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DYNAMICS OF CLIMATE CHANGE AND FOOD SECURITY IN INDIA

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Abstract- *Global climate change denotes changing the pattern of long-term weather events that encompass the geographical regions of the world. It is continuously argued that trends of climate change have posed challenges to end hunger and malnutrition in India. In a long way, dynamics of climatic change could affect agricultural practice, transpiration rates, moisture availability, productivity etc. And all these climate changes will have serious impacts on the four dimensions of food security: food utilization, food system stability, food availability, and food accessibility. Looking at the importance of the specific goals, the paper provides a detailed overview of the dynamics of climate change and its impact on India's food security and food production. Due to climate change, increasing incidence of extreme events is noticed which poses new risks at the global level. Global warming has triggered the melting of glaciers and submergence of coastal regions of the world and also changes the trends and patterns of rainfall and temperature. Indicators of climate change have already started impacting on cropping pattern, agricultural productivity and food security in several agro-climatic regions and sub-regions of India. Climate change will probably increase the risk of food insecurity hence it requires special agricultural measures to combat these climate challenges.*

Key words: Climate change, Food Availability, Agriculture Productivity, Global Warming, Food Security.

Introduction

Climate change is a long-term shift in the weather conditions of a specific location or region. The shift is measured by changes in features related to average weather conditions, such as temperature, wind patterns, and precipitation. These shifts may take perhaps millions of years. But increase in anthropogenic activities like- deforestation, shifting agriculture pattern, industrialization, and urbanization, change in land use pattern etc. lead to the emission of greenhouse gases (CFCs) due to which the rate of climate change is much faster. Trends of climate change include changes in precipitation, the higher atmospheric rate of CO₂ concentrations and higher temperatures. The greenhouse effect may be important for agriculture from two ways. First, increased CO₂ concentrations in the atmosphere can have a direct effect on the growth rate and productivity of plants. Secondly, concentrations of CO₂ induced changes of climate may alter levels of rainfall and temperature that can affect animals and crop productivity. The rise in sea level may lead to loss of land and increasing salinity of ground water in the coastal regions. Today, climate change affects cropping pattern, agriculture production, and food systems in several ways like- changes in rainfall leading to drought or flooding, warmer or cooler temperatures leading to changes in the length of growing season which

consequently affect the food security. It also affects the overall infrastructure of market, prices and supply chain mechanism. The average of global surface temperature has increased 0.74°C since the late 19th Century. It is expected to increase by 1.4°C - 5.8°C by 2100 AD with significant regional variations (IPCC, 2007). According to World Bank estimates, based on the International Energy Agency's (IEA) trend of current policy and other economic sector models, for a global mean warming of 4°C, there will be a 10 percent increase in annual mean monsoon intensity and 15 percent increase in the year to year variability in monsoon precipitation. Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 1996)¹. Swaminathan (1986)² has focused the need for shifting to the concept of nutrition security, which he has defined as "physical, economic and social access to a balanced diet, clean drinking water, environmental hygiene, primary health care and nutritional literacy". Decreasing agriculture land and increasing population are contrary to agriculture production. Because food production is not increasing in proportion to population, hence huge pressure on the available resources to meet the expanding demand for food. Land use change has created the problems like- soil erosion, soil alkalinity, and salinity, water logging etc. and immediate attention is required in order to sustain the growing population, and, through diversified land use techniques (Singh, R.B., 1997)³.

Objectives

- To understand the dynamics of climate change and its impacts on food security.
- To identify the prominent factors of climate change in India.
- To assess the vulnerability of agriculture practices to climate change.
- To suggest measures of mitigation and adaptation strategies in view of climate change

Data Base and Research Methodology

The research study is based on the secondary data sources. The secondary data involves the collection of data and information from published literature, reports, conference papers, IMD reports including the basic statistics. We used data from India Meteorological Department for looking into the trend of annual rainfall, annual average temperature, and crop area affected. Impact of vulnerable food security due to the effects of climate change is looked into through the data of projections of change in temperature and rainfall for different seasons in India. The vulnerability of food security is very importantly evaluated using nutrition status of children and therefore child nutrition status data is obtained from national family health survey (NFHS).

