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ACHIEVING CARBON NEUTRALITY IN THE CONTEXT OF AGRICULTURE: A WAY OF MITIGATING CLIMATE CHANGE

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Achieving carbon neutrality in the agriculture sector is an essential objective for nations worldwide. Particularly through the production of methane and nitrous oxide by animals and the use of synthetic fertilizers, agriculture is a significant contributor to greenhouse gas emissions. Several strategies, including reducing methane emissions from livestock, reducing nitrous oxide emissions from synthetic fertilizers, practising conservation agriculture, promoting the use of renewable energy, and planting trees and other vegetation, can be implemented to achieve carbon neutrality in the agriculture sector. Governments and other stakeholders can also contribute to reaching carbon neutrality in agriculture by establishing carbon taxes, cap-and-trade systems, subsidies for renewable energy and low-carbon farming methods, and regulations and standards. Together, it is possible to minimize the agriculture industry's carbon footprint and contribute to a more sustainable future.

Carbon neutrality, often known as net zero carbon, is the balance between the quantity of carbon dioxide and other greenhouse gases generated into the atmosphere and the amount removed through carbon sinks or offset programmes. In other words, it indicates that there was no overall emission of CO_2 into the atmosphere. The accumulation of greenhouse gases, such as carbon dioxide, in the atmosphere causes climate change by trapping heat and contributing to rising temperatures and other negative environmental effects. Carbon neutrality can be accomplished by engaging in activities like reforestation and carbon sequestration, as well as reducing the amount of carbon that is emitted into the atmosphere and increasing the amount of carbon that is removed from the atmosphere. The objective of

carbon neutrality is to minimize or eliminate the net emission of greenhouse gases into the atmosphere in order to alleviate the adverse effects of climate change. In recent years, the concept of "carbon neutrality" or "net-zero carbon" has attracted increased attention as a means to combat climate change. In the late 1980s, researchers at the University of California, Davis were the first to adopt the term "carbon neutrality" to express the concept of offsetting carbon dioxide emissions with an equal quantity of carbon dioxide removal from the atmosphere. Since then, the term has grown and is now extensively employed in conversations about climate change and measures to cut carbon emissions. The Paris Agreement, which was endorsed by the United Nations Framework Convention on Climate Change in 2015, established the objective of limiting global warming to far below 2 degrees Celsius and pursuing efforts to restrict it to 1.5 degrees Celsius. Many nations and businesses have pledged to reduce their carbon footprint to zero, for achieving this objective.

A large portion of the greenhouse gas emissions that affect our planet come from the agricultural sector, which yet has a vital place in the world economy. Methane production is one of the most significant means through which agriculture emits carbon. Methane is a powerful greenhouse gas. Over a period of one hundred years, the potential for methane to contribute to global warming is twenty-eight times more than that of carbon dioxide. The digestive activities of cows and other ruminant animals, such as sheep and goats, as well as the decomposition of organic materials in landfills and rice fields, both contribute to the emission of this gas into the atmosphere. Nitrous oxide is an additional greenhouse gas created by the use of synthetic fertilizers and animal manure. On a 100-year timescale, its global warming potential is 298 times larger than carbon dioxide's. Methane and nitrous oxide emissions aren't the only ways agriculture adds to global warming; vehicles running on fossil fuels like gasoline and diesel also do their part. Producing synthetic fertilizers and insecticides, as well as transporting them, are both activities that also contribute to carbon emissions. In order to reach carbon neutrality, these emissions will need to be cut down significantly, and any leftover emissions will need to be neutralized through the purchase of carbon credits or participation in other offset schemes.

Achieving carbon neutrality in the agricultural sector is a significant goal that can promote the transition toward a food system that is more sustainable and resilient while also curbing the adverse effects of climate change. Increase in food production with the agriculture must be linked with efforts on reducing greenhouse gas emission and restoring forests (Searchinger *et al.*, 2021). Agro-forestry shall help in improvement of livelihood

opportunity of poor people through economic and environmental security (Basu, 2014). Although there are obstacles that need to be overcome in order to achieve carbon neutrality in agriculture, such as the requirement to measure and verify emissions and ensure that offset programmes are accurate, there is also significant potential to make significant progress in this area through the adoption of sustainable agriculture practises and the development of effective carbon offset projects. Most commonly, sustainable intensification of agricultural production is viewed as a crucial step in this direction (Aubert *et al.,* 2019). Agriculture that is more climate-resilient can improve both food and nutritional security (Ghosh, 2019).

