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Girish Goyal

Department of Agronomy, C. S.
Azad University of Agriculture &
Technology, Kanpur, Uttar
Pradesh, India

Aparajita Singh

Department of Farm
Engineering, Institute of
Agricultural Sciences, BHU,
Varanasi, Uttar Pradesh, India

Ashok Kumar

Department of Soil Science, C. S.
Azad University of Agriculture &
Technology, Kanpur, Uttar
Pradesh, India

Sanjay Kumar

Department of Agronomy, S. V.
P University of Agriculture &
Technology, Meerut, Uttar
Pradesh, India

Neeraj Kumar Gupta

Department of Horticulture,
Rabindranath Tagore
University, Bhopal, Madhya
Pradesh, India

Correspondence**Girish Goyal**

Department of Agronomy, C. S.
Azad University of Agriculture &
Technology, Kanpur, Uttar
Pradesh, India

Impact of climate change in Indian agricultural context: A review article

Girish Goyal, Aparajita Singh, Ashok Kumar, Sanjay Kumar and Neeraj Kumar Gupta

Abstract

The climate change and clear evidence of observed changes in climate during 20th century, an increasing emphasis on food security and its regional impacts has come to forefront of the scientific community. In recent times, the crop simulation models have been used extensively to study the impact of climate change on agricultural production and food security. The paper ends with some comments on Indian agricultural policy in the era of climate change. An extended annotated bibliography provides a compendium of the likely impact of climate change on the yield and productivity of several major crops in India, on water-related parameters such as evaporation, water runoff and soil moisture; and on soil productivity, pests and crop diseases. Agriculture is facing ecological and economical challenges. The major effects can be generalized as changes in the geographical limits to agriculture, changes in crop yields and impacts on agricultural system. Indian agriculture is particularly sensitive to climate change and variability. The economic impact of climate change on Indian agriculture. I estimate the effect of random year-to-year variation in weather on agricultural output using a 40-year district-level panel data set covering over 200 Indian districts. These results suggest that climate change is likely to impose significant costs on the Indian economy unless farmers can quickly recognize and adapt to increasing temperatures. Such rapid adaptation may be less plausible in a developing country, where access to information and capital is limited. *Indian agriculture remains vulnerable to the vagaries of weather, and the looming threat of climate change may expose this vulnerability further.*

Keywords: Climate change, GHGs, Indian agriculture

Introduction

Climate change is the rising temperature of the earth due to an increased amount of carbon dioxide (CO₂) and other greenhouse gases (GHGs). Ministry of Environment and Forests, Government of India defines it as “a statistically significant variation in either the mean state of the climate or in its variability” (Hans *et al.* 2011) [5]. As a result of global warming catastrophic events tends to occur frequently which would definitely ruins our planet, our life and our children’s lives too. Evidently, there is growing pressure and struggle for resources which for developing and agrarian economies like India pose serious challenges. Climate change is the warming that the world has experienced in the past 200 years, especially so in the past 30 years. Depending on the place where one live, this warming could be as little as 0.5°C to more than 2°C. Change in climate is not only restricted to a simple rise in temperature but it also includes rainfall patterns change - dry regions are getting drier while wet regions getting wetter. Due to change in climate, rain are concentrated to fewer days but with an increased intensity and this intense rains create the problem of poor urban planning, waste-clogged drains and rivers which ultimately results in flooding. Climate change and agriculture are interrelated phenomena occurs at global level. Agriculture in India is a gamble which played during monsoon as because still today majority of agriculture is monsoon based. Monsoon gets highly affected by climate change and factors like, the heat wave generated due to climate change which severely affect the livestock and brought drought and increased amount of CO₂ affected the pastures with prevalence of parasites and diseases impacting agriculture and Agriculture productivity decreases to.

