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# Agronomic Interventions for the Mitigation of Climate Change

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## ABSTRACT

*The most significant risks to agricultural sustainability are climate change and variability, which negatively influence farmer lives and agricultural output, particularly in emerging nations like India. Indian agriculture is especially vulnerable because the majority of farmers there are smallholders who depend on the monsoon, are subsistence farmers, and have inadequate coping strategies. Technologies for adaptation and mitigation to climate change and variability are crucial for increasing productivity, supporting resilience, and mitigating when it is practical. Options for adaptation and mitigation depend on the context, and technologies should be prioritized based on the biophysical environment and farmers resource endowments. The strategy is to maintain productivity under pressure and to increase output in ideal circumstances. The degree of yield improvement depends on the circumstances. The strategy is to maintain productivity under pressure and to increase output in ideal circumstances. Several mitigation technologies include Improved planting techniques, rice cultivation systems, In-situ moisture conservation, Water harvesting, Stress tolerant cultivars, Optimizing nutrient application, Soil carbon sequestration, Intercropping systems, Agroforestry systems and Agro–advisories are developed and the extent of mitigation is variable. To increase their acceptance, efforts will be made to popularize these technologies among farmers. Additionally, efforts must be made to incorporate cutting-edge technologies into the ongoing state and federal government development plans in order to reap the rewards of increased productivity and effective climate change adaptation and mitigation.*

***Keywords:*** *Adaptation and mitigation, Agricultural sustainability, Agronomic interventions, Climate change, Indian agriculture.*

## INTRODUCTION

Climate change is considered one of the most important environmental issues of the modern 21st century. According to the IPCC (2007), climate change is defined as "Change in the composition of the atmosphere as a result of human activities". When a shift in the normal distribution of weather patterns lasts for a long time (i.e., decades to millions of years), it is referred to as climate change.

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A change in typical weather conditions or the seasonal variance of weather around longer-term average conditions (i.e., more or fewer extreme weather events) are both instances of climate change. Biotic processes, fluctuations in the amount of solar energy that Earth receives, plate tectonics, and volcanic eruptions are some of the elements that trigger climate change. It has been determined that specific human activities (beginning with industrial revolution) are the main contributors to the current climate change, often known as global warming. Climate change may be due to natural processes or external forces or persistent anthropogenic activities in the atmosphere's composition. According to the Intergovernmental Panel on Climate Change (IPCC, 2007), anthropogenic activity, environmental variation, or any changes in climate over time are the three main causes of climate change. The rise of greenhouse gases (GHGs) in the atmosphere causes the accretion of GHGs, which is the cause of climate change. Globally speaking, there are connections between the agricultural and climate change sectors, and these connections are particularly significant given the growing disparity between the world's population and food supply. The most hazardous environmental hazard that has a negative impact on agricultural productivity is climate change (CC) (Enete & Amusa, 2010). In many parts of the world, desertification and land degradation are being exacerbated by climate change, which is increasing the frequency and intensity of severe events (IPCC, 2019).

