**Review Article**

# Strategies for Minimizing Greenhouse Gas Emissions in Agriculture through Sustainable Agriculture Practices


## ABSTRACT

The growing global population has resulted in anincreased demand for agricultural products.The second-largest source of releases of greenhouse gases is agriculture, which includes land use, agricultural production, and animal husbandry. Consequently, there has been a rise in GHG emissions.The three main greenhouse pollutants (often referred to as GHGs) that are contributing to the phenomenon of global warming and its many catastrophic effects are carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), and methane ($CH_4$). Despite being generated in lesser amounts than the greenhouse gas carbon dioxide ($CO_2$), methane, also called $CH_4$, and the gases nitrous oxide ($N_2O$) have a higher potential to contribute to global warming. Thisresearchwill examinethe factors affecting greenhouse gas emissions, including organic (crop species, animal dung, composted manure, and biosolids) and inorganic (such as fertilizers containing phosphate, nitrogen, and potassium) variables.Major sources of agricultural GHG emissions include agricultural soils, field burning of agricultural wastes, enteric fermentation, manure management, and liming. Strategies to mitigate GHG emissions from agriculture encompass improving crop residue management, enhancing nitrogen use efficiency in plants, optimizing nutrient management, implementing sustainable livestock production and feeding practices, adopting climate-smart agriculture, and reducing methane emissions.In this paper deals with the future trends in carbon reduction.



**Keywords:** *Greenhouse gases; sustainability; ecology;environmental pollution;climate-smart agriculture*




## 1. Introduction

Greenhouse gas (GHG) emissions are mostly caused by human-caused events, mostly in the agricultural industry. Because they absorb and release energy from the atmosphere below them, gases such as carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$) are especially contributing to changing the environment on Earth (Shakoor et al. 2021). The potential to cause warming of methane ($CH_4$) and nitrous oxide ($N_2O$) is approximately twenty-one times that of the gases carbon dioxide ($CO_2$), despite their lower levels of emissions (Thangarajan et al. 2013). Roughly 12%of the world's anthropogenic greenhouse gas emissions are caused by farming. The atmospheric concentration of carbon dioxide ($CO_2$) has risen progressively since the Industrial Revolution and is today 100 parts per million (ppm) more than what it was before (Shibata et al. 2016). According to recent studies, the amount of nitrous oxide ($N_2O$) levels in the atmosphere rose from around 270 parts per billion (ppb) in the period before industrialization to 319 ppb in 2005. Between 2000 and 2030, overall GHG emissions are expected to rise by about 50%, with additional effects on the natural environment and climate. Perhaps one of the greatest risks to humanity is climate change's impact, which jeopardizes our common future (Holden et al. 2014). The effect of climate change has an impact on the five Ps: people, planet, partnership, prosperity, and peace (Mpabangaet al. 2020). Persistent rising temperatures and times of biotic and abiotic stress are the primary effects of climate change. All of these variables worsen our present economic situation, increase food insecurity, and raise social vulnerability and inequality (Hasegawa et al. 2018). The empirical evidence indicates that the primary cause of documented increasing temperature events and climate disasters is the documented continual and persistent emission of atmospheric greenhouse gases (GHGs), such as carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$), into the atmosphere. Greenhouse gases can be produced naturally or by biological mechanisms. The most significant danger to humanity is the phenomenon of climate change, which is brought on by an increase in the total amount of greenhouse gases in the atmosphere. The levels of carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), and methane ($CH_4$) concentrations have increased by 150%, 40%, and 20%, respectively, since before the Industrial Revolution.One of the key economic sectors and the source of both food and nutrition security is agriculture. Nevertheless, it contributes around 16% of the country's overall emissions of greenhouse gases, which either directly or indirectly contribute to global climate change. Out among several greenhouse gases possessing relative atmospheric warming potentials (GWP), nitrous oxide ($N_2O$) and methane ($CH_4$), two non-$CO_2$ gases, make up an important percentage of agricultural-related emissions. According to estimations from 2018, the emission of carbon dioxide, the primary human emission of greenhouse gases (GHG), is responsible for over 81% of the global greenhouse gas emissions in the European Union (EU).With 10%-6% and 6% of the emissions, accordingly, methane and nitrogen oxide (NO) come next. Despite possessing relatively low atmospheric quantities, methane and nitrous oxide contribute significantly to emissions of greenhouse gases. This is connected to the global warming potential, which determines how much heat one kilogram of petrol can absorb over a century. Nitrous oxide ($N_2O$) is 265–310 times more powerful than the greenhouse gases carbon dioxide ($CO_2$), and methane ($CH_4$) is 21–36 times more potent. The length of time that gases stay in the upper atmosphere is another crucial factor. Nitrous oxide also referred to as $N_2O$, may remain in the atmosphere for several millennia and is quicker to be broken down than atmospheric carbon dioxide. The compounds nitrogen oxide($N_2O$) and the gas carbon dioxide require several millennia to break down and stay in the earth's atmosphere, but methane only lasts for around 12 years (Myhre et al. 2014). Agriculture-related releases of greenhouse gases can act as both sources and sinks. Approximately 10% of the carbon dioxide ($CO_2$) in the atmosphere passes through agricultural soils annually, and the soil stores massive quantities of organic carbon. This highlights the potential influence of soil on greenhouse gas emissions. The agricultural sector is thought to be responsible for about 40% of anthropogenic methane ($CH_4$) emissions, 70% of human-caused environmental ammonia ($NH_3$) emissions (primarily from the application of livestock manure and inorganic fertilizer), and 80% of human-caused environmental nitrous oxide ($N_2O$) emissions. To fulfill the increasing demand for rice, fertilizer use has significantly increased over the past 70 years, and rice agricultural areas have expanded globally. precisely a result, the magnitude of greenhouse gas (GHG) emissions per tonne of food grain production has dropped by 15%, whereas the concentration of pollutants per hectare of land utilized for food grains has grown by over 90%.These changes are attributed to advancements in agricultural practices,including the use of high-yielding variety (HYV) crops and improved crop and animal management techniques.Despite these improvements,there has been no significantincrease in the rice cultivation area or the population of ruminant animals, which are the main methane emitters (Gupta et al. 2021).