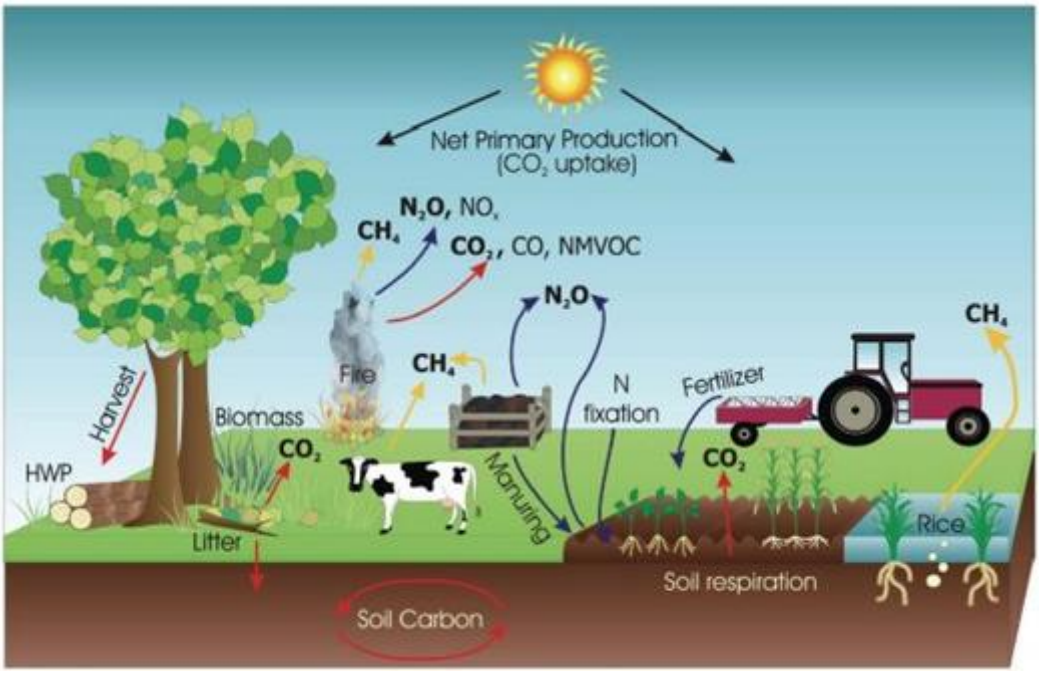

Fig. 1: Carbon emission from agricultural sector; Source: Carbon Neutrality - Farming the Way Out (tracextech.com)

How to Achieve Carbon Neutrality in Agriculture?

A significant goal that can assist to alleviate the negative impacts of climate change and support the transition to a more sustainable and resilient food system is achieving carbon neutrality in the agriculture sector. This can be accomplished by reducing emissions of greenhouse gases. It is possible to achieve carbon neutrality in agriculture through the implementation of a number of different strategies, such as lowering greenhouse gas emissions through the implementation of sustainable agricultural practises and offsetting any remaining emissions through the utilization of carbon credits or other offset programmes. Table 1 provides brief explanations on techniques to achieve carbon neutrality in agriculture.

