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Climate and its impact on agriculture and allied activities: An over view

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INTRODUCTION

Climate change is not a new phenomenon in the world. The rise in temperature of the earth surface and in atmosphere, fluctuation in rainfall, declining ground water, flooding due to high rainfall, drought, soil erosion, heavy wind, rising sea level due to melting of glacier, cyclone, wind speed, hail storm, fog, earthquake and landslide etc., are all the clear evidence of climate change phenomenon. Though, it is a natural process but in some cases human activities are also responsible for this. There are many examples across countries where increase in the possibilities of climate change due to growing population, rapid urbanization, higher industrialization, use of modern technology, innovation, higher economic development, transport, building construction, reduction in forest area etc. are observed. In mid, high latitude and higher income countries climate change has positive impact on agricultural production or crop yield, and on the other hand, lower -latitude and lower income countries experience a negative effect on agricultural production. On the other hand, developing countries are most vulnerable compared to developed countries. There are many reasons which increase the vulnerabilities for developing countries like low level of technological progress, lack of resources to mitigate the adverse effect of climate change on agriculture and due to their greater dependence on agriculture for livelihood of large populations.

Impact of Climate Change :

Climate and its variability impact all sectors of economy in several ways like abnormality in rainfall, results in severity and frequency of floods. Any increment in maximum temperature may increase mean sea levels and it would affect large populations in peninsular and coastal areas. It may increase 15 to 40% rainfall there and raise the annual mean temperature by 3 to 6 degree. Climate change adversely affects the food security in all countries through agriculture production. It affects to food security is in four dimensions, food availability, food accessibility, food utilization and food system stability. It will also have an impact on human health, livelihood assets and food production and distribution channels. Due to rising global population size, climate change will challenge agricultural production and food security (location of production, supply, volume, quality) and by 2080, agriculture output in Least Developed Countries (LDCs) may decline by 20 per cent due to climate change and yields could decrease by 15 per cent on average, while output in industrial

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countries is expected to decrease by 6 per cent . It will affect about 200 million people and their families worldwide who live by fishing and aquaculture. In India, Gross Domestic Product (GDP) may decrease up to 6.2% and agriculture production may decrease up to 24% by 2080 due to climate change.

Main projections for climate change at Global Level:

The projections of future climate patterns are largely based on computer-based models of the climate system that incorporate the important factors and processes of the atmosphere and the oceans, including the expected growth in greenhouse gases from socio-economic scenarios for the coming decades. The IPCC has examined the published results from many different models and on the basis of the evidence has estimated that by 2100.

– The global average surface warming (surface air temperature change) will increase by 1.1 - 6.4 °C.

– The sea level will rise between 18 and 59 cm.

– The oceans will become more acidic.

– It is very likely that hot extremes, heat waves and heavy precipitation events will continue to become more frequent.

– It is very likely that there will be more precipitation at higher latitudes and it is likely that there will be less precipitation in most subtropical land areas.

– It is likely that tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and heavier p recipitation associated with ongoing increases of tropical sea surface temperatures.

Likely Effects of climate change on key sectors at Global Level:

The IPCC Fourth Assessment Report of the Working Group II: Impacts, Adaptation and Vulnerability describe the likely effects of climate change, including from increases in extreme events. The effects on key sectors, in the absence of countermeasures, are summarized as follows.

Water:

Drought affected areas are likely to be more widely distributed. Heavier precipitation events are very likely to increase in frequency leading to higher flood risks. By mid-century, water availability is likely to decrease in mid-latitudes, in the dry tropics and in other regions supplied by melted water from mountain ranges. More than one sixth of the world‘s population is currently dependent on melt water from mountain ranges.

Food:

While some mid latitude and high latitude areas will initially benefit from higher agricultural production, for many others at lower latitudes, especially in seasonally dry and tropical regions, the increases in temperature and the frequency of droughts and floods are likely to affect crop production negatively, which could increase the number of people at risk from hunger and increased levels of displacement and migration. Industry, settlement and society: The most vulnerable industries, settlements and societies are generally those located in coastal areas and river flood plains, and those whose economies are closely linked with climate sensitive resources. This applies particularly to locations already prone to extreme weather events and especially to areas undergoing rapid urbanization. Where extreme weather events become more intense or more frequent, the economic

and social costs of those events will increase.

Health:

The projected changes in climate are likely to alter the health status of millions of people, including increased deaths, disease and injury due to heat waves, floods, storms, fires and droughts. Increased malnutrition, diarrhea disease and malaria in some areas will increase vulnerability to extreme public health, and development goals will be threatened by long term damage to health systems from disasters.