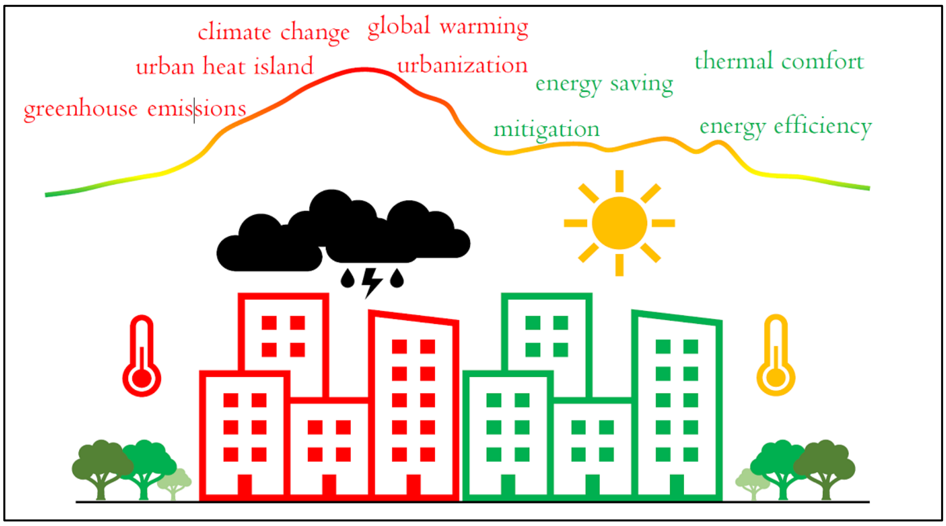


**Figure 1 Transition to climate-smart economy (Source: Battista et al., 2021)**

Between 1850 and 1900 and 2006 to 2015, the mean land-surface air temperature ascended by 1.53°C, whereas the average world surface temperature (land and ocean) rose by 0.87°C. In most geographical regions, global warming has increased the frequency, severity, and duration of heat-related events such as heat waves. In certain areas, such as the Mediterranean, west Asia, large portions of South America, much of Africa, and north-eastern Asia, both the frequency and intensity of droughts have risen, and there has also been an increase in the intensity of heavy precipitation events globally (IPCC, 2019). There are several indications of temperature fluctuation and growth across India as well (IPCC, 2014). Smallholders, the stability of food production, and low-income populations' access to it are all impacted by increased climate variability, increased frequency and intensity of weather aberrations (rainfall, temperature, and wind patterns), as well as extreme events (cyclones, hailstorms, etc.), as they do not have access to credit, climate forecasts, essential inputs, insurance, and efficient options for mitigation and adaptation. Nutritional and food security is impacted by climate change, which also influences consumers' ability to buy food and the livelihoods of small-scale and marginal farmers.

**Effect of climate change on plants processes and productivity of crops**

Agriculture, being driven majorly by weather elements, is most devastated by climate change. Climate change is most dangerous to agriculture. In order to fulfil the rising and diverse requirements of an expanding population while also managing diminishing and precious natural resources, global agriculture confronts enormous problems. According to Asseng et al. (2019), wheat grain protein is expected to decrease by 1.1% due to climate change, which may have a 60% impact on crop output. Global crop yields of wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.), maize (*Zea mays* L.), soybean (*Glycine max* (L.) Merr.), and rice are projected to decline by 6.0%, 3.2%, 7.4%, and 3.1%, respectively, (Zhao et al., 2017) with the average reduction in crops by 2-6% globally (IPCC, 2014). Extremely unstable food supplies and a shortage of dryland water are risks posed by global warming. At the current rate of global warming (1.5°C), there is a risk of increased desertification leading to a shortage of dryland water, land degradation resulting in soil and vegetation loss, and food security affecting the systems for producing and supplying food. About one-fourth of all greenhouse gas emissions are caused by land use, including nitrogen oxides ($N_2O$) emissions from fertilization, $CH_4$ emissions from rice production, and $CO_2$ emissions from deforestation. Dryland dwellers are more susceptible to water stress, severe droughts, and habitat destruction, which is expected to affect 178 million people by 2050 with a global temperature of 1.5°C. According to the IPCC (2019), food loss may account for 8–10% of all human GHG emissions globally. reducing food loss and waste can cut GHG emissions and aid in adaptation by reducing the amount of land required for food production as well as the inputs required for it.

**Effect of climate change on agriculture in India**

Interestingly, more than 58 per cent of Indians (two-thirds of the nation's population) make their living from agriculture. India is one of the nations most impacted by climate change due to its reliance on the monsoon for farming, low per-person land availability (1.08 ha), sparse infrastructure, and smallholders' reliance on technology and resources to adapt to the climate shift (Birthal et al., 2014). By 2030, temperatures are projected to rise by 1.0 to 2.5°C, which would likely significantly impact agricultural output. According to Srinivasarao et al. (2016), rainfed agriculture is more susceptible to abiotic stresses like low and high rainfall and their erratic distribution, an increase in droughts and mid-season droughts, the exposure of crops to prolonged dry spells during critical stages, a drop in the number of rainy days, an increase in the frequency of heat stress and cold stress, and extreme events like hailstorms and cyclones. High temperatures and unpredictable rains reduce crop grain production by shortening the growing season. By 2040, it is expected that climate change would have reduced rice and wheat yields by 9 and 12%, respectively. Breeds with higher metabolic heat generation are more susceptible to heat stress, which can result in a 50% drop in milk production due to lower feed intake (Das et al., 2016). According to The Economic Survey (2018), the impact of extreme weather events on crops during the rainy season (Kharif) and the winter season (rabi) is projected to be 2% for Kharif and 6% for rabi, respectively, which adds to the reduced production of grains in rainfed regions. Severe weather extremes such as cyclonic storms are experienced by one or the other part of the nation, which affects the livelihood of the farmers by causing an enormous amount of damage to the agriculture and horticulture sectors. Given that agriculture currently accounts for around 17% of India's GDP, a negative impact on production implies that the cost of climate change will likely range between 0.7 and 1.35% of GDP annually. Therefore, there is a great need for innovative strategies to counteract the effects of climate change and give farmers quick solutions for sustainable agricultural production.

