

# Climate Change and the Fall of Agricultural Production in Some Selected Regions of India

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**Abstract** - Climate is changing naturally at its own pace, since the beginning of the evolution of earth, billion years ago, but presently, it has gained momentum due to inadvertent anthropogenic disturbances. These changes may culminate in adverse impact on human health and the biosphere on which we depend. The study revealed that there is decline in yield of maize, wheat and potatoes in the study area. Moreover, both the farmers and Government of India are trying to reduce the negative impacts of Climate change on Agricultural production through various adaptive strategies and programs. Some adaptation measures employed by farmers include seed banking, integrated farm management and irrigation among others, while the government of India employs farmers awareness programs on climate change, establishment of village climate risk management committee (VCRMC), provision of weather insurance, establishment of crop calendar rainfall pattern, provision of loss payment through weather insurance, establishment of pest calendar and establishment of one rain gauge for one village as adaptive strategies consequently.

**Keywords:** Climate Change, Impact, Agriculture, Productivity, India.

## I. INTRODUCTION

Asia is the largest continent on Earth and has over four climatic zones (boreal, arid and semi-arid, tropical and temperate (Chopra, 1987). The region faces formidable environmental and socio-economic challenges in its effort to protect valuable natural resources. Land and ecosystems are being degraded, threatening to undermine food security. In addition, water and air quality are deteriorating while continued increases in consumption and associated waste have contributed to the exponential growth in the region's existing environmental problems (Easterly, 2007). There is evidence of prominent increases in the intensity and/or frequency of many

extreme weather events such as heat waves, tropical cyclones, prolonged dry spells, intense rainfall, tornadoes, snow avalanches, thunderstorms, and severe dust storms in the region (Cruz et al. 2007).

Impacts of such disasters range from hunger and susceptibility to disease, to loss of income and livelihoods, affecting human survival and well-being. For example, the extreme weather events in China during 2006 included major storms and flooding in the east and south, as well as heat and drought in central, western and north eastern regions, killing more than 2700 people and causing USD 20 billion in damages. Climate change will affect many sectors, including water resources, agriculture and food security, ecosystems and biodiversity, human health and coastal zones (Nayak, 2007).

### a) Climate Change and Crop Productivity: Indian Experiences

Agriculture plays a key role in overall economic and social wellbeing of India. The country faces major challenges to increase its food production to the tune of 300 million tons by 2020 in order to feed its ever-growing population, which is likely to reach 1.30 billion by the year 2020 (Mehta, 2007). To meet the demand for food from this increased population, the farmers need to produce 50% more grain by 2020 (Paroda and Kumar, 2000; DES, 2004). Unfortunately, there are evidences of stagnation in yield growth rates of majority of food crops in recent decades. Climate change of some sort accompanied with rising temperature and altered pattern of precipitation would further negate the improvement in productivity by on-going genetic and other technological effort. In general, consequence of climate change may have serious implications for India's food security and economy (Mehta 2007).

Agricultural seasons naturally obtained in India are mainly divided into two, the summer or Kharif 'and the Winter or Rabi '. Kharif 's season begins with the onset of south west monsoon (June - July) and end during the autumn

(October –November) or winter (December –February) depending on crop duration. The major crops grown in this season are rice, maize, sugarcane, jute, cotton, soya bean, groundnut and bajra etc. This contributes more than 50% of the food-grain production and 65% of the oilseed production in the country( Singh, 2010). Rabi ‘season starts after the post /summer monsoon (October-November) and the major Rabi ‘crops are wheat, mustard, potato, onion, gram and barley. Summer monsoon provide essential soil moisture and often irrigation water for Rabi ‘crops (Mall et al., 2006). In India about 60 % total cropped area is under rain fed conditions and any changes in precipitation pattern will affect the overall crop productivity.

The various studies conducted in India and abroad have shown that due to global warming, the surface air temperatures in India are going up at the rate of 0.4oC per hundred years, particularly during the post-monsoon and winter seasons (Pandey, 2009). It has been predicted with the help of Global Circulation (GCM) models that mean winter temperatures in India will increase by as much as 3.2oC in the 2050s and 4.5oC by 2080s, and summer temperatures will increase by 2.2oC in the 2050s and 3.2oC in the 2080s due to global warming (Singh, 2010). The expected increase in mean temperature in India during Kharif and Rabi season are respectively, 1.1 – 4.5oC by 2070.

