. And by 2000, emissions had increased to roughly 5 billion tonnes annually.
- **2000-present:** The United States has made some progress in curbing its CO2 emissions in recent years, but it remains one of the world's largest emitters.

In recent years, the United States has made some headway in curbing its CO2 emissions. In 2021, the United States CO2 emissions approximated around 4.7 billion tonnes annually.

However, the United States remains the second largest emitter of CO2 worldwide, after China.

The United States' CO2 emissions have had a significant impact on climate change. The United States is responsible for roughly 15% of global CO2 emissions, and its emissions contribute to the phenomenon of global warming. Global warming is causing a number of issues which includes elevated sea levels, occurrences of extreme weather, and changes in flora and fauna."

USA's response to climate change

The United States government aims to decrease its CO2 emissions. The United States has established a goal of reducing its CO2 emissions by 50-52% by 2030

compared to 2005 levels. The US is also committed to attaining net-zero emissions by 2050.

The Biden administration has invested heavily in renewable energy, electric vehicles, and energy efficiency. USA stands as the second largest producer of renewable energy worldwide, and it is pouring significant investments into new renewable energy technologies.

The US government is also collaborating with other nations to diminish global CO2 emissions. The United States is a member of the Paris Agreement, and it is working to execute the agreement's objectives. By reducing its CO2 emissions, the United States can help to mitigating the repercussions of climate change and safeguard the environment for future generations.

Moreover, the US government is also supporting a number of research and development initiatives. The US is also working to promote climate change education and awareness among the public.

CHINA

The nation's economy has boomed quickly in recent years, this surge has not been without consequences. China is now the world's largest emitter of CO2, and its emissions are continuing to rise.

China's economic development began in the late 1970s, when the country embraced a series of economic reforms. These reforms triggered rapid economic growth, and China's economy has flourished at an average rate of about 10% per year for the past four decades.

- **1950-1970:** China was a developing country during this period, and its CO2 emissions were comparatively low.
- **1970-2000:** China started industrializing rapidly during this period, leading to a significant increase in CO2 emissions. In 1978, China emitted approximately 123 million tonnes of CO2.
- **2000-present:** By 2020, China's CO2 emissions had surged to approximately 10.78 billion tonnes. China has become the world's second largest economy, and its CO2 emissions have excelled those of the United States.

China's CO2 emissions are primarily due to the country's reliance on fossil fuels for energy. In 2020, coal constituted about 63% of China's primary energy consumption. Oil and natural gas comprised the remaining 37% of China's primary energy consumption.

China's response to climate change

China has set a target of peaking its CO₂ emissions by 2030. In 2020, China set a target to achieve net-zero greenhouse gas emissions by 2060.

In 2022, China proclaimed a prohibition on the establishment of new coal-fired power plants.

The Chinese government is financing renewable energy, energy efficiency, and carbon capture and storage technologies to aid in achieving its climate objectives. It holds the title of the world's largest producer of renewable energy. The government is also working to promote sustainable transportation and reduce deforestation. China is the world's largest electric vehicle market, and it is pouring substantial investments into electric vehicle charging infrastructure.

JAPAN

Japan underwent a rapid process of industrialization and economic expansion in the late 19th and early 20th centuries. It emerged as a significant industrial and technological powerhouse after the conclusion of World War II.

Japan's history of development and CO₂ emissions can be traced back to the late 19th century, wherein it embarked on a period of rapid modernization and industrialization. This era of rapid economic growth, referred to as the Meiji Restoration (political revolution in 1868), was fueled by the assimilation of Western technologies and institutions, as well as the exploitation of Japan's natural resources.

- **1870-1900:** Japan began to industrialize rapidly during this period, leading to a significant increase in CO₂ emissions.
- **1900-1950:** Japan continued to industrialize and grow economically, leading to further increases in CO₂ emissions.
- **1950-1970:** In the aftermath of World War II, Japan's economy experienced another period of rapid growth, known as the Japanese economic miracle. During this time in the 1950s, Japan became one of the wealthiest countries in the world, and its exports were in high demand around the globe. This growth was accompanied by a significant increase in CO₂ emissions.
- **1970-2000:** Japan's economic growth slowed during this period, but its CO₂ emissions continued to increase.
- **2000-present:** Japan has made some progress in reducing its CO₂ emissions in recent years, but it remains one of the world's largest emitters per capita.

In recent years, Japan's economic growth has slowed down somewhat. However, the country remains a major economic power and a significant emitter of CO₂. In 2020, Japan emitted approximately 1.16 billion tonnes of carbon dioxide equivalent (CO₂e), making it the fifth largest emitter of greenhouse gases in the world.

Japan's response to climate change

In 2020, Japan set a target to reduce its greenhouse gas emissions by 46% by 2030 and achieve net-zero greenhouse gas emissions by 2050.

