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Evaluating The Role of Agriculture in Greenhouse Gas Emissions Using The MOORA Method

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Abstract

Agriculture plays a significant role in greenhouse gas emissions, contributing around 20-30% of global emissions, primarily through methane, nitrous oxide, and carbon dioxide. Key sources include livestock digestion, manure management, rice cultivation, and the use of synthetic fertilizers. Deforestation and land-use changes for agricultural expansion also release large amounts of carbon dioxide. Additionally, agriculture's reliance on fossil fuels for machinery and transport further contributes to emissions. Reducing these emissions is essential for mitigating climate change, making it vital to explore sustainable practices like improved livestock management, reduced fertilizer use, and agro forestry to minimize agriculture's environmental footprint. Understanding agriculture's role in greenhouse gas emissions is crucial for developing effective climate change mitigation strategies. As a major source of methane and nitrous oxide, agriculture significantly impacts global warming, making it essential to identify practices that reduce emissions without compromising food security. Research in this area can inform policies promoting sustainable agricultural techniques, such as precision farming, carbon sequestration, and reduced reliance on chemical inputs. By advancing knowledge on emission sources and reduction strategies, this research can help farmers, policymakers, and stakeholders make informed decisions that support both environmental sustainability and agricultural productivity, ultimately contributing to global climate goals. To study agriculture's role in greenhouse gas emissions, a mixed-methods approach combining quantitative and qualitative research is effective. Quantitative data collection includes measuring emissions from various agricultural sources such as livestock, fertilizer application, and land use using tools like gas chromatography and satellite monitoring. Life Cycle Assessment (LCA) can evaluate the emissions impact of different farming practices. Qualitative methods involve interviews with farmers and stakeholders to understand adoption barriers for sustainable practices. Comparative analysis of conventional vs. sustainable techniques highlights effective mitigation strategies. This comprehensive approach enables a nuanced understanding of emission sources and the potential for reducing agriculture's carbon footprint. Alternative taken as Conservation Tillage, Crop Rotation & Diversification, Improved Irrigation Management, Methane Capture from, Manure Methane Capture from. Evaluation preference taken as Emission Reduction Potential (tons CO_2e/ha), Cost-Effectiveness (\$/ton CO_2e), Scalability (% Adoption Rate), Impact on Soil & Water Health. Methane Capture from Manure is getting first place of the table and Improved Irrigation Management is getting last place of the table

Keywords: Conservation Tillage, Crop Rotation & Diversification, Improved Irrigation Management.

I. Introduction

A source refers to any process or activity that emits greenhouse gases (GHGs), aerosols, or GHG precursors into the atmosphere. In contrast, a sink is a mechanism that removes these substances from the atmosphere. Carbon sequestration involves capturing and securely storing carbon that would otherwise be released into or remain in the atmosphere. Agriculture contributes to carbon emissions through direct fossil fuel use in food production, indirect energy use from inputs that require significant energy to produce, and soil cultivation or erosion, which can lead to the loss of soil organic matter.[1] The database and methodology presented in this letter go beyond merely tracking emissions. The results offer valuable insights into the main sources of greenhouse gas (GHG) emissions within the Agriculture, Forestry, and Other Land Use (AFOLU) sector, identifying specific regions and their emission trends.[2] Since emissions present opportunities for reduction, this study's findings can pinpoint regional and activity-based "hotspots" where mitigation actions could be most effective. By identifying region-specific mitigation strategies, this spatial emissions database can help translate identified issues into actionable solutions for reducing emissions. Actions aimed at reducing GHG emissions in agriculture are also crucial for climate adaptation, as boosting carbon sequestration relies on minimizing nutrient losses from agro ecosystems and enhancing biomass and soil carbon stocks (Oliveira et al., 2014).[3] These efforts help sustain high production levels and improve the use of natural resources, particularly soil and water. By reducing emissions, agro ecosystems can achieve a more favorable GHG balance, potentially becoming carbon-neutral or even acting as GHG sinks. Ultimately, decreasing GHG emissions and increasing organic carbon sequestration are primary goals in the transition to low-carbon agriculture.[4] In agriculture, emissions from energy sources are primarily driven by diesel oil, which made up half of the emissions in 2018 and continues to grow. Bituminous coal and electricity also play significant roles, contributing 34% and 11% of emissions, respectively. To identify ways to lower energy consumption and reduce greenhouse gas emissions, comprehensive research was conducted to determine which farms have the highest emissions from energy sources.[5] This research also aims to pinpoint the best opportunities to reduce energy use and, consequently, greenhouse gas emissions. Agricultural activities contribute significantly to greenhouse gas (GHG) emissions, with emissions from agriculture in Africa among the fastest-growing globally.[6] Rising food demand, driven by population growth in Africa and other regions, will likely continue to impact emissions on the continent. This study reviews GHG emissions from Africa's agricultural sector between 1994 and 2014, discussing the policy measures needed for mitigation. Emission ranges were determined by the highest and lowest annual emissions, except in 2014 when only one source was available.[7] The agricultural sector is a major source of greenhouse gas (GHG) emissions, and with a growing global population, high levels of agricultural production will be necessary to meet food demands. Therefore, it is essential to implement mitigation methods to reduce emissions in this sector, as well as to identify and quantify emission sources to enable the agricultural community to act and track progress.[8] International regulations mandate annual reports on agricultural GHG emissions. Accurately attributing emissions to agriculture is crucial; however, the current IPCC approach, as reported to the UNFCCC, excludes emissions from soils during agricultural land-use changes from its agricultural inventory. For instance, transitioning from conventional tillage to no-till agriculture in the U.S. is expected to lead to an average net carbon sequestration of 337 kg C per hectare per year during the first 20 years, which will taper off to nearly zero in the subsequent 20 years, alongside ongoing reductions in CO2 emissions due to less fossil fuel usage.[9] Overall, considering all factors, long-term outcomes are likely to show a decrease in net greenhouse gas emissions. However, the specific quantitative impacts will vary based on site-specific effects of converting to no-till farming on agricultural yields and nitrous oxide (N2O) emissions from nitrogen fertilizers. Agriculture is a significant contributor to greenhouse gas emissions and plays a direct and indirect role in climate change. While there has been ongoing development of technologies to reduce agricultural greenhouse gas emissions, it is crucial that these advancements do not compromise farm productivity or economic viability.[10] To achieve lower GHG emissions in agriculture, climate-smart practices and enhanced food security are essential for creating a climate-resilient landscape. Climate-smart technologies effectively optimize inputs in the fields, helping to reduce greenhouse gas emissions. This article examines the primary sources of carbon emissions within the agricultural sector and reviews efficient methods for mitigating GHG emissions through smart farming technologies. According to publicly available GHG datasets, livestock farming emerges as the largest emitter within agriculture, accounting for 70% of total emissions.[11]

