

Low Carbon Agriculture For Better Environment

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Introduction

According to the World Resources Institute (WRI), the agriculture sector is responsible for nearly 12% of the world's greenhouse gas emissions. Carbon sequestration and reduction in greenhouse gas emissions can be achieved through a variety of agricultural practices. The term "low-carbon agriculture" encompasses actions to reduce the energy inputs and greenhouse gas emissions associated with agriculture.

The primary greenhouse gases linked with agriculture are carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). Although carbon dioxide is the most abundant greenhouse gas in the atmosphere, nitrous oxide and methane have longer atmospheric lifetimes and absorb more long-wave radiation. Therefore, even small quantities of methane and nitrous oxide can have significant effects on climate change. On the other hand, carbon dioxide is removed from the atmosphere and converted to organic carbon through photosynthesis. Conservation tillage, organic production, cover cropping, and crop rotations are practices that can significantly increase the amount of carbon stored in soils.

Low-carbon agriculture is characterized by low energy consumption, minimal greenhouse gas emissions, reduced pollution, and high efficiency. It involves cleaner production, waste utilization, and incorporates principles of sustainable, ecological, and circular agriculture. Carbon efficiency is an essential aspect of low-carbon agriculture, not only from a practical but also a conceptual perspective. The shift towards carbon efficiency in agriculture is crucial for balancing economic, environmental, and social objectives, with the primary aim of mitigating climate change and promoting sustainable development. The concept of low-carbon agriculture draws on various scientific fields and disciplines.

Greenhouse gas emissions from Agriculture

Agriculture is a significant contributor to greenhouse gas emissions. Poor management of nitrogen-based fertilizers can generate considerable amounts of nitrous oxide emissions, and irrigation systems used in crop production can also be significant drivers of GHG emissions.

Agriculture production contributes to climate change by emitting greenhouse gases, some of which can be avoided or reduced.

Nitrogen-based fertilizers: Poor management of nitrogen-based fertilisers can generate considerable amounts of nitrous oxide emissions, in addition to the GHG emissions associated with the production of fertilisers and pesticides.

Water: Irrigation systems used in crop production can be significant drivers of GHG emissions in certain areas where water must be pumped and moved across long distances or where the electricity grid operates on high-emitting power sources like coal.

Deforestation: Forests, wetlands and grasslands converted for crop production can eliminate natural vegetation that store carbon.

Agricultural activities serve as both sources and sinks for greenhouse gases. The primary sources of greenhouse gases in agriculture are the production of nitrogen-based fertilizers, the combustion of fossil fuels used by farm machinery, and waste management. Livestock enteric fermentation, which takes place in the digestive systems of ruminant animals, results in methane emissions. The concept of low-carbon agriculture combines cleaner production and utilization of waste, with a goal of balancing economic, environmental, and social goals while limiting climate change and promoting sustainable

development. The evolution of agricultural activities towards carbon efficiency is an important condition for achieving these goals.

The main sources of greenhouse gas emissions in agriculture are N₂O from soil, CH₄ from enteric fermentation, CO₂ from biomass incineration, and CH₄ from manure. The use of synthetic (N) fertilizers and incorporation of crop residues into soil result in nitrous oxide (N₂O) emissions, while the application of urea and lime to the soil leads to carbon dioxide (CO₂) emissions. While there is no universally accepted definition of a “low-carbon economy,” it generally refers to a series of actions aimed at reducing greenhouse gas emissions while respecting the principles of sustainable development, promoting innovation, and enhancing competitiveness in the global market. Achieving a low-carbon economy requires the adoption of practical actions in all sectors and industries, including agriculture. The study of interdependencies and relationships between phenomena, concepts, and objects is essential to understand the conditions for low-carbon economic development, and this subject is studied in various fields, including agricultural, technical, and economic sciences.

Agriculture is a significant source of nitrous oxide (N₂O) and methane (CH₄) emissions, contributing to greenhouse gas emissions. However, agriculture also has the potential to limit carbon emissions by sequestering carbon in soils, resulting in a relatively small share of agriculture in net CO₂ emissions. Both plant and animal production are linked to agricultural emissions. Nitrous oxide (N₂O) is a greenhouse gas that is 300 times more effective than CO₂ in terms of heat absorption and is a fundamental emission from agriculture. Undesirable decomposition of nitrogen fertilizers in the soil (natural and mineral fertilizers) is a significant cause of N₂O emissions. Nitrous oxide emissions are affected by other factors as well, such as soil temperature, oxygenation, availability of hydrocarbons, pH, and soil humidity, and are associated with denitrification and, to a lesser extent, nitrification through microbiological processes. Nitric oxide is poorly soluble in water, does not elute with precipitation, and can accumulate in the atmosphere for approximately 150 years.

The emission of N₂O from agricultural soils occurs both directly and indirectly. Direct emissions of N₂O are mainly due to the use of nitrogen fertilizers and the emission of N₂O from organic nitrogen in animal waste, while indirect emissions are related to ammonia (NH₃) emissions and nitrogen leaching. Intensively supplying soil with nitrogen fertilizers is a significant source of N₂O formation. Emissions of these compounds can lead to adverse changes in agricultural soil, such as acidification and eutrophication of natural ecosystems. Additionally, nitrous oxide intensifies the greenhouse effect and contributes to the depletion of the ozone layer.

