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IMPACT OF CLIMATE CHANGE ON INDIAN AGRICULTURE ECONOMY

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Abstract:

In a country like India, where more than half of the population relies on agriculture for their livelihood and food security, climate change has emerged as one of the most severe challenges to the long-term viability of agriculture. Traditional agricultural cycles have been disturbed and crop output has decreased as a result of the growing frequency of extreme weather events such as droughts, floods, unpredictable rainfall, heatwaves, and cyclones. The Indian agricultural sector is directly impacted by these climate changes, which have a negative influence on yields, raise the cost of inputs, decrease the incomes of farmers, and contribute to rural hardship and migration. Additionally, adjustments in cropping patterns have been implemented as a result of temperature fluctuations and shifting patterns of precipitation, both of which have had an impact on the geographical adaptability of particular crops. This has repercussions not only for the safety of food supplies within the country, but also for the competitiveness of exports and the total contribution of the agricultural sector to the gross domestic product. The purpose of this article is to investigate the myriad ways in which climate change affects agricultural output, farm revenue, regional inequities, and policy interventions. Additionally, it assesses the capacity of Indian farmers to adapt to changing conditions and the efficacy of various mitigation techniques, such as climate-resilient crops, enhanced irrigation practices, crop insurance, and government support programs. In order to ensure sustainable rural development and national food sovereignty, it is essential to have an understanding of the economic effects that climate change will have on Indian agriculture and to take steps to address these consequences.

Keywords: Climate change, Precipitation, Temperature, Crop growing, Yield, India

INTRODUCTION

Almost half of India's workforce is employed in the agricultural sector, which is the backbone of the country's rural economy. Agriculture also makes a substantial contribution to the nation's economic growth, as well as to the nation's food security and livelihoods. On the other hand, this most important industry is extremely susceptible to the consequences of climate change. Over the course of the last several decades, India has witnessed a significant rise in the frequency and severity of extreme weather events. These occurrences have included everything from irregular monsoons and lengthy droughts to destructive floods and increasing temperatures. Not only are these changes causing alterations to the physical environment, but they are also having significant repercussions for the amount of agricultural produce, the earnings of farmers, and the general economic stability of rural India. Agriculture is impacted by climate change in a variety of ways, including a decrease in crop yields, a shift in the timing of planting and harvesting, an increase in the number of insect infestations, and a degradation of soil and water resources. Due to the fact that the majority of Indian farmers rely on rain-fed agriculture, the unpredictable patterns of rainfall and the lack of available water are directly harming agricultural growth. Wheat, rice, and pulses are among the major staple crops that are already exhibiting indicators of decreased yields as a result of rising temperatures and water stress. Because agriculture continues to contribute somewhere between 15 and 18 percent to India's gross domestic product and because it plays an essential part in providing support for agro-based sectors, this has a domino effect on the national economy. The economic risks that are presented by climate change are not allocated fairly; small and marginal farmers, who make up the bulk of India's farming population, are disproportionately affected by these hazards. They have limited access to technology, limited financial resources, and poor risk mitigation techniques, all of which make it difficult for them to adjust to the fluctuation of the climate. In addition, the changing climate conditions are causing regional shifts in crop patterns, which is putting the traditional agroclimatic balance at risk and leading to an increase in input prices as a result of a greater dependency on irrigation and fertilisers. It is becoming increasingly important to conduct an in-depth research of the economic impact that climate change is having on Indian agriculture in light of the expanding number of issues associated with it. This involves analysing the immediate repercussions, such as decreased productivity and income loss, as well as the indirect implications, such as higher governmental expenditure on relief and subsidies, as well as food inflation and rural unemployment. In addition, it is essential for the creation of policies to have a solid understanding of the effectiveness of the existing adaptation and mitigation techniques, which include both climate-resilient crop varieties and crop insurance, as well as sustainable agricultural practices. This research is to investigate the intricate relationship that exists between climate change and the agricultural sector of India. Its objectives include identifying significant vulnerabilities, evaluating the economic effects of climate change, and offering solutions that may be implemented to promote climate-resilient agriculture. By acting in this manner, it intends to make a contribution to the greater conversation concerning sustainable development as well as the long-term economic and food security in India. In India, agriculture is highly dependent on the monsoon, which is responsible for providing approximately 75% of the country's yearly rainfall. This dependency makes Indian agriculture more susceptible to the effects of climate change. Not only can a delay or shortfall in the monsoon season cause disruptions to sowing plans, but it also severely constrains the amount of water that is available for irrigation. Furthermore, climate anomalies such as unseasonable rains and hailstorms taking place during harvest seasons are responsible for major crop losses, which in turn have a direct impact on the earnings of farmers and the availability of food worldwide. Variability in rainfall and rising temperatures have already begun to undermine productivity gains that have been obtained over the course of decades of agricultural growth, as stated by the Economic Survey of India and reports from the Indian Meteorological Department (IMD).

