

Carbon Farming: Strategy to Minimize Agricultural Carbon Footprints

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Abstract

A significant portion of the world's greenhouse gas emissions comes from agriculture. 48% of worldwide non-CO₂ anthropogenic GHG emissions and 10% to 15% of overall anthropogenic GHG emissions are thought to be directly caused by agriculture. However, estimates of present contributions differ, and a variety of other techniques could raise C sequestration or lower agricultural GHGs. Carbon farming is a new farming technique designed to reduce greenhouse gases and lock away carbon in agricultural lands. This is an agricultural practice that integrates techniques like no-till farming, agro forestry, cover cropping, and application of biochar. All these enhance soil health, increase organic matter, and retain atmospheric carbon dioxide in the soil. All these methods not only mitigate climatic change but also help in enhancing crop yields and increase their tolerance against adverse environmental factors. It is a viable approach to producing food and related products in a more sustainable manner. Concurrently, it aims to generate a wide range of natural farming practices and economically feasible goods. It continues to rise due to its integration of various land use methods, forestry, and agriculture. Carbon farming, through carbon-friendly agriculture, therefore promises a double reward: it can reduce the footprint of the agricultural sector while ensuring sustainable farming systems. Carbon farming henceforth helps make agriculture climate positive in securing food for human kind, while helping fulfill environmental conservation ends.

Keywords: Carbon farming, Carbon sequestration, Climate change mitigation, Soil health, Sustainable agriculture

Introduction

Agriculture significantly contributes to global greenhouse gas (GHG) emissions, accounting for about 13% of total global emissions. Therefore, the agricultural sector is considered the second-leading emitter of GHGs worldwide after the energy sector. The most important GHGs released through agriculture include methane (CH₄), nitrous oxide (N₂O), and carbon dioxide (CO₂). Methane mainly stems from enteric fermentation in ruminant animals like cattle, while rice production constitutes another major source. Nitrous oxide is almost entirely emitted as a result of applying nitrogen-based fertilizers to soils. Carbon dioxide is also partly associated with deforestation and changing land use patterns as agricultural lands expand. Given the significant contribution of agriculture to GHG emissions in India, effective mitigation strategies are very important. Practices like sustainable farming, better management of livestock, fertilizer optimization, and alternative methods of crop residue management can considerably lower emissions. Moreover, empowering smallholder farmers with advanced tools, including artificial intelligence for weather forecasting, will enhance climate resilience and contribute to emission reductions.

Carbon Farming

Carbon farming is a holistic approach to land management that seeks to enhance the natural capacity of forest and agricultural areas to absorb and store carbon dioxide (CO₂) from the atmosphere. This includes

implementing specific techniques that increase the carbon stored in soils and vegetation - carbon sequestration. Carbon farming has been defined by the Carbon Cycle Institute as “a whole farm approach to optimizing carbon capture on working landscapes by implementing practices that are known to improve the rate at which CO₂ is removed from the atmosphere and stored in plant material and/or soil organic matter”.

