

Climate resilient agriculture

to combat food and nutritional security

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Agriculture sector in India is highly vulnerable to climate change. In the years to come, globe is likely to experience a much warmer climate owing to greenhouse gas (GHG) emissions that have accumulated in the atmosphere over the years. To meet the challenges of sustaining domestic food production in the face of changing climate, Ministry of Agriculture & Farmers Welfare, Government of India has initiated several schemes under NMSA and NICRA. These schemes have helped to develop new and innovative resilient technologies and promote them to cope with weather extremes. Advanced research infrastructure has been established across the country and large-scale capacity building on resilient agriculture is taking place. Climate resilient crop varieties, fodder systems, livestock and fisheries technologies have been introduced in drought, flood, heat wave affected districts, and have been well adopted by farmers resulting in increased crop yields and monetary returns. Further upscaling of resilient practices developed and evaluated for crops, horticulture, livestock and fisheries sectors will be feasible by convergence with the state and central departmental schemes, involving civil societies and corporate sectors. We should pave way for achieving carbon neutral agriculture in India without compromising on food and nutritional security.

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CLIMATE change has become an important area of concern for India to ensure food and nutritional security for growing population. Indian agriculture is highly vulnerable to climate change and variability. One or other part of the country is experiencing frequent extreme weather events such as heavy rainfall, droughts, floods, frost, heat wave, cold wave, hailstorm, etc. causing severe yield and income loss to the farmers. The agriculture sector is likely to be one of the worst affected directly in terms of crop yields, water availability and indirectly through changes in pest and pathogen incidence. The last four decades have been continuously warmer than the preceding decades since 1850. The global surface temperatures in last two decades (2001-2020) is higher by 0.99°C (0.84-1.10°C) compared to 1850-1900, larger increase over the land than over the ocean. Further,

the number of dry days as well as days with extremely high levels of rainfall have increased in India. The frequency of extreme rainfall events of about 20-30 cm rainfall in a single

day has increased in the recent years. As per the recent sixth Assessment Report by United Nations Framework Convention on Climate Change (UNFCCC) the climate

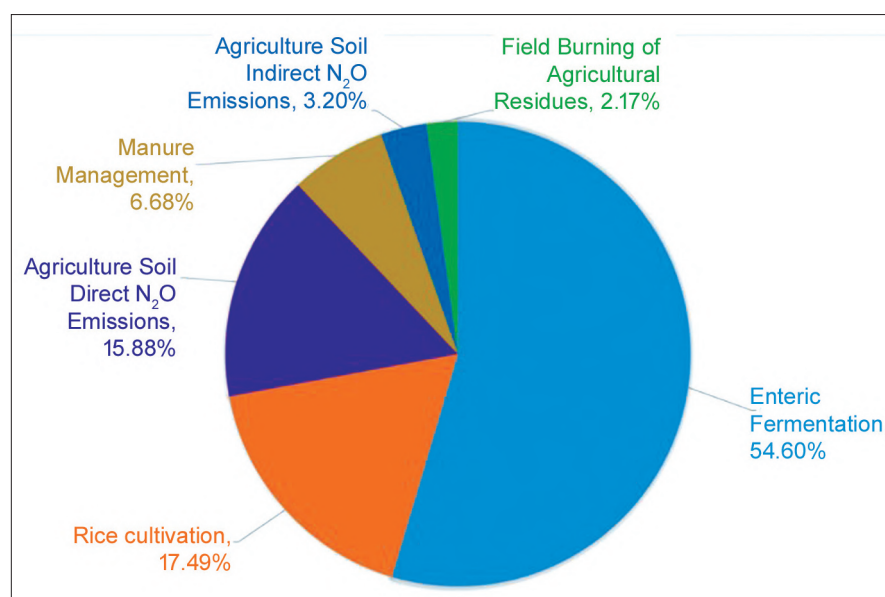


Fig. 1. GHG emissions from different sectors of Indian agriculture.

change will be a major problem in the coming years and the globe will experience a much warmer climate owing to greenhouse gas (GHG) emissions that have accumulated in the atmosphere over the years. The concentrations of GHG emissions in the atmosphere have continued to increase since 2011, reaching annual average of 410 ppm for carbon dioxide (CO₂), 1866 ppb for methane (CH₄) and 332 ppb for nitrous oxide (N₂O) in 2019.

