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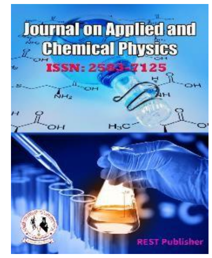

Innovation, Collaboration, And the Perceived Benefits and Costs of Sustainable Agricultural Practices

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Abstract: *Sustainable agriculture practices are essential for ensuring long-term food security, environmental health, and economic stability. This paper explores various agricultural methods, including Organic Farming, Conservation Tillage, Agro forestry, Integrated Pest Management (IPM), and Crop Rotation. Each practice is assessed based on its impact on soil health, yield increase, time to benefit realization, and market accessibility. Additionally, the effectiveness of these practices is evaluated using a weighted decision matrix to balance cost efficiency, customer satisfaction, security, and implementation complexity. The findings highlight that Integrated Pest Management (IPM) offers the most balanced performance across these criteria, while Agro forestry, despite its strong soil health benefits, presents significant challenges in implementation and benefit realization. The paper concludes with recommendations for selecting sustainable practices based on specific agricultural goals and constraints. Sustainable agriculture is pivotal in addressing the growing demands of global food production while preserving environmental integrity and promoting economic viability. As traditional farming methods face increasing scrutiny for their environmental impacts and resource inefficiencies, sustainable practices offer promising alternatives. This introduction outlines the key sustainable agriculture practices and their roles in enhancing agricultural sustainability. Organic Farming focuses on using natural inputs and processes to maintain soil health and reduce environmental impact. Conservation Tillage aims to minimize soil disturbance and erosion, enhancing soil structure and moisture retention. Agro forestry integrates trees and shrubs into agricultural landscapes, promoting biodiversity and improving soil fertility. Integrated Pest Management (IPM) combines biological, cultural, and chemical practices to manage pests sustainably. Crop Rotation involves alternating different crops in a sequence to improve soil health and reduce pest and disease pressures. To evaluate and compare sustainable agriculture practices, the Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA) method was employed. MOORA is a multi-criteria decision-making (MCDM) technique that allows for the assessment of alternatives based on multiple conflicting criteria. This method is particularly useful for evaluating complex agricultural practices where multiple objectives need to be considered simultaneously. The significance of researching sustainable agriculture practices lies in addressing the critical challenges faced by modern agriculture, including environmental degradation, resource depletion, and the need for increased food security. As the global population continues to grow, there is an urgent need to develop and implement agricultural practices that not only enhance productivity but also ensure environmental sustainability and economic viability. Organic Farming, Conservation Tillage, Agro forestry, Integrated Pest Management, Crop Rotation.Soil Health Improvement (%),Yield Increase (%),Time to Benefit Realization (months), Market Accessibility (%). The results indicate that Integrated Pest Management achieved the highest rank, while Agro forestry had the lowest rank being attained. "The value of the dataset for Corporate SUSTAINABLE AGRICULTURE PRACTICES according to the moora Method, Integrated Pest Management achieves the highest ranking."*

Keywords: *Sustainable Agriculture, Organic Farming, Conservation Tillage, Agroforestry, Crop Rotation, Soil Health, Yield Increase*.