Projected Impact on Asia :

Asia-Pacific region may experience the worst effect on rice and wheat yields worldwide, and decreased yields could threaten the food security of 1.6 billion people in South Asia.

– The crop model indicates that in South Asia, average yields in 2050 for crops will decline from 2000 levels by about 50 per cent for wheat, 17 per cent for rice, and about 6 per cent for maize because of climate change.

– In East Asia and the Pacific, yields in 2050 for crops will decline from 2000 levels by 20 per cent for rice, 13 per cent for soybean, 16 per cent for wheat and 4 per cent for maize because of climate change.

– With climate change, average calorie availability in Asia in 2050 is expected to be about 15 per cent lower and cereal consumption is projected to decline by as much as 24 per cent compared to a no-climate change scenario.

– In a no-climate change scenario, the number of malnourished children in South Asia would fall from 76 to 52 million between 2000 and 2050, and from 24 to 10 million in East Asia and the Pacific.

– Climate change will erase some of this progress, causing the number of malnourished children in 2050 to rise to 59 million in South Asia and to 14 million in East Asia and the Pacific, increasing the total number of malnourished children in Asia by about 11 million.

– To counteract the effects of climate change on nutrition, South Asia requires additional annual investments of 1.5 billion USD in rural development, and East Asia and the Pacific require almost 1 million USD more. Over half of these investments in both regions must be for irrigation expansion.

– The Asian countries most vulnerable to climate change are Afghanistan, Bangladesh, Cambodia, India, Lao PDR, Myanmar, and Nepal. Afghanistan, Bangladesh, India, and Nepal are particularly vulnerable to declining crop yields due to glacial melting, floods, droughts, and erratic rainfall, among other factors.

– Asia is the most disaster-afflicted region in the world, accounting for about 89 per cent of people affected by disasters worldwide.

Observed Changes in Climate and Weather Events in India :

***Surface Temperature* :**

At the national level, increase of 0.4° C has been observed in surface air temperatures over the past century. A warming trend has been observed along the west coast, in central India, the interior peninsula, and north eastern India. However, cooling trends have been observed in northwest India and parts of south India.

Rainfall :

While the observed monsoon rainfall at the All India level does not show any significant trend, regional monsoon variations have been recorded. A trend of increasing monsoon seasonal rainfall has been found along the west coast, northern Andhra Pradesh, and north-western India (+10% to +12% of the normal over the last 100 years) while a trend of decreasing monsoon seasonal rainfall has been observed over eastern Madhya Pradesh, north-eastern India, and some parts of Gujarat and Kerala (-6% to - 8% of the normal over the last 100 years)

Extreme Weather Events :

Trends of Extreme Weather Events observed in multi-decadal periods of more frequent droughts followed by less severe droughts. There has been an overall increasing trend in severe storm incidence along the coast at the rate of 0.011 events per year. While the states of West Bengal and Gujarat have reported increasing trends, a decline has been observed in Orissa. Scientists, while analysing a daily rainfall data set, have shown (i) a rising trend in the frequency of heavy rain events, and (ii) a significant decrease in the frequency of moderate events over central India from 1951 to 2000.

Rise in Sea Level :

Using the records of coastal tide gauges in the north Indian Ocean for more than 40 years, Scientists have estimated that sea level rise was between 1.06-1.75 mm per year. These rates are consistent with 1-2 mm per year global sea level rise estimates of the IPCC. Indian Summer Monsoon (ISM) intensity is projected to increase in the beginning of 2040 and by 10% by 2100. Some Projections of Climate Change over India for the 21st Century Some modelling and other studies have projected the following changes due to increase in atmospheric GHG concentrations arising from increased global anthropogenic emissions: Annual mean surface temperature. The simulation studies by Indian Institute of Tropical Meteorology (IITM), Pune, estimated that annual mean surface temperature is expected to raise by the end of century, ranges from 3 to 5° C with warming more pronounced in the northern parts of India.

Impacts on Water Resources :

Changes in key climate variables, namely temperature, precipitation and humidity, may have significant long-term implications for the quality and quantity of water. River systems of the Brahmaputra, the Ganga, and the Indus, which benefit from melting snow in the lean season, are likely to be particularly affected by the decrease in snow cover. A decline in total run-off for all river basins, except Narmada and Tapti, is projected in India's NATCOM I. A decline in run-off by more than two thirds is also anticipated for Sabarmati and Luni basins. Due to sea level rise, the fresh water sources near the coastal regions will suffer salt intrusion.