II. Material and Method

Alternative:

1. **Conservation Tillage:** Conservation tillage minimizes soil disturbance, enhancing soil health and moisture retention. It reduces erosion, promotes carbon sequestration, and supports sustainable agriculture practices while lowering greenhouse gas emissions and improving crop yields.
2. **Crop Rotation & Diversification:** Crop rotation and diversification involve alternating different crops to enhance soil fertility, disrupt pest cycles, and improve biodiversity. This practice reduces reliance on chemical inputs and boosts overall agricultural sustainability and resilience.
3. **Improved Irrigation Management:** Improved irrigation management optimizes water use efficiency through techniques like drip irrigation and scheduling. It reduces water waste, enhances crop yields, and minimizes environmental impacts, supporting sustainable agricultural practices.
4. **Methane Capture from:** Methane capture from agricultural waste involves collecting and utilizing methane emissions from manure or organic waste. This process reduces greenhouse gas emissions, generates renewable energy, and enhances sustainability in farming practices.
5. **Manure Methane Capture from:** Manure methane capture involves collecting methane produced from livestock waste. This process reduces greenhouse gas emissions, converts waste into renewable energy, and supports sustainable agriculture by improving nutrient management and soil health.

Evaluation preference:

1. **Emission Reduction Potential (tons CO_2e/ha):** Emission reduction potential (tons CO_2e/ha) measures the effectiveness of agricultural practices in lowering greenhouse gas emissions per hectare. Higher values indicate greater potential for mitigating climate change impacts through sustainable farming methods.

2. **Cost-Effectiveness (\$/ton CO_2e):** Cost-effectiveness (\$/ton CO_2e) evaluates the economic efficiency of reducing greenhouse gas emissions in agriculture. Lower costs per ton indicate more viable practices, facilitating broader adoption of sustainable agricultural strategies.
3. **Scalability (% Adoption Rate):** Scalability (% adoption rate) reflects the feasibility of implementing agricultural practices across various farms. Higher adoption rates signify greater accessibility and practicality, promoting widespread acceptance of sustainable methods within the farming community.
4. **Impact on Soil & Water Health:** Impact on soil and water health assesses agricultural practices' effects on ecosystem quality. Positive impacts improve soil fertility, enhance water retention, and promote biodiversity, fostering sustainable and resilient agricultural systems.

