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Climate Change And Impact Of Economic Growth And Agriculture In India: A Perspective Study

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Abstract

Agriculture is significant for ensuring food, nutrition and living securities for India and it connect almost two-third of the labour force in lucrative employment. On account of its close linkages with other economic sectors, agricultural growth has a multiplier effect on the entire economy of the country. Even though in the past years, Indian agriculture had made a significant progress, but currently it faces many challenges. Stagnation of net sown area, plateauing yield level, and deterioration of soil quality, reduction in per capita land availability and the adverse effect of climate change are the major challenges to Indian agriculture. Agriculture is a cause of climate change and also suffers from the consequences. key adverse impacts of climate change on agriculture are owing to increase in temperature; change in rainfall pattern; weather hazards, decline in soil and water quality; shifting dynamics of insects, diseases, soil flora and fauna; intrusion of sea water on land and biotic and a biotic stresses arising due to climatic extremes. There could be a few positive impacts of climate change on agriculture in some locations because of change in temperature and moisture regimes.

Key Words: Agriculture, climate change employment, economic sector, food and nutrition

1) Introduction:

Agriculture is crucial for ensuring food, nutrition and livelihood securities for India and it engage almost two-third of the workforce in gainful employment. On account of its close linkages with other economic sectors, agricultural growth has a multiplier effect on the entire economy of the country. Although in the past years, Indian agriculture had made a significant progress, but currently it faces many challenges. Stagnation of net sown area, plateauing yield level, and deterioration of soil quality, reduction in per capita land availability and the adverse effect of climate change are the major challenges to Indian agriculture. Moreover, the increased rate of population is pressurizing the agricultural sector for enhanced food production. The task is very challenging because, about 60% of the net cultivated area is rainfed and exposed to biotic and a biotic stresses arising from climatic variability and climate change. More than 80% of Indian farmers are marginal farmers, having cultivable land of less than one hectare or small farmers with cultivable land area of one to two hectares, with poor coping capacity. Additionally, the Indian farmers are heterogeneous and unorganized in nature. Climate change and its variability are likely to aggravate the problem of future food security by putting pressure on agriculture affecting its sustainability.

2) Statement of the Problem:

Climate change prediction points a warmer world within the next 50 years, a trend that is increasingly being supported by 'ground-truth'. Climate change threatens to increase the crop losses, increase in the number of people facing malnutrition, and changing the development pattern of plant diseases and insect-pests. Agriculture production of rain fed regions, which constitute about 68% of the area under cultivation and account for about 40-45 percent of the total production in India, varies from year to year. Hence, in order to sustain and enhance the production of the rain fed crops of semi-arid tropics, it is necessary to use the knowledge of climate variability to tailor the practical innovative cropping pattern and insect-pest and disease management for location specific agro-climatic zone. Current estimates of change in climate indicate an increase in global mean annual temperatures of 1ºC by 2025 and 3ºC by the 2100. Variability in rainfall pattern and intensity of rain are expected to increase. Increasing concentration of greenhouse gases (CO_2 and O_3) would result in increase in global precipitation of 2 ± 0.5ºC per 1ºC warming. Overall, changes in these elements will result in i) warmer and more frequent hot days and nights ii) erratic rainfall distribution pattern leading to drought or high precipitation and iii) drying of rained semi-arid tropics (SAT) in Asia and Africa.

3) Review of Literature:

The vast literature that examines the role of climate in the economy is discussed. The present paper provides information on data sources, model specification, and estimation strategy. This section reviews the various empirical and theoretical studies outlining the potential channels through which climate impact the economy. Impact of climate change on civilization can be broadly categorized into three main categories: health impacts, social impacts, and economic impacts (Carleton and Hsiang, 2016). Extreme exposure to hot and cold temperatures leads to several cardiovascular, respiratory, and 'cerebrovascular' diseases that can increase hospital visits leading to higher costs and can even result in death (Kovats et. al., 2004, Basu and Samet, 2002, Deschenes, 2014). In Delhi, it is estimated that an increase in temperature by 1°C increases death rate by 3.2 precent (Hajat et. al., 2005). There is also an increase in risk of public health security due to water-borne diseases like cholera, and vector-borne diseases like malaria and dengue (Kibria, 2016).

