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A Review – Climate Smart Agriculture: A Key to Sustainability

Amit Kumar and Umesha C
[1]M.Sc. Scholar, Department of Agronomy, (Naini Agricultural Institute), Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj, U.P, India
[2]Assistant Professor, Department of Agronomy, (Naini Agricultural Institute), Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj, U.P, India

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Introduction

Human interferences like industrialization, deforestation, etc. have augmented the concentrations of GHGs in the atmosphere. As stated by the Intergovernmental Panel on Climate Change IPCC (Intergovernmental Panel on Climate Change, the atmospheric CO_2 concentration has been amplified more than 50% concerning to the pre-industrial concentration. The impacts of Climate Change and Climate Variance are felt as the global temperature is increasing and there is irregular precipitation pattern, gradual rise in sea levels, and increased frequency of EWE. Their negative impacts are expected to deepen shortly. Not only is agriculture affected by the impacts of CC and CV, but it also intensifies this problem by emitting GHGs through various farming practices. In this context, the CSA can bring adaptation and mitigation to sustain ACP. Climate Smart Agriculture is a strategy for improving scientific rule and investment setting to achieve Sustainable Agriculture Development to ensure food availability in the light of Climate Change. CSA is a strategy to design a framework of policy, capital, and technology to accomplish SAD for ensuring FNS in the context of changing climatic scenarios. CSA also seeks to improve the livelihoods and food safety, particularly of small and marginal farmers, by enhanced management and utilization of natural endowments and employing suitable production, development, storage, processing, and marketing strategies for agricultural commodities.

Climate Smart Agriculture is not a standard, specifically relevant agricultural technology or procedure. It is a methodology that calls for site-based evaluations to determine the correct techniques and methods for ACP. This approach:

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1. Attempts to recognize and examine interconnected alternatives that establish synergetic advantages and reduce trade-offs in complex and closely related problems of Sustainable AD, FNS, growth, and Climate Change
2. Identifies the choices sculpted by specific situations and capability of each nation and by the particular socioeconomic and environmental condition to which they are used
3. Evaluates the relationships among industries and the demands of various stakeholders engaged
4. Recognizes obstacles to adoption, particularly between farmers, and offers effective policy, strategy, intervention, and opportunity strategies and solutions
5. Strives for the integration of strategies, financial investment, and institutionalized structures to build supporting environments
6. Endeavors to accomplish several goals by recognizing the need to prioritize CSA practices and to agree together on its various potential advantages and compromises
7. Ought to give priority to improve living standards, particularly livelihoods of small farmers by enhancing access to information, awareness, knowledge and capital, resources, financial products, and marketing sector of economies
8. Improves resilience and enhances adaptability to shocks, particularly that associated with Climate Change, as weather impacts have severe consequences on rural and agricultural development
9. Acknowledges the mitigation of Climate Change as a probable secondary advantage, particularly for poor farming people

   Strives to define the possibilities and recognize transparency gaps for climate- related funding and incorporate them into conventional agricultural investment financing outlets

CSA puts together and incorporates methods, strategies, and organizations which are not precisely first and but which are not familiar to peasants, shepherds, farmers, growers, or fishermen in the light of changing climate. What's unique and innovative is also the idea that the integrated and comprehensive solution to several challenges concurrently and internationally experienced by agriculture and food processes is approached concomitantly and comprehensively, which prohibits detrimental and ineffective strategies, regulation, funding, and investment.

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Fig 1 Adapting CSA Approaches for Sustainability.