Rainfall will increase up to 10% in both seasons by 2070 (Mall et al, 2006). There have been a few studies in India which aimed at understanding the nature and magnitude of yield gains or losses of crops at selected sites under elevated atmospheric CO<sub>2</sub> and associated climatic change (Aggarwal and Sinha, 1993; Gangadhar Rao et al., 1994; Lal et al., 1999; Rathore et al., 2001; Mall and Aggarwal, 2002; Attri and Rathore, 2003, Mall et al., 2004).

Most of the simulation studies have shown a decrease in duration and yield of crops as temperature increased in different parts of India. Such reductions were, however, generally, offset by the increase in CO<sub>2</sub>; the magnitude of these changes varied with crop, region and climate change scenario. Sinha and Swaminathan (1991) showed that an increase of 2oC in temperature could decrease the rice yield by about 0.75 ton/ha in the high yield areas; and a 0.5oC increase in winter temperature would reduce wheat yield by 0.45 ton/ha. Gangadhar Rao and Sinha (1994) showed that wheat yields could decrease between 28 to 68% without considering the CO<sub>2</sub> fertilization effects; and would range between +4 to -34% after considering CO<sub>2</sub> fertilization effects.

Aggarwal and Sinha (1993) using WTGROWS model showed that a 2oC temperature rise would decrease wheat yields in most places. Lal et al., (1999) concluded that carbon fertilization effects would not be able to offset the negative impacts of high temperature on rice yields. Saseendran et al. (2000) showed that for every one-degree rise in temperature the decline in rice yield would be about 6%. Aggarwal et al., (2002) using WTGROWS and recent climate change scenarios estimated impacts on wheat and other cereal crops. In north India, irrigated wheat yields decreased as temperature increases, a 2oC increase resulted in 17 % decrease in grain yield but beyond that the decrease was very high.

The effect of climate change scenario of different periods can be positive or negative depending upon the magnitude of change in CO<sub>2</sub> and temperature (Aggarwal, 2003) has crop simulation runs for two scenarios based on IPCC (2001) and pointed out that the irrigated wheat and rice yields in north India will not be significantly affected due to direct effect until 2050. It is only in 2070 when the temperature increases are very large, that the crops show large reduction in yield. The study conducted by Aggarwal and Mall, (2002) shows the combined effect of atmospheric CO<sub>2</sub> and temperature on rice crop in different Indian regions, showed that productivity gains possibly achieved in northern region through beneficial effect of 450,550 and 650 ppm CO<sub>2</sub> could be nullified by 1.7, 3.5 and 5.0oC increase in temperature.

## II. THE STUDY AREA

### a) Location

India is a vast country lying entirely in the Northern hemisphere. The main land extends between latitudes 8°4'N and 37°6'N and longitudes 68°7'E and 97°25'E. The Tropic of Cancer (23° 30'N) divides the country into almost two equal parts. To the southeast and southwest of the mainland, lie the Andaman and Nicobar Islands and the Lakshadweep islands in Bay of Bengal and Arabian Sea respectively.

### b) Size

The land mass of India has an area of 3.28 million square km. India's total area accounts for about 2.4 per cent of the total geographical area of the world (Lal et al 1999).