In addition, climate change has an impact on the output of cattle, fisheries, and horticulture, all of which are essential components of the rural economy as a whole. Animals that are subjected to heat stress produce less milk, and the warming of the ocean has an effect on the breeding cycles of fish and the biodiversity of marine organisms. These disruptions have direct consequences for the security of nutrition, particularly among rural households with low incomes that are dependent on a variety of agricultural outputs for both their nutritional needs and their ability to diversify their income. Impact on the socioeconomic system is significant. There has been a terrible increase in the number of farmer suicides in a number of Indian states as a result of the growing number of cases of crop failure and increases in debt. As agriculture becomes economically unsustainable for many people, there is also an increase in the number of people moving from rural regions to urban areas. Not only does this change put a strain on urban infrastructure, but it also results in the depopulation of rural areas and the destruction of traditional agricultural knowledge systems. As a reaction, the government of India has implemented a number of policy initiatives, such as the National Mission on Sustainable Agriculture (NMSA), which falls under the National Action Plan on Climate Change (NAPCC). The primary objective of these efforts is to encourage agricultural methods that are compatible with climate change conditions. projects such as the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), the Pradhan Mantri Fasal Bima Yojana (PMFBY), and the Soil Health Card are projects that are meant to increase water efficiency, risk reduction, and soil management. The execution of these initiatives, on the other hand, is fraught with difficulties because of delays caused by bureaucratic procedures, insufficient outreach, and a dearth of locally tailored adaption frameworks. In order to effectively manage climate threats, technological innovation and agriculture that is driven by data are becoming more significant approaches. There are a number of intriguing alternatives available, including the creation of drought-resistant crop types, mobile advising services for farmers, precision farming, and weather forecasting tools that are based on satellites. Nevertheless, equal access to these technologies continues to be limited, particularly in places that are economically less developed and more isolated. Building an agricultural sector that is climate-resilient is not just an environmental imperative, but it is also a socio-economic requirement as India navigates its way towards becoming an economy worth $5 trillion. In order to solve the interconnected issues of climate change, agriculture, and the economy, it is necessary to take a holistic strategy that incorporates scientific research, public policy, and the involvement of the community. For the purpose of guaranteeing that the livelihoods of millions of Indian farmers are preserved against the harmful effects of a changing climate, it will be essential to make a transition towards sustainable agricultural models, which will be supported by targeted investments, public awareness, and institutional change.

Climate change and agriculture

The impact of climate change on agriculture will be one of the primary deciding elements that will influence the future food security of humans on earth, according to some of the previous experiences that were mentioned above. The agricultural sector is not only vulnerable to the effects of climate change, but it is also one of the primary contributors to climate impact. The expansion of the agricultural sector as a whole faces obstacles in the form of not only gaining an understanding of the changes in weather that occur over a period of time but also modifying management techniques in order to achieve greater harvests. Due to the fact that there is regional diversity in rainfall, temperature, crops and cropping systems, soils, and management approaches, the climate sensitivity of agriculture is unknown. The fluctuations in temperature and precipitation that occurred between years were significantly more than the changes that were projected to occur with regard to temperature and precipitation. In the event that the expected climate change causes an increase in the variability of the climate, crop losses may become more severe. 6. As a result of the multifaceted impact that global warming will have, many fruits and vegetables will react differently. The tropics are more reliant on agriculture due to the fact that seventy-five percent of the world's population resides in the tropics, and agriculture is the primary profession of two thirds of these people. Because of the low levels of technology, the broad variety of pests, illnesses, and weeds, the degradation of land, the unequal distribution of land, and the rapid rise of the population, any influence on tropical agriculture will have an effect on their means of subsistence. The six most important crops in the world are rice, wheat, maize, sorghum, soybeans, and barley. These crops are cultivated in forty percent of the world's cropped land and are responsible for fifty-five percent of the calories that are not derived from meat and more than seventy percent of the animal feed (FAO, 2006). As a consequence, any impact on these crops would have a negative impact on the protection of the food supply.