**Agro-techniques for the adaptation and mitigation of climate change**

Adapt-led mitigation is a potential approach to successfully reduce the effects of climate change and encourage diverse stakeholders to embrace various adaptation and mitigation technologies. According to the IPCC (2007), adaptation is the process of changing a human or natural environment in response to climate change to lessen its effects. In the field, adaptation may be accomplished by modifying the current packages of practices to deal with climatic fluctuation and change. Any technical advancement that reduces the amount of additional inputs and emissions (GHGs into the environment) per unit of output is known as mitigation. Mitigation is the process of reducing the amount of greenhouse gases (GHGs) released into the atmosphere as a result of the use of applied inputs. This is done by implementing various practices that improve the efficiency of those inputs. In order to handle the issue of climate change and variability from the standpoint of India's agriculture industry, adaptation and mitigation are crucial.

Agricultural innovations have been recognized during the past several decades by creating technologies and evaluating them in the context of farmers' needs in various agro-ecological zones of the country. Agronomic interventions in agriculture (Fig. 1.), which primarily focus on adaptation to climatic variability and further enhance agricultural productivity at the farm level, inculcates a variety of approaches such as improved planting techniques and in-situ moisture conservation, water harvesting and its efficient use, multiple-stress tolerant cultivars, soil-test-based nutrient application, enhancing soil carbon and health, system innovations for enhancing productivity and stress tolerance, and more.

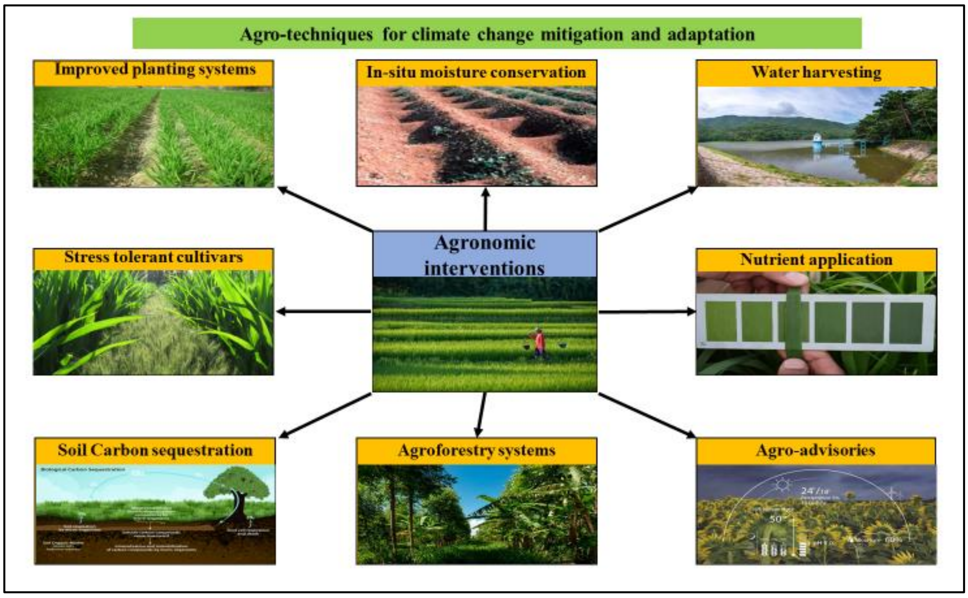


**Figure 2 Different agro-techniques for climate change mitigation and adaption**

**Improved planting techniques**

In deep black soils where infiltration is low, improved planting techniques increase drainage and conserve soil moisture by minimizing runoff water velocity. Water harvested in furrows also acts as a pathway for drainage during heavy rainfall (Ashraf & Raghavan, 2021; Table. 3). In Vertisols of areas with yearly rainfall, crops such as soybean, cotton, pigeon pea [*Cajanus cajan* (L.) Millsp.] and safflower [*Carthamus tinctorius* L.] develop broad bed furrows (Naresh et al., 2014). Similar yield improvements can also be achieved under furrow irrigated raised bed planting of wheat and ridge furrow planting of maize.

