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Interdependency of Climate and Indian Agriculture in relation to National Food Security

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ABSTRACT

An attempt is made in this chapter to analyse the Indian agriculture and climate interdependency. The analysis is based on the national food security report and various studies in this regard. This paper highlights the importance of climate change and exploitation of natural resources and importance of agriculture as an important contributor to global emissions of greenhouse gases (GHG). Scientific evidences show that temperature changes and increased extreme events such as flooding and drought, are likely to have profound negative consequences for the natural systems and their functioning and provisioning of ecosystem services, for the human society and national economy. Thus, the paper stressed that mitigation and adaptation to climate change is essentially needed and suggested that a holistic approach should be made to achieve food security keeping all inter-dependable factors on climate as well as sustainable agriculture.

Key words: *Climate, Food Security, soil erosion, livestock, energy*

INTRODUCTION

Climate and Agriculture are interdependent factors playing a pivotal role in achieving food security not only to mankind but also all other living beings. As change is inevitable, Climate Change is expected to influence crop and livestock production, hydrologic balances, input supplies and other components of agricultural systems. The nature of biophysical effects and the human responses to them are complex and uncertain. Climate change may also change the types, frequencies, and intensities of various crop and livestock pests; the availability and timing of irrigation water supplies; and the severity of soil erosion. Being managed eco-systems, agricultural systems are critical to understanding and estimating the effects of climate change on production and food supply. These are also dynamic producers and consumers are continuously responding to changes in crop and livestock yields, food prices, input prices, resource availability, and technological change. Accounting for these adaptations and adjustments is difficult but necessary in order to measure accurately climate change impacts. Failure to account for human adaptations, either in the form of short-term changes in consumption and production practices or long-term technological changes, will overestimate the potential damage from climate change and underestimate its potential benefits. Interest in this issue has motivated a substantial body of research on climate change and agriculture over the past decade.

India is one of the most important countries in the world with regard to climate change sources and impacts. Continuing dependence upon agriculture for food and livelihood 25% of GDP and 60% of labour force (2002 and 1999 estimates) makes the Indians particularly vulnerable to climate variability and change. The rising temperatures and carbon dioxide and uncertainties in rainfall associated with global warming may or may not have serious direct and indirect consequences on crop production. Studying the potential socioeconomic impacts of climate change involves comparing two future scenarios, one with and one without climate change. Uncertainties involved in such an assessment include: (1) the timing, magnitude and nature of climate change; (2) the ability of ecosystems to adopt either naturally or through managed intervention to the change; (3) future increase in population and economic activities and their impacts on natural resources systems; and (4) how society adapts through the normal responses of individual, businesses and policy changes that after the opportunities and incentives to respond. The uncertainties, the long periods involved and the potential for catastrophic and irreversible impacts on natural resources systems raise questions as to how to evaluate climate impacts, investments, and other policies that would affect or be affected by changes in the climate. In India, substantial work has been done in last decade aimed at understanding the nature and magnitude of change in yield of different crops due to possible climate change.

Objectives:

The objective of the present review is to examine the present status of the knowledge of climate change impact on Indian agricultural production, and to discuss the uncertainties and limitation of these studies in Indian conditions and identifying future research needs.

Climate Change Scenarios

The anthropogenic increases in emissions of greenhouse gases and aerosols in the atmosphere result in a change in the radioactive forcing and a rise in the Earth's temperature. The bottom-line conclusion of the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2001) is that the average global surface temperature will increase by between 1.4 and 3 ^{0}C above 1990 levels by 2100 for low emission scenarios and between 2.5 and 5.8 ^{0}C for higher emission scenarios of greenhouse gases and aerosols in the atmosphere. Lal *et. al*. (1995) presents a climate change scenario for the Indian subcontinent, taking projected emissions of greenhouse gases and sulphate aerosols into account. It predicts an increase in annual mean maximum and minimum surface air temperatures of 0.7 ^{0}C and 1.0 ^{0}C over land in the 2040s with respect to the 1980s. Since the warming over land is projected to be lower in magnitude than that over the adjoining ocean, the land-sea thermal contrast that drives the monsoon mechanism could possibly decline. However, there continues to be considerable uncertainty about the impacts of aerosols on the monsoon. Recently, Lal *et al*., 2001 estimated that CO_2 level will increase to 397–416 ppm by 2010s from the present CO_2 level of 371 ppm and this would further increase by 605–755 by 2070s. They projected between 1 to 1.4 ^{0}C & 2.23 to 2.87 ^{0}C area-averaged annual mean warming by 2020 and 2050 respectively. Comparatively, increase in temperature is projected to be more in *rabi* than in *kharif* crop growing season. A large uncertainty is associated with projected *rabi* rainfall than *kharif* rainfall in 2050s. Moreover, the standard deviation of future projections of area-averaged monsoon rainfall centred on 2050s is not significantly different relative to the present-day atmosphere implying thereby that the year-to-year variability in mean rainfall during the monsoon season may not significantly change in the future. More intense rainfall spells are, however, projected over the land regions of the Indian subcontinent in the future thus increasing the probability of extreme rainfall events in a warmer atmosphere.

