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Research Article

The Impact Of Climate Change On The Agriculture In India

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ABSTRACT

In order to overcome these obstacles, policies that take into account farmers' views of and responses to the rapidly changing climate are deemed necessary. The current study thoroughly evaluates the literature on the perceptions and adaptations of Indian farmers, with a particular focus on Scopus and Web of Science. The results show that most Indian farmers have seen both irregular and decreasing rainfall and rising temperatures, which is consistent with meteorological data. This report estimates the economic impact of climate change on Indian agriculture. I compute the impact of random differences in weather each year on agricultural output using a 40-year district-level panel data collection spanning over 200 Indian districts. These panel estimates include the within-year adjustments made by farmers to annual weather shocks. Assuming that farmers have limited ability to quickly identify and adapt to changing mean climate conditions, I argue that these estimates, which are based on short-term weather effects, are equally applicable to assessing the medium-term economic effects of climate change. In this article, we'll discuss. The implications of global warming on agriculture in India.

Keywords: Climate Change, Agriculture, Farmers, Rainfall, Economic, Weather, Atmosphere, Temperature, Humidity, Wind, Crop Production, Carbon Dioxide

Introduction:

The weather is the state of the atmosphere at a certain place and time. Factors such as wind, rain, temperature, and humidity describe it. The climate of a certain place is the long-term pattern of weather there. Climate change is defined as a long-term, statistically significant change in the average state of the climate or its variability. From warm in the south to alpine and temperate in the Himalayan north, where highlands experience constant winter snowfall, India boasts an incredible diversity of climate zones. The Himalayas and the Thar Desert both significantly affect the nation's climate. There are four primary climatic groups that comprise the seven climate zones that are categorized based on precipitation and temperature. [1]
The Indian government is aware of the ways in which climate change impacts agriculture and farmer lives. The country's network centers carried out in-depth field and simulation research in agriculture. The projected climates for 2050 and 2080 were included in the evaluation of the effects of climate change using the crop simulation models. The yields of rice that are rainfed in India are predicted to decline by 20% in 2050 and 47% in 2080 if adaptation measures are not implemented, while the yields of rice that are irrigated are predicted to decrease by 3.5% in 2050 and 5% in 2080 scenarios. By the end of the century, wheat yield is expected to decline by 19.3% in 2050 scenarios and 40% in 2080 scenarios as a result of climate change, with significant regional and temporal variability. It is projected that the effects of climate change will cause kharif maize yields to decrease by 18% and 23% in 2050 and 2080, respectively. Climate change reduces crop yields and lowers the nutritional content of the product. Farmers are impacted by droughts and other extreme weather patterns in addition to the amount of food and nutrients they consume.
India's agriculture industry is one of the largest and most important economic sectors. Roughly 19.9% of India's GDP will come from agriculture in 2020–2021. Furthermore, this industry employs 42.6% of Indian workers. However, it also contributes significantly to the production of methane and nitrous oxide, two harmful greenhouse gases that contribute to climate change and the greenhouse effect.
Crop yields and total food production are declining nationally as a result of more heat and erratic rainfall brought on by climate change. Climate change can affect the productivity of irrigated agriculture in all agro-ecological zones by increasing temperatures and causing changes in the availability of water.

