*Plant Archives* Vol. 24, Special Issue (GABELS), 2024 pp.718-723 e-ISSN:2581-6063 (online), ISSN:0972-5210

**Plant Archives**

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.SP-GABELS.111

# STRATEGIES AND TECHNOLOGIES FOR CLIMATE CHANGE ADAPTATION FOR SUSTAINABLE AGRICULTURE

**Sahadeva Singh[1*] and Vimal Kumar Sharma[2]**
[1]Galgotias University, Greater Noida, U.P., India
[2]G. D. Goenka University, Gurugram, Haryana, India
*Corresponding author Email: dean.soagri@galgotiasuniversity.edu.in

**ABSTRACT**

Sustainable agriculture can improve environmental health, carbon sequestration, economic profitability, and soil and economic equity by adopting organic farming, agroforestry, natural farming, integrated pest management, system of rice intensification, cover crops and mulching, precision farming, no till or reduced tillage, integrated farming system, intercropping and crop rotation. It can reduce the number of chemical pesticides and fertilizers used. Sustainable agriculture promotes use of solar, wind, biofuel, biogases technologies and minimizes fossil fuel requirement. Climate change impact such as drought, floods, pests and disease outbreak, and extreme weather can be minimized by adopting sustainable agriculture practices. Sustainable agriculture is helpful for increasing crop production, reducing the cost of production, minimizing risk, improving food security and nutrition, enhancing livelihood security, and maintaining natural resources and ecosystem. Sustainable agriculture faces some challenges such as lack of technology, knowledge and awareness, lack of infrastructure in irrigation, storage, marketing links and processing. The food system needs to be strengthened by adopting various strategies such as crop diversification, diversifying farming systems, investment in infrastructure in irrigation and storage, and promoting organic farming practices, natural farming, climate resilient crops, drought resistant planting materials, strengthening market linkage and value chains and providing credit facilities in investment in sustainable agriculture practices could be helpful to overcome the challenges facing the system.

***Keywords***: Sustainable agriculture, carbon sequestration, climate change, diversification, climate resilient

## Introduction

Food demand is increasing as the population grows and eating patterns change. The global need of food production will be about 70 percent more in 2050 for projected population of 9 billion. The food and nutritional security will be a challenge after two decades. Climate change is going to worsen the environmental effects on agriculture as it tries for higher production to meet the requirement of food demand. Agriculture is one of the most significant causes of climate change due to various environmental issues. Currently, it contributes about 19–29% of the world's greenhouse gases. The amount of garbage that occurs worldwide accounts for around one-third of all manufacturing, this leaves an enormous carbon footprint. Agriculture and climate are closely related to global dynamics. A slight alteration in the climate can have a negative impact on agriculture and lower the rate of production. The United Nations has acknowledged the susceptibility of food production systems to climate change (IPCC 2022 Climate change 2022). India is globally leading in the production of wheat and rice thanks to its green revolution, but both the environment and the populace have suffered as a result. The green revolution has resulted in a decrease in agrobiodiversity (Perfecto *et al*., 2019), an increase in greenhouse gas emissions (Sapkota, 2019), a loss of soil nutrients (Tilman, 1998), and the depletion of water resources (Davis *et al*., 2018). To improve agricultural productivity and enable farming adaptation, an evaluation of the effects of atmospheric fluctuations on agricultural is fundamentally necessary (Fraser *et al*., 2008). Sustainable agricultural practices are required to reduce the release of greenhouse gases,

maintain output levels, and maintain the sustainability of ecological services. India must improve the way it manages its natural resources, reduce waste from food, boost the retention of carbon, and boost ecological diversity on and around fields. Sustainable agricultural strategies are targeted to reduction of greenhouse gases and maintaining agricultural production levels without adversely affecting natural resources. India must improve the way it manages its natural resources, reduce food waste, boost carbon sequestration, and boost biodiversity on and around fields. The main advantage of the practice is that it is aligned with natural process and so it is healthier for climate, natural resources, and human among living beings.

