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Rising Costs of Climate Change and Pollution: A Comparative Case Study of India and the United States

Authors:

First author: Abhiraj Singh Rana

Second author: Dr. Manisha Raj

Institutional affiliation: Amity University, Noida

- **Abstract**

According to the Global Climate Risk Index 2021, India was the 7th most affected nation by climate change. The brunt of climate change has been evident in a monsoon driven country like India, in the way of growing unpredictability in rainfall, rise in annual median temperature, irregular flooding and frequent droughts. In comparison, while the United States of America happens to be the 2nd greatest emitter of carbon dioxide, it did not feature in the Global Climate Risk Index 2021, indicating an enhanced resilience to the climate change phenomena. This study aims to assess the impact of this phenomena on India and draw comparisons with the United States to suggest policy measures and steps that can create a more climate change resilient and sustainable economy for the developing nation.

JEL Classification: Q540, Q560, Q520, R110, D620

Key words: Climate Change, Sustainability, Pollution, Regional Development, Externality

1. Introduction

The notion of global heating and climatic changes was introduced in the 1980, in the background of rapidly rising emissions since the 1970s and a rise of 1.5 degree Celsius in temperatures compared to the previous centuries. Global warming is defined as an increase in combined atmosphere and ocean surface temperatures averaged over the globe and over a 30-year period ("Chapter 1 — Global Warming of 1.5 ºC", 2021). Global warming has already had a significant impact in many regions and seasons, with average temperature rise higher in land areas than above the surface of the ocean. Most regions of the planet have experienced greater global warming than the world average, putting them at more risk than other region in terms of changes in their environment. One estimate suggests that if temperatures rise to 4°C over pre-industrial levels over the next 80 years, global economic losses could mount to $23 trillion per year. In discussions about weather alterations, it is observed that climate change not only includes global warming (driven by human activities) but also large scale changes in weather pattern and characteristics globally. And owing to the variable nature of climate change, it is seen that there will be variability in economic consequences as well. Several literature studying the impact of climate change have agreed that the economic costs of these changes won't be equal for all nations; some nations will suffer severe financial costs while in others, the effect may not be significant and may end up be beneficial. It is vital to take note of, however, that in the long run, the entire world would be severely effected by increasing temperatures and "freakish" variations in weather conditions and seasonal pattern.

Currently, it is seen that the tropical, growing and low-income nations are the highest at risk to the impact of climatic changes, while developed and countries in North-West hemisphere are further resistant and adaptable to these changes, even if in the short run. Warming in some areas may lead to a gain in some sectors, while other sectors may face economic losses. The costs of climatic change can be divided into market prices and non-market costs, with the market costs being quantifiable (measurable in a currency like the US$) while the non-market costs are hard to quantify due to no existing market for them. The primary and secondary sector are the most affected sectors in the economy when it comes to sensitivity to climate changes. For instance, a slight rise in temperature (as much as 0.1-0.5%) in a freshwater river/lake could adversely affect the fish and aquatic life there, adversely affecting the fisheries that depend on these for their revenue and consumption. Similarly, the gradual rise in sea level which threatens to submerge low lying coastal areas is credited to the rise in global temperatures, which in turn are due to increasing CO2 emissions. Similarly, man-made pollution, apart from being an additive to climatic changes, has also several social and economic costs. The rise in cases of chronic obstructive pulmonary disease (COPD), due to enormous air pollution in several areas of the world like Delhi and New York, lead to immense health expenditure both public and private for their treatment, thus diverting health funds which could have perhaps been used for more innovative and productive purpose. Another type of pollution, water pollution, has reduced the crop yield in several rural areas and increased the medical expenses of the households living there.