## 2. Impact of GHG Emissions.

The mechanism that controls Earth's temperature and renders it habitable is known as the natural greenhouse effect. The Earth's surface would be around 19 degrees Celsius colder in the absence of this impact (Kweku et al. 2018). This impact is caused by greenhouse gases (GHGs), which take in and release radiation into the atmosphere of the world. The primary greenhouse gases are ozone ($O_3$), carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), and water vapour ($H_2O$). The effect of greenhouse gases, more commonly referred to as global warming, is intensifying as a result of these gases' rising atmospheric concentration.

Methane and nitrous oxide are the next most common anthropogenic greenhouse gases in the European Union (EU), accounting for around 81% of global GHG emissions. Methane($CH_4$) and nitrous oxide($N_2O$) contribute significantly to greenhouse gas emissions while having relatively low concentrations in the atmosphere because of their tremendous potential for causing global warming. Methane ($CH_4$) is 21–36 times more potent than Carbon dioxide ($CO_2$), and the nitrous oxide it produces is 265–310 times more potent than Carbon dioxide($CO_2$), according to (Myhre et al. 2014). How long these greenhouse gases stay in the atmosphere is another crucial factor. According to (Myhre et al.2014), methane and nitrous oxide($N_2O$) have half-lives of around eleven and 121 generations, respectively, while carbon dioxide($CO_2$), another greenhouse gas, may stay in the surroundings for years.

**Table 1. Cumulative $CO_2$ emissions of top emitting countries from 1750-2020 (MT = Metric Megatons)**

| Rank | Country | $CO_2$ Emissions(MT) |
|---|---|---|
| 1 | United States | 421,907 |
| 2 | China | 249,353 |
| 3 | Russia | 117,548 |
| 4 | Germany | 93,291 |
| 5 | United Kingdom | 78,509 |
| 6 | Japan | 65,711 |
| 7 | India | 57,105 |
| 8 | France | 39,106 |
| 9 | Canada | 34,115 |
| 10 | Ukraine | 30,785 |



## 3. Mainsources and causes of greenhouse gas (GHG)emissions

### 3.1 Sources of Primary Agricultural Greenhouse Gas Emissions

The main sources of greenhouse gas emissions from agriculture, according to the IPCC methodology, include agricultural soils Nitrogen dioxide($N_2O$), field burning of agricultural wastes Methane, Nitrous oxide($CH_4$,$N_2O$), Urea, enteric fermentation Methane($CH_4$), and manure management Methane, Nitrous oxide($CH_4$, $N_2O$). The use of natural and mineral fertilizers is the primary cause of emissions from agricultural soils (37.8%) and enteric fermentation (45%), which were the two major sources. In contrast to Syp's research on greenhouse gas emissions from the EU's agricultural sector in 2014, agricultural soils accounted for 45% of the two primary emission sources, whereas enteric fermentation accounted for 38% (Fig. 1.).The EU's examination of greenhouse gas emissions from agricultural sources between 2005 and 2018 revealed a decreasing trend in emissions from liming, field burning of agricultural wastes, manure management, and enteric fermentation.