Climate Smart Agriculture (CSA) Climate-smart agriculture (CSA) is an approach that helps guide actions to transform agri-food systems towards green and climate resilient practices. It aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gas emissions, where possible. CSA puts together and incorporates methods, strategies, and organizations which are not precisely firsth and but which are not familiar

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Pillars of Climate-Smart Agriculture

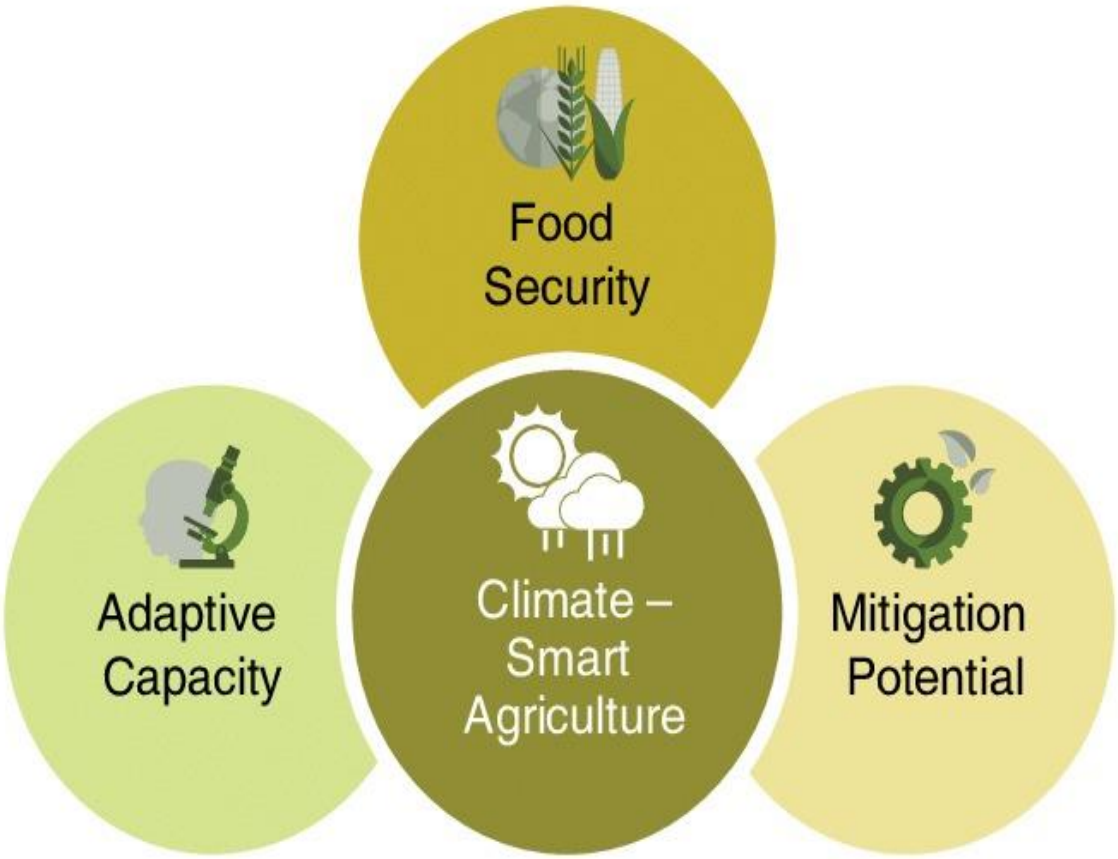

Fig 2. Pillars of CSA

1. **Increased productivity:** First pillar deals with the sustainable enhancement of agricultural productivity and livelihood. CSA is a way of achieving both sustainable development and green economy objectives. This aims to achieve FNS as well as the protection of natural resources Productivity enhancement can be achieved through the use of renewable energy, efficient resource management, resource conservation technologies, land use management, etc. Produce more and better food to improve nutrition security and boost incomes, especially

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of 75 percent of the world's poor who live in rural areas and mainly rely on agriculture for their livelihoods.