Contribution of GHG to Climate Change

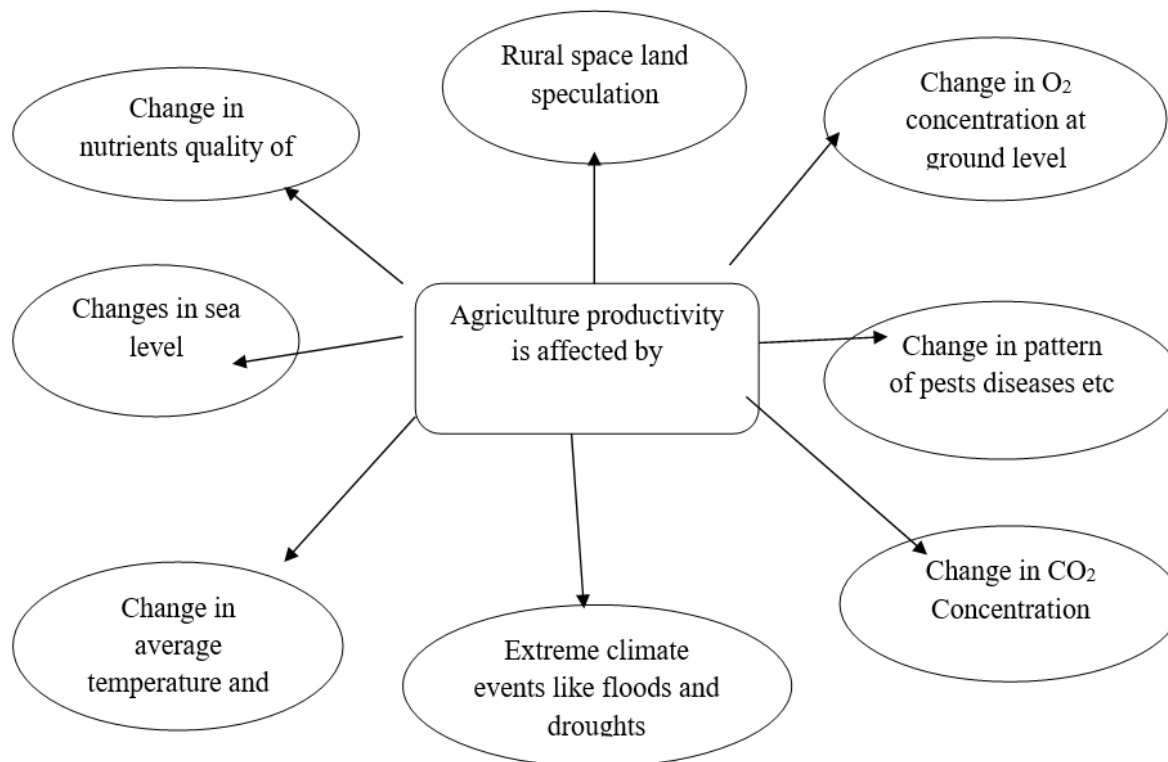
A study revealed that out of the 100 per cent GHG emissions sector-wise, agriculture and its related sectors account for 23 per cent.

According to Scientists, India's contribution to global warming is 4 percent while that of China is 6 percent. The growing of rice which is most exclusively food grains, results in the emission of about 12 to 14 percent of the world's annual methane (CH₄) budget which is about half of which is produced in India (Christianson *et al.* 2000) ^[1]. Agriculture in

India is in a peculiar situation of growth with vulnerability (Hans *et al.* 2010) ^[10].

Factor Affecting Agriculture Productivity

Climate change affects agriculture productivity in various ways. Some of them are mentioned with block diagram below



Direct and Indirect Impacts of Climate Change

The impact of climate change on agriculture is more pronounce at regional level rather than global level. Some of the potential impacts of climate change on agriculture sector are as written below:-

- Shifting in sowing time and length of growing seasons which necessitate the adjustment in sowing and harvesting windows.
- Change in genetic traits of cultivars.
- Adjustment of cropping system.
- Warmer environment with erratic rainfall distribution,
- Higher rate of evaporation
- Depletion of soil moisture.
- Decrease in crop productivity
- Increase in water scarcity
- Decrease nutrient efficiencies of food by adopting resilient management practices.
- Increase in extreme events like heat and cold waves
- Increase in droughts and floods
- Ill effect on livestock
- Increase incidences of pest-disease weeds
- Deterioration of soil health
- Threatening the food security

Instead of direct effects on crops, climate change also affects natural resources like soil and water.

- Increased rainfall intensity causes soil erosion leading to land degradation.
- Water requirement of crops increases with warming.
- Increase in extreme events like floods cyclones, heat wave and cold wave.

- Decrease in availability of viable pollen and sufficient numbers of germinating pollen grains
- Reduced flowering
- Reduced fertility of pollen grains as well as pollen germination on stigma. These effects are more pronounced in Basmati rice as well as Durum wheat cultivars.

