Climate Sustainable Agriculture

Agriculture in coming years and decades is sure to face formidable challenges for the simple reason that climate change and its inherent impacts are a reality now. The challenge aggravates multiple times as the world would need an increase of around 70% by 2050 in its food production to feed its ever increasing population. So, the world needs to find ways to sustainable agriculture and the answer lies in Climate Smart Agriculture (CSA).

Bhuwan Bhaskar

Multiple studies by the Indian Government and various global institutions have proved beyond any doubt that, with an increasing population, the question of food security is going to be one of the biggest challenges facing humanity. According to the Food and Agriculture Organization (FAO) data, the relative rates of increase in yield for major cereal crops are decreasing. The food security challenge will only become more difficult, as the world will need to produce about 70 per cent more food by 2050 to feed an estimated 9 billion people, while the population is projected to reach 11 billion in 2100 (UN Population Division report). Rising temperatures due to global warming have already started eating up the yield of food grains and other agricultural crops. It has been predicted that the temperature will rise 2–5°C in the future climate by 2100 (IPCC, 2014). The interesting fact about the relationship between global warming and agriculture is that they are interdependent.

Global Warming Challenge

The situation for agri-production is a two-way challenge: first, to shield the production from the

The author is a Commentator on contemporary issues related to Indian economy and agriculture.
Email: bhaskarbhuwan@gmail.com

effects of global warming, and second, to increase the production for a larger population in the years to come despite the symptoms of global warming.

It is evaluated that without the use of CO_2 fertilisation, efficient solutions, and genetic transformation, each 1°C rise in the global mean temperature reduces global maize yield by 7.4%, wheat yield by 6.0%, rice yield by 6.2%, and soybean yield by 3.1%. An increase in the average temperature of 2°C could lead to 20–40% reductions in cereal grain output, notably in Asia and Africa. The fifth assessment report (AR5) by the Intergovernmental Panel on Climate Change (IPCC, 2018) predicts that the temperature will increase by 2.5–5.8°C before 2100. With such an increase, the damage to crops can only be imagined. Numerous food crops such as rice, wheat, soybeans, maize, cotton, sorghum, and tomatoes are tremendously vulnerable to high temperatures. The maximum threshold temperature for various crops differs. However, high temperatures above 35°C can cause damage to rice crops. Evident injuries were observed due to high temperatures in different developmental stages. Recent studies have revealed that sorghum pistils and pearl millet are both similarly sensitive to high temperatures. High temperatures during grain filling have a significant effect on sunflower seeds and oil constituents. In addition, it also reduces the linoleic acid content of numerous oilseed oils. It also reduces the oil content and seed yield, and speeds up seed maturity, which influences erucic acid over seed development.

Producing crops with the least impact from deteriorating climate conditions is easier said than done. It is, in fact, a very complex process that needs a thorough overhaul of the whole production cycle in agriculture. In fact, agriculture is as much responsible for the rapid deterioration of normal weather conditions as it is for being negatively impacted by global warming. According to IPCC, 2013, agriculture, forestry, and the change of land-use, account for as much as 25% of human-induced GHG emissions. Agriculture is one of the main sources of methane and nitrous oxide emissions. Besides its contribution to global warming, farming has other detrimental effects on the environment. Agriculture is often the reason for deforestation and a change in land use, from natural ecosystems that take up and store carbon dioxide (CO_2) from the atmosphere to farmland.

So, when a 360-degree solution is envisaged for sustainable agriculture, it must also take care of saving the environment from agriculture along with saving agriculture from the environment. In other words, the world needs to find ways to sustainable agriculture and the answer lies in Climate-Smart Agriculture (CSA).

What is Climate-Smart Agriculture (CSA)

As defined by the World Bank, 'Climate-smart agriculture (CSA) is an integrated approach to managing landscapes—cropland, livestock, forests and fisheries, that address the interlinked challenges of food security and climate change.' A range of agricultural practices that transform agricultural systems to support food security in the face of climate change have been collectively known by the name CSA. Basically, the CSA targets three outcomes simultaneously:

1. Increased productivity

A 2020 World Bank report found that nearly 690 million people—or 8.9 per cent of the global population—are hungry, up by nearly 60 million from 2015 onwards. Saving this population from hunger in the first place and providing them with necessary nutrition are the two major dimensions of increasing the productivity of agricultural produce.