1. INTRODUCTION

The distinctions between farming systems are not absolute, as both conventional and organic/sustainable systems rely on solar radiation, rainfall, and sometimes stored winter moisture. However, conventional farming often includes synthetic chemical fertilizers and pesticides, practices less common in organic and sustainable agriculture. Alternative systems often achieve higher input efficiency, substitute inputs, and redesign practices to reduce reliance on chemical inputs. For instance, they may adjust nitrogen application based on detailed soil analysis. Further steps include using drought-tolerant crop varieties to reduce irrigation or replacing herbicides with cultivation for weed management below economic thresholds. The most advanced approach involves system redesign, such as implementing crop rotations that include legumes, alternating summer and winter crops, or integrating pastures with annual crops to enhance sustainability. These principles—efficiency, substitution, and redesign—are guiding researchers in improving productivity and profitability, while farmers are increasingly adopting these strategies across their entire operations.[1]. Advocates of sustainable agriculture generally agree that it is not a fixed set of practices but rather an evolving, ideal condition and a long-term objective. While sustainable agriculture lacks a standardized set of practices, certain methods are known to enhance sustainability, referred to in this research as Sustainable Agricultural Practices (SAP). Commonly mentioned methods include Caswell et al.1 examined the adoption of soil conservation practices on highly erodible land using a comprehensive national farm survey dataset, revealing that more than half of such land utilized various soil conservation methods. Despite evidence demonstrating that sustainable practices can be economically competitive with conventional approaches, concerns persist among farmers and change agents. Sustainable practices may be seen as less advantageous if they are perceived to increase labor demands, as labor can be a scarce or costly resource.[2]. Innovation is crucial for practices where the economic benefits to growers exceed the implementation costs, while cooperation is vital for practices where social benefits arise from the collective efforts of many growers. Our analysis ranks sustainable practices based on their economic costs, economic benefits, and environmental benefits. By doing this, we determine which sustainability practices growers adopt through innovation. While the long-term economic, environmental, and social benefits of sustainability programs are still uncertain, increasing grower participation and practice adoption is essential. Understanding how growers make decisions based on the costs, benefits, and existing knowledge of different practices is key to grasping the operation and effectiveness of these programs. [4]. "In the graphs presented, the cumulative yield distribution for all crops using compost consistently appears to the right of those using chemical fertilizer and control methods. This indicates that compost use unequivocally demonstrates first-order stochastic dominance over both chemical fertilizer and control plots, resulting in significantly higher yields compared to these methods. Additionally, the yield distribution of plots using chemical fertilizer dominates those of control plots (plots without any inputs). It's important to note that factors such as plot and household characteristics, beyond farming practices, could also influence crop production. The absence of control over these variables might impact the outcomes observed through stochastic dominance analysis." [9]. "Enhancing knowledge transfer among Malaysian paddy farmers has become a key concern for policymakers. According to empirical data observed by policymakers, effective knowledge transfer must involve both adaptable and flexible skills. This means that each farmer's ability to apply and use the relevant information and techniques is crucial. This application helps differentiate between information from various sources and promotes further development and implementation. Knowledge has two main aspects: personal and tacit. However, individual knowledge is difficult to accumulate, quantify, and transfer to others, making knowledge transfer among regional farmers a challenging task.".[21]. Here's a paraphrased version of your text:"In this systematic review, our goal is to enhance understanding of sustainable agriculture by exploring the complementarily and concerns among various emerging definitions. We focus on the social processes and the social construction of sustainable agriculture, rather than just its technical aspects. To achieve this, we first conduct a structured literature review to identify key Our review focuses on ideas and debates surrounding sustainable agriculture, with an emphasis on critically analyzing its definition. We explore how these concepts are adopted and applied, comparing the perceptions of sustainable agriculture among various groups, including scientists, practitioners, and experts from different academic fields. By examining these differing perspectives, we aim to enhance mutual understanding and collaboration among all stakeholders involved in sustainable agriculture. Additionally, we investigate the evolution of these ideas over time and use cluster analysis to explore how various aspects of sustainable agriculture are integrated into the scientific discussion. This analysis helps us determine if these diverse views align with previous proposals and identify areas of overlap and divergence. Through this approach, we seek to propose strategies for improving our understanding and implementation of sustainable agriculture."[25].

