Climate Risks in India – A Performance Analysis

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Abstract

The climate in India is generally monsoonal whilst at the same time possessing a wide variety that ranges from tropical in the south to temperate and alpine in the Himalayan north. India's climate is strongly influenced by the Himalayas and the Thar Desert. The Himalayas act as a barrier to cold winds from central Asia, keeping most of the country warmer than other places found at similar latitudes around the world. The Thar Desert attracts the summer monsoon winds from the south-west regulating the rainy season. Under a low emissions scenario projected temperature variations will remain contained under +1.5°C, both by 2050 and 2100. Under a high emissions scenario, with no reduction in GHG emissions, much greater temperature anomalies are expected by both 2050 and 2100. Climate Risk is the potential for negative consequences for human or ecological systems from the impacts of Climate Change and also recognises the different values and preferences that people have towards the human or ecological systems at risk. The IPCC defines climate risk as a function of hazard, vulnerability, and exposure. These are termed determinants of risk. The framework acknowledges response to climate risk as a critical component that influences all three determinants of risk. Burning fossil fuels, cutting down forests and farming livestock are increasingly influencing the climate and the earth's temperature. This adds enormous amounts of greenhouse gases to those naturally occurring in the atmosphere, increasing the greenhouse effect and global warming. Risk is used mainly to talk about the potential effects of climate change, but it may also result from the measures that we take to respond to those changes. Based on these implications, this paper analyses the nature and trend of Climate Risk of India and Climate performance of India their relationships and India's climate policy initiatives. Methodology: Analysis would be based on India's Climate Risk Index (2014-2019) Data and

the Climate Change Performance Index (2007-2023) data released by German watch, New Climate Institute and Climate Action Network

Keywords: Climate Risks, Climate Performance, Climate Policy

Introduction

Climate risk occurs due to uncertain changes in climate and to create adverse consequences for human or ecological systems. This includes impacts on lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, services provision, ecosystems and species.

The IPCC defines climate risk as a function of hazard, vulnerability, and exposure and are termed as determinants of risk. (IPCC,2020). There are two types of Climate risks such as Physical Climate risks and Transition climate risks. Physical climate risk takes into account both the direct physical impacts of climate change (such as floods , droughts. Rainfall variation, losses caused by direct damage to assets, Shocks such as, storms or wildfires changes in precipitation, rising temperatures and seasonal shifts. Transition climate risks are risks related to a transition away from fossil fuels and other greenhouse gas (GHG)-emitting activities of different sectors of the economy. Burning fossil fuels, cutting down forests and farming livestock are increasingly influencing the climate and the earth's temperature. This adds enormous amounts of greenhouse gases to those naturally occurring in the atmosphere, increasing the greenhouse effect and global warming. (EPA,2023)

Climate Disasters in India

India experienced extreme weather events on 235 of the 273 days, or a little over 86% of the days from January 1 to September 30, 2023. These events claimed 2,923 human lives, affected 1.84 million hectares (ha) of crop area, damaged 80,563 houses and killed over 92,519.

Rainfall Pattern

Monsoon 2023 has been deficit to the tune of 5.6% of LPA, which according to IMD falls under ‘normal’ rainfall category. However, a closer look suggests that the rainfall distribution has been skewed by large margins. A total of 221 out of 717 districts remain deficient to large deficient as of September 30, 2023.Out of 36 meteorological subdivisions in

the country, 26 subdivisions recorded normal rainfall, constituting 73% of the area of the country. Meanwhile, seven subdivisions recorded deficit rainfall that covers 18% of the area of the country. Only three subdivisions witnessed excess rainfall amounting to an area of 7% (Neel Kamal ,2023)

Floods in India

Floods in India are among the most destructive natural disasters, accounting for nearly 40 per cent of all disaster-related deaths in the country. Between 1980 and 2017 alone, India experienced as many as 235 major floods. These calamities claimed the lives of about 126,286 people and severely affected the living conditions of around 1.93 billion individuals. The recurring floods not only take away thousands of lives but also cause large-scale disruption to livelihoods, infrastructure, and the economy.

One of the most devastating events took place in 2005, when Mumbai was hit by unprecedented rainfall. The city recorded 567 millimetres in a single day, leading to massive flooding that claimed the lives of at least 1,094 people. The disaster paralysed India's financial capital and left long-lasting effects on its civic and social systems.

Similarly, in 2008, Lucknow witnessed heavy flooding caused by the overflow of the Gomti River. This disaster affected more than 100,000 residents, damaging homes and essential services, and forcing many people to abandon their belongings in search of safer ground.

In June 2013, another severe calamity struck the northern states of India. Torrential rains triggered heavy floods and landslides in hilly regions, resulting in one of the deadliest disasters in recent decades. More than 5,700 people were reported dead, while thousands of others were left homeless and stranded in remote areas. The tragedy highlighted the vulnerability of people living in mountainous terrains and the urgent need for better disaster preparedness and relief measures. June 2015 Gujarat flood: The wild life of Gir Forest National Park affected besides 75 human death. Nov-Dec 2015 resulted in flooding of Adyar, Cooum rivers in Chennai, Tamil Nadu resulting in financial loss and human lives. Kaziranga National Park was affected by 2016 Assam Floods killing around 200 wild animals. 2017 Gujarat flood resulted 200 deaths. August 2018 Kerala Flood caused445 deaths. in late July and early August 2019, series of floods that affected over nine states in India including Kerala, Madhya Pradesh,

Karnataka, Maharashtra and Gujarat in October 2020 Hyderabad Flood caused 98 fatalities. During 2021. Floods occurred in Uttarakhand, Maharashtra and Assam. Nearly 1300 villages of were affected in May 2022 due to heavy Balarampur Floods.