2. Enhanced resilience

Developing crops that could sustain extreme weather conditions like drought, flooding, etc., and sustain against pests, diseases, and other climate-related risks and shocks; and improve capacity to adapt and grow in the face of longer-term stresses like shortened seasons and erratic weather patterns are the major objectives under enhancing resilience.

3. Reduced emissions

As discussed in the above section, agriculture is responsible for global warming on a large scale. So, for climate-smart agriculture, it is imperative to find ways to reduce emissions for each kilo of food produced, avoid deforestation, and identify ways to absorb carbon out of the atmosphere.

Climate-Smart Crop Production Practices and Technologies

The Food and Agriculture Organization (FAO) says in its 2011 report that it is impossible to harvest good crops with bad seeds. Therefore, for the success of any climate-smart agriculture, it is very important to develop and follow smart management practices and technologies. These practices and technologies must be able to address the problems of production as well as emissions in agriculture. Most of these practices prevent soil damage that releases carbon and water into the atmosphere, promote soil and water conservation; and increase productivity. The Organization has laid down a fairly elaborative system of such practices and technologies to be followed by the countries for climate-smart crop production.

The varieties being bred to resist the detrimental effects of climate change should be resistant to the climate-related phenomena and should be able to thrive on limited resources so that their own regressive impact on the atmosphere could be curtailed significantly. Drought, floods, extreme heat waves, extreme cold conditions, and salinity are the most common manifestations of global warming for which crop varieties are being bred. There are other impacts too, like increasing pest attacks, higher frequencies of frosts at the seedling and/or pollination stages, high temperatures at the grain-filling stage, heavy rains that compress the soil, and alternate light rains and hot temperatures that stimulate seed germination but prevent the establishment of seedlings. Climate-smart crops have to take care of all these situations in order to secure food for the world population. But it is important to note that only developing such varieties is not enough to secure the food production for the world population or the livelihood of farmers. It needs to lay down an efficient process of the production of such seedlings on a commercial level and develop channels of distribution for them among farmers. The seed delivery system involves multiple other stages too, for example, multiplication, processing, storage, and marketing, apart from development and distribution.

Use of quality seeds and planting materials of well-adapted crops and varieties: To effectively implement a climate-smart agriculture strategy, there are some components that are recommended by FAO:

1 Conservation of plant genetic resources for food and agriculture

To address the challenges posed by climate change, there is an increasingly urgent need for the investment of greater resources and efforts in safeguarding the widest possible diversity of plant genetic resources for food and agriculture in their natural habitats, on farms and in gene banks.

2 Crop variant development

Two approaches need to be adopted for the development of climate-resistant varieties. First, the range should be as wide as possible. More diverse will be the portfolio of varieties of an extensive range of crops, more likely will be the chances for the production systems to adapt to climate change. The second approach should be to involve farmers in the process from the beginning. The farmers' perspective contributes to the decisions about which varieties are proposed for official release and registration. Participatory plant breeding is an effective way to achieve demand-driven crop improvements for adaptation to climate change.

3 Seed production and delivery

For the success of any strategy in climate-smart agriculture, the affirmative participation of the farmers is a must. To ensure the same, it is very important that the problem of global warming be seen from the farmers' livelihood perspective too. Farmers must be convinced to use climate-resistant varieties. This can only be done by gaining their trust that the new variety will meet their needs.

Biodiversity Management

All major grain crops, including maize, wheat, rice, and most other crops, are often grown in monoculture systems that require significant investments in pesticides and herbicides. Any crop variety is never found alone in one field. Carl Folke, in his 2006 research paper, successfully proved that when agricultural ecosystems are simplified, whole functional groups of species are removed, and their capacity to respond to changes and provide ecosystem services is compromised. In a cropping system, greater diversity of crops and other living organisms is an important criterion for ensuring farm resilience, economic stability, and profitability.

