

Impact of Climate Change on Agriculture-*Mitigation and Adaptation approach (A review)*

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ABSTRACT

Today, climate change is one of the biggest challenges the world is facing and it has the potential to create havoc with the agrarian livelihoods across the globe. Therefore, this paper attempts to explain the probable impacts of human induced climate change on natural resources in India. An ample amount of literature was reviewed meticulously to ascertain the impacts of climatic variability on natural resources vis-a-vis agriculture, biodiversity and water bodies as well as other common issues related to human resources in India. Loss of certain indigenous food varieties, reduction in natural forest cover and loss of important water resources has aggravated the already dilapidated situation in this most vulnerable state of India. Scientific evidences revealed that there will be more devastating climatic effects on natural resources in India, which will fall disproportionately on poor communities, particularly dry land farmers, forest dwellers and fishermen of the state.

Keywords: Climate, natural forest, India.

INTRODUCTION

Global climate change is a widespread and growing concern that has led to extensive international discussions and negotiations and is undoubtedly one of the major environmental issues of this century. The CO₂ concentration in atmosphere increased from 280 ppm at the beginning of the industrial revolution to present levels of 392 ppm (IPCC,

2014). Climate has been the most determinable factor for livelihood patterns on the earth. It is now a universally accepted phenomenon that, climate change is one of the principal environmental problems of present times (IPCC, 2014). It is also important to note that the climate change is not only a major global environmental problem, but also an issue of great concern at local level, especially within developing countries like India (Gerlitz, 2015).

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. (Kumar and Gautam, 2014). 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.

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".

Impact

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. 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.

Crops and Livestock

Climate change will affect 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 (IPCC, 2014). 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 eco-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. (Basannagari and Kala, 2013).

Fisheries and aquaculture

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 (IPCC, 2007). 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 (IPCC, 2014).

Land

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 (IPCC, 2007).

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.

Water

Climate change will have an impact on the predictability and variability in the availability of water and also increase in frequencies of droughts and floods (IPCC, 2007). Worst sufferers would be farmers of the rainfed 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. Areas

projected to experience lower precipitation will need to improve water management system and water storage capacity that can enhance crop productivity. While large irrigation schemes will need to adapt to changes in water supply regimes, small-scale irrigation schemes will need field-based water control measures.

Biodiversity

The inflexibility of many ecosystems is likely to exceed in future by an unprecedented combination of climate change and associated disturbances like drought, wildfire, floods, infestation of insects; and other global change drivers viz., land use change, pollution, and overexploitation of natural resources particularly forests. Scientists have reported that approximately 20-30 % of plant and animal species assessed so far are likely to be at increased risk of extinction if increase in global average temperature exceeds 1.5°C to 2.5°C (Chand and Kumar, 2011). 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.

Trans-boundary pests and diseases

Climate change is altering the distribution pattern of animal and plant pests and diseases (IPCC, 2007). Changes in temperature, moisture and atmospheric gases accelerate growth and generation rates of plants, fungi and insects, which alter the interaction between pests, their natural predators and hosts. Changes in land cover, more importantly deforestation or desertification make remaining plants and animals increasingly vulnerable to pests and diseases.

Studies in India

A World Bank report on climate change impact based on case studies in drought-prone regions of Andhra Pradesh and Maharashtra, and flood-prone districts in Orissa on the edge of climate tolerance limits, highlights the possibility of declining the yields of major dry land crops in Andhra Pradesh, sugarcane yields declining by 30% in Maharashtra and rice production by 12% in the flood-prone coastal regions of Orissa. The worst sufferers would be the poor and marginal farmers who own less than one acre of land and mostly populate these regions.

Climate change and agriculture are interrelated

Agricultural sector is extremely sensitive to climate variability and weather extremes, such as droughts, hail storms, wind storms and early frosts. The parameters that form our climate are also significant to farm productivity; the increased potential of droughts, floods and heat waves will pose challenges for farmers (Kumar and Gautam, 2014). In addition, the continuing changes in climate, water supply and soil moisture could make it less feasible to continue crop production in certain areas. Climate variability and change also increases the risks of fires, pest and pathogen outbreak, negatively affecting food, fiber and forestry (IPCC, 2007).

Agriculture contributes, of course partly, to the global warming by spewing greenhouse gas 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 greenhouse gases, 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 emissions, from the country's 42.21 million hectares of land under rice cultivation, comprise about 2.07 Tg of methane [Tg is the unit of measurement of greenhouse gas emissions and is equivalent to 10¹² grams], 0.19 Tg nitrous oxide and 72 Tg of carbon dioxide, annually. However, the emission levels vary from region to region depending on cultivation practices and the inherent carbon content of the soils. The methane outflow from the paddy fields of some districts in West Bengal has been observed to be relatively high. This is due to the presence of higher organic carbon content in the soils and the traditional practice of keeping rice fields constantly submerged under water. Similarly, emission of nitrous oxide is higher in paddy fields in Andhra Pradesh and northern States because of application of high doses of nitrogenous fertilizers. On the whole, the eastern and southern parts of the country have a relatively higher global warming potential because of higher discharge of methane and carbon dioxide and the predominance of rice cultivation in these regions.