Climate change may lead to restrictions on the quantity, quality, and accessibility of food. Lower agricultural output is caused by a number of factors, including rising temperatures, changed precipitation patterns, fewer extreme weather events, and a shortage of water.
The current effects of climate change on food production could have a negative effect on agricultural income. Therefore, it is essential that we incorporate the climate-resilient agriculture (CRA) approach into our farming operations and apply it more rigidly. [2]
The unpredictability and changing climate is a concern for humans. The recurrent floods and droughts pose a serious threat to the lives of billions of people who depend mostly on land for their needs. The global economy is often negatively impacted by extreme weather events such as heat waves, cold snaps, forest fires, landslides, droughts, and floods.
Natural disasters such as earthquakes, tsunamis, and volcanic eruptions can change the chemical composition of the atmosphere, even though they are not directly related to meteorological calamities. Weather-related disasters will come next. Burning fossil fuels releases many pollutants into the environment, including hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and chlorofluorocarbons (CFCs). Greenhouse gases, such as carbon dioxide, are also released into the atmosphere. The "human hand" in deforestation through forest fires, volcanic eruptions, UV-B filtered radiation, ozone depletion, and the disappearance of rainy regions are the main causes of weather extremes. When there is less forest cover, precipitation reaches more areas of the country, eroding the top soil and producing floods and droughts. Rainfall is often intercepted by forest cover, which then permits the earth to absorb it.
Paradoxically, a shortage of trees causes the soil to dry out more quickly, exacerbating dryness in arid years. Because CO_2 absorbs long wave radiation and reemits it into space, it is the primary greenhouse gas responsible for catastrophic global warming. Global warming is defined as the prolonged increase in temperature of the atmosphere due to the heating of the surface atmosphere caused by greenhouse gas emissions. Climate change is the term used to describe these variations in surface air temperature and their long-term negative effects on rainfall. [3]

Climate change and agriculture:

The impact of climate change on agriculture will be one of the primary factors determining humankind's future food security on Earth. Not only is agriculture susceptible to climate change, but it also plays a major role in it. The ability to comprehend weather differences over time and modify management practices to maximize crop yields are barriers to the agriculture industry's overall growth. The vulnerability of agriculture to climate change is uncertain due to regional differences in rainfall, temperature, crops and cropping practices, soils, and management approaches. The variations in precipitation and temperature from year to year were far bigger than predicted. Crop losses may increase in the event that the predicted climate change causes more climate variability.
India's average temperature has increased, and within the last three decades, there have been more intense rainfall events, both of which are signs of climate change. As a result, the yield of significant crops varies between years.
The impact of climate change on Indian agriculture has been studied under National Innovations in Climate Resilient Agriculture (NICRA). It is projected that in India, yields from rainfed rice will fall somewhat (<2.5%) in both scenarios, whereas yields from irrigated rice will rise by 10% in 2080 and 7% in 2050. Furthermore, it is predicted that in 2100, wheat yields will drop by 6-25% and maize yields by 18-23%. Future climates are likely to have an increase in chickpea productivity of 23–54%.

The Indian Council of Agricultural Research (ICAR) launched the NICRA network initiative in 2011 to address the impact of climate change on Indian agriculture. The NICRA project is being reviewed by a High-Level Monitoring Committee (HLMC), which is presided over by the DG of ICAR and the Secretary of DARE. A number of Ministries within the Indian government have extended invitations to committee members to represent them. This committee recommends that the required actions to fortify Indian agriculture's resilience to climate change be carried out through NICRA. A team of experts also regularly evaluates the project and provides guidance on multiple topics.
Weather patterns are altered by climate change, which has a direct, indirect, and biophysical impact on agricultural productivity. Climate change has the potential to have both good and negative effects on crop yield and human population. Raising the temperature can lead to a decline in crop output as well as an increase in pest and disease outbreaks. Heat waves may cause a higher rate of plant mortality. Heat waves produce reduced photosynthesis, slower development, increased leaf abscission, photooxidative stress, and health issues in people more quickly than any other meteorological event. The effects of climate change are particularly vulnerable to the agriculture sector. High temperatures stimulate the infestation of weeds and other pests. When the temperature is less than or equal to 25°C, the rust fungus, which functions similarly to cancer, cannot spread. The climate turns hot and dry as soon as the temperature increases, which speeds up the breeding process and covers and destroys entire crops and plantations that are more vulnerable to the heat. In addition to having a substantial effect on insect reproduction, survival, and epidemic, raising the temperature can decrease crop life, increase vapor-transpiration, speed up crop respiration, quickly mineralize minerals, and affect nutrient consumption efficiency. Increases in temperature and drops in precipitation have a greater

detrimental effect on unirrigated lands than on irrigated ones. The fertility and productivity of the soil have been altered by variations in rainfall. By the end of the twenty-first century, there will likely be a 15–40% increase in India's rainfall. These changes would further pressure Indian agriculture and have a major impact on agricultural operations. It might affect the nutritional content of particular foods, restrict access to food, and cause problems with the food supply. [4]

