

Carbon Sequestration through Sustainable Farming Practices

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INTRODUCTION

Climate change is one of the most pressing global challenges of the 21st century, largely driven by the increasing concentration of greenhouse gases such as carbon dioxide (CO₂) in the atmosphere. Agriculture, while essential for food production, is both a contributor to and a potential solution for climate change. One of the most promising solutions is carbon sequestration through sustainable farming practices, which involves capturing atmospheric carbon dioxide and storing it in soil, plants, and biomass.

Carbon sequestration in agriculture not only helps mitigate climate change but also improves soil health, enhances crop productivity, and supports long-term sustainability. Sustainable farming practices focus on maintaining ecological balance, conserving natural resources, and reducing environmental impacts while ensuring food security.

Understanding Carbon Sequestration

Carbon sequestration is the process of capturing and storing carbon dioxide from the atmosphere for long periods. In agriculture, this process primarily occurs through plants and soil.

Plants absorb CO₂ during photosynthesis and convert it into organic matter such as roots, stems, and leaves. When plants shed leaves or die, this organic matter decomposes and becomes part of the soil organic carbon pool. Healthy soils can store large amounts of carbon, making them a critical component in climate change mitigation.

There are two main types of carbon sequestration in agriculture:

- **Biological sequestration:** Storage of carbon in plants, trees, and soil.
- **Geological sequestration:** Storage of carbon underground in rock formations (less related to farming).

Sustainable farming focuses mainly on biological sequestration.

Importance of Carbon Sequestration in Agriculture

1. Climate Change Mitigation

By capturing atmospheric CO₂, agricultural soils act as carbon sinks, reducing the overall concentration of greenhouse gases.

2. Improved Soil Health

Higher levels of soil organic carbon improve soil structure, fertility, and water-holding capacity.

3. Enhanced Crop Productivity

Healthy soils rich in organic matter support better plant growth and yield stability.

4. Water Conservation

Soils with higher organic content retain more moisture, reducing irrigation requirements.

5. Biodiversity Conservation

Sustainable farming practices promote soil biodiversity, including beneficial microorganisms and insects.

Sustainable Farming Practices for Carbon Sequestration

1. Conservation Tillage

Traditional plowing disturbs soil structure and releases stored carbon into the atmosphere. Conservation tillage, including reduced tillage and no-till farming, minimizes soil disturbance and helps retain soil carbon.

In no-till systems, crops are planted without turning the soil, allowing organic matter to accumulate over time. This practice not only sequesters carbon but also reduces soil erosion.

2. Cover Cropping

Cover crops are plants grown during off-seasons to protect and enrich the soil. Common cover crops include legumes, grasses, and clovers.

These crops absorb CO₂, add organic matter to the soil, and prevent soil erosion. When cover crops decompose, they contribute to soil carbon storage and improve soil fertility.

3. Crop Rotation

Crop rotation involves growing different crops in a sequence on the same land. This practice enhances soil health and promotes carbon sequestration by increasing biomass production and reducing soil degradation.

Different crops contribute varying amounts of organic matter, improving soil carbon levels over time.

4. Agroforestry

Agroforestry integrates trees and shrubs into agricultural systems. Trees play a significant role in carbon sequestration by storing carbon in their biomass and roots.

Agroforestry systems, such as alley cropping and silvopasture, provide multiple benefits including improved biodiversity, soil fertility, and microclimate regulation.

5. Organic Farming

Organic farming avoids synthetic fertilizers and pesticides, relying instead on natural inputs such as compost, manure, and green manure.

These organic inputs increase soil organic carbon and promote microbial activity, enhancing carbon sequestration.

6. Application of Compost and Manure

Adding compost and animal manure to soil increases organic matter content and improves soil structure.

These materials provide a stable form of carbon that can remain in the soil for long periods, contributing to long-term carbon storage.

7. Improved Grazing Management

Sustainable grazing practices, such as rotational grazing, help maintain healthy grasslands and prevent overgrazing.

Well-managed pastures can sequester significant amounts of carbon in both soil and plant biomass.

8. Biochar Application

Biochar is a stable form of carbon produced by heating organic materials in the absence of oxygen (a process called pyrolysis).

When added to soil, biochar enhances carbon storage, improves soil fertility, and increases water retention.

9. Precision Agriculture

Precision agriculture technologies help optimize the use of inputs such as water, fertilizers, and pesticides.

Efficient resource use reduces greenhouse gas emissions and enhances soil carbon retention.

Mechanisms of Carbon Storage in Soil

Soil carbon is stored in two main forms:

- **Active carbon:** Easily decomposable organic matter that provides nutrients for plants.

- **Stable carbon:** Long-lasting organic compounds that remain in the soil for decades or even centuries.

Sustainable farming practices increase both active and stable carbon pools, ensuring long-term carbon sequestration.

Microorganisms such as bacteria and fungi play a crucial role in converting plant residues into stable soil organic matter. Healthy soils with diverse microbial communities are more effective at storing carbon.

Benefits Beyond Carbon Sequestration

1. Soil Fertility Enhancement

Increased organic matter improves nutrient availability and soil structure.

2. Reduced Input Costs

Sustainable practices reduce dependence on chemical fertilizers and pesticides.

3. Climate Resilience

Carbon-rich soils are more resilient to drought, floods, and extreme weather conditions.

4. Improved Water Management

Enhanced soil structure allows better water infiltration and reduces runoff.

5. Sustainable Livelihoods

Farmers adopting sustainable practices can benefit from improved yields and reduced costs.

Role of Technology and Innovation

Modern technologies are playing an important role in promoting carbon sequestration in agriculture.

- **Remote sensing and satellite monitoring** help track changes in vegetation and soil carbon.
- **Soil sensors** provide real-time data on soil health and moisture levels.
- **Data analytics and AI** help farmers make informed decisions about sustainable practices.

Digital platforms also enable carbon credit systems, where farmers can earn income by adopting practices that sequester carbon.

Policy Support and Global Initiatives

Governments and international organizations are recognizing the importance of carbon sequestration in agriculture.

Programs promoting climate-smart agriculture, sustainable land management, and agroforestry are being implemented worldwide. Carbon credit markets are also emerging as a way to incentivize farmers to adopt sustainable practices.

Initiatives such as afforestation and soil conservation programs contribute to increasing carbon storage at a large scale.

Future Prospects

The future of carbon sequestration in agriculture lies in integrating traditional knowledge with modern technologies.

Innovations such as regenerative agriculture, climate-smart farming, and digital monitoring systems will enhance the effectiveness of carbon sequestration practices.

Research is also focusing on developing crop varieties with higher carbon sequestration potential and improving soil management techniques.

As awareness increases and policies evolve, sustainable farming practices will play a key role in combating climate change while ensuring food security.

CONCLUSION

Carbon sequestration through sustainable farming practices offers a powerful solution to address climate change while improving agricultural productivity and environmental sustainability. By adopting practices such as conservation tillage, cover cropping, agroforestry, organic farming, and improved grazing management, farmers can transform agricultural lands into effective carbon sinks.

These practices not only reduce greenhouse gas emissions but also enhance soil health, conserve water, and support biodiversity. Despite challenges such as lack of awareness and financial constraints, continued innovation, policy support, and education can accelerate the adoption of sustainable farming methods.

In the long run, integrating carbon sequestration into agricultural systems will contribute to a more resilient, productive, and sustainable future for global agriculture.