**Table 1 Effect of different planting methods on yield improvements under different locations**

| Practice | Crop | Location | Rainfall (mm) | Increase in yields (%) | Reference |
|---|---|---|---|---|---|
| Broad bed furrow | Cotton | Tamil Nadu | 700 | 18 | Ashraf and Ragavan (2021) |
| Broad bed furrow | Soybean | Maharashtra | 892 | 58 | Pendke et al. (2019) |
| Wide raised beds | Wheat, maize | Uttar Pradesh | 805 | 12-14 | Naresh et al. (2014) |
| Ride and furrow | Maize | China | 580.5 | 31.9 | Liu et al. (2018) |
| Furrow irrigated raised bed system | Wheat | Haryana | 320 | 14-15 | Kumar et al. (2010) |

***Systems of rice cultivation***

Rice-cultivation methods that use less water, such as aerobic rice culture, the System of Rice Intensification (SRI), the Modified System of Rice Intensification (MSRI), and direct-seeded rice (DSR) in dry conditions, can reduce GHG emissions by between 21 and 50 per cent. SRI and MSRI approaches, which use less water than conventional flooded rice farming techniques, have become popular as alternatives. By reducing the methane flow, these methods can dramatically reduce emissions. The SRI method improves soil conditions and encourages greater root growth, unlike the MSRI method, which is an intermediate practice between SRI and conventional rice transplanting system, and includes transplanting 20-day-old seedlings in square planting at 20 cm spacing. This method influences the amount of methane emission by providing less pathways for methane emission coming from the soil into the atmosphere (Uphoff, 2011). Direct-seeded rice (DSR) technology effectively utilizes precipitation, consumes less irrigation water than transplanted paddy farming, and lowers emissions. By reducing global emissions and boosting rice output, these methods can aid in the realization of a sustainable rice production system (Verma et al., 2022a,b). The SRI and MSRI methods, which intermittently aerate the soil to affect the activity of methanogens and prevent their growth when compared to flooding conditions, are options to reduce GHG emissions by 30–38% with less potential for global warming while maintaining productivity (Jain et al., 2014). In comparison to rice that had been transplanted, the DSR significantly reduced emissions (30-50%) (Pathak, 2015).

**In-situ moisture conservation**

In-situ moisture conservation techniques preserve soil and water by limiting runoff, increasing infiltration time, increasing soil moisture, decreasing soil evaporation, and promoting root system development. These techniques gather rainwater where it falls and provide water to help plants cope with stress during the growing season, increasing yields (Srinivasarao et al., 2016). When compared to the flatbed method, in-situ moisture conservation measures in sorghum (*Sorghum bicolour* (L.) Moench) increased yield by 94% and soil moisture retention by about 50% (Kalhapure & Shete, 2013). According to Pendke et al. (2019), the use of conservation furrows in deep Vertisol soybean fields with medium rainfall of 500 to 1,000 mm improved soil moisture availability and ultimately boosted production by 35%. Trench cum bunding is one of the efficient in-situ solutions appropriate for medium black to red soils where runoff water may be held to penetrate into the soil and keep moisture at the root zone for a longer length of time, resulting in noticeably better grain production of up to 12% (Tripathi et al., 2020). Effective in-situ conservation techniques include ridge and furrow, land levelling and bunding, opening furrow, and deep ploughing, which may be used in a variety of crops and geographical areas (More et al., 2021). Despite dry spells, these techniques increased soil moisture retention by up to 24%. In locations with heavy rainfall, furrows serve as drainage channels by supplying drainage and aiding in increased agricultural yields for crops like sorghum, castor (*Ricinus communis* L.), cotton, etc. (18-61%). Utilizing crop residues, such as mulch in sorghum (with cowpea at 45 days after sowing (DAS)), significantly conserved soil moisture (29%) by extending infiltration times and reducing evaporation losses of stored water, enhanced soil fertility and health by increasing organic matter, inhibited weed growth, and decreased soil erosion, all of which helped to increase crop yields by up to 44% (Nalatwadmath et al., 2006). Bunding increased chickpea (*Cicer arietinum* L.) yields in the Bundelkhand area of Uttar Pradesh by 17% compared to no bunding (Tripathi et al., 2020).