**Sustainable Agriculture**

Sustainable agriculture emphasizes eco-friendly methods that strengthen farming systems' resilience while lowering greenhouse gas emissions. It reduces the impacts of weather changes. In the following ways, sustainable agriculture is an effective weapon in the battle against climate change:

**Reduced emissions:** Synthetic pesticides and fertilizers are frequently used extensively in conventional agriculture, which results in a considerable amount of greenhouse gas emissions. By encouraging organic farming and agroforestry, among other sustainable methods, pest control and natural soil enrichment, agriculture's carbon footprint is decreased.

**Soil Health**: The maintenance and improvement of soil health are key components of agricultural sustainability. Soils with good health take up atmospheric carbon dioxide from the environment and decrease its effects. Additionally, agriculture is more resistant to adverse weather occurrences when soil management is done properly.

**Biodiversity conservation**: agriculture practices promote diverse cropping systems and the protection of natural habitats. This not only fosters a healthier ecosystem but also aids in climate change adaptation by maintaining robust food production systems in the face of environmental disturbances.

**Water Efficiency**: Sustainable farming techniques prioritize efficient water use, which is vital in a world where water resources are becoming scarcer due to climate change. Drip irrigation, rainwater harvesting, and conservation tillage are examples of methods that reduce water waste.

**Renewable Energy Integration**: Renewable energy sources, including solar and wind turbines, are frequently used in sustainable agriculture to power farms, therefore cutting emissions and dependency on fossil fuels.

**Reduced food waste**: From the farm to the table, food waste is decreased via sustainable measures. By doing this, the carbon footprint connected to the production and disposal of food is decreased in addition to saving resources.

**Local Food Systems**: Promoting local and regional food systems reduces the emissions associated with long-distance transportation and supports small-scale, sustainable farming practices.

**Community resilience:** Sustainable agriculture fosters community resilience by promoting local food production, reducing dependency on imports, and creating economic opportunities in rural areas.

**Tolerant breeds:** Adaptation of suitable mitigating technology, including breeding tolerant breeds that can resist the effects of the changing climate.

**Conservation agriculture**: Conservation agriculture techniques include managing waste and creating a conducive environment for plant development by increasing soil carbon.

**Strategies and technologies for climate change adaptation**

**Increase soil fertility while using fewer applications of synthetic fertilizer:** Reducing soil tillage and using organic inputs lowers greenhouse gas emissions while preserving a robust subsurface ecosystem. Although these methods have been applied in India (Jat *et al*., 2020), the results have not been thoroughly examined. Synthetic fertilizers may appear almost necessary because a minimum of 40 to 55 percent of the country's soils currently have serious deficiencies in carbon, nitrogen, phosphate, potassium, (Soil Health Survey, 2019–20). However, fertilizers are now applied erratically and inefficiently (Das *et al*., 2022), partially due to the unbalanced usage of potassium and phosphorus caused by governmental subsidies that have maintained the pricing of nitrogen-based fertilizers abnormally low (Gulati & Banerjee, 2015). Rather of being burnt, crop leftovers and weed biomass can be used in certain ways. A combination of the livestock and agricultural sectors can produce manure and dung. Aquaculture waste from fisheries, seaweed, and aquatic weed biomass can compensate for the lack of organic inputs. As a result of all these initiatives, waste products from other sectors can discover new markets. Approaches to integrated nutrient management (Wu & Ma, 2015) and free of chemical pesticide farming (https://www.safeharvest.co.in/) that allow just a few of fertilizers that are synthetic but