The Japanese government is also working with other countries to reduce global CO₂ emissions. Japan is a member of the Paris Agreement, and it is working to implement the agreement's goals.

The Japanese government is taking a number of steps to reduce its CO₂ emissions, including investing in renewable energy such as solar and wind power with a goal of increasing the share of renewable energy in its energy mix to 38-45% by 2030, promoting energy efficiency, electrifying transportation. Japan is working to protect its forests, which play an important role in absorbing carbon dioxide from the atmosphere.

GERMANY

Germany has a long history of industrialization and economic development, tracing back to the 19th century. This development has been accompanied by a notable surge in CO₂ emissions.

After World War II, West Germany experienced a phase of rapid reconstruction and industrialization. After the reunification of East and West Germany in 1990, the nation continued its economic growth.

- **1850-1900:** Germany began to industrialize rapidly during this period, resulting in a substantial increase in CO₂ emissions. In 1850, Germany emitted approximately 20 million tonnes of CO₂ per annum.
- **1900-1950:** Germany continued to industrialize and expanded economically, leading to further increase in CO₂ emissions. By 1950, emissions had reached approximately 200 million tonnes per year.
- **1950-1970:** Germany encountered rapid economic growth during this period, known as the *Wirtschaftswunder* (economic miracle). This growth was accompanied by a surge in CO₂ emissions.
- **1970-2000:** Germany's economic growth decelerated during this period, yet its CO₂ emissions continued to rise. By 2000, emissions had reached

approximately 900 million tonnes per year.

- **2000-present:** Germany has made some progress in curtailing its CO₂ emissions in recent years. In 2021, Germany emitted approximately 750 million tonnes of CO₂ per year. However, Germany remains one of the major contributors to global CO₂ emissions.

Germany's CO₂ emissions have exerted a substantial influence on climate change. Germany is responsible for roughly 2% of global CO₂ emissions which contribute to global warming.

Germany's response to climate change

Germany emerges as one of the foremost nations globally in the battle against climate change. The German government has set ambitious goals aimed at reducing greenhouse gas emissions, while directing substantial investments into renewable energy, energy efficiency, and other eco-friendly technologies.

In the year 2021, over 40% of Germany's electricity was produced by renewable energy sources. The German government has set a target of increasing the proportion of renewable energy in its energy mix to a staggering 80% by 2030.

Germany is promoting energy efficiency through a number of measures, such as stricter building codes and appliance standards. The German government has set a target of reducing its primary energy consumption by 50% by 2050.

By propelling electric vehicles and hydrogen fuel cells, Germany is electrifying its transportation sector. The German government has established a goal of having 10 million electric vehicles traversing the roads by 2030.

Germany endeavors to safeguard its forests, with a target of increasing the forest coverage to 37% by 2030.

Germany finances numerous research and development projects that strive to forge inventive solutions for curbing greenhouse gas emissions and mitigating the impacts of climate change. For instance, Germany is a pioneer in the development of technologies for carbon capture and storage technology.

BACKGROUND OF INDIA

India is a developing country with a rich history and culture. The country has experienced rapid economic growth in recent decades, but this growth has come at a cost. India is presently the world's third largest emitter of CO₂, and its emissions are continuing to rise.

India's trajectory of growth is closely linked with its greenhouse gas emissions and their repercussions on climate change. Here's a brief history of India's growth and its emissions profile, along with the related impact on climate change:

Before gaining independence in 1947, India's emissions were relatively low, primarily from traditional agricultural practices and limited industrialization. The period of British colonialism witnessed limited industrialization and deforestation, with emissions primarily driven by the extraction of natural resources for export.

After independence, India prioritized economic development and industrialization to combat poverty and improve living standards. Rapid industrialization and urbanization led to significant surge in emissions, particularly from the combustion of fossil fuels, expansion of industries, and the growth of the transportation sector. Energy generation, predominantly reliant on coal, also contributed to emissions growth.

India's economic development began in the early 1990s, when the country adopted a series of economic reforms, liberalizing its economy and encouraging foreign investment. These reforms led to the rapid economic growth, and India's economy has grown at an average rate of approximately 6% per year for the past three decades.

India's CO₂ emissions have increased rapidly since the early 1990s. In 1990, India emitted approximately 456 million tonnes of CO₂. By 2020, India's CO₂ emissions had increased to approximately 2.54 billion tonnes. This makes India the world's third largest emitter of CO₂, followed by China and the United States. India's CO₂ emissions are primarily due to the country's reliance on coal for energy. In 2020, coal accounted for about 57% of India's primary energy consumption. India is the second largest producer and consumer of coal after China. Oil and natural gas accounted for the remaining 43% of India's primary energy consumption.

INITIATIVES OF THE GOVERNMENT OF INDIA

The Indian government is aware of the need to address climate change and has taken a number of initiatives to address them.