Integrated Pest Management

Climate change will affect the spread and establishment of a wide range of insect pests, diseases, and weeds. Integrated Pest Management is an ecosystem approach to crop production and protection. It is based on the careful consideration of all available pest management techniques. Integrated pest management involves the use of appropriate measures to discourage the development of pest populations, and keep pesticides and other interventions to levels that are economically justified, reduce or minimise risks to human health and the environment, and disrupt the agricultural ecosystem as little as possible. The ability to make good decisions in the field is crucial for effective integrated pest management. Integrated pest management is valid in a variety of different and evolving farming conditions. Independent of how climate change will affect agricultural ecosystems, farmers who understand integrated pest management principles will be better equipped to cope with the effects of climate change and develop sound and location-specific adaptation strategies (M. Allara et al., 2012).

Improved Water Use and Management

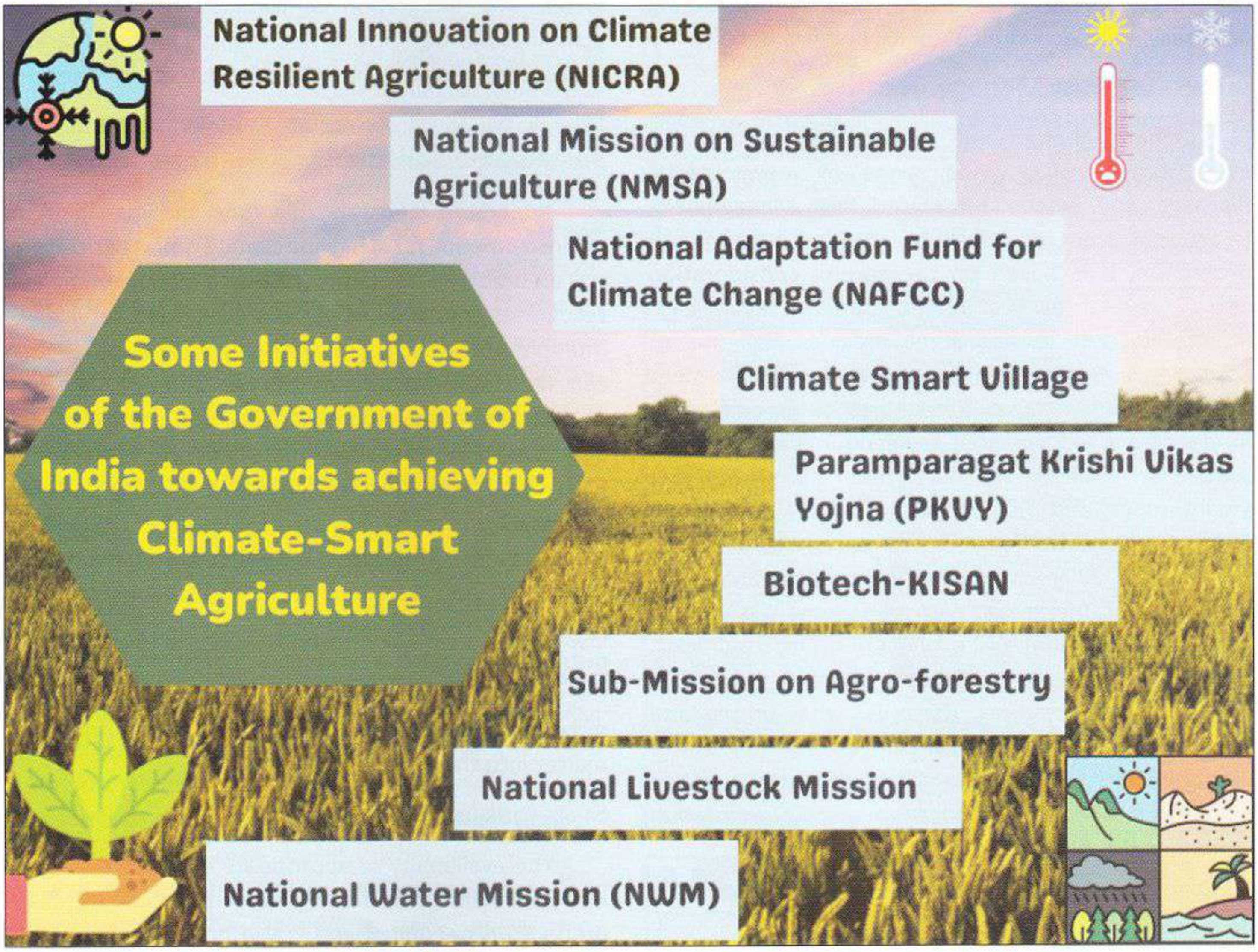
Water is a scarce resource these days. The water table across regions is depleting, and in many areas, the groundwater has become unusable due to its salinity. The situation is going to worsen in the future with climate change phenomena. Climate change, which will increase crop evapotranspiration, change the quantity of rainfall and rainfall patterns, and lead to greater variations in river runoff and groundwater recharge, will affect both rainfed and irrigated agriculture. The impacts of climate change on water resources used for agriculture must be situated in a wider context. Responses to address these impacts need to consider the other pressures that are affecting water resources, such as the increasing demand and competition for water by all sectors and the degradation of water quality. So, to achieve sustainability in agriculture, water resource management comes on top. This can be achieved through measures that conserve soil and water, with deficit irrigation that can maximise crop yields per volume of water applied; and/or more efficient irrigation technologies that can reduce unproductive evaporation losses. The integration of climate change into the planning and design of investments can considerably reduce the risks to the water infrastructure used for agriculture.