limit other types of chemical materials, may prevent some negative effects while retaining efficiency amounts; however, they require to be thoroughly tested. The National Soil Health Card program needs to be strengthened and broadened. It is a government initiative designed to assist farmers in tracking the condition of their soil. Farmers will be better equipped to apply fertilizers responsibly and less dependent on perverse fertilizer subsidies if they have a thorough understanding of soil health and proper fertilizer application. Programmes that are designed to match all Indian soil types, hydrologist, temperature regimes, and cultural traits would always fall short due to their variety. One of the main issues with the Green Revolution was this. Soil carbon reserves may be raised, and soil functional stability can be stimulated by varying farm management techniques. By providing a protective soil cover, conservation agriculture technologies (such as decreased tillage, rotational cultivation, and cover crops), techniques for conserving soil (such as contoured farming), and nutrients restore methods may recover soil organic material. The secret to the sustainable future of Indian agricultural land involves nourishing the soil with nutrients instead of adding fertilizers to its crops without using organic inputs. The integrated management of nutrients addresses the utilization of both inorganic as well as organic fertilizers, along with compost, farmyard vermicompost, legumes that are in turning, and agricultural residue. (Srinivasarao, 2021).

**Tolerant crops**: Drought patterns may need different sets of adaptive forms. to give farmers with early-maturing, drought-tolerant crop cultivars that can withstand insufficient rainfall. The green gram (BM 2002-1), chickpeas and the pigeon pea (BDN-708) types have been introduced to a few farmer's land in the Aurangabad area of Maharashtra, where there was 645 millimeters in rainfall. The yield was 20–25% greater from this than from native varieties. Similarly, early ripening, drought-tolerant cultivars of sorghum and the pigeon pea were introduced at farmers field in different villages of Amravati District of Maharashtra.

**Breeds of cattle and poultry that are tolerant:** Native American and local breeds believe that they should fend for themselves. The animals in nomadic systems indicate to their owners when it is time to relocate in quest of new meadows. Native American breeds are distinct due to their adaptation to global ecologies. These special qualities include the capacity to travel great distances, thermoregulation, resilience to illnesses, fertility and maternal instincts, and the capacity to absorb and process poor-quality feed. They are also resistant to droughts. Although the yield of meat and milk may not be very great among these livestock breeds, they have minimal resource footprints and are extremely adaptable to the unpredictable nature of the environment.

**Feed management**: According to the GoI DAHD (2019), India is presently home to around 535 million animals, which have the annual capacity to emit 467.5 million tons of carbon dioxide in greenhouse gases. Enhancing feeding practices as a technique of adaptation may improve the efficacy of livestock produce in an indirect manner. Agroforestry species can be included in the animal's diet, and producers can be trained in the manufacture and preservation of feed for different agro-ecological zones. Other feeding techniques include modifying the frequency or timing of feedings as well as the content of the diet. These measures assist reduce the risk from climate change by, among other things, encouraging greater utilization or solving for not enough consumption of feed, decreasing extreme temperature load, reducing animal hunger and mortality, and reducing food insecurity throughout dry months.

**Water management**: Water-smart technologies can help farmers reduce the impact of climatic variability. These techniques include raised beds with furrow watering, micro-irrigation, collection systems for rainwater, cover crop cultivation, greenhouses, lasers land levelling out, reuse of wastewater, deficits water supply, and draining management. Many technologies, such as precise crop water requirement estimation, groundwater recharge strategies, scientific water conservation methods adopted, fertilizer and irrigation schedule adjustments, cultivation of water-efficient varieties, planting date adjustments, irrigation timing, and zero-tillage adoption, might allow producers to achieve adequate crop production during many years with inadequate rainfall and more extreme temperatures. To boost the effectiveness of water usage, many international agencies, research institutions of national governments, farmers' associations, nonprofit organizations, and businesses have concentrated their endeavors upon designing and production of cost-effective and environmentally friendly water-conserving equipment. Crop diversification can aid in addressing the existing difficulties in achieving food security while adjusting to climate change, particularly in arid regions.

**Agro-advisory**: Response farming, often known as farming with technocrat-taken advises based on local meteorological data, is an integrated technique. Tamil Nadu and many other states have previously embraced responsive farming's success, which entails reduced risk and increased yield. Given that climatic shifts are

gradual, response farming may be a good alternative for adopting methods related to climate change. Response farming's primary success may be attributed to time- and location-specific technology. It's time to spread responsive farming's success throughout the farming community.

