

Climate change and its impact on Indian agriculture

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Abstract

India is a large country with a diverse climate. There is a high dependency of agriculture on the monsoon rains and a close link exists between climate and water resources. Two thirds of the area is rain dependent. Add to this picture the small land holdings, poor cropping mechanisms and low penetration of risk management products. According to World Meteorological Organization, climate change can adversely impact global environment, agricultural productivity and the quality of human life. More importantly in developing countries, it will be difficult for farmers to carry on farming in the increased temperatures. Recognizing this, it is necessary that India should address the issue of climate change and focus on providing better environment to improve quality of human life. With a 0.68 degrees Celsius increase in temperature so far in India, it is expected that there will be pronounced warming in future, particularly during the post monsoon period and winter.

Keywords: Monsoon rain | Climate change | Global environment | Global warming | Nutrients

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There will be an increased frequency of floods during the monsoon and a decrease in winter precipitation with a lower number of rainy days. Climate change affects everyone. But the worst sufferers would be hundreds of millions of small and marginal farmers and people depending upon forests, who are already vulnerable and food insecure. The rise in global temperature on account of climate change would affect agriculture. While in temperate latitudes a rise in temperature would help countries increase food productivity, it will have adverse effects in India and countries in the tropics. The monsoon accounting for 75% of India's rainfall significantly impacts country's agriculture and livelihood of tens of millions of small farmers. Climate change is likely to intensify the variability of monsoon dynamics, leading to a rise in extreme seasonal aberrations, such as increased precipitation and devastating floods in some parts of the country as well as reduced rainfall and prolonged droughts in other areas. The present paper discusses the climate change and its impact on Indian Agriculture.

Introduction

Climate change is the most serious and most difficult environmental challenge that

humanity faces today. It is variously described as the ultimate weapon of mass destruction and a threat worse than terrorism or nuclear war. It was around the middle of the twentieth century that scientists began to take note of the human-action-induced warming of the earth, but real warning bells began to be sounded only from the 1980s, when the process of warming accelerated and more evidence surfaced linking this to human action, mostly the burning of the fossil fuels-coal, oil and gas (Prasad, 2008).

Earth's climate is a result of complex interactions between the sun, atmosphere, oceans, land and biosphere. Change is a fundamental characteristic of the environment. From the ice age of the past to the industrial age of the present, the climate of the earth has been changing. The ice age of the past are examples of climate changes due to natural factors. What is disturbing today is that human activities are leading to an unprecedented acceleration in such changes. The scientific evidence suggests that the earth's climate is changing. The atmosphere is warming, and this trend will continue. By the year 2050, scientists predict that the world will be warmer by an average of between 1.5 °C and 4.5 °C. (Kiran B. Chhokar, 2004).

According to World Meteorological Organization, climate change can adversely affect global environment, agricultural productivity and the quality of human life. More importantly in developing countries, it will be difficult for farmers to carry on farming in the increased temperatures. Recognizing this, it is necessary that India should address the issue of climate change and focus on

providing better environment to improve quality of human life.

Climate Change

Any long-term change in the statistics of weather over periods of time (range from decades to millions of years) is termed as climate change. Climate change may occur in a specific region, or across the whole earth. (Jayashree A. Parikh, V. M. Balsaraf and P. B. Dwivedi, 2010). Climate change will affect on the health, growth and productivity of crops, livestock, fish, forest and pasture in different ways. It will, also, have an impact on the incidence of pests and diseases, biodiversity and ecosystems. Frequent changes in weather parameters, more importantly temperature and precipitation would not only threaten food production but also access, stability and utilization of food resources. Adaptation to climate change will need to focus on strengthening measures, such as early warning systems; systems to identify climate change "hot spots" and disaster risk management; and evolving sustainable and ecol-friendly farming practices. Other equally important measures call for significantly increase in rural investments to reduce the long-term effects of short-term climate variability on food security, through provision of crop and livestock insurance and incentives that encourage farmers to adopt farm and social forestry, conserve resource and better agricultural and land use practices.

