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Climate Change and Adaptation Strategies for Rainfed Agriculture

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Abstract
Indian economy is mainly dependent on agriculture, which contributes 21 per cent of the country's GDP and 60 per cent of the employment. Rainfed agriculture occupies 67 percent net sown area, contributing 44 percent of food grains and supporting 40 percent of the population. In view of the growing demand for food grains in the country, there is a need to increase the productivity of rainfed areas from the current 1 t ha-1 to 2 t ha-1 in the next two decades. The quality of natural resources in the rainfed ecosystem is gradually declining due to over exploitation. Rainfed areas suffer from bio-physical and socio economic constraints affecting the productivity of crops and livestock. In this context a number of economically viable rainfed technologies have been discussed. These include soil and rainwater conservation measures, efficient crops and cropping systems matching to the growing season.. The farming systems approach in rainfed agriculture not only helps in addressing income and employment problems but also ensures food security.

Keywords: Rainfed agriculture, climate change and crops

1. Introduction

Climate change is a severe threat that can lead to increasing damage to the ecological foundations of agriculture such as, land, water, forests, biodiversity and the atmosphere. There are distinct possibilities for occurrence of adverse changes in climate threatening the future food security across the nations including India. During the 20th century, there had been a significant increase in the concentration of greenhouse gases (GHG) in the atmosphere contributing nearly 64% of the global warming (379 ppm of CO2). Experts fear that if the emissions of the GHG continue to increase, then it will cause adverse effects on environment and food security of human beings. The Inter-Government Panel on Climate Change (IPCC, 2007) [2] has projected a possible increase in temperature between 1.50 C and 5.8 ^{0}C with the best possible value of 3.80 C by 2100 AD. The net result of climate change as anticipated is recurring drought and floods and significant changes in production environments.

Government has conducted several studies to measure and quantify the adverse effects of climate change on agriculture. Ex tensive field and simulation studies were carried out in agriculture and allied sectors by several network centers consisting ICAR Institutes such as Indian Agricultural Research Institute at New Delhi, Central Research Institute for Dry land Agriculture at Hyderabad, CMFRI, Cochin, IIHR, Bangalore etc. and State Agricultural Universities, located in different parts of the country. The climate change impact assessment was carried out using the crop simulation models by incorporating the projected climates of 2020, 2050 and 2080. Most of the results were obtained through incorporating the future projections by Had CM3 model. From these projections, variability in temperature and rainfall pattern was observed in future periods with significant impact on crop yields. The Indian Network for Climate Change Assessment (INCCA) of the Ministry of Environment & Forests (MoEF) has studied the climate change impact assessment in the Himalayan region.

Climate change denotes long term changes in climate including mean temperature and precipitation. Shifting weather patterns result in changing climate, which threatens food production through high and low temperature regimes, increased rainfall variability, rising sea levels that contaminate coastal freshwater reserves and increased risk of flooding. Climate change and its variability are emerging as major challenges facing Indian agriculture. The high inter and intra-seasonal variability in rainfall distribution, extreme temperature and rainfall events are causing crop damages and huge losses to farmers. Each year, one or the other part in the country is affected by droughts, floods, cyclones, hailstorms, frost and other climatic events.

Hail storms (February- March -2014)

Hail storms were hit the states of Maharashtra, Madhya Pradesh, Rajasthan, Haryana, Karnataka and Telangana during February to March 2014. There was lot of damage to field as well as horticultural crops.

Hudhud cyclone (October 2014)

Hudhud caused extensive damage to the city of Visakhapatnam and the neighboring districts of Vizianagaram and Srikakulam of Andhra Pradesh. Damage to Agriculture: kharif/ rabi: 182128 hectares

South Indian floods 2015

Heavy rainfall generated by the annual northeast monsoon in November–December 2015 caused severe floods in the South Indian states of Tamil Nadu and Andhra Pradesh, and the union territory of Pondicherry, with Tamil Nadu and the city of Chennai particularly hard-hit. Clear indications of change in climate are being noticed in the country. Last three decades saw a sharp rise in all India mean annual temperature. Analysis of data for the period 1901-2005 by IMD suggests that annual mean temperature for the country as a whole has risen to 0.51 ^{o}C over the period. It may be mentioned that annual mean temperature has been consistently above normal (normal based on period, 1961-1990) since 1993. This warming is primarily due to rise in maximum temperature across the country, over a larger part of the data set. However, since 1990, minimum temperature is steadily rising and rate of rise is slightly more than that of maximum temperature.

Climate change studies pertaining to India show enough evidence of rising mean temperatures during post-1970 period. It was reported that greater warming (mean annual surface air temperature) of 0.21 °C/10 years during post-1970 period as compared to 0.51 °C/100 years during the past century. On the other hand, all-India average monsoon rainfall is found trend-less over an extended period starting from the year 1871, though significant spatial variations are found at division level.

At present in India, blue and green water availability are above the 1300 m3/capita/year threshold in present. However, with climate change, blue-green water availability is estimated to decrease to below 1300 m3/capita/year, implying that by 2050, all of India could be exposed to water stress. Resilience to climate change will depend on increasing agricultural productivity with available water resources; refining technologies and timely deployment of affordable strategies to accomplish potential levels of arable land and water productivity.