III. Multi-Objective Optimization On the Basis of Ratio Analysis (MOORA)

Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA) is a decision-making method that enables the optimization of multiple objectives by comparing various alternatives based on a set of criteria. This method is particularly useful when dealing with complex decisions that involve conflicting objectives, such as cost, efficiency, and sustainability.[12] MOORA is widely applicable in fields like engineering, economics, management, and environmental science, where decision-makers need to evaluate multiple criteria to identify the best possible option.[13] MOORA was first introduced by Brauers and Zavadskas in 2006 as a simple yet effective technique for multi-objective optimization. The method provides a structured approach for decision-makers to evaluate multiple alternatives by calculating a ratio for each objective. These ratios are then aggregated to generate an overall score for each alternative, allowing them to be ranked accordingly.[14] MOORA is particularly advantageous for its simplicity, as it requires minimal computation and does not demand complex mathematical models or programming. The first step involves defining the alternatives to be evaluated and the criteria by which they will be assessed. For example, in the context of material selection for a windmill, the alternatives might include Aluminum, Stainless Steel, and Carbon Fiber, while the criteria could include cost, weight, durability, and environmental impact.[15] Once the alternatives and criteria are identified, a decision matrix is created to represent the performance of each alternative against each criterion. This matrix is typically structured with rows corresponding to alternatives and columns corresponding to criteria. Each cell in the matrix contains a value that quantifies the performance of a particular alternative with respect to a specific criterion. Normalization is essential in MOORA as it ensures that all criteria are comparable. This process involves scaling the values in the decision matrix to a common range, typically by dividing each value by the square root of the sum of squares of all values within the same criterion column.[16] The normalized matrix allows for objective comparisons between criteria, even if they originally have different units or scales. For each alternative, a ratio is calculated based on the normalized values. The ratio is determined by separating the criteria into beneficial and non-beneficial categories. Beneficial criteria are those where higher values are preferable, such as efficiency or durability, while non-beneficial criteria are those where lower values are better, like cost or environmental impact.[17] The ratios are calculated by adding the normalized values of the beneficial criteria and subtracting the normalized values of the non-beneficial criteria. Each alternative's overall score, or composite score, is derived by combining the calculated ratios. This composite score provides an aggregated value that reflects the performance of each alternative across all criteria. Alternatives with higher scores are considered more favorable, while those with lower scores are ranked lower in the optimization process. Finally, the alternatives are ranked based on their composite scores. The alternative with the highest score is considered the most suitable option based on the multi-objective optimization process, while alternatives with lower scores are ranked accordingly. This ranking provides a clear indication of which option best satisfies the selected criteria.[18]

IV. Result and Discussion

Table 1. Green house gas emission

alternative	Emission Reduction Potential (tons CO_2e/ha)	Cost-Effectiveness (\$/ton CO_2e)	Scalability (% Adoption Rate)	Impact on Soil & Water Health
Conservation Tillage	2.20	12.00	65.00	4.00
Crop Rotation & Diversification	1.80	14.00	55.00	5.00
Improved Irrigation Management	1.50	11.00	70.00	4.00
Methane Capture from Manure	3.50	22.00	40.00	3.00
Use of Cover Crops	2.00	16.00	50.00	5.00

The dataset evaluates five agricultural practices for their greenhouse gas emissions reduction potential. Conservation Tillage offers a reduction of 2.20 tons CO_2e/ha at \$12/ton, with a 65% adoption rate and a positive soil impact (4/5).

Crop Rotation & Diversification reduces emissions by 1.80 tons CO_2e/ha for $14/ton and is highly beneficial for soil health (5/5), with a 55% adoption rate. Improved Irrigation Management shows a potential of 1.50 tons CO_2e/ha at $11/ton, widely adopted (70%) with a soil impact of 4/5. Methane Capture from Manure reduces 3.50 tons CO_2e/ha, but it's costlier ($22/ton) and less scalable (40%, soil impact 3/5). Lastly, Use of Cover Crops offers 2.00 tons CO_2e/ha reduction for $16/ton, with a 50% adoption rate and strong soil health benefits (5/5).

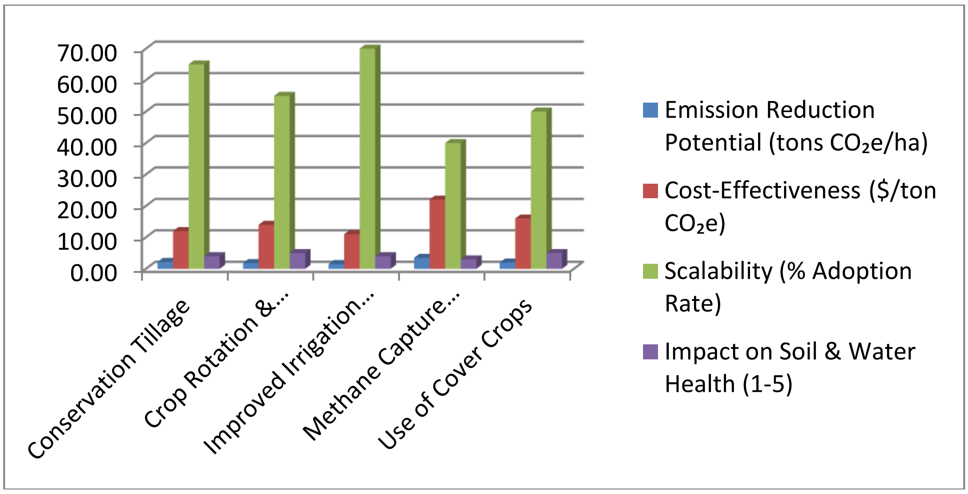

Figure 1. Greenhouse gas emission

The bar graph compares five agricultural practices based on four key parameters: emission reduction potential, cost-effectiveness, scalability, and impact on soil and water health. Conservation Tillage and Crop Rotation & Diversification show high emission reduction potential and scalability, with strong benefits for soil health. Improved Irrigation Management has the lowest emission reduction potential but the highest scalability. Methane Capture from Manure presents significant emission reductions, but its cost-effectiveness is lower, and scalability is limited. Use of Cover Crops demonstrates good emission reduction and soil health impact, although its adoption rate is moderate compared to the others.