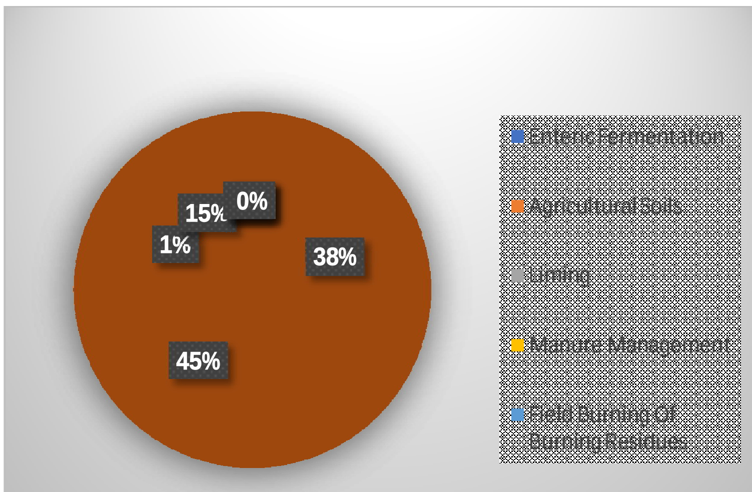


**Fig. 1. European Union's greenhouse gas emissions from agricultural sources**



### 3.2 Crop residue management and agricultural land use

Burning crop leftovers leads tothe loss of essential nutrients such as nitrogen, phosphorous, potassium, sulfur, and organic carbon, whicharecrucial for soil fertility, plant development, and productivity. In addition to contributing significantly to air contamination, this behaviour raises death rates and lowers production from agriculture, posing serious risks to the environment, human wellness, and welfare. According to reports, burning agricultural residues creates heat, which damages important soil microbes and raises the temperatures of the soil. Repeated burningof crop waste in agricultural fields can destroy organic matter and carbon in the topsoil layer, deplete nutrients like nitrogen, and potentially eradicate the microbial population, leading to decreased soil fertility and lower yields overtime. This decline in soil health can ultimately result in decreasedcrop output.According to (Singh et al.2022), onaverage, 90% of the greenhouse gases released from burning crop leftovers are

Carbon dioxide($CO_2$) 8% areCarbon monoxide(CO), and the remaining 2% come from Methane($CH_4$), Sulphur dioxide($SO_2$), NOx, Ammonia($NH_3$),Nitrous oxide($N_2O$), and other sources. Based on estimates of climate change emissions, burning agricultural residue may contribute to 12%–14% of projected global warming(Fig. 2.).

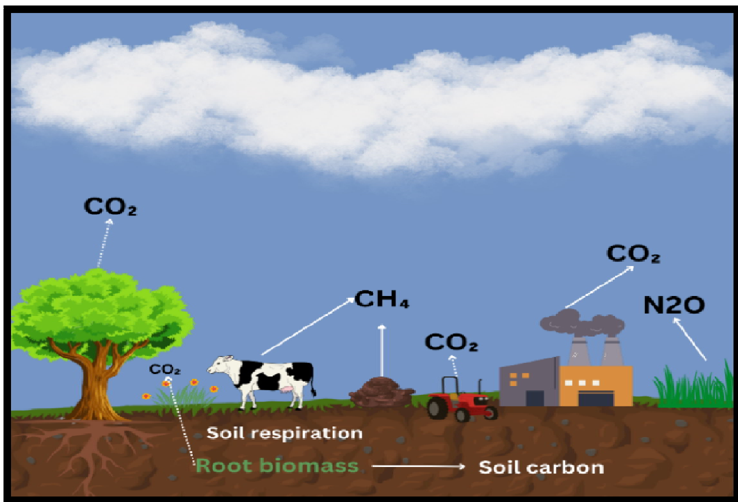


**Fig. 2. Various causes contributing to greenhouse gas emissions**

### 3.3 Agricultural Fertilizers as well as Farming Methods

The second-biggest greenhouse gas emissions, after the power generation industry, is the agricultural sector, which includes farming operations, crop production, and livestock breeding. The development of novel agricultural methods and tools to boost food production and feed animals is becoming more and more popular, and this has served as the subject of research on agriculture all around the world. Nevertheless, it wasn't until the past 20 years that the environmental effects of these agricultural methods were publicly acknowledged. Certain activities' detrimental impacts on the environment, human health, and other people's lives are becoming increasingly apparent. According to the amounts of emissions they generate, carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$) are each of the three primary greenhouse gases that cause global temperatures to rise (Baggs et al. 2010).