Droughts in India

Since 1997, the drought-prone regions of India have expanded by almost 57 per cent, showing a sharp rise in the vulnerability of the land to water scarcity. This growing challenge has left a significant portion of the country struggling to cope with recurring dry spells.

Between the years 2020 and 2022, nearly two-thirds of India's geographical area came under the grip of drought. Such widespread conditions had severe effects on agriculture, rural livelihoods, and the availability of drinking water in many states, causing distress to millions of families.

Over the past ten years, close to one-third of the districts in India have faced more than four drought situations. This shows how frequent and repetitive the problem has become, making it increasingly difficult for affected regions to recover before the next cycle of water shortage begins.

On average, drought impacts nearly 50 million people across the country every year. The consequences are not limited to crop losses but extend to food security, health, and economic stability, highlighting the urgent need for stronger water management and long-term resilience strategies. 2009, Wildfires erupted in Bundelkhand with 40-50% deficit. Over 400 million people impacted nationwide. 2014-2016 Central India's Bundelkhand region faced successive drought years. Acute water shortage emerged. 2019 Parts of Tamil Nadu, Karnataka, Andhra Pradesh reported crop failures due to moisture stress. The SRM Institute of Science and Technology, India, and Skolkovo Institute of Science and Technology, Russia attempted a long-term forecasting of droughts in India. They adopted the deep learning machine model called "long short-term memory" to analyse rainfall and drought conditions of 117 years using the average monthly forecast from 1901 to 2000 and the model is tested with the average monthly forecast from 2001 to 2017.Till 2027, this study says that the states of Karnataka, Gujarat and Uttarakhand would be affected by severe drought while Arunachal Pradesh, Rajasthan, Haryana, Kerala, Maharashtra, Punjab, Tamil Nadu and Telangana would be affected by moderate drought(Richard Mahapatra,2023)

Climate Change Mitigation Policies of Government of India

India envisaged several policy measures to subsidise several effects of climate change in different sectors of the economy. The first initiative was The National Action Plan on Climate Change (NAPCC) was introduced in 2008 under the guidance of the Prime Minister's Council on Climate Change. This initiative marked a significant step towards addressing the growing concerns of climate change in India. Later, in 2015, the Paris Agreement was adopted at the global level, making it legally binding for countries to cut down their carbon emissions. The core aim of this agreement is to restrict the rise in global temperature to 1.5°C above pre-industrial levels, thereby reducing the harmful effects of climate change.

The NAPCC is supported by eight core National Missions, each focusing on a specific aspect of climate action. These include: the National Solar Mission, which promotes renewable energy; the National Mission for Enhanced Energy Efficiency, which works towards reducing energy wastage; the National Mission on Sustainable Habitat, which ensures environmentally friendly urban planning; and the National Water Mission, which focuses on conservation and sustainable use of water. In addition, there is the National Mission for Sustaining the Himalayan Ecosystem, the National Mission for a Green India, the National Mission on Sustainable Agriculture, and the National Mission on Strategic Knowledge for Climate Change. Together, these missions provide a multi-dimensional approach to tackling climate issues in the country.

The guiding principles of the NAPCC are equally important in shaping India's climate strategy. First, it emphasises protecting the vulnerable, especially the poor, through an inclusive and sustainable development path that considers the challenges of climate change. Second, it aims to achieve economic growth and reduce poverty while safeguarding ecological sustainability. Third, the plan encourages efficient and cost-effective measures for managing energy demand at the consumer level. Fourth, it stresses the large-scale and timely adoption of suitable technologies for both adaptation and mitigation.

Furthermore, the NAPCC calls for new and innovative approaches through market-based, regulatory, and voluntary mechanisms that support sustainable development. Finally, it highlights the need for effective implementation by creating unique partnerships with civil society, ensuring that communities and organisations actively participate in climate action. In

this way, the NAPCC combines national priorities with global commitments, aiming for long-term resilience and sustainability, Local government units, and public-private partnerships.(Press Information Bureau,2021)

Sectoral Policies of India to face Climate Change Risks

To the **Power sector** the Policies introduced are: PLI scheme for high efficiency solar PV modules, Repurchase Obligations (RPOs) and Renewable energy certificates (RECs), Green open access, 2022, Development of ultra-mega and mega solar parks,

For the **Industrial Sector** the schemes enunciated are The Perform, Achieve, Trade (PAT), National Motor Replacement Program (NMRP), CBC commercial.

