



Climate Change Mitigation Strategies for Sustainable Agriculture, Livestock, Forestry and Fisheries

*Munira S. Mandviwala¹ and J. B. Vasave²

¹Assistant Professor, Kishorbhai Institute of Agriculture Sciences and Research Centre (KIASRC), Uka Tarsadia University, Bardoli, Gujarat, India

²Polytechnic in Agriculture, Navsari Agricultural University, Vyara, India

*Corresponding Author's email: munira0412@gmail.com

Climate change, a significant disruptor of the global agricultural systems has created severe discrepancies in the crop production and lead to yield instability and altered cropping patterns. These environmental shifts pose a direct threat to global food security and the ability to feed an ever-growing population. Moreover, the livestock sector along with its high contribution in the global greenhouse gas emissions is also highly susceptible to heat stress, changing water availability and fodder scarcity. Forests, which serve as the planet's primary carbon sinks, are under immense pressure from deforestation, the spread of wastelands and frequent forest fires. This degradation of forest land along with disrupting weather cycles also results in carbon imbalance. Furthermore, the fisheries sector, which supports millions of livelihoods, is in threat from rising oceanic temperatures and the decline of coral reefs which leads to the migration of fish species and mass mortality events. This has led to an urgent need for management strategies like diversification, policy making, controlled grazing and controlled fishing and GHG emission control which are essential to mitigate the climate change impacts on agriculture and allied sectors.

Keywords: Agriculture, Afforestation, Climate change, Diversification, Fisheries, GHG emissions, Livestock

Introduction

Climate change is one of the greatest challenges of the 21st century, posing significant threats to agriculture, livestock, forestry and fisheries, which rely greatly on climatic conditions. Rising temperatures, erratic rainfall patterns, frequent droughts, floods and extreme weather events have adversely influenced the food production, natural ecosystems and rural livelihoods. Simultaneously, these sectors contribute substantially to greenhouse gas (GHG) emissions through activities such as enteric fermentation, manure management, deforestation, rice cultivation, fertilizer application and fuel-intensive farming practices. Therefore, it is necessary to adopt effective climate change mitigation strategies to reduce emissions and ensure sustainable production and food security. Climate-smart agricultural practices, including conservation agriculture, crop diversification, integrated farming systems, precision nutrient management and efficient irrigation, can significantly lower the carbon footprint of crop production. Furthermore, in the livestock sector, improved feeding strategies, genetic improvement, manure management and methane reduction technologies play an important role reducing emissions. Sustainable forestry practices, including agroforestry, afforestation, reforestation and forest conservation, enhance carbon sequestration along with preserving biodiversity and ecosystem services. Similarly, climate-resilient fisheries and aquaculture systems, habitat preservation and restoration and sustainable harvesting practices contribute to both emission reduction and adaptation. The integration of renewable energy, and waste recycling further strengthens mitigation efforts across these sectors. Technological

innovations such as remote sensing, artificial intelligence, geographic information systems (GIS) and precision farming improve resource-use efficiency and environmental sustainability (Getahun *et al.*, 2024). National and international initiatives which include the Paris Agreement, Sustainable Development Goals (SDGs) and India's National Action Plan on Climate Change (NAPCC). These initiatives provide policy frameworks to support low-carbon development. A holistic approach involving farmers, researchers, policymakers and local communities is essential for the successful implementation of mitigation strategies. Strengthening these sectors through climate-smart interventions will reduce greenhouse gas emissions, enhance resilience, improve productivity, conserve natural resources and ensure long-term food and livelihood security.

➤ Agriculture

In the face of climate change in recent times, the agricultural crop production is facing severe discrepancies leading to altered cropping patterns, yield instability, pest- outbreaks and economic uncertainties. All these effects of climate change have posed a great threat to the crop production and feeding the growing population of the world. Some of the strategies that can be opted to mitigate and adapt the climate change effect on agriculture are listed in the table below.