Evidence on Adaptation

Three different adaptation margins may be investigated using the data that is now available. Initially, in the event of a severe weather shock, the application of fertiliser might be modified to accommodate the situation. Nitrogen, phosphorus, and potassium are comprised of the fertilisers that are given in the data. These fertilisers are aggregated at the mean costs from 1960 to 1965. Fertiliser consumption decreases by around 4.5 percent. When considering the impact on yields, it is possible that the genuine welfare impact of a climatic shock may be slightly exaggerated. This is because farmers have the ability to lower the amount of inputs they use. Secondly, in order to mitigate the negative effects of a shock, farmers might begin planting during the second winter season. Nevertheless, the data shown in column (2) indicates that the degree of double-cropping8 is not significantly influenced by a temperature shock of one degree. It is possible that this tolerance for adaptability will be restricted, at least in the short term. Last but not least, although there is no data available on labour inputs on an annual basis, annual earnings are known at the district level. If we make the assumption that the temperature primarily influences the agricultural labour market through the channel of labour demand rather than labour supply, then the behaviour of wages in response to temperature shocks can provide valuable insights into the reaction of labour demand to temperature. According to the data presented in column 3, the pay decreases by about two percent as a result of an increase in temperature of one degree. When considering the situation of full employment, it is possible to perceive this as a reduction in the welfare impact of a climatic shock. This is because farmers utilise less precious resources, similar to how fertiliser is used. However, because India has a persistently high unemployment rate, it is quite probable that these resources are not being utilised, which results in a welfare effect that is unclear. As a result of Topalova's (2005) findings, which demonstrated the sluggish reaction of factor quantities in India to shocks, it is possible that this effect might be long-lasting.

Impacts on Water Resources

Alterations in the most important climatic factors, particularly temperature, precipitation, and humidity, have the potential to have substantial long-term repercussions for the amount and quality of water. It is expected that the decline in snow cover will have a disproportionately negative impact on the river systems of the Brahmaputra, the Ganga, and the Indus. These river systems are able to reap the benefits of melting snow throughout the dry season. A decrease in the total run-off is anticipated for all river basins in India's NATCOM I for all river basins with the exception of the Narmada and Tapti. In addition, it is expected that the Sabarmati and Luni basins would see a reduction in runoff that is greater than two-thirds. As a result of the rise in sea level, fresh water sources that are located in close proximity to coastal areas will experience salt intrusion.

Impacts on Agriculture and Food Production

The fluctuation of monsoon rainfall and temperature fluctuations within a season are two examples of climate-related factors that can have a significant impact on food production in India. There is a bigger anticipated loss in the Rabi crop, according to research conducted by the Indian Agricultural Research Institute (IARI) and other researchers. For every one degree Celsius increase in temperature, wheat output drops by four to five million eleven tonnes. The quality of fruits, vegetables, tea, coffee, aromatic and medicinal plants, and basmati rice can be significantly impacted by even minute shifts in temperature and rainfall even when the changes are quite minor. Temperature and humidity are two elements that have a significant impact on the dynamics of insect and pathogen populations. Pathogens and insect populations are highly reliant on conditions of temperature and humidity. More negative effects on agriculture and allied industries include decreased milk production from dairy animals and a decrease in the number of fish that are bred, migrated, and harvested. According to projections from throughout the world, agricultural output will drop by 10–40% by the year 2100. The southwest monsoon is the primary contributor to the climate of India, since it is responsible for the majority of the region's precipitation. The availability of potable water and irrigation opportunities for agricultural use is of the utmost importance. Agricultural productivity is sensitive to two broad classes of climate-induced effects: (1) direct effects, which can be caused by changes in temperature, precipitation, or carbon dioxide concentrations; and (2) indirect effects, which can be caused by changes in soil moisture as well as the distribution and frequency of infestation by pests and diseases. It is possible that climate change would result in a significant decrease in the yields of rice and wheat (IPCC 1996; 2001). The vulnerability of agricultural production to climate change, on the other hand, is not only dependent on the physiological response of the plant that is being affected, but also on the capacity of the socio-economic production systems that are being affected to deal with changes in yield, as well as changes in the frequency of droughts or floods. The large amount of reliance that farmers in India have on natural forces, in addition to the absence of complementing inputs and institutional support structures, significantly limits their capacity to adjust to changing conditions. For a temperature increase of 2 degrees Celsius to 3.5 degrees Celsius, it is projected that the loss in net revenue at the farm level will range between 9 and 25 percent. A rise in mean temperature of 2 degrees Celsius and an increase in mean precipitation of 7 percent, according to the estimates of scientists, would result in a decrease of 12.3 percent in net profits for the entire nation. It has been discovered that agriculture in the coastal areas of Gujarat, Maharashtra, and Karnataka is the sector that is seeing the greatest adverse effects. The key food-grain producing regions of Punjab, Haryana, and western Uttar Pradesh are also showing signs of experiencing some losses, albeit more modest ones. On the other side, it is anticipated that West Bengal, Orissa, and Andhra Pradesh would reap some benefits brought about by the warming of the climate.