The schemes for the **Agriculture Sector** are Sustainable Agrarian Mission on use of Agro Residue in coal fired Power Plants, National Policy on Biofuels, 2018 and 2022 amendment, Agriculture Demand Side Management (AgDSM), The Kisan Urja Suraksha evam Utthaan Mahabhiyan (KUSUM), Revamped Distribution Sector Scheme – agricultural feeder component under PM KUSUM.

Transport sector schemes include 100 percent railways electrification, The Faster Adoption and Manufacturing of Electric Vehicles (FAME) 1.0 (2015- 2019), 2.0 (2019-), PLI for ACC batteries, BS IV Fuel Economy Standards, Corporate Average Fuel Economy (CAFE) norms,

Residential Sector schemes contain Eco-Niwas Samhita (ENS), Standard and Labelling program (S&L) Unnat jyoti by affordable LED for all (UJALA) c, Street Lights National Program (SNLP), Super-Efficient AC Program (ESEAP), Municipal Energy Efficiency Programme (MEEP), Building Energy Efficiency Project (BEEP). (Jean Chateau et al,2023).

Climate Change Policy Performance Analysis

The central aim of this paper is to examine the effectiveness of climate change policies in India. To achieve this, several variables have been considered, including the Climate Change Performance Index (CCPI), the Global Climate Risk Index, total fatalities, fatalities per 100,000 people, average total losses (in million US$ PPP), average losses as a percentage of

GDP, and the Human Development Index. In addition, budget estimates and actual expenditure on climate change projects have been reviewed, along with the specific actions undertaken by the Ministry of Environment, Forest and Climate Change. The analytical tools applied in this study include the annual growth rate, compound growth rate, and correlation analysis.

The Climate Change Performance Index (CCPI) is jointly released by Germanwatch, the New Climate Institute, and the Climate Action Network. This index evaluates and compares the climate protection performance of 60 to 61 countries, which collectively account for more than 90 per cent of global greenhouse gas (GHG) emissions. The CCPI assesses performance across four dimensions: GHG emissions, renewable energy, energy use, and climate policy. India has received a strong rating in the categories of GHG emissions and energy use, while earning a medium rating in renewable energy and climate policy. The index also notes that India is progressing well towards meeting its 2030 emission reduction targets, which are consistent with a global warming pathway of well below 2°C.

The Global Climate Risk Index, prepared by Germanwatch, presents a broader picture of the impacts of climate-related events and the vulnerabilities associated with them. However, it does not cover certain critical issues such as rising sea levels, melting glaciers, or the increasing acidity and warming of oceans. Instead, the index provides an indication of the level of exposure and sensitivity to extreme weather events. It serves as an important warning sign for countries, urging them to strengthen their preparedness and response measures in anticipation of more frequent and severe climate-related disasters in the years ahead.

Analysis of Climate Change Performance in India through Climate Change Performance Index

Formula for AGR and CAGR

$AGR = \frac{\boldsymbol{Current\ Value}}{\boldsymbol{Previous\ Value}} - \mathbf{1}$, = Annual Growth rate,

$CAGR = \left(\frac{Final\ Value}{Begin\ Value}\right)^{1/t} - 1$ = Compound Growth Rate

Table 1: Global Ranking of India's Climate Change Performance Index

Year	Rank	Scores Out of 100	Annual Growth Rate of Score	Total Countries Participated
2007	9	41		56
2008	5	62.4	0.52	56
2009	7	62.1	0.00	60
2010	9	63.1	0.02	60
2011	10	64.1	0.02	60
2012	23	58.6	-0.09	61
2013	24	60.77	0.04	61
2014	30	57.16	-0.06	61
20 15	31	56.97	0.00	61
2016	25	58.19	0.02	61
2017	20	59.08	0.02	61
2018	14	60.02	0.02	60
2019	11	62.93	0.05	60
2020	9	66.02	0.05	61
2021	10	63.98	-0.03	61
2022	10	68.22	0.07	60
2023	8	67.35	-0.01	63
Annual Average Growth Rate (2007-2023)		0.643		
Compound Growth Rate(2007-2023)		0.030		

Source: Jan Burck Thea Uhlich Christoph Bals Niklas Höhne Leonardo Nascimento, Various issues published by German watch, https://ccpi.org/download/climate-change-performance-index-

Figure 1: Global Ranking of India's Climate Change Performance Index (Actual Scores)