In general, there exist various climate elements affecting agriculture in the country and across the globe but in this study data of projected change till 2050's in important climate elements is considered and the projected data is taken from Ministry of agriculture, fisheries and food.

Climate Change Trends 2001-2011

The major problem faced by the entire world today is "Climate Change". Every country is taking various control measures to decrease the factors of Climate Change. The Climate Change causes a greater impact on food security, agriculture production and cropping pattern in India. Particularly, Indian agriculture is highly affected due to the climate change. In India, agriculture depends on monsoon and favorable weather conditions. There are certain variables which play major role to determine the agriculture productivity and shows impact of climate change (Table: 1), are discussed as-

1. Overall annual rainfall (mm)
2. Cropped area affected (in lakh hectares)
3. Annual Average Temperature (°C)

Table: 1 Climate Change Trends 2001-2011

Year	Overall annual rainfall (mm)	Cropped areas Affected (in lakh hectares)	Annual Average Temperature
2000-01	1035.40	21.08	10.27
2001-02	1100.70	18.72	10.50
2002-03	935.90	21.00	10.45
2003-04	1187.30	31.98	10.05
2004-05	1106.50	32.53	10.10
2005-06	1208.30	35.52	10.02
2006-07	1161.60	70.87	9.99
2007-08	1179.30	85.13	10.15
2008-09	1118.00	35.56	10.04
2009-10	953.70	47.13	10.35
2010-11	1215.50	46.25	9.97
Min	935.90	18.72	9.97
Max	1215.50	85.13	10.50
Average	1109.29	40.52	10.17
CV	8.77	51.81	1.87
Growth Rate	1.74	11.94	-0.29
Exponential Growth Rate (EGR) (%)	0.55	1.55	-0.30

Source: IMD (2001-2011)

Overall Annual Rainfall: Overall Annual Rainfall shows an irregular pattern of increase. Maximum Rainfall is reported in the year 2010-11 with 1215.50 mm whereas minimum value is reported in the year 2002-03 with 935.90 mm. The average value is 1109.29 mm, so the years 2001-02 and from 2003-04 to 2010-11 represent above average. The Average annual growth rate is 1.74% whereas exponential growth rate is 0.55%. The coefficient of variation stands 8.77%. Thus, it can be stated that the trend of average annual rainfall is increasing but not in a way.

Cropped Areas Affected: This indicator shows the impact of extreme weather conditions like droughts, floods, landslide or any other natural calamity on agriculture. It is 85.13 lakh hectares in the year 2007-08 and 70.87 lakh hectares in 2006-07. It means a huge area of agriculture land is affected adversely in this time period. The coefficient of variation reaches the highest limit among the 3 indicators with the value of 51.8%. The Growth rate is calculated 11.94% whereas exponential growth rate is counted 1.55%. The minimum value is reported in the year 2001-02 that is 18.72 lakh hectares. So here on the table some years shows the growing trend of cropping area affected by extreme events which are an alarm bell of danger and negative impacts of climate change.

Annual average temperature: This shows an irregular pattern of diminution maximum temperature reported of in the year 2001-02 with 10.5⁰ whereas minimum value is recorded in the year 2010-11 with 9.97⁰C. The average value is 10.17⁰C so the years 2007-08, 2003-04, 2004-05, 2005-06, 2006-07, 2008-09 and 2010-11 represent below average trend whereas years 2000-01, 2001-02, 2002- 03 and 2009-10 represent above average trend. The coefficient of variation appears to be lowest of all the three indicators with the value of 1.87%.