Table 1: Techniques to achieve carbon neutrality in agriculture

Technique	Description
Reducing methane emissions from livestock	Improving the feed and management of livestock. Methane emissions can be reduced by feeding animals a high-fibre, low-protein diet. Providing animals with enough space and sociability can also minimize methane emissions. Capturing and using methane from manure for energy. Livestock manure contains methane that can be utilized as energy. Anaerobic digestion systems can break down manure's organic materials to produce methane for energy or heat. Approaches to limit methane emission can greatly reduce the agricultural carbon footprint (Sah & Devakumar, 2018).
Reducing nitrous oxide emissions from synthetic fertilizers	Improving soil health to decrease synthetic fertilizers and nitrous oxide emissions. This can be accomplished via techniques like as cover cropping, composting, and mulching, which enhance the soil's structure and fertility. Using more efficient fertilizers: Slow-release synthetic fertilizers lessen nitrous oxide emissions. Using fertilizers suited to soil and plant nutrient needs can also reduce fertilizer use and nitrous oxide emissions. Use of alternative sources of nutrients such as compost and animal manure. These fertilizer sources can improve soil health, provide plants with nutrients, and reduce nitrous oxide emissions.
Conservation agriculture	Practices such as no-till farming and cover cropping that help to improve soil health and reduce carbon dioxide emissions. Water conservation and pest/weed management will help achieve carbon neutrality.
Renewable energy	Providing electricity to irrigation pumps and other machinery through the utilization of renewable energy sources such as solar and wind power.
Planting trees and other	Detoxifying the air by using photosynthesis to remove carbon

vegetation	dioxide.
Carbon sequestration	Carbon sequestration strategies, which include reforestation and afforestation, help plants take up and store carbon dioxide.
Carbon capture and storage	Keeping carbon dioxide from being released into the environment by capturing and storing emissions from agricultural sources underground.
Carbon pricing	Carbon pricing aims to reduce greenhouse gas emissions by pricing carbon dioxide emissions. By pricing carbon, emitting greenhouse gases will become more expensive, creating an economic incentive to limit emissions.
Carbon offsetting	Offsetting carbon emissions by reducing or eliminating an equal amount of carbon dioxide from the atmosphere.

Examples of Carbon Neutral Agriculture Initiatives across the Globe

Several organizations and programmes strive to create carbon neutrality in the agriculture industry. These efforts have the potential to offer other nations and organizations who are interested in reaching carbon neutrality in agriculture significant examples and lessons.

The Carbon Neutral Farms programme in New Zealand, launched in 2015 by the Ministry of Primary Industries and the Ministry of the Environment, is one example. Farmers in New Zealand are offered assistance through this initiative, which is supported by the government of New Zealand. The programme encourages farmers and ranchers to embrace sustainable agricultural techniques and build carbon offset projects. The initiative provides a certification mechanism for farmers who may verify that their businesses have achieved carbon neutrality. Another example is the Natural Resources Conservation Service's administration of the Carbon Farm Plan in the United States (NRCS). Farmers who are interested in implementing sustainable agriculture techniques and constructing carbon offset projects on their operations receive technical and financial assistance through this programme. The programme emphasizes a variety of measures, including conservation agriculture, precision farming, and manure management, in addition to carbon offset programmes such as reforestation and afforestation, methane capture and destruction, and renewable energy projects. A third example is the Carbon Neutrality Coalition in Europe, an effort of the European Commission that intends to facilitate the transition to a carbon-neutral

economy in Europe. The coalition is interested in many different areas, such as agriculture, and wants to speed up the use of clean technologies and the creation of carbon offset projects. It is backed by a network of partners, which includes governments, businesses, and research institutions. It gives farmers money, technical help, and other support to help them switch to sustainable farming practises and start carbon-offsetting projects. These initiatives and programs provide valuable examples of how carbon neutrality can be achieved in the agriculture sector through the adoption of sustainable agriculture practices and the development of carbon offset projects

Initiatives to Bring Carbon Neutrality in Agriculture in India

India is a prominent player in the global agriculture industry and is also promoting carbon neutrality in this area. Agricultural development in India is good for mitigation of carbon in the long run (Zafar *et al.,* 2022). Numerous initiatives and activities in India are geared toward achieving carbon neutrality in agriculture, including the following:

The National Action Plan on Climate Change: This plan, which was established by the Government of India in 2008, lays out a variety of policies and activities for tackling climate change, including those that pertain to the agricultural industry. As part of the strategy, there will be an emphasis placed on environmentally friendly agricultural methods including precision farming and conservation agriculture, and there will also be help provided for the creation of carbon offsetting enterprises.

The National Mission on Sustainable Agriculture: This mission, which was initiated by the Government of India in 2010, is geared toward the reduction of greenhouse gas emissions from the agricultural sector as well as the promotion of sustainable agricultural practises within India. The objective encompasses a wide range of operations, including the development of carbon offset projects, training programmes for farmers and extension services, research and development, and more.