**Table 2 Impact of different in-situ moisture conservation measures on yields of crops**

| Practice | Crop | Location | Increase in yields (%) | Reference |
|---|---|---|---|---|
| Foliage mulch + Jalshakti | Chickpea | Jhansi, U.P. | 32.9 | Dhar et al. (2008) |
| Flat sowing and ridging after 30 days | Fodder maize | Bhilwara, Rajasthan | 25.4 | Jat *et al.* (2012) |
| Vegetative mulch | Pearl millet | Bikaner, Rajasthan | 37.32 | Shekhawat *et al.* (2015) |
| Contour bunding | Chickpea | Chitrakoot, Uttar Pradesh | 17 | Tripathi *et al.* (2020) |

**Water harvesting and its efficient use**

The process of inducing, gathering, storing, and preserving surface runoff for agricultural crop production is known as rainwater harvesting (RWH). Harvesting and recycling stored water give farmers a chance to produce a second and occasionally third crop depending on water availability, promoting agricultural intensification and boosting groundwater availability. Farmers may also supply supplemental watering to crops during dry spells. Rainwater harvesting, which is used in a variety of agro-ecological regions and involves check dams, farm ponds, percolation tanks, and bore-well-recharge technology, has been shown to significantly increase groundwater storage to the extent of 15–30% and provide access to harvested water for field and horticultural crops in regions receiving rainfall under 1,000 mm (Pendke et al., 2017). Using drip irrigation to effectively use augmented groundwater in wells to provide life-saving irrigation to crops like rice, groundnut (*Arachis hypogaea* L.), pearl millet, and sweet orange (*Citrus sinensis* (L.) Osbeck) increased crop yields by 20–112% (Rao et al., 2019). Farm ponds are tiny bodies of water that are built in varied rainfall zones either by excavating or digging out an embankment across a canal. Runoff from a 5.6 ha catchment in the semi-arid Vertisols of Nagpur that was used to provide protective irrigations to the cotton (*Gossypium hirsutum* L.) crop increased seed cotton yield by 47% (Rao et al., 2010) and led to improvements in yields of 21–80% in various crops. In semi-arid and sub-humid areas of the country, rainwater harvesting using farm ponds with various lining materials reduced seepage losses and allowed for the storage of harvested water for longer periods of time. This allowed for the application of harvested water through effective irrigation and lifting systems and crop diversification, which increased water productivity and income (Srinivasrao et al., 2016).

**Stress tolerant cultivars**

One of the crucial techniques for ensuring food security in drought-prone areas might be the use of drought-tolerant cultivars (Dar et al., 2020). Several drought-tolerant cultivars were evaluated for their viability for commercial cultivation in several of the country's drought-prone areas. With the use of drought-tolerant crop varieties, such as bajra ('ICTP 8203'), castor ('GCH2') in low-rainfall regions with 500mm or less of rainfall, rice ('Sahbhagi Dhan', 'Abhishek', 'Shushk samrat', 'DRR 42'), pigeon pea ('PRG176', 'BRG1'), wheat ('HPW349', 'HS542', 'HPW368'), in 500–1,000 mm rainfall regions. In comparison to farm conserved seed and local varieties, varieties of maize ('Double Dekalb'), rice ('Maheshwari', 'Indira''Barani Dhan'), and wheat ('HI 1563', 'HD 2967') that are resistant to dry spells in high-rainfall areas have significantly greater yields of 12–47% (Srinivasarao et al., 2016).