However, evidence suggests that adaptation reduces the ill effects of rise in temperature as humans find ways to mitigate extreme temperatures. For instance, heat related mortality rates in US fell by over 80 percent with the advent of air conditioners (Barreca et. al., 2016). Other hydro- climatic disasters like cyclones and tsunamis also cause a sharp rise in the death rates (Hsiang and Narita, 2012).

Soaring temperatures and inadequate rainfall increase collective violence, land invasions and chances of civil war intensity (Hidalgo et. al., 2010). The effects emerge majorly in poor backward areas like rural India and Tanzania, most likely as a result of depressed agricultural yield (Miguel, 2005).

Economy-Wide Impact of Climate Change:

In their cross-sectional study conducted worldwide, Dell et. al. (2009) employed data from 12 countries in the Western Hemisphere. The authors concluded that national income per capita falls by 8.5 percent per degree Celsius (henceforth ℃) rise in temperature. However, there are two limitations to the approach adopted by Dell et. al. (2009): firstly, it does not take into account the time factor which plays a critical role in the climate change literature; secondly, many researchers believe that results derived using this approach are not accurate because changes in economic variables may be attributed to other distinctive characteristics like quality of institutions (Rodrik et. al., 2004). Therefore, refining their study to include a panel data model, Dell et. al. (2012) established three primary results. First, higher temperatures substantially reduce economic growth in poor countries. They estimated that a 1°C rise in temperature in a given year reduces economic growth in that year by 1.3 percentage points. However, changes in temperature in richer countries did not show a substantial and significant effect on output. Second, higher temperatures not only reduce the absolute level of output, but also the growth rates. They estimated a statistically significant downward sloping relationship in poorer countries and a statistically insignificant relationship in richer countries (Dell et. al., 2012, Hsiang and Jina, 2014). This implies that poorer countries have little impetus to adapt to climate change. Moreover, there is suggestive evidence that richer countries may be less impacted by a rise in temperature (Burke et. al., 2015). As a result, inter- country inequality has increased over the years. Diffenbaugh and Burke (2019) estimated that there is an approximate 25 percent rise in population-weighted inter-country inequality during the past 5 decades. However, most recent evidence suggests that the negative long-run growth effects impact all countries, rich or poor, hot or cold (Kahn et. al., 2019). Third, higher temperatures have wide-ranging effects on other sectors of the economy besides agriculture.

While many researchers studied the linear relationship between climate change and economic growth (Dell et. al., 2012, DARA 2012), Burke and Tanutama (2019) tested for a non-linear relationship using data from 11,000 districts across 37 countries worldwide. This study established that growth in aggregate output responds non-linearly to temperature across all regions, with output peaking at cooler temperatures, typically less than 10°C and declining steeply thereafter. Using data from 166 countries over a period of 50 years, Burke, Hsiang, and Miguel (2015) find that economic production at the national level is smooth, non-linear, and concave with respect to temperature, with an optimal temperature of 13°C.

A district level study was conducted by Mani et. al. (2018) for South Asia using average temperature and precipitation data along with household survey data the study examined the impact of change in climatic conditions on average living standards. The study results suggest that a rise in average temperatures led to a decline in the living standards in India, Pakistan, Sri Lanka, Nepal and Bangladesh as compared to business as-usual scenario. Only Nepal and Afghanistan did not see a negative impact because they experience relatively colder temperatures. Temperature and consumption have a U-shaped relationship for all the South Asian countries. A similar study conducted in Latin America by Verner (2010) tests the relationship between climate change and standard of living using municipal level data from Chile, Brazil, Bolivia, Peru and Mexico. The results range from showing a negative relationship in Chile, and U shaped curve in Brazil, Bolivia, Peru, and insignificant results in Mexico.

Several future projections have been made in an attempt to estimate the extent of negative impact on economic output brought forth by climate change. It has been predicted that average income in the poorest 40 percent of countries could decline by 75 percent by 2100 relative to a world without climate change (Burke et. al., 2015).

Burke and Tanutama (2019) estimated that climate change has cost the United States and the European Union more than $4 trillion in lost output since 2000. Another recent study concluded that if temperature deviates from its historical norm by 0.01°C annually, long-term income growth will be lower by 0.05 percentage points per year (Kahn et. al., 2019). An obvious consequence of such magnitudes of losses in economic output due to climate change will reflect in the number of people living in poverty.