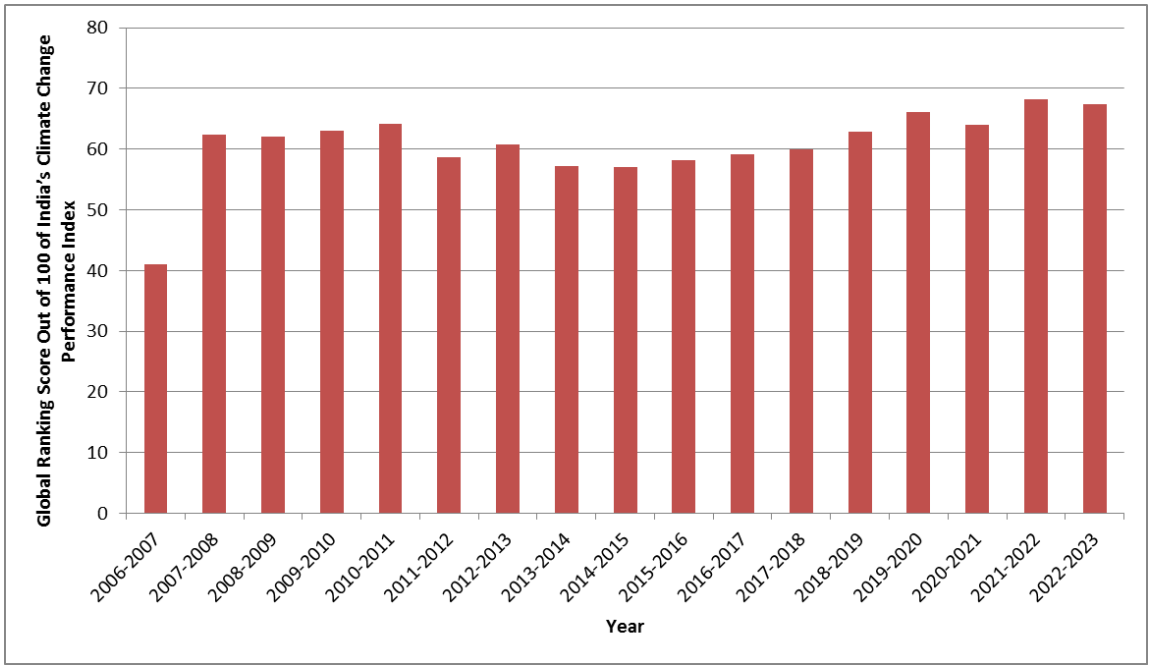


Figure 2: Annual Growth rate of Global Ranking of India's Climate Change Performance Index

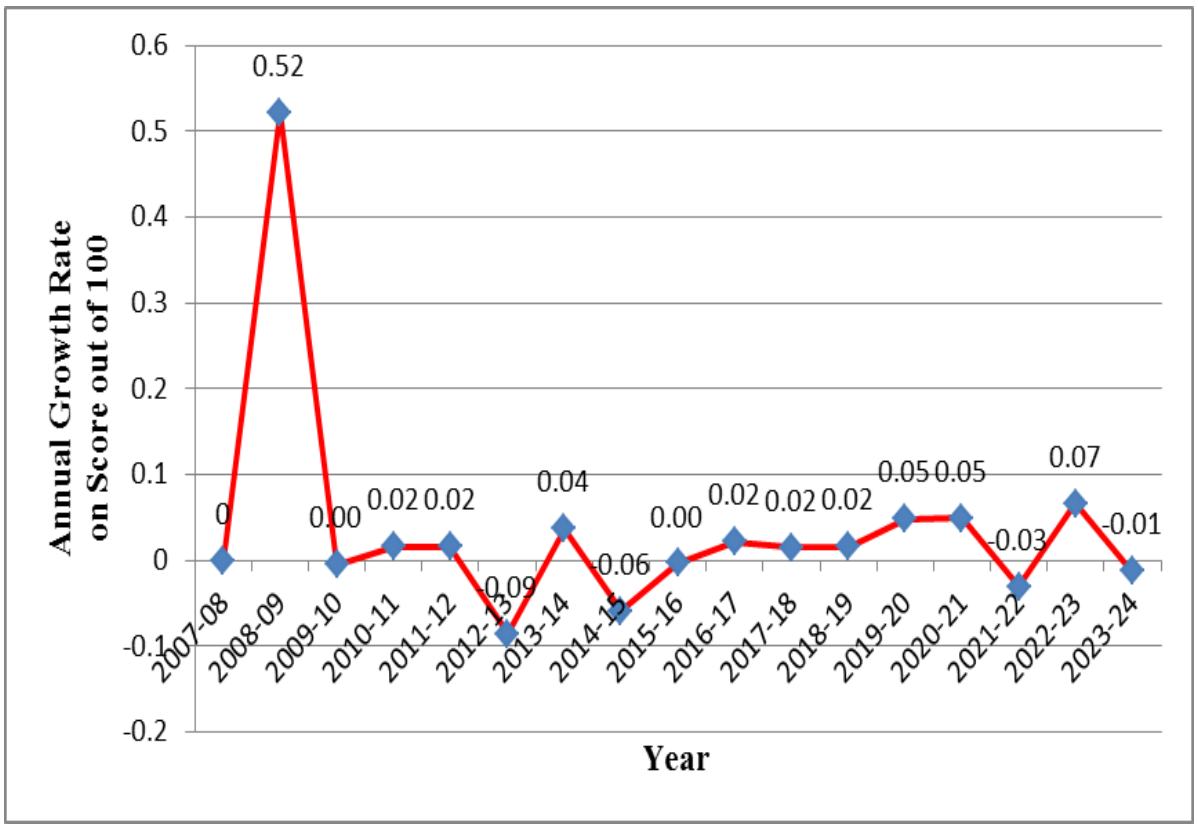


Table 1 explains the global ranking of Climate Change performance of Indian Economy developed by Germanwatch. Rankwise India's rank globally ranges between 2007 to 2023. But score wise during several years such as 2012,2014,2021 and 2023, the annual growth rates of Climate change Performance Index scores are negative. This indicates that India had moved up Rankwise from 10th rank during 2022 to 8th rank globally but score wise decreased from 68.22 to 67.35. The overall Annual growth rates of scores between 2007 to 2023 are 0.643 and low compound growth rate of 0.030..Figure shows the actual scores of Climate Change performance Index highest score secured during 2023 and the lowest one during 2007. Figure 2 shows the annual growth rates of scores wherein highest growth rate is between the years 2007 to 2008.The other years it ranges between.52 to - .09 . These results imply that India need to improve its climate Change performance through its effective policies.