Review of Literature:

Global dynamics and agriculture are strongly intertwined. Even slight climatic changes have an adverse impact on agriculture, lowering production rates. The effects of climate change and global warming are causing an increase in the average air temperature; these phenomena has grown into a megatrend that will fundamentally disrupt the path of human history. Because carbon dioxide (CO_2) contributes more to global warming than any other substance, the World Meteorological Organization (WMO) and United Nations Environment Program (UNEP) have also proclaimed that carbon dioxide (CO_2) is the main cause of climate change 2. The 1972 Club of Rome Report provided official confirmation that global warming is a worldwide concern. Evaluating how changes in the global climate affect agriculture is crucial for boosting agricultural output and enabling farming response (Fraser et al., 2008). [5]
Given that 85% of farmers in India lack financial stability, the nation is very concerned about the effects of climate change. As a mitigating measure, adaptation is crucial since, even with sharply lower greenhouse gas emissions, the effects of climate change won't go away in the coming decades. As the "front lines of climate change," farmers are the ultimate practitioners of adaptation strategies to decrease the difficulties on the production system in this context (Soubry et al., 2020). It has long been known that adopting adaptive action requires awareness of climate change. Recognizing the negative effects of climate change, farmers are more likely to support legislative actions targeted at solving it. [6]

In recent years, there has been a notable advancement in the understanding of how and why Earth's climate is changing, as well as how it impacts many natural and human systems, by the national and international scientific communities. Food supply and quality have decreased, land erosion has occurred, the ozone layer is being destroyed, air and marine pollution has increased, and other effects of climate change. Changes that occur outside of ordinary atmospheric conditions drive global climate change. Natural occurrences like temperature changes, volcanic eruptions, crustal movements, and the burning of fossil fuels contribute much less to the atmosphere than anthropogenic activities like deforestation, emissions from cars, factories, and power plants, and burning fossil fuels, which releases large amounts of carbon dioxide and suspended particulate matter (SPM). These changes can be attributed to both natural and human-caused factors. Every year, human activity contributes 35 billion metric tons of carbon dioxide to the atmosphere. (S. Tong, 2019) [7]

Objectives:

- Integrated approach can enhance the assessment of farmers' adaptation to climate change.
- To analyze how climate change has impacted the Indian agriculture.
- To study the factors that can influence the climate change for creating a situation of food insecurity.

Research Methodology:

This study's overall design was exploratory. The research paper is an endeavor that is founded on secondary data that was obtained from reliable online resources, newspapers, textbooks, journals, and publications. The research design of the study is mostly descriptive in nature. This research is entirely dependent on secondary data that demonstrates the significant impact that climate change has had on Indian agriculture.

Result and Discussion:

Climate change is affecting India's agricultural sector, which employs 40% of the nation's labor force, according to a report compiled by Climate Trends, a research-based consulting and capacity-building initiative that aims to bring greater focus on issues of environment, climate change, and sustainable development.
A little over 70% of India's rural population is employed in agriculture. A study found that during the previous three decades, 59,000 suicides in India had been connected to warmer growing season temperatures, which caused damage to crops.

Figure 1: A representational image for agriculture. (Source: Credit: PTI File Photo)

Policy implications of these predictions:

The multidisciplinary policy ramifications of climate change impacts on agriculture include possible solutions for:

- A food security policy that accounts for the fact that crop yields and agricultural boundaries are subject to change and can impact food supply.
- Trade policy: Changes in some crops may affect imports or exports, depending on the crop (this is especially true for cash crops like chilies).
- Livelihoods: Given that a significant amount of the nation's gross domestic comes from agriculture, policy must handle issues related to livelihood loss brought on by crop changes, the need to switch some regions to other crops, and the corresponding skills training required.
- Water policy: Climate change will have an impact on agricultural water consumption, but the impact will vary significantly depending on whether crops are rain-fed or irrigated.
- Adaptive measures: Policymakers will also need to consider them in order to address changing agricultural trends. Among these include the introduction of substitute crops, adjustments to cropping plans, and promotion of irrigation and water-saving techniques. [8]