Impacts on Agriculture and Food Production :

Food production in India is sensitive to climate changes such as variability in monsoon rainfall and temperature changes within a season.

– Studies by Indian Agricultural Research Institute (IARI) and others indicate greater expected loss in the *Rabi* crop. Every 1°C rise in temperature reduces wheat production by 4-5 Million Tonnes.

– Small changes in temperature and rainfall have significant effects on the quality of fruits,

vegetables, tea, coffee, aromatic and medicinal plants, and basmati rice.

– Pathogens and insect populations are strongly dependent upon temperature and humidity, and changes in these parameters may change their population dynamics.

– Indian climate is dominated by the southwest monsoon, which brings most of the region‘s precipitation. It is critical for the availability of drinking water and irrigation for agriculture.

– Agricultural productivity is sensitive to two broad classes of climate-induced effects (1) direct effects from changes in temperature, precipitation or carbon dioxide concentrations, and (2) indirect effects through changes in soil moisture and the distribution and frequency of infestation by pests and diseases.

– The adaptability of farmers in India is severely restricted by the heavy reliance on natural factors and the lack of complementary inputs and institutional support systems. The loss in net revenue at the farm level is estimated to range between 9% and 25% for a temperature rise of 2 °C to 3.5 °C. Scientists also estimated that a 2°C rise in mean temperature and a 7% increase in mean precipitation would reduce net revenues by 12.3% for the country as a whole.

– Agriculture in the coastal regions of Gujarat, Maharashtra, and Karnataka is found to be the most negatively affected. Small losses are also indicated for the major food-grain producing regions of Punjab, Haryana, and western Uttar Pradesh. On the other hand, West Bengal, Orissa, and Andhra Pradesh are predicted to benefit to a small extent from warming.

– Although an increase in carbon dioxide is likely to be beneficial to several crops, associated increase in temperature and increased variability in rainfall would considerably affect food production. The recent IPCC report (IPCC, 2007) and a few other global studies indicate a probability of 10 to 40% loss in crop production in India with increase in temperature by 2080 – 2100.

– A few Indian studies on this theme generally confirm an agricultural decline with climate change. Recent studies done at the Indian Agricultural Research Institute indicate the possibility of a loss of 4 to 5 million tons in wheat production in future with every 1 degree C rise in temperature during the growing period (but no adaptation benefits). It also assumes that irrigation would be available in future at today’s levels. Losses for other crops are still uncertain but they are expected to be relatively smaller, especially for *Kharif* crops.

– It is, however, possible for farmers and other stakeholders to adapt to a limited extent and reduce the losses (possible adaptation options are described later in this document). Simple adaptations such as change in planting dates and crop varieties could help reduce the adverse effects of climate change to some extent. For example, the Indian Agricultural Research Institute study cited above indicates that loss in wheat production in future could be reduced from 4 – 5 million tons to 1 – 2 million tons if farmers adopted timely planting habits and changed to better adapted wheat varieties. This change of planting, however, would have to be examined from the cropping systems perspective.

– Increasing climatic variability associated with global warming, nevertheless, will result inconsiderable seasonal/annual fluctuations in food production. All agricultural commodities even today are sensitive to such variability. Droughts, floods, tropical cyclones, heavy precipitation events, hot extremes and heat waves are known to impact agricultural production and farmers’ livelihood negatively . The projected increase in these events will result in greater instability in food production and threaten the livelihood of the farmers.

– Increasing glacier melt in the Himalayas will affect availability of irrigation especially in the Indo-Gangetic plains, which, in turn, has large consequences on our food production.

– Global warming in the short - term is likely to favour agricultural product ion in the temperate

regions (largely northern Europe, North America) and negatively impact crop production in tropical areas (South Asia, Africa). This will affect food prices and trade and , consequently, our food security.

– Small changes in temperature an d rainfall could have a significant effect on the quality of cereals, fruits, aromatic and medicinal plants and result in changes in prices and trade patterns.

– Pathogens and insect populations are strongly dependent upon temperature and humidity .Increases in these parameters will change their population density resulting in loss in yield.

– Global warming could increase water, shelter and energy requirement s of livestock to meet the projected increase in demand for milk. Climate change is likely to aggravate the heat stress in dairy animals and adversely affect their productive and reproductive capabilities. A preliminary estimate indicates that global warming is likely to lead to a loss of 1.6 million tonnes in milk production in India by 2020.