The Intergovernmental Panel on Climate Change (IPCC) provides the most comprehensive statement of what climate experts considers the weather will be like in

this century. It is this projection that we will use as the base-line for assessing and predicting the changes in the 21st century. The IPCC (2001) predicts that human activities will lead to climate warming during this century. Global temperature will rise by 1.5 - 5.8 °C between 1990 and 2100 (Dasgupta, 2009).

Variations in solar radiation, deviations in the earth's orbit, changes in Green House Gases (GHGs) concentrations, etc. are the factors that shape climate. Some parts of the climate system, such as the oceans and ice caps, respond slowly in reaction to climate forcing because of their large mass. Therefore, the climate system can take centuries or longer to fully respond to these external forces. (Jayashree A. Parikh, V. M. Balsaraf and P. B. Dwivedi, 2010)

Climate change, more particularly harsher weather conditions, will have impact on the quality, productivity, output and viability of fish and aquaculture enterprises, thereby affecting fishing community. The small-scale fishers may be faced with greater uncertainty as availability, access, stability and use of aquatic food, supplies would diminish, and work opportunities would dwindle. Aquaculture development opportunities will increase in particular in tropical and sub-tropical regions. The climate change in warmer regions offers new opportunities as production in warmer regions will increase because of better growth rates, a longer growing season and the availability of new fish farming areas where it was once too cold.

According to FAO, *“ocean warming, frequent tropical cyclones, flash floods and droughts are likely to bring a devastating impact on food production systems in Pacific islands countries”* The Report on *“Climate Change and Food Security in Pacific Island Countries”* says *“climate change-related disasters have already seriously constrained the development of these islands and reduced food security, especially for households”*.

The climate change will have impact on the predictability and variability in the availability of water and also increase in frequencies of droughts and floods. Worst sufferers would be farmers of the rain-fed agriculture, which covers 60% of all cultivated land in the country. The risk of crop failures will increase in semi-arid zones with prolonged dry seasons forcing people to migrate, when stability of food production cannot be assured. Irrigated areas in large river basins and deltas can also be at risk because of a combination of factors, such as reduced runoff, salinity, increasing floods, sea level rise, urban and industrial pollution. All these in one or the other way will affect the land to maintain the level of agricultural productivity and farm output; cause loss of biodiversity and the reduction in the natural ability of ecosystems to recover.

India is a large country with a diverse climate. Diverse seasons mean diverse crops and farming systems. There is a high dependency of agriculture on the monsoon rains and a close link exists between climate and water resources. Two thirds of the area is rain dependent. Add to this picture the small land

holdings, poor cropping mechanisms and low penetration of risk management products.

Impact on Indian agriculture

India, being a largely agricultural economy, is particularly vulnerable to the impacts of climate change in that sector. The increasing frequency and intensity of extreme weather events will also have a direct bearing on agriculture. With a 0.68 degrees Celsius increase in temperature so far in India, it is expected that there will be pronounced warming in future, particularly during the post monsoon period and winter. There will be increased frequency of floods during the monsoon and a decrease in winter precipitation with a lower number of rainy days. Amongst the key impacts will be the faster retreat of Himalayan glaciers, frequent floods and decrease in crop yields. Yield reductions are predicted in wheat and rice due to temperature rise in key growing regions. Until last year, 2009 was the warmest year on record in India since 1901 (+0.913 degrees C above the normal of 24.64 degrees C) now the warmest year is 2010 (+0.93 degrees C).