Principles of carbon farming

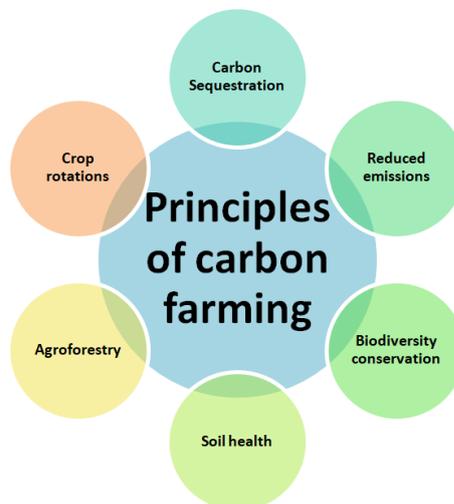


Fig. 1

Carbon Sequestration

It is a process of transferring CO₂ from the atmosphere into the soil through plants, plant residues, and other organic solids that are stored or retained in the unit as part of the soil organic matter. The term SOC sequestration is frequently used with the same meaning although it is not totally correct as it involves the sequestration of atmospheric CO₂ rather than soil organic carbon (SOC). That is, in order for C sequestration in soils to take place, CO₂ must be transferred from the atmosphere and converted to organic C via autotrophs metabolic activities, and then needs to enter the soil directly (plant matter and plant residues produced on the same site) or indirectly (plant-derived organic matter such as manure or compost that derive mostly from other sites) in quantities large enough to compensate losses caused by respiration and result in a net C stock increase in the soil.

Reduced emissions

Carbon is derived from atmospheric CO₂. If the emission of other greenhouse gases (GHGs) is not simultaneously added and the total of all GHG fluxes (in CO₂ equivalent) is negative, there is a corresponding net removal of carbon from the atmosphere, which is referred to here as negative emissions. A measure that takes potential leakage into account must convert the soil from a GHG source to a GHG sink in order to generate negative emissions.

Biodiversity conservation

Carbon farming is the term used for practices in agriculture that increase carbon sequestration in soil and vegetation to reduce climate change. Along with the prime objective of carbon storage, carbon farming can substantially help biodiversity conservation.

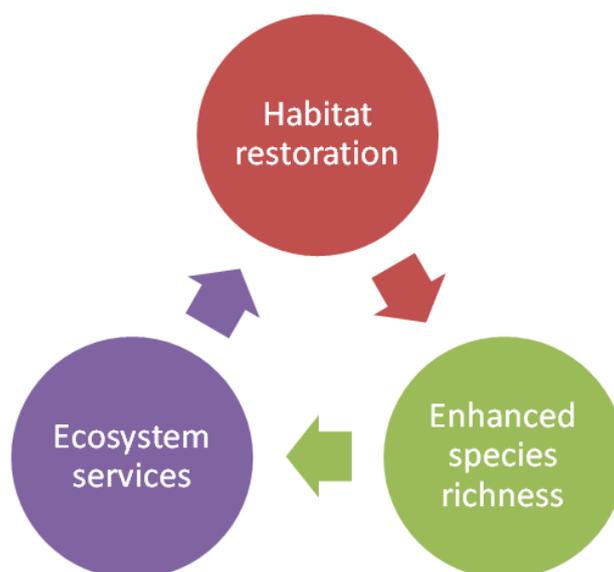


Fig. 2 Positive Impacts on Biodiversity

Soil Health

It is stimulating to see that effective input management leads to carbon sequestration, which promotes more efficient use of agricultural inputs. Sequestration of soil organic carbon contributes to the soil's improved chemical, biological, and physical health. Water, fertilizer, energy, and agrochemicals are the agricultural inputs.

Agroforestry

Carbon sequestration refers to the net removal of CO₂ from the atmosphere and storage in long-lived pools of C. Such pools include the aboveground plant biomass and belowground biomass such as roots, soil microorganisms, and the relatively stable forms of organic and inorganic C in soils and deeper subsurface environments, and the durable products derived from biomass (e.g., timber). Agroforestry systems are believed to have a higher potential to sequester C than pastures or field crops. This conjecture is based on the concept that tree incorporation in croplands and pastures would result in greater net aboveground as well as belowground C sequestration

Crop rotations

Crop rotation is one of the most basic practices in carbon farming, where different crops are alternated on the same land over successive seasons. This strategy not only improves soil health but also plays a substantial role in carbon sequestration.

Carbon Farming Practices

Carbon farming refers to a range of techniques aimed at improving soil carbon sequestration and hence aiding in the mitigation of climate change. Carbon farming techniques have a big impact on nutrient availability, soil health, and total agricultural output.