The government of India launched The National Hydrogen Energy Mission (NHEM) in 2021. The mission aims to make India a global hub for production, usage and export of green hydrogen and its derivatives.

The mission has the following key objectives:

- To develop a green hydrogen ecosystem in India.
- To reduce India's dependence on fossil fuels.
- To create jobs and economic opportunities in the hydrogen energy sector.

- To protect the environment and mitigate climate change.

The government of India is working hard to achieve sustainable development goals. The various policies taken by the government includes Swachh Bharat Abhiyan, Make in India, Digital India, ban of plastic, poverty alleviation program and solution to climate change.

The government of India has undertaken 'Waste to Wealth Mission' as a part its commitment to effective waste and pollution management in India. A United Nations report states that India is one of the biggest producer of e-waste in the world.

Besides, India is a member of a number of international organizations and groups that are working to address climate change.

United Nations Framework Convention on Climate Change (UNFCCC): The UNFCCC is the main international treaty on climate change to stabilize greenhouse gas emissions. India is a party to the UNFCCC and is actively engaged in its negotiations.

Prime Minister Narendra Modi at the UNFCCC COP26 climate summit in Glasgow in November 2021. The Panchamrit consists of the following goals:

- India will reach 500 GW of non-fossil fuel energy capacity by 2030.
- India will meet 50% of its energy requirements from renewable energy by 2030.
- India will reduce its total projected carbon emissions by one billion tonnes from now to 2030.
- India will reduce the carbon intensity of its economy by less than 45% by 2030.
- India will achieve net-zero emissions by 2070.

The Panchamrit is important for India for a number of reasons. First, it will help to reduce India's greenhouse gas emissions and mitigate climate change. Second, it will help to improve India's energy security. Third, it will create jobs and economic opportunities in the clean energy sector.

Mission LiFE or Lifestyle for Environment is an India-led global mass movement that promotes an environmentally conscious lifestyle. It was launched by Prime Minister Narendra Modi at the COP26 climate summit in Glasgow in November 2021. Mission LiFE is based on the principle of "mindful and deliberate utilization" of resources, instead of mindless and destructive

consumption. It aims to nudge individuals and communities to adopt sustainable practices in their daily lives.

Mission LiFE is a significant effort to combat climate change. By changing our lifestyles, we can reduce our environmental impact and help to create a more sustainable future.

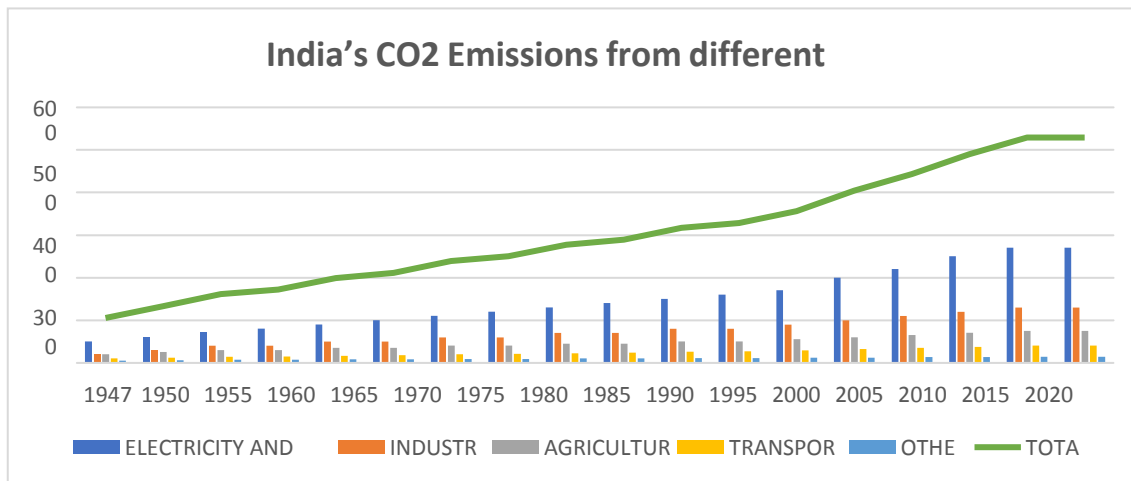
Paris Agreement: The Paris Agreement is a landmark international agreement that sets a goal of limiting global warming to well below 2 degrees Celsius, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. India is a party to the Paris Agreement and has committed to reducing its greenhouse gas emissions intensity by 45% by 2030 compared to 2005 levels.