Another area of concern in agriculture sector is GHG emissions like methane (CH₄) and nitrous oxide (N₂O) form the major share. CH₄ emissions occur mainly due to livestock rearing (enteric fermentation and manure management) and rice cultivation. N₂O emissions are mainly due to the application of fertilizers to agricultural soils. Agriculture sector emitted 407,821 Gg of CO₂e (14% of the emissions from India) in 2016, which is 2.25% low compared to 2014. Within agriculture sector, the major share of GHG emissions was due to enteric fermentation (54.6%), followed by rice cultivation (17.5%), fertilizer applied to agricultural soils (19.1%), manure management (6.7%) and field burning of agricultural residues (2.2%) (Fig. 1).

Agriculture is the only sector that has contributed to positive growth in the COVID-19 pandemic with a growth of 3.4% that resulted in an increase in its share in gross domestic product (GDP) to 19.9% in 2020-21

from 17.8% in 2019-20 with about 50% of workforce engaged in this sector. In view of the increased frequency and intensity of weather extremes, it is important to accelerate climate change research in agriculture and allied sectors for developing resilient technologies and their up scaling. The Prime Minister's National Action Plan on Climate Change (NAPCC) has identified agriculture as one of the key sectors out of 8 National Missions in India. To meet the challenges of sustaining domestic food production in the face of changing climate, Ministry of Agriculture & Farmers Welfare, Government of India has initiated few schemes to promote adaptation to climate change, viz. National Mission on Sustainable Agriculture (NMSA) and National Innovations in Climate Resilient Agriculture (NICRA). These schemes aim to develop and promote climate resilient technologies that help the districts and regions prone to extreme weather conditions like droughts, floods, frost, heat waves, etc. to cope with such extremes.

Indian Council of Agricultural Research (ICAR) has launched NICRA in 2011. The project aims to develop and promote climate resilient technologies in agriculture which will address vulnerable areas of the country and the outputs of the project will help the districts and regions cope up with extreme weather conditions. The project is implemented through components,

viz. strategic research, technology demonstration and capacity building in 151 clusters of villages in each one of the identified climatically vulnerable districts to demonstrate proven technologies and enhance adaptive capacity of farmers.

Climate Change Research

Under NICRA, state-of-the-art infrastructure facilities (Fig. 2.) have been established by Indian Council of Agricultural Research (ICAR) in National Agricultural Research, Education and Extension System (NAREES) across the country to facilitate the climate change research on crops, livestock, fisheries, natural resources like soil organic carbon and water. More than 1600 scientists, research scholars and students from different parts of the country are engaged in climate change research.

Studies of climate change impacts on agriculture indicated that in the absence of adoption of adaptation measures, climate change projections are likely to reduce rainfed rice yields by 20% in 2050 and 47% in 2080 scenarios while, irrigated rice yields by 3.5% in 2050 and 5% in 2080 scenarios, wheat yield by 19.3% in 2050 and 40% in 2080 scenarios and *kharif* maize yields by 18 to 23% in 2050 and 2080 scenarios. To improve the food grain production, resilient varieties to climatic stresses have been developed and released for cultivation in different crops. Adopting resilient varieties coupled with improved agronomic management can improve



Fig. 2. State-of-the-art climate change research infrastructure.

the rice yields by 17% in irrigated condition and by about 35% in rainfed condition, wheat yields by about 40%, maize yields by about 10%. Prominent drought tolerant varieties and resilient cropping systems adopted by farmers resulted in yield advantage up to 80%. Resilient inter-cropping systems in place of sole crops, contributed in stabilizing productivity under variable climatic stresses in frequently drought affected regions in Peninsular and Central India.