Table 2. Green house gas

Conservation Tillage	4.84	144	4225	16
Crop Rotation & Diversification	3.24	196	3025	25
Improved Irrigation Management	2.25	121	4900	16
Methane Capture from Manure	12.25	484	1600	9
Use of Cover Crops	4	256	2500	25

This dataset evaluates five agricultural practices by four metrics: emission reduction potential, cost-effectiveness, initial investment, and impact score. Conservation Tillage has an emission reduction potential of 4.84 tons CO_2e/ha, with a cost of $144 per ton and an initial investment of $4,225, scoring 16 in impact. Crop Rotation & Diversification offers 3.24 tons CO_2e/ha reduction, costing $196 per ton with a $3,025 investment and an impact score of 25. Improved Irrigation Management shows a lower potential (2.25 tons CO_2e/ha) but costs $121 per ton and requires $4,900, also scoring 16. Methane Capture from Manure excels with 12.25 tons CO_2e/ha, but at a high cost of $484 per ton and $1,600 investment, scoring 9. Use of Cover Crops achieves 4 tons CO_2e/ha reduction, costing $256 per ton with a $2,500 investment and a high impact score of 25.

Table 3. Normalized data

	Emission Reduction Potential (tons CO_2e/ha)	Cost-Effectiveness ($/ton CO_2e)	Scalability (% Adoption Rate)	Impact on Soil & Water Health (1-5)
Conservation Tillage	0.4267	0.3463	0.5099	0.4193
Crop Rotation & Diversification	0.3491	0.4040	0.4315	0.5241
Improved Irrigation Management	0.2909	0.3174	0.5491	0.4193

Methane Capture from Manure	0.6789	0.6348	0.3138	0.3145
Use of Cover Crops	0.3879	0.4617	0.3922	0.5241

This normalized dataset presents five agricultural practices based on four performance metrics standardized on a scale of 0 to 1. Conservation Tillage scores 0.4267 for emission reduction potential, 0.3463 for cost-effectiveness, 0.5099 for scalability, and 0.4193 for impact on soil and water health. Crop Rotation & Diversification has scores of 0.3491, 0.4040, 0.4315, and 0.5241, respectively. Improved Irrigation Management shows lower values with 0.2909 for emission reduction and 0.3174 for cost-effectiveness, but a higher scalability score of 0.5491. Methane Capture from Manure excels in emission reduction potential (0.6789) and cost-effectiveness (0.6348) but scores lower in scalability (0.3138) and impact (0.3145). Use of Cover Crops scores 0.3879, 0.4617, 0.3922, and 0.5241, indicating balanced effectiveness across metrics.

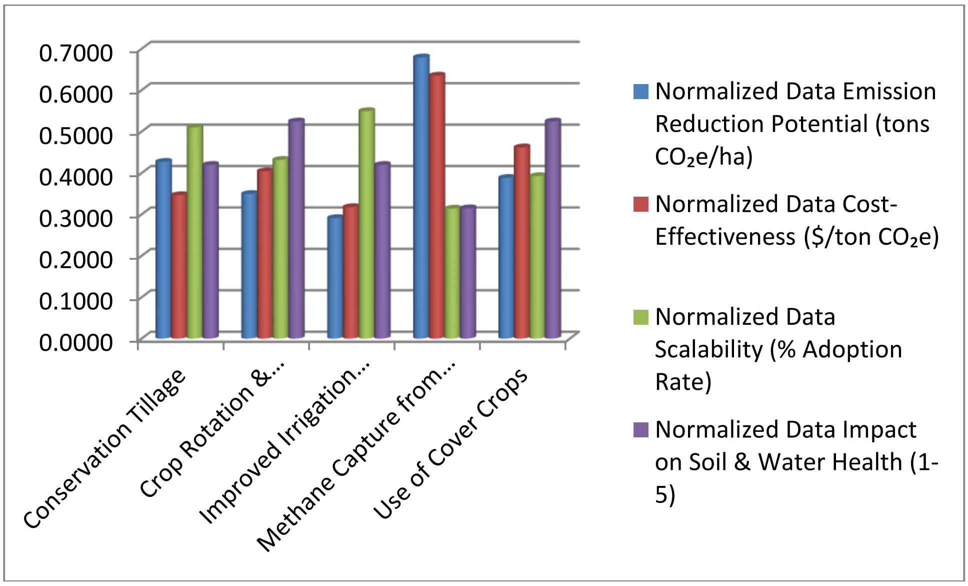

Figure 2. Normalized data

The bar graph illustrates the normalized data for five agricultural practices across four key metrics: emission reduction potential, cost-effectiveness, scalability, and impact on soil and water health. Methane Capture from Manure leads in emission reduction potential, indicating its effectiveness in lowering greenhouse gas emissions. Crop Rotation & Diversification scores well in cost-effectiveness and impact on soil health, while Conservation Tillage shows balanced scores across all metrics. Improved Irrigation Management has the highest scalability score, highlighting its potential for widespread adoption. Use of Cover Crops demonstrates consistent performance, particularly in soil health, indicating overall benefits to sustainable agriculture.