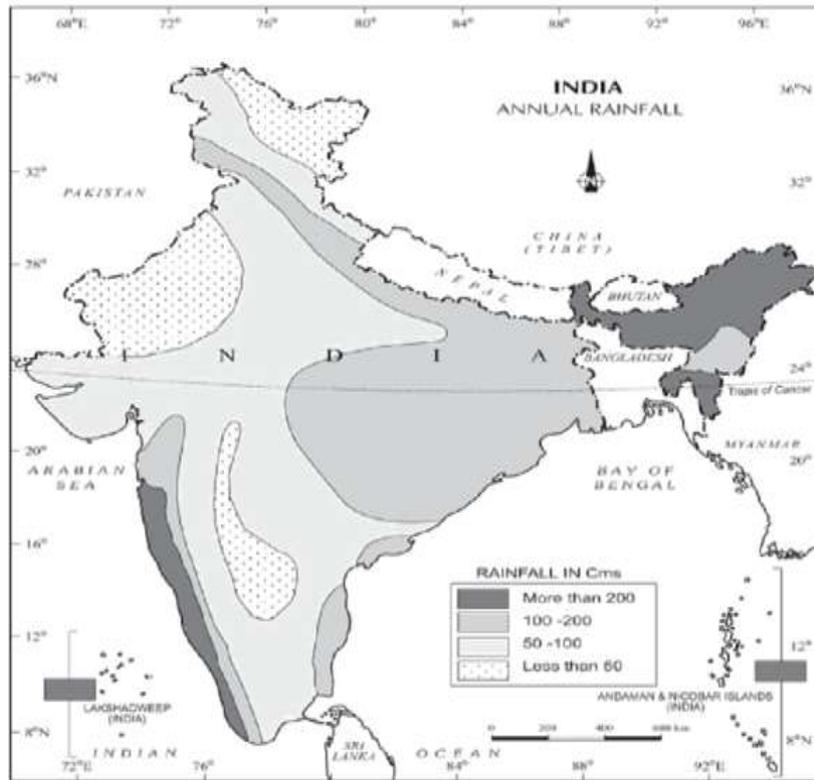


Figure 1: Indian annual rainfall

Source: (NCERT, 2006)

The self-sufficiency in Indian food grain production and its sustainability is in ambiguity due to the climate variability and change that occurred in the recent past. About 43% of India’s geographical area is used for agricultural activity (Pandey, 2009) Agriculture accounts for approximately 33 per cent of India’s GDP and employs nearly 62 per cent of the population (Singh, 2010). It accounts for 8.56% of India’s exports (Mall et al, 2006). About one third of the cropland in India is irrigated, but rain fed agriculture is central to the Indian economy (Paroda et al, 2000). Despite technological advances such as improved crop varieties and irrigation systems, weather and climate are still playing key role in Indian agricultural productivity thereby national prosperity.

Agriculture adversely affected not only by an increase or decrease in the overall amounts of rainfall, but also by shifts in the timing of rainfall. For instance, over the last few years, the Chhattisgarh region has received less than its share of pre-monsoon showers in May and June (Mehta, 2007). These showers are important to ensure adequate moisture in fields being prepared for rice crops.

Agriculture is worst affected in the coastal regions of Gujarat and Maharashtra, where agriculturally fertile areas are vulnerable to inundation and salinization (Lal et al 1999).

Standing crop in these regions are also more likely to be damaged due to cyclonic activity. In Rajasthan, a 20C rise in temperature was estimated to reduce production of pearl millet by 10-15 per cent (Paroda et al, 2000). The State of Madhya Pradesh, where soybean is grown on 77 per cent of all agricultural land, could dubiously benefit from an increase in carbon dioxide in the atmosphere (Easterly, 2007). According (Chopra, 1984) soybean yields could go up by as much as 50 per cent if the concentration of carbon dioxide in the atmosphere doubles. However, if this increase in carbon dioxide is accompanied by an increase in temperature, as expected, then soybean yields could actually decrease (Cruz et al, 2007).

If the maximum and minimum temperature goes up by 10C and 1.50C respectively, the gain in yield comes down to 35 per cent. If maximum and minimum temperatures rise by 30C and 3.50C, respectively then soybean yields will decrease by five per cent compared to 1998 (Attri et al, 2003) Changes in the soil, pests and weeds brought by climate change will also affect agriculture in India. For instance, the amount of moisture in the soil will be affected by changes in factors such as precipitation, runoff and evaporation (Aggarwal, 2003).

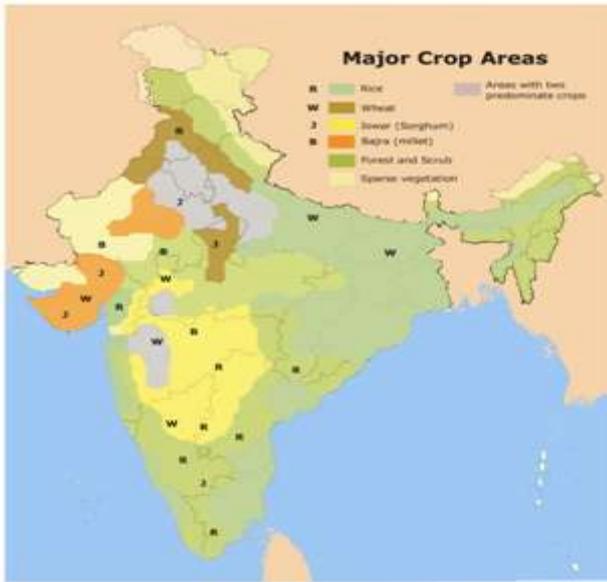


Figure 2: Map of India showing Agricultural Production

Source: (NCERT, 2006)

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### III. METHODOLOGY

This study has used secondary data collected from various published sources, viz. input data on fertilizer use, irrigation facility, area under high-yielding varieties (HYVs) by farm-size, etc. were taken from various volumes of the Input Surveys published by the Directorate of Economics and

Statistics, Ministry of Agriculture, Government of India (GOI). The analytical measures like simple tabular analysis, growth rate, and fertilizer imbalance index were applied to evaluate accessibility and use of production resources by smallholders versus other farmers. Meanwhile, strategic planning method used to evaluate the strength, weaknesses, opportunities and threats (SWOT) involved in the research, which specify the and identify the internal and external factors that are favorable and unfavorable to the farmers.