2. **Enhanced resilience:** Second pillar deals with adapting and developing resilience toward the impacts ofCC. Adaptation aims "to reduce the vulnerability of human or natural systems to the impacts of CC and climate-related risks, by maintaining or increasing adaptive capacity and systems resilience". Adaptation initiatives tackle CC impacts by reducing the vulnerability of human Reduce vulnerability to drought, 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 and natural systems towardit. CC adaptation in the agricultural system can be achieved either by specific actions like cultivating the improved crop variety or by systemic changes involving livelihood diversification, better resource management through institutional reforms, etc.
3. **Reduced emissions:** Pursue lower emissions for each calorie or kilo of food produced, avoid deforestation from agriculture and identify ways to absorb carbon out of the atmosphere. Mitigation deals with the reduction of atmospheric GHG concentration by tacklingits emission sources. The strategies for CC mitigation involve the assimilation of those technologies which reduce GHG emissions and inputs per unit of output. Agriculture and deforestation activities contribute to 30% global emissions of GHGs, which provides adequate potential for mitigation. The three ways to mitigate CC in agriculture are given below:
   - **Reducing GHG emissions:** The emission of CO2, CH4, or N2O can be minimized by efficient management of carbon and nitrogen flows in the agricultural ecosystems.
   - **Avoiding or displacing emissions:** There is much scope in improving energy efficiency in the agricultural sector. For instance, the use of biofuels in place of FF in agricultural operations can avoid or displace a significant amount of GHG emissions.
   - **Removing emissions:** The GHGs or their precursor can be removed and sequestered from the atmosphere through CSA operations.
   - All these pillars can be achieved by embracing various interventions of CSA.

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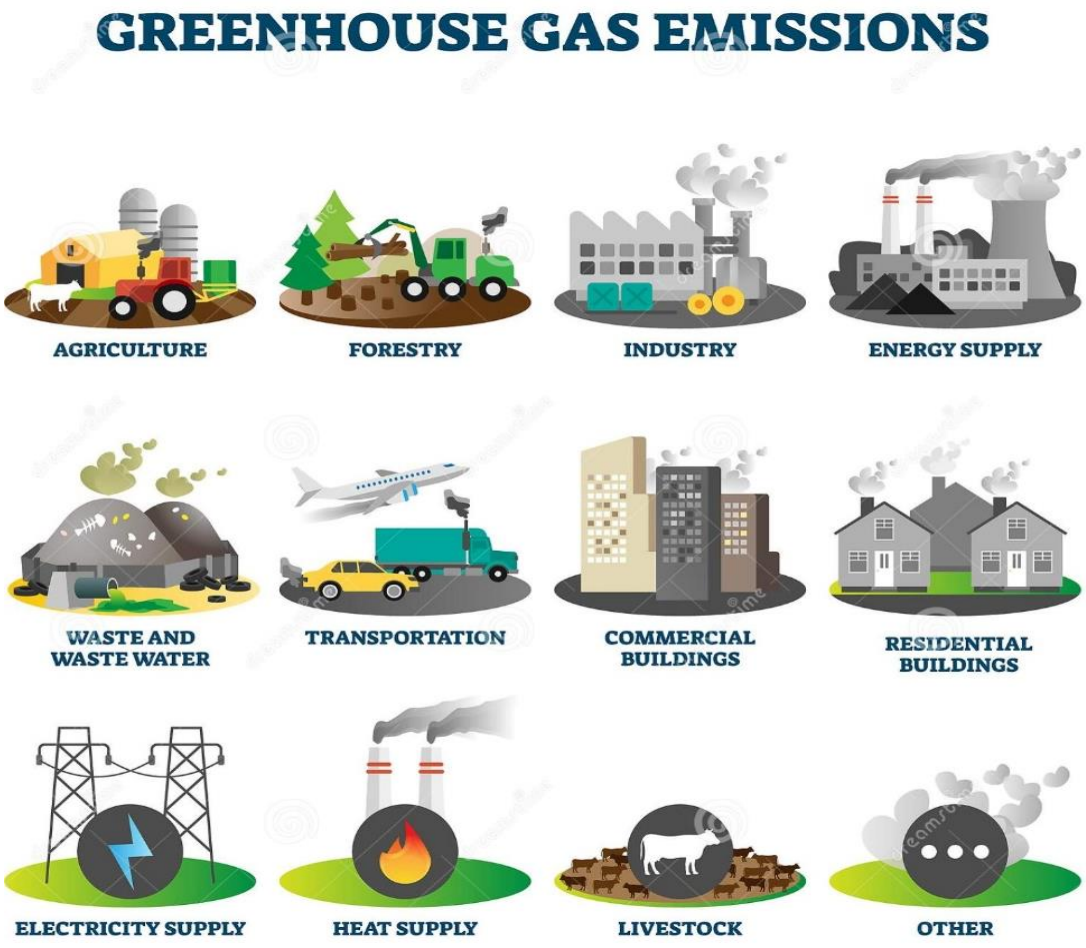