Table 4. Weight

Conservation Tillage	0.25	0.25	0.25	0.25
Crop Rotation & Diversification	0.25	0.25	0.25	0.25
Improved Irrigation Management	0.25	0.25	0.25	0.25
Methane Capture from Manure	0.25	0.25	0.25	0.25
Use of Cover Crops	0.25	0.25	0.25	0.25

The weight distribution in this dataset indicates that each agricultural practice is evaluated with equal importance across four key metrics: emission reduction potential, cost-effectiveness, scalability, and impact on soil and water health. Each practice Conservation Tillage, Crop Rotation & Diversification, Improved Irrigation Management, Methane Capture from Manure, and Use of Cover Crops receives a weight of 0.25 for each metric, reflecting a balanced assessment approach. This uniform weighting ensures that no single factor disproportionately influences the overall evaluation, promoting a comprehensive understanding of each practice's contribution to sustainable agriculture and greenhouse gas mitigation.

Table 5. Weighted normalized decision matrix

Conservation Tillage	0.1067	0.0866	0.1275	0.1048
Crop Rotation & Diversification	0.0873	0.1010	0.1079	0.1310
Improved Irrigation Management	0.0727	0.0794	0.1373	0.1048
Methane Capture from Manure	0.1697	0.1587	0.0784	0.0786
Use of Cover Crops	0.0970	0.1154	0.0981	0.1310

The weighted normalized decision matrix evaluates five agricultural practices by incorporating weights for four key metrics: emission reduction potential, cost-effectiveness, scalability, and impact on soil and water health. Each practice's score reflects its performance in these areas. Methane Capture from Manure scores highest in emission reduction potential (0.1697) and cost-effectiveness (0.1587), indicating its strong impact on reducing greenhouse gases. Crop Rotation & Diversification and Use of Cover Crops perform well in overall impact scores. Conservation Tillage and Improved Irrigation Management provide balanced contributions but score lower, suggesting a need for further optimization in those areas.

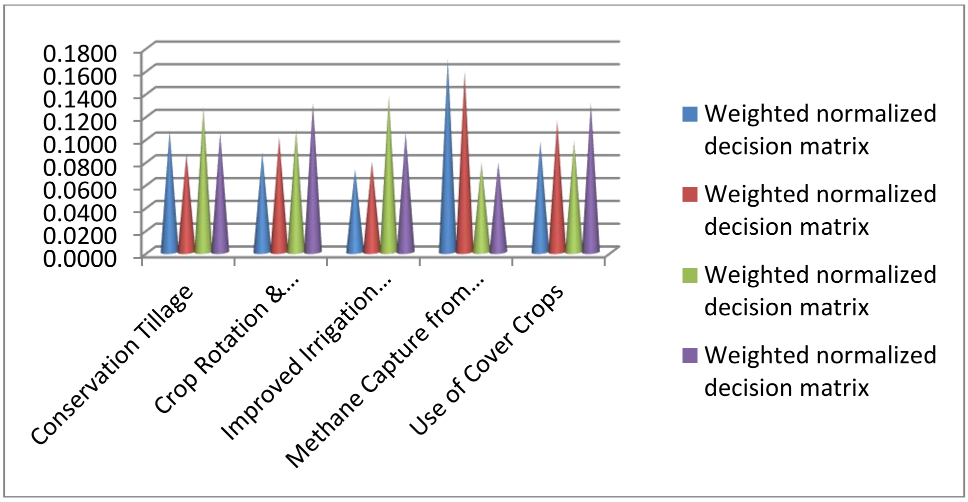

FIGURE 3. Weighted normalized decision matrix

The bar graph displays the weighted normalized decision matrix for five agricultural practices based on four metrics: emission reduction potential, cost-effectiveness, scalability, and impact on soil and water health. Each color represents a specific metric across the practices: Conservation Tillage, Crop Rotation & Diversification, Improved Irrigation Management, and Methane Capture from Manure, and Use of Cover Crops. Methane Capture from Manure consistently shows the highest values in emission reduction potential and cost-effectiveness, indicating its strong overall performance. In contrast, other practices demonstrate varied strengths, particularly in scalability and impact scores, highlighting areas for potential improvement in sustainable agriculture practices**.**