Crop Production and Climate Change

Changes in climate are expected to affect the crop production and aggregate demand for factors of production such as water, labor, energy, equipment, and materials. Climate change is analogous to technological change in agriculture which can increase or decrease the total productivity of factors collectively and can increase or decrease the productivity of one factor relative to another.

A few research studies in India showed that there was a decline of 600–650 grains $m-2$ in wheat crop with every 1 ^{0}C increase in mean temperatures above 17–17.7 ^{0}C during the terminal spikelet initiation to anthesis. Integrated impact of a rise in temperature and CO_2 concentration on yield of crops may be negative (Sinha and Swaminathan,1991). They estimated that a 2 ^{0}C increase in mean air temperature could decrease rice yield by about 0.75

ton/hectare in the high yield areas and by about 0.06 ton/hectare in the low yield coastal regions. Further, a 0.5 ^{0}C increase in winter temperature would reduce wheat crop duration by seven days and reduce yield by 0.45 ton/hectare. An increase in winter temperature of 0.5◦Cwould thereby translate into a 10% reduction in wheat production in the high yield states of Northern India. Achanta (1993) simulated irrigated yields for Pantnagar district under doubled CO_2 and increased temperature and concluded that the impact on rice production would be positive in the absence of nutrient and water limitations.

In a detailed study, Aggarwal and Kalra (1994) developed and evaluated the WTGROWS crop simulation model to estimate the effect of climate change on productivity of wheat in India was simulated for normally sown crops at three levels of production (potential, irrigated and rainfed). The CO_2 level of 425 ppm and temperature rise options of 0, 1 and 2◦C were assumed. At 425 ppm CO2 concentration and no rise in temperature, grain yield at all levels of production increased significantly at all places. One degree Celsius rise in mean temperature had no significant effect on potential yields. Irrigated yields however showed a small increase in most places where current yields were greater than 3.5 t/ha. In central and peninsular India, where current irrigated yields were between 2 to 4 t/ha, the response varied from a significant decrease to a significant increase. Rainfed yields, however, showed a significant increase. An increase of 2◦C in temperature reduced potential yields at most places. The magnitude was, however, less at places with low potential productivity. In fact, for a few locations there was a small increase or no significant effect. In sub-tropical (above 23◦N) environments there was a small decrease in potential yields (1.5 to 5.8%) but in tropical locations the decrease was 17–18%. In the same study, mean simulated yield of wheat for current and changed climate scenario (2◦Crise and CO_2 level of 425 CO_2 ppm) in different latitudinal ranges was evaluated. Irrigated yields slightly increased for latitudes greater than 27∘N but were reduced at all other places. The decrease in yield was much higher in lower latitude. These results were closely related to the effects of changed climate on crop duration. Depending upon the magnitude of temperature increase, crop duration, particularly the period up to anthesis was reduced.

The positive effects of increased CO2, if any, were masked by the adverse effects of predicted increase in temperature resulting in shortened crop growing seasons. The study also has shown that the effects of climate change on the same crop would depend upon the season it is grown. Mohandass *et al*. (1995) used ORYZA1 model to simulate rice production in India under current and future climates. They predicted increase in rice production under the GCMs scenarios used. This was mainly due to an increase in yields of main season crops where the fertilizing effect of the increased CO_2 level is more than able to compensate the crop for any detrimental effects of increased temperatures. Although large decreases were predicted for second season crops at many of the locations due to high temperatures being encountered, the relatively low proportion of total rice produced in this season meant that its overall effect on the rice production was small.

