Effect of Climate Change on Indian Agriculture

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Abstract

This paper effect of climate change on Indian Agriculture' mainly deals with the change of temperature which affects the evapotranspiration rates, soil moisture etc. Agriculture and allied activities constitute the single largest components of India's GDP, Contributing 24% of the total. The importance of this sector to the Indian economy can be gauged by the fact that it provides employment to two-thirds of the total workforce. About 60% of net sown area of India is rain fed. The change of temperature would adversely affect the Indian agriculture. In a major way while changes in precipitation would affect the timing and magnitude of droughts and floods. Shift runoff regimes and alter groundwater recharge characteristics. These temperature and precipitation changes will have significant effects on the demand, supply and quality of water. The change of climate also effect the fertility of soil. It also points out that the impact of climate change is likely to be most serious in unmanaged or unsustainably managed water systems that are currently water stressed. Due to climate change erratic monsoon precipitation would adversely affect the farming community in India and ability to adapt to the impact of climate change. Finally the paper ends with conclusion and references.

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Climate change is defined as change in climate over time, whether due to natural variability or as a result of human activity. Climate change is caused by the release of green house gases in the atmosphere. These greenhouse gases accumulate in the atmosphere which results in global warming. The greenhouse gases, on one hand, allow the transmission of light reaching the earth, and on the others hand block the transmission of heat (infra-red radiation) trying to escape from the atmosphere, thus trapping the heat as in a 'greenhouse'. The major changes observed as a result of global warming are changes in global climate change related parameters such as temperature, precipitation, soil moisture and sea level. Global warming is the observed increase in the average temperature of the Earth's atmosphere and oceans in recent decades and its projected continuation into the future. The decade of 2001-2009 was the warmest decade recorded on earth.

In India the direct impact of climate change would effect the plant growth, development and yield due to change in rainfall and temperature. Increase in temperature would reduce crop duration, increase crop respiration rates change the pattern of pest attack and new equilibrium between crops and pests hasten mineralization in soil and decrease fertilizer use efficiency. All these could considerably affect crop yield in long run. In general the simulation results indicate that increasing temperature and decreasing solar radiation levels pose a serious threat in decreasing growth and yield of agriculture crops.

Climate change in India represents an additional stress on a country that is already facing tremendous pressure due to rapid development. With its growing population, India is particularly vulnerable to the impacts of climate change. Understanding climate change and its consequences is critical to protect lives and assets upon which India's economy is dependent. Awareness of climate change and its impact on people, the economy and livelihood will be important to balance economic growth and development with a changing resource base.

The effects of climate change on the Indian subcontinent vary from the submergence of low lying island and coastal lands to the melting of glaciers in the Indian Himalayas, threatening the volumetric flow rate of many of the most important rivers of India. In India, such effects are projected to impact millions of lives. As a results of ongoing climate change, the climate of India has become increasing volatile over the past several decades; this trend is expected to continue.

Agriculture and allied activities constitute the single largest component of India's GDP (Gross domestic product), contributing 24% of the total. The importance of this sector to the Indian economy can be gauged by the fact that it provides employment to two-third of the total workforce. The share of agricultural products

in exports is also substantial, with agriculture accounting for about 15% of export earning. With a weight of 57% in the consumer price index, food prices are closely linked with inflation and any adverse shock on agriculture could have cumulative effect on the economy. Agriculture growth also has a direct impact on poverty eradication, and is an important factor in employment generation.

The growth of Indian agriculture post independence and the country's attainment of self sufficiency in food grains has been an impressive achievement, but it has come at a high ecological cost. Moreover the challenges is far from over. The food demand of the present and future generation have yet to be met, while the limits of expansion of cultivated land have been reached. Finally, given that almost two-third of the net sown area is rain fed, Indian agriculture continues to be fundamentally depend on weather and hence highly vulnerable to climate change.