**Agroforestry:** According to Dagar (2020), agroforestry as service is potentially essential to an environmentally friendly farming ecosystem in India, as many small holding farmers lack access to forest lands. Essential ecosystems goods and amenities such as fruits and leafy vegetables, fodder, and fibers and other edible products are provided by agroforestry in mixed-use, multifunctional landscapes. The green infrastructure of agroforestry may absorb some of the carbon dioxide in the atmosphere, stabilize unstable soils, and limit erosion.

**Efforts for the Prevention of Climate Change Mitigation**

As will be mentioned below, The Indian government made several actions to establish the best initiatives to combat and prepare for climate change (Reference: Handbook, 2018). These missions all employed a variety of ICAR-developed technology packages. The key to a few significant endeavors is provided here.

**National Innovation on Climate Resilient Agriculture (NICRA):** NICRA as a networking programmes was launched by Indian Council of Agricultural Research (ICAR) with the financial support of Rs. 350 crores from Ministry of Agriculture during 2011. The objective of the initiative is to enhance Indian farming's resilience to weather fluctuations and changes in the climate by creating and carrying out improved production and risk management technology that benefit dairying, agriculture, and fishery.

**National Mission on Sustainable Agriculture (NMSA):** The Government of India launched National Action Plan on Global Climate Change (NAPCC) during 2008, that serves as a general framework for environmental policy and outlining 8 national missions on specific sectors for climate change mitigation. The National Mission for Sustainable Agriculture (NMSA) was an initiative part of NAPCC. The National Mission on Sustainable Agriculture programmme was launched to enhance agriculture production and productivity, and income of farmers without adversely affecting natural resources by promoting location specific technologies. Through progressively introducing efficiency in terms of energy machinery, promoting eco-friendly low-cost technologies, conserving natural resources, integrated farming, etc., the power source NMSA follows a path of sustainable development. In addition, by controlling soil quality, enhancing the use of water effectiveness, using pesticide minimally, and other regional measures, the NMSA aims to promote enhanced agricultural approaches.

**National Adaptation Fund for Climate Change (NAFCC):** The National Adaptation Fund for Climate Change (NAFCC) was established to provide technical and financial support for adaptation activities in various States and Union Territories in India that are vulnerable to the adverse impacts of climate change. NAFCC is being implemented in project mode. This strategy took effect in 2015 to promote real adaptability and to reduce the adverse impacts of climate change in several sectors, especially agricultural. The NAFCC projects implemented in the coastal states of Kerala, Tamil Nadu and Andhra Pradesh include activities relating to promotion of integrated farming system, management and rehabilitation of coastal habitats and biodiversity for climate Change Adaptation and Sustainable Livelihood coastal areas of implemented States. The NAFCC has authorized several initiatives in coastal states as well as northern eastern and eastern states.

**Climate Smart Village:** The objective of the societal approach in climate-smart villages (CSV) is to increase the capacity of agriculture to adjust to the adverse effects of climate change by adopting an integrated approach to climate adaptation, resilience, and food security. To tackle the climate change related challenges confronting the agricultural industry, the CSV carries out a range of programmes that include every facet of farm work. To create CSVs in India, several national research organizations in agriculture are collaborating. Two districts namely Karnal and Vaishali chosen initially to test CSVs. After then, regions like Punjab, Andhra Pradesh, and Karnataka received the technological advances.

**Pradhan Mantri Krishi Sinchayee Yojna (PMSKY**): PMKSY Scheme was launched during 2015 with estimated cost of Rs. 50,000 crores to enhance physical access of water on farm and expand cultivable area under assured irrigation for improving on-farm water use efficiency by introducing sustainable water conservation practices. PMKSY is an umbrella scheme of various water management schemes being implemented by Ministry of Jal Sakti. The goal of the 'Har Khet Ko Paani' programme as an important component of PMKVY is to improve the efficiency of water utilization. Comprehensive solutions of water for source generation, distribution, and administration are provided by the "More Crop Per Drop" initiative.

