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CLIMATE CHANGE IMPACTS AND ADAPTATION STRATEGIES OF AGRICULTURE

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Introduction

Climate refers to a long-term variation within the climate of a selected region or region, and global climate change means a gradual change within the climate system both by natural and artificial causes. Climate change is caused by the change in each component of the climate system like atmosphere, hydrosphere, biosphere, lithosphere and cryosphere or by complicated interactions among those components. The causes of global climate change are largely divided into natural causes and artificial causes. Natural causes include the change in solar activity, eruption, seawater temperature, ice cap distribution, westerly waves and atmospheric waves. On the other hand, artificial causes include CO_2 emission from industry and agricultural production activities, deforestation, acid rain and the destruction of the ozonosphere by Freon gas, with heating by the rise of greenhouse gases because of the representative (Presidential Advisory Council on Education, Science &Technology: PACWEST, 2007). Global warming, means a continuous increase of the Earth's temperature due to the greenhouse effect caused by CO_2, methane (CH_4), laughing gas (N_2O), hydrofluorocarbon (HFCs), perfluorocarbon (PFCs) and Sulphur hexafluoride (SF6), started from the time of the Industrial Revolution which was accompanied by a rapid increase in fossil fuel consumption. This issue has attracted international interests as the scientific knowledge of climate has accumulated since the 1970s and it has been widely accepted by scientists that the anthropogenic greenhouse gas emissions are the explanation for heating.

Climate change refers to changes beyond the typical climate that are caused both by natural factors like the orbit of earth's revolution, volcanic activities and crustal

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movements and by artificial factors like the rise within the concentration of greenhouse gases and aerosol. Climate change by heating, which refers to the typical increase in global temperature, has become a megatrend that will cause significant global changes in the future. Concerning its impacts, the UN Intergovernmental Panel on global climate change (IPCC) presented considerable scientific pieces of evidence in its fourth report on global climate change (2007) and that they became recognized worldwide.

Climate change is already affecting agriculture, with effects unevenly distributed across the planet. Future global climate change will likely negatively affect crop production in low latitude countries, while effects in northern latitudes could also be positive or negative.Climate change will probably increase the danger of food insecurity for a few vulnerable groups, like the poor. For example, South America may lose 1–21% of its arable acreage, Africa 1–18%, Europe 11–17%, and India 20–40%.

Projected Impacts of Climate Change on Indian Agriculture

- Cereal productivity to decrease by 10-40% by 2100.
- Greater loss expected in rabiseason. Every 1°C increase in temperature reduces wheat production by 4-5 million tons. Loss only 1-2 million tons if farmers could plant in time.
- Reduced frequency of frost damage: less damage to potato, peas, mustard.
- Increased droughts and floods are likely to increase production variability.
- Imbalance in food trade due to positive impacts on Europe and North America, and negative impacts on us.
- Increased water, shelter, and energy requirement for livestock; implications for milk production.
- Increasing sea and river water temperatures are likely to affect fish breeding, migration, and harvests. Coral reefs start declining from 2030.
- Considerable effect on microbes, pathogens, and insects.

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- The increasing temperature would increase fertilizer requirement for the same production targets, and result in higher emissions.

Sector-wise Effects of Climate Change in Agriculture

Field crops:

An average of 30% decrease in crop yields is expected by mid-21st century in South Asian countries. North Indian states and Bangladesh are highly susceptible due to erratic changes in rainfall and temperature (World Bank, 2008). For example, in India, a rise in temperature by 1.5° C and reduction within the precipitation of twomm, reduces the rice yield by three to fifteen per cent (Ahluwalia and Malhotra, 2006). Climatic changes are driven by increasing Green House Gases (GHGs) possibly affects the yield and productivity of crops from region to region. According to the Met Office (United Kingdom's National Weather Service), the normal crop yield is anticipated to decrease by 50 per cent in Pakistan. The production of maize in European countries is expected to increase by 25 per cent in ideal hydrologic conditions (en.wikipedia.org). The drastic climate changes alter the progressive stages of pathogens that eventually affect the growth and yields of crops severely and also could lead to an increase in pest and insect population, ultimately devastating the overall productivity.

Horticulture:

Vegetable crops when exposed to extremely high temperatures are subject to very high transpiration losses, and it also limits fruit set in citrus fruits. High temperature causes the burning or scorching effect of blossoms, predominantly on young trees. The fruit setting stage of navel oranges is recorded to be severely affected by high temperatures during flowering (Davies, 1986). High temperature induces moisture stress conditions leading to sunburn and cracking symptoms in fruit trees like apricot, cherries and apples. The temperature enhancement at the ripening stage causes fruit burning and cracking in litchi plantations (Kumar and Kumar, 2007). Most of the vegetable crops are severely affected by flooding, particularly tomatoes. Another possibility of causing severe damage to crops is due to the accumulation of endogenous ethylene (Drew, 1979). If the ozone concentration reaches >50 ppb/day, the yield of vegetable crops will be reduced by 5 to 15 per cent (Raj, 2009).