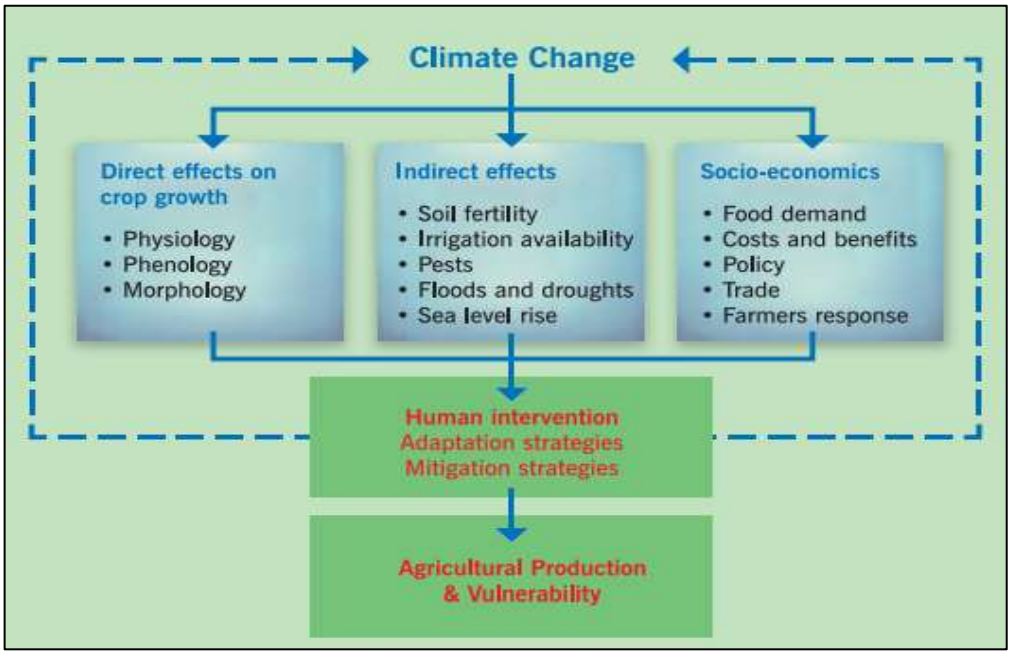

Figure 2: Assessment of Vulnerability of Agriculture to Climate Change

Climate Change can Affect on Agriculture in a Various of Ways:

Soil:

The impact of India's agriculture on the overall increase in greenhouse gas emissions is thought to be negligible. This is related to the low fertility of the country's soil and its limited use of fertilizers. The severity of soil erosion, the quantity and availability of irrigation water sources, the types, frequencies, and intensities of various livestock pests, and crop yields are all impacted by climate change. India experiences harsh and unsuitable weather, which raises the risk of reduced crop quality and quantity as well as infertile soil. The frequency of droughts and floods, soil moisture, groundwater level, and groundwater recharge will all be impacted differently by climate change. Warmer soil may also lead to an increase in the autotrophic CO_2 losses from the soil as a result of root respiration, root exudates, and fine-root turnover. [9]

• Impact of Climate Change on Agriculture and Soil Properties

Climate change has increased the frequency of extreme events that lead to flood and drought disasters in the agricultural sector. These events are a huge danger to the world's crops and grain yield. These fluctuations include differences in average temperature, the rate of increase in carbon dioxide, and worldwide rainfall (Figure 3). Variations in temperature and precipitation expose crops to a variety of biotic and abiotic stresses, which in turn affects crop growth and maturity. According to a study, these biotic and abiotic stresses result in 30% to 50% worldwide losses in crop production. In addition to threatening this productivity loss, a significant increase in the spectrum of pests and pathogens brought on by climate change also poses a threat to the frequency and severity of plant diseases.

