

Sustainable and resilient agriculture for the changing climate

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Earth's rising temperature and unpredictable weather patterns due to climate change insist a paradigm shift in farming operations. Climate resilience for developing sustainable agriculture systems that maximise crop production is of paramount importance. Farmers are adopting changes in land usage, labour and resource allocations, occupational patterns, irrigation systems and cropping methods to cope with the rising global temperature due to climate change. Shifting to climate-resistant cultivars is another adaptation method practised by the Indian farmers.

Keywords: Climate resilience, Sustainable agriculture, Weather pattern

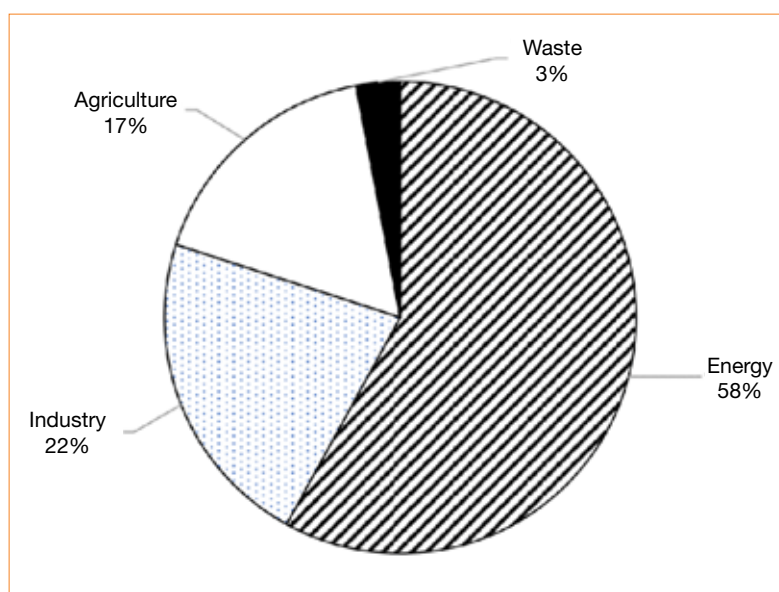
Consequent to climate change and its far-reaching impacts on agriculture, practising sustainable and resilient farming practices have gained much significance. Unpredictable weather patterns, extreme temperatures and shifts in precipitation affect crop yields and farm productivity. The concept of sustainable farming has thus gained prominence, emphasizing the adoption of practices that ensure environmental conservation and contribute to the resilience of agriculture systems. This involves a holistic consideration of environmental, economic and social factors in farming practices and practices that enable crops to withstand and recover from climate-related stresses. Sustainable farming and resilient agriculture in the changing climate is a necessity and also an opportunity for propelling innovation and growth in the sector.

Agriculture-induced climate change

Agriculture is a significant contributor to anthropogenic climate change accounting for nearly 17% of global greenhouse gas (GHG) emissions, notably methane (CH_4) from the paddy field and nitrous oxide (N_2O) from nitrogenous

fertilizers. The expansion of agricultural lands often involves deforestation, which contributes to increased carbon dioxide (CO_2) levels in the atmosphere. Forests act as carbon sinks, absorbing and storing CO_2 , so their removal exacerbates the greenhouse effect. Changes in land use for agriculture can alter local and regional climate patterns. For example, the conversion of natural landscapes to croplands can affect evapotranspiration leading to changes in precipitation patterns.

Farmers are contributing to climate change knowingly or unknowingly. Stubble burning especially in the states of Punjab, Haryana and western Uttar Pradesh emits large quantity of CO_2 along with other harmful gases in the atmosphere. It also poses severe implications on human health due to air pollution. Besides, many crops such as sugarcane, rice, wheat, maize, and millet are often burn after harvest to prepare the land for next crop contributing to the problem as stated.



GHG emission from different sectors

Impact of climate change on agriculture

Climate change has complex impacts on agriculture, livestock and food security, often region-specific, depending upon the local climate, agricultural practices and socioeconomic factors. Some examples of climate change affecting the agriculture are furnished below.