Climate Change and Indian Agriculture

Climate change affects agriculture unevenly through worldwide. Unfortunately, India as a hot and dry country with the pronounce effect of climate change. Indian agriculture already suffers from very poor yield. It is below world average in many of the crops. Even we are exhausting our groundwater in parallel. The main reason for this is that in most states of India, farmers don't charge any price for electricity but also do not have predictable electricity supply. So they run their groundwater pumps continuously for sucking out far more and more water than they need. Besides this the combination of problems including rising of temperature, changing rainfall patterns -a more unpredictable monsoon, flooding, drought, changing pest patterns will result in decrease of yields upto 10–20%. Farmers are committing suicide every year is another problem associated with Indian agriculture and changing climate need to combat soon. Future Climate change will likely negatively affect crop productivity in low latitude countries while their effects in northern latitudes may be positive or negative. According to IPCC third assessment report, poor countries would be most affected by climate change including India, were maximum population still depend on agriculture. This leads to reduction in crop yield in most tropical and sub tropical regions due to

reduce in water availability and changed new insect pest incidents. Climate change impacts on agriculture are a big problem all over the world but the developing countries like India are more vulnerable in respect of its high population which directly depends on agriculture for their survival and exerts excessive pressure on natural resources. The warming trend in India over the past 100 years from 1901 to 2007 was observed to be 0.51°C with an accelerated warming of 0.21°C per every 10 years since 1970 (Kumar 2009) [7]. The accelerated warming impacts are likely to cause yield fluctuations of many crops with impacts on food security and prices. Cereal productivity decreases 10.40% by 2100 and greater loss is expected in *rabi*. Various studies already provided evidences of negative impacts on yield of wheat and paddy in parts of India due to increased temperature, increasing water stress and reduction in number of rainy days. Climate change impacts are likely to vary in different parts of the country. Parts of western Rajasthan, Southern Gujarat, Madhya Pradesh, Maharashtra, Northern Karnataka, Northern Andhra Pradesh, and Southern Bihar are likely to be more vulnerable in terms of extreme events (Mall *et al.* 2006a) [9]. For every one degree increase in temperature, yields of wheat, soybean, mustard, groundnut and potato are expected to decline by 3.7% (Agarwal *et al.* 2009). Similarly, rice yields may decline by 6% for every one degree increase in temperature (Saseendran *et al.* 2000). Water requirement of crops is likely to go up with accelerated warming and more extreme events are likely to cause. Due to this there is an urgent need to address the whole issue of climate change and its impacts on Indian agriculture to cope with it through various adaptation and mitigation methods. According to IPCC 2001, the extreme events become norm of the day for farming community. The result of the study which was carried by Agarwal *et al.* (2009) have indicated that a marginal 1 °C increase in atmospheric temperature along with increase in CO₂ concentration would cause minimal reduction in wheat production of India if simple adaptation strategies like adjustment of planting date and varieties are adopted uniformly. But in absence of any adaptive mechanism, it may decline by 6% for every one degree increase in temperature (Saseendran *et al.* 2000).

According to field experiments which was conducted by using advanced 'Temperature gradient tunnels' with different dates of sowing to study the impact of rising temperature on growth and development of different crops revealed that an increase of temperature from 1 to 4 °C reduced the grain yield of rice (0.49%), potato (5.40%), green gram (13.30%) and soybean (11.36%). However, an important pulse, chickpea, registered 7.25% increase in grain yield by an increase. The impact of rising temperature and CO₂ are also likely to change insect-pest dynamics. Simulation of water balance using Global and Regional Climate Models revealed likely increase in annual as well as seasonal stream-flows of many Indian River basins pointing to the need for adoption of more effective runoff and soil loss control measures to sustain crop production across the country. The Indian Council of Agricultural Research instituted All India Network Project on Climate Change in 2004 to study in detail the possible impact of climate change on major crops, livestock, fisheries, soils and other biotic factors as well as to understand different natural adaptation capabilities of both flora and fauna.

India owns 57% of the world's buffalo population and 16% of the cattle population. It ranks first in the world in respect of cattle and buffalo population, third in sheep and second in goat population. The sector utilizes crop residues and

agricultural by-products for animal feeding that are unfit for human consumption. Livestock sector had registered a growth rate of more than 4.0% during last decade. Increased heat stress due to rising temperature cause distress to dairy animals and possibly impact milk production. A rise of 2 to 6 °C in temperature is expected to negatively impact growth, puberty and maturation of crossbred cattle and buffaloes. Upadhyay *et al.* (2009) at National Dairy Research Institute, Karnal studied the temperature and humidity induced stress level on Indian livestock. Climate change scenario constructed for India revealed that temperature rise of about or more than 4 °C is likely to increase uncomfortable. A rise in temperature as small as 1 °C could have important and rapid effect on the mortality of fish and their geographical distributions.