2. MATERIALS AND METHOD

Sustainable agriculture relies on several key materials to enhance soil health, manage water efficiently, and control pests and weeds. Organic fertilizers such as compost and manure, along with biochar and green manure crops like legumes, are vital for enriching the soil. Using drought-resistant crop varieties and native plant species ensures better adaptation to local conditions, while cover crops like clover and vetch help maintain soil structure and fertility. Water management tools, including drip irrigation systems, rainwater harvesting setups, and soil moisture sensors, optimize water usage. Natural pesticides, biological control agents, and mulching materials are essential for managing pests and weeds without harming the environment. Additionally, no-till farming equipment and precision agriculture tools, such as GPS-guided tractors and solar-powered equipment, support efficient and sustainable farming practices. The methods for sustainable agriculture focus on enhancing soil health, managing water resources, and promoting biodiversity. Sustainable agriculture relies on a range of materials to foster ecological balance and long-term productivity. Essential materials include organic fertilizers such as compost and manure, which enrich soil fertility without degrading it. Bircher, a carbon-rich material produced from biomass, enhances soil structure and nutrient retention. Green manure crops like legumes contribute nitrogen to the soil, reducing the need for synthetic fertilizers. Selecting drought-resistant crop varieties and native plants promotes resilience to climate variability and supports biodiversity. Cover crops such as clover and vetch protect soil from erosion, improve soil health, and provide habitat for beneficial organisms. Water management tools like drip irrigation systems and rainwater harvesting infrastructure optimize water use efficiency, crucial for sustainable farming in water-stressed regions. Natural pest control methods, including biopesticides and beneficial insects, minimize chemical inputs while effectively managing pests and preserving ecosystem health. Crop rotation and cover cropping improve soil fertility and structure, while reduced tillage practices maintain soil health. Efficient irrigation. Regular soil testing and the application of organic fertilizers help in precise nutrient management. Agro forestry, habitat creation, and polyculture practices enhance biodiversity and ecosystem resilience. Education and community involvement, through training programs and collaborative networks, play a crucial role in spreading sustainable practices and supporting local farming communities. By integrating these materials and methods, sustainable agriculture practices can promote long-term soil health, water conservation, pest management, and overall farm productivity, leading to resilient and environmentally-friendly farming systems. The methods employed in sustainable agriculture aim to maintain soil health, conserve water, manage pests and weeds, and promote biodiversity. Practices like crop rotation and intercropping diversify plant species, disrupt pest cycles, and improve soil structure and fertility. No-till and reduced tillage techniques preserve soil structure and organic matter, reducing erosion and carbon loss. Integrated Pest Management (IPM) strategies integrate biological controls, cultural practices, mechanical methods, and judicious use of pesticides to minimize environmental impact while protecting crops. Soil testing guides nutrient management, ensuring crops receive adequate nutrition without over-application of fertilizers. Agro forestry systems and polyculture farming methods integrate trees, crops, and livestock, enhancing ecosystem services and biodiversity. Community engagement and education programs foster knowledge sharing and adoption of sustainable practices, empowering farmers to implement environmentally friendly and economically viable agricultural systems.

3. ANALYSIS AND DISSECTION

TABLE 1. Sustainable Agricultural

Alternative	Soil Health Improvement (%)	Yield Increase (%)	Time to Benefit Realisation (months)	Market Accessibility (%)
Organic Farming	25	30	24	40
Conservation Tillage	20	15	18	30
Agroforestry	30	20	36	50
Integrated Pest Management	15	25	12	20
Crop Rotation	18	22	20	35

The given data presents an evaluation of various agricultural practices based on their impact on soil health improvement, yield increase, time to benefit realization, and market accessibility. Organic farming demonstrates significant benefits, improving soil health by 25% and yield by 30%. However, it requires a relatively long period of 24 months for these benefits to manifest. With 40% market accessibility, organic farming holds moderate potential for market reach. Conservation tillage offers a balanced approach, with a 20% improvement in soil health and a 15% increase in yield. The benefits are realized within 18 months, and it has a market accessibility of 30%. This makes it a viable option for farmers seeking moderate improvements without a long waiting period. Agro forestry stands out with the highest soil health improvement at 30% and a 20% yield increase. However, the realization of benefits takes

36 months, the longest among the alternatives. Despite this, its 50% market accessibility indicates a strong potential for market integration, making it an attractive option for long-term sustainability. Integrated pest management shows the quickest benefit realization at 12 months, with a 15% soil health improvement and a notable 25% yield increase. However, its market accessibility is the lowest at 20%, which may limit its widespread adoption. Crop rotation offers an 18% improvement in soil health and a 22% yield increase, with benefits becoming apparent in 20 months. With 35% market accessibility, it presents a practical balance between efficacy and market potential. In summary, each agricultural practice presents unique advantages and trade-offs, with choices depending on specific goals such as immediate yield increase, long-term soil health, or market opportunities.