Strategies	
Planting of drought resistant crop varieties	In drought-prone areas, putting more emphasis on drought-resistant crops may help decrease vulnerability to climate change.
Change in cropping pattern and calendar of planting	Change in sowing date and planting pattern, staggered planting to align with monsoon patterns.
Crop diversification	Diversification and modification of crop species and variety portfolios are widespread strategies used by farmers to cope with environmental and socio-economic variability and to adapt to change including climate change. (Labeyrie <i>et al.</i> , 2021)
Mixed cropping	Mixed cropping refers to growing of two or more crops in proximity in the same field. The advantages of mixing crops is mainly attributed to variation in maturity period, tolerance to climate vagaries, differential input requirements and end users of the product.
Improved irrigation efficiency	The ongoing introduction of high-yielding varieties, change in evapotranspiration patterns due to climate change and intensive agriculture, it is anticipated that there will be less fresh water available (both surface and groundwater) and less soil moisture during the dry season.
Adopting soil moisture conservation measures	Proper timing of different farming activities, water conservation measures including terracing and bunding and burying of crop residues to replenish soil fertility
Agroforestry	Tree planting for land reclamation and landscaping purpose. Growing of crops and trees together results in better nutrient cycling, resource use and beneficial to soil.
Precision Farming and Remote Sensing	To assist farmers in decision making in order to reduce inputs and increase productivity along with reducing the pollution as well as input costs (Gatkal <i>et al.</i> , 2024).
Renewable Energy	Use of solar, wind and biomass energy as alternative to fossil fuel-derived energy.

➤ Livestock

Livestock sector contributes to 14.5% of the global greenhouse gas (GHG) emissions and 50 % of agricultural GHG emissions (Rojas-Downing *et al.*, 2017). Moreover, it is highly susceptible to heat stress, change in water patterns, fodder availability and diseases outbreak. This leads to an urgent need of a targeted management system, policies and framework to improve livestock productivity.

Strategies	
Nutritional Interventions	Diet modification by addition of high energy feeds and supplements to reduce intestinal methane emission. (Bačėninaitė <i>et al.</i> , 2022)
Rotational Grazing	Prevention of overgrazing by rotating livestock or pastures in grazing management.
Heat Mitigation	Installation of shade and cooling equipments in animal shelters.
Breed Adaptation	Rearing of breeds that can tolerate wider range of climatic conditions and feed on wider range of feed types.
Manure/ Waste Management	Processing manures using effective anaerobic methods to reduce nitrous oxide and methane emissions and increase their application to soil. (Anonymous, 2024)

➤ Forestry

In the cotemporary era, haphazard deforestation, increase in area of wastelands and degraded lands, higher incidence of forest fires had led to the raising concerns as forests primary carbon sinks of earth, regulating the weather cycles and playing role in environmental, economic and social aspects of earth and human life. Forest protection requires policies, diversification of species and regular monitoring of forest cover. Deforestation and forest degradation account for up to one-fifth of the global GHG emissions (Anonymous, 2023). Only 24.62% of total land area is under forest cover in India.

Strategies	
Climate- resilient tree species	Breeding programmes to develop tree species that can withstand adverse climatic conditions.
Redefining 'forests' and how to measure them	Rather than relying on satellite mapping of canopy cover or hectares of trees, focus should shift to the measurement of the relative density of a 'thriving forest' or an 'ecosystem'.
Sustainable Approach	Afforestation, Reforestation and Agroforestry
Updating forestry policies	A new policy should be implemented that considers current changes in forests due to pressing issues such as climate change and pollution.
Effective institutional and monitoring mechanism	The state governments must conduct an inventory of interventions, put in place solid action plans for managing funds appropriately, and develop open information systems for interested parties. A useful tool for online recording, monitoring, and checking leaks as well as accurate mapping of forested landscapes would be geotagging technology.
Empowering local communities	The participation of local communities must work synonymously with the coordination of impartial and credible processes to operationalize sustainable use and conservation strategies. (Anonymous, 2023)
Forest Fire Management	Steps and precautions to prevent forest fire and resources to fight fire in case of emergency.