Strategy to Food Security and for Mitigation and Adaptation to Climate Change

The important mitigation and adaptation strategies required to cope with anticipated climate change impacts include adjustment in sowing dates, breeding of plants that are more resilient to variability of climate, and improvement in agronomic practices. The country faces major challenges to increase its food production to the tune of 300 million tones by 2020. The problem has become acute due to because urbanization and industrialization have rapidly dwindled the per capita availability of arable land from 0.48 ha in 1950 to 0.08 ha by 2020. Attri and Rathore (2003) suggested the adaptation strategies for sustainable production of wheat and ensuring food security. Adaptation measures to mitigate the potential impact of climate change included possible changes in sowing dates and genotype selection. Enhancement of sowing by 10 days in late-sown cultivars and delaying of sowing by 10 days in normally sown cultivars resulted in higher yields under a modified climate, whereas a reduction in yield was observed.

Discussion and Conclusion

Studies on inter-annual and long-term variability of monsoon and annual rainfall have found that the variation in rainfall for the subcontinent is within statistical limit (Srivastava *et al*., 1992). However, analysis of past weather data indeed indicates a warming trend at many places in India and changes in rainfall (statistically not significant) pattern in different parts of the country. Therefore, it is very difficult, at this juncture, to convince the planner and development agencies to incorporate the impact of climate change into their projects and agricultural system. However, 60% of the total cropped area is still rainfed in India and dependent on uncertainties of monsoon. The country's food grains production during 2002–03 had slumped to 174.19 Mt, due to widespread drought, from the record level of 212.02 Mt in 2001–02; which shows the dependency of Indian agriculture on climate in spite of recent technological development. Therefore, given the potential adverse impacts on agriculture that could bring about by climate change, it is worthwhile to conduct more in-depth studies and analyses to gauge the extent of problems that the country may face in future. For this more studies are needed on direct or indirect effect of climate change on crop growth, uncertainties of onset of rainfall, spatial and temporal rainfall variability, duration and frequency of drought and floods, availability of irrigation, changes in groundwater level, soil transformations, crop-pest interaction and submergence of coastal land due to sea level rise.

The crop-pest-weather interaction and socio-economic components are relatively weaker, and need to be strengthened. Generally the studies reviewed in this paper used dynamic crop simulation models to simulate yield impacts. With the development of science and technology, dynamic crop simulation models have been developed, tested and have become the main method of analyzing the potential impacts of climate change on agriculture. As a tool to assess the vulnerability and adaptation of agriculture to climate change, it is more accurate. Increase in food grain production during last three decades made India self sufficient and contributed tremendously to their food security. The later, however, is now at risk due to increased demand of continuously increasing population. Also the situation is grim as decline in soil fertility, decline in groundwater level, rising salinity, resistance to many pesticides, degradation of irrigation water quality and genetic diversity of the popular varieties in the farmers field has been rapidly decreasing. It is however of paramount importance to sustain the natural resource. Enhancing the organic matter content of soils will ensure better soil fertility, irrigation pricing in the western Indo-Gangetic plains will ensure the efforts to increase the efficiency of water use and improve other associated environmental impact. However, since this adversely affects income from the rice-wheat system, there is considerable sociopolitical resistance to its implementation. In recent years, the prospect of climate changes has stimulated considerable research interest in attempting to predict how production of crops will be effected. The purpose of this review was to provide overview of the likely effect of the climate change on food production in India. Several studies projected increase or decrease in yields of cereal crops (rice, wheat, maize and sorghum), Oilseed and pulses crops (soybean, groundnut, chickpea, mustard and pigeon pea) depending on interaction of temperature and CO_2 changes, production environment, season and location in India. Still the climate change impact studies have not conducted on several important crops in India such as sugarcane, cotton, jute, sunflower, potato and onion etc., which may be done in future for better assessment of vulnerability of Indian agriculture due to climate change. However, these studies have indicated that the direct impacts of climate changes would be small on 'kharif' crops but overall '*kharif*' agriculture will become vulnerable due to increased incidence of weather extremes such as onset of monsoon, duration and frequency of drought and floods, and pest incidence and virulence. Production of '*rabi*' crop is relatively more risky due to projection of larger increase in temperature and higher uncertainties in rainfall. Unless considerable adaptation takes place, this would result in decreased winter or '*rabi*' production. An index of sustainability that included economic (Agricultural production, income, and risk) and environmental (ground water level, land degradation and biodiversity) indicators clearly shows that the agricultural production is under threat and needs immediate attention (Joshi *et al*., 2003) Although, the effect of climate change on crop productivity could be biased depending upon the uncertainties in crop models used for impact assessment, climate change scenarios, region of study, technological changes and the agronomic management, the integrated assessment of climate change impact on different sectors of Indian economy is very important to determine future strategies for sustainable development, adaptation and other policy decisions. It is worthwhile to note that Kumar and Parikh (2001) projected that with 2°C increase in temperature and 7% increase in the precipitation the net-revenue of India will be decline by 8.4%. It is also important that losses expected from the climate change on Indian agriculture will be more. This should be due to the warmer temperature that the Indian farmers face under the present climatic conditions and also the relatively low level of management because small and marginal farmers with less land holding are more than 60% of the total farmers.