### 3.4 Livestock production

Agricultural greenhouse gas (GHG) emissions are mostly caused by ruminant carbon dioxide emissions, rather than crop yield, soils, and crop burning. Estimates available on June 13, 2023, from several sources, place the global contribution of cattle to the emission of greenhouse gases between 11.1% and 19.6%. Approximately 18.4% of global greenhouse gas emissions are produced and emitted by agriculture, with 6.2% coming from livestock and manure, according to other sources. Cattle and sheep are generally referenced when critics highlight the influence that animals, especially ruminants, play in environmental change. However, reducing greenhouse gas (GHG) emissions through livestock remains an especially important objective (Xu et al. 2021).

**3.5 Animal Manure**

Animal manure,approximately seven billion tonnes of which are used in agriculture worldwide(Thangarajanet al. 2013),isbeneficialfor soil health and agricultural output. Its application as organic fertilizer also significantly reduces greenhouse gas emissions. However, it's still uncertain how much greenhouse gas emissions arise from applying manure under different environmental conditions(Shakoor et al.2021). The manure of poultry increases emissions of carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$) more than pig and cow dung, according to a systematic review of research. Spraying fertilizer raised nitrous oxide emissions by an average of 32.7% (95% CI: 5.1%–58.2%) compared to nitrogen-based fertilizer alone. Conversely, organic farming methods contribute to better carbon storage (Gattingeret al. 2012). An anaerobic atmosphere and degradable organic manure (OM) combine to produce methane and other contaminants in animal waste(Fig. 2). The waste from livestock is responsible for around 6% of all environmental greenhouse gas ($CH_4$) emissions, as estimated by (Yusuf et al. 2012).

**3.6 Composed Manure**

Decomposition is a naturally occurring process that turns organic waste into substances that resemble humus. As substances decompose, a variety of pollutants are released, such as carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), and carbon monoxide (CO). The agronomic value of compost is limited by carbon and nitrogen losses, which can also leadto increased greenhouse gas emissions.Improper management of the composting process can contribute to these increased emissions (Chadwick et al.2011).In Nebraska, for example, it was discovered that when cow grazing manure was composted, between 19% and 42% of the overall nitrogen content disappeared through ammonia ($NH_3$) volatilization, and between 46% and 62% of the carbon was lost as carbon dioxide ($CO_2$). The bacterial processes of nitrification and denitrification result in the production of the gas nitrous oxide. Equipment for composting windrows has the potential to greatly enhance the atmospheric release of atmospheric greenhouse gases, especially oxygen ($O_2$), Nitrogen ($N_2$), and Methane ($CH_4$). There are several ways to lower the release of greenhouse gases, including reducing the windrow to increase ventilation and stop the waste from becoming too anaerobic.

## 4. Strategies for Reducing Greenhouse Gases

### 4.1 Improving Management of Crop Residues

Farmers around the world continue to burn crop leftovers as a method of getting rid of agricultural waste, despite the harmfuleffects of air pollution and greenhouse gas emissions on the environment and public health. Thispractice is deeply rooted in many farming systems, but many nations are now implementing policies and taking action to reduce its use. However, burning crops still has a big effect on food supply, food production, the environment, and human health, thus this problem has to be addressed globally (Fig. 3). To tackle this problem,scientists and regulatory bodies in several nations are promoting or implementing efficient crop residue management techniques as alternatives to burning.To prevent the loss of vital nutrients, they are suggesting several strategies for managing agricultural residues, including the prohibition of crop residues, the development and promotion of technologies for their optimal use and in-situ leadership, and the diversification of crop residue's industrial applications. In collaboration with specified government entities, they are also encouraging the use of suitable agricultural machinery in farming operations as well as tracking crop residue management using satellite-based remote sensing technologies (Bhuvaneshwari et al. 2019).