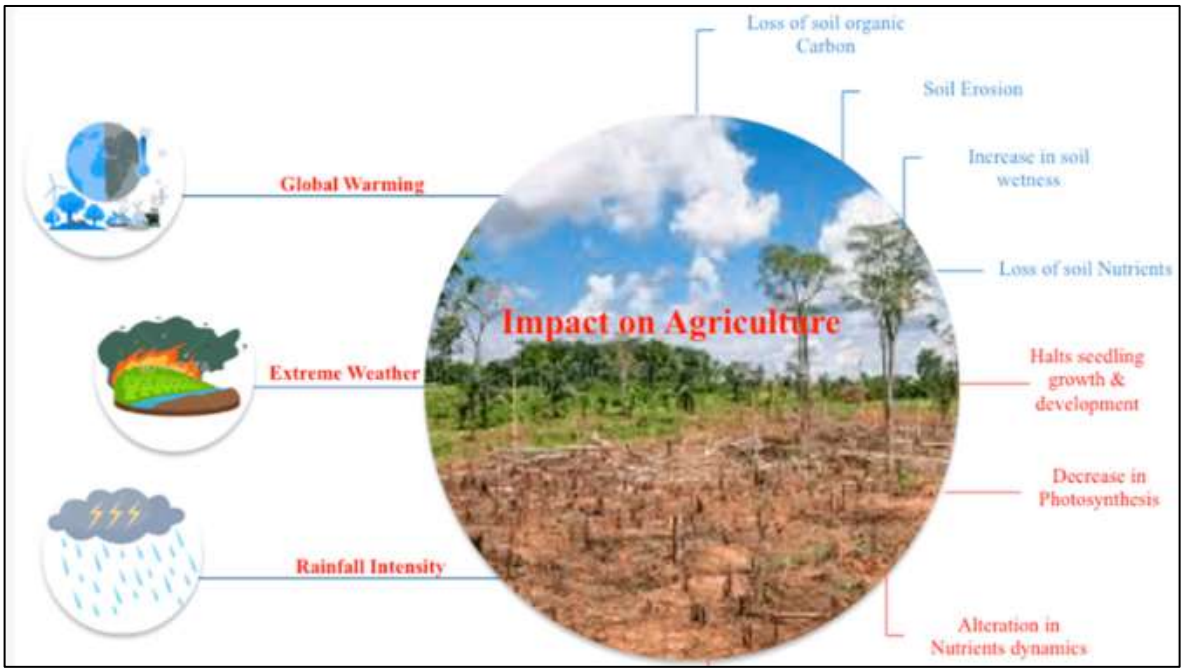

Figure 3. Impact of climate-induced environmental extremes on agriculture, soil and crops. [10]

Crop production and Livestock:

A decrease in crop productivity could result from lower temperatures during the dry season, which could possibly prevent or completely destroy crop growth. The average yearly enthusiasm trend of net income is determined by the seasons and can have a marginal effect that is either positive (warm) or negative (cold). prove that a 10C increase in temperature reduces wheat productivity by 4-5%. In rising market economies, a 10C increase in temperature would lead to a 1.7% decrease in agricultural output, while a 100 millimeter drop in rainfall would result in a 0.35% decrease in growth, citing an IMF estimate from 2017. Both animals and aquatic species production are negatively impacted by climate change. Animals would be impressed by climate variance in two ways: first, it might negatively impact the amount and quality of steppe feed; second, it could have an immediate effect on cattle due to higher temperatures.