Table 1: India's CO2 Emissions from different sectors (in million metric tons)

INDIA (YEARS)	ELECTRICITY AND HEAT	INDUSTRY	AGRICULTURE	TRANSPORT	OTHER	TOTAL
1947	50	20	20	10	5	105
1950	60	30	25	12	6	133
1955	70	40	30	14	7	161
1960	80	40	30	15	7	172
1965	90	50	35	16	8	199
1970	100	50	35	18	8	211
1975	110	60	40	20	9	239
1980	120	60	40	21	9	250
1985	130	70	45	22	10	277
1990	140	70	45	24	10	289
1995	150	80	50	26	11	317
2000	160	80	50	27	11	328
2005	170	90	55	29	12	356
2010	200	100	60	32	12	404
2015	220	110	65	35	13	443
2020	250	120	70	37	13	490
2022	270	130	75	40	14	529
2023	270	130	75	40	14	529

Source: Compiled from IEA

In the above table the other sectors include residential, commercial etc.



Source: Compiled from IEA

REVIEW OF LITERATURE

The literature available on estimations and analysis of climate change is vast and the contributions of various authors have proved to be extremely helpful and significant.

Nicholas Stern's publication in 2006, "The Economics of Climate Change: The Stern Review" examines the economic expenses and advantages of climate change, and he concludes that the advantages of taking action to alleviate climate change far surpass the costs. It further argues that the costs of inaction would be excessively high, and thus, it is of utmost importance to take action now to reduce greenhouse gas emissions.

The World Bank's 2018 report on "The Global Economic Impact of Climate Change" evaluates the economic repercussions of climate change on diverse regions and sectors of the global economy. It discovers that climate change could curtail global GDP by up to 10% by 2090 if no action is taken to mitigate emissions. The World Bank report reveals that the economic repercussions of climate change would be most severe in developing countries, where populations are more susceptible to climate hazards and economies are more reliant on agriculture. The report also uncovers that climate change could lead to increased migration, conflict, and instability. However, the report is founded on a number of assumptions about the future of climate change and the global economy.

Special Report on Global Warming of 1.5°C (2018), by the IPCC scrutinize the effects of global warming of 1.5°C above pre-industrial levels and the pathways that could lead to limiting warming to 1.5°C. It finds that limiting warming to 1.5°C would require rapid and far-reaching transitions in all sectors of society.

The Intergovernmental Panel on Climate Change (IPCC) published “The Physical Science Basis: Summary for Policymakers” in 2021. This report provides a comprehensive and authoritative assessment of the physical science basis of climate change. It concludes that it is extremely likely that human activities are the main cause of the observed warming since the mid- 20th century, and that the impacts of climate change are already being felt around the world. The report's key findings include that the human influence has warmed the atmosphere, ocean and land and unless there are immediate, rapid and large-scale reductions in greenhouse gas emissions, limiting warming to close to 1.5°C or even 2°C will be beyond reach.

Sixth Assessment Report on Climate Change 2021-2022: Impacts, Adaptation and Vulnerability (2022), by the IPCC. This comprehensive assessment evaluates the impacts of climate change on human and natural systems, explores potential adaptation strategies for climate change, and the vulnerabilities of different communities and ecosystems. The report reveals that climate change is already having significant impacts on individuals and ecosystems around the world. Moreover, it predicts that these impacts will intensify in the future, emphasizing the urgent need for nations to prioritize mitigating the consequences of climate change.

“A Comparative Assessment of Sustainable Economic Development among the G20 Countries” by Pallabi Mukherjee and Kanhaiya Ahuja. This research paper compares the G20 nations in terms of their sustainable development present and progress scores.

OBJECTIVE OF THE STUDY

The primary objective of the study is to understand the global climate change dynamics. However, to understand the difference in variances among top 5 economies individual dimensions and nations as a whole.

The secondary objective of the study is to compare the progress of these countries in reducing CO₂ emissions.

RATIONALE OF THE STUDY

The rationale of the study for a research paper on the topic "Global Climate Change Dynamics: A multidimensional study on the Top Five Economies in the World" is to provide a comprehensive and in-depth understanding of the intricate and interconnected nature of climate change in the top five economies in the world.

Climate change has significant environmental and socio-economic impacts on the world that possess the potential to derail the sustainable development goals. The top five economies in the world (the United States, China, Japan, Germany, and India) are also the top emitters of greenhouse gases. This implies that they play a significant role in driving climate change. Additionally, these economies are also highly vulnerable to the impacts of climate change.

A multidimensional study on climate change is important as it help us to better understand the complex interactions between the economy, the environment, and society. Climate change is not solely an environmental issue, it is also an economic and social issue. A multidimensional study can enhance our understanding of how climate change is impacting diverse sectors of the economy and different groups of people. The study will also help to inform future response planning to climate change and to better anticipate and mitigate the potential consequences of climate change on sustainable development goals and the world. Moreover, it may also help in monitoring the progress of the nations in mitigating climate change.

The rationale of the study is to provide comprehensive analysis of the climate change in the top five economies in the world. The research covers various sectors such as energy, transport, industry, agriculture etc. and provides an assessment of the progress made in each of these areas in terms of mitigating climate change.