1.1 United States and Climate Change

United States is the second largest emitter of carbon dioxide emissions in the world after China, while amongst countries with a sizeable population, the US has highest CO2 emissions per capita. In 2019, the United States emitted over 6.5 million metric tons of greenhouse gases. While being a rich country does give the US better resilience to climate alterations than other nations, the low lying and coastal areas of the nation have been found to have already been adversely affected by climatic changes. For instance, fisheries in the eastern regions have been facing a decline in catch rate and yield, due to the death and/or migration of fish species which were unable to adapt to the rise in temperature of their water bodies. In the US, apart from the coastal regions, the Southern states such as Texas, Florida et cetra are the ones most severely affected, so much so that certain natural disasters and events have amounted to billions of USD worth of losses. Since 1980, the United States has undergone 285 climate and weather-related disasters, costing greater than $1.875 trillion in

total. In 2013 there were 11 weather events and climate disasters with more than $ 1 billion in losses each in the USA. In all, the loss of 11 events was more than $ 110 billion. 2013 was the warmest year in the United States of America and almost a third of all Americans experienced ten or more days of 100-degree temperatures. These extreme and severe weather situations have put immense pressure on existing disaster relief efforts. For example, an increase in wildfires, a growing fire duration, and increasing temperatures have put pressure on both domestic and international resources and facilities. In the US, state firefighting efforts exceeded $ 2 billion a year for the first time in 2017, and this amount was doubled in 2018.

The authorities have however taken steps to combat and mitigate the effects of climate breakdown, by the passing of and implementation of certain laws and policy outlines. One of the most famous programs to combat air pollution in USA was the sulphur dioxide (SO2) allowance-trading programme established under Title IV of the 1990 Clean Air Act Amendments. (CAAA), was the world's first large-scale pollutant cap-and-trade system ('Allowance trading' and 'cap-and-trade' are synonymous.). The stated purpose of the Acid Rain Program was to reduce aggregate yearly SO2 emissions in the US by ten million tons relative to 1980, when total US emissions were about 26 million tons. In a departure from conventional environmental regulation, the legislation did not prescribe how power plants would reduce their SO2 emissions. Instead, with a phase-in beginning in 1995 and culminating in 2000, the statute capped aggregate SO2 emissions at the nation's 3,200 coal plants and created a market for firms to buy and sell government-issued allowances to emit SO2. By 2007, annual emissions had declined below the programme's nine million ton goal (a 43% reduction from 1990 levels), despite electricity generation from coal-fired power plants increasing more than 26% from 1990-2007 (EPA 2012; EIA 2011). There are several reasons why Acid Rain Program had been successful. Of critical importance is the non-existence of prerequisite for regulatory pre-approval of single transactions. Like the Lead Trading Program, the sulphur dioxide program dispensed with curbs and cumbersome bureaucracy that characterized the EPA ET program. Title IV took the further steps of explicitly recognizing the right to emit (albeit at a reduced quantity) and then determining conformity established on an account of all discharges, not just the differences from the agreed-upon baseline. The Sulphur dioxide trading programmes success prompted several European nations as well to adopt similar measures to combat rising air pollution. While there is still a lot more the country can do to combat climate change, certain policy frameworks and measures adopted by it could be implemented or used in developing nations as well, who are perhaps the most vulnerable to climatic changes.

1.2 India and Climate Change

Even though India just ranks 140th in terms of per capita emissions worldwide, it is the third biggest emitter of carbon dioxide gas due to its huge population. India also happens to be positioned as the 7th worst affected nation from climate change, as per the global Climate Risk Index. According to the Economic Survey report of 2019-2020, India suffered losses worth 9-10 billion USD per annum, due to severe climate occurrences like droughts, cyclones, flooding et cetra. Climatic alterations in the country has adversely altered the crop yield in several areas, apart from damaging infrastructure, reducing industrial output et cetra. For instance ,the Economic Survey pointed out that 2014 floods in Kashmir cost the country more than 15 billion USD, while the Cyclone HudHud in the same year cost 11 million USD. In addition to the costs incurred due to damage to infrastructure and trade, the loss of lives and mortality further exacerbates the situation. Certain regions, more prone to vulnerability to climate change, end up losing out on development compared to more resilient regions, thus increasing the inequality gap. Since agriculture is still the largest employer, followed by the construction sector, the adverse influence of climate change can and have already often led to thousands losing their income and being pushed further into poverty. It is crucial to take note that majority of the population of the country works in the informal sector, rendering them especially vulnerable to these changes since they lack the wealth and facilities to be additionally resilient to the economic losses. Apart from climate changes, man induced pollution also bears heavy economic losses. In India, air and water pollution are among the major causes of economic losses. According to the Global Burden of Disease Study (GBD) 2019, 1.67 million deaths were a direct consequence of air pollution, primarily from ambient particular matter and household air

pollution. In addition, the premature deaths and morbidity also led to a lost output of USD 28.8 billion. Delhi has the highest per capita economic loss due to air pollution. Similarly, Murty and Kumar (2004) estimated the cost of industrial water pollution abatement and found that these costs account for about 2.5 per cent of industrial GDP in India.