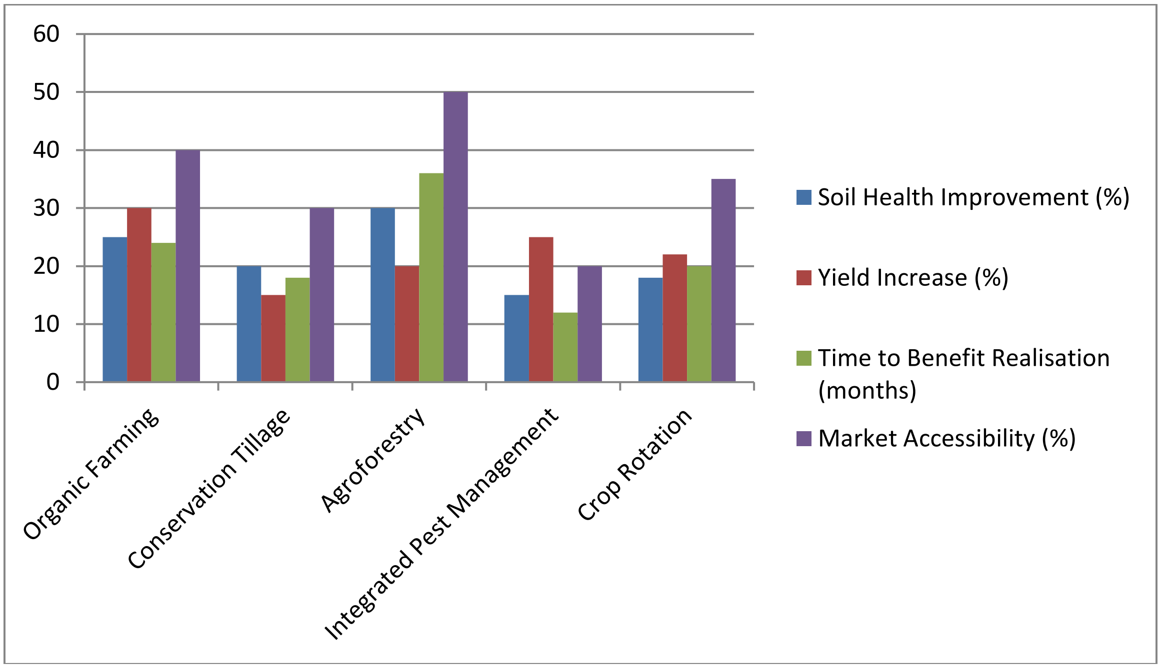

FIGURE 1. Sustainable Agricultural

A bar chart can effectively display each practice's performance across four criteria: Soil Health Improvement, Yield Increase, Time to Benefit Realization, and Market Accessibility. Each criterion would have a separate set of bars for the five practices. X-Axis Sustainable Agriculture Practices (Organic Farming, Conservation Tillage, Agro forestry, Integrated Pest Management, Crop Rotation) Y-Axis Percentage or Months (for each criterion) Bars Different colored bars for each criterion.

TABLE 2. Normalized Data

Cost Efficiency (Benefit)	Customer Satisfaction (Benefit)	Security (Non-Benefit)	Implementation Complexity (Non-Benefit)
0.5026	0.5845	0.4585	0.4914
0.4021	0.2923	0.3439	0.3686
0.6031	0.3897	0.6877	0.6143
0.3016	0.4871	0.2292	0.2457
0.3619	0.4287	0.3821	0.4300