Assessment of Vulnerability to Climate Change

Atlas on vulnerability of Indian agriculture to climate change was prepared under National Innovations on Climate Resilient Agriculture (NICRA) project of Indian Council of Agricultural Research (ICAR) considering a number of aspects including such weather related aspects as incidence of droughts, floods and cyclones, projected changes in rainfall and temperatures in future. The institute developed vulnerability index and based on this index, all the districts were divided into five categories with equal number of districts. It can be observed that districts with higher levels of vulnerability are located in the western and peninsular India. It is also observed that the highly fertile indo-genetic plains are relatively more sensitive, but less vulnerable because of higher adaptive capacity and lower exposure.

Vulnerability = {Sensitivity + Exposure} – Adaptive Capacity

Adaptation and Mitigation Measures

The first step is to watch the weather forecast and plan the operations accordingly by following the options available in district agricultural contingency plans.

Weather Forecast and Agromet Advisory

All India Coordinated Research Project on Agro meteorology (AICRPAM) under ICAR issues weekly National Agromet Advisory Services Bulletins in collaboration with India Meteorological Department (IMD) during southwest monsoon season. In addition to this, daily rainfall status of the country during southwest monsoon is monitored by AICRPAM and based on these weekly bulletins, 'Status of monsoon, progress in kharif sowing and agromet advisory for deficit/excess rainfall areas' are prepared and supplied to the stake holders. It is also kept in the website www.cropweatheroutlook.com

District Agricultural Contingency Plans (DACPs) to Mitigate Climate Change

CRIDA in collaboration with SAUs and ICAR Institutes has prepared 614 district level agricultural contingency plans to meet various natural calamities like drought, floods, cyclones, temperature extremes, etc. These plans not only deal with agriculture but also with allied sectors like horticulture, livestock, fisheries, etc. These contingency plans are available on the CRIDA website (www.crida.in) and also on Department of Agriculture and Cooperation (DAC), Ministry of Agriculture and Farmers Welfare, Government of India.

Production System based Adaptation and Mitigation Measures

The rainfed agro-ecosystem has been sub-divided into 5 homogenous production systems, viz.,

- Rainfed rice based system
- Nutritious (coarse) cereals based system
- Oilseeds based system
- Pulses based system
- Cotton based system

Venkateswarlu and Shankar (2009) [3] demonstrated adaptation and mitigation strategies of adverse impact of climate change in rainfed agriculture. These production systems involve invariably horticulture, livestock and forestry as one of the components of farming systems.

i) Rainfed Rice-based Production System

The system is prevalent in Eastern and Northeastern part of India which is experiencing negative departure in rainfall. Any decrease in rainfall associated with increase in temperature due to climate change, will have an adverse impact on pollen sterility and germination. The effect will be more pronounced in fine quality varieties of rice like basmati. Rice production system is considered to be non-eco-friendly as it is one of the sources of release of methane and nitrous oxide, green house gases responsible for climate change. The climate change mitigation strategy thus should aim at:

- Adoption of aerobic, direct seeded & SRI method of rice cultivation to minimize the release of harmful gases
- Growing of legumes as relay crop in rice fallows and intercropping with pigeon pea, wherever feasible
- Boundary bund plantation of *Gliricidia* and *Pongamia* and use of leaves as green leaf mulch for saving on nitrogenous fertilizers.

- Integrated farming systems approach involving rice-fish-duck by allocating 10% of the area under on-farm reservoirs by individual farmers or on community basis
- Improved water management practices and recycling of water from on-farm reservoirs during the period of dry spells.

ii) Nutritious (coarse) Cereal-based Production System

Coarse cereals are staple food of poor people and principal source of fodder for livestock. The area under millets excepting maize is showing a declining trend. Nutritious cereals like sorghum, pearl millet and finger millet despite their low cost of cultivation and having greater yield stability and drought hardiness characteristics are losing area due to poor patronage by people and government alike. This production system needs reinforcement as it is highly adaptable to climate change mainly through government policies like:

- Higher Minimum Support Price (MSP) for nutritious millets as an incentive to the growers as it supports livestock too. The pressure on forest and grazing land can be minimized by expanding area under millets. This will benefit both the environment as well as livestock1.
- Inclusion of these millets in public distribution system (PDS) as it can to some extent meet the nutrition deficiency in the poor in rural areas and gradual removal of fine cereals like rice and wheat (having high demand of water) from PDS.

iii) Oilseeds - based Production System

Oilseed crops are grown both during *kharif* and *rabi* seasons under sole, inter and sequence cropping systems and are most affected by biotic and biotic stresses. Most oilseeds have shown positive response to climate change particularly elevated CO2. However, variability in rainfall may result in more number of dry or wet spells affecting their performance. This will be an additional cause of concern and can be overcome mainly through soil moisture conservation, rainwater Harvesting and recycling. The strategy should focus on: Promotion of *in-situ* conservation measures like broad-bed & furrow, conservation furrow, ridge and furrow, etc.