RESEARCH METHODOLOGY

This study is descriptive in nature. In the first half I have analyzed the picture of the top five economies in the world with primary focus on India. I have discussed about the history of climate change in these nations over the years of their development. For fulfilling the research objective, I have collected the secondary data of CO₂ emissions from IEA, World Bank, EPA, Ministry of Environment (Japan), Federal Statistical Office (Germany), National Bureau of Statistics of China.

DATA INTERPRETATIONS

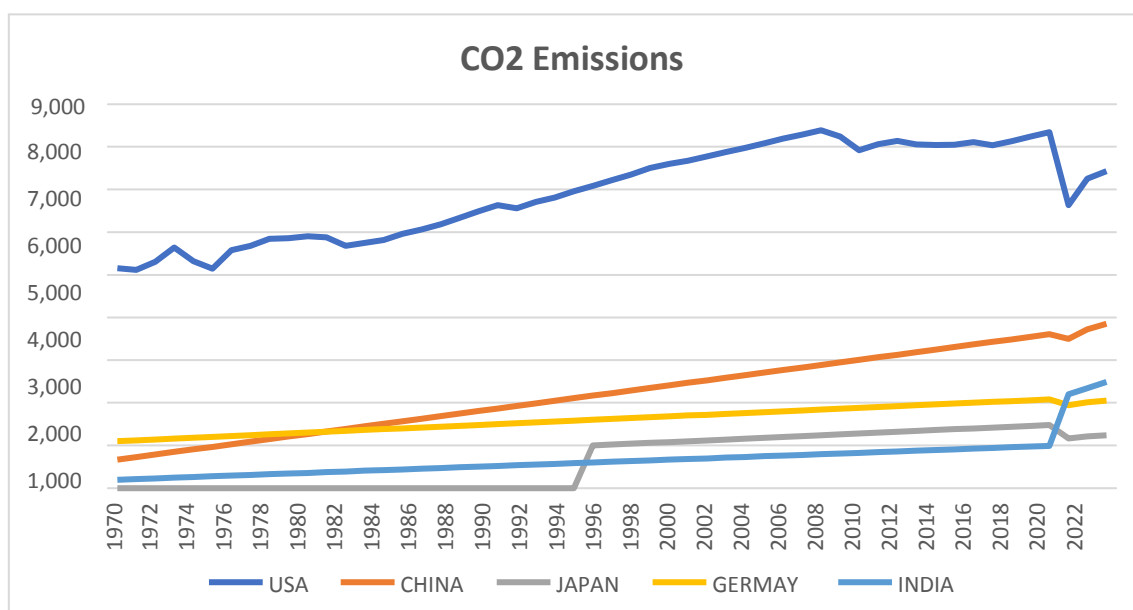
The CO₂ emissions scores calculated by the International Energy Agency has been compiled for the current study. The top 5 countries CO₂ emission from 1970s to 2022 has been plotted.

Table 2: Top 5 economies CO2 emissions (in million metric tonnes) from 1970s to 2022

YEARS	USA	CHINA	JAPAN	GERMAY	INDIA
1970	5,154	670	500	1100	196.2
1971	5,114	730	520	1120	212.4
1972	5,307	790	540	1140	228.6
1973	5,639	850	560	1160	244.8
1974	5,318	910	580	1180	261
1975	5,145	970	600	1200	277.2
1976	5,578	1,030	620	1220	293.4
1977	5,682	1,090	640	1240	309.6
1978	5,842	1,150	660	1260	325.8
1979	5,861	1,210	680	1280	342
1980	5,907	1,270	700	1300	358.2
1981	5,876	1,330	720	1320	374.4
1982	5,683	1,390	740	1340	390.6
1983	5,750	1,450	760	1360	406.8
1984	5,817	1,510	780	1380	423
1985	5,960	1,570	800	1400	439.2
1986	6,059	1,630	820	1420	455.4
1987	6,183	1,690	840	1440	471.6
1988	6,336	1,750	860	1460	487.8
1989	6,491	1,810	880	1480	504
1990	6,635	1,870	900	1500	520.2
1991	6,556	1,930	920	1520	536.4
1992	6,711	1,990	940	1540	552.6
1993	6,808	2,050	960	1560	568.8
1994	6,958	2,110	980	1580	585
1995	7,084	2,170	1000	1600	601.2
1996	7,221	2,230	1020	1620	617.4
1997	7,348	2,290	1040	1640	633.6
1998	7,504	2,350	1060	1660	649.8
1999	7,604	2,410	1080	1680	666
2000	7,674	2,470	1100	1700	682.2
2001	7,781	2,530	1120	1720	698.4
2002	7,877	2,590	1140	1740	714.6
2003	7,973	2,650	1160	1760	730.8
2004	8,084	2,710	1180	1780	747