In rainfed lowlands of south and south-east Asia, flash floods that completely submerge rice plants for 10 to 15 days are one of the main obstacles to rice production (Septiningsih et al., 2009). In India, rain-fed low-lying regions in Assam, Odisha, West Bengal, and portions of Andhra Pradesh, Maharashtra, and Tamil Nadu coastal states, as well as seasonal floods in Bihar, have a considerable negative impact on crop establishment and cause significant yield losses. However, rice with the SUB-1 gene has resistance to submersion for up to 14 days. When a plant is submerged, the SUB-1A gene activates, causing it to become dormant and conserve energy until the floodwaters recede (Singh et al., 2013). The submergence-tolerant rice varieties "Swarna Sub1," "Jalashree," and "Ranjit Sub1" produced yields that were up to 40% greater than those of the farmers' varieties "Swarna" and "BPT5204" in the Dhubri district of Assam. The flood-tolerant cultivars 'MTU1061', 'RGL2537', and 'Ratnagiri 1,5,6' minimized yield losses and produced 27 and 83% greater yields in flooding circumstances compared to non-flooding varieties in coastal regions like Srikakulam.

Wheat heat stress in eastern Gangetic Plains and western areas of India was addressed by varieties appropriate for advanced planting and early maturity. When compared to local varieties, heat-stress tolerant wheat ('Raj4120', 'Raj4037', 'HI1544', 'Raj4238'), chickpea ('JG130'), and pigeonpea ('NA1') recorded higher yields of 26-51%. Crop production potential can be reduced by up to 40% due to soil salinity. Hence it is necessary to cultivate salt-tolerant types on salt-affected soils to reduce economic losses. Short duration (110 days) rice varieties ('CSR43', 'CSR36'), wheat variety ('KRL210'), Indian mustard ('CS58', 'CS56') enhanced the yields by 15-25% in saline soils of India compared to the local varieties (Singh et al., 2019).

**Optimizing nutrient application**

Important nutrient-application techniques to improve nutrient efficiency include site-specific nutrient management (SSNM), soil-test-based nutrient application, green manure, integrated nutrient management (INM), and balanced fertilization strategies. In order to improve soil fertility using INM, plant nutrients must be recycled by applying compost, manure, mulch, sludge, biological N fixation through rotational or mixed cropping with legumes, and further usage of synthetic fertilizers. In the semi-arid and subtropical region of Karnataka, INM with 50% RDF (50 and 10.91 kg N and P/ha) + FYM 2.5 t/ha + multi-crop consortia boosted winter (rabi) sorghum production by 26% with a 31% improvement in rainwater-use efficiency (RWUE) (Lal, 2008; & Mudalagiriyappa et al., 2012). However, SSNM for a targeted yield of 4 t/ha (155, 45, 203 kg NPK/ha) in finger millet (*Eleusine coracana* Gaertn.) + pigeon pea contributed to higher yield by up to 60% (Ramachandrappa et al., 2015). A low-cost tool called a leaf-colour chart can help farmers manage nitrogen in real time for their rice crops, increasing nitrogen use efficiency by 42% and minimizing excess N application (Bhavana *et al*., 2020). The long-term manure experiments conducted as part of the All India Coordinated Research Project on Dry Land Agriculture (AICRPDA) showed that applying groundnut (*Arachis hypogaea* L.) shells and other crop residues as well as green-leaf manure improved soil infiltration and water retention (AICRPDA, 2018–19).

**Soil carbon sequestration and soil health**

An essential part of soil organic matter, soil carbon enhances soil fertility and health, reducing agricultural production's vulnerability to climate change. Resilience is aided by soil carbon building, which lowers atmospheric greenhouse gas concentration and improves soil water-holding capacity. Green-leaf manuring includes summer mungbean [*Vigna radiate* (L.) R. Wilczek], and other techniques provide significant amounts of biomass to the soil and help the soil build up its carbon content. Alternatives to burning straw exist in rice-straw management systems in Punjab, Haryana, and western Uttar Pradesh. In terms of timely sowing of wheat, rice-straw management, and reducing residue burning, practises like bailing and cutting standing paddy stubbles into small pieces with the aid of machinery like a reaper, cutter-cum-slasher, and mulcher enable uniform spreading of the paddy stubbles in the field (Bindu & Manan, 2018). The Pusa decomposer, a recent alternative, can decompose paddy crop residue and stubble straw within three weeks and totally disintegrate them in around seven weeks when mixed with the soil to create manure. In addition, zero-till wheat planting reduces soil disturbance, reduces $CO_2$ emissions into the environment by avoiding burning paddy residues, and conserves water and energy for pumping water (Sapkota et al., 2015). Other alternatives include recycling paddy residues to generate electricity through biomass energy plants, compost, biochar, etc.