Fig 3. Emission of Greenhouse Gases through Different sources.

It is imperative to understand the concept of Climate Change and Climate Variance before gaining insights into CSA. According to IPCC, "Climate change is defined as a change in the state of theclimate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. CC may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use" (IPCC (Intergovernmental Panel on Climate Change).

Climate Change is a long-term gradual shift (rise or fall) in normal (e.g., normal temperature)or the range of weather conditions (e.g., frequency and severity of EWE). It is slowand steady and is quite hard to observe without scientific records of statistical data ofclimatic variables as it progresses gradually, dissimilar from year-to-year variability.It is attributable to

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both natural variabilities and human activity. It takes place as aresult of variations in the earth's atmosphere, such as deviations in its orbit around the sun or alteration in the atmosphere due to human activities. There's nothing fundamentally wrong with Climate Change. It was experienced in the past and will happen in the future again. The present problem comes from the rate of change – how rapidly changes are happening. There is strong evidence enough to prove that human-driven anthropogenic activities are causative of this exceptional, unprecedented rate of global temperature rise. Since the pre-industrial era in the mid-twentieth century, anthropogenic actions such as fossil fuel (FF) burning and land clearing for intensive agricultural practices and industrialization have enhanced to drastic GHG emissionsin the atmosphere, which is responsible for trapping more thermal energy to raise thesurface temperature of the earth.