Table 2: Global Ranking of Climate Risk Index of India and its Impact

Year	Rank	Score 100	Annual Growth Rate Score 100	Fatalities (Total)	Annual Growth Rate Fatalities (Total)	Fatalities per 1,00,000 Inhabitants	Annual Growth Rate Fatalities per 1,00,000 Inhabitants	Average Total Losses(in Millian USPPP)	Annual Growth Rate Average Total [illegible]	Average losses per GDP in %	Annual Growth Rate Average losses per GDP in %	Human Development Index
2013	3	12.67		7437		0.6		15147.02		0.22		135
2014	10	16.17	0.28	1863	-0.75	0.141	-0.77	36950.507	1.44	0.4986	1.27	135
2015	4	15.33	-0.05	4317	1.32	0.33	1.34	40071.32	0.08	0.501	0.00	130
2016	6	18.33	0.20	2119	-0.51	0.16	-0.52	21482.79	-0.46	0.247	-0.51	131
2017	14	22.67	0.24	2736	0.29	0.208	0.30	13789.86	-0.36	0.146	-0.41	131
2018	5	18.17	-0.20	2985	0.09	0.16	-0.23	37807.82	1.74	0.36	1.47	130
2019	7	16.67	-0.08	2267	-0.24	0.17	0.06	68812.35	0.82	0.72	1.00	131

Average Annual Growth Rate (2013-2019		0.32		-0.7		-0.72		3.54		2.27	
Compound Growth Rate (2013-2019		0.04		-0.16		-0.16		0.24		0.18	

Source: Various issues published by Global Climate Risk Germanwatch, https://www.germanwatch.org/sites/default/files/Global%20Climate%20Risk%20Index%202021_2.pdf

Figure 3: Global Ranking of Climate Risk Index of India and its Impact on different Variables