**Pradhan Mantri Fasal Bima Yojna (PMFBY)**: PMFBY Scheme was launched by Ministry of Agriculture on 18th February 2016. PMFBY aims to support agriculture production by providing affordable crop insurance to ensure comprehensive risk cover for crops of farmers against all non-preventable natural risks from pre-sowing to post-harvest stage, on an area approach basis and helping in stabilising the income of the farmers. The Scheme covers all the Food Grain & Oilseeds crops and Annual Commercial Horticultural Crops for which past yield data is available and for which requisite number of Crop Cutting Experiments (CCEs) are conducted being under General Crop Estimation Survey (GCES). The scheme is compulsory for loanee farmers availing Crop Loan /KCC account for notified crops and voluntary for other others. States and UTs may participate in the scheme depending on their level of risk tolerance, budget limits, and other factors.

**Soil Health Card Scheme:** The Soil Health Card Scheme was launched in February 2015 with the purpose of issuing soil cards to farmers which will provide crop -wise recommendation on the test-based soil nutrient status of their agriculture farmland to increase productivity via sensible feed utilization. Throughout the start, the Indian government planned to issue 10.48 crore SHCs. The Soil Health Card portal integrated with a Geographic Information System (GIS) system so that all the test results are captured and seen on a map. Soil Health Card scheme has been merged in Rashtriya Krishi Vikas Yojana (RKVY) scheme as its one component under name 'Soil Health & Fertility' from the year 2022-23.

**National Water Mission (NWM)**: National Water Mission was started as a campaign for adoption of Integrated Water Resource Management (IWRM) approach to preserve watersheds and to reduce the loss of water, in addition to increase Water Use Efficiency (WUE) by 20% in agriculture sector.

**Paramparagat Krishi Vikas Yojna (PKVY)**: This is an enhanced form of Soil Health Management (SHM), that was established in 2015 by the NMSA alongside the goal of encouraging and supporting organic farming by establishing a sustainable village via the clustering approach, hence improving the condition of the soil.

**Biotech-KISAN:** The scientist-farmer collaboration programme, which began operations in 2017, intends to stimulate innovation in agriculture by bringing scientists and farmers together to find new ideas and technology which may be applied on farms. So, to date, 146 Biotech-KISAN Hubs are currently established through the scheme, comprising all 15 agroclimatic zones and 110 aspirational districts around the country. At this point, the scheme has improved the income and productivity of about two lakh farmers in agriculture. In addition, almost 200 firms were formed in remote regions.

**Neem Coated Urea:** This is a urea-based fertilizer covered in neem substance which acts like the nitrogen releaser over time, restricting the spread of diseases and insects and, ultimately, reducing the requirement for urea in farming by improving crop yield.

**Sub-mission on Agro-forestry:** The scheme was initially begun in 2016 to plant more trees along agricultural bunds. By mitigating the consequences of climate change, agro-forestry has the potential to boost productivity and move agriculture closer to sustainable.

**National Livestock Mission**: The objective of the mission is to promote livestock improvement in a sustainable manner, having the goal of protecting biosecurity, the environment, livestock biodiversity, and the livelihoods of farmers.

**Impacts of National Programs and Policies**

**The National programs and policies made following impact on Sustainable Agriculture**

I. Under NICRA, state-of-the-art facilities for researching climate change have been constructed at several institutions nationwide, and climate resilient technologies have been developed for a variety of crops. A risk assessment of district-level climate variability and Indian agriculture has been completed 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.

II. The key component of India's entire agricultural water use plan is the slogan "More Crop per Drop." In addition to MGNREGA, the Prime Minister Krishi Sinchayee Yojana (PMSKY) has made significant contributions to the coverage of more areas under assured irrigation and to the nation's ground water recharge and conservation of water resources. A Micro Irrigation Fund is housed inside PMSKY, emphasising climate-conscious protective irrigation and water-use efficiency measures. Programmes and regulations pertaining to increased water usage efficiency have a

favourable influence on both the field crop and horticultural subsectors.

III. India's fertilizer policy has improved crop 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 changes in 11.48 million hectares for forest area into farmland. Neem coated urea has also decreased greenhouse gas emissions from fertilizer nutrient sources, enhanced nutrient usage efficiency, and lowered the cost of fertilizer inputs.