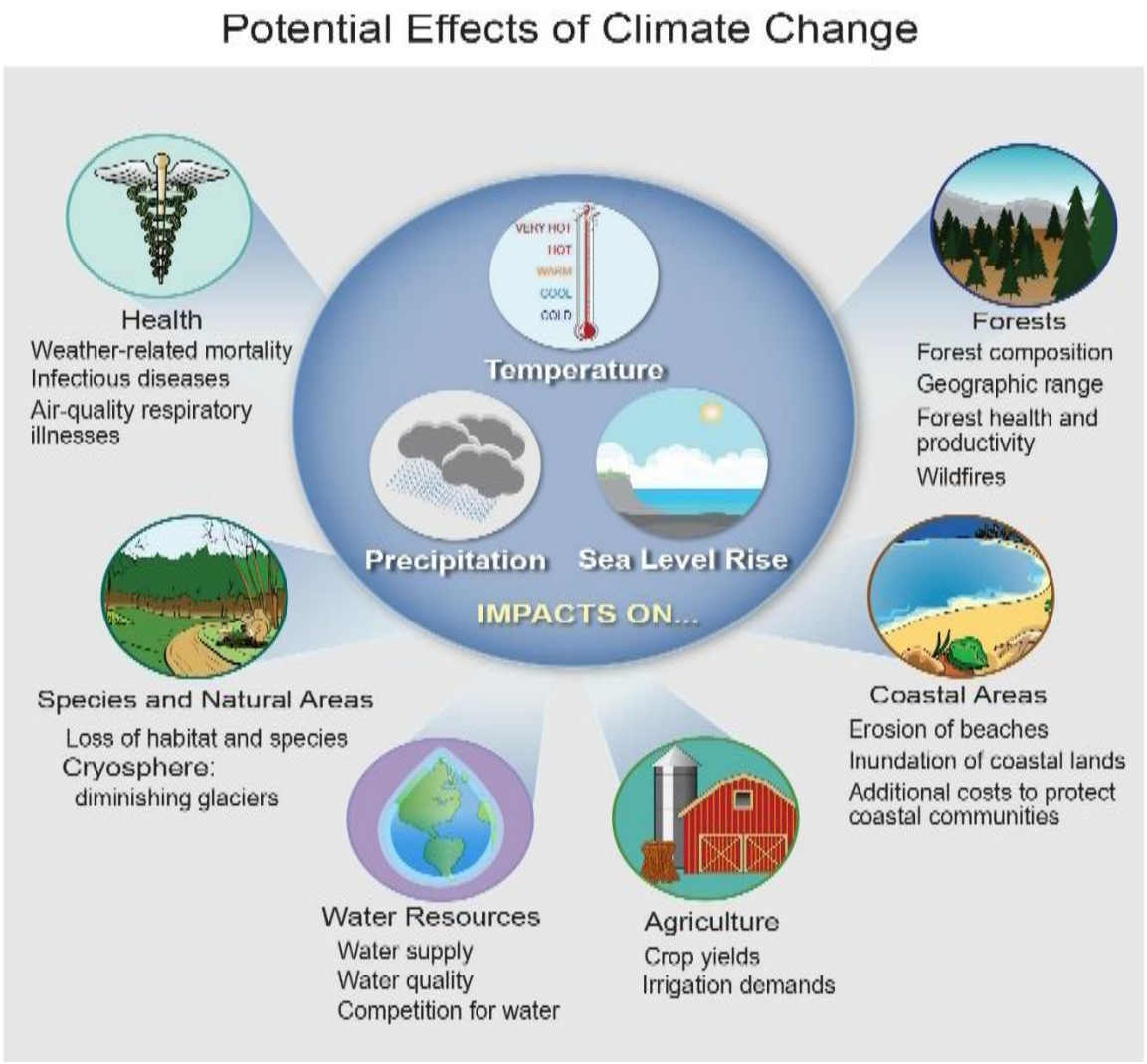

Fig 4. Effect of Climate Change (CC) on Agriculture.

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Climate Variance is more harmful to agriculture and livelihood as compared to Climate Change. Accordingto IPCC, "Climate variability is defined as variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability)" (IPCC (Intergovernmental Panel on Climate Change). Scientists believe Climate Variance in the manner that it oscillates around the long-term statistical value of climatic normal on seasonal, annual, or decadal time scale. For easy understanding, this scenario can be divided into two parts: average and range. Working out the range gives a rough idea about average, and the converse is alsotrue. So, both are complementary to each other.