TABLE 6. Assessment value

Conservation Tillage	-0.0391
Crop Rotation & Diversification	-0.0506
Improved Irrigation Management	-0.0900
Methane Capture from Manure	0.1714
Use of Cover Crops	-0.0167

The assessment values for the five agricultural practices indicate their overall effectiveness in reducing greenhouse gas emissions and promoting sustainability. Conservation Tillage has a slight negative value of -0.0391, suggesting limited effectiveness. Crop Rotation & Diversification scores lower at -0.0506, indicating challenges in impact. Improved Irrigation Management has the lowest value at -0.0900, reflecting significant room for improvement. In contrast, Methane Capture from Manure stands out with a positive assessment value of 0.1714, highlighting its strong potential for emission reduction and sustainability. Use of Cover Crops has a minor negative value of -0.0167, suggesting moderate effectiveness overall.

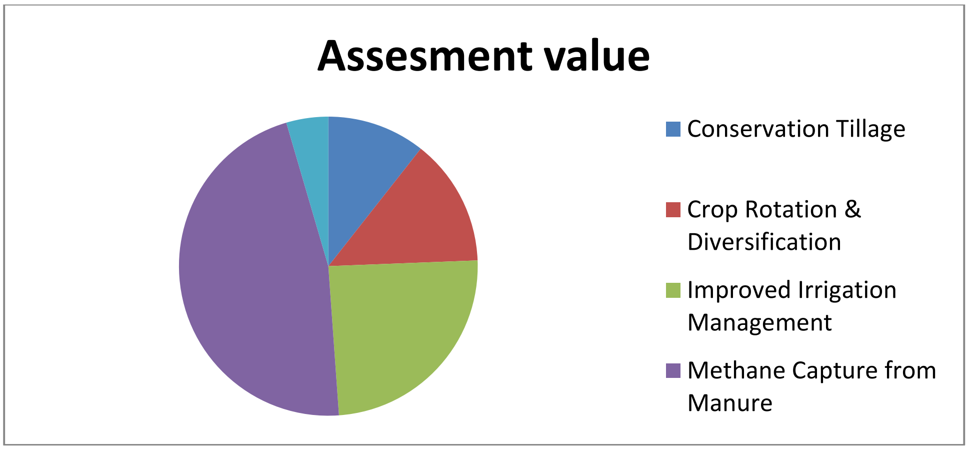

Figure 4. Assessment value

The pie chart illustrates the distribution of "Assessment value" across five agricultural practices. Each practice is represented by a color-coded segment, indicating its relative importance or emphasis. The largest segment is "Methane Capture from Manure," followed by "Improved Irrigation Management" and "Conservation Tillage." Smaller portions are dedicated to "Crop Rotation & Diversification" and "Use of Cover Crops." This visual suggests a focus on methane management and irrigation improvements as primary areas of assessment, with crop rotation and cover crops given comparatively less emphasis. Overall, it highlights diverse sustainable practices to enhance agricultural productivity and environmental impact.

Table 7. Rank

Conservation Tillage	3
Crop Rotation & Diversification	4
Improved Irrigation Management	5
Methane Capture from Manure	1
Use of Cover Crops	2

The ranking of the five agricultural practices reflects their effectiveness in reducing greenhouse gas emissions and promoting sustainability. Methane Capture from Manure is ranked first, indicating it has the highest potential for emissions reduction. Use of Cover Crops follows closely in second place, showing significant benefits for soil health and carbon sequestration. Conservation Tillage is ranked third, demonstrating moderate effectiveness in emission reduction. Crop Rotation & Diversification ranks fourth, indicating it faces challenges in achieving substantial impacts. Improved Irrigation Management is placed last at fifth, highlighting considerable room for improvement in its contributions to sustainability.