Climate Resilient Varieties

Screening of numerous germplasm including local genetic resources in several crops (rice, wheat, maize black gram, green gram, pigeonpea, chickpea and lentil) for different abiotic stresses (drought, heat, salinity, NUE, submergence tolerance, etc.) helps in identifying donors for stress tolerance. Further, genes responsible for imparting resistance for climatic stresses in field crops have been identified and characterized through molecular approaches. Thousands of wild germplasm lines collected from several locations across the country have been screened to identify new sources which could be used in future breeding programs to develop new tolerant varieties to drought, flood and heat stress. Continuous efforts of research have resulted in development of improved seed varieties of rice (CR Dhan 201, NICRA Aerobic Dhan 1), greengram (Virat, Varsha, Heera, Kanika) and lentil (IPL 534) resistant to diseases and extreme weather conditions. These climate resilient varieties have been introduced in drought, flood, heat wave affected districts, well adopted by farmers resulting in increased crop yields and monetary returns at different locations. On-farm evaluation of several climate resilient varieties in different crops, viz. rice (74 varieties), soybean (9 varieties), finger millet (11 varieties), maize (17

varieties), black gram (20 varieties), greengram (20 varieties), groundnut (14 varieties), pigeonpea (31 varieties), sesame (9 varieties), wheat (3 varieties), pearl millet (4 varieties) and 51 varieties in other crops were demonstrated and integrated into developmental programs in climatically vulnerable districts.

Natural Resources Management

In recent times, intense rainfall of about 20-30 cm of per day is increasing, causing severe yield loss. For location-specific technologies for rainwater harvesting with farm ponds, percolation tanks, check dams, etc. have been developed. Further, groundwater recharge technologies including open well and tube well recharge models have been developed and upscaled. The *in-situ* and *ex-situ* rainwater management resulted in higher yields and income under deficit rainfall conditions in major crops. The extent of yield improvement due to critical irrigation is up to 85% in some of the low rainfall regions. Harvested water was used for increasing the cropping intensity by bringing more area under *rabi* crops resulting in enhanced yields and returns in wheat, mustard, chickpea and vegetable crops.



Fig. 3. Rice residue management in farmers' fields.

Apart from water, soil health management is also of prime importance for sustainable agriculture. Soil health management aims to promote crop and location specific sustainable practices that include residue management, organic

farming practices, nutrient management, balanced application of fertilizers and minimizing the soil erosion/degradation. Soil aggregates and water stability improved under conservation practices. Recent investigations on maize based cropping system in North-Eastern Hill region have shown that biochar enhanced productivity, nutrient use efficiency and C sequestration potential of the system. Further, soil microbial biomass carbon (SMBC), dehydrogenase enzyme activity (DHA) and soil organic carbon (SOC) improved greatly with application of biochar @ 5.0 t/ha along with 75% RDF + 4 t/ha FYM, while exchangeable aluminium and exchangeable acidity were reduced. Balanced fertilization and integrated nutrient management systems are the keys to sustainable crop production in terms of building up of C, structural stability and crop yield and climate mitigation options.

Reducing emissions from agriculture sector

Several climate resilient technologies have been developed in ICAR that helps in reducing emissions from agriculture sector. The mitigation of GHG emissions can be achieved by implementation of technologies like System of Rice Intensification (SRI) cultivation as alternative to transplanted paddy, Direct Seeded Rice (DSR) cultivation, use of slow release nitrogen fertilizers, integrated nutrient management practices, soil health card based fertilizer application, leaf colour charts based N fertilizer application, integration of trees especially fruit trees in the arable systems, integrated farming systems in reducing emissions, replacing fossil fuels with biogas and vermicomposting, micro-irrigation (drip and sprinkler), balanced ration for livestock, neem-coated urea, solar pumps, avoidance of crop residue burning by promoting zero tillage cultivation in rice-wheat.

Demonstration of zero-till cultivation in NICRA villages has resulted in 26 villages as residue burning-free villages in the two states of Haryana and Punjab. Crop residue management with appropriate farm mechanization is one of the key strategies both for adaptation and mitigation (Fig. 3).