The IPCC Report (2007) speaks of 'Asian Brown Haze'- a dark layer of pollutants hanging in a cloud seven times the size of India over the Indian Ocean, which adds to the warming. This is an evidence of the developing countries generating the GHGs and being one of the contributors to global warming. For countries like India it is a political setback in the sense that its own defence for climate change at the international forums becomes weak. (S. N. Chary, 2008)

In more detail, the potential impacts on Indian agriculture would look like this: the productivity of most cereals would decrease due to increase in temperature and CO₂, and the decrease in water availability. There will be a projected loss of 10-40% in crop production by 2100 if no adaptation measures are taken. A one degree Celsius increase in temperature may reduce yields of major food crops by 3-7%. The length of the growing period in rain fed areas is likely to decrease, especially in peninsular regions. We are also going to see increased climatic extremes such as heat and cold waves, which are likely to increase production variability. IPCC predicts that a 1 m rise in sea level would inundate about 1,700 sq. km of agricultural land in Orissa and West Bengal.

The UN Conference on Climate Change in Copenhagen concluded on 18th December'09 did not yield expected results. Meanwhile it is, therefore, necessary that each individual country should formulate its own action plan to minimize the incidence of carbon emission to the maximum extent possible within its own resources and capabilities and monitor meticulously on an annual basis in the interest of human survival. In so far as India is concerned the common but differentiated responsibilities should focus sharply on the concern, commitment and accountability of all stakeholders for investing adequate resources to support climate change mitigation, adaptation, technology development, transfer and dissemination to make country's agriculture resilient, since the Report on Global Warming sufficiently warns that climate change is likely to affect agriculture adversely

and increase the risks of hunger & drinking water scarcity due to enhanced variability & more rapid melting of glaciers.

Climate change affects everyone. But the worst sufferers would be hundreds of millions of small and marginal farmers and people depending upon forests, who are already vulnerable and food insecure. The rise in global temperature on account of climate change would affect agriculture. While in temperate latitudes a rise in temperature would help countries increase food productivity, it will have adverse effects in India and countries in the tropics. The monsoon accounting for 75% of India's rainfall significantly impacts country's agriculture and livelihood of tens of millions of small farmers. Climate change is likely to intensify the variability of monsoon dynamics, leading to a rise in extreme seasonal aberrations, such as increased precipitation and devastating floods in some parts of the country as well as reduced rainfall and prolonged droughts in other areas.

International Symposium on “*Agrometeorology and Food Security*” organized in February 2008 in Hyderabad, noted with concern that agricultural productivity has come down over a period of time. Growth of world agricultural output is expected to fall to 1.5% per year over the next three decades and further to 0.9% per year in the succeeding 20 years to 2050. The farmers would have to produce 40% more grain to meet the increasing global demand for cereals, when the world's population would be 7.5 billion by 2020.

Agriculture accounted for 70% of all water use in the world. Per capita use of water has decreased from about 700 cubic meters per year since 1980. More than 1.2 billion people live in areas of physical water scarcity and by 2025 over three billion people are likely to experience water stress. Climate change will manifest its different types of effects on crops and livestock; fisheries and aquaculture; land; water; biodiversity; and trans-boundary pests and diseases as under.

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quality, productivity, output and viability of fish and aquaculture enterprises, thereby affecting fishing community. The small-scale fishers may be faced with greater uncertainty as availability, access, stability and use of aquatic food and supplies would diminish and work opportunities would dwindle. Aquaculture development opportunities will increase in particular in tropical and sub-tropical regions. The climate change in warmer regions offers new opportunities as production in warmer regions will increase because of better growth rates, a longer growing season and the availability of new fish farming areas where it was once too cold.

Rising sea levels owing to climate change would force communities in low-lying coastal areas and river deltas to move to higher ground level. Similarly, increase in frequency of droughts due to climate change would force farmers and pastoralists, who rely on rainfall to raise their crops and livestock, to migrate to areas in search of land and water. This migration/displacement of people would result in direct conflict and competition between migrants and established communities for access to land and water. It may be difficult for displaced communities to maintain their farming or pastoral traditions. A broad based policy and program that provides opportunities for the displaced communities to earn livelihood outside the agricultural sector may need to be evolved. Governments would have, also, to face challenge to reconcile competing demand and diverse land use needs. In cases, where land rights are informal and different customary land tenure systems coexist, Governments and local communities may need

to establish fair and equitable systems of land tenure.