Greenhouse gas emissions from agricultural production are also impacted by the mechanization of agriculture. The emissions of air pollutants as a result of using agricultural machinery such as tractors, power tillers, harvesters, etc., need to be

considered. Farm tractors, as well as other diesel-powered vehicles, emit gases that contain carbon monoxide (CO), hydrocarbons (HC), particulate matter (PM), and nitrogen oxides (NO_x). Agricultural tractors contribute more than 6% of the total nitrogen oxide emissions from transportation.

Mitigating climate change through agriculture

There are various farming practices and technologies that can help to reduce greenhouse gas emissions and prevent climate change. These include enhancing carbon storage in soils, preserving existing soil carbon, and reducing emissions of carbon dioxide, methane, and nitrous oxide.

Key actions in low-carbon agriculture: The Better Farming Principles and Criteria require farmers to adopt good management practices that maintain soil integrity, restore degraded soils, and reduce greenhouse gas emissions.

Improving fertilizer management: Nitrogen fertilizer use efficiency can be improved by adjusting application timing, tillage practices, and other methods to limit nitrous oxide emissions. This can also decrease nitrogen leakage into the environment and contamination of surface and groundwater. Precision farming, which uses GPS tracking, is one strategy to improve fertilizer efficiency and reduce nitrous oxide emissions. Other strategies include the use of cover crops and animal and green manures, nitrogen-fixing crop rotations, composting, compost teas, and integrated pest management.



Implement efficient irrigation practices: To optimize water productivity and reduce emissions from irrigation, it is important to improve water use efficiency through various measures. This can be achieved by using mechanical improvements in irrigation systems, reducing operating hours, and implementing drip irrigation technologies or center-pivot irrigation systems. By reducing the amount of water and nitrogen applied to crops, these practices can help to lower greenhouse gas emissions of nitrous oxide and decrease water withdrawals.

The ten activities to reduce emission: In agriculture, there are ten activities that can be implemented to reduce emissions. The first is to reduce methane emissions in rice fields, followed by the reduction of chemical fertilizer use and improving its efficiency as the second action. The third is to reduce low-carbon emissions from livestock and poultry, while the fourth is

to reduce emissions from fisheries. The fifth activity is focused on promoting energy-saving green agricultural machinery. The sixth is to improve the carbon sink in farmland, while the seventh is to promote the comprehensive utilization of straw. The eighth action is to promote the use of renewable energy sources, the ninth is to support scientific and technological innovation, and the tenth is to disseminate scientific and technological innovations.



Conservation Tillage and Cover Crops: Conservation tillage encompasses various strategies and techniques for establishing crops in the residue of previous crops, which are deliberately left on the soil surface. Reducing tillage minimizes soil disturbance and helps mitigate the release of soil carbon into the atmosphere. Conservation tillage also enhances the carbon sequestration capacity of the soil. Besides, conservation tillage offers other benefits like improved water conservation, reduced soil erosion, reduced fuel consumption, reduced compaction, increased planting and harvesting flexibility, reduced labor requirements, and improved soil tilth. Cover crops are another approach used in conservation agriculture, as they can help prevent erosion, reduce nutrient loss, and provide additional organic matter to the soil.



Improved Cropping Systems: Recent reports suggest that organic agriculture can reduce greenhouse gas emissions by increasing soil organic matter levels through the use of composted animal manures and cover crops. Organic cropping systems eliminate the emissions from the production and transportation of synthetic fertilizers. The components of organic

agriculture can be combined with other sustainable farming systems, such as conservation tillage, to further increase climate change mitigation potential. Generally, conservation farming practices that conserve moisture, improve yield potential, reduce erosion and fuel costs also increase soil carbon. Direct seeding, field windbreaks, rotational grazing, perennial forage crops, reduced summer fallow, and proper straw management are examples of practices that reduce carbon dioxide emissions and increase soil carbon. Using higher-yielding crops or varieties and maximizing yield potential can also increase soil carbon.

Land Use Changes: Land restoration and land use changes can encourage the conservation and improvement of soil, water, and air quality, and typically reduce greenhouse gas emissions. Implementing sustainable grazing practices such as sustainable stocking rates, rotational grazing, and seasonal use of rangelands can lead to greenhouse gas reductions. Converting marginal cropland to trees, shrubs, or grass can maximize carbon storage on land that is less suitable for crops.

Methane capture: Livestock waste treatment, especially in dairies, contributes significantly to large emissions of methane and nitrous oxide. Methane capture and combustion systems in agriculture include covered lagoons, complete mix and plug flow digesters. By using anaerobic digestion, animal waste can be converted to energy, capturing methane and preventing it from being released into the atmosphere. The captured methane can then be used to fuel a variety of on-farm applications or generate electricity. This process also reduces odors from livestock manure and labor costs associated with manure removal.

Other renewable energy options, such as wind and solar, provide significant opportunities for the agricultural sector to reduce greenhouse gas emissions.

Conclusion

The low-carbon economy responds to the challenges associated with climate change and aims to counteract disturbances in ecosystems, while also promoting agribusiness development in a more sustainable way. The transformation of agriculture towards low-carbon practices involves changing production and consumption processes, reducing emissions of pollutants and greenhouse gases, minimizing waste and ineffective use of natural resources, preserving biological diversity, and improving energy security. The transition to a low-carbon economy in agriculture requires smart growth based on knowledge and innovation. Innovative means of agricultural production with relatively low environmental impact, such as biofertilizers and biopesticides, precision agriculture (using GPS), and low-emission energy sources on farms (e.g., agricultural biogas energy plants), should be utilized. Additionally, crop rotation plants with a positive index of reproduction of soil organic matter and nitrogen compounds can help reduce emissions. Rational environmental management is also crucial for the development of a low-carbon economy, including the use of appropriate technical equipment.