Besides affecting crop maturity and reducing crop yields, increased temperatures will also increase crop water requirement. A study carried out by CRIDA (unpublished) on the major crop growing districts in the country for four crops, viz., wheat, maize, sorghum and pearl millet indicated a 2.2% increase in crop water requirement by 2020 and 5.5% by 2050 across all the crops or locations. The climate scenarios for 2020 and 2050 were obtained from HadCM3 model. It can be seen from the projections of future water requirements that would result due to climate change that the current level of water availability is fast dwindling and may fail to meet the future water needs. At present, available statistics on water demand shows that the agriculture sector is the largest consumer of water in India using 83% of the available water. The quantity of water used for agriculture has increased progressively through the years as more and more areas were brought under irrigation. The enhanced surface warming over the Indian subcontinent by the end of the next century would result in an increase in pre monsoonal and monsoonal rainfall, with no substantial change in winter rainfall over the central plains. This would result in an increase in the monsoonal and annual run-off in the central plains, with no substantial change in winter run-off and increase in evaporation and soil wetness during the monsoon on an annual basis (Mall *et al.* 2006b) [9].

Strategies to Mitigate Climate Change

It is clear that if no immediate steps were taken, global warming could prove much more than just an economic threat. Since second decade of the UN Framework Convention on Climate Change (UNFCCC), the larger developing countries such as Brazil, India, China and South Africa (BASIC) remained focused more on reducing emissions (mitigation) than adaptation to climate impacts (Marcoux *et al.* 2013) [10]. Now there is need of efforts to scrutinize and rethink on the existing schemes of global warming which may add to vulnerabilities (Shyamala *et al.* 2011) [11]. Some strategic suggestions are as follows.

- Increasing efforts which help to recover of ozone layer, as it traps harmful UV rays.
- Reducing air pollution.
- Encouraging and enlisting people's participation in fighting against global warming by creating a green patriotism
- Developing efficient and healthy practices at all levels from personal, family and community that strengthen adaptive mechanism e.g. planting a carbon neutral rooftop garden, recycling our wastes, buying locally and healthily grown foods, regulating vehicular services etc.
- Support for consumption of vegetarian food regularly.
- Promoting an integrated growth process – agriculture, industry and services, involving all stakeholders – rural

people, urban people, manufacturers, consumers, policy-makers, scientists and green movement leaders.

- In the integrated development and management of three environments – Natural, Built and Socio-economic – making “optimization in managing available resources” the bottom-line (Hans and Jayasheela 2007) ^[4].
- Ensuring equity in emissions in GHGs
- Avoiding the farm sector crisis (e.g. farmers’ suicides, misuse of forest land etc)
- Promote the appropriate coping skills, link gender and poverty concerns with ecological.
- Promoting the organic farming and
- Encouraging the people to use bio-fertilizers and biomass fuel
- Strict on population growth and control the use of fuel to fire.
- Bring awareness all around through ‘education’ about climate change, its impact and the modes to cope with these problems.
- People do not lose common sense when nature calls.

Further research on climate change and its impact on agriculture done for

1. Precision in climate change prediction with higher resolution on spatial and temporal scales.
2. Linking of predictions with agricultural production systems to suggest suitable options for sustaining agricultural production.
3. Preparation of a database on climate change impacts on agriculture.
4. Evaluation of the impacts of climate change in selected locations.
5. Development of models for resource and livelihood dynamics.

Conclusion

Dealing with Climate change is very much a part of environmental governance and are parts of the developmental process.

There will be a 10% reduction in wheat production in the high yield states of Punjab, Haryana and Uttar Pradesh (India’s wheat belt). Besides cereals, there will be loss of non-food crops: fish and dairy products. The loss in farm-level net revenue will range between 9 and 25 percent for a temperature rise of 2-3.5 °C. Agriculture in the coastal regions of Gujarat, Maharashtra and Karnataka is also likely to be affected negatively. India’s 70 percent of rural population faces risk especially in the North Eastern states including Bihar and Uttar Pradesh with a combined population of 250 million and adjacent states of West Bengal and Odisha. Agriculture will become more capital-intensive. Small and marginal farmers will be forced to leave land leading to economic inequality. Climate change not only affects agriculture but also results in change of topography, change in farm size, change in cropping pattern, loss of inputs and output, change in employment pattern and change in consumption pattern (Kumar *et al.* 2009) ^[7].

People need to realize that ecological balance through sustainability and climate stability is as important as national security and public health. People need to come together for the cause by upholding Gandhian principles of self-help, self-reliance and self-sufficiency. Today India has a strong baseline scheme *i.e.* Mahatma Gandhi National Rural Employment Guarantee Act (MGNREA) and its provisions

farm management for both pre harvest and post harvest. Healthy civic response and responsibility can go a long way in mitigating the problem posed by climate change. We must join with our citizens to stop global warming with one consciousness, one purpose and intelligence, for once (Makower *et al.* 2010) ^[8]. We need to continue such steps together. There is life in movement and death in stagnation. The risk of climate change alone should be enough to motivate and re-energize us. As agriculture is concerned – the first culture of man, it may longer be a way of life, but can we allow it to be away from life? The old saying still holds good-if there is a will, there is a way.

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