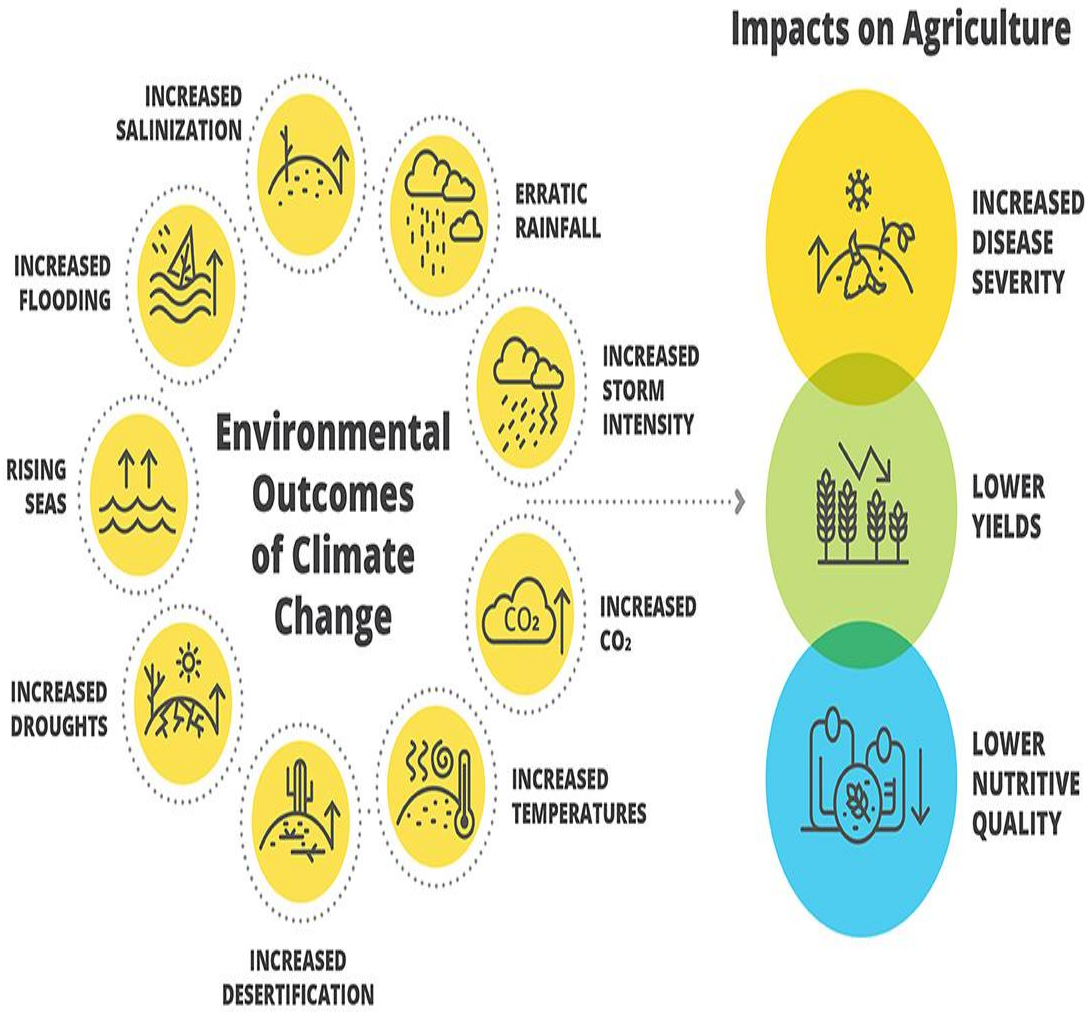

Fig 5. Influence of Climate Variance on Agriculture

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Table 1. There are three kinds of impact of change in climate

A concurrent impact that is taking place over the decades. This has already affected productivity and reduction in water resources, while the cost of energy is growing higher	At the local level action plan is needed to provide by taking stock of what has happened to soil and its productivity and the same about livestock due to changes in weather – increase in temperature etc
The unexpected change in weather patterns during the monsoon season like delayed rain, long intervals of rain, or heavy rain – floods have already affected Horticulture crops.	A contingency plan to modify the cropping pattern. This has to be part of the local level (Taluka Level) action plan and Comprehensive District Agriculture Plan (CDAP). This is already prepared by Agri. Universities need to be made available to farmers
Major calamities like floods, cyclones/tornados, cloud bursts, etc	Need restoration strategy because such disasters sometimes wipe out entire soil strata and sweet water sources including livestock and shelter

Climate smart agriculture involves:

- Crop pattern based on soil health and moisture analysis of individual pieces of land to support crops that can be sustained by its soil.
- Local Weather Advisory – not national or state level - long term, medium term and short term with inputs to take precautionary actions directly to farmers.
- Immediate Agro – advisory after unexpected weather changes have occurred for timely corrective action to prevent crop loss.
- Nutritional and preventive vaccination to cattle and poultry.
- All these by direct communication to the farmers at their doorsteps.
- And use all available scientific technology to make agriculture more productive, less costly, and linked with value-added market mechanisms.