## IV. RESULTS AND DISCUSSION

### a) Impacts on Wheat Production

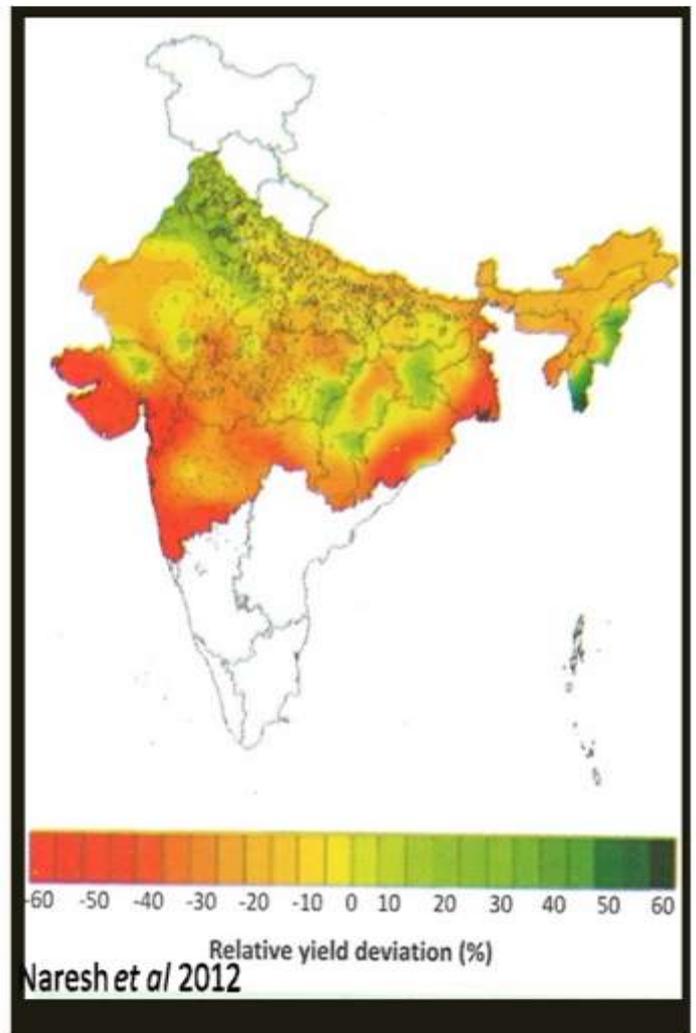


Figure 3: Impact of climate change on wheat production

Source: Naresh et al, 2012

Climate change reduced the irrigated wheat production by 6%, adaptive strategies can not only offset the production losses but can increase the yield.

**b) Trends in Rice Production**

Rice is one of the important food crops cultivated in India. Its production in 2008-09 is estimated to be 99.15 million tones. During triennium ending 2005-06, the major rice producing states in the country were: West Bengal (17 per cent), Uttar Pradesh (12.6 per cent), Andhra Pradesh (11.7 per cent), Punjab (11.5 per cent), Orissa, Madhya Pradesh and Bihar (7.5 per cent each). These seven states together accounted for about 75 per cent of total rice production in the country. The Rice production has reduced due to the climate change if necessary adaptive strategies are not put in place in the rice producing regions of India.

**c) Impact on Rice Production**

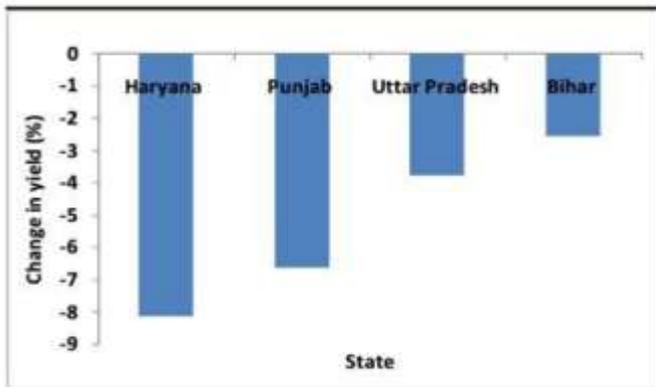


Figure 4: Impact of climate change on rice production

Source: Indian Council of Agricultural Research

**d) Impact on potato production**

Potato is cultivated in India in about 21.3 million hectares with a total production of 24.7 million tons. The areas where potato crop is prominently cultivated are: Uttar Pradesh, West Bengal, Bihar and Punjab. In India Uttar Pradesh is the area where potatoes are grown in a big way. Almost over 41% of the total production of potato is from Uttar Pradesh.