– Increasing se a and river water temperature is likely to affect fish breeding, migration and harvest. A rise in temperature as low as 1°C could have an important and rapid effect on the mortality rate and the geographical distribution of fish . The oil sardine fishery did not exist before 1976 in the northern latitudes and along the east coast as the resource was not available since the sea surface temperature (SST) was not congenial for it. With warming of sea surface, oil sardine is able to find the temperature in the northern latitudes and eastern longitudes suitable for survival and breeding, thereby extending the boundaries to larger coastal areas.

Impacts on health :

Changes in climate may alter the distribution of important vector species (for example, malarial mosquitoes) and may increase the spread of such diseases to new areas. If there is an increase of 3.8 °C in temperature and a 7% increase in relative humidity, the transmission windows *i.e.*, months during which mosquitoes are active, will be open for all 12 months in 9 states in India. The transmission windows in Jammu and Kashmir and in Rajasthan may increase by 3-5 months. However, in Orissa and some southern states, a further increase in temperature is likely to shorten the transmission window by 2-3 months.

Impacts on Forests :

Climate projections indicate that the country is likely to experience shift in forest types, with consequent changes in forests produce, and, in turn, livelihoods based on those products. Correspondingly, the associated biodiversity is likely to be adversely impacted.

Impacts on Coastal Areas :

A mean Sea Level Rise (SLR) of 15-38 cm is projected along India's coast by the mid 21st century and of 46-59 cm by 2100. In addition, a projected increase in the intensity of tropical cyclones poses a threat to the heavily populated coastal zones in the country (NATCOM, 2004).

Impacts on Biodiversity :

The Intergovernmental Panel on Climate Change has projected that global average temperature increase during 21st century will range from 1.4^{0}C to 4^{0}C. Research by the Consultative Group on International Agricultural Research based on distribution models of wild relatives of three staple crops of the poor *i.e.* Peanuts, cowpea and potato suggests that 16-22 per cent of wild species will be threatened by extinction by 2055. Loss of genetic diversity can have serious long-term

consequences globally.

Impacts on Pest :

Some of the most dramatic effects of climate change on pests and diseases are likely to be seen among arthropod insects like mosquitoes, midges, ticks, fleas and sand flies, and the viruses they carry. With changes in temperature and humidity levels, the populations of these insects may expand their geographic range, and expose animals and humans to diseases to which they have no natural immunity. Plant pests, which include insects, pathogens and weeds, continue to be one of the biggest constraints to food and agricultural production. Fruit flies, for instance, cause extensive damage to fruits and vegetables production. Controlling such pests often requires the use of pesticides, which can have serious side effects on human health and the environment. Climate change may also play a role in food safety. A growing number of pests and diseases could lead to higher and even unsafe levels of pesticide residue and veterinary drugs in local food supplies. And changes in rainfall, temperature and relative humidity can readily contaminate foods like groundnuts, wheat, maize, rice and coffee with fungi that produce potentially fatal mycotoxins.

Conclusion :

From the above, it is clear that the occurrence of floods and droughts, heat and cold waves are common across the world due to climate change. Their adverse impact on livelihood of farmers is tremendous. It is more so in India as our economy is more dependent on Agriculture. Interestingly, weather extremes of opposite in nature like cold and heat waves and floods and droughts are noticed within the same year over the same region or in different regions and likely to increase in ensuing decades. The human and crop losses are likely to be heavy. The whole climate change is associated with increasing greenhouse gases and human induced aerosols and the imbalance between them may lead to uncertainty even in year-to-year monsoon behaviour over India. Therefore, there should be a determined effort from developed and developing countries to make industrialization environment friendly by reducing greenhouse gases pumping into the atmosphere. In the same fashion, awareness programmes on climate change and its effects on various sectors *viz*., agriculture, health, infrastructure, water, forestry, fisheries, land and ocean biodiversity and sea level and the role played by human interventions in climate change need to be taken up on priority basis. In the process, lifestyles of people should also be changed so as not to harm earth atmosphere continuum by pumping greenhouse gases and CFCs into the atmosphere. From the agriculture point of view, effects of extreme weather events on crops are to be documented on regional scale so that it will be handy to planners in such re-occurrence events for mitigating the ill effects. Also, there is need to guide farmers on projected impact climate change and sensitise them on probable mitigation and adaptation options to minimize the risk in Agricultural sector.

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