Indian Agriculture and Climate Change

Indian economy from times immemorial has been dependent on Monsoon which bring relief not just to the food security but to the whole economy. Rising temperatures and changes in rainfall patterns have direct effects on crop yields, as well as indirect effects through changes in irrigation water availability. Recent studies have shown that the rain fed yield changes are driven by both precipitation and temperature changes; the irrigated yield effects are from temperature changes alone. The result of the research suggest that in developing countries, yield declines predominate for most crops. Irrigated wheat and irrigated rice are especially hard hit. On an average, yields in developed countries are affected less than those in developing countries. For a few crops, climate change actually increases yields in the developed country. In the East Asia and Pacific region, some crops fare reasonably well because higher future temperatures are favourable in locations where current temperatures are at the low end of the crops optimal temperature. South Asia is particularly hard hit by climate change. For almost all crops, it is the region with the greatest yield decline. Rainfed maize and irrigated and rainfed wheat still see substantial areas of reduced yields. Sub-Saharan Africa sees mixed results, with small declines or increase in maize yields and large negative effects on rainfed wheat. The Latin America and Caribbean region also has mixed yield effects, with some crops up slightly and some down.

The increase in temperature is a result of the build up of the GHG (greenhouse gases) emission accumulating in the region. This is and will result in more frequent hot days, hot nights and heat waves. This will also result in the erratic precipitation and rise in sea level and low lying agriculture will be seriously affected. Even the tropical cyclones in the Bay of Bengal is set to increase and the glaciers in the

Himalayas are going to contact flooding the perennial rivers like Ganga, Yamuna and Bhrahmputra's. More specifically the clear impact of climate change is the increase in Vulnerability of the crops, livestock, plantation crops, fisheries, soil fertility and water balance. This in turn will make the ecology unstable. Agriculture cultivation is a natural carbon sink where in plants absorbs Co, and naturally sequester the carbon from the atmosphere contributing to natural mitigation. An increase in Co, to a level of 550 parts per million increase the yields of rice, wheat, legumes and oilseeds by 10-20 percentage. However an increase of 1°C in temperature reduce yields of wheat, soybean, mustard, groundnut and potato by 3-7%. Reports indicate that the productivity of most crops decrease marginally by 2020 but by 10-40% by 2100. The variation in temperature will also affect yields of apples (including ripening), coconuts and all fruits and vegetable.

Industrialized agriculture in developed countries contribute more intensively to the build up of Co, than the subsistence and traditional agriculture practiced in developing countries. Similarly on meeting the growing demand commercial cultivation in Indian farm using synthetic fertilizer and chemicals is further adding to the GHG emission and degrading the fertility and productivity of Indian agriculture.

The new farming policies using Genetically Modified (GM) seeds is posing a serious threat since these crops use more water and synthetic fertilizers and chemicals which add to the Carbon foot-prints and further aggravated climate change. These crops also reduces the biomass and biodiversity of the region and pose a threat and extinction of traditional crops and varieties.

Water Availability

Climate change has a direct impact on water availability for irrigated crops. The availability of water for agriculture will be a key issue for crop production in the coming decades. There is a focus worldwide on how to improve the efficiency of water use for crop production. Higher Co, levels improve the water usage efficiency of most crops. Plant transpiration is reduced under higher Co2 levels and the crop looses less water. Reduced transpiration over a sufficiently large region could lead to reduced precipitation there as well.

These changes in transpiration can alter the hydrological balance over land and affect the local climate. This highlights the inherent links between crops, climate and the water cycle. Climate change will modify rainfall, evaporation, runoff, and soil moisture storage. Changes in total seasonal precipitation or in its pattern of variability are both important. The occurrence of moisture stress during flowering, pollination and grain filling is harmful to most crops and particularly so to corn, soybeans and wheat. Increased evaporation from the soil and accelerated transpiration in the

plants themselves will cause moisture stress; as a result there will be a need to develop crop varieties with greater drought tolerance. The demand for water for irrigation is projected to rise in a warmer climate, bringing increased competition between agriculture, urban as well as industrial users. Falling water tables and the resulting increase in the energy needed to pump water will make the practice of irrigation more expensive, particularly when with drier conditions more water will be required per acre Peak irrigation demands are also predicted to rise due to more severe heat waves. Additional investment for dams, reservoirs, canals, wells, pumps and piping may be needed to develop irrigation network in new location. Finally, instensified evaporation will increase the hazard of salt accumulation in the soil.

High Temperature Impact on Crops

In middle and higher latitudes, global warming will extend the length of the potential growing season, allowing earlier planting of crops in the spring, earlier maturation and harvesting and the possibility of completing two or more cropping cycles during the same season. Many crops have become adapted to the growing season day lengths of the middle and lower latitudes and may not respond well to the much longer days of the high latitude summer. In warmer lower latitude regions, increased temperatures may accelerate the rate at which plants release Co, in the process of respiration, resulting in less than optimal conditions for net growth. When temperatures exceed the optimal for biological processes, crops often respond negatively with a steep drop in net growth and yield. If night time temperature minimum rise more than daytime maximum, as is expected from greenhouse warming projections, heat stress during the day may be less severe than otherwise, but increases night time respiration may also reduce potential yields. Another important effect of high temperature is accelerated physiological development, resulting in hastened maturation and reduced yield.

Pest and Disease

Condition are more favourable for the proliferation of insects pest in warmer climates. Longer growing seasons will enables insects such as grasshoppers to complete a greater number of reproductive cycles during the spring, summer and autumn. Warmer winter temperatures may also allow larvae to winter-over in areas where they are now limited by cold, thus causing greater infestation during the following crop season. Altered wind patterns may change the spread of both wind-borne pests and of the bacteria and fungi that are the agents of crop disease. Crop pest interactions may shift as the timing of development stages in both hosts and pests is altered. Livestock diseases may be similarly affected. The possible increases in pest infestations may bring about greater use of chemical pesticides to control them, a

situation that will require the further development and application of integrated pest management techniques.

Sustainability and Food Security

Climate change can impact agricultural sustainability in two interrelated ways: first, by diminishing the long term ability of agro-ecosystems to provide food and fiber for the world's population; and second, by inducing shifts in agricultural regions that may encroach upon natural habitats, at the expense of floral and faunal diversity. Global warming may encourage the expansion of agricultural activities into regions now occupied by natural ecosystems such as forests, Particularly at mid and high-latitudes. Forced encroachments of this sort may thwart the processes of natural selection of climatically-adapted native crops and other species .

Extreme Climate and Agriculture

Important climate thresholds for food crops include episodes of high temperatures that coincide with critical phases of the crop cycle. These high-temperature episodes can lead to dramatic reductions in yield, in some cases in excess of 50%; for example, temperatures greater than 30° C lasting for more than 8 hours lead to reduced grain set in wheat. Climate change scenarios suggest that critical temperature thresholds for food crops will be exceeded with increasing frequency in the future. For some crops, these critical temperatures, particularly at flowering and fruit or grain bearing, are reasonably well known (e.g. temperatures greater than 35°C for more than 1 hour leads to pollen sterility in rice).

Climate Change and Quality Depreciation

Food systems can be vulnerable to climate change. Grains quality of wheat (e.g. protein content) is highly susceptible to current variations in climate and affects the type of foods that can be produced through, for example, gluten levels and related dough strength will affect crop storage and thereby increase the cost of transportation and storage. Other impact on crop quality include, pests and diseases, such as dangerous levels of mycotoxin contamination of groundnuts. Vegetable and fruits dehydrate and get contaminated besides losing texture and human find it difficult to consume.

Climate Change and Soil Fertility

Higher air temperature will also affect the soil, where warmer conditions are likely to speed the natural decomposition of organic matter and to increase the rates of other soil processes that affect fertility. With dryer condition lesser water the decomposition will make available NPK for the plant to grow. This would also enhance the depletion of micronutrients and its availability and reduce the quality of produce from the land. Additional application of fertilizer may be needed to counteract these processes and to take advantage of the potential for enhanced crop growth

that can result from increased atmospheric Co, . However, of adequate irrigation not provided the application of fertilizer will serve no purpose. Further excess application of fertilizer to overcome stress would pose a severe cost to environment impact water and air quality besides contamination of food chain. The continual cycling of plant nutrients (Carbon, nitrogen, phosphorus, potassium and sulphur) in the soil-plant- atmosphere system is also likely to accelerate in warmer conditions, enhancing Co, and N20 green house gas emissions.

Climate Change and Monsoon Impact

Climate change warming in the ocean disturbs the pressure zones thereby disturbing the monsoon. Rice cultivation would be worst affected with a disturbed monsoon and unpredictable weather. Scheduled planting and harvesting based on weather patterns will become less effective. Even regions adjoining India like Indonesia where the main crops consists of rice will be more vulnerable to the increased intensity of ENSO effects in the future of climate change. Normal planting of rice crops begin in October and harvested by January. However, as climate change affects ENSO and consequently delays planting, harvesting will be late and in drier conditions, resulting in less potential yields.

Conclusion

At the end we can say that the vulnerability of agricultural production to climate change depends not only on the physiological response of the affected plant but also on the ability of the affected socio-economic systems of production to cope with changes in yield, as well as changes in the frequency of drought or flood. The adaptability of farmers in India is severely restricted by the heavy reliance on natural factors and the lack of complementary input and institutional support system. It is important to recognize that policy decisions related to agriculture or water resources will influence decisions from the farmer's level to the national level, and have the potential to enhance adaptive capacity to climate change. Alternately, factors that reduce vulnerability to climate risks-irrigation, better infrastructure, electricity, credit, crop insurance, markets, transport, and price information- reduce farmers dependence on climate, and help them to benefit from market opportunities, or switch to alternative crops or employment options. At the other end of the scale are better health facilities, education and awareness, which are key developmental priorities but are often ineffectively implemented due to conflicts, policy gaps, and the sheer magnitude of the problem. The incorporation of climate change risks in such policies can help farmers tackle current climatic variability as well as extreme events like droughts and floods. As a result such policies have significant implications for long term vulnerability reduction and poverty alleviation.

In India, integrated watershed development has emerged as an effective approach in augmenting water supply through conservation of rainwater in rain fed farming systems. These farmlands account for nearly two-thirds of the country's cultivated land and encompass the arid, semi-arid and drought prone regions. Interventions in the dry land/rain fed regions that are the characteristic of poor climate were targeted under 'Integrated watershed.

Management Project. This project suggests that an integrated and co-ordinate approach be deployed across various ministries to promote soil and water conservation by optimising land use production systems and use of sustainable low-cost location-specific technologies. The watershed approach basically is a project based development plan for water harvesting, water conservation, and other related social and economic activities that seek to enhance the production potential of an area on a sustainable basis. There is growing awareness at the central government level that integrated watershed development can also prove to be a potent instrument of adaptation to climate change. There are special programmes such as Drought prone areas programme for almost one sixth of the land area in the arid and semi-arid regions of the country, in addition to the special programme of watershed treatment in the catchment of river valley projects and flood prone rivers.

The role of science and technology has, in the past, also played a crucial role in increasing yields and production across the country. Biotechnology could be used to develop cultivars specific to certain weather conditions. This would include the development of drought resistant, salt tolerant treatment and pest-resistant cultivars of different crops. This would ensure a strong approach to dealing with flood security besides addressing climate change (Brenner 1996). At the same time important insights can be drawn from local knowledge or traditional know-how. Furthermore, local institutions and indigenous arrangements (e.g. micro credit and land tenure) have an important role in enhancing the resilience of the poor.

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