- Individual and community-owned farm ponds for water harvesting and recycling for supplemental irrigation.
- Promotion of site-specific nutrient management (SSNM) and thrust on seed village concept as a contingency measure.

iv) Pulses - based Production System

Ninety per cent of pulses are grown under rainfed conditions as intercrops or in sequence cropping system all over the country. Pulses have shown a positive response to elevated CO2. Pigeon pea and chickpea are the two most important pulse crops and grown during *kharif* and *Rabi* seasons, respectively. Pigeon pea because of its longer growing season, generally experiences terminal drought due to withdrawal of monsoon especially if it is a early withdrawal, while chickpea suffers from lack of residual moisture in the soil profile during *Rabi*. Supplemental irrigation to both the crops in general and chickpea in particular can, however, double the crop yield. The drought mitigation erasures thus lie in adopting *in-situ* soil moisture conservation measures like ridge and furrow for pigeon pea and *ex-situ* harvesting of rain water through farm ponds, percolation ponds or check dams. In addition to rainwater conservation and harvesting, promotion of short duration varieties will improve the productivity of these crops and can cope up with changing climatic scenarios.

Cotton - based Production System

Sixty per cent of the cotton crop is grown in the rainfed condition and is considered as commercial crop. Introduction of Bt cotton has raised the hopes of farming community and there are savings on use of pesticides. Of late, sucking pests have taken a heavy toll of Bt *hirsutum* cotton, which is also susceptible to drought compared to *arboreum*. The ruling varieties are susceptible to both drought and floods besides sucking insects. The likely incidence of biotic and abiotic stresses is going to be more with the changing climate scenario and the mitigation strategy should focus on the following:

- Crop-crop diversity to minimize the risks like 3-tier cropping system of cotton + sorghum + pigeon pea in the row ratio of 6:2:1 as promoted in the Vidharba region of Maharashtra.
- Intercropping of cotton + maize in 1:1 row ratio to promote predation of sucking insects as maize favors laying of eggs by predators and also being C4 plant responds well to the elevated CO2. This is widely practiced in tribal regions of Madhya Pradesh and Rajasthan as an ITK.

All the above rainfed production systems need to be integrated with livestock, horticulture and agro forestry to minimize the risks associated with climate change and to improve profitability in rainfed areas. The existing Central and State government's programmers/ schemes need to be dovetailed to mitigate both the biotic and abiotic stresses as a result of climate change. Success can be achieved through efficient rainwater management and land use diversification in a farming system mode on watershed basis. Further, forewarning and crop insurance will help in managing the risks associated with climate change by poor rainfed farmers.

Risk Transfer Measures

One of the measures to avert the risk of climate change impacts is to opt for insurance and the National Agriculture Insurance Scheme adequately covers all the risks involved of all the farmers including small and medium farmers in terms of insurance cover. The anomalies have been addressed in the new Insurance Policy titled, *Pradhan Mantri Fasal Bima Yojana* (PMFBY). Once the extreme weather event has happened, to compensate for the crop damage, Ministry of Agriculture and Farmers Welfare has started

'**Pradhan Mantri Fasal Bima Yojana'**. The main highlights of the scheme are mentioned below:

- There will be a uniform premium of only 2% to be paid by farmers for all Kharif crops and 1.5% for all Rabi crops. In case of annual commercial and horticultural crops, the premium to be paid by farmers will be only 5%. The premium rates to be paid by farmers are very low and balance premium will be paid by the Government to provide full insured amount to the farmers against crop loss on account of natural calamities.
- There is no upper limit on Government subsidy. Even if balance premium is 90%, it will be borne by the Government.
- Earlier, there was a provision of capping the premium rate which resulted in low claims being paid to farmers. This capping was done to limit Government outgo on the

premium subsidy. This capping has now been removed and farmers will get claim against full sum insured without any reduction.

- The use of technology will be encouraged to a great extent. Smart phones will be used to capture and upload data of crop cutting to reduce the delays in claim payment to farmers. Remote sensing will be used to reduce the number of crop cutting experiments.

Table 1: The details of the crops covered by AIC are as follows:

S. No.	Crops	Season
1	Paddy	*Kharif &Rabi*
2	Sorghum	*Kharif*
3	Pearl millet	*Kharif*
4	Maize	*Kharif*
5	Finger millet	*Kharif*
6	Wheat	*Rabi*
7	Barley	*Rabi*
8	Potato	*Rabi*
9	Coriander	*Rabi*
10	Cumin	*Rabi*
11	Fenugreek	*Rabi*
12	Isabgol	*Rabi*
13	Onion	*Kharif*
14	Garlic	*Rabi*
15	Pepper	*Kharif*
16	Apple	*Rabi*
17	Coffee	Annual
18	Orange	Annual
19	Groundnut	*Kharif*
20	Soybean	*Kharif*
21	Linseed	*Rabi*
22	Rape seed &	*Rabi*
23	Black gram	*Kharif*
24	Green gram	*Kharif*
25	Pigeon pea	*Kharif*
26	Cotton	*Kharif*
27	Tomato	*Kharif &Rabi*
29	Banana	Annual
30	Grapes	*Rabi*
31	Mango	*Rabi*
32	Cashew nut	*Rabi*

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