Impact on Crop Production:

Food security on a regional and global scale would be seriously jeopardized by rising global temperatures and food prices, according to the Intergovernmental Panel on Climate Change (IPCC) Report, Climate Change 2014 - Impacts, Adaptation and Vulnerability. It comes to the conclusion that important crops like corn, wheat, and rice would be negatively impacted even at a temperature of only 10C. It is expected that the strain on China's and India's main wheat crops would increase, affecting the food security of the continent as a whole. The majority of food production will decrease after 2030, however some regions may see a small increase. [11]

Table 1: Estimated impact of Climate change on Crop Production in South Asia- 2050s

Crops	Crop production (year 2000)	Crop as % of total Production	Projected yield improvement No. Climate Change (% p.a.)	Crop production 2050s, No Climate Change	Crop Production 2050 2050s with Climate Change and No Co2 Fertilization Effect	Average Annual yield change with Climate Change
Rice(mmt)	120	48%	0.9%	169	145	-0.2%
Wheat(mmt)	97	38%	1.6%	191	103	-1.3%
Maize(mmt)	16	6%	0.6%	19	16	0.1%
Millet(mmt)	11	4%	1.5%	12	11	0.0%
Sorghum(mmt)	8	3%	1.2%	10	8	1.4%
Total(mmt)	252			401	282	
Cereal Availability	185			174	122	

Source: World Bank Report, June 2013 'Then Down the Heat; Climate Extremes Regional Impact and the case for Resilience'

Water:

The water cycle will be impacted by climate change as well. Additionally, as sea levels rise, there is a greater chance that rivers and groundwater could experience seasonal or stable saline intrusion. This might have an effect on the properties of the water and its possible use in home, industrial, and agricultural contexts. There will be a wide range of consequences from climate change on agriculture. Pesticide resistance, shifting water tables, rising salinity, diminishing irrigation water quality, and falling soil fertility are currently major concerns in northwest India. Water supplies may be disrupted by variations in runoff and groundwater recharge rates. They can also change the amount of money and technology required, as well as the methods for storing surface water and irrigation. There is evidence of climate variation due to the typical topography of its high mountains; for example, flash floods occur more frequently and have less time to build up between rainstorms and critical water levels; rainfall levels are rising and the rainy season, which brings more frequent rain, is approaching.

Temperatures:

Based on the results of the model runs performed for the specific scenarios B2 of Northwest Vietnam, an increase in temperature of 1.1 0C and 1.5 0C in 2050, 2.2 0C and 3.0 0C in 2100 was taken into consideration. It is feasible to determine that the winter or rabi crop season is getting 1-4 degrees Celsius warmer, that the concentration of CO2 is rising, and that the total amount of rainfall is rising by roughly 20% using the UKMO GCM model. Because temperature and precipitation are more harmful to crops, they have a bigger negative effect on net revenue. Warmer conditions cause some crops to grow more quickly, increasing yields and earnings. Prolonged exposure to excessive heat or cold, however, would be harmful to agricultural productivity. In the high mountain regions, the temperatures drop significantly during the dry season. In fact, below-freezing temperatures have been recorded, with the lowest temperature ever being minus 3.7 0C.

Pests and Diseases:

The environment's fluctuations in temperature and precipitation can cause pest and disease outbreaks, impair national food security by affecting harvests, and affect food production systems. Changes in the frequency and geographic distribution of illnesses and pests have indirect impacts. decrease in crop yield due to altered pest and disease patterns brought on by climate change. Insect pests and illnesses may be promoted by somewhat higher temperatures and precipitation during the already dry season, as winter is a dry season. Climate change increases the rate at which pests and insects multiply. The need for more pesticides has increased due to an increase in insect populations, which has negative effects on human society and the ecosystem. [12]

Impact of Elevated CO2, Temperature & Precipitation on Agriculture:

Some people think that as a result of climate change, agriculture will benefit from increased temperatures and carbon dioxide levels. Higher CO2 concentrations may boost crop productivity, but only in circumstances when moisture is not a constraint. With increased CO2 levels, some plants can speed up their photosynthetic process by 30–100%. Experimental results demonstrate that higher carbon absorption causes plants to grow larger and faster. This is particularly true for C3 plants, so called because of the three carbon atoms that are present in the end product of their first metabolic processes during photosynthesis. Higher CO2 levels tend to decrease photorespiration, which makes these plants more water-efficient. C4 plants wouldn't respond with the same intensity. C3 plants are linked to mid-latitude staple foods like wheat, rice, and soy beans, whereas C4 plants are linked to low-altitude crops like sugarcane, sorghum, and maize. Low-latitude crop yields may be adversely

affected by 10% to 30%, however it is more difficult to predict how increasing summer dryness may influence mid-latitude crops.

