



Climate Smart Agriculture: A Key to Sustainability

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India is one of the largest agricultural sector in the world where 54.6% population dependent on agriculture. India is one of the top producers of rice, wheat, sugarcane, cotton, pulses, and other food grains, with annual growth in this area. In addition, India is the world's largest producer of milk and the second-largest producer of fruits and vegetables. According to agricultural statistics, 2022-23, the agricultural and allied sector's share of the overall GVA is 21.1%. Indian agriculture is still reliant on the monsoon, even with improved agricultural production 62% of the country's agricultural output still depends on it (GOI, 2023). As a result, changes in temperature, precipitation, carbon dioxide, and other factors have a direct effect on the agriculture sector, which in turn has an impact on the nation's economy and food security.

Impact of climate change on Indian agriculture

Climate change affects Indian agriculture because of heat waves, irregular rainfall, frequent dry spells, flooding, etc. In the short term, crop yield will decrease by 4.5–9%, and if farmers do not adjust, it would drop by an astounding 25%. Moreover, real earnings and agricultural productivity fall by 9.8% and 12.6%, respectively, with every standard deviation increase in the number of days with high temperatures in a year (Anonymous, 2021). Meteorological statistics show that while the total annual rainfall in India has remained constant over the past few decades, the frequency and spread of Extreme Weather Events (EWE) have increased the severity of precipitation. Compared to previous years' regular rains, the nation has been seeing abnormally high levels of rainfall in recent years. Moreover, the sea level rise of several meters and major disruption to monsoon rains in India is among biggest global risks from climate change.

Government initiatives on Climate Smart Agriculture

- Climate resilient technologies have been developed under NICRA for a variety of crops in state-of-the-art climate change research facilities built at multiple national institutes. A risk assessment of Indian agriculture to climate change at the district level has been prepared for 572 rural districts. District Agriculture Contingency Plans have been created by ICAR and NARS for 650 Indian districts, and they are updated on a regular basis. Under the NICRA Project, 151 climatically susceptible districts have one climate-resilient hamlet established in each and location-specific technologies have been tested in these districts.
- The National Action Plan on Climate Change (NAPCC), which offers the broad framework for climate initiatives, is being implemented by the government through national missions in certain regions. Programmatic interventions such as the Soil Health Card, Paramparagat Krishi Vikas Yojana, Mission Organic Value Chain Development for

Northeastern Region, Rainfed Area Development, National Bamboo Mission and Submission on Agro-Forestry are part of the NAPCC's National Mission for Sustainable Agriculture (NMSA). In order to implement a sustainable development pathway, the NMSA gradually transitions to environmentally friendly technology, adopts energy-efficient equipment, conserves natural resources, practices integrated farming, etc. Additionally, through soil health management, improved water usage efficiency, cautious chemical use, and crop diversity, the NMSA seeks to promote location-specific improved agronomic practices.

- The National Adaptation Fund for Climate Change (NAFCC) was created to cover the costs of climate change adaptation for India's states and union territories that are most at risk from its negative consequences. This program was put into place in 2015–16, primarily to assist with practical adaptation efforts aimed at reducing the negative impacts of climate change in a number of industries, notably agriculture. Numerous projects in several states including Punjab, Himachal Pradesh, Odisha, Manipur, Tamil Nadu, Kerala, Mizoram, Chhattisgarh, J&K, Meghalaya, Telangana and Andhra Pradesh have been approved under the NAFCC.
- An institutional strategy called Climate-smart village (CSV) aims to improve farmers' capacity to adapt to climate change by testing, implementing, modifying, and promoting CSA at the local level. The CSV implements a portfolio of initiatives that encompasses all aspects of farm operations to address the climate issues facing by the agriculture sector. Numerous national research organizations and Consultative Group on International Agricultural Research (CGIAR) centres are working together to support CSVs in India. CSVs were tested in two Indian states: the districts of Karnal in Haryana and Vaishali in Bihar. Afterwards, the technology was extended to districts in Punjab, Andhra Pradesh and Karnataka.
- A key component of India's total water use plan is the slogan "More Crop per Drop." In addition to MGNREGA, the Prime Minister Krishi Sinchayee Yojana (PMSKY) has made a significant contribution to the nation's ground water recharging and conservation efforts. A Micro Irrigation Fund is housed inside PMSKY, emphasizing climate-conscious protective irrigation and water-use conservation measures. Programs and regulations pertaining to increased water use efficiency have a positive impact on both the field crop and horticultural subsectors.
- India's fertilizer policy have improved agriculture yield and output, which has resulted in growth. 2013 Mt of GHG emissions were decreased because the additional 13.66 Mt of food grain produced with fertilizers prevented the conversion of 11.48 million hectares of forest land to crop land. Neem coated urea has also reduced fertilizer input cost, improved nutrient use efficiency and reduced GHGs from fertilizer nutrient sources.
- In India, a genuine attempt has been made to promote Zero Budget Natural Farming, or ZBNF. When compared to conventional agriculture, it provides a more environmentally benign and commercially viable option with superior climate adaption.
- Agroforestry's acreage is trending increasing toward greater carbon fixation and lower greenhouse gas emissions. In addition to providing environmental benefits, a pricing mechanism will help Indian agroforestry producers maintain stable incomes.
- The record milk production for 2017–18 was 176.3 metric tons, as opposed to 132.4 metric tons in 2012–13. In addition to marketing and promoting agripreneurship ecosystems in India, a number of livestock-related laws improved animal health, immunization, availability of feed, and artificial insemination.
- Aiming to connect research labs with farmers to discover novel ideas and technology to be implemented at the farm level, Biotech-KISAN is a scientist-farmer partnership scheme that was introduced in 2017 for agriculture innovation. Thus, all 15 agro-climatic