**Intercropping systems for mitigation of climate change**

Adopting an intercropping system allows for the spatial and temporal intensification of crops, which has a number of advantages, such as increased yield, environmental security, production sustainability, and increased ecosystem services. Intercropping benefits from diverse land uses because it makes better use of water and other resources, offers protection from the failure of one crop by reducing risk, and stabilizes production, especially in rainfed circumstances (Manasa et al., 2018; & Sisodiya et al., 2022). In comparison to solitary maize, Mandal et al. (2014) obtained a yield of maize equivalent that was 121% higher. Similar to this, in the Kurnool district, which frequently receives deficiency rainfall, Seteria + pigeonpea (5:1) intercropping decreased risk and offered income stability by boosting yields up to 118% (Chary et al., 2019).

**Agroforestry systems**

The integration of trees on farms and in landscapes is known as agroforestry (AF), which improves sustainable social, economic, and environmental production. Numerous ecosystem services are provided by trees, including the regulation of water and sediment flows, the cycling of carbon and nutrients in soils, the provision of habitat for biodiversity that benefits soil moisture availability and soil fertility, the stabilization of productivity and resilience of production systems, the reduction of $CO_2$ emissions, and the potential for increased carbon sequestration capacity. According to Prasad et al. (2012), eastern cottonwood (*Populus deltoids*) boundary plantation systems with species sequester about 4.56 t/ha/year of carbon, while sublabel or white popinac systems with species *Leucaena leucocephala* (Lam.) sequester about 14.42 t/ha/year (Rizvi et al., 2011).

**Table 3 Carbon sequestration by different tree species**

| Botanical name | Carbon sequestration (in t) at different girth classes (cm) | | | | |
|---|---|---|---|---|---|
| | 10-30 | 31-60 | 61-90 | 91-120 | 121-150 |
| *Acacia catechu* | 0.486 | 1.368 | | 1.568 | 1.888 |
| *Acacia nilotica* | 0.034 | 0.145 | 1.289 | 0.146 | 0.546 |
| *Azadirachta indica* | 0.148 | 0.486 | 1.098 | 0.155 | 2.308 |
| *Cassia fistula* | 0.234 | 0.255 | 0.107 | | |
| *Dalbergia sisso* | 0.081 | 0.212 | | | |
| *Eucalyptus globulus* | | | 0.159 | 4.567 | |
| *Pongamia pinnata* | 0.298 | 1.327 | 0.936 | 0.590 | 0.910 |
| *Tectona grandis* | 23.859 | 48.862 | 65.172 | 49.491 | 34.722 |

(**Source:** Pilania et al., 2019)

**Agro–advisories and their effective use**

Since the monsoon-dependent Indian agriculture is extremely susceptible to severe weather, forecast information on potential weather conditions that are likely to occur within the next two to three days can assist farmers in making pre-cautionary decisions to reduce risk and other farm operations. Agrometeorological advisories (AAS) and weather forecasts, in addition to providing real-time weather information, aid in stabilizing agricultural production by managing agroclimatic resources and other inputs like irrigation, fertilizer, and pesticides. In addition to promoting weather-based irrigation management, pest/disease management, and increased use of post-harvest technologies, the AAS has assisted in promoting the adoption and use of contemporary agricultural production technologies and practices (Rao & Rao, 2013). Weather-based cropping system technology may be a workable substitute for climate change adaptation strategies because climate change is not sudden. The main factors influencing the site- and time-specific technology that makes weather-based pasture cropping successful. It benefits the farmers by carrying out agricultural operations per the current weather conditions.

## CONCLUSION

Climate change is that irrevocable phenomenon which is accelerating with each day passing by. This cannot be stopped, but its adverse effects can only be reduced. The development, dissemination and adoption of climate-smart agricultural practices can reduce the negative impact of climate change. Thus, agronomic interventions can successfully help to mitigate climate change. However, there is a need to evaluate the impact of agronomic practises from the perspective of adaptation and mitigation and analyze their performance via a climatic lens because many agronomic practices contribute to the improvement of productivity and resource use efficiency. There is a need for the widespread transfer of effective adaptation and mitigation practices to prevent the looming adverse effects of climate change and variability on the nation's smallholder systems and to stabilize production, income, and livelihoods.

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**Conflict of Interest:**

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**Author Contribution**

Both authors have participated in critically revising the entire manuscript and approving the final manuscript.

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