Research Methodology

For the purpose of this study, a quantitative research approach and secondary data were utilised to investigate climate change factors, GDP, and population of India from 2007 to 2023. The information was obtained from the data source of the World Bank as well as data.gov.in. E-views 9.0 and SPSS 22.0 were utilised for the purpose of conducting data analysis, and statistical techniques such as Multiple Regression Analysis and Pearson Correlation were put to the test in order to investigate the impact that climatic factors have on the expansion of the Indian economy. The Gross Domestic Product (GDP) is the dependent variable, whereas rainfall, temperature, and population are the independent variables.

Data Analysis

In Table 1, it is evident that the Gross Domestic Product (GDP) has the greatest mean value (2.724 ± 0.354), followed by the Rainfall (with a mean of 1.9367 ± 0.0361), Temperature (with a mean of 1.5530 ± 0.255), and Population (with a mean of 1.484 ± 1.5580). Diagrams depicting the variables are presented in Figure 1.

Variables Affecting Economic Growth Due to Climate Change

The effect of population, weather, and precipitation on GDP using multiple regression

The findings of the study indicate that temperature, rainfall, and population all had a substantial impact on GDP in conjunction with one another [(R2=0.747; F A table containing the following information is shown here, taken from the image:

Table 1: Descriptive Statistics.

	LOGGDP	LOGPOPULATION	LOGRAINFALL	LOGTEMP
Mean	2.724054	1.484324	1.938757	1.552973
Median	2.820000	2.040000	1.930000	1.390000
Maximum	3.360000	3.120000	2.000000	2.000000
Minimum	2.260000	-0.160000	1.880000	1.380000
Std. Dev.	0.354218	1.558007	0.036137	0.255004
Skewness	0.506564	-0.003011	0.073202	0.910481
Kurtosis	1.850489	1.045889	2.246106	1.867098
Jarque-Bera	3.619530	5.888987	0.909260	7.090692
Probability	0.163693	0.052681	0.634683	0.028859
Sum	100.7900	54.92000	71.66000	57.46000
Sum Sq. Dev.	4.516892	87.38591	0.047011	2.340973
Observations	37	37	37	37