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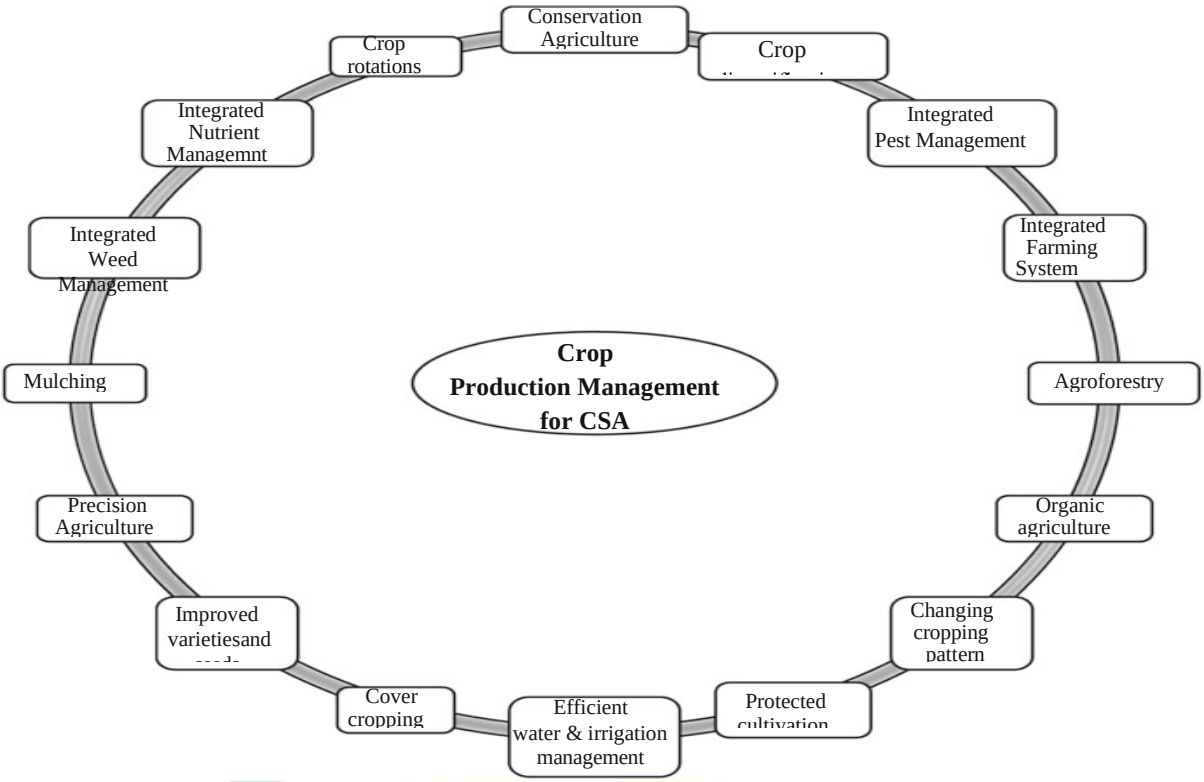

Fig 6 Crop Production and Management Strategies for Climate Smart Agriculture

Table 2. Climate change threats and required Climate Smart Agricultural Practices.

Climate change indicator	Impact on Agriculture	CSA practices required
Higher temperatures	Reduced crop yields	New crop varieties with greater heat tolerance
Less precipitation	Reduced crop yields inrain-fed agriculture	New crop varieties with lower water requirementsImproved irrigation techniques Improved water collection, storage and distributiontechniques
Reduced availability of irrigation water	Reduced crop yields in irrigated agriculture	Improved irrigation efficiency New crop varieties with lower water requirements
Saltwater intrusion	Reduced irrigation water	Barrier to salt water intrusion New crop varieties with greater salinity tolerance Improved water collection, storage and