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Biodiversity

According to the “2005 Millennium Ecosystem Assessment”, the climate change will cause loss of biodiversity by the end of this century. The significance and utility value of biodiversity for food and agricultural purpose will increase as and when climate changes. Genetic resources are the living materials that

local communities, researchers and breeders use to develop high yielding crop varieties/strains that can adapt to changing needs. Maintaining and using this reservoir of genetic diversity will be the foundation for coping with climate change.

Climate change and agriculture are interrelated. Agriculture contributes, of course partly, to the global warming by spewing GHGs and in turn gets affected by its consequences. However, greenhouse emissions from different farm sectors and the effect of global warming on these sectors have not been quantified, except in few cases, such as wheat. The Indian Council of Agricultural Research (ICAR) has estimated that annual wheat output may decline by four to five million tons with every one degree Celsius rise in temperature. The impact of climate change will have to be mitigated by modifying farming practices by farmers, for which ICAR has already undertaken various studies. These studies emit some light on the emissions of GHGs, such as methane, nitrous oxide and carbon dioxide arising from paddy fields and farm animals. They also explain the impact of climate change on some crops and other farm sectors like fisheries.

The IPCC has developed a range of scenarios, IS92a-f, of future greenhouse gas and aerosol precursor emissions based on CLIMATE CHANGE 1995: IPCC SECOND ASSESSMENT REPORT assumptions concerning population and economic growth, landuse, technological changes, energy availability and fuel mix during the period 1990 to 2100. Through understanding of the

global carbon cycle and of atmospheric chemistry, these emissions can be used to project atmospheric concentrations of greenhouse gases and aerosols and the perturbation of natural radiative forcing. Climate models can then be used to develop projections of future climate (IPCC Report, 1995, pp. 22-23).

Regarding India, IPCC made the following observations:

- Temperature in India may rise by 5⁰ C.
- Himalaya's glaciers will also be a casualty; they will melt and recede, affecting the quantity of water in some of India's major rivers like Ganga, Brahmaputra and Indus. Gangotri glacier which feeds the river Ganga is now retreating at a rate of 34 metres per year compared to 19 metres in 1971.
- There will be a 20 per cent increase in the rainfall. Hence, the frequency of floods would also be on the side.
- Freak rains will flood desert areas.
- Incidence of cyclones would increase in the Bay of Bengal
- As temperature gets warmer, incidence of Malaria would increase posing a serious public health hazard. Malaria is already on the resurgence. (Chary, 2008, p.211).

Overcome Strategies

India's commitment to addressing climate change issues is reflected in the various steps it has taken over the years in policy initiatives,

development plans, and support to research and to a variety of initiatives and activities for promoting energy conservation, energy efficiency and renewable energy, and in its persistent pursuance of large-scale afforestation programmes. Environmental protection and sustainable development are India's key national priorities. Therefore, even though the climate change convention does not require India to reduce its GHGs emissions, several ongoing activities and programmes as well as new initiatives contribute to achieving this end either directly or indirectly.

At the policy level, India's commitment is reflected in the principal aim of the National Forest Policy of 1988, which is to ensure environmental stability and ecological balance including atmospheric equilibrium, which are vital for sustenance of all life forms, human, animal and plant. The National Agricultural Policy of 2001 states, ' In order to reduce risk in agriculture and impart greater resistance to Indian agriculture against droughts and floods, efforts will be made to achieve greater flood proofing of flood prone agriculture and drought proofing of rain fed agriculture for protecting the farmers from the vagaries of nature.

We need crops and varieties that fit into new cropping systems and seasons. We need to develop varieties with changed duration and varieties for high temperature, drought, inland salinity and submergence tolerance. We also need crops and varieties that tolerate coastal salinity and seawater inundation and varieties which respond to high CO₂. Lastly, we need

varieties with high fertiliser and radiation use efficiency.