Factors of Climate Change n

The climate is a dynamic phenomenon and changes through a natural cycle. The factors of climate change (Table: 2) are divided into two categories –

Table: 2 Factors of climate change

Sr. no.	Natural factors	Manmade factors
1.	Continental drift	Agricultural Activates
2	Volcanic Eruption	Deforestation
3.	Ocean Currents	Land use change
4.	Earth Orbital changes	Industrialization
5.	Solar Output	Burning of fossil fuel

Source: Compiled by the Researcher

Natural causes of Climate Change:

- **Continental drift:** Continental drift has an impact on the climate because it changed the physical features of the landmass and position of water bodies. The separation of landmasses changed the flow of ocean currents and winds, which affected the climate. This drift of the continents continues even today, evidence is probing that Himalayan range is rising by about 1 millimeter every year.
- **Volcanic Eruption:** Volcanic eruptions are large enough to affect climate. During a volcano erupts, it throws out large volumes of sulphur dioxide, water vapor, dust and ash particles into the atmosphere and impacts climatic patterns.
- **Ocean Currents:** The oceans are the major controlling component of the climate system and cover an about 71percent area of the earth surface. Its absorb about twice as much of the sun radiation as the atmosphere or the land surface. The oceans play an important role in determining the atmospheric concentration of CO₂.
- **Earth Orbital Changes:** The changes in the tilt of the earth orbit can lead to seasonal changes in weather conditions. More tilt means warmer summers and colder winters, less tilt means cooler summers and milder winters.
- **Solar Variation:** The sun is the predominant source of energy. Both long and short-term variation in solar intensity is known to affect global climate patterns. Although the sun's energy output appears constant but small changes over an extended period can lead to climatic changes.

Anthropogenic causes of Climate Change:

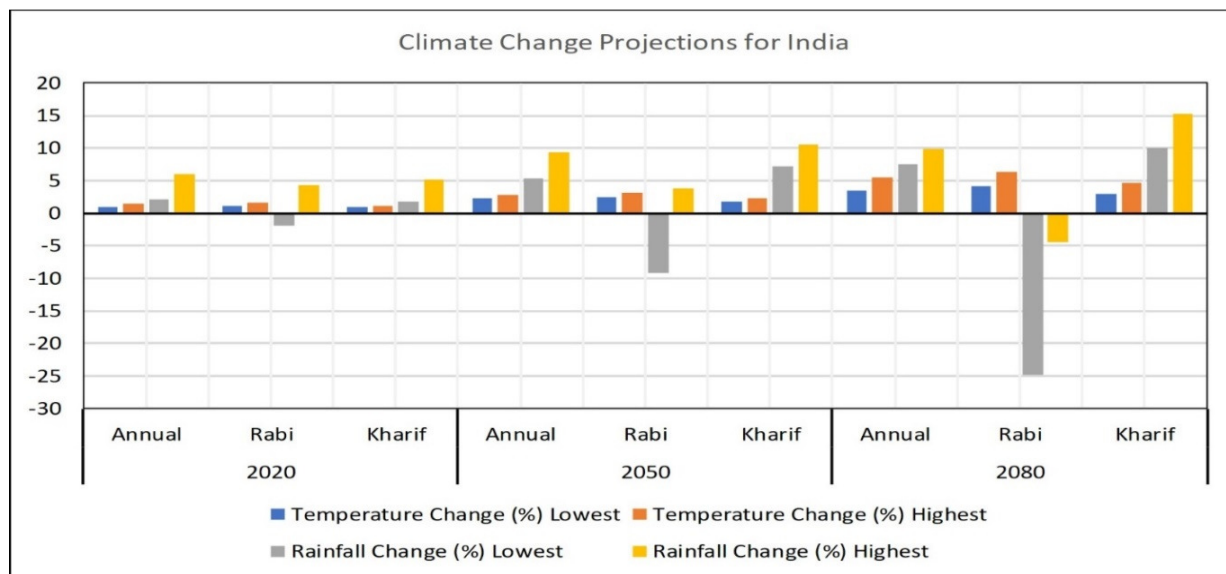
- **Agriculture and climate change:** According to Intergovernmental Panel on Climate Change (IPCC) agriculture has been shown to produce significant effects on climate change, primarily through the production and release of greenhouse gases such as carbon dioxide, methane and nitrous oxide. CO₂ is undoubted, the most important greenhouse gas in the atmosphere. Change in land use pattern, deforestation, animal husbandry and other activities of agriculture have all led to rise in the emission of CO₂.
- **Deforestation and Climate Change:** As per one estimate, almost 20% of manmade CO₂ emission is absorbed by rainforests. Therefore, cutting down forest means less absorption of CO₂ and more carbon concentration in the atmosphere which further lead to global warming and climate change.
- **Land use change and Climate Change:** Land use change refers to the conversion of forest into the agricultural land which is one of the humongous human activities that leads to GHG emission. The largest effect of deforestation and land use change are estimated to be at high latitudes where the Albedo of snow-covered land, previously forested, has increased because snow on tree reflects only about half of the sunlight falling on it whereas snow-covered open ground reflects about two third part.
- **Industrialization and Climate Change:** During the process of industrialization, the use of factories and mass production has led to a depletion of certain natural resources, leaving the environment permanently damaged. The industrialization is leading to destroying the environment in a cyclic way by increasing carbon emission, diminishing the count of natural resources, water as well as land pollution and promote deforestation. The industrial activities have increased carbon dioxide levels in the atmosphere from 280 parts per million to 379 parts per million in the last 150 years.
- **Burning of Fossil Fuel and Climate Change:** Human activities primarily the burning of fossil fuels like coal and oil, and clearing the forests are triggering the changes which are witnessed in the global climate. CO₂ is one of the greenhouse gases that enhances radioactive forcing and contributes to global warming causing the average surface temperature of the earth to rise.