No-till farming.	Cover Crops	Biogas / Biomethane	Carbon Sequestration	Organic Fertilization and Biochar
Traditional methods of tillage can result in high soil organic matter losses, directly increasing soil erosion and fracturing the structure of the soil. It has also been found that crops intensification and reduced tillage can raise soil fertility as well as offset anthropogenic emissions of CO ₂ . Another crucial element of minimum tillage systems is the retention of crop residues which promotes the sequestration of soil carbon	Carbon farming practices, cover crops are gaining increasing recognition for their potential to enhance ecosystem services and sequester carbon in soils. Across a variety of European climate zones, the use of cover crops has increased SOC sequestration, thus proving that cover crops can be one of the major ways to retain soil fertility and health	The potential of biogas production as a carbon farming solution and concluded that a range of carbon farming techniques, including biogas and biomethane production, would be needed to make agriculture carbon neutral	Soil management practices are among the most important strategies for carbon sequestration. Carbon Farming mitigating climate change and improving soil health. The carbon farming strategies of effectiveness have to take into account the local soil characteristics coupled with the management practices. Type of agricultural system practiced also determines the SOC sequestration	Biochar has attracted attention because of its ability to sequester carbon in soils. Numerous studies have shown that biochar can considerably increase SOC levels, thus further contributing to enhanced soil biological activity. Combining biochar with organic fertilizers can have synergistic effects, improving nutrient availability and soil structure

Role of Carbon Credits in Promoting Carbon Farming

Carbon credit farming involves the removal of CO₂ from the atmosphere by using specific techniques of land management or agricultural practice that enhances carbon sequestration and storage in plants, trees, or soils. In essence, one can only take part in this practice after obtaining carbon credits, which are essentially tradable licenses or certificates giving an individual, organization, or state the authority to emit a specific quantity of CO₂ or other greenhouse gases.

The idea is that by engaging in activities that take carbon out of the atmosphere or to prevent its release, such as planting trees, practicing sustainable agriculture, or bringing back degraded lands, people or entities can get carbon credits. These carbon credits may then be sold or traded on carbon markets to companies or entities looking to offset their own carbon emissions.