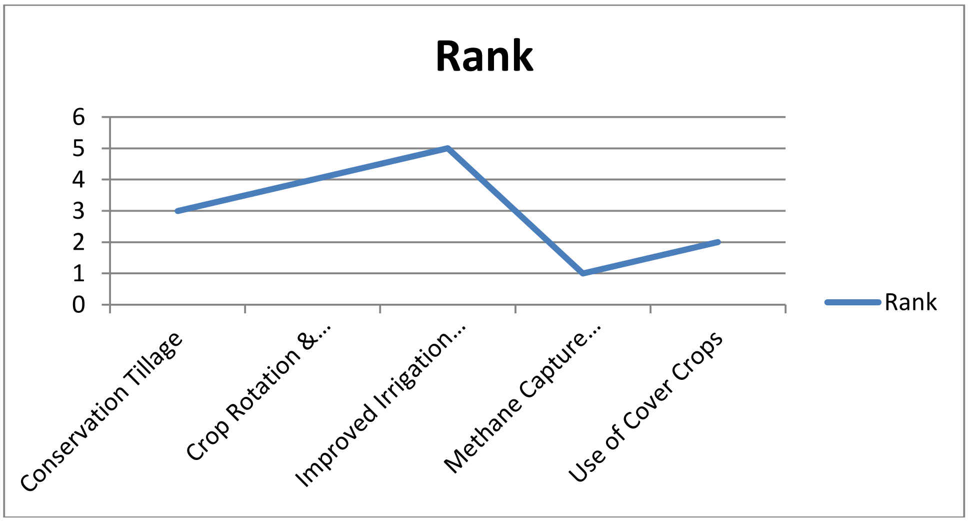

FIGURE 5. Rank

The line graph titled "Rank" displays the ranking of five agricultural practices based on an unspecified criterion. The vertical axis represents the rank values, with lower numbers indicating a higher rank. "Methane Capture from Manure" ranks highest, followed by "Use of Cover Crops" and "Conservation Tillage." "Improved Irrigation Management" holds the lowest rank (highest numerical value), indicating it is ranked least favorable among the practices. "Crop Rotation & Diversification" sits in the middle. The graph suggests that methane capture is prioritized over other practices, while irrigation management is given lower priority in this ranking assessment.

V. Conclusion

These emissions arise from diverse sources, including enteric fermentation in livestock, fertilizer application, deforestation, and soil management practices. While agriculture is vital for food production and economic stability, it presents both challenges and opportunities when it comes to addressing climate change.

Deforestation and land-use changes for agricultural expansion further exacerbate GHG emissions. Clearing forests to create agricultural land not only releases stored carbon dioxide but also diminishes the land's capacity to sequester carbon, ultimately affecting the global carbon cycle. Additionally, land degradation and soil erosion, often a result of intensive agricultural practices, reduce soil organic matter, impacting soil fertility and further releasing carbon into the atmosphere. Such issues highlight the need for improved land management strategies and reforestation efforts to mitigate the adverse impacts of agricultural expansion.

Agriculture, in turn, must adapt to these changing conditions, which often requires increased energy use, more intensive farming practices, and greater reliance on chemical inputs each contributing to GHG emissions. This cycle underscores the urgent need for sustainable agricultural practices that can reduce emissions while ensuring resilience to climate change.

To address the role of agriculture in GHG emissions, a range of mitigation strategies are available. Improved livestock management practices, such as altering feed composition to reduce methane emissions from ruminants or adopting anaerobic digesters to manage manure, can significantly lower emissions from livestock. Precision agriculture, which leverages advanced technologies to optimize resource use, can also help reduce emissions. By precisely applying fertilizers and other inputs based on real-time data, farmers can minimize excess nitrogen that would otherwise convert to nitrous oxide.

Agro forestry and reforestation are additional strategies that contribute to reducing agriculture's carbon footprint. Agro forestry, which integrates trees and shrubs into agricultural systems, enhances biodiversity, improves soil health, and sequesters carbon. Reforestation, particularly on marginal or degraded agricultural lands, restores ecosystems and enhances carbon sequestration potential, offsetting some of the emissions associated with agriculture. Both practices highlight how integrating natural systems into agricultural landscapes can provide ecological and climate benefits.

Another promising avenue for reducing agriculture’s GHG emissions lies in the development and use of bio-based fertilizers and biopesticides. Unlike conventional fertilizers, which are often energy-intensive to produce and can contribute to nitrous oxide emissions; bio-based alternatives utilize natural processes to enhance soil fertility and crop protection. Biopesticides, derived from natural organisms and substances, offer an eco-friendly alternative to chemical pesticides, which can have significant environmental and health impacts.

While these practices offer tangible benefits, their widespread adoption is often constrained by economic, social, and policy factors. Transitioning to sustainable agricultural practices requires investments in technology, knowledge transfer, and infrastructure. Many farmers, particularly smallholders in developing countries, may lack the resources or access to information necessary to implement such changes. Therefore, supportive policies, incentives, and financial mechanisms are essential to enable and encourage the adoption of these practices on a large scale.

Carbon pricing and carbon markets can also incentivize reductions in agricultural emissions by assigning a monetary value to carbon sequestration. Additionally, investments in research and development can drive innovation in agricultural technologies, creating new tools and techniques that further reduce emissions and enhance agricultural productivity. Consumer choices and market trends also have a significant impact on agricultural practices and emissions. Increasing demand for sustainably produced food encourages farmers and companies to adopt practices that prioritize environmental considerations. Certifications like organic, Fair Trade, and other eco-labels provide consumers with information on the sustainability of their food choices, potentially shifting market dynamics in favor of lower-emission agricultural products. In this way, consumer awareness and behavior can indirectly contribute to emissions reductions in the agricultural sector. Education and awareness programs are also essential to fostering a deeper understanding of the connection between agriculture and climate change. By educating farmers, policymakers, and the public about sustainable practices and their benefits, these programs can help build a foundation for more climate-resilient agricultural systems. As agriculture evolves to meet the challenges of a changing climate, the integration of sustainable practices and the promotion of a low-carbon food system will be essential to achieving long-term environmental and economic sustainability. By aligning agricultural practices with climate goals, we can work toward a future where food production supports both human needs and ecological well-being, ensuring that agriculture remains a vital and sustainable component of our global economy

