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Effects of Climate Change on Agriculture

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INTRODUCTION

Climate is a complex phenomenon described in simply as the average weather conditions at a place that vary with time. Temperature, wind direction and speed, water vapor content in the air, atmospheric composition, pressure and density are the parameters that define the state of the atmosphere at a place. Atmosphere continuously interacts with the underlying surface of the earth like the oceans, land and ice and this interaction is termed as the climate system. Measurements through the direct and the indirect methods of the past variations in the earth's climate validate that there has been a significant variation in the climate on a wide range of time scale. This variation has been termed the global climate change by the group of scientists and policy makers all over the world.

Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or persistent anthropogenic changes in the composition of the atmosphere or in land use. This change in the climate is a continuous phenomenon, and is happening since the pre-historic times. Various reasons that were attributed to its cause in pre-industrial era were changes in the earth's orbit and the sun's intensity. Volcanic eruptions also emitted aerosols and carbon dioxide into the atmosphere. Changes in ocean currents are caused by the heating and cooling of the earth, which are responsible for distribution of heat on the earth's surface. There are periods of stability as well as periods of rapid change. Interglacial climate (such as the present) is more stable than cooler glacial climate. Rapid climate changes usually occur in between the glacial and interglacial periods. Any geological period in which long-term cooling takes place and ice sheets and glaciers exist is described by the scientists as ice age or glacial age. An ice age or glacial age is a long interval of time when global temperatures are relatively low and large areas of the Earth are covered by continental ice sheets and glaciers. There are multiple shorter-term periods of warmer temperatures within an ice age when glaciers retreat (called interglacials or interglacial cycles) and colder temperatures when glaciers advance (called glacials or glacial cycles).

Since the industrial revolution, human activities have increased at a very rapid rate which is causing atmospheric, temperature, and precipitation and sea level changes. Anthropogenic activities like the burning of fossil fuels, agriculture and land-use changes like deforestation has notable contribution to climate change. These activities result in the emissions of carbon dioxide (CO2), the main gas responsible for climate change, as well as of other 'greenhouse' gases.

The increasing green house gas concentrations raise the temperature of the earth, influence precipitation patterns, and sea level changes. The main driver of climate change in the future would be the concentrations of the green house gases and how long these gases would persist in the atmosphere. Accelerated melting of glaciers, sea level rise, submergence of islands or coastal areas and deviant rainfall patterns are one of the most common outcomes of increase in the green house gas emissions (IPCC, 2007).

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Climate and agriculture

The primary determinant of agricultural productivity is the climate of a place. Plausible climate change scenarios include elevated temperatures, changes in the rainfall patterns, and higher atmospheric carbon dioxide concentrations. Crop production, hydrologic balances, livestock, soil processes and other components of agricultural systems are expected to be influenced by climate change. The nature and magnitude of the impacts of climate change on these components is complex and uncertain.

Crop response to climate change

Changes in climatic factors such as temperature, rainfall patterns and the frequency and severity of extreme events such as droughts, floods, and wind storms directly affect the crop production. It is expected that warmer temperatures will cause crops to grow faster, but it could also reduce yields. On the same hand, faster growth could reduce the amount of time that seeds require to grow and mature fully. Therefore, the effect of temperature increase will ultimately depend on the optimal temperature of a crop required for its growth and reproduction. Plant growth fundamentally depends on carbon dioxide. Rising concentrations of carbon dioxide have the potential to enhance the crop yield. However, yield increases may be reduced or reversed by some factors that may counteract the increases in yield. For example, if the temperature surpasses a crop's optimal temperature range or if adequate water and soil nutrients are unavailable. Increased temperatures, humid climates, and elevated carbon dioxide levels favor the proliferation and spread of pathogens, parasites, weeds, pests and diseases. This would lead to increased financial burden on the farmers for the use of pesticides and fungicides which will indirectly affect human health negatively.

Dealing with extreme events such as floods and drought could become a challenge in areas where summer temperatures are projected to increase and precipitation is projected to be erratic. It may be more difficult to meet water demands for agriculture, as water supplies are reduced and water quality is compromised. Droughts will increase the soil water deficit significantly and impact the availability and timing of irrigation water supplies. Floods lead to inundation of a large area of agricultural land as a result which there will be huge crop loss. This will result in shortage of food, and animal fodder. Floods may also affect the soil characteristics. The land may be rendered infertile due to erosion of top layer or may turn saline if sea water floods the area.