➤ Fisheries

Fisheries sector supports livelihood of millions of people across the globe and play an important role in economy of a country, trade and social aspects of lives of people in coastal region. Climate change poses number of threats like migration of fish species due to changing oceanic temperature, high mass mortality, decline in coral reefs and fish habitats. This

ultimately leads to socio-economic decline of those whose livelihood is associated with fishing sector.

Strategies	
Understanding the Indigenous Technical Knowledge	Greater understanding of how communities cope with and adapt to fisheries with extreme natural variations would assist in developing adaptation strategies for climate change. Fishermen in India are generally able to track seasonal and spatial variations in fish stock availability and relate it to climatic and oceanographic variabilities. They are able to detect some variables such as speed and direction of wind and current, watermass movement and upwelling, and make short-term predictions regarding distribution of fish, spawning and abundance. (Ramachandran, 2013)
Develop knowledge-base for climate change and marine fisheries	Considerable effort should be made for gathering historic climatic and oceanographic data in addition to monitoring these key parameters to suit climate change research. It is also important to recognize the importance of changes in these parameters as drivers of change in marine communities including fish.
Climate change risk assessments	To conduct climate change risk assessment estimate the cost of adaptation of fisheries sector under different climate scenarios. The current and future risks and mechanisms within communities may be identified.
Protecting Vulnerable Ecosystems	Establishment of Marine Protected Areas (MPAs) and make policies restricting activities that destroy coral reefs.
Evolving models to understand impacts of climate change	Mass-balance models – Ecopath, Ecosim and Ecospace
Financing climate change adaptation and mitigation measures	Incentive for reducing the sector's carbon footprint and other mitigation and adaptation options
Check on overfishing and pollution	To reduce uncertainty in fish availability and supply

Conclusion

Climate change has posed a serious threat to crop, livestock, trees and marine ecology. This had led to a dire need to take steps to preserve the ecosystems and protect the agriculture and allied sector from the vagaries of climate change. This demands implementation of scientific steps and policies along with increased participation of local communities to mitigate the adverse effects and maintain the productivity and functioning of ecosystems.

References

1. Anonymous (2023). Forests can help us limit climate change – here is how
2. Anonymous (2024). Livestock and Climate Change: How Sustainable Livestock Production Helps
3. Bačėninaityė, D., Džermeikaitė, K. and Antanaitis, R. (2022). Global Warming and Dairy Cattle: How to Control and Reduce Methane Emission. *Animal: an open access journal from MDPI*, 12(19), 2687. <https://doi.org/10.3390/ani12192687>
4. Gatkhal, N. R., Nalawade, S. M., Sahni, R. K., Walunj, A. A., Kadam, P. B., Bhanage, G. B. and Datta, R. (2024). Present trends, sustainable strategies and energy potentials of crop residue management in India: A review. *Heliyon*, 10(21).
5. Getahun, S., Kefale, H. and Gelaye, Y. (2024). Application of Precision Agriculture Technologies for Sustainable Crop Production and Environmental Sustainability: A

Systematic Review. *TheScientificWorldJournal*, 2024, 2126734. <https://doi.org/10.1155/2024/2126734>

6. Labeyrie, V., Renard, D., Aumeeruddy-Thomas, Y., Benyei, P., Caillon, S., Calvet-Mir, L. and Reyes-García, V. (2021). The role of crop diversity in climate change adaptation: Insights from local observations to inform decision making in agriculture. *Current Opinion in Environmental Sustainability*, 51, 15-23.
7. Ramachandran, C. (2013) ICT-oriented Strategic Extension for Responsible Fisheries Management.
8. Rojas-Downing, M. M., Nejadhashemi, A. P., Harrigan, T. and Woznicki, S. A. (2017). Climate change and livestock: Impacts, adaptation, and mitigation. *Climate risk management*, 16, 145-163