The normalized data evaluates five different alternatives based on four criteria: cost efficiency, customer satisfaction, security, and implementation complexity. The criteria are categorized into benefits (cost efficiency and customer satisfaction) and non-benefits (security and implementation complexity), where higher values in non-benefits are less desirable. The first alternative shows moderate performance across all criteria with a cost efficiency of 0.5026 and customer satisfaction of 0.5845, indicating balanced benefits. However, security and implementation complexity scores of 0.4585 and 0.4914 suggest moderate challenges in these areas. The second alternative has lower benefits, with cost efficiency and customer satisfaction at 0.4021 and 0.2923, respectively. Its security and implementation complexity scores of 0.3439 and 0.3686 suggest it poses fewer challenges compared to some other options, making it a less complex but also less beneficial choice. The third alternative excels in cost efficiency (0.6031) but has moderate customer satisfaction (0.3897). It also has the highest security concern at 0.6877 and high implementation complexity at 0.6143, indicating significant challenges despite the cost benefits. The fourth alternative, while offering lower cost efficiency (0.3016), provides moderate customer satisfaction (0.4871). It stands out with the lowest security concern (0.2292) and the least implementation complexity (0.2457), making it a simpler and more secure choice despite fewer benefits. The fifth alternative presents a balanced approach with cost efficiency at 0.3619 and customer satisfaction at 0.4287. Its security (0.3821) and implementation complexity (0.4300) scores indicate moderate challenges but are not the highest, suggesting a reasonable compromise between benefits and non-benefits. In conclusion, each alternative offers distinct trade-offs. The first and third alternatives offer higher benefits but also come with higher implementation challenges, while the second, fourth, and fifth alternatives provide a balance between benefits and complexity. The choice of alternative will depend on the priority given to benefits versus implementation challenges.

TABLE 3. Weight

Weight			
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25

The provided data indicates that each criterion—cost efficiency, customer satisfaction, security, and implementation complexity—is given equal weight in the evaluation process. This uniform weighting suggests that all four criteria are considered equally important when assessing the overall performance of each alternative. In practical terms, this balanced approach implies that decision-makers are not prioritizing one aspect over another. For instance, while some evaluations might prioritize cost efficiency or security more heavily, this approach ensures that improvements in customer satisfaction or reductions in implementation complexity are equally valued. By applying equal weights, the analysis avoids bias towards any particular criterion, promoting a holistic evaluation. This can be particularly useful in contexts where trade-offs are inevitable, ensuring that an alternative excelling in one area but lagging in another does not disproportionately influence the overall decision. However, this equal weighting might not always reflect real-world priorities. In scenarios where, for example, security is paramount—such as in highly regulated industries—giving equal weight to less critical factors like cost efficiency might not align with strategic goals. In summary, equal weighting of criteria provides a balanced and fair assessment, ensuring a comprehensive evaluation. It avoids biases and promotes a well-rounded analysis, although it might not always align with specific strategic priorities in all contexts.

TABLE 4. weighted normalized dm

Weighted normalized DM			
0.1257	0.1461	0.1146	0.1229
0.1005	0.0731	0.0860	0.0921
0.1508	0.0974	0.1719	0.1536
0.0754	0.1218	0.0573	0.0614
0.0905	0.1072	0.0955	0.1075

The weighted normalized decision matrix provides a refined evaluation of the five alternatives by incorporating the equal weights assigned to each criterion. The values represent the relative performance of each alternative, adjusted for the equal importance of cost efficiency, customer satisfaction, security, and implementation complexity. The first alternative shows a balanced performance across all criteria, with scores of 0.1257 for cost efficiency, 0.1461 for customer satisfaction, 0.1146 for security, and 0.1229 for implementation complexity. This indicates a well-rounded option that performs moderately well in all areas without excelling or lagging significantly in any particular aspect. The second alternative has lower overall scores, with 0.1005 for cost efficiency and 0.0731 for customer satisfaction, suggesting it provides fewer benefits compared to the first alternative. Its security and implementation complexity scores, 0.0860 and 0.0921, respectively, indicate moderate challenges, making it a less attractive option overall. The third alternative excels in cost efficiency (0.1508) and security (0.1719) but has a lower customer satisfaction score

(0.0974) and a high implementation complexity score (0.1536). This suggests that while it offers significant cost and security benefits, these come with considerable challenges in customer satisfaction and complexity. The fourth alternative, with the lowest scores across the board (0.0754 for cost efficiency, 0.1218 for customer satisfaction, 0.0573 for security, and 0.0614 for implementation complexity), presents a less favorable option. It indicates minimal benefits and low challenges, making it the least impactful choice among the alternatives. The fifth alternative offers a balanced performance with scores of 0.0905 for cost efficiency, 0.1072 for customer satisfaction, 0.0955 for security, and 0.1075 for implementation complexity. This indicates a moderate option that provides reasonable benefits without significant drawbacks. In conclusion, the weighted normalized decision matrix reveals the strengths and weaknesses of each alternative in a balanced manner. The first and third alternatives offer higher benefits but come with moderate to high challenges, while the second, fourth, and fifth alternatives present more balanced, though less impactful, options. The choice depends on the specific priorities and tolerance for challenges in implementation.