We stress the importance of germplasm. Wild and extant varieties have traits tolerant to high temperature, elevated CO₂ etc. These might have been discarded in the past due to low yield potential but can be made use of today as parents for the breeding of tolerant varieties to climate change. There is a need to revisit gene banks with a view to searching for unique traits required for climate change. In this search, indigenous knowledge and farmer's wisdom have immense value.

Better management practices hold the key to adaptation and mitigation. For example, there is raised-bed planting of wheat in the Indo-Gangetic plains which entails 20-25% saving in irrigation water and is suitable for mechanical weeding, and results in reduced herbicide use. We also need better water management and nutrient management of rice paddies. The ICAR has in fact started the "National Initiative on Climate Resilient Agriculture" (NICRA) towards this goal. This programme has three components: strategic research, technology demonstration and capacity building. The strategic research will focus on crops, natural resource management, horticulture, livestock and fisheries and aspects of climatic resilience in the production systems of the northeastern region. The demonstration will be of existing management practices for enhancing resilience of crops/livestock to current climate variability in 100 most vulnerable districts. The capacity building will be of scientists and other stakeholders in

climate resilient agricultural research and its application.

The objectives of the programme are to enhance the resilience of Indian agriculture to climatic variability and climate change through the development and application of improved production and risk management technologies. The challenge will be to see if the research and development and economic viability keep up with the pace of climatic change and enable food security in the decades to come.

Climate change has been a cause of serious concern if the agricultural sector has to grow in the context of country's overall economic growth, to respond to rural households' livelihood, country's food security and poverty alleviation. It may take some years to fully experience the devastating effects of climate change on agriculture but the time is ripe for the Government, private sector and public to have adequate concern, commitment and accountability to mitigate the effects of climate change.

Adaptation in climate policy

The following measures are necessary to better adapt to climate change impacts.

- Effective drought management
- Promotion of efficiency of irrigation and water use and dissemination of conservation management practices.
- Rehabilitation of degraded forests and watersheds
- Research on understanding of climate eco-system social system interaction.

- To develop land use plans, food security programs, fisheries and forestry policies that can help farming community suitably adapt to climate changes.
- To undertake cost/benefit analyses of climate change risks for irrigation or coastal protection and for investment decision.
- Promotion of “ best crop-livestock-fish farming practices” through farmers' capacity building and networking.
- Conceptualization and Implementation of “National Adaptation Programme of Action on Climate Change”.
- Developing contingency plans to cover new and evolving risk scenarios.
- Breeding of new crop varieties and species (heat-and salt tolerant crops, low-water use crops)

Conclusion

A broad based policy and program that provides opportunities for the displaced communities to earn livelihood outside the agricultural sector may need to be evolved. Governments would have, also, to face challenge to reconcile competing demand and diverse land use needs. In cases, where land rights are informal and different customary land tenure systems coexist, Governments and local communities may need to establish fair and equitable systems of land tenure. Agriculture development in India needs to focus on reducing GHGs emissions through measures, such as significant reduction of deforestation; improving forest conservation

and management; effective control of wildfires; promotion of agro-forestry for food or energy; soil carbon sequestration; restoring land through controlled grazing; improving nutrition for ruminant livestock; efficient management of livestock waste (through biogas recovery); and developing strategies that conserve soil and water resources by improving their quality, availability and efficiency of use. While a National Network Project “Impact, Adaptability and Vulnerability of Indian Agriculture to Climate Change” has been launched with focus on impact of climate change on different sectors of agricultural production” it is necessary to make sufficient investment to support climate change to adaptation, mitigation, technology development, transfer and dissemination among farmers. It is clear that the conception of climate change based on scientific studies of the present and perhaps the immediate past has been accepted as a very likely scenario for the future. To conclude, we should observe best practices in controlling global warming to save humanity from impending environmental catastrophe.

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