Hallegatte et. al. (2016) show that climate change will push 100 million people below the poverty line in 10 years, with India alone contributing about 40 percent

Mani et. al. (2018) estimated a decline in living standards by 6.7 percent for Bangladesh, 2.8 percent for India, 2.9 percent for Pakistan, and 7.0 percent for Sri Lanka by the end of 2050. In terms of absolute amount of total GDP losses, the cost of continuing with the business as-usual scenario is estimated at $171 billion for Bangladesh, $1,178 billion for India, and $50 billion for Sri Lanka by 2050. Another study estimated that the aggregate loss to consumption is at 0.4 percent of GDP for India (Hallegatte et. al., 2016).

The economic impacts of climate change are realized through impacts on agricultural yields, average productivity and supply of labour, supply and demand dynamics of energy, global trade and overall economy-wide effects (Carleton and Hsiang, 2016). Temperature and precipitation play a pivotal role in determining farm outcomes (Auffhammer and Schlenker, 2014). Several studies have highlighted the adverse impact of climate change on crop yield ranging from 3.8 to 5.7 percent (Auffhammer et. al., 2012, Lobell et. al., 2011). Increasing evidence shows that crop cycles have been altered in South Asian countries like India, Bangladesh and Pakistan causing serious damage to productivity and yields (Burke et. al., 2015). On a particular day of extreme heat, worker productivity tends to be much lower, especially in tropical climates (Mani et. al., 2018). Heat stress lowers productivity (Seppänen et. al., 2006), reduces cognitive performance (Graff Zivin et. al., 2018) and decreases work hours in sectors that require heavy outdoor activity like construction (Somanathan et. al., 2015). On another note, energy and climate share a distinctive relationship such that rising temperatures demand a surge in energy usage to assist the process of mitigating the heat effects, while suppressing the supply and transmission process (Auffhammer and Mansur, 2014; Davis and Gertler, 2015). Lower industrial and agricultural yields (Jones and Olken 2010) lead to decreased exports which in turn leads to lower national incomes indirectly affecting the world trade (Hsiang and Jina, 2014). The aforementioned effects of climate change across sectors and stakeholders are likely to reflect in the relationship between climate and some broad measure of economic performance. Besides studying sectoral effects, one can also therefore study the impact of climate change at a macro level by studying the effect of temperature rise on the GDP. Such top down approach is adopted in the present study.

4) Historical Perspective of Climate Change in Global and Indian Context:

The confirmation of changing climate from observations has grown significantly during recent years. At the same time improved ways of characterizing and quantifying uncertainty have highlighted the challenges that remain silent for developing long-term global and regional climate quality data records. The globally averaged combined land and ocean surface temperature data as calculated by a linear trend, show a warming of 0.85 (0.65 to 1.06) °C, over the period 1880–2012, when multiple independently produced datasets exist and about 0.72°C (0.49°C to 0.89°C) over the period 1951–2012. The total increase between the average of the 1850–1900 period and the 2003– 2012 period is 0.78 (0.72 to 0.85) °C and the total increase between the average of the 1850–1900 period and the reference period for projection 1986”2005 is 0.61 (0.55 to 0.67) °C. This is based on the single longest dataset available. Averaged over the mid-latitude land areas of the Northern hemisphere, precipitation has likely to be increased since. For other latitudinal zones area-averaged long-term positive or negative trends have low confidence due to data quality, data completeness or disagreement amongst available estimates. It is very likely that the numbers of cold days and nights have decreased and the numbers of warm days and nights have increased globally since about 1950. However, it is likely that heat wave frequency has increased during this period in large parts of Europe, Asia and Australia. It is likely that since about 1950, the number of heavy precipitation events over land has increased in more regions than it has decreased.

The projected change in global mean surface air temperature is likely being in the range from 0.3 to 0.7°C (medium confidence). It is more likely that the global mean surface air temperature for the period 2016–2035 will be around 1°C above the mean temperature of 1850–1900. Zonal mean precipitation is likely to increase in high and some of the mid latitudes, and is more likely than not decrease in the subtropics. At more regional scales precipitation changes may be influenced by anthropogenic aerosol emissions and will be strongly influenced by natural internal variability. Models project near-term increases in the duration, intensity and spatial extent of heat waves and warm spells. These changes may proceed at a different rate than the mean warming. The frequency and intensity of heavy precipitation events over land are likely to increase on average in the near term. However, this trend will not be apparent in all the regions because of natural vari-ability and possible influences of anthropogenic aerosols.