IV. The Government agencies and private institutions made sincere efforts to spread awareness about Zero Budget Natural farming, or ZBNF, throughout India. In comparison to conventional agriculture, it provides a more climatically adaptable and ecologically benign option.

V. Agroforestry's acreage is trending upward towards more carbon fixation and lower greenhouse gas emissions. In addition to providing environmental benefits, a pricing mechanism will help Indian agroforestry producers maintain stable incomes.

VI. The record milk output for 2017–18 was 176.3 metric tons, up from 132.4 metric tons in 2012–13. Several livestock-related regulations improved animal well-being, immunization, availability of feed, and artificial insemination in addition to promoting and marketing agribusiness ecosystems in India.

## Way forward

i. It is imperative to give priority to reducing emitted greenhouse gases originating from sources other than agriculture. The implementation of urea coated with neem is one example of a policy intervention.

ii. To increase stakeholders' confidence and make them more aware of the events related to climate change, structured training is crucial.

iii. Adjusting the discrepancy between the management techniques used today and the necessary agro-advisories.

iv. It is imperative that CRA be implemented nationwide.

v. It is necessary to implement flagship farmer-oriented projects to enhance skills in agriculture and related fields.

**vi.** Working together, farmers, academic institutions, funding organizations, governments, non-governmental organizations, and the commercial sector may leverage our capabilities to advance community-supported agriculture.

## References

Dagar, J.C. *et al*. (2020). Agroforestry for Degraded Landscapes. (Springer, 2020).

Das, B.S. *et al*. (2022). Soil Health and its relationship with food security and human health to meet the Sustainable Development Goals in India. Soil Security 8, 100071 (2022).

Davis, K.F. *et al*., (2018). Alternative cereals can improve water use and nutrient supply in India. *Sci. Adv*. 4, eaao 1108.

Fraser, E.D.G., Termansen, M., Sun, N., Guan, D., Simelton, E., Dodds, P., Feng, K. and Yu, Y. 2008. Quantifying socioeconomic characteristics of drought sensitive regions: evidence from Chinese provincial agricultural data. *Comptes Rendus Geosciences.* 340:679-688.

GoI DAHD (2019). 20th Livestock Census. Government of India, Department of Animal Husbandry & Dairying ttps://dahd.nic.in/sites/default/filess/Key% 20Results% 2BAnnexure%2018.10.2019.pdf .

GoI MAFW-DAFW. Soil Health Survey 2019–20. Government of India, Ministry of Agriculture & Farmers' Welfare-Department of Agriculture & Farmers' Welfare. https://soilhealth.dac.gov.in/PublicReports/MacroNutrientsStateWiseNPK (2020)

Gulati, A. and Banerjee, P. (2015). Rationalizing Fertilizer Subsidy in India: Key Issues and Policy Options. Working Paper 307. ICRIER: New Delhi.

Handbook (2018). Schemes, programmes and missions promoting agricultural development and farmer's welfare. MoA & FW.

IPCC 2022 Climate change 2022: impacts, adaptation, and vulnerability Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change ed HO Portner *et al.* (Cambridge: Cambridge University Press) (available at: www.ipcc.ch /report/ar6/wg2/about/how-to-cite-this-report/) (accepted).

Jat, M.L. *et al*. (2020). Conservation agriculture for sustainable intensification in S. *Asia. Nat. Sustain*. 3, 336–343.

Sapkota, T.B. *et al*. (2019). Cost-effective opportunities for climate change mitigation in Indian agriculture. *Sci. Total Environ*., 655, 1342–1354.

Srinivasarao, Ch. (2021). Climate resilient agriculture system: the way ahead. Sown to Earth.

Tilman, D. (1998). The greening of the green revolution. Nature 396, 211-212.

Wu, W. and Ma, B. (2015). Integrated nutrient management (INM) for sustaining crop productivity and reducing environmental impact: a review. *Sci. Total Environ.* 512, 415–427.