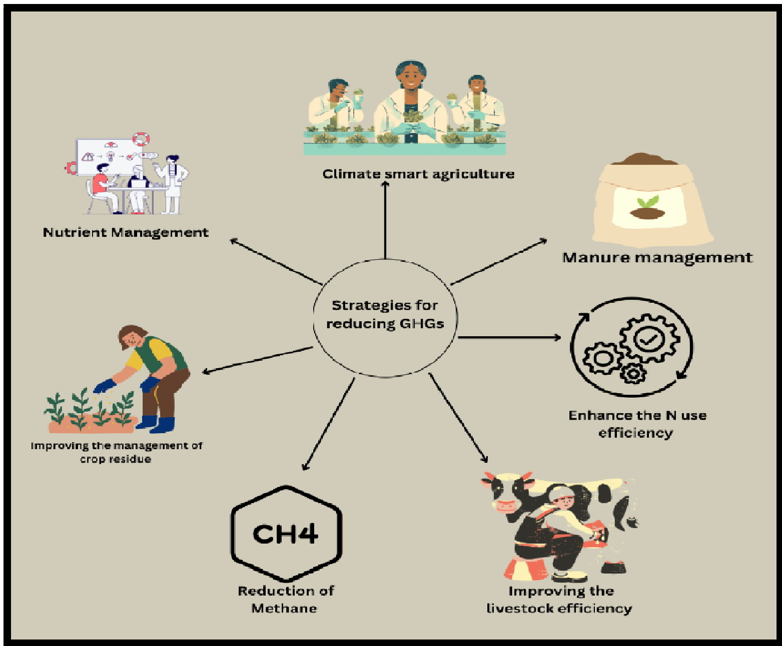


**Fig. 3. Various Strategies for Reducing Emissions of Greenhouse Gases**



### 4.2 Improving Plant Nitrogen Utilization Efficiency

The rate through which nitrogen is absorbed, transported, translocated, assimilated, and remobilized is known called nitrogen utilization effectiveness (NUE), and it provides insight into the link between total nitrogen inputs and outputs. The intricacy of nitrogen uptake and absorption by plants makes breeding for increased NUE difficultyet necessary. A forward-looking genetic approach that addresses the genetic regions that control various aspects of NUE needs to be taken to enhance NUE. This entails concentrating on certain genes or transcription factors that produce genes linked to the absorption, transportation, and absorption of nitrogen. The genes in question can be identified by genome-wide association investigations, fine-mapping of existing QTLs, or quantitative trait location (QTL) research. Additionally, by combining the molecular instruments of downstream genomics with genetic engineering and sequencing technology, we may develop crop varieties that have elevated nitrogen utilization efficiency and get a better understanding of how genes function. Such a strategy can reduce the need for synthetic fertilizers, especially in areas where marsh cultivation is practiced (Fig. 3).

### 4.3 Managing of Nutrients

Concerns have frequently been raised about the excessive, inappropriate, and uneven use of nitrogen and fertilizer in the field. Enhancing agricultural nitrogen consumption efficiency and effectiveness may help lower nitrous oxide (NO) emissions by reducing the possibility of excessive residual nitrate ($NO_3$) in the soil profile (Fig. 3).

**4.4 Manure management**

Some of the most important variables influencing the production of methane, or $CH_4$,in manure management procedures are slurry temperature, inhibition, inoculation with old slurry, hydrolysis rate, and the capacity to decompose organic matter (OM). The activity of microbial cells can be affected by changes in these variables, and research conducted on farmland has shown that such modifications can result in adaption phases and lag phases of different lengths (Dalby et al. 2021). Decomposition provides the potential to drastically lower greenhouse gas emissions. Carbon degradation for methane ($CH_4$) in manure has been determined at $CO_2$ 16.3 kgC Mg1 in the passive aeration treatment, but it was found to be 168.0 and 8.1 kgC Mg1 in the active treatment. The primary reasons for the lower emissions of passive treatment were a decreased gas distribution rate and insufficient compost breakdown. Three specific methods for reducing GHG emissions include adjusting the planting season to decrease the amount of nitrogen oxide ($N_2O$) emissions from soil and anaerobic digestion of animal manure to reduce methane ($CH_4$) emissions during storage (Bai et al. 2020). The demand for meat and dairy products is rising globally, and during the preceding 50 years, meat output has expanded dramatically. By 2050, its size is expected to have doubled or tripled, achieving an annual total of 340 million tonnes (Mahesh et al. 2014). Animal husbandry is a major source of methane ($CH_4$) emissions worldwide as of the 26th of April 2023.Despite the potential negative effects associated with meat and dairy products (Shaheen et al. 2016). In many countries, they are also important suppliers of vital minerals, vitamins, and proteins that are good for people's wellness. Methane ($CH_4$) and other greenhouse gases are released during the manufacturing of animals and dairy products, which has an impact on the climate. The demand for meat and dairy products is rising worldwide, and during the last 50 years, there has been a notable growth in meat production. By 2050, it is expected to have expanded by two to three times, to reach 340 million tonnes annually (Mahesh et al.2014). As of April 26, 2023, animal farming has a highly documented contribution to world Methane ($CH_4$)emissions. Although meat and dairy products provide possible health hazards(Shaheen et al.2016).They are also key sources of proteins, vitamins, and critical minerals that are beneficial to human health in many nations.Similar to how the production of dairy and meat affects the climate, it also releases greenhouse gases like Methane($CH_4$) (Fig. 3).