The National Initiative on Climate Resilient Agriculture: This programme, which was started by the government of India in 2011, is geared on assisting farmers in adjusting to the effects of climate change as well as lowering the amount of greenhouse gas emissions they produce. The strategy encompasses a variety of activities, including training programmes, extension services, and the creation of carbon offset projects.

The National Adaptation Fund for Climate Change: The Government of India established this fund in 2015 to provide financial and technical support to state and municipal governments for the development and implementation of adaptation projects, especially those in the agriculture sector. The fund supports a variety of initiatives, including the development of drought-resistant crops and the implementation of sustainable agricultural techniques.

These initiatives and activities illustrate the Government of India's dedication to fostering carbon neutrality in the agriculture sector and facilitating the transition to a more sustainable and resilient food system and greenhouse gas emission from agriculture can be reduced significantly in the country with adoption of various mitigation practices (Sapkota *et al.*, 2019).

Challenges to Achieving Carbon Neutrality in Agriculture

Achieving carbon neutrality in the agriculture sector is a crucial objective that can help alleviate the negative effects of climate change and facilitate the transition to a more sustainable and resilient food system. However, in order to attain carbon neutrality in agriculture, a number of obstacles must be surmounted. Some of the primary obstacles include:

Measuring and verifying greenhouse gas emissions and reductions: Due to the complexity of the agriculture industry as well as the diversity of the sources of greenhouse gas emissions, it can be difficult to accurately measure and verify both the sector's greenhouse gas emissions and the reductions in those emissions. Developing reliable and precise methods for monitoring emissions and reductions is a crucial step toward attaining carbon neutrality, since it enables farmers to track their progress and verify that their actions are having an effect.

Ensuring that offset programs accurately reflect emissions reductions: Carbon offset programmes, which enable companies to offset their emissions by funding initiatives that reduce or remove greenhouse gases from the atmosphere, can be a valuable tool for reaching carbon neutrality in agriculture. To provide a trustworthy and transparent method of offsetting remaining emissions, it is essential, however, that these programmes accurately and effectively reflect emissions reductions.

Providing support and incentives to farmers and ranchers to adopt sustainable agriculture practices: Adopting sustainable agriculture methods can contribute to the

reduction of greenhouse gas emissions and facilitate the transition to a more sustainable and resilient food system. However, it can be difficult to give farmers with the required support and incentives to implement these methods, particularly in underdeveloped nations where resources and capability may be limited. Providing support and incentives, such as training, technical assistance, and financial aid, can be an effective method to encourage farmers and ranchers to adopt sustainable agricultural practises and reach carbon neutrality.

In spite of the difficulties involved, reaching the aim of carbon neutrality in the agricultural industry is a significant objective that can contribute to the reduction of the harmful effects of climate change and support the transition to a food system that is more sustainable and resilient.

Conclusion

In conclusion, carbon neutrality in the agriculture sector is an important objective that can mitigate the negative effects of climate change and facilitate the transition to a more sustainable and resilient food system. Carbon neutrality in agriculture necessitates a combination of techniques, including the reduction of greenhouse gas emissions through sustainable agriculture practises and the offsetting of remaining emissions through carbon credits or other offset schemes. There are a number of initiatives and programs that are working to promote carbon neutrality in the agriculture sector, in both developed and developing countries. These initiatives provide valuable examples of how carbon neutrality can be achieved in the agriculture sector and can serve as models for other countries and organizations.

However, achieving carbon neutrality in agriculture involves obstacles, such as the requirement to quantify and verify greenhouse gas emissions and reductions, ensure the accuracy of offset programmes, and provide assistance and incentives for farmers to adopt sustainable agriculture methods. To address these difficulties, governments, industry, and other stakeholders will need to do continuing research and development and collaborate.

Significant potential exists for carbon neutrality in the agriculture sector, and reducing emissions from this sector will be an integral aspect of global efforts to combat climate change. By supporting sustainable agriculture practises and implementing efficient carbon offset programmes, we can support the transition to a more sustainable and resilient food system and reduce greenhouse gas emissions.

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