

3. Sources of Greenhouse Gas Emissions in Agriculture

Agriculture is one of the important sectors contributing to global greenhouse gas (GHG) emissions. The major greenhouse gases emitted from agricultural activities include carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). These gases are released through various farming practices such as land preparation, fertilizer use, livestock production, and rice cultivation. Understanding the major emission sources is essential for developing strategies to reduce emissions and move toward net-zero emission farming.

3.1 Carbon Dioxide (CO₂)

Carbon dioxide emissions in agriculture mainly result from the use of fossil fuels and soil degradation processes. Farm machinery such as tractors, harvesters, and irrigation pumps consume diesel or petrol, which releases CO₂ into the atmosphere. In addition, land clearing, deforestation, and conversion of natural ecosystems into agricultural land also contribute significantly to CO₂ emissions. Excessive tillage and continuous soil disturbance accelerate the breakdown of soil organic matter, releasing stored carbon as carbon dioxide.



Source: <https://www.sciencedirect.com/>

3.2 Methane (CH₄)

Methane is another major greenhouse gas produced in agriculture. It is mainly generated during flooded rice cultivation due to anaerobic decomposition of organic matter in waterlogged soils. Livestock, particularly cattle and buffalo, produce methane through a digestive process called enteric fermentation. Methane is also released during the decomposition of organic materials in manure storage systems. Compared to carbon dioxide, methane has a significantly higher global warming potential.

3.3 Nitrous Oxide (N₂O)

Nitrous oxide emissions are primarily associated with nitrogen fertilization and manure management. Excessive application of nitrogen fertilizers and inefficient nutrient management lead to the conversion of nitrogen compounds in soil into N₂O through microbial processes such as nitrification and denitrification. Manure decomposition in soils also contributes to nitrous oxide emissions. This gas is extremely potent, with a global warming potential nearly 300 times greater than carbon dioxide, making it a major concern in agricultural climate mitigation efforts.

4. Principles of Net-Zero Emission Farming

Net-Zero Emission Farming is based on several fundamental principles that guide sustainable agricultural practices.

4.1 Efficient Resource Use

Efficient use of inputs such as water, fertilizers, and energy reduces waste and emissions. Precision agriculture techniques help farmers apply inputs only where and when they are needed.

4.2 Soil Carbon Sequestration

Soil acts as a major carbon sink. Increasing soil organic matter through crop residues, compost, and cover crops helps capture atmospheric carbon and store it in soil.

4.3 Renewable Energy Utilization

Using renewable energy sources such as solar pumps, wind energy, and biogas reduces dependence on fossil fuels.

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INTRODUCTION

Agriculture plays a vital role in ensuring food security for the growing global population. However, agricultural activities are also a major contributor to greenhouse gas (GHG) emissions such as carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). These emissions mainly arise from fertilizer use, livestock production, rice cultivation, and land-use changes. As climate change becomes one of the most pressing global challenges, the concept of Net-Zero Emission Farming has gained significant importance.

Net-Zero Emission Farming refers to an agricultural system in which the total greenhouse gases emitted from farming activities are balanced by the amount of greenhouse gases removed or absorbed from the atmosphere. In simple terms, it means producing food while ensuring that agricultural activities do not add additional greenhouse gases to the atmosphere. This approach promotes climate-smart agriculture by reducing emissions, increasing carbon sequestration in soils and plants, and improving resource efficiency. Net-Zero farming integrates modern technologies, sustainable farming practices, and ecological principles to create a more resilient and environmentally friendly agricultural system.



Source: <https://www.siani.se/>

2. Concept of Net-Zero Emissions

The term Net-Zero means that the amount of greenhouse gases emitted into the atmosphere is equal to the amount removed or offset. It does not necessarily mean eliminating all emissions but rather balancing them.

In agriculture, emissions occur from several sources:

- Use of nitrogen fertilizers
- Methane emission from rice fields
- Methane from livestock digestion (enteric fermentation)
- Manure management
- Soil disturbance and land use changes
- Energy use in farm machinery

To achieve net-zero emissions, farmers adopt practices that:

- 1.Reduce greenhouse gas emissions
 - 2.Capture carbon in soil and vegetation
 - 3.Improve energy efficiency
- Use renewable energy sources

THE NET ZERO FARMING GUIDE STEP 1 - MORE EFFICIENCY AND PRECISION



BETTER ORIGIN

Source: <https://betterorigin.co.uk/>

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कोटा, राजस्थान



Net-Zero Emission Farming

संकलन

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4.4 Sustainable Crop and Livestock Management

Improved crop varieties, efficient feeding strategies, and better manure management help reduce greenhouse gas emissions.

4.5 Ecosystem Restoration

Planting trees, restoring degraded lands, and practicing agroforestry increase carbon storage and biodiversity.

5. Practices for Achieving Net-Zero Emission Farming

Achieving net-zero emission farming requires the adoption of sustainable agricultural practices that reduce greenhouse gas emissions while enhancing carbon sequestration in soil and vegetation. Several climate-smart farming approaches can significantly contribute to this goal.

5.1 Conservation Agriculture

Conservation agriculture focuses on improving soil health and reducing emissions through sustainable land management. It includes practices such as minimum or zero tillage, crop residue retention, and no-till rotation. These methods reduce soil disturbance, help maintain soil organic carbon, improve soil structure, and decrease fuel consumption from farm machinery. As a result, conservation agriculture supports both productivity and environmental sustainability.

5.2 Precision Nutrient Management

Efficient nutrient management plays an important role in reducing nitrous oxide emissions. Applying fertilizers according to crop requirements prevents excessive nitrogen losses. Technologies such as soil testing, GPS-based fertilizer application, and controlled-release fertilizers help farmers apply nutrients accurately and improve nutrient use efficiency.

5.3 Improved Rice Cultivation Techniques

Rice cultivation is a major source of methane emissions due to flooded field conditions. Techniques such as Alternate Wetting and Drying (AWD) and the System of Rice Intensification (SRI) reduce methane production by limiting continuous flooding while maintaining or even improving crop yields.

5.4 Agroforestry

Agroforestry integrates trees with crops or livestock systems. Trees capture atmospheric carbon dioxide and store it in biomass and soil. This system increases carbon sequestration, enhances soil fertility, improves biodiversity, and provides additional income through timber, fruits, and other tree products.

5.5 Organic and Bio-based Inputs

The use of biofertilizers, compost, and green manure improves soil health and reduces dependence on synthetic fertilizers. These inputs enhance soil microbial activity and help maintain long-term soil fertility.

5.6 Renewable Energy in Agriculture

The use of renewable energy sources such as solar irrigation pumps, biogas plants, and wind energy systems can significantly reduce fossil fuel consumption. Biogas produced from livestock manure can also be used for cooking and electricity generation, making farms more energy-efficient and environmentally sustainable.

6. Benefits of Net-Zero Emission Farming

Net-Zero Emission Farming provides a wide range of environmental, economic, and social benefits. By reducing greenhouse gas emissions and promoting sustainable agricultural practices, this approach helps create a more resilient and environmentally friendly farming system. It supports both climate protection and long-term agricultural productivity.

6.1 Climate Change Mitigation

One of the most important benefits of net-zero emission farming is its contribution to climate change mitigation. By reducing the release of greenhouse gases such as carbon dioxide, methane, and nitrous oxide, farming systems can significantly decrease their impact on global warming. Practices like improved nutrient management, reduced tillage, and efficient livestock management help lower emissions and stabilize the climate.

6.2 Improved Soil Health

Net-zero farming promotes soil conservation and increases soil organic matter. Practices such as the application of organic manure, compost, crop residue management, and reduced tillage improve soil structure, water-holding capacity, and microbial activity. Healthy soils are essential for sustainable crop production and environmental balance.

6.3 Sustainable Crop Production

Efficient use of natural resources and improved soil health lead to more stable and productive farming systems. Sustainable practices increase crop resilience against climate variability, pests, and diseases, ensuring consistent yields and food security.

6.4 Reduced Input Costs

Adopting precision farming technologies and renewable energy sources helps farmers reduce the use of expensive chemical fertilizers, pesticides, and fossil fuels. This lowers production costs and increases farm profitability.

6.5 Biodiversity Conservation

Practices such as agroforestry, crop diversification, and ecological farming enhance biodiversity in agricultural landscapes. These practices create habitats for beneficial organisms and help maintain ecological balance.

6.6 Long-Term Farm Sustainability

Net-zero emission farming ensures the sustainable use of soil, water, and energy resources. By protecting natural resources and reducing environmental degradation, it secures agricultural productivity for future generations.

7. Challenges in Achieving Net-Zero Farming

Although Net-Zero Emission Farming offers significant environmental and economic benefits, its adoption faces several challenges. One of the major barriers is the lack of awareness and technical knowledge among farmers regarding climate-smart agricultural practices. Many farmers are not fully informed about the methods and benefits of reducing greenhouse gas emissions in farming systems.

Another important challenge is the high initial cost of advanced technologies such as precision farming equipment, renewable energy systems, and modern irrigation technologies. Small and marginal farmers often find it difficult to invest in such technologies due to limited financial resources. In addition, limited access to renewable energy infrastructure, such as solar pumps and biogas plants, restricts the transition toward low-emission farming systems.

Inadequate policy support and limited financial incentives also slow the adoption of net-zero practices. Farmers require proper subsidies, training programs, and extension services to encourage sustainable farming practices. Furthermore, measuring and monitoring greenhouse gas emissions at the farm level remains complex and requires advanced tools and technical expertise. Addressing these challenges requires strong government policies, farmer education, financial support, and technological innovation to promote widespread adoption of net-zero farming practices.

8. Role of Technology and Innovation

Modern technology and innovation play a vital role in achieving the goals of Net-Zero Emission Farming. Advanced tools and digital technologies enable farmers to monitor agricultural activities more efficiently and reduce greenhouse gas emissions.

Technologies such as Artificial Intelligence (AI) help in analyzing large amounts of agricultural data to improve crop management and optimize resource use. Remote sensing and satellite monitoring provide real-time information about crop health, soil moisture, and land use, helping farmers make informed decisions.

The Internet of Things (IoT) is widely used in precision agriculture through smart sensors that monitor soil conditions, temperature, and nutrient levels. Smart irrigation systems ensure efficient water use, reducing energy consumption and improving water management. Additionally, carbon monitoring tools help track carbon emissions and carbon sequestration in agricultural systems.

9. Future Prospects

Net-Zero Emission Farming is gaining global importance as countries work to address climate change and ensure sustainable agricultural development. Governments, research institutions, and international organizations are promoting climate-smart agriculture to reduce greenhouse gas emissions while maintaining food production. In the future, the development of climate-resilient crop varieties will help farmers adapt to extreme weather conditions such as drought, heat, and floods.

Another important strategy is the expansion of carbon credit programs, which provide financial incentives to farmers who adopt practices that reduce emissions and increase carbon sequestration. In addition, the promotion of regenerative agriculture, including cover cropping, crop diversification, and reduced tillage, will help restore soil health and enhance carbon storage.

The integration of digital technologies, such as artificial intelligence, remote sensing, and precision farming tools, will further improve resource management and emission monitoring. With proper policy support and farmer awareness, Net-Zero Emission Farming can transform agriculture into a climate-friendly and sustainable system.

CONCLUSION

Net-Zero Emission Farming represents a transformative approach to agriculture that balances food production with environmental sustainability. By reducing greenhouse gas emissions and enhancing carbon sequestration, farmers can play a vital role in combating climate change. Adoption of sustainable practices such as conservation agriculture, agroforestry, renewable energy use, and precision farming will help achieve the goal of net-zero emissions. Collaboration among farmers, researchers, policymakers, and industries is essential to promote this innovative farming system.