Climate Change and Food Security: Indian Scenario

The climate changes phenomena are more noticeable in the northern parts of India. The change in maximum and minimum temperatures conditions are expected to increase under changing climatic conditions. In Indian region, some states are getting more rainfall while some may remain dry. Except Rajasthan and Punjab in the North-West region and some part of the Southern region in Tamilnadu

show a slight decrease in an average rainfall. In the Indian Ocean, corals reefs will be soon exposed to summer temperatures will become almost a certainty by 2050. Presently, the districts in Odisha, Nellore and Nagapattinam in Tamilnadu and Junagadh and Porbandar districts in Gujarat are the most vulnerable to impacts of increased intensity and frequency of cyclones in India (NATCOM, 2004)⁴. Indian forests are likely to experience change in forest types and adversely impacting on regional climate and livelihoods based on forest products (Figure: 1).

Figure: 1 Climate Change Projections for India



Source: Compiled by the Researcher

In India, 12 states come under the alarming category of the Global Hunger Index (GHI). According to the National Family Health Survey (NFHS) 2015-16, the proportion of children under five years who are underweight is significantly high in states such as Bihar, Madhya Pradesh and Andhra Pradesh. (Table: 3) show the Child Nutritional Status in urban India (2014-15). The high child nutritional status in urban India found in Bihar state.

Table: 3 Child Nutritional Status in Urban India (2014-15)

States	Proportion of children under 5 who are underweight (%)
Andhra Pradesh	28.4
Assam	21.4
Bihar	37.5
Goa	25.3
Haryana	28.5
Karnataka	31.5
Maharashtra	30.7
Manipur	13.1
Meghalaya	22.9
Madhya Pradesh	36.5
Puducherry	23.3
Sikkim	12
Telangana	22.2
Tamil Nadu	21.5
Tripura	21.7
Uttarakhand	25.6
West Bengal	26.2

Source: National Family Health Survey 4 Database

In a long way, the climatic change could affect cropping pattern and agriculture quality and quantity (growth rates, transpiration rates, moisture availability, productivity, etc.). These changes will have serious impacts on the four dimensions of food security: food utilization and food system stability, food availability, food accessibility (Table: 4). Climate change directly impacts on cropping pattern and food production in India and as well as across the globe.

Table: 4 Food Security Dimension and Consequences of Climate Change

Food Security Dimension	Consequences of Climate Change
AVAILABILITY (sufficient quantity of food for consumption)	<ul style="list-style-type: none"> • Reduced agricultural production in some areas and changes in the suitability of land for crop production. • Increases in temperature could lead to longer growing seasons in temperate regions and reduced frost damage.
ACCESS (ability to obtain food regularly through own production or purchase)	<ul style="list-style-type: none"> • Lower yields in some areas could result in higher food prices and loss of income due to the potential increase in damage to agricultural production.
STABILITY (risk of losing access to resources required to consume food)	<ul style="list-style-type: none"> • Instability of food supplies due to an increase in extreme events.
UTILISATION (quality and safety of food, including nutrition aspects)	<ul style="list-style-type: none"> • Food security and health impacts include increased malnutrition and ability to utilize food might decrease where changes in climate increase disease.