- **Shifts in growing season:** Rising temperatures lead to changes in the timing and duration of growing season. In some regions, this may extend the growing season, allowing for additional crops, while in others, it may lead to heat stress and reduced yields.
- **Water scarcity and drought:** Altered precipitation patterns can result in frequent droughts, negatively impacting crop yields and water availability for irrigation posing a challenge, especially in low rainfall areas.
- **Flooding:** Some regions may experience increased precipitation and flooding, leading to soil erosion, waterlogging and increased vulnerability of crops to diseases.
- **Reduced productivity:** The combined effects of temperature changes, altered precipitation and increased pest pressure lead to reduced crop yields with implications on food security and the livelihoods of farmers.
- **Crop migration:** Some crops may become less viable in their traditional regions due to changed climate, prompting a shift in cultivation to other areas.
- **Changing water availability:** Climate change affects the availability and distribution of water resources. Changes in precipitation patterns and the melting of glaciers impacts water sources critical for agriculture, especially in areas dependent on seasonal snowmelt and glacial runoff.
- **Storms and hurricanes:** More intense and extreme weather events such as storms and hurricanes/cyclones can cause physical damage to crops and

infrastructure, disrupting agricultural activities and supply chains.

- **Heat waves:** Prolonged heat waves can lead to heat stress in crops and livestock, affecting their growth and productivity. High temperatures can also accelerate the evaporation of soil moisture. Many crops and varieties fail in their potential yields due to heat waves.
- **Spread of pests and diseases:** Warmer temperatures and changes in humidity can alter the distribution and prevalence of pests and diseases affecting both crops and livestock. New pests and diseases may emerge, while existing ones may expand their range.

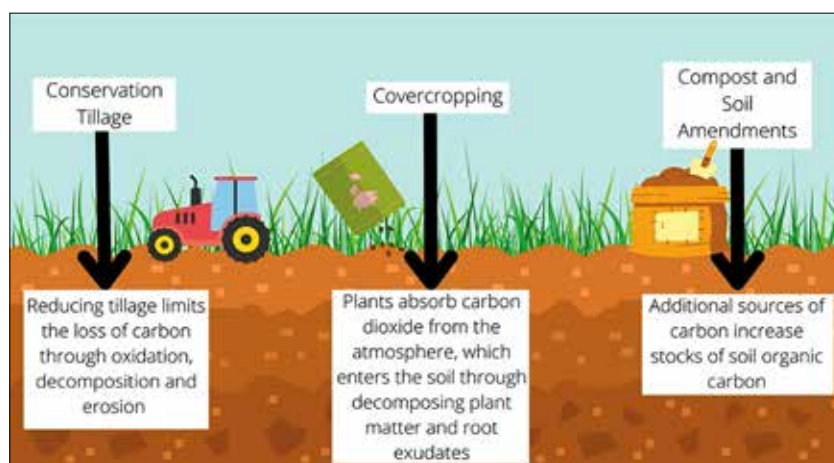
Sustainable farming and climate change

Sustainable farming and climate change are closely interconnected. Addressing the impact of agriculture on the environment is crucial for building a resilient and sustainable future. Agriculture contributes to climate change through greenhouse gas emissions, deforestation and other practices that degrade ecosystems. At the same time, climate change poses significant challenges to agriculture, affecting crop yields, water availability and the overall stability of food production systems. The following practices help reducing the scale of climate change.

- **Mitigation strategies:** Sustainable farming practices such as improved livestock management, precision

agriculture and organic farming which help reduce the emission of GHG such as CH_4 , N_2O and CO_2 are to be widely practiced.

- **Carbon sequestration:** Farming practices that enhance carbon sequestration in soils, such as agroforestry, cover cropping and minimum tillage are to be encouraged.
- **Resilient crop varieties:** Resilient and climate-adapted crop varieties that can withstand changing climate conditions, including drought, extreme temperatures and increased pests and diseases are to be extensively adopted.
- **Water management:** Water management techniques such as rainwater harvesting, drip irrigation and soil moisture conservation measures are to be routinely practiced.
- **Ecosystem services:** For healthy ecosystems and agriculture resilient to climate change, farming practices that enhance biodiversity, such as polyculture, crop rotation and the preservation of natural habitats are to be encouraged.
- **Natural pest control:** Natural pest control services reducing the need for chemical inputs are to be adopted.
- **On-farm renewable energy:** Renewable energy sources such as solar and wind power that reduce reliance on fossil fuels and decrease the carbon footprint of agricultural operations, are to be promoted.