In the last hundred years the mean annual surface air temperature of India has increased by 0.4-0.6°C (Rupakumar 2002). Annamalai *et al.* (2010) reported decreasing rainfall tendency in both southwest and northeast monsoon seasons in most parts of central and northern India. In contrast, peninsular parts of India particularly over the region from 9-16°N encompassing the rice growing areas showed an increasing rainfall tendency. This increase was particularly strong during the northeast monsoon season.

Climate change refers to historically unprecedented changes in the various climatic parameters due to human activities. Abnormal increases in average temperature, changing rainfall patterns, increases in frequency and intensity of extreme events like cyclones, and rise in the sea levels due to melting of glaciers are manifestations of the phenomenon of climate change. It has adverse impacts on humans ranging from sudden disruption in routine existence to a gradual fall in the standard of living. The contribution of environment to the economy is a multi-faceted phenomenon encompassing various channels through which the environment facilitates the working of an economy. As a result, over the past several decades, several economists have attempted to decode the nature and extent of the impacts of environmental change in general and climate change in particular on the functioning of the economies as well as the overall human well-being.

5) Conceptual Frame Work:

The concept of social impact of climate is as old as Aristotle. One of the greatest political philosophers of the modern times, Montesquieu first propagated the idea that climate played a crucial role in defining differential characteristics among non-identical societies. Later, in the 19^{th} century, the idea was formally introduced as "environmental determinism", referring to the notion that climatic conditions governed a region's social, economic and political outcomes, with less emphasis on other factors that set regions apart (Howe, 2002).

India has diverse geographical terrains representing varied agro-climatic zones. Close to 60 percent of India's population is dependent on agriculture for employment. In rural India, this proportion could be as high as 97 percent (Jha, 2006). Therefore, the agricultural sector plays a pivotal role in the Indian economy. Agriculture is also one of the climate sensitive sectors. Given India's historical reliance on agriculture and other sectors that are highly dependent on climatic conditions, it is imperative to assess the influence of climatic factors on economic well-being.

6) Objective:

The main objective of this study is to assess the effects of historical changes in weather and/or climate on economic growth at the sub-national level.

7) Impacts of Climate Change on Indian Agriculture:

Indian agriculture is highly prone to the risks due to climate change; especially to drought, because $2/3^{rd}$ of the agricultural land in India is rain fed and evens the irrigated system is dependent on monsoon rain. Flood is also a major problem in many parts of the country, especially in eastern part, where frequent flood events take place. In addition, frost in north-west, heat waves in central and northern parts and cyclone in eastern coast also cause havoc. In recent years, the frequency of these climatic extremes are getting more due to the increased atmospheric temperature, resulting in increased risks with substantial loss of agricultural production.

- Climate change can affect agriculture through their direct and indirect effects on the crops, soils, livestock and pests. Increase in atmospheric carbon dioxide has a fertilization effect on crops with C_3 photosynthetic pathway and thus promotes their growth and productivity.
- Increase in temperature can reduce crop duration, increase crop respiration rates, alter photosynthesis process, affect the survival and distributions of pest populations and thus developing new equilibrium between crops and pests, hastens nutrient mineralization in soils, decrease fertilizer use efficiencies, and increase in evapo-transpiration.
- Climate change also have considerable indirect effect on agricultural land use in India due to availability of irrigation water, frequency and intensity of inter and intrapersonal droughts and floods, soil organic matter transformations, soil erosion, changes in pest profiles, decline in arable areas due to submergence of coastal land, and availability of energy.

8) Challenges:

Critical challenges that agriculture sector would face in the event of climate change are:

(i) Water availability as result of changing rainfall patterns, alteration in stream flow and increase in crop water demand;

(ii) Deterioration of water quality due to sea water intrusion, transport of salts from the deeper soil layers as a result of over exploitation of aquifers and faulty irrigation practices;

(iii) Increased frequency and intensity of extreme weather events such as droughts, floods and cyclones and these would affect the production levels more than the impact of mean changes in the climate;
(iv) Heat stress due to higher temperature at critical stage of the crop growth; and
(v) Unpredictable change in pest and disease load. There is also possibility of minor pest becoming major pest with changing climatic condition.
The classified impacts on crops, water, livestock, fisheries and pest and diseases are presented below (Aggarwal et al. 2009):