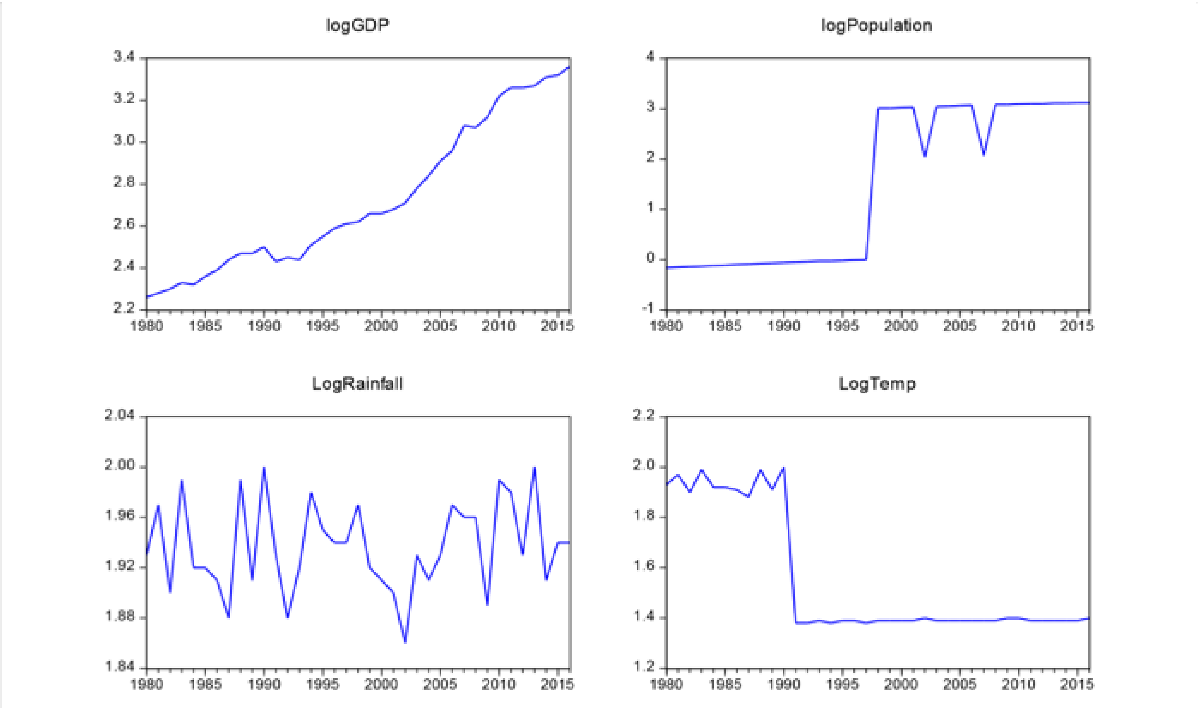

Figure:1 Graphs of Variable

Table 2: Model summary

Model	R	R^2	Adjusted R^2	Std. Error
1	0.864	0.747	0.724	0.18596
Predictors:	Log Population, log Rainfall, log Temp			

Table 3: ANOVA Result

Model	SS	df	MS	F	Sig
Regression	3.376	3	1.125	32.540	0.000
Residual	1.141	33	0.035		
Total	4.517	36			

Predictors: log Population, log Rainfall, log Temp

Dependent Variable:logGDP

(3.36) equals 32.540; p000000). The conclusion that can be drawn from this is that rainfall, temperature, and population all contribute to the expansion of India's economy. However, when considered separately, rainfall and population have a considerable impact on economic growth, whilst temperature has little impact on economic growth (Tables 2-5). The results of the correlation demonstrate that there is a highly significant positive association between GDP and population (r=0.840), as well as a negative relationship between temperature and GDP (r=-0.639). However, there was no correlation between rainfall and GDP. Moreover, the population was found to be significantly positive, but the temperature was shown to be significantly negative.

Table 4: The impact is independent.

Model		Unstandardized Coeff.		Standardized Coeff.	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.412	1.653		-0.249	0.805
	Log Temp	-0.245	0.164	-0.177	-1.498	0.144
	Log Rainfall	1.691	0.861	0.174	1.964	0.058
	Log Population	0.163	0.027	0.718	6.097	0.000

Dependent Variable: log GDP.

Table 5: Matrix of correlations between the variables.

		Log GDP	Log Temp	Log Rainfall	Log Population
Log GDP	Pearson Correlation	1	-0.639	0.181	0.840
	Sig. (2-tailed)		0.000	0.283	0.000
	N	37	37	37	37
Log Temp	Pearson Correlation	-0.639	1	0.080	-0.664
	Sig. (2-tailed)	0.000		0.640	0.000
	N	37	37	37	37
Log Rainfall	Pearson Correlation	0.181	0.080	1	0.030
	Sig. (2-tailed)	0.283	0.640		0.858
	N	37	37	37	37
Log Population	Pearson Correlation	0.840	-0.664	0.030	1
	Sig. (2-tailed)	0.000	0.000	0.858	
	N	37	37	37	37

Conclusions

Urgent and far-reaching, climate change is affecting India's agriculture industry. Extreme weather events are becoming more common, and the country's already high temperatures aren't helping matters. The majority of India's population lives in rural areas, and many of them rely on farming for a living. Aside from lowering agricultural output, these climate disruptions also impact rural incomes, food security on a national level, and the country's economic stability as a whole. The research shows that marginal and small-scale farmers suffer the most from climate-related losses because they are less equipped to adapt and have less access to resources like financing, technology, and market assistance. There is growing evidence of regional discrepancies as well; for example, some states are suffering from chronic droughts while others are dealing with floods or cyclonic interruptions, which is causing agricultural hardship in certain areas. There has been some success with government initiatives to promote climate-resilient farming techniques, insure crops, and improve irrigation systems. Implementation, awareness, and equal access remain problems that restrict their efficacy, nevertheless. In addition, there has to be strong scientific investigation, data-driven predictions, education for farmers, and institutional backing for the shift towards sustainable agriculture. Climate change is clearly a social and economic problem that endangers the very basis of India's agricultural economy, in addition to being an environmental worry. It is critical to have a long-term strategic vision for agriculture that incorporates climate resilience at every stage of planning and development. Infrastructure investment, stress-tolerant crop variety development, increased use of renewable energy in agriculture, improved rural finance systems, and farmer engagement in climate governance are all part of this plan. The challenge of mitigating climate change's effects on India's agricultural industry is complex and calls for a wide range of expertise and perspectives. To ensure the survival of millions of farmers and advance climate justice, communities, scientists, and policymakers must work together to strengthen adaptive skills. In order to protect its agricultural sector and guarantee sustainable food systems for future generations, India must take such concerted action.

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