Sustainable Soil and Land Management

Integrated landscape planning and management are instrumental for achieving climate-smart agriculture. It is an umbrella for natural resource management that recognises the value of various ecosystem services to multiple stakeholders, and the different values that can lead stakeholders to pursue different land-use objectives or livelihood strategies. Soil protection can be achieved by practising direct seeding in combination with the sustainable management of crop residues within a broader framework of integrated soil fertility management. The most cost-effective management strategies for sustainable intensification of crop production involve achieving a balanced cycling of nutrients through the production system and protecting the soil on the field. Nutrient cycling refers to the movement and exchange of organic and inorganic matter into the production of crops.

Sustainable Mechanisation

The availability of appropriate machinery to carry out sustainable crop management practices increases productivity per unit of land. It also increases efficiency in the various production and processing operations and in the production, extraction, and transport of agricultural inputs, including coal and oil. Tractor-operated tillage is the single most energy-consuming operation in crop production. Using smaller tractors, making fewer passes across the field, and reducing working hours, when combined with conservation agriculture, reduce carbon dioxide emissions, minimise soil disturbance, and curtail soil erosion and degradation that are common in tillage-based crop systems (Lal, 2016). The timely availability of agricultural equipment, such as drills, harvesters, and threshers, permits producers to plant, harvest, and process crops in an efficient manner. This increases yields and reduces post-harvest losses. Precision farming equipment, along with controlled release and deep placement technologies, make it possible to accurately match production inputs with plant needs. This improves efficiency in the use of inputs and reduces direct and indirect greenhouse gas emissions.



In India, the countrywide decline in major crop yields due to climate change effects between 2010 and 2039 could be as high as 9%, worsening further with time. The loss can be up to 35% for rice, 20 per cent for wheat, 50% for sorghum, 13% for barley, and 60% for maize, depending on the location and future climatic scenario, according to a reference note uploaded on the Loksabha website. The Productivity of most crops is likely to decrease 10-40% by 2100 due to increase in temperature, rainfall variability, and decreases in irrigation water. The major impacts of climate change will be on rainfed or un-irrigated crops, which are cultivated on nearly 60% of cropland. A temperature rise of 0.5 degree Celsius in winter is projected to reduce rainfed wheat yield by 0.45 tonnes per hectare in India. The Government of India's economic survey (2018) estimated that the annual loss of US$ 9-10 billion was due to the adverse effects of climate change.

To mitigate the impending impact, the Government has taken many initiatives, some of which are as follows: *(source: reference note from Parliament Library And Reference, Research, Documentation And Information Service):*

National Innovation on Climate Resilient Agriculture (NICRA): This is a network project of the Indian Council of Agricultural Research (ICAR) launched in February 2011 with an outlay of Rs. 350 crore. The project aims to enhance the resilience of Indian agriculture, covering crops, livestock, and fisheries to climatic variability and climate change through development and application of improved production and risk management technologies.