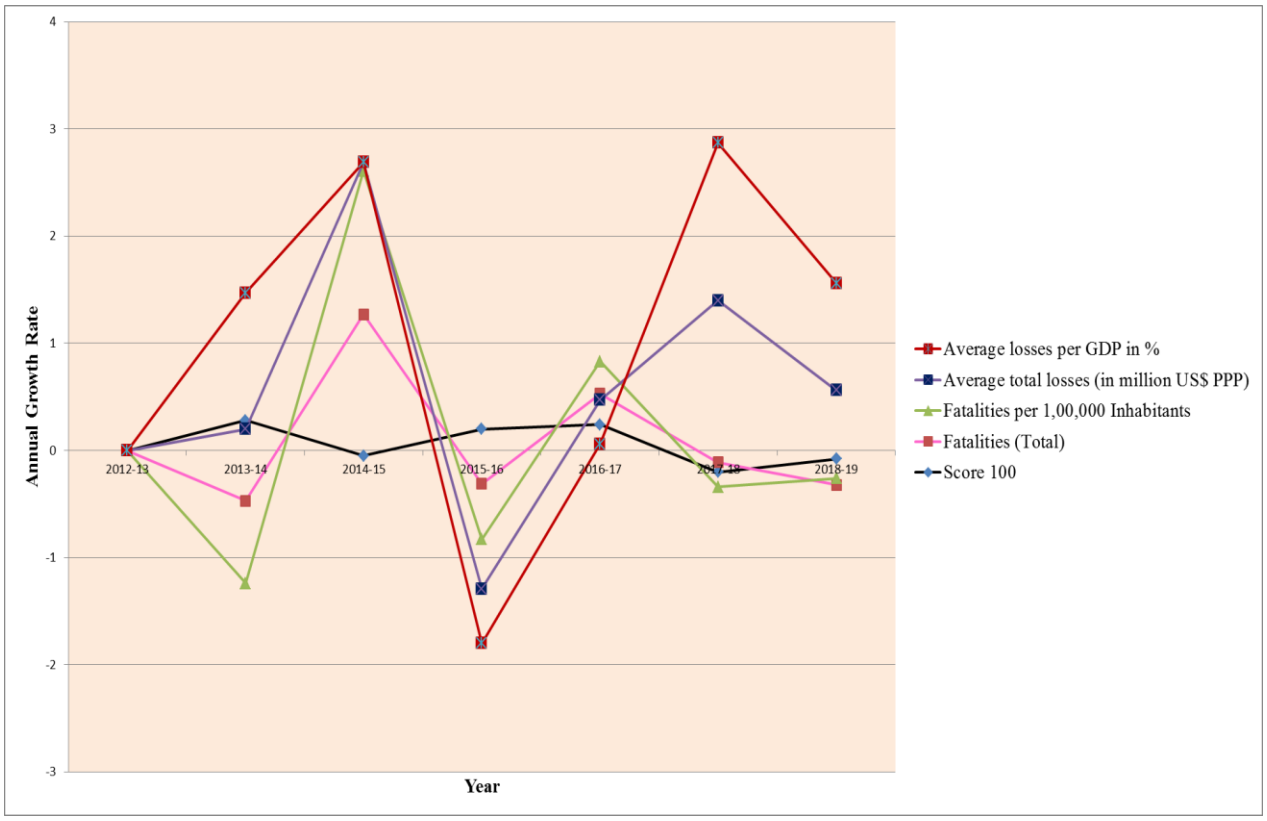


Table 2 explains the Global Ranking of Global Risk Index of India from the year 2013 to 2019.Thehighest Climate Risk year was 2017 where the rank was 14 and the score was 22.67. The lowest risk year was 2013 where the rank was 3 and the score. But contrary to this result the fatalities are high during the year 2013 to the tune of 7437 and lowest in the year 2014causing1863fatalities. Year 2014 also witnessed Fatalities per 1,00, 000.Inhabitants also low to the value of 0.141. Due to various climate risks in India the Average total losses in million US $PPP is highest in the year 2019 such as 68812.35 and lowest in the year to the tune of 13789.86. Likewise the Average losses per GDP in Percentage is also high in 2019 to the tune of 0.72 and lower value of 0.146 in the year 2017.The last column of the table shows the Human Development index of India, remains as not much improvement. The Annual Growth pf these variables are shown in Figure 3.

Table 3: Budget Estimates and Actual Expenditure of Climate Change Project / Climate Change Action Programme of India's Ministry of Environment, Forests and Climate Change

Year	Budget Estimates Rupees in Thousands	Actual Expenditure Rupees in Thousands	Difference	Percentage Over Budget Expenditure
2007-2008	26500	40374	-13874	152.35
2008-2009	35000	34289	711	97.97
2009-2010	72500	60501	11999	83.45
2010-2011	70000	62501	7499	89.29
2011-2012	70000	61501	8499	87.86
2012-2013	223500	20542	202958	9.19
2013-2014	445000	409000	36000	91.91
2014-2015	230000	118183	111817	51.38
2015-2016	250000	128460	121540	51.38
2016-2017	300000	426653	-126653	142.22
2017-2018	395000	268613	126387	68.00
2018-2019	395000	331679	63321	83.97
2019-2020	395000	229924	165076	58.21

2020-2021	400000	326214	73786	81.55
2021-2022	300000	203993	96007	68.00
Average Annual Growth Rate from 2007-2008 to 2021-2022	10.321	4.053		
Compound Growth Rate (2013-2019	0.164	0.107		

Source: Detailed Demands for Grants of Ministry of Environment, Forests & Climate Change, Various Issues, https://moef.gov.in/moef/division/establishment-divisions/budget-and-accounts-ba/detailed-demand-for-grants/index.html

Figure 4: Difference Between Budget Estimates and Actual Expenditure of Climate Change Project/Climate Change Action Programme of India's Ministry of Environment, Forests and Climate Change (Actual Figures)