Crops

Increase in ambient CO_2 is beneficial since this leads to increased photosynthesis in several crops, especially crops with C3 mechanism of photosynthesis such as wheat and rice, and decreased evaporative losses.
a) Enhanced frequency and duration of extreme weather events such as flood, drought, cyclone and heat wave; that adversely affect agricultural productivity;
b) Reduction in yield in the rain fed areas due to increased crop water demand and changes in rainfall pattern during monsoon season;
c) Declined quality of fruits, vegetables, tea, coffee, aromatic, and medicinal plants;
d) Alteration of agricultural pests and diseases because of more pathogen and vector development, rapid pathogen transmission and increased host susceptibility;
e) Threatened agricultural biodiversity by rainfall uncertainty and temperature increase, sea level rise, and increased frequency and severity of drought, cyclones and floods; and
Contrary to all the above negative impacts, predictions have been made for decreased cold waves and frost events in future due to the atmospheric temperature rise, which would lead to a decreased probability of yield loss associated with frost damage in northern India in crops such as mustard and vegetables.

Fishery

- Increasing sea and river water temperature is likely to affect fish breeding, migration, and harvest;
- Impact of increased temperature and tropical cyclonic activity would affect the capture, production and marketing costs of the marine fish; and
- Coral bleaching is likely to increase due to higher sea surface temperature.

Livestock

Climate change has pronounced effect on feed production and nutrition of livestock. Increased temperature results in enhanced lignifications of plant tissues and reduced digestibility. Increased water scarcity would also decrease food and fodder production.

- In cooler areas, climate change has major impact on vector-borne diseases of livestock by the expansion of vector population. Changes in rainfall pattern may also influence expansion of vectors during wetter years, leading to large outbreaks of disease;
- Global warming would increase water, shelter, and energy requirement of livestock for meeting projected milk demand; and
- Climate change is likely to aggravate the heat stress in dairy animals, adversely affecting their reproductive performance.

Insects and diseases

- Extension of geographical range of insect-pests and pathogens;
- Changes in population growth rates of pathogens and insect-pests;
- Changes in relative abundance and effectiveness of bio control agents;
- Emergence of new diseases/pest problems and increased risk of invasion by migrant diseases and pests; and

- Reduced efficacy of different components of disease and insect-pest management.

Soil

Reduced quantity and quality of organic matter content, which is already quite low in Indian soil. Under elevated CO_2 concentration, crop residues have higher C:N ratio, which may reduce their rate of decomposition and nutrient supply.

- Increase of soil temperature will increase N mineralization but its availability may decrease due to increased gaseous losses through processes such as volatilization and gentrification;
- Change in rainfall volume and frequency and wind intensity may alter the severity, frequency and extent of soil erosion; and
- Rise in sea level may lead to salt-water ingression in the coastal lands turning them less suitable for conventional agriculture.

Water

- Increased irrigation demands with increased temperature and higher evaporate-transpiration. This may also result in lowering groundwater table at some places;
- Melting of glaciers in the Himalayas may lead to increased water availability in the Ganges, Bhramaputra and their tributaries in the short run but in the long run the availability of water would decrease considerably;
- A significant increase in runoff is projected in the wet season that may lead to increase in frequency and duration of floods and also soil erosion;
- However, the excess water can be harvested for future use by expanding storage infrastructure; and
- The water balance in different parts of India is predicted to be disturbed and the quality of groundwater along the coastal track will be more affected due to intrusion of sea water.

9) Conclusion:

- Climate change property on agriculture is likely to be everywhere, both in terms of direct and indirect impacts.
- Maintaining plant health across the planet, in turn, is a key prerequisite for climate change alleviation, as well as the conservation of biodiversity and the provision of ecosystem services under global change. Information gathered so far has been fragmented and a inclusive analysis of climate change impacts on agriculture is required.
- Investigational research on a diverse range of crop and biotic and a biotic systems is necessary to improve comprehension of climate change impacts on agriculture.
- To preserve ecosystem health and services under variable, unpredictable or unknown conditions, we need more resilient systems, decentralization, participatory research and breeding networks.

10) Policy Suggestions:

- To countenance the challenges of food security and climate change, the country needs to reorient its land use and agriculture with the state-of-the-art technologies and policy initiatives.
- Collision of climate change on gender is another area that needs to be concentrated. Cost on adaptation and economics need to be worked out for the future climate under business as usual condition and for changed management situation for up-scaling adaptation options to larger regions.
- There is a need to develop policy framework for implementing the adaptation and mitigation options so that the farmers are saved from the adverse impacts of climate change

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