2005	8,193	2,770	1200	1800	763.2
2006	8,289	2,830	1220	1820	779.4
2007	8,390	2,890	1240	1840	795.6
2008	8,238	2,950	1260	1860	811.8
2009	7,924	3,010	1280	1880	828
2010	8,061	3,070	1300	1900	844.2
2011	8,142	3,130	1320	1920	860.4
2012	8,060	3,190	1340	1940	876.6
2013	8,043	3,250	1360	1960	892.8
2014	8,052	3,310	1380	1980	909
2015	8,112	3,370	1400	2000	925.2
2016	8,037	3,430	1420	2020	941.4
2017	8,130	3,490	1440	2040	957.6
2018	8,244	3,550	1460	2060	973.8
2019	8,341	3,610	1480	2080	990
2020	6,631	3,499	1164	1944	2,200.80
2021	7,251	3,727	1210	2012	2,345.40
2022	7,433	3,855	1240	2054	2,490

Source: Compiled from IEA



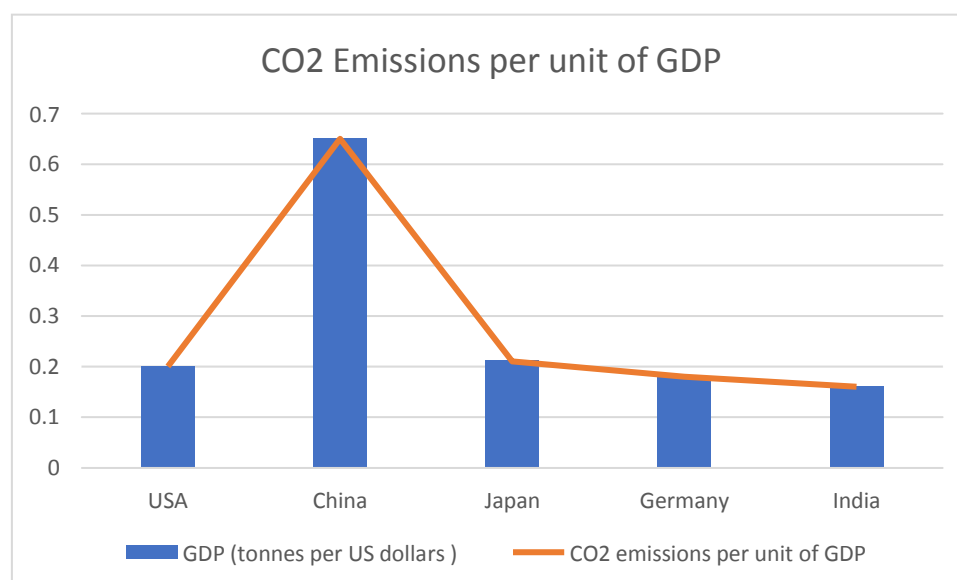
Source: Compiled from IEA

It can be noticed that the countries CO₂ emissions have fluctuated over the past 45 years, but overall, they have increased leading to climate change. USA (14.02%), China (29.18%), Japan (3.47%), Germany (2.17%), and India (7.09%) are the countries that are responsible for the majority of the global CO₂ emissions. China is the largest emitter of CO₂ in the world followed by USA and India. Japan's and Germany's CO₂ emissions have increased steadily over the past 45 years, with a slight decrease in 2020 due to the COVID-19 pandemic. Japan and Germany are now the world's fifth and seventh largest emitter of CO₂ respectively.

Table 3: Comparison of top 5 countries on CO₂ emissions per unit of GDP (tonnes per 1000 US dollars) and CO₂ emissions per unit of GDP (in percentage)

Country	unit of GDP (tonnes per 1000US dollars)	CO ₂ emissions per unit of GDP (in percentage)
USA	0.2	20%
China	0.651	65%
Japan	0.213	21%
Germany	0.18	18%
India	0.16	16%