Upscaling of climate resilient practices

Under NICRA-Technology Demonstration Component, location-specific climate resilient technologies are being demonstrated in 151 climatically vulnerable districts through Krishi Vigyan Kendras (KVKs) for enhancing the adaptive capacity and resilience against climatic variability. In NICRA villages, innovative village level institutions such as Village Climate Risk Management Committee (VCRMC), Custom Hiring Centers (CHCs) for farm implements, seed and fodder production system, commodity groups, water sharing groups, community nursery were established as enabling support systems. Also, collective marketing by tapping value chains was initiated. Convergence with the development departments is the key to upscale the proven resilient technologies in the district. These technologies are being upscaled by convergence with the relevant state and central department schemes/programmes, viz. Rashtriya Krishi Vikas Yojana (RKVY), Agriculture Technology Management Agency (ATMA), Integrated Tribal Development Agency (ITDA), Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), National Bank for Agriculture and Rural Development (NABARD), National Horticulture Mission (NHM), National Food Security Mission (NFSM), Assam Agribusiness and Rural Transformation Project (APART) and *Pradhan Mantri Krishi Sinchayee Yojana* (PMKSY). Demonstrating such resilient technologies in the farmers' fields across the country will send the benefits to large number of farmers in the vulnerable districts. The climate resilient agriculture practices need to be upscaled, further involving civil societies and tapping funding

opportunities available under corporate social responsibility. There are also international funding opportunities like Green Climate Fund (GCF), Global Environmental Facility (GEF) and Adaptation Fund (AF), etc.

Other Government initiatives for climate resilient agriculture

India is committed to the implementation of mitigation policies and is proactively promoting low carbon and sustainable lifestyles. Adaptation and adaptation-led-mitigation is the central strategy for agriculture sector. Several climate friendly initiatives have been taken up to promote sustainable development of agriculture sector. The details are given here.

National Mission on Sustainable Agriculture (NMSA)

This mission was structured under the National Action Plan on Climate Change (NAPCC) and made operational during 2014-15. It aimed to synergize resource conservation, enhancing or restoring the soil fertility, thereby, improving productivity with focus on soil health management, Integrated Farming System (IFS), integrated animal component and Water Use Efficiency (WUE) specifically in rainfed areas.

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)

This scheme was planned and formulated during 2015 to give more priority on water conservation and its management in agriculture with the vision to extend the area under irrigation. The main motto of this scheme is 'More crop per drop' to provide end-to-end solutions in water source creation, distribution channels and its management.

Pradhan Mantri Fasal Bima Yojana (PMFBY)

This scheme was introduced in January, 2016 in order to reduce the agricultural distress and farmer's welfare without affecting substantial hikes in the Minimum Support Prices (MSP) on agricultural produces during monsoon fluctuations or any

other natural calamity by providing full insured amount on crop losses.

Soil Health Card (SHC)

This scheme was launched in February, 2015 to issue soil health cards (SHC) to the farmers providing detailed information on test-based soil nutrient status of their own land along with recommended dose of fertilizers for improving productivity through judicious use of inputs.

Paramparagat Krishi Vikas Yojna (PKVY)

This scheme was 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.

Bharatiya Prakritik Krishi Paddhati Programme (BPKP)

This scheme was launched recently in 2020-21 under existing sub-scheme of PKVY with the aim to promote traditional indigenous practices. It excludes all synthetic chemical inputs directly or indirectly and is largely based on on-farm biomass recycling with emphasis on biomass mulching, and use of cow dung-urine formulations. This scheme gives more emphasis on creating awareness and capacity building.

SUMMARY

Climate change impacts on crops, natural resources, livestock and fisheries was assessed and adaptation and mitigation technologies for various systems have been developed. The proven resilient technologies have been demonstrated in 151 climate resilient village clusters. The adaptation and mitigation practices are being upscaled by several State Governments across the country. Integrated approach at village level by implementing the package of climate resilient practices over years will immensely contribute to climate resilient agriculture and food and nutritional security in the country.

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