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		distributiontechniques
Increased flooding or waterlogging	Reduced crop yields or loss of crops	New crop varieties with higher moisture tolerance Improved drainage or flood control techniques
Increase incidenceof pests and diseases	Reduced crop yield	New crop varieties with improved pest and diseaseresistance Improved pests and disease management techniques
Extreme weather events	Loss of crops	Improved techniques to increase resilience of crops toextreme weather events. Improved extreme weather events prediction and earlywarning systems

Constraints and Opportunities

For the successful adoption of CSA practices, there is a requirement to identify constraints in its adoption by various stakeholders and harnessing of the available opportunities. The main constraints for the adoption of CSA practices by Indian farmers are mentioned below.

a. Farmers with small landholdings don't have space for the installation of water harvesting structures, specifically in rainfed regions.
b. Less availability of labor for carrying out CSA practices.
c. Unavailability of good quality inputs to the farmers by the local dealers ortraders.
d. Lack of awareness and willingness among farmers for adopting CSA practices.
e. Unavailability of proper marketing infrastructures.
f. Inaccessibility of farmers to credit facilities for insurance of their crops.
g. Conflicts among farmers while conducting extension activities like demonstrations, training programs, etc.

Other constraints include a lack of proper awareness about CC and its mitigation and adaptation by CSA practices among the various stakeholders. The lack of proper storage, processing, and transportation facilities for agricultural products is another barrier.

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Unavailability or lack of timely availability of machinery implements, or various inputs required for practicing CSA also creates an obstruction. The poor financial condition of most of the farmers and unwillingness to change their attitude toward innovative CSA practices also hinder them from adopting it.

Despite all these constraints, there are ample opportunities available that need to be harnessed. Cooperative farming can be promoted among small and marginal farmers so that they can easily adapt to CSA practices by reducing their risk. Weather forecasting and early warning systems could be quite helpful in reducing risks linked with weather and climate. ICT has great potential in developing and communicating contingency plans with the help of researchers and administrators. The seed banks should be created in appropriate numbers for timely providing quality seeds to the farmers, particularly in case of crop failure caused by unwanted weather events. There are enormous opportunities for improved post-harvest technologies that aids in energy efficiency, as well as a sustained rise in productivity and revenue generation, like better quality storage of crop, produce, its packing, and supply.

The awareness can be spread among farmers and other stakeholders by using voice messages and videos through mobile phones, which may bridge the know ledge gap. Climate-smart model villages can be developed, which can act as a model village among farmers and encourage them to adopt CSA practices. The rewards should be provided to incentivize innovative farmers or agencies involved in CSA, and their success stories should be promoted for sensitizing farmers and stakeholders. Appropriate financing and funds should be provided to various sectors for the development of proper infrastructure and spreading awareness, which may facilitate the adoption of CSA. So, there is a need to increase investment in promoting CSA adoption.

Conclusion.

Climate Change and Climate Variation are affecting agriculture, and its adverse effects are projected to become graver in the future. Climate Smart Agriculture is very pertinent for mitigation and building resilience or adaptation of agricultural systems along with increasing or sustaining production in CC scenarios. There are various CSA practices that should be adopted based on the farmers' condition and availability of resources. These practices include cultivation of improved varieties resistant to insects, pests, diseases, high temperature, drought, or salinity; CA; using energy-smart technologies like biofuels, solar energy, etc.; efficient water

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management by micro-irrigation, rainwater harvesting, drainage structures, etc.; precision farming, integrated farming system; integrated pest, weed, and nutrient management; agroforestry, crop, and livestock insurance; improved breeds of livestock; modeling and forecasting for appropriate decision-making; and so on. The effective adoption of these CSA interventions can be possible through a holistic and integrated approach of all stakeholders involved in agriculture. CSA has huge potential in combating CC and CV. Appropriate policies and their effective implementation at the field level are essential for the success of CSA. Thus, CSA has huge potential for attaining agricultural sustainability, providing FNS, and improvement of livelihood and income in an environment-friendly way.