

Potential of Regenerative Agriculture to Reduce Greenhouse Gas Emissions

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Abstract

The agricultural sector is a significant contributor to global greenhouse gas (GHG) emissions, accounting for approximately 25% of emissions through activities such as land clearing, soil degradation, methane from livestock, and nitrous oxide from fertilizers. However, regenerative agriculture offers a promising alternative to reduce and even reverse the environmental damage caused by conventional farming. This approach focuses on restoring soil health, increasing biodiversity, and improving ecosystem resilience to climate change. Regenerative agriculture employs practices like minimal tillage, cover cropping, crop rotation, agroforestry, and rotational grazing to enhance soil carbon sequestration, decrease reliance on synthetic inputs, and restore ecosystems. Carbon sequestration, a key feature of regenerative practices, helps capture and store atmospheric CO₂ in soil and plant biomass, creating a carbon sink. Techniques such as reduced tillage and agroforestry also improve soil structure and biodiversity, further enhancing carbon storage and reducing emissions. In addition to environmental benefits, regenerative agriculture offers economic and social advantages, such as improved soil fertility, higher yields, and participation in carbon markets. Moreover, it strengthens local food systems and reduces the carbon footprint associated with food transportation and industrial processing. Despite its potential, the transition to regenerative agriculture faces barriers, including initial costs, knowledge gaps, and policy frameworks favouring conventional farming. Scaling up regenerative practices will require supportive government policies, financial incentives and educational programs to assist farmers in adopting these sustainable methods. Ultimately, regenerative agriculture holds the potential to transform the agricultural sector from a major emitter into a key player in mitigating climate change.

Key words: Cover cropping, Ecosystems, Greenhouse gases, Reduced tillage,

Introduction

The agricultural sector is both a significant contributor to and a potential mitigator of greenhouse gas (GHG) emissions. Conventional agricultural practices are responsible for around 25% of global GHG emissions, largely through activities such as land clearing, soil degradation, methane production from livestock, and nitrous oxide emissions from fertilizers. However, an emerging approach known as “regenerative agriculture” offers a viable solution for not only reducing emissions but also reversing some of the environmental damage caused by industrial farming. Regenerative agriculture focuses on restoring and enhancing natural ecosystems, building soil health, increasing biodiversity, and improving the resilience of agricultural systems to climate change.

What is Regenerative Agriculture?

Regenerative agriculture is a system of farming principles and practices that aim to regenerate degraded soils, increase biodiversity and improve the water cycle. Unlike conventional farming, which often prioritizes maximizing short-term yields, regenerative agriculture promotes long-term sustainability by working in harmony with natural processes. Core practices of regenerative agriculture include minimal soil disturbance (no-till or reduced tillage), cover cropping, crop rotation, integrated livestock management, agroforestry and composting. These methods help to increase organic matter in the soil, enhance soil structure and promote biodiversity above and below ground.

The regenerative approach differs from sustainable agriculture in that it not only seeks to maintain current resources but actively works to rebuild and restore degraded systems. In this way, regenerative agriculture not only addresses immediate environmental concerns but offers the potential to transform farming from a net contributor to a net mitigator of climate change.

Carbon Sequestration through Regenerative Practices

One of the most promising aspects of regenerative agriculture is its potential to sequester carbon in the soil. Soil contains a vast carbon reservoir, with the capacity to store more carbon than the atmosphere and plants combined. Through photosynthesis, plants capture carbon dioxide (CO₂) from the atmosphere, converting it into organic matter that is stored in plant biomass and, eventually, in the soil. Healthy, carbon-rich soils act as a "carbon sink," capturing and storing CO₂ that would otherwise remain in the atmosphere and contribute to global warming.

Several regenerative practices enhance this process:

1. Cover Cropping: Cover crops, which are planted during off-seasons when primary crops are not growing, help to maintain continuous ground cover. This prevents soil erosion and ensures that the soil remains biologically active, allowing carbon to continue being sequestered. Cover crops also improve soil fertility, which can reduce the need for synthetic fertilizers that contribute to nitrous oxide emissions.

2. Reduced Tillage: Conventional tillage practices disturb the soil, releasing stored carbon back into the atmosphere. Reduced or no-till farming minimizes this disruption, allowing more carbon to remain trapped in the soil. By preserving soil structure, no-till farming also fosters a healthier soil microbiome, which enhances nutrient cycling and increases the soil's capacity to store carbon.

3. Agroforestry: Integrating trees and shrubs into farming systems (agroforestry) significantly increases the amount of carbon sequestered both in the soil and in the above-ground biomass. Trees have deep roots that help to store carbon deep within the soil, making it less susceptible to disturbances. In addition to carbon sequestration, agroforestry enhances biodiversity and provides additional ecosystem services, such as improved water retention and erosion control.

4. Rotational Grazing: In livestock management, rotational grazing involves moving animals between different pastures, allowing grasses time to recover between grazing. This practice increases the amount of organic matter in the soil, improves root growth and enhances carbon sequestration. Well-managed grazing systems can turn pastureland into significant carbon sinks while also improving animal welfare and reducing the need for synthetic fertilizers.

Reduced Reliance on Synthetic Inputs

Another major way regenerative agriculture can reduce GHG emissions is by decreasing reliance on synthetic fertilizers and pesticides, which are major sources of nitrous oxide (N₂O) and CO₂ emissions. Nitrous oxide is a particularly potent GHG, with a global warming potential nearly 300 times that of CO₂. Conventional farming often depends on large quantities of nitrogen-based fertilizers, which can lead to significant N₂O emissions as well as nutrient runoff that degrades water quality.

Regenerative practices such as cover cropping and composting reduce the need for synthetic fertilizers by naturally replenishing soil nutrients. Cover crops like legumes can fix atmospheric nitrogen in the soil, providing a natural source of fertilizer that improves soil fertility without the environmental costs associated

with synthetic inputs. Similarly, composting organic matter (crop residues, animal manure) recycles nutrients back into the soil, reducing the need for external inputs.

Furthermore, regenerative farming methods promote pest resilience through biodiversity, minimizing the need for chemical pesticides. This reduces both direct emissions from pesticide production and indirect impacts such as soil degradation and loss of biodiversity.

Restoration of Ecosystems and Biodiversity

Regenerative agriculture also contributes to reducing GHG emissions by restoring ecosystems and increasing biodiversity. Diverse ecosystems are more resilient to climate change and better able to store carbon. By prioritizing biodiversity, regenerative farming systems help to stabilize ecosystems, enhance soil health, and increase productivity without relying on monocultures and heavy chemical inputs.

Agroforestry, silvopasture and polyculture systems are examples of regenerative practices that enhance biodiversity. These practices mimic natural ecosystems by integrating multiple species of plants and animals into the farming landscape. The inclusion of trees, shrubs and livestock creates a mosaic of habitats, fostering a rich array of microorganisms, insects and wildlife. This ecological complexity enhances the system's ability to absorb and store carbon while providing numerous co-benefits such as improved water retention, soil stabilization and increased resilience to pests and diseases.

Economic and Social Benefits

Beyond environmental benefits, regenerative agriculture can offer economic and social advantages that encourage its wider adoption. Regenerative farming practices tend to increase soil health and fertility over time, leading to higher yields and lower input costs. Additionally, improved soil health can make farms more resilient to climate extremes, reducing the economic risks posed by droughts, floods, and other climate-related events. Farmers practicing regenerative agriculture may also access new revenue streams through carbon markets, where they can sell carbon credits based on the amount of CO₂ their farming systems sequester.

Socially, regenerative agriculture fosters stronger relationships between farmers and their communities by promoting local, diversified food systems. Local food production and shorter supply chains help to reduce the carbon footprint associated with transportation and industrial food processing.

Challenges and Barriers to Adoption

Despite its potential, several barriers prevent the widespread adoption of regenerative agriculture. One of the primary challenges is the initial investment in transitioning from conventional to regenerative practices. Many regenerative techniques, such as no-till farming or establishing agroforestry systems, require upfront costs and a transition period during which yields may decline before the long-term benefits are realized. Additionally, knowledge gaps, limited access to technical assistance, and the lack of clear economic incentives for carbon sequestration hinder the adoption of these practices.

Government policies and subsidies often favour conventional agriculture, making it difficult for farmers to shift to regenerative methods. Therefore, supportive policy frameworks, financial incentives and educational programs are essential to scaling up regenerative agriculture on a global scale.

Conclusion

Regenerative agriculture offers a transformative approach to reducing greenhouse gas emissions while simultaneously improving the resilience and sustainability of food systems. By focusing on practices such as carbon sequestration, reduced reliance on synthetic inputs, and ecosystem restoration, regenerative farming can turn agriculture from a climate problem into a climate solution. However, for regenerative agriculture to reach its full potential, broader adoption will require overcoming economic, technical, and policy barriers. If these challenges are addressed, regenerative agriculture could play a crucial role in mitigating climate change,

enhancing biodiversity, and securing global food security.

References

Blanco-Canqui, H. and Rattan, L. (2017). Principles of Soil Conservation and Management. Springer.

Garnett, T. (2017). Regenerative Agriculture for Climate Mitigation and Food Security. Frontiers in Sustainable Food Systems. 4(8): 1-10.

Lal, R. (2004). Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. Science. 304(5677): 1623-1627.

Mbow, C. (2019) Food Security. In: Climate Change and Land. IPCC Special Report.

Smith, P. (2013). How Much Land-Based Greenhouse Gas Mitigation Can Be Achieved Without Compromising Food Security and Environmental Goals. Global Change Biology, 26(2), 320-340.

Teague, R. W. (2016). The Role of Ruminants in Reducing Agriculture's Carbon Footprint in North America. Journal of Soil and Water Conservation. 71(2): 156-164.