Water

The global hydrological cycle can have major impacts on regional water resources, affecting

both ground and surface water supply for domestic and industrial uses, irrigation, hydropower generation, navigation, in-stream ecosystems and water based recreation. Increase in surface temperature warms the climate, which in-turn may lead to intensification of the hydrological cycle, resulting in higher rates of evaporation and increase of liquid precipitation.

On regional scales, mountain snow, glaciers, and small ice caps play a crucial role in freshwater availability. However, widespread mass losses from glaciers due to climate change have resulted in glacier advance, retreat, reduction in snow cover and landslide threat over the recent years (IPCC, 2014). If such situation continues it will reduce the water availability and hydropower potential, and changing seasonality of flows. Talib (2007) reported that reduction of the Himalayan glaciers, could endanger water supplies for hundreds of millions of people.

Studies on the impact of global warming conducted in Andhra Pradesh indicate that the rise in temperature will lead to an increase in water requirement of crops like maize, groundnut, pigeon pea and cotton, though their growing duration will decrease by one to two weeks.

Livestock

In the case of methane emissions from the

livestock sector, it has been observed that though cross-bred cattle discharge relatively more methane per animal, the bulk of the total emissions is accounted for by buffaloes and indigenous cattle because of their far larger population. Of the total livestock sector's greenhouse gas emissions, female buffaloes contributed 59.6%, followed by indigenous cows 28.9% and cross-bred cows 11.5%. The total emissions from this sector are reckoned at 9.37 Tg, varying in different years from 7.26 Tg to 10.4 Tg.

Mitigation and Adaptation

Agriculture is one of the major sources of greenhouse gas emissions. 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.

Significantly investing in expanding, modernizing and equipping agricultural meteorology facilities in all 127 agro-ecological regions to make it world class, thereby continuously improving weather and climate forecasting system.

1. Evolving policy and programs to manage and mitigate risks due to climate change.
2. Improving early warning systems followed by effective monitoring and evaluating its impact.
3. Developing climate impact modules that give a better understanding of how climate change may affect crop, livestock and fish farming and forestry at a local level in order to be well prepared.
4. Diversifying pattern of livelihoods and adapting agricultural, fishing and forestry practices to efficient water management and soil conservation practices and growing resilient crops and trees.
5. Developing a database on climate, soil and water use and crop yields to assess, map and monitor land-use performance under given technology conditions. Assessment of how vulnerable our food system is and how we can adapt agriculture, livestock, fisheries and forestry to future climate-related disasters.

Increasing coastal inundation, salinisation and erosion as a consequence of sea-level rise and human activities may contaminate and reduce the size of productive agricultural lands, thereby threatening households' livelihood and country's food security.

Steps to mitigate the impact of climate change on agriculture need top priority

Building sufficient resilience of the food systems to avoid enormous future economic losses in agriculture, livestock, fisheries and forestry.

Evolving comprehensive climate resilience strategies comprising risk assessment, development of varieties that can perform well in stressful conditions, better land, water and livestock management and bringing about specific changes in agricultural practices that can respond to climate change.

While agricultural research institutes and universities have already been engaged in researching drought-resistant and saline-resistant crop varieties for the arid regions and rainfall-tolerant and short-duration varieties for flood-prone regions, Government and private sector will have to invest substantially in agricultural research on one hand and motivate/train farmers to take better advantage of the dry rabi season in the flood-prone regions and help them supplement their income through non-farm activities on the other.

Adaptation

Besides, following measures are necessary to better adapt to climate change impacts:

1. To develop land use plans, food security programs, fisheries and forestry policies that can help farming community suitably adapt to climate changes.
2. To undertake cost/benefit analyses of climate change risks for irrigation or coastal protection and for investment decision.
3. Promotion of “best crop-livestock-fish farming practices” through farmers' capacity building and networking.
4. Conceptualization and Implementation of “National Adaptation Program of Action on Climate Change”.
5. Developing contingency plans to cover new and evolving risk scenarios.

CONCLUSION

Agriculture development in India needs to focus on reducing greenhouse gas 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 a focus on impact of climate change on different sectors of agricultural production” it is necessary to make sufficient investments to support climate change to adaptation, mitigation, technology development, transfer and dissemination among farmers.

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