The Indian government and stakeholders have started to take steps to mitigate the impact of climate change and render the country further robust to climatic variations. The National Action Plan on Climate Change (NAPCC) is a major step taken by the central government to alleviate the financial costs from climate change. Another mitigation program implemented in India, is the ETS framework in Gujarat. The Gujarat Pollution Control Board launched India's first ETS—and, the world's first cap-and-trade market in particulate pollution—on July 15, 2019, in the manner of a large-scale pilot programme in Surat, Gujarat. The Surat ETS began with two months of mock-trading to allow for intensive stakeholder capacity building before coming into full force on September 15, 2019, in collaboration with the National Commodities and Derivatives Exchange. This ground breaking step by the state of Gujarat represented the realization of an idea that was first conceptualized by the Ministry of Environment, Forests, and Climate Change (MoEFCC) in 2012 in sync with the state boards of Gujarat, Maharashtra, and Tamil Nadu. The GPCB has partnered with researchers from top intellectual institutes around the world to develop ETS rules and evaluate the benefits and cost. Thus, even though India has taken several steps to tackle climatic changes and alterations and boost investment in renewable energy, it still needs to work extensively in this direction to reduce the vulnerability of the economy. This paper draws comparisons to the economies of United States and India and aims to find measures and policies which could work in the developing economy as well.

2. Literature Review

India and US, both are geographically large countries with diverse climatic conditions in different regions. India's geographical landscape consists of the snow capped mountains in Jammu and Kashmir, to the coastal areas in the southern states of Kerala and Tamil Nadu, to name a few. Similarly, Florida in the United States has a tropical climate owing to its proximity to the ocean, while the state of Alaska's average temperature in summer alone ranges from 4 to 15 degree Celsius, going below zero in the winters. **Sen et al. (2015)** observed that due to an increase of 1.2 degree Celsius in the annual average extreme temperature in the lower half of the Kullu Valley (located in Himachal Pradesh) in the period of 1985-2009, a shift was found in the apple cultivation belt, that happens to be one of the most important exports and products of the state. These changes, primarily significant rises in the temperature in the region, have led to a depletion in the production of commercially and traditionally important apple varieties, in addition to a switch to alternate crops in the region. This loss in yield of apples poses a threat to one of the major exports for the state of Himachal Pradesh, adversely effecting several apple cultivators, vendors et cetra. This kind of an impact is visible in other regions of the country as well, albeit for different industries. **Hsiang et al.(2017)** develops a framework to estimate and compute damages from climatic changes. The value of these damages increases with every increase in global mean temperature. Risk due to climatic changes was not distributed equally around sites in the United States; while some locations such as the seaside regions would face several economic losses, other regions such as those in the extreme north and west may not be unfavourably impacted, and in fact may actually gain from the rise in temperature (Alaska for example). This transfer of value would increase income inequality across the country. Several prominent literature has found that the increase in likelihood of natural disasters and flooding due to rise in sea level were positively linked with rise in temperature by at least around 1.5 degree Celsius in the study, thus further heightening volatility in loss of life and financial losses for certain vulnerable areas in the country. **Frame et al.(2020)** attributes increasing economic risks globally to human induced changes in the climate systems. Taking the case study of New Zealand for the period of 2007-2017, the authors' find that occurrence of severe occurrences like forest fires, droughts and floods have heightened in frequency rather unpredictably, mainly due to climatic changes which are non-static.