### 4.5 Climate Smart Agriculture

Climate-smart agriculture (CSA), a promising agricultural innovation, integrates traditional farming practices with technologies to increase agricultural output while lowering greenhouse gas emissions and taking climate limitations into account. Accordingly, CSA encompasses better food system vulnerability and climate change adaptation; environmentally friendly farming methods that promote increased crop yields, profitability, and income; and, to the greatest extent feasible, the reduction of greenhouse gas emissions (Pinto et al. 2020; McNunnet al. 2020). Numerous farm-level studies included in the scientific literature have demonstrated that the execution of CSA methods improves and increases crop yields in terms of quality and quantity, net income, efficient use of investment materials, and—above all—the decreasing of emission of greenhouse gases. techniques that are carbon-smart and reduce greenhouse gas emissions (Maraseniet al. 2021). Reducing the usage of pesticides is the aim of integrated pest management or IPM. Agroforestry, or (AF), and feeder management (FM) both prioritize sustainable land management and carbon emission reduction. By reducing the loss of nutrients, concentrate feeding (CF) reduces the quantity of food that animals require (Fig. 3).

### 4.6 Reducing Methane($CH_4$) Emissions

Existing research suggests that it is possible to reduce methane emissions into the atmosphere by 20%-40% through continuous improvement of production efficiency using current technology (Sudmeyeret al.2014).Methane emissions from livestock farms depend on factors such as the number of animals, the type and amount of feed theyconsume, and their digestive systems. Different animals emit different amounts of methane per unit of feed consumed, indicatingpotential geneticdifferences in methane generation.Selecting genetic lines of cattle and sheep on farms can lead tolower methane emissions as a function of productivity,suchas feed conversion(Fig. 3).

## 5. Sustainable Agriculture Practices for reducing GHG

### 5.1 Greener farming systems

Farming practices that are more environmentally friendly and sustainable can significantly reduce greenhouse gas emissions. There are various types of these systems.Some improve input usage efficiency, such as precision farming, while others favor safer alternatives by rejectingcertain inputs or activities.This chapter covers more examples of techniques that redesign systems to maximize the ecological interactions that support them. These approaches are known as functional biodiversity, ecofunctional intensification, agroecosystem management, and agroecology. Integrated pest control, integrated farming, organic farming, conservation agriculture, agroforestry, and permaculture are a few examples of these strategies(Fig. 4).