Source: Compiled from IEA



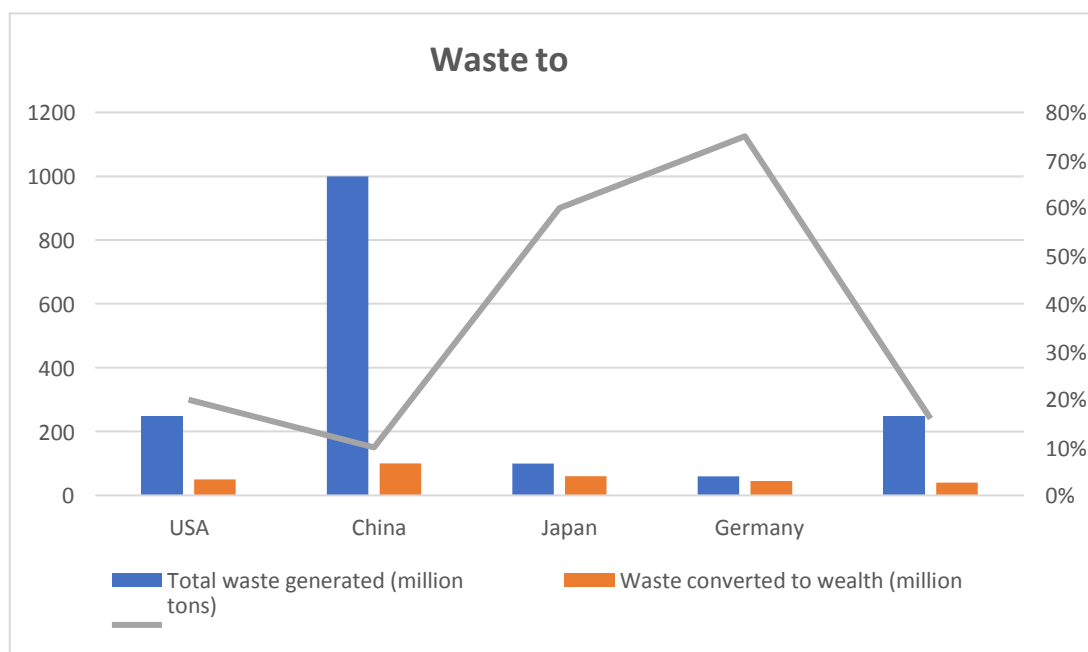
Source: Compiled from IEA

It can be noticed that India has the lowest CO2 emissions per unit of GDP, while China has the highest. This is likely due to India’s lower level of economic development whereas China has arapidly growing economy.

Table 4: Comparison of top five countries on Total waste generated (million tons), Wasteconverted to wealth (million tons), Waste conversion rate (%), Waste-to-wealth potential(%)

Country	Total waste generated (million tons)	Waste converted to wealth (milliontons)	Waste conversion rate(%)	Waste-to-wealth potential(%)
USA	250	50	20%	5-7%
China	1000	100	10%	8-10%
Japan	100	60	60%	6-8%
Germany	60	45	75%	7-9%
India	250	40	16%	4-6%

Source: Compiled from World Bank, EPA, Ministry of Environment (Japan), Federal Statistical Office (Germany), National Bureau of Statistics of China



Source: Compiled from World Bank, EPA, Ministry of Environment (Japan), Federal Statistical Office (Germany), National Bureau of Statistics of China

Waste-to-wealth can reduce greenhouse gas emissions and conserve natural resources and the countries can develop in a sustainable and environmentally friendly manner.

Waste-to-wealth potential means that USA, China, Japan, Germany and India could generate an additional 5-7%,8-10%,6-8%,7-9%,4-6% of GDP by converting waste into valuable resources respectively.

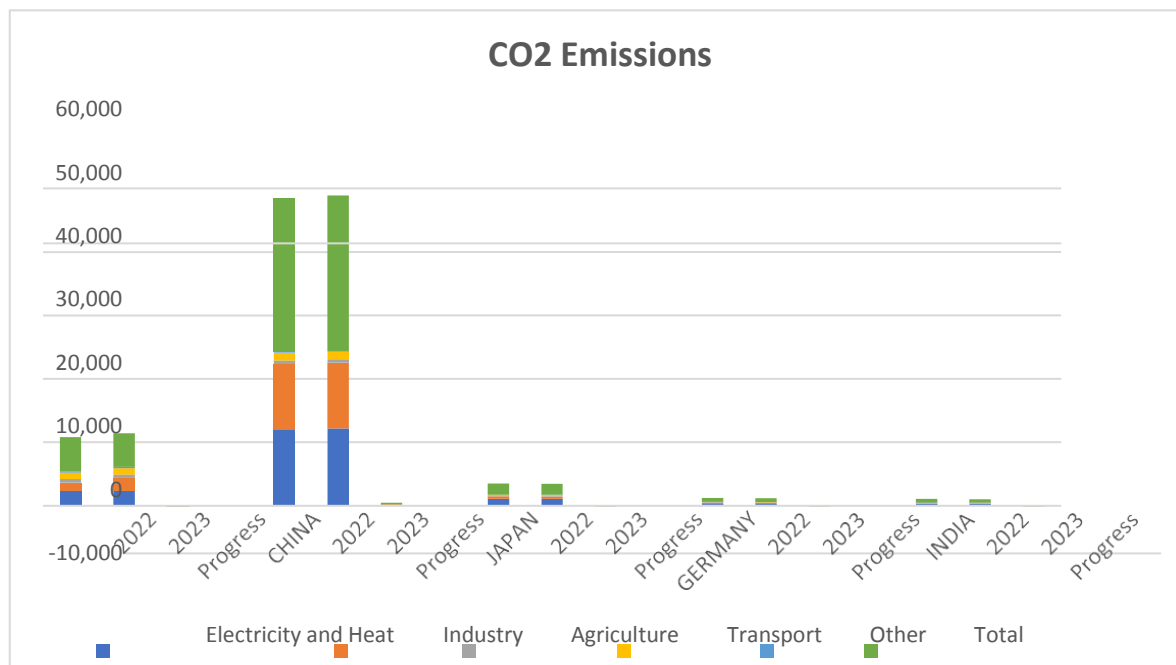
As you can see, Germany has the highest waste conversion rate followed by Japan. This is likely due to a number of factors such as the availability of waste management infrastructure and awareness among the public about the importance of recycling and composting.