Source: Compiled by the Researcher

Impact of Climate Change on Indian Agriculture

Climate change impacts agriculture production, cropping pattern and food productivity across the globe level. Increase in the mean seasonal temperature can reduce the duration of crops. In areas where temperatures are already close to the growing time period of crops, warming will impact yields more immediately (IPCC, 2007)⁵. Indian agriculture depends on monsoon and any change in monsoon directly effects on agriculture production and cropping pattern (MAFF, 2000)⁶ (Table: 5). In Jharkhand, Odisha and Chhattisgarh rice production losses during severe droughts average about 40 percent of total production (Pandey, 2007)⁷. The major impacts of climate change will be on rain-fed crops. The increase of temperature by 0.5°C in winter temperature is projected to reduce rain fed wheat yield by 0.45 tons per hectare in India (Lal, 2001⁸; Lal et al., 1998⁹).

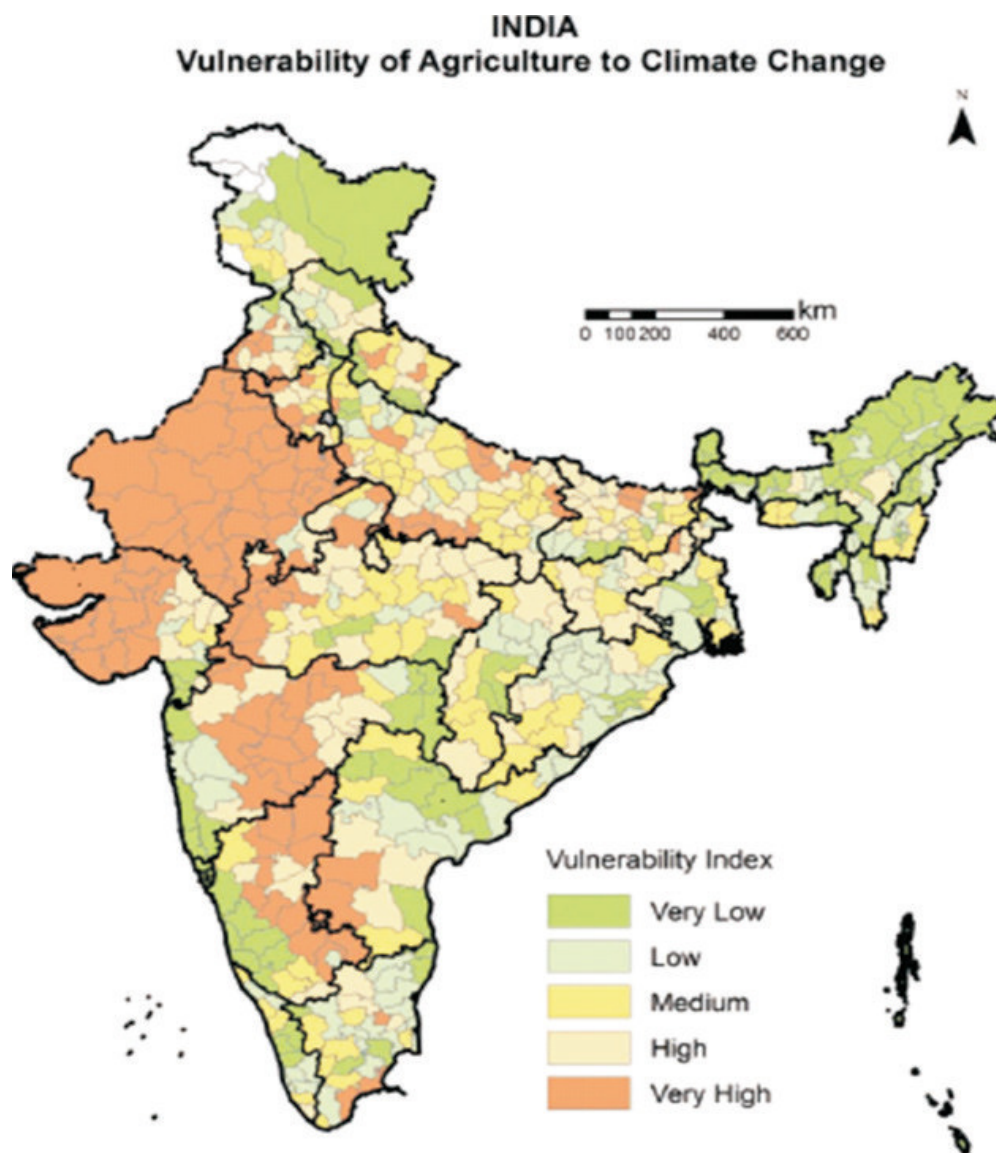
Table: 5 Climatic Element and Effects on Agriculture