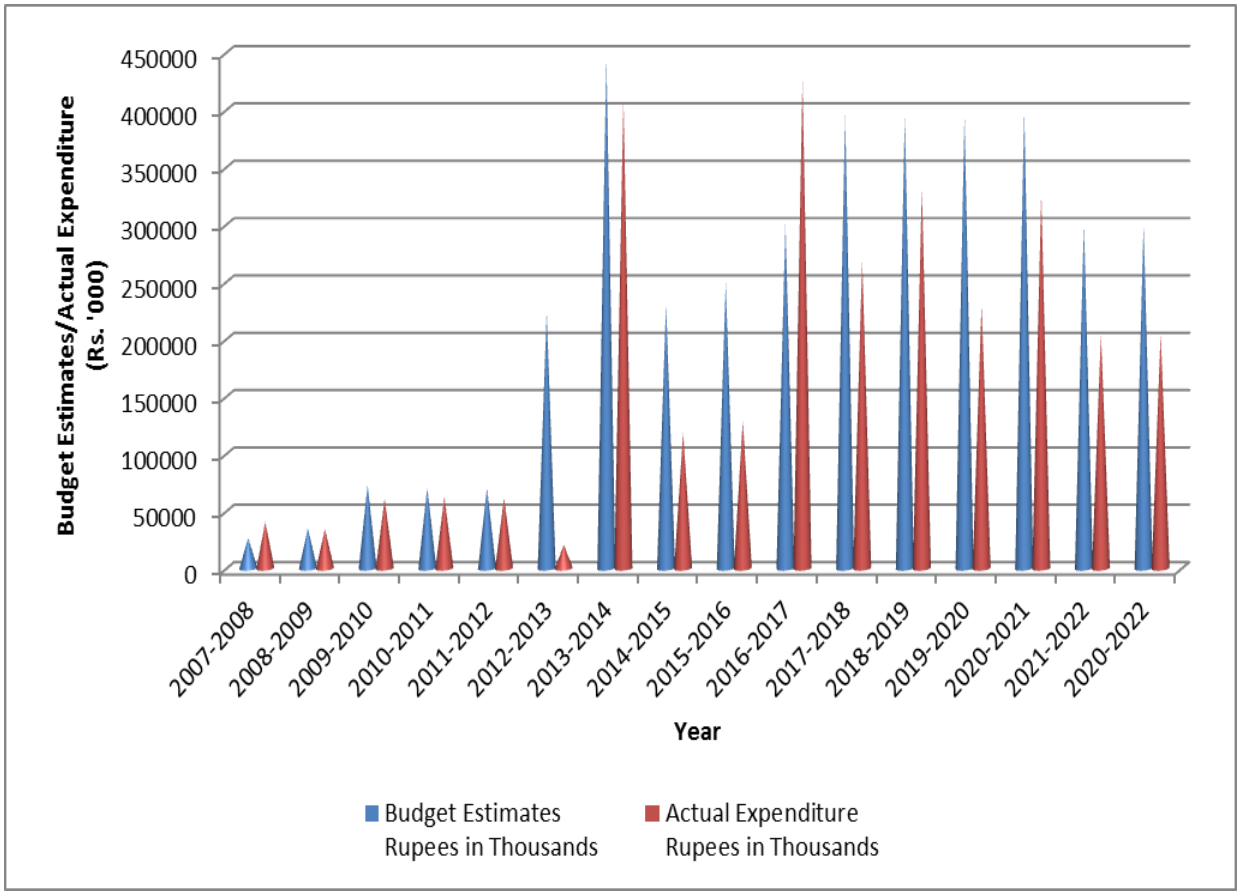


Figure 5: Difference Between Budget Estimates and Actual Expenditure of Climate Change Project / Climate Change Action Programme of India's Ministry of Environment Forests and Climate Change (Percentages)