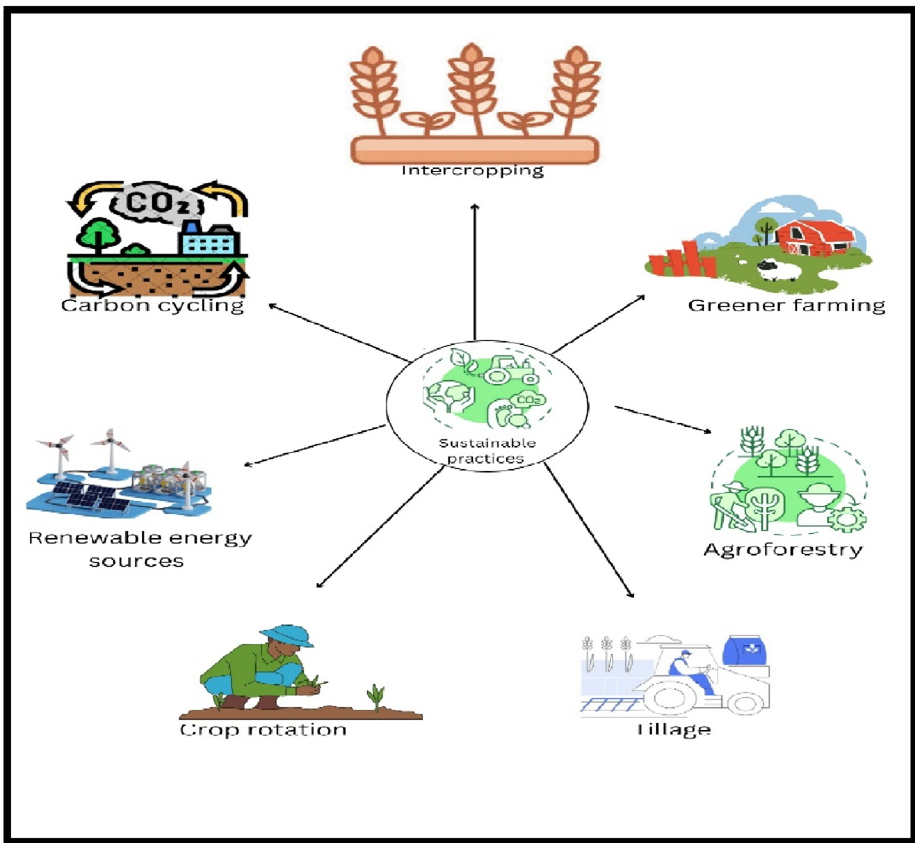


**Fig. 4. Sustainable Agriculture Practices**

## 5.2 Agroforestry Systems

The use of agroforestry systems, especially the accumulation of leaf litter by tree species that produce large amounts of leaves (e.g., hybrid poplar), can promote improved nitrogen-use efficiency in crop production. This can decrease the need for mineral fertilizer and the resultingNitrous oxide($N_2O$) emissions. Agroforestry systems may also potentially reduce Nitrous oxide($N_2O$) from denitrification in surface water byminimizing leaching (Smith et al. 2013). Additionally, agroforestry systems can decrease ammonia ($NH_3$) levels(Fig. 4).

### 5.3 Resources for Renewable Energy

Renewable energy sources are believed to be limitless and sustainable, in contrast to fossil fuels. The following information discusses this. Globally, geothermal energy, biomass, solar, wind, and hydropower are examples of renewable energy sources. In the last few years, there has been a notable growth in the use of solar technologies to create grid energy, including solar photovoltaic (PV), concentrated solar power (CSP), solar thermal electricity (STE), and solar hot water (Nathan et al. 2018; Bolaget al. 2021). The optimal placement and size of PV distributed generation (PV-DG) are examined from two different perspectives in the literature. One approach employs a renewable energy process to achieve a desired single or multi-objective function by use of search algorithms and energy process limitations. The improperallocation of PV-DGs can reduce energy process potential and increase energy loss, limiting the penetration level. Another perspective explores the potential of PVsources for networkconnection and can be broadly classified into four categories: technological, geographical, theoretical, and economical. Each potential has unique parameters and mathematical models, which can be influencedby national policies and legislation.It's important to consider the energy processcapabilities in investigatingthe potential of PV sources (Fig. 4).

### 5.4 Conservation Tillage

To accomplish the profitable and sustainable intensification of agricultural systems, the agroecological technique known as preservation tillage-conservation agriculture (CA), which is based on locally established methods, uses three interrelated principles: crop rotations, permanent soil cover, and minimal soil disturbance. According to (Basavanneppaet al.2017; Yadav et al.2017), conservation agriculture (CA) can alter the physical, chemical, and biological characteristics of soil quality, which sets it apart from conventional tillage (CT) systems. By enhancing soil carbon sequestration sinks, improved bio-physico-chemical soil health mitigates climate unpredictability, which impacts ecosystem services and the sustainability of agricultural production systems (Yadav et al. 2017). Conservation agriculture may successfully promote an agricultural production plan that enhances soil microbial life. The functional diversity of soil microorganisms, which are crucial for increased agricultural productivity, soil quality, and several ecosystem services, can also be impacted by CA (Yadav et al. 2017) (Fig. 4).

### 5.5 Intercropping

Growing two or more crops on a field during the same time is known as intercropping, and it is typically utilized in regions with severely degraded soils. As farmers strive to maintain soil health and be more sustainable, combining is gaining popularity as an agricultural practice globally (Corcoran and Glaze., 2020). To supply nitrogen, early research focused on using legume species as intercropping plants (Stagnariet al. 2017). To enhance the soil's quality, several non-monetary plants are being utilized as cover crops (Crusciolet al. 2012). Reports on current studies in this special issue addressed the advantages and challenges of establishing intercropped systems in the most diverse locations of the world: Asia, Europe's northern region, North and South America, and sub-Saharan and Central Africa (Fig. 4).

**5.6 Crop Rotation**

One helpful method in the practice of sustainable agriculture is crop rotation. Diversified Crop Rotation (DCR) is a set or several rotations of three or more crops, as opposed to monocultures or double-farmed rotations (Wang et al. 2020). Rotating the crops is a useful technique in sustainable agriculture. Unlike monocultures or double-farmed assignments, Diversified Crop Rotation (DCR) consists of one or more rotations of three or more crops (Wang et al. 2020). Through fundamental recycling of nutrients, crop rotation systems can interfere with the microbial and disease cycle process, avoid trade-offs between crop viability and environmental consequences, and maintain long-term fertility in the soil (Andam et al. 2016). Different cropping systems are one potential substitute for better-performing agriculture (Hufnagel et al. 2020). This variable agricultural rotation strategy offers several benefits for soil quality by enhancing the condition of the soil and increasing the productivity of systems worldwide. The rotation of crops increases productivity and profit and allows for continued output. Legumes encourage crop rotation, which not only increases cropping intensity but also increases food supply and sales profit margin. Applying a legume cover in crop rotation can provide a substantial amount of nitrogen, called N, to a succeeding crop. The topography greatly impacts the Nepalese system of agriculture and cultivation patterns(Fig. 4).