When assessing the impact of climate change in India, one cannot ignore its metropolitan cities. **Murali et al. (2019)** assess the effect of climate change and pollution on the financial capital of India- Mumbai. Having one fourth of its area falling under low lying area, the city has been prone to excess flooding every year, with the poor and slum dwellers being the most immensely impacted because of low climate change resilience and capital to adapt. The trend in increase in rainfall, along with the poor drainage system of the city, puts it at risk to face an increase in frequent floods in the coming years. With coastline destruction and precipitation rising, along with rise in populace density and unplanned urban ecosystem, Mumbai remains extremely vulnerable to climate change. Rising sea level has also other secondary risks apart from flooding, such as inundation, spread of waste into even fresh water bodies, mangrove degradation et cetra. **Birthal et al. (2014),** in their study, analyse the variations in temperature and rainfall for the years 1969-2005, in particular to draw a conclusion on in what way they have impacted the produce of crucial food crops in India. Observing an rise in both monthly and yearly maximum temperature, the authors' find a negative connection between harvest produce and this rise in temperature. However, in certain areas with predominantly cold weather all year round, the rise in minimum temperature was actually beneficial for crop yields, which I found to be similar to the West European nations and Canada, who are likely to actually benefit from the rise in temperature. According to the study, rise in precipitation did have a positive effect on crop yield in several areas in the Northern plains, however it was not able to offset the negative impacts of rise in temperature. Further, the analysis indicated that the negative impact of maximum temperature was greater than the optimistic impact of minimum temperature because the positives of a rise in minimum temperature was unable to compensate for a rise in highest temperature. The study points out to the looming problem of food security due to climate change for a country that already faces problems in ensuring access to food to lower income groups. It suggests measures such as growing drought resistant crop breeds, watershed management et cetra to avert losses in crop yield.

Taking the case of the United**,** a paper the using global climate models (GCM) and relating them with fish capture rate yields in North-eastern United States fisheries, found a negative relation between the yield in fish catch and rise in temperature and CO2 emissions States (**Pendleton and Mendelsohn, 1998)**. The climatic changes are projected to adversely affect these fisheries, and even the consumers, since the low yield could lead a rise in prices. **Mendelsohn et al.(2006)** in his study compares the impact of climatic changes and global heating on developed and developing economies, using the indicators of impact per capita and impact per GDP. The authors' note that when looking at the agriculture sector, farmers in cooler regions that have a temperature below the 'optimum temperature', warming could cause revenue per capita to increase. For farmers and cultivators in tropical or warm climates beyond the optimum temperature, warming further could lead to a fall in generation of revenue. These results mean that countries are situated in relatively cool regions of the world would actually benefit to an extent from the warmth and that of those countries which are situated in the warmer regions of the world will face economic losses due to a further rise in temperature. Its important to know however, that in the long term, the economic losses from global heating will outweigh the pros.

Thaker & Leiserowitz (2014) points at increasing awareness of India's vulnerability to climate change, especially for the deprived and rural Indians, amongst the awareness yet chosen ignorance of some wealthy industrialists, have led some to re-examine the Indian growth approach, where the profits of economic growth to the marginalised communities haven't been significant; they haven't trickled down to the grass roots as had been thought initially. When including the effect of the COVID-19 pandemic on the existing climate change phenomena, it was seen in several nations certain short term variations in their surface air quality and other natural bodies. **Andreoni (2021)** analyses the variations in carbon dioxide emissions in 23 European countries, during the COVID-19 pandemic. Due to the pandemic and subsequent lockdown, there was a huge reduction in economic activity for the first 6 months of 2020. Trade, retail, wholesale, transport and food services had the most amount of reduction in emissions generated] Thus, the restrictions in lieu of COVID-19 led to a decline in carbon intensive production activities in these countries, opening scope for a further analysis into finding ways of reducing emissions in the long run. However, sacrificing economic activity to the extent that took place during the lockdown would be disastrous for the economy of any nation. It is thus crucial to find ways to mitigate the negative effects of climate change and yet ensure development and economic growth takes place without harming the needs of the future generation.

3. Research Objectives

1. To analyse the socio-economic impact of climate change on India.

2. To identify the successful measures taken by the United States in combatting rising pollution costs.

3. To suggest policy recommendations and measures that can be taken by the concerned authorities to help mitigate the rising costs of climate change and pollution in India.