Carbon sequestration through agriculture

Climate resilient agriculture

Climate-resilient agriculture refers to the set of practices, technologies and strategies that enable farmers to adapt and mitigate the impacts of climate change on agricultural systems. As the global climate continues to change with rising temperatures, changing precipitation patterns and increased frequency of extreme weather events, the option ahead is climate resilient agriculture for ensuring food security, sustaining livelihoods and preserving natural resources. Following are some key aspects of climate-resilient agriculture.

- **Diversification of crops and livestock:** Planting a variety of crops that are able to adapt to different climate conditions can help mitigate the risks associated with climate change. Diversification by integrating livestock into farming systems adds further to the resilience.

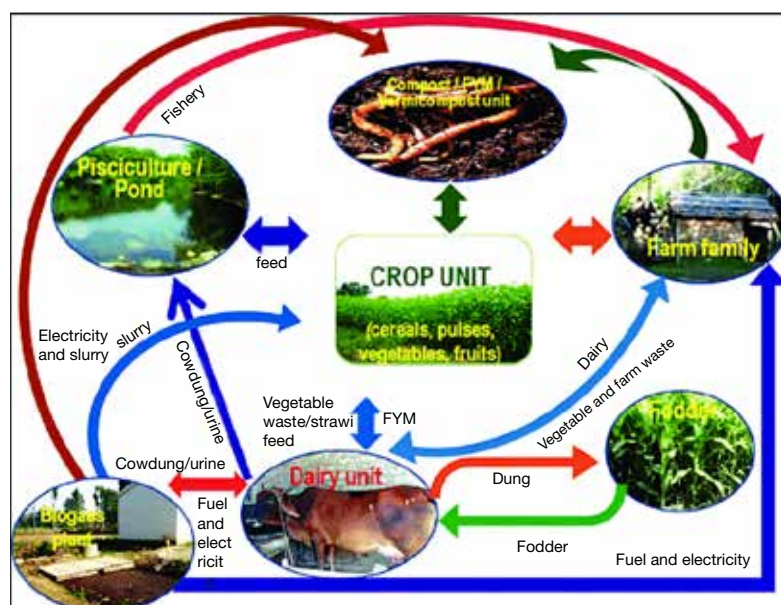
- **Water resource management:** Rain water harvest in high rainfall areas can be used during rain deficit period. Improved irrigation methods like drip system also plays an important role towards a resilient agriculture.
- **Soil health and conservation:** Practices that promote soil health such as cover cropping, agro-forestry and conservation tillage enhance the resilience of agricultural systems.
- **Crop rotation and integrated farming system (IFS):** Alternating crops in a specific sequence, planting multiple crops in the same field (intercropping, mixed cropping and multi-tier cropping) and integrated farming can help reduce the risk of crop failure, nutrient cycling and pest control.
- **Climate-adapted crop varieties:**

Crop varieties specifically bred to withstand the challenges posed by climate change is essential. These varieties may be more drought-resistant, heat-tolerant and resistant to certain pests and diseases. Modern technologies such as genome wide association studies (GWAS) for stress tolerance, genome-led breeding, marker-assisted selection (MAS) and genome editing (CRISPR/Cas9) are important in developing new varieties of crop plants in climate resilient agriculture. CRISPR-Cas9 has been extensively used for plant genome editing to cope with abiotic and biotic stresses.

- **Early warning systems:** Implementing early warning systems for extreme weather events such as cyclones, droughts and floods can help farmers protect their crops and livestock.
- **Capacity building and knowledge transfer:** Imparting knowledge and skill to farmers to adapt to the changing climatic conditions is crucial. Extension services, farmer training programmes and the dissemination of climate-smart agricultural practices play a key role at the grassroots level.



Rain water harvesting and drip irrigation in the agriculture field



Integrated farming for sustainable agriculture

SUMMARY

Resilient agricultural practices are the solutions to address the challenges posed by climate change. The focus is to be on developing the farming methods that can withstand and adapt to the impacts of climate change along with ecological balance. Strategies such as crop diversification, water conservation, soil health management and integrated pest management are to be implemented to create a resilient agricultural system that ensures food security and minimize negative environmental impacts. By doing so, farmers can deal with climate change mitigation, thus fostering a sustainable and secured future for agriculture.

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