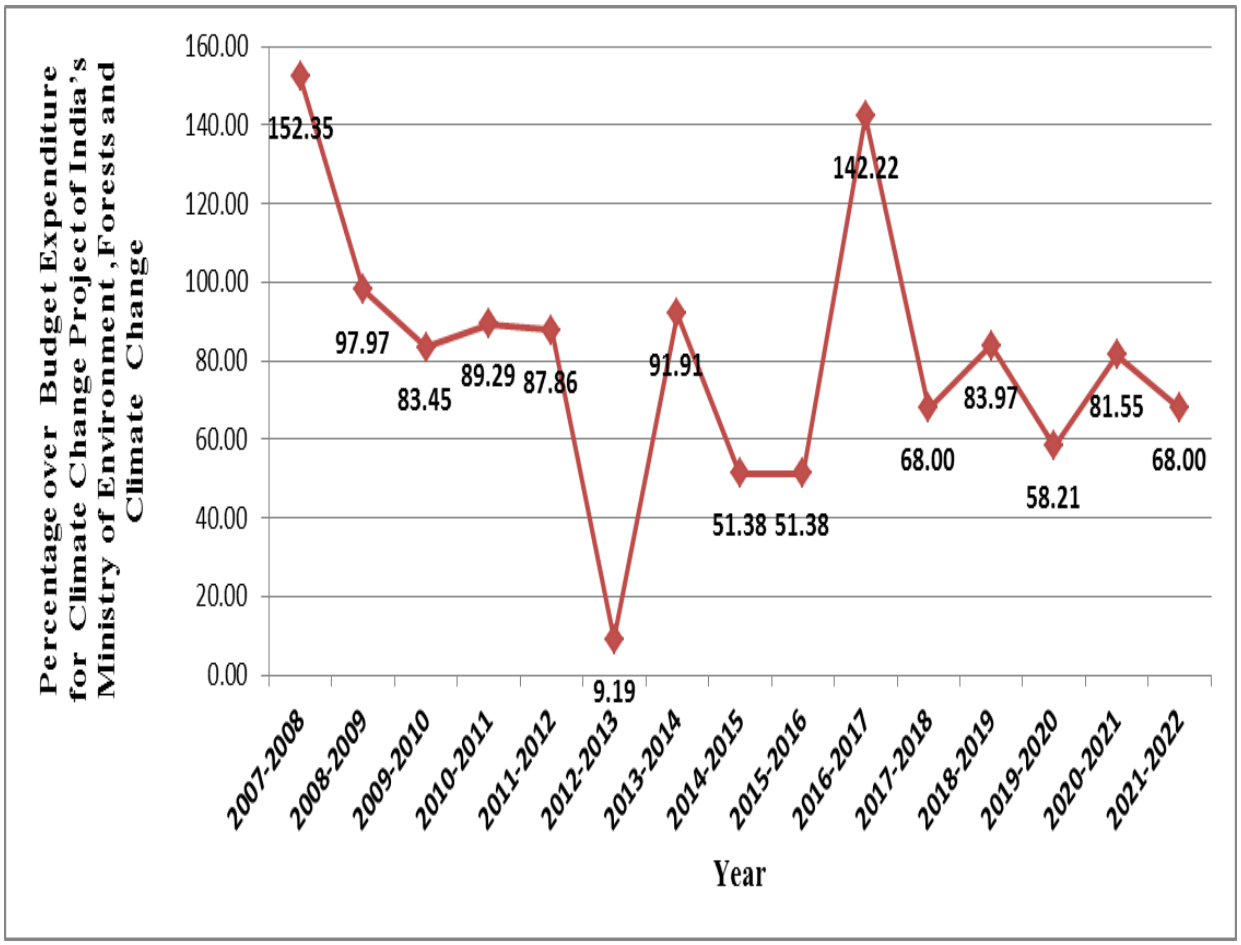


Table 3 shows the Budget Estimates and Actual Expenditure of Climate Change Project/Climate Change Action Programme of India's Ministry of Environment, Forests and Climate Change from the year 2007-2008 to 2021-2022.Except the year 2007-2008 all other years the actual expenditure incurred is less than the Budget estimated amount towards Climate change projects and Climate change action. The difference is high during the tear 2012-2013 and lowest during 2008.-2009. Both Annual and Compound Growth rates of these two variables are positive. For Effective implementation of Climate change orientation programmes actual expenditure is essential. But what is needed is proper utilisation and estimation of performance analysis of actual expenditure incurred, Figure 4 explains the Difference Between Budget Estimates and Actual Expenditure and Figure 5 represents the difference between Budget Estimates and Actual Expenditure in Percentages.

Table 4: Correlation Between Actual Expenditure towards Climate Change Action by Ministry of Environment, Forests, India and Climate Change and Climate Performance Index

Climate Change Performance Index			Actual Expenditure Ministry of Environment and Forests
Year	**Rank**	**Scores Out of 100**	**Expenditure in Thousands**
2007	9	41	40374
2008	5	62.4	34289
2009	7	62.1	60501
2010	9	63.1	62501
2011	10	64.1	61501
2012	23	58.6	20542
2013	24	60.77	409000
2014	30	57.16	118183
2915	31	56.97	128460
2016	25	58.19	426653
2017	20	59.08	268613
2018	14	60.02	331679
2019	11	62.93	229924
2020	9	66.02	326214
2021	10	63.98	203993
2022	10	68.22	203993
2023	8	67.35	

Correlation Coefficient Analysis between Climate Change Performance Index and Actual expenditure on Climate Action by Ministry of Environment, Forests and Climate.

A **correlation coefficient** reflects how similar the measurements of two or more variables are across a dataset.

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{[n\Sigma x^2 - \Sigma x^2]\,[n\Sigma y^2 - \Sigma y^2]}$$

n = Quantity of information

Σx = Total of all values for climate change performance index

Σy = Total of all values for expenditure of Ministry of Environment and Forests, India

Σxy = Sum of product of climate change performance index value and Expenditure of Ministry of Environment and Forests, India value

Σx^2 = Sum of squares of the climate change performance index

Σy^2 = Sum of squares of an expenditure of Ministry of Environment and Forests, India

Table 5: The association between India's Climate Change Performance Index (CCPI) and the spending of the Ministry of Environment and Forests is significant

Pearson's Correlation Coefficient	CCPI Rank	CCPI Scores Out of 100	The expenditure of the Ministry of Environment and Forest, India
CCPI Rank	1		
CCPI Scores Out of 100	-0.249	1	
The expenditure of the Ministry of Environment and Forest, India	0.281	0.218	1

Source: The Author's own calculation using secondary data.

Results and Discussion

The correlation coefficient measures the strength of the linear relationship between variables. The Pearson correlation coefficient is applied to estimate the relationship between the climate change performance index score and the expenditure of the Ministry of Environment and Forests in India plays a vital role in shaping the country's climate change response. Statistical analysis shows that the calculated value of r is 0.218, which indicates a positive correlation between the Climate Change Performance Index (CCPI) score and the ministry's expenditure.

This relationship suggests that an increase in financial allocation is associated with an improvement in climate change performance. Specifically, the results reveal that for every one per cent rise in expenditure, there is a corresponding increase of 0.218 per cent in the CCPI score. This finding highlights the importance of sustained investment in environmental projects, as financial support directly contributes to strengthening India's performance in global climate indicators.

Conclusion

From December 1, 2022 till November 30, 2023, India assumed the G20 Presidency. using the Sanskrit phrase "*Vasudhaiva Kutumbakam*," meaning One World, One Family, and One Future, India tried to bring about a paradigmatic shift in the global discussions on climate change. Key environmental issues are being discussed as part of G20 working groups. They include climate finance under the sustainable finance working group, climate resilience as part of the disaster risk reduction, lifestyles and consumption under the development Energy transition is being deliberated under the energy. The environmental [ministry placed the three issues of land degradation, blue economy and circular economy as priority areas for India. But despite of its efforts Globally and Nationally, India is still facing various climate disasters causing Climate Risks. Government of India is taking several measures to subsidise the severe impacts of climate change on various sectors in different dimensions. To boost up its climate change performance Ministry of Environment, Forests and Climate Change is spending on Climate Change Projects and various programmes on Climate Change Action. To conclude what is needed is proper implementation, monitoring and assessment of performance of all Climate change programmes.

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