Additionally, it is anticipated that there would be a notable drop in winter rainfall in northern India, a 10-15% increase in monsoon precipitation in various regions, and a simultaneous 5-to 25% decline in precipitation in central India, which is prone to drought. This implies that there has been a shift in the yield of winter wheat and mustard crops in northwest India. During the monsoon season, more days with heavy rainfall are predicted along with less wet days—an average of 5 to 15 days—for a large portion of India (Indian Institute of Tropical Meteorology, Ministry of Earth Sciences, Government of India). It is expected that these changes will increase the vulnerability of Indian agriculture.

The agricultural industry has the primary responsibility for the effects of land consumption and greenhouse gas emissions. The three primary causes of the increase in GHGs over the preceding 250 years have been land use, agriculture, and fossil fuels. Two agricultural practices that contribute significantly to carbon dioxide emissions and produce 54% of methane and 80% of nitrous oxide emissions are the cultivation of rice and enteric fermentation in cattle. [13]

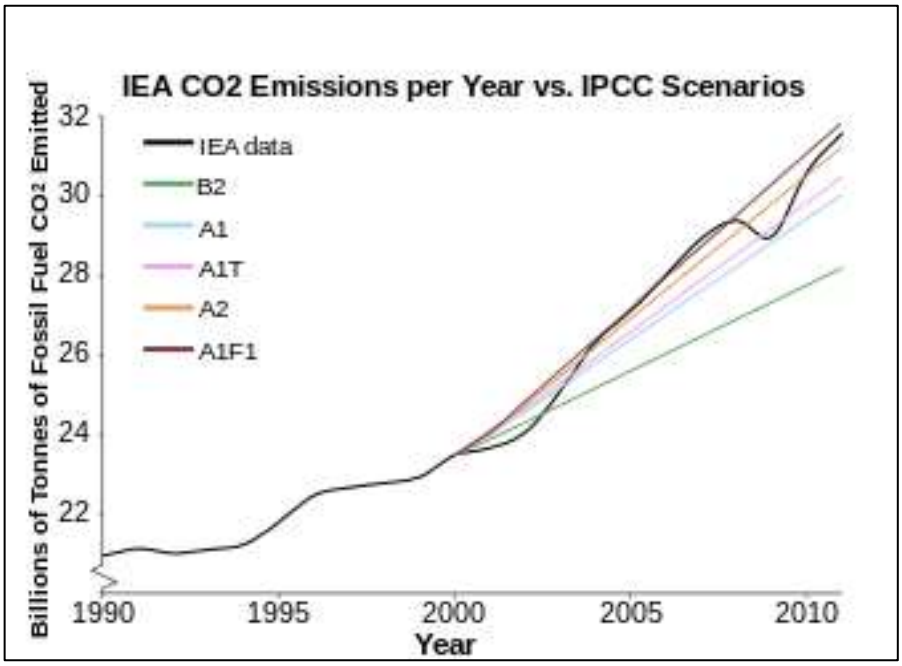

Figure 4: IEA CO2 Emission per year vs. IPCC Scenarios

Conclusion:

One of the most important economic sectors in India is thought to be the agriculture sector. For half the population, it offers both direct and indirect reliance. India has been noted to contribute 7.4% of the global agricultural output. In a nation like India, the agriculture sector is both more important and more vulnerable to changes in the weather. These changes in the climate are caused by the rise in temperature brought on by greenhouse gas emissions. A drop in crop output makes the economy less self-sufficient in terms of food security. It mostly impacts people with lower incomes. Meeting the people's insatiable demands for food production in higher quality and quantity is the main focus of the majority of the major ramifications. The surge in weeds and pests is a result of rising temperatures.

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