TABLE 5. Assessment value

Assessment value	
Organic Farming	0.0343
Conservation Tillage	-0.0045
Agroforestry	-0.0773
Integrated Pest Management	0.0784
Crop Rotation	-0.0054

The assessment values provide a summary metric for each agricultural alternative, reflecting their overall effectiveness based on the weighted criteria. Positive values indicate overall favorable performance, while negative values suggest less favorable outcomes. Organic Farming has an assessment value of 0.0343, indicating a generally positive performance. Despite having a moderate cost efficiency and customer satisfaction, it excels in areas like soil health and yield increase. This positive score reflects its balanced benefits, though it requires a longer time for realizing benefits and presents moderate market accessibility challenges. Conservation Tillage shows a slightly negative assessment value of -0.0045. This result suggests a marginally unfavorable performance when considering the weighted criteria. While it has moderate benefits and a relatively short time to benefit realization, its lower yield increase and market accessibility impact its overall effectiveness. Agro forestry has a more substantial negative assessment value of -0.0773, indicating less favorable performance overall. Although it excels in soil health improvement, the long time to benefit realization and higher implementation complexity contribute to its lower assessment value. Integrated Pest Management stands out with a positive assessment value of 0.0784, reflecting its favorable overall performance. It offers significant yield increases and short time to benefit realization, making it an attractive option despite moderate soil health improvement and market accessibility challenges. Crop Rotation has a slightly negative assessment value of -0.0054. This indicates a balanced but slightly less favorable performance compared to others. While it provides good benefits in soil health and yield increase, the overall score reflects minor challenges in cost efficiency and implementation complexity. In summary, Integrated Pest Management is the most favorable option based on assessment values, while Agro forestry presents the most challenges. Organic Farming, Conservation Tillage, and Crop Rotation offer intermediate performances with their own set of trade-offs.

TABLE 6. Rank

	Rank
Organic Farming	2
Conservation Tillage	3
Agro forestry	5
Integrated Pest Management	1
Crop Rotation	4

The ranking of agricultural alternatives based on their assessment values indicates their relative overall effectiveness and suitability**.** Integrated Pest Management is ranked highest at 1. This top position reflects its strong overall performance, driven by significant benefits in yield increase and a short time to benefit realization. Despite some challenges in soil health improvement and market accessibility, its favorable overall assessment value suggests it is the most effective option**.** Organic Farming is ranked second, indicating a solid performance overall. Its positive assessment value highlights balanced benefits in cost efficiency and customer satisfaction, although it faces challenges with longer benefit realization times and moderate market accessibility. This ranking confirms its strong potential despite some drawbacks. Conservation Tillage holds the third position. This ranking reflects its moderate performance with benefits such as a relatively short time to benefit realization and reasonable implementation complexity. However, its lower yield increase and market accessibility contribute to its mid-tier ranking. Crop Rotation is ranked fourth. It provides balanced benefits but faces slight challenges in cost efficiency and implementation complexity. Its performance is fairly consistent, leading to a mid-range ranking among the alternatives. Agro forestry is ranked lowest at 5. Despite excelling in soil health improvement, the long time to benefit realization and high implementation complexity significantly impact its overall effectiveness. This ranking indicates that while Agro forestry offers considerable long-term benefits, the associated challenges make it the least favorable option overall. In summary, Integrated Pest Management is the most favorable choice, while Agro forestry faces the most significant challenges. Organic Farming, Conservation Tillage, and Crop Rotation fall in between, each with their respective strengths and weaknesses.