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Livestock, Poultry and Fishery sectors:

Global climate change, whether it's global, regional or on a smaller scale, features a greater impact on biological production, or some of these processes acts directly on individual organisms or species. The expansion and development of any species with some specific characteristics are governed by their resilience and tolerance to the changes in their environment. Global climate changes affect numerous factors which are related to the production, reproduction, health and adaptableness of each animal. Higher temperatures abruptly change the animal's body physiology (Pereira et al., 2008) like a rise in respiration rates (> 70- 80/minute), blood flow and blood heat (>102.5º F). Dairy breeds are more vulnerable to heat stress than meat breeds. A rise in metabolic heat production in higher milk-producing breeds results in higher susceptibility to heat stress; while the low milk-producing animals are resistant (Dash et al., 2016). An increase in temperature and temperature-humidity index value beyond the critical intensity reduces the dry matter intake and milk yield. It also interrupts the physiology of an animal's body (West, 2003). During 2009-10, acute events like floods and cyclones devastated agricultural production in a large home in southern and central Mozambique, consequently loss of livestock, its infrastructure and feed (Musemwa*et al.*, 2012). Poultries are extremely sensitive to temperature-associated issues, specifically heat stress. Endocrinological changes caused by prolonged heat stress in broiler chickens enhance lipid accumulation reduced lipolysis and induced aminoalkanoic acid catabolism (Geraert et al. 1996). Thanks to heat stress, feed intake of poultries are going to be reduced (Deng et al., 2012), which results in less weight, egg production and quality of meat, and also reduces the thickness of the eggshell and increases the egg breakage (Lin et al., 2004). Heat stress harms the strength, weight, ash content and thickness of the eggshell (Miller and Sunde, 1975). The rising environmental temperature may cause seasonal improvement in the growth and development of fishes, but increases the risks to the populations living beyond the thermal tolerance zone (Morgan et al., 2001). The increase in temperature of 1° C will affect the mortality of fish and its geographical distribution (Vivekanandan et al., 2009). The temperature rises of 0.37° C to 0.67° C alter the pattern of monsoon differences due to the season, eventually shifting the breeding period of Indian main carps from June to March in West Bengal and Orissa's fish hatcheries (DARE/ICAR Annual Report, 2008-09).

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Strategies for Climate Change Adaptation

As adaptation contributes to reducing the negative risks of worldwide global climate change and provides opportunities to use the climate for positive effects, it plays an important role in mitigating the impacts of global climate change. Adaptation includes both actions taken to directly mitigate the damages from the climate and enhance the longer-term adaptive capacity and actions to contribute to indirectly mitigating the damages from global climate change. Implementation of adaptation should satisfy several conditions including economic strength, technology, information, infrastructure, institutions, and equity, which are mentioned because of the components of adaptive capacity. Sometimes, adaptation could even be implemented free of charge or at a low cost. But in most cases, implementation for viable adaptation measures accompanies a specific amount of expenses. Additionally, implementation of adaptation presupposes applicable technologies. It's also necessary for the effective implementation of adaptation measures that the need for adaptation measures should be acknowledged and best-suited adaptation measures should be selected through the assessment of obtainable adaptation measures.

It involves adjusting to the actual or expected future climate. The goal is to scale back our vulnerability to the harmful effects of global climate change (like sea-level encroachment, more intense extreme weather events or food insecurity). It also encompasses making the foremost of any potential beneficial opportunities related to global climate change (for example, longer growing seasons or increased yields in some regions).

The important adaptation options include:

- New varieties: drought/heat resistant
- New farm management practices
- Change in land use
- Watershed management
- Agri-insurance

Strategies for Climate Change Mitigation

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In reality, it's almost impossible to implement the first-best solution to accurately measure the external effects of worldwide warming and impose the economic costs to the precise greenhouse gas emitters. Under this background, the second-best solution for developing relevant policy programs and forming appropriate portfolios to approach is addressed as a practical method employing a policy mix. Considering the circumstances realistically means for greenhouse emission reduction are classified into economical means, regulatory means, voluntary agreement, R&D and popularization, information provision, and promotion of public awareness.

It involves reducing the flow of heat-trapping greenhouse gases into the atmosphere, either by reducing sources of those gases (for example, the burning of fossil fuels for electricity, heat or transport) or enhancing the "sinks" that accumulate and store these gases (such because the oceans, forests and soil). The goal of mitigation is to avoid significant human interference with the climate, and stabilize greenhouse gases emission levels during a timeframe sufficient to permit ecosystems to adapt naturally to global climate change, confirm that food production isn't threatened and enable economic development to proceed during a sustainable manner" (from the 2014 report on Mitigation of worldwide global climate change temperature change" global climate change from the United Nations Intergovernmental Panel on global climate change).

The important mitigation options include:

- Efficient water and nutrient management options to enhance use efficiency
- Evaluation of carbon sequestration potential of different land-use systems
- Understanding opportunities offered by conservation agriculture and agro-forestry
- Identifying cost-effective methane emission reduction practices in ruminants and rice paddy