National Mission on Sustainable Agriculture (NMSA): The Government is implementing the National Action Plan on Climate Change (NAPCC) which provides the overarching framework for climate actions, through national missions in specific areas. The NMSA works through adoption of sustainable development pathway by progressively shifting to environment friendly technologies, adoption of energy efficient equipments, conservation of natural resources, integrated farming, etc. Besides, the NMSA aims at promoting location-specific improved agronomic practices through soil health management, enhanced water use efficiency, judicious use of chemicals, and crop diversification.

National Adaptation Fund for Climate Change (NAFCC): It was established to meet the cost of adaptation to climate change for the State and Union Territories of India that are particularly vulnerable to the adverse effects of climate change. This Scheme was implemented during 2015-16 mainly for supporting concrete adaptation activities dealing with mitigating the adverse effects of global climate change in various sectors including agriculture. Under the NAFCC, various projects have been sanctioned in different states, i.e., Punjab, Himachal Pradesh, Odisha, Manipur, Tamil Nadu, Kerala, Mizoram, Chhattisgarh, J&K, Meghalaya, Telangana, Andhra Pradesh, etc.

Climate Smart Village (CSV): It is an institutional approach to test, implement, modify, and promote CSA at the local level and to enhance farmers' abilities to adapt to climate change. CSVs were piloted in two states of India: Karnal district of Haryana state and Vaishali district of Bihar state, which later spread into the districts of Punjab, Andhra Pradesh, and Karnataka.

Paramparagat Krishi Vikas Yojna (PKVY): It is an extended component of Soil Health Management (SHM) launched in 2015 under NMSA with the objective of supporting and promoting organic farming through adoption of organic village by cluster approach, which in turn results in improvement of soil health.

Biotech-KISAN: It is a scientist-farmer partnership scheme launched in 2017 for agriculture innovation with an objective to connect science laboratories with the farmers to find out innovative solutions and technologies to be applied at farm level. Under this scheme, so far 146 Biotech-KISAN Hubs have been established covering all 15 agroclimatic zones and 110 aspirational districts in the country.

Sub-Mission on Agro-forestry: This Mission was launched during 2016-17 with the objective of planting trees on farm bunds. Agro-forestry has the potential to bring sustainability in agriculture and also achieving the optimum productivity by mitigating the impact of climate change.

National Livestock Mission: This Mission was initiated by the Ministry of Agriculture and Farmers' Welfare and got commenced from 2014-15 focusing mainly on livestock development through sustainable approach ultimately protecting the natural environment, ensuring bio-security, conserving animal bio-diversity and farmers' livelihood.

National Water Mission (NWM): A Mission was launched to ensure Integrated Water Resource Management (IWRM) for conserving the water sources and minimising its wastage and to optimise Water Use Efficiency (WUE) by 20 per cent including agriculture sector.

The Government of India has aggressively embarked upon the process of evaluating the climate change impact on agriculture supplemented by strong interventions. District-level risk assessment of the Indian agriculture to climate change (572 rural districts) have been prepared. ICAR along with NARS has developed District Agriculture Contingency Plans for 650 districts in India and is being updated regularly. Climate-resilient villages have been developed, one in each of 151 climatically vulnerable districts under the NICRA Project and location-specific technologies have been demonstrated in these districts. The fertiliser policies in India have grown positively by enhancing crop production and productivity. The additional food grain production of 13.66 Mt using fertilisers avoided the conversion of 11.48 million hectares of forest land to cropland, thereby, reducing 2013 Mt of GHGs emissions. Neem coated urea has also reduced fertiliser input cost, improved nutrient use efficiency and reduced GHGs from fertiliser nutrient sources. There has been a sincere effort to promote Zero Budget Natural farming (ZBNF) across India. It offers a commercially viable and environment friendly alternative and offer better climatic adaptation compared to conventional agriculture. Area under agro-forestry is on upward trend towards more carbon fixation and reduced GHGs. ❑