Overall the progress in waste to wealth conversion in all the five economies is positive. However, there is still room for improvement.

Table 5: Comparison of top 5 countries on current level of CO2 emissions (in million metric tonnes) and progress scores

Country	Electricity and Heat	Industry	Agriculture	Transport	Other	Total
USA						
2022	2,400	1,200	600	1000	200	5,400
2023	2,350	1,990	590	990	190	5,310
Progress	-50	-10	-10	-10	-10	-90
CHINA						
2022	12,100	10,200	600	1200	100	24,200
2023	12,200	10,300	600	1200	100	24,500
Progress	100	100	No change	No change	No change	300
JAPAN						
2022	1,080	400	144	90	47	1,761
2023	1,060	390	142	89	46	1,727
Progress	-20	-10	-2	-1	-1	-34
GERMANY						
2022	290	195	67	47	16	615
2023	280	190	65	45	15	595
Progress	-10	-5	-2	-2	-1	-20
INDIA						
2022	270	130	75	40	14	529
2023	260	125	73	39	13	510
Progress	-10	-5	-2	-1	-1	-19

Source: Compiled from IEA



Source: Compiled from IEA

As you can see, all the sectors in these countries are estimated a reduction in CO2 emissions in 2023 with electricity and heat sector seeing the largest reduction. This is due to various factors including the governments investment in renewable energy sources, energy efficiency measures etc. In US CO2 emissions declined by 50 million metric tonnes from the electricity and heat sector which is the largest source of CO2 emissions. In India the estimated progress in CO2 emissions from 2022 to 2023 is a reduction 19 million metric tonnes. (The data of 2023 are just estimates and it may vary due to factors such as economic growth, government policies etc.) This is a positive progress towards mitigating climate change in the world.

CONCLUSION

It is true that the world leaders are trying to reduce CO2 emissions. As part of the Paris Agreement, every nation is collaborating to fight climate change. However, the progress in reducing CO2 emissions is slow since there are still number of challenges that they are facing in reducing CO2 emissions such as rapid population growth in India and China, high demand for energy, rapidly growing economy etc. All the countries are heavily investing in renewable energy sources, promoting electric vehicles, enhancing energy efficiency measures, reducing reliance on coal etc. The study has not been able to cover the entire global scenario as the major concern was to compare between top five economies in the world but I have honestly tried to put up a true picture of these countries contributing to climate change to a great extent to the world.

In this study we have seen that these countries are responsible for the majority of the global CO₂ emissions. China is now the world's largest emitter of CO₂ followed by USA and India. All five of the world's largest economies have seen an increase in CO₂ emissions during the past 45 years. When it comes to comparison between countries on the basis of CO₂ emissions per unit of GDP, India has the lowest CO₂ emissions while China has the highest. In the study I have also been able to evaluate that waste-to-wealth conversion and the progress in reducing CO₂ emissions in 2023 is positive in all the top five economies in the world.

Climate change is a serious threat to our planet and our way of life. We all have a role to play in reducing our impact on the environment. We can do this by reducing our carbon footprint, supporting renewable energy, divesting from fossil fuels, and promote climate action. Together, we can create a more sustainable future for ourselves and for generations to come.

REFERENCES

- IEA. <https://www.iea.org/data-and-statistics/data-sets/?filter=emissions>
- World Bank. <https://www.worldbank.org/en/home>
- EPA. <https://www.epa.gov/>
- Ministry of Environment, Japan. <https://www.env.go.jp/en/>
- Federal Statistical Office, Germany. https://www.destatis.de/EN/Home/_node.html
- National Bureau of Statistics of China. https://www.destatis.de/EN/Home/_node.html
- IPCC. <https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr/>
- CCPI. <https://ccpi.org/>
- Invest India. <https://www.investindia.gov.in/waste-to-wealth>
- Mukherjee, P., and K. Ahuja. "A Comparative Assessment of Sustainable Economic Development among the G20 Countries"
- Nicholas Stern. 2006. "The Economics of Climate Change: The Stern Review" http://mudancasclimaticas.cptec.inpe.br/~rmclima/pdfs/destaques/sternreview_report_complete.pdf