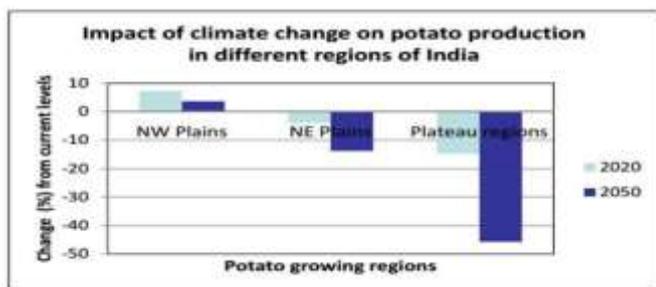


Figure 5: Impact of climate change on potato production

Source: Indian Council of Agricultural Research

Global climate change may raise production of potato in Punjab, Haryana and western and central UP by 3.46 to 7.11% in A1b 2030 scenario, but in rest of India particularly West Bengal and plateau region potato production may decline by 4 to 16%

**V) ADAPTIVE STRATEGIES TO CLIMATE CHANGE IMPACTS ON AGRICULTURAL PRODUCTION BY FARMERS IN INDIA**

1. Community seed bank (E.g., in Dubri and Assam)

Maintenance of seed bank purposely to keep quality seeds of submergence tolerant and short duration late transplanted rice varieties for flood affected areas and quality seed of summer rice and toria for rabi.

2. Minimizing loss of fish during floods (E.g., in Dubri and Assam)

Intervention: Placement of nylon net along the periphery of pond and establishment of horticultural plants Purpose:

- To prevent escape of cultured fish and entry of predatory fish
- Prevent water contamination and change in water quality
- Prevent escape of cultured fish and entry of predatory fish

3. Integrated farming system (E.g., in Kendrapara and Orissa)

Intervention: To increase water productivity, water use efficiency and better land husbandry practices Purpose:

- It will store runoff water
- Recharging of ground water
- Increase the availability of moisture
- Provide lifesaving irrigation during drought
- Generate employment

**a) Government Intervention to tackle Climate Change impact of agriculture in India**

1. Farmers awareness programs on climate change
2. Establishment of Village Climate Risk Management Committee (VCRMC)
3. Provision of Weather Insurance
4. Establishment of Crop Calendar Rainfall Pattern
5. Provision of Loss Payment through Weather Insurance
6. Establishment of Pest Calendar
7. Establishment of One Rain gauge for One Village

## VI. CONCLUSION

The climate change, as realized through trends of temperature rise and increased CO<sub>2</sub> concentration, is a major concern. In the recent past, the number of studies for assessing its impact on agriculture has increased. However, this study concludes that climate change has significantly reduce the agricultural production turn over India which consequently persist the rate of hunger and poverty in India.

## VII. RECOMMENDATIONS

To mitigate the climate change effects on agricultural production and productivity, a range of adaptive strategies need to be considered.

- Changing cropping calendars and pattern will be the immediate best available option with available crop varieties to mitigate the climate change impact. The options like introducing new cropping sequences, late or early maturing crop varieties depending on the available growing season, conserving soil moisture through appropriate tillage practices and efficient water harvesting techniques are also important.
- Developing heat and drought tolerant crop varieties by utilizing genetic resources that may be better adapted to new climatic and atmospheric conditions should be the long-term strategy. Genetic manipulation may also help to exploit the beneficial effects of increased CO<sub>2</sub> on crop growth and water use. One of the promising approaches would be gene pyramiding to enhance the adaptation capacity of plants to climatic change inputs (Mangala Rai, 2007).
- Protection of groundwater resources and improved management and maintenance of existing water supply systems.
- Protection of water catchment areas, improved water supply and employ Groundwater and rainwater harvesting and desalination.
- Educational and outreach programs on conservation and management of soil and water.

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