Such an assessment on agriculture and therefore policy responseto manage climate change impacts will not be complete unless the biophysical, environmental and socioeconomic sectors of agro-ecosystems are studied together.

Global integrated impact assessment models though provide such a framework, but are inadequate for regional policy planning because these are not validated at that scale and due to their inherent inter-and intra-sectoral conflicts. We need to urgently develop our own integrated assessment simulation models in which cropping systems; water use and socioeconomic parameters need to be brought together for assessing the impact of environmental change in diverse regions of the country. It may be developed in collaboration with several stakeholders including policy makers, agricultural and environmental scientist, climatologist, economist, administrators, industry and farmers organization. In future studies, only when the uncertainties and limitations discussed above have been considered in the crop simulation modeling and climate change scenarios, the assessment of climate change on Indian agriculture can be more precise and provide sound basis for regional policy planning.

However, it is expected that the fast improvement of climate and crop model across the global and regional level in the last decades to be sustained. It is not too distant future; these models should yielding reliable results on regional scale for the nature of climate change in response to various factors.

References:

Achanta, A. N. 1993. An assessment of the potential impact of global warming on Indian rice production, In Achanta A N (ed). *The Climate Change Agenda: An Indian Perspective*, TERI, New Delhi.

Aggarwal, P. K. and Kalra, N. 1994. Simulating the effect of climatic factors, genotype and management on productivity of wheat in India, *Indian Agricultural Research Institute Publication,New Delhi, India*, pp. 156.

Attri, S. D. and Rathore, L. S. 2003. Simulation of impact of projected climate change on wheat in India, *Int. Journal of Climatology* 23, 693–705.

Joshi, P. K., Joshi, L., Singh, R. K., Thakur, J., Singh, K. and Giri, A. K.: 2003, Analysis of procuctivity changes and future sources of growth for sustaining rice – wheat cropping system, *NATP Report submitted to the Irrigated Ecosystem. National Centre for Agricultural Economics and Policy Research*, New Delhi.

Kaur, P. 1993. Dynamic simulation of groundnut growth and yield with “PNUTGRO” model, M.Sc. Thesis (Unpublished), PAU, Ludhiana, India, pp. 125.

Kumar KSK and Parikh J. 2001. Indian Agriculture and Climate sensitivity, Global Environmental Change 11 (2): 147-154.

Lal, M., U. Cubasch, R. Voss and J. Waszkewitz.1995. Effect of transient increases in greenhouse gases and sulphate aerosols on monsoon climate, *Current Science*, 69(9), 752–763.

Mohandass, S., Kareem, A. A., Ranganathan, T. B. and Jeyaraman, S. 1995. Rice production in India under current and future climates. in Matthews R. B., Kropff M. J, Bachelet D. and Laar van H. H.(eds.), *Modeling the impact of climate change on rice production in Asia*, CAB International, U.K. pp. 165–181.

Sinha, S. K. and Swaminathan, M. S. 1991. Deforestation climate change and sustainable nutrients security. *Clim. Change* 16, pp. 33–45.

Srivastava, H. N., Dewan, B. N., Dikshit, S. K., Rao, G. S. P., Singh, S. S. and Rao, R.: 1992. Decadal trends in Climate over India, *Mausam* 43, 7–20.