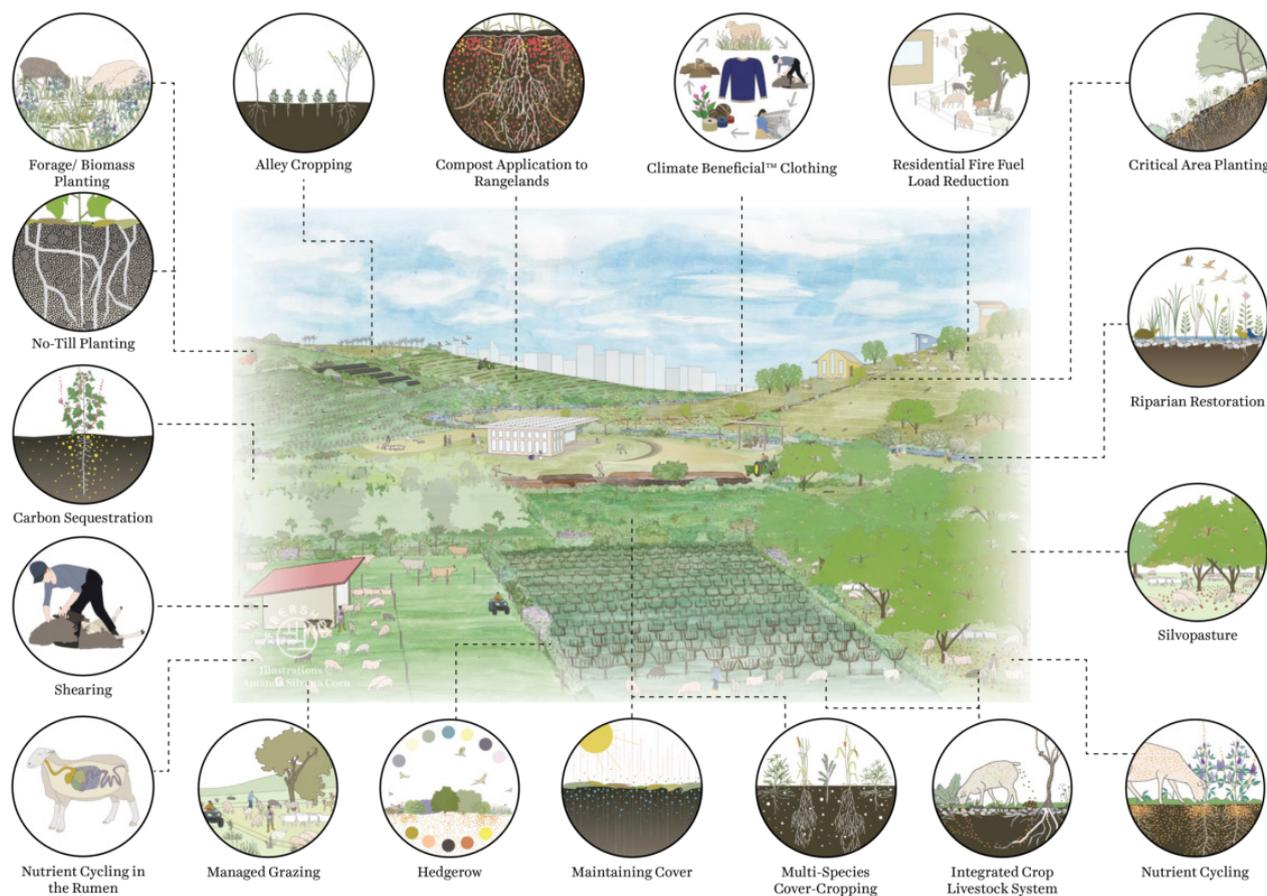


Fig. 3 Illustration of Sustainable Agriculture Practices: Integrating biodiversity, soil health, carbon farming, and agro forestry techniques to promote resilient ecosystems and mitigate climate change.

Table 1: Soil organic carbon fractions

Variations between the different Soil Organic Carbon Pools	Labile/Active/Particulate/Decomposable Carbon Pool	Intermediate/Slow/ Partially Stabilized Carbon Pool	Recalcitrant/Stabile/Passive/ Inert/Resistant Carbon Pool
Nature	Easily decomposable organic matter	Partially stabilized organic matter	Highly stable, resistant organic matter
Decomposition Rate	Very fast	Moderate	Very slow
Turnover Time	Short (days to months)	Intermediate (years to decades)	Long (centuries to millennia)
Contribution to Soil Fertility	Immediate nutrient release	Slow, sustained nutrient release	Minimal contribution to short-term fertility
Carbon Storage	Short-term	Medium-term	Long-term
Examples	Fresh plant residues, root exudates, microbial biomass	Partially decomposed plant material, humus formation	Charcoal, humus, highly lignified plant residues

Case Studies: Success Stories in Carbon Farming

Carbon farming initiatives in India, particularly in the states of Maharashtra and Telangana, have been the subject of recent studies highlighting both their potential and challenges.

Maharashtra: In Maharashtra, a pilot project was initiated involving 20 smallholder farmers practicing the Saguna Rice Technique (SRT), a form of zero-till conservation agriculture. This method not only aims to increase farm yields and income but also enhances soil health by storing more carbon. The project compensates farmers for increases in soil organic carbon, with initial ‘carbon checks’ expected to be about ₹9,000 (US\$128) over three years based on half-acre experiments. Verification and validation of soil carbon increases are conducted independently to ensure credibility.

Telangana: In Telangana, a carbon farming project was implemented focusing on practices like Alternate Wetting and Drying (AWD) in rice cultivation to reduce methane emissions. However, the adoption of AWD was context-specific; for instance, abundant rainfall led to its discontinuation in some areas. The project also highlighted the importance of local implementation partners for effective execution and noted social benefits such as improved water availability and increased Rabi season cultivation.

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