References

1. Greenhouse Gas Working Group. *Agriculture's role in greenhouse gas emissions and capture*. Madison, WI: Greenhouse Gas Working Group Rep. ASA, CSSA, and SSSA, 2010.
2. Cerri, Carlos Clemente, Stoecio Malta Ferreira Maia, Marcelo Valadares Galdos, Carlos Eduardo Pellegrino Cerri, Brigitte Josefine Feigl, and Martial Bernoux. "Brazilian greenhouse gas emissions: the importance of agriculture and livestock." *Scientia agricola* 66 (2009): 831-843.
3. Tubiello, Francesco N., Mirella Salvatore, Simone Rossi, Alessandro Ferrara, Nuala Fitton, and Pete Smith. "The FAOSTAT database of greenhouse gas emissions from agriculture." *Environmental Research Letters* 8, no. 1 (2013): 015009.
4. Gołasa, Piotr, Marcin Wysokiński, Wioletta Bieńkowska-Gołasa, Piotr Gradziuk, Magdalena Golonko, Barbara Gradziuk, Agnieszka Siedlecka, and Arkadiusz Gromada. "Sources of greenhouse gas emissions in agriculture, with particular emphasis on emissions from energy used." *Energies* 14, no. 13 (2021): 3784.
5. McCarl, Bruce A., and Uwe A. Schneider. "US agriculture's role in a greenhouse gas emission mitigation world: An economic perspective." *Applied Economic Perspectives and Policy* 22, no. 1 (2000): 134-159.
6. Bell, M. J., J. M. Cloy, and R. M. Rees. "The true extent of agriculture's contribution to national greenhouse gas emissions." *Environmental Science & Policy* 39 (2014): 1-12.
7. Desjardins, R. L., W. Smith, B. Grant, C. Campbell, and R. Riznek. "Management strategies to sequester carbon in agricultural soils and to mitigate greenhouse gas emissions." *Increasing Climate Variability and Change: Reducing the Vulnerability of Agriculture and Forestry* (2005): 283-297.
8. Cerri, Carlos Clemente, Stoecio Malta Ferreira Maia, Marcelo Valadares Galdos, Carlos Eduardo Pellegrino Cerri, Brigitte Josefine Feigl, and Martial Bernoux. "Brazilian greenhouse gas emissions: the importance of agriculture and livestock." *Scientia agricola* 66 (2009): 831-843.
9. Marland, Gregg, Tristram O. West, Bernhard Schlamadinger, and Lorenza Canella. "Managing soil organic carbon in agriculture: the net effect on greenhouse gas emissions." *Tellus B: Chemical and Physical Meteorology* 55, no. 2 (2003): 613-621.
10. Panchasara, Heena, Nahidul Hoque Samrat, and Nahina Islam. "Greenhouse gas emissions trends and mitigation measures in Australian agriculture sector—A review." *Agriculture* 11, no. 2 (2021): 85.
11. Moreau, Tara L., Jennie Moore, and Kent Mullinix. "Mitigating agricultural greenhouse gas emissions: A review of scientific information for food system planning." *Journal of Agriculture, Food Systems, and Community Development* 2, no. 2 (2012): 237-246.
12. Nayak, Dali, Eli Saetnan, Kun Cheng, Wen Wang, Frank Koslowski, Yan-Fen Cheng, Wei Yun Zhu et al. "Management opportunities to mitigate greenhouse gas emissions from Chinese agriculture." *Agriculture, Ecosystems & Environment* 209 (2015): 108-124.
13. Laborde, David, Abdullah Mamun, Will Martin, Valeria Piñeiro, and Rob Vos. "Agricultural subsidies and global greenhouse gas emissions." *Nature communications* 12, no. 1 (2021): 2601.
14. Karande, Prasad, and Shankar Chakraborty. "Application of multi-objective optimization on the basis of ratio analysis (MOORA) method for materials selection." *Materials & Design* 37 (2012): 317-324.
15. Brauers, Willem Karel M. "Multi-objective contractor's ranking by applying the MOORA method." *Journal of Business Economics and management* 4 (2008): 245-255.
16. Gadakh, V. S., Vilas Baburao Shinde, and N. S. Khemnar. "Optimization of welding process parameters using MOORA method." *The International Journal of Advanced Manufacturing Technology* 69 (2013): 2031-2039.
17. Brauers, Willem K., and Edmundas K. Zavadskas. "Robustness of the multi-objective MOORA method with a test for the facilities sector." *Technological and economic development of economy* 15, no. 2 (2009): 352-375.
18. Stanujkic, Dragisa, Nedeljko Magdalinovic, Rodoljub Jovanovic, and Sanja Stojanovic. "An objective multi-criteria approach to optimization using MOORA method and interval grey numbers." *Technological and Economic Development of Economy* 18, no. 2 (2012): 331-363.