4. Research Methodology

This paper uses secondary information as its basis for analysis. Secondary data is the research data that has been gathered previously by others and can be retrieved by others. In this paper, secondary data has been collected from organizational databases, websites, books, journals and other research papers. By using secondary data pertaining to the effect of climate change on the economies of US and India ,a proper assessment of the socio-economic situation in the two nations, and how they can mitigate the impact of these changes can be done.

5. Data Analysis

Analysis for links between climatic alterations and economic losses begins with analyzing the connection between the certain variables of the two. Before we analyse the economic effect of climate change on USA and India respectively, the paper first takes a look at the global economic damages from natural disasters, in particular from wildfires, extreme weather and flooding whose causes are credited directly to climate change and pollution.

Table-1: Global economic damage from natural disasters, differentiated by disaster category and measured in US$ per year.

Year	Economic loss due to Wildfire (in USD billion)	Economic loss due to Extreme weather (in USD billion)	Economic loss due to Flooding (in USD billion)
2000	2.56	12.96	25.8
2001		14.55	4.75
2002		14.75	26.83
2003	6.09	21.36	20.87
2004		84.23	10.38
2005	3.85	184.79	17.94
2006		17.7	7.81
2007	4.6	29.56	24.59
2008	2.53	60.73	19.62
2009	1.51	26.13	8
2010	2.07	28.12	49.14
2011	3.14	50.87	70.76
2012	1	85.73	25.79
2013	1.07	52.39	54.78
2014	0.259	40.11	36.23
2015	3.44	33.05	21.09
2016	6.29	45.11	57.38
2017	1.02	122.12	15.78
2018	22.75	59.25	17.44
2019	80*	137*	10*

Source: EMDAT (2020): OFDA/CRED International Disaster Database, Université catholique de Louvain – Brussels – Belgium

It is interpreted from Table-1 that the period of 2000-2009 suffered less economic damages from climate change compared to 2010-2019 period, in spite of more climate change awareness and attempted mitigation activities taking place across both developed and developing nations. The difference in economic costs was over 251. 689 billion USD.

Sum total of economic damages (2000-2009)= $654.49 billion-(1)

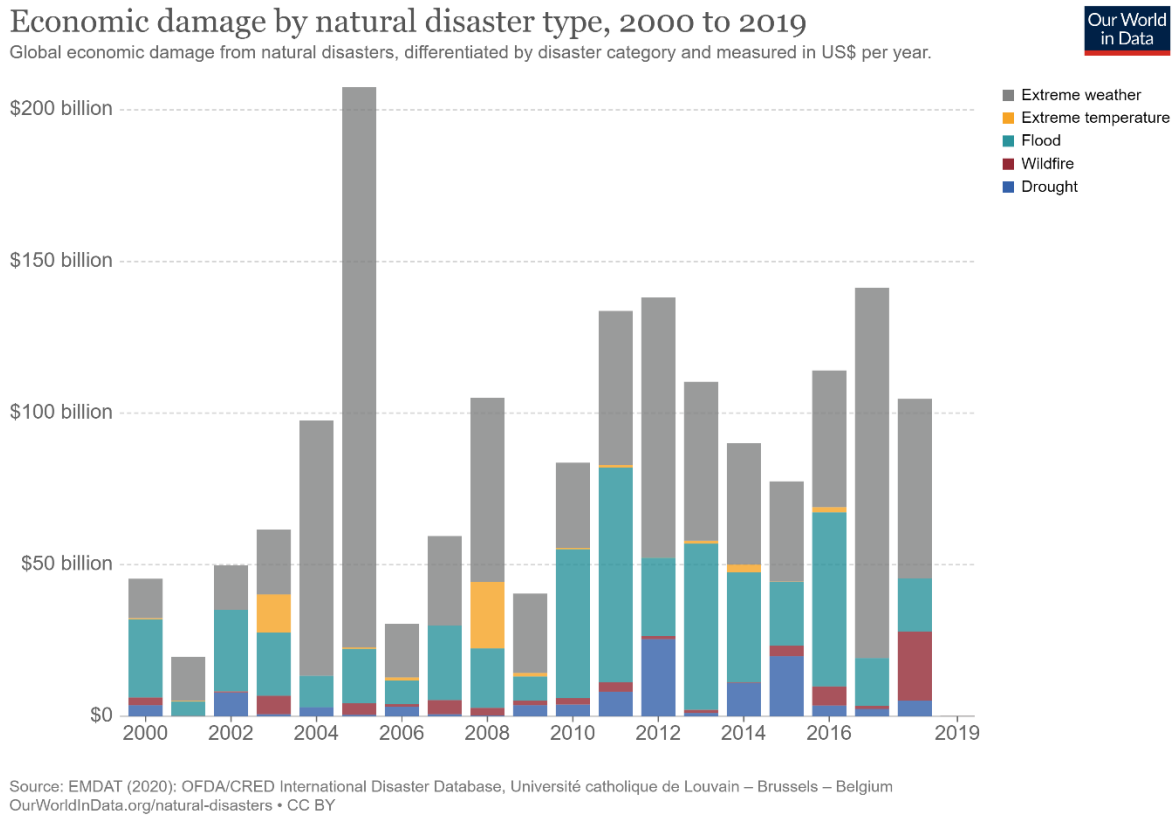
Sum total of economic damages (2009-2019)= $906.179 billion -(2)