Different elements of climate	Expected changes (2050's)	Prediction	Impacts on agriculture
CO2	Increase from 360 ppm to 450 - 600 ppm	Very high	Increased photosynthesis process.
Increasing sea level	10 -15 cm Increased in south	Very high	Loss of land, coastal erosion and flooding.
Temperature	Increased frequency of heat waves	High	Earlier growing seasons, heat stress risk and increased evapotranspiration process.
Precipitation	Seasonal changes by ± 10 percent	Low	Impacts on drought risk and water logging irrigation supply.
Storminess	Increased wind speeds especially in the north.	Very low	Soil erosion, reduced infiltration of rainfall.
Variability	Increases across most climatic variables.	Very low	Changing risk of damaging events which effect crops and timing of farm operations.

Source: (MAFF, 2000)

Vulnerability of the Indian Agriculture Sector to climate change and Food Security

Food security is directly related to climate change phenomena. Climatic parameters such as rainfall, temperature and humidity direct impact on cropping pattern and food production in India. Recently, it has been noticed that changing unpredictable weather event patterns in India will lead to fall in agricultural production and increase food insecurity vulnerability. The vulnerability of India in the event of Climate Change is more pronounced due to its ever-increasing dependency on agriculture, excessive pressure on natural resources and poor coping mechanism. While in the short run impact might not be severe, most crops are likely to witness yield decline after 2020 when temperature threshold limit of many crops might get breached. In India, rice and wheat are the major crops in total food grain production area but global warming has significant consequences for agricultural productivity and increased risk of hunger.



Source: CA.R. Rao et al ; (2013)¹⁰

So, food production in India must be increased because the population is increasing exponentially. And agriculture practices must be aligned with the climate suitability.

Mitigation and Adaptation Strategies:

- (i). Develop and implement future contingency plans at the national level to cope with weather events such as floods, cold and heat waves, drought etc.
- (ii). Proper selections of crop varieties according to site conditions and prepare integrated farming system models.
- (iii). Develop rainwater harvesting techniques for conservation of water resources.
- (iv). Drip and sprinkler water conservation techniques for agriculture development at village level on a large scale.
- (v). Create a knowledge-based decision support system at district, block and panchayat level for operational management practices. Therefore, is a need to increase climate literacy among all stakeholders of agriculture and allied sectors.
- (vi). Reducing greenhouse gas emissions from different land use systems techniques such as raising horticultural and multi-purpose tree species on degraded soils.
- (vii). Improving and promotion of conservation efficiency of energy using better designed efficient machinery in agriculture practices.
- (viii). Creating awareness and mitigation programmes to tackle climate change at the local, national and global level.

Conclusion

Climate change is the primary indicator of agricultural productivity and cropping pattern which has a direct impact on food production and food security at the global level. Increase in the mean seasonal temperature due to greenhouse gases can reduce the final yield of many crops. The agriculture sector is the primary sector in India and it is the most impacted to the climate changes activities because the climate of a region or area determines the nature of vegetation cover. Food production systems and food security are extremely impacted by climate changes like changes in temperature and precipitation. Coping with the impact factors of climate change on food security in India will require careful mitigation and management of soil, water and biodiversity at the local level as well as national level.

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