zones and 110 aspirational districts of the nation have been covered by the 146 Biotech-KISAN Hubs that have been developed under this initiative. Thus, the programme has increased the income and output of almost two lakh farmers. In rural areas, over 200 entrepreneurial ventures have also been established.

- The Pradhan Mantri Fasal Bima Yojana (PMFBY), which was implemented nationwide in the *Kharif* 2016 season is optional for farmers as well as States and Unions. It helps the farmers to get some relaxation, through this scheme the government is also giving financial support as well as insurance coverage to farmers in case of crop failure due to natural climate change, pests, or diseases.
- The goal of the National Water Mission (NWM) is to maximize Water Use Efficiency (WUE) by 20%, especially in the agriculture sector and to ensuring that Integrated Water Resource Management (IWRM) conserves water resources and minimizes waste.

Climate resilient techniques in Indian agriculture

Climate-resilient agriculture or CRA, is a strategy that aims to increase farm incomes and productivity over the long run by exploiting the natural resources that are already available through systems of crop and livestock production. Using crop varieties tolerant to climate stress, water-saving technologies, conservation agriculture, integrated nutrient management, pest forecasting, integrated farming systems, weather forecasting and dissemination, precision farming and other strategies are some of the potential adaptation strategies that need to be implemented to deal with climate change.

- 1) **Development of crop varieties & cropping system tolerant to climatic stress:** Farmers typically plant local, traditional crop varieties, which have low yields during weather-related stressors such as heat waves, droughts, pest and disease outbreaks, etc. In order to ensure sustainable agricultural production, farmers should choose crop varieties that are tolerant of many types of stress, such as heat, drought, disease, and pests. Crop like millets are generally having both important characteristics *i.e.* thermophillic (can thrive at relatively higher temperature) and xerophillic (can reproduce in limited water input), which are very much necessary in response to climate change. Therefore, Government of India has declared 2023 as the “International Year of Millet”.
- 2) **Developing & promoting water saving technologies:** Farmers should use technologies like drip irrigation, sprinkler irrigation, rain gun irrigation, laser-assisted field leveling, crop need-based irrigation, rainwater gathering, etc. to improve water availability and minimize losses. Furthermore, drip irrigation and alternating wetting and drying (using field water tubes) systems have been developed for paddy farming in order to save water and reduce greenhouse gas emissions, such as nitrous oxide and methane. Methods such as the composite drought index have also been developed to tackle the drought on a regular basis.
- 3) **Conservation agriculture:** Conservation agriculture has the power to reduce climatic stress, provide economic advantages, and optimize resource utilization. It is predicated on three methods that lead to sustainable intensification of agriculture: crop rotation, limited tillage and mulching with crop residue. Zero tillage causes the next crop to be sown early in a rice-based cropping sequence, allowing the crop to avoid the final heat stress. A cropping system based on zero tilled direct seeded rice yields increased production, efficient use of resources and decreased methane emissions.
- 4) **Nutrient management:** In order to reduce the detrimental effects of climate change on crops, proper fertilizer management is crucial. The management of nutrients particular to a given site is crucial in reducing greenhouse gas emissions and offering advantages for adaptation.

- 5) **Pest forecasting:** Incidence of pests is impacted by anomalous variations in temperature or precipitation. A sudden pest or disease outbreak could result in a significant loss of crop productivity. Thus, fast and accurate pest forecasting can assist farmers in taking prompt action to minimize the effects of pest outbreaks and effectively control agricultural pests.
- 6) **Weather forecasting & dissemination:** Disseminating weather forecasts could be a useful strategy to reduce the threat of climate adversaries. Farmers can manage the abnormal weather conditions with the use of agromet advisories and weather bulletins which are generated and distributed to them via phone, email, and SMS.

Conclusion

Climate change may provide a significant challenge to India's agricultural production system, hence impacting the nation's food security. Therefore, climate resilient technology may show to be a blessing for agricultural output in order to address the issue of poor productivity and revenue. In order to preserve food security, soil fertility and sustainability while managing biotic and abiotic stress, farmers need to be aware of climate smart technologies.