**5.7 Improvements in carbon cycling can help mitigate greenhouse gas emissions.**

Life with Earth depends on the carbon cycle. It has to do with how carbon moves through the land, seas, atmosphere, and living things. This biological process has been disrupted by human activity, especially the combustion of fossil fuels, which has raised atmospheric carbon dioxide levels and accelerated the rate of global warming. Managing carbon in agricultural soils and plant biomass is crucial to solving this problem. Carbon emissions can be partially mitigated through increasing the amount of carbon stored in soil and plants. Restoring vegetation on underutilised land and using farming techniques that improve soil carbon storage, for instance, can be successful tactics. Furthermore, shifting to a "no-animal products" scenario would lessen the effect of the emissions of greenhouse gases originating from land (Fig. 4).

## 6. Future trends in carbon reduction

The concepts of "carbon peak" and "carbon neutrality" are now significantly affectingtraditional heavy industries such as coal, smelting, and the petrochemical sector. Theseindustries face challengesrelated to excessive carbon emissions, pollution control, and limited development areas. However, they also stand to benefit from advancements in equipment and technology, as well as strong industrial connections. One reason for this is the complexity of the factors influencing global climate and the wide range of anomalies, making it difficult for scientists to fully understand global warming intuitively. In light of potential future trends, low-carbon development needs to be examined from three perspectives.First, there needs tobe an increase in theproduction anduse of hydrogenenergy.Among all fossil fuels, chemical fuels, and biofuels as well hydrogen has the highest density of energy since it is the lightest chemical element. It is more than 10 times more effective than other gases at transmitting heat. Hydrogen fuel cells are appealing in several applications, even if because of budgetary constraints, the economic benefits of hydrogen are still unknown. For instance, a car that uses five kilograms of hydrogen can go 650 kilometers for 27 USD, but a car that uses petrol can do the same for about 54 USD, which is half as costly. From the standpoint of environmental security, burning hydrogen produces no harmful externalities like carbon dioxide ($CO_2$), carbon monoxide (CO), hydrocarbons, or dust particles—only water. As a result, hydrogen has the potential to become the world's cleanest energy source and contribute significantly to humanity's future decarbonization. According to the International Hydrogen Energy Committee, the industrial chain for the production of hydrogen is expected to be worth over 2.5 trillion US dollars by 2050, and it will make up around 18% of the global supply of energy. Because of its high efficiency, affordability, and security, the worldwide hydrogen energy market is expected to grow rapidly during the next ten to twenty years with continued investments in industrial capital and advancements in technology. Accordingly, hydrogen has been described as the 21$^{st}$ century's greatest potential alternative energy source (Abe et al. 2019).

## 7. Conclusions

The primary contributors to greenhouse gas emissions include agricultural activities, livestock production, feed, cultivation methods, and soil fertility management. Given the rising. Global awareness of the climate problem and the significance of environmental issues for the sustainability of the global food production system is growing. The inequalities and lack of development in the current food production systems have been highlighted by the current trend of increasing temperatures, which increases the emissions of greenhouse gases and exacerbates the effects of climate change. The strategies to reduce greenhouse gas emissions from agriculture have been thoroughly examined in this study. Their varied effects on fertilizer consumption and potential to provide abiotic stress tolerance, among other benefits, make them the most promising for sustainability. This entails optimising the use of nitrogen (NUE) and controlling agricultural wastes and their use in various industries. Additionally, increased radial oxygen loss in plants affects the metabolic activity of soil microbes, particularly methane-producing bacteria. The rearing of livestock and the manure it generates continue to be the largest contributors to the emissions of greenhouse gases, although accounting for a considerable portion of the agricultural economy. The best agricultural practices for sustainability might therefore involve enhancing the production of the livestock supply chain, optimizing feed use, and reducing the release of greenhouse gases and production through the use of genetic engineering, breeding, and effective livestock feed utilisation techniques. As part of international initiatives to lessen the consequences of climate change, these areas of great importance may be at the forefront of measures to reduce the contribution that agriculture makes to the world's greenhouse gas (GHG) release records.

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