Subtracting (1) from (2), we get

Difference in economic damages= 906.179-654.49 = $251. 689 billion

The worldwide economic losses increase by 38.45% due to climate changes and weather alterations. Figure-1 below further shows the periodic economic damages globally from other climate change led disasters as well.

Figure-1 Bar diagram economic losses from natural disasters.



One may see from the above figure that extreme weather events contribute the maximum share to economic damages from natural disasters. Extreme weather conditions, as other literature has also discussed, are considered a causal effect of variation in climatic conditions and rising levels of pollution.

6. Findings of the Study

The paper finds that, despite rising consciousness regarding climatic alterations and efforts to curb pollution, the economic damages caused have continued to be on a rise. The United States, while successfully curbed the excess released sulphur pollutants, still suffers from chronic air pollution in several cities, while hydrological bodies' contamination is a key issue in the eastern states of the nation. Rise in quantities of ground level ozone further worsens the quality of air and puts the population at risk of developing respiratory illnesses. In India, it can be seen that the morbidity and rising mortality due to particulate matter pollution causes immense economic losses, particularly to the state and regional governments.

7. CHAPTER-VII Conclusion

The Sulphur trading programme's success in the United States, along with the Water Shedding Program to restrict the levels of dissolved nitrogen in fresh water bodies proved vital in reviving productivity of those regions, decreasing medical expenditure due to pollution-borne diseases and increasing the yield of fish incase of the water shedding program. In India as well, the ETS programme has a lot of potential to curb pollution in the town of Surat, however, to curb pollution on a large scale, the ETS programme or new programmes to curb air pollution can take certain lessons from the US Sulphur trading scheme. It is crucial to incentivise industries to invest in technology that reduces the particulate matter content of smoke and other emissions from the factories, as what took place in the United States of America. In addition, using command and control and other pollution curbing measures, India should introduce a uniform framework to curb pollution so that one city or region doesn't bear the brunt of pollution in the search for being attractive for business. Similarly, a clamp down on coal mafias and other illegal fossil fuel generation enterprises needs to be carried out, especially in the states of Jharkhand and Uttar Pradesh, and bring them under a trading scheme that is both profitable and yet reduces the release of particular matter in the air. As for water pollution, the Water-shedding management program of the United States can serve as an motivation for India to curb pollution and spruce up the rivers like Markanda (490 mg/l BOD), river Kali (364), river Amlakhadi (353), Yamuna canal (247) et cetra. Creating a permit based scheme and providing the facility to trade these permits can incentivise the private sector to be involved in the cleaning up and conservation of these rivers. In addition, including the indigenous populace and making them stakeholders would prove to be useful in the long term to curb pollutant amounts in these water bodies.

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