Livestock response to climate change

Climate change poses formidable risk to the livestock sector which is an important component of agricultural systems. The anticipated rise in temperature profile with erratic rainfall patterns resulting from climate change is likely to exacerbate heat stress in animals, affecting them both directly and indirectly. Heat stress directly induces behavioral and metabolic changes, which include reduced feed intake and metabolic activity and thereby a decline in their overall productivity. Reduced diet and slow metabolism indirectly causes increased vulnerability to disease, reduce fertility, and reduce milk production. Extreme events such as summer heat waves, winter storms, floods, droughts etc. can also result in the death of vulnerable animals. Drought may pose a threat to regular pasture, crop by-residues, and feed supplies for the animals. The amount of quality forage available to grazing livestock is also considerably reduced by droughts. Increased temperatures and humid climates may also affect the severity and distribution of livestock diseases and parasites. Increases in the atmospheric carbon dioxide (CO2) may step-up the yield of pastures quantitatively, but it may also drop-off their quality. As a result, cattle would need to feed more in quantity to obtain the same nutritional benefits qualitatively.

THE INDIAN CONTEXT

India, being an agrarian economy, is the most vulnerable to the impacts of climate change. Agriculture represents a core part of the Indian economy and provides food and livelihood activities to much of the Indian population. While the magnitude of impact depends on the region and its location, climate change is expected to impact adversely on agricultural productivity and shifting crop patterns. The key characteristics of Indian agriculture that could influence its vulnerability to climate change are high level of subsistence agriculture with small land holdings of farmers; majority of agriculture is rain-fed; frequent occurrence of extreme weather events such as droughts and cyclones; and the wide variation in agricultural productivity across the country.

Climate change directly affects food security and nutrition. Climate change will affect food security

through its impacts on all components of global, national and local food production systems, which is projected to affect all four dimensions of food security, namely food availability; stability of food supplies; access to food and; food utilization. It challenges the current efforts to protect the lives and livelihoods of the over 1 billion food vulnerable people and will increase the risk of hunger, malnutrition and poverty by an unprecedented scale within the next decades. People who are already vulnerable and food insecure are likely to be the first affected. Agriculture-based livelihood systems that are already vulnerable to food insecurity face immediate risk of increased crop failure, new patterns of pests and diseases, lack of appropriate seeds and planting material, and loss of livestock. People living on the coasts and flood plains and in mountains and dry lands are most at risk.

CONCLUSIONS

The agriculture sector represents 35% of India's Gross National Product (GNP) and as such plays a pivotal role in the development of the nation. Exposure to climate change poses an unprecedented challenge to agriculture in the next decades. Any adverse impacts in the agricultural sector also affect other downstream industries of agriculture that depend on agricultural goods and determine cross-effects in the economy of a country. Changing climatic and weather conditions affect crop yields and supply. Decline in supply will lead to higher and more volatile prices. Higher costs will affect the most vulnerable section of the society and will cause further malnutrition and poverty. Thus, the impacts slowly spread into the social fabric as the regular sources of income dwindle, food shortage, health reduction and loss of life, increased poverty, reduced quality of life and social unrest leading to migration. Therefore, formulation of appropriate adaptation and mitigation strategies is the need of the hour to respond to the challenge of climate change. Failure to identify agriculture as a priority sector for adopting adaptation and mitigation measures will lead to further aggravation of the potential damages from climate change to this sector.

Possible adaptations may include changes to the food security policy of the country to account for changes in the total crop produce as well as shifting boundaries for crops and crop acreage, and the rippling impact it will have on the food supply. Changes in the yield of the cash crops of the country will significantly affect the revenue generated by their exports. To accommodate such changes in the import/exports of the country, modifications to trade policy of the country would be a possible adaptation measure. With agriculture contributing significantly to GNP, it is vital that the policy also addresses the issues of loss of livelihood and the imparting of advanced set of skills to such people to cope with the changes. Water policy will also need to consider the implications for water demand of agricultural change due to climate change, since the impacts vary significantly according to whether crops are rain fed or irrigated. Policy-makers will also have to consider adaptive measures such as the introduction of the use of alternative crops, changes to cropping patterns, and promotion of water conservation and irrigation techniques to cope with changing agricultural patterns.

Therefore, there is an urgent need to harmonize the policies so that each policy acts as a compliment to one another. The policy implications for climate change impacts in agriculture are multi-disciplinary and cross-sectoral in nature. All mitigation and adaptation strategies should be reflected in the action of the nation's administration and it should be ensured that they are adequately internalized across the various sectors.

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