Carbon Negative Farming: A Solution for Climate Change Mitigation

Rimzim[1]*, Sandeep Manuja[2], G D Sharma[3], Rameshwar Kumar[4] and Deeraj Sain[5]

[1]Ph.D. Scholar, [2]Professor, [3] Principal Scientist, [4] Principal Scientist, [5] M.Sc. Scholar, Department of Agronomy, CSK HPKV, Palampur, HP, India-176062

Corresponding Author
Rimzim
Email: rimzimbhattiabc@gmail.com

OPEN ACCESS

Keywords

Carbon Farming, Climate Change, Mitigation

How to cite this article:

Rimzim, Manuja, S., Sharma, G. D., Kumar, R. and Sain, D. 2025. Carbon Negative Farming: A Solution for Climate Change Mitigation. *Vigyan Varta* 6(4): 68-71.

ABSTRACT

Carbon negative farming is an agricultural approach that removes more carbon dioxide (CO_2) from the atmosphere than it emits, helping to mitigate climate change. This is achieved through regenerative practices such as agroforestry, cover cropping, no-till farming, biochar application, and holistic grazing management. These methods enhance soil carbon sequestration, improve soil health, and reduce greenhouse gas emissions. Additionally, minimizes the carbon footprint of farming operations. By adopting carbon-negative farming, promoting sustainable food production while restoring ecosystems and enhancing biodiversity.

INTRODUCTION

Climate change and global warming have emerged as pressing challenges of our time, with far-reaching consequences for the environment, societies and economies worldwide. Human activities significantly increase the concentration of GHG in the atmosphere, intensifying the greenhouse effect and impacting the climate (Zheng *et al*. 2019). In 2024, global mean atmospheric concentrations of CO_2, CH_4 and N_2O had reached record highs of 423 ppm, 1932 ppb, and 338 ppb, respectively (Lan *et al*.

2024; Lan *et al*. 2024). The agricultural sector is one of the largest producers of nitrous oxide (N_2O) and methane (CH_4), which are two GHGs with significant global warming potentials, lowering carbon footprint (Jackson *et al*. 2009).

The GHG emission is mainly influenced by the type of inputs used for production, such as fertilizers, pesticides, organic manure, fossil fuels, machinery and irrigation methods (Soni *et al*. 2013). Recently, Global awareness is increasing about environmental safety and the need for cleaner agricultural systems (Khoshnevisan *et al*. 2015). Carbon negative farming is the best approach for greenhouse gas reduction. Carbon negative farming refers to agricultural practices that remove more carbon dioxide (CO_2) from the atmosphere than they emit. This approach is critical in mitigating climate change by transforming agriculture into a net carbon sink rather than a source of greenhouse gas (GHG) emissions. (Lal. 2021)

Practices for Carbon Negative Farming

Carbon negative farming incorporates a variety of techniques designed to enhance carbon capture in soil and biomass. Some practices include:

1. **Agroforestry**: Integrating trees into agricultural landscapes absorbs CO_2 while improving soil stability and water retention (Jose. 2009).

2. **Cover Cropping:** Cover crops, grown during off-season periods, protect soil from erosion, suppress weeds, and enhance soil organic matter. A study spanning 2,400 acres across Iowa, Kansas, and Nebraska demonstrated that fields with cover crops sequestered nearly three times as much greenhouse gas as conventional fields, rendering them carbon negative. Additionally, sheet and rill erosion were halved, and wind erosion reduced by 72%.

3. **Biochar Application:** Adding biochar to soil can significantly enhance carbon sequestration while improving soil fertility (Lehmann and Joseph. 2015). Biochar, produced through pyrolysis of biomass, serves as a soil amendment that enhances carbon sequestration. Its application can reduce methane (CH_4) emissions by 79% during dairy composting and nitrous oxide (N_2O) emissions by 22%–48% over 2–7 years. Moreover, biochar application has been associated with a 10% improvement in crop yields when applied at a rate of 15.6 mg ha^{-1}.

4. **Zero Tillage (No-Till Farming):** Zero tillage involves minimal soil disturbance, preserving soil structure and enhancing carbon sequestration. This practice can reduce soil erosion by 1 gigaton and fuel use by 3.9 gallons per acre. Additionally, it decreases CH_4, CO_2, and N_2O emissions by an average of 20%, 15%, and 8%, respectively, leading to a net global warming potential reduction of 8%–31% compared to conventional systems.

5. **Alternative Wetting and Drying (AWD) in Rice Cultivation:** AWD is an irrigation technique that reduces water usage and methane emissions in rice paddies. Implementing AWD can decrease water requirements by 15%–20% and reduce CH_4 emissions by 30%–70%, depending on water usage and rice residue management.

6. **Direct-Seeded Rice (DSR):** DSR eliminates the need for traditional transplanting of rice seedlings, reducing labor and water usage. This method improves water use efficiency by 44%–50% and can reduce greenhouse gas emissions in rice-growing regions by 25%. In Punjab, adopting DSR has been associated with a 54%–59% lower global warming potential compared to conventional practices.

7. **Intercropping:** Intercropping involves growing two or more crops in proximity, promoting efficient resource use and enhancing soil health. Combining cereals and legumes reduces nitrogen fertilizer use, as legumes supply 15% of nitrogen needs, emitting fewer greenhouse gases compared to non-legumes. On average, intercropping can sequester 0.184 tC ha^{-1} yr^{-1}.

8. **Precision Farming with Artificial Intelligence (AI):** Utilizing AI in regenerative agriculture enhances the monitoring, reporting, and verification processes for soil carbon sequestration. Technologies like spectral probes and automated soil core extraction vehicles enable efficient soil carbon analysis. Machine learning models predict soil organic carbon levels, reducing the need for extensive physical sampling and improving accuracy.

9. **Sustainable Grazing Practices:** Implementing intensive rotational grazing and silvopastoral systems (SPS) can make livestock farming more sustainable. For instance, cattle ranchers in Colombia have adopted these methods, moving cattle to new pastures daily to promote maximum grass growth, healthier cows, and carbon capture. These techniques help mitigate deforestation and reduce greenhouse gas emissions associated with traditional livestock farming.

Benefits of Negative Carbon Farming

Climate Change Mitigation

Negative carbon farming actively removes CO_2 from the atmosphere, helping to offset emissions from other sectors. Research suggests that agricultural soils have the potential to sequester up to 5 Gt CO_2 per year globally (Paustian *et al*. 2016).

- **Improved Soil Health:** Practices such as no-till farming and organic amendments increase soil organic matter, enhance nutrient cycling, and improve soil structure, leading to greater resilience against drought and erosion.

- **Enhanced Biodiversity:** Agroforestry and diversified cropping systems support a wider range of plant and animal species, creating healthier and more resilient ecosystems.

- **Economic Opportunities:** Carbon farming initiatives, such as carbon credit markets, provide financial incentives for farmers who adopt regenerative practices. Companies and governments are increasingly investing in carbon sequestration projects.

Challenges and Barriers

While negative carbon farming offers significant benefits, it also faces several challenges:

- **Adoption Barriers** – Farmers may be hesitant to adopt new practices due to lack of knowledge, economic constraints, or policy limitations.

- **Measurement and Verification** – Accurately quantifying soil carbon sequestration remains a complex and evolving field.

- **Policy and Incentives** – Governments must develop effective policies and financial mechanisms to support carbon farming initiatives.

CONCLUSION

Negative carbon farming represents a transformative approach to addressing climate change while promoting sustainable agriculture. By adopting techniques like agroforestry, cover cropping, and biochar application, farmers can turn their land into effective carbon sinks. In addition, it provides economic opportunities for farmers through

carbon credit programs that reward them for their contributions to carbon sequestration.

REFERENCES

Jackson J, Choudrie S, Thistlethwaite G, Passant N, Murrells T, Watterson J, Mobbs D, Cardenas LM, Thomson and Leech A. 2009. UK Greenhouse Gas Inventory, 1990 to 2007: Annual Report for Submission under the Framework Convention on Climate Chang

Jose S. 2009. Agroforestry for ecosystem services and environmental benefits: An overview. *Agroforestry Systems* 76:1-10

Khoshnevisan B, Bolandnazar E, Shamshirband S, Shariati HM, Anuar NB and Mat KML. 2015. Decreasing environmental impacts of cropping systems using life cycle assessment (LCA) and multi-objective genetic algorithm. *Journal of Cleaner Production* 86: 67-77

Lan X, Tans P and KW Thoning. 2024. Trends in globally averaged CO_2 determined from NOAA global monitoring laboratory measurements. Version 2024 08.https://doi.org/10.15138/9N0HZH07.

Lan X, KW Thoning and EJ Dlugokencky. 2024. Trends in globally-averaged CH_4, N_2O and SF_6 determined from NOAA global monitoring laboratory measurements. Version 2024-08.https://doi.org/10.15138/P8XGAA10

Paustian K, Lehmann J, Ogle S, Reay D, Robertson GP and Smith P .2016. Climate smart soils. *Nature* 532: 49-57

Lal R. 2021. Negative emission farming. *Journal of Soil and Water Conservation* 76: 61-64

Zheng X, Streimikiene D, Balezentis T, Mardani A, Cavallaro F and Liao H, 2019. A review of greenhouse gas emission profiles, dynamics and climate change mitigation efforts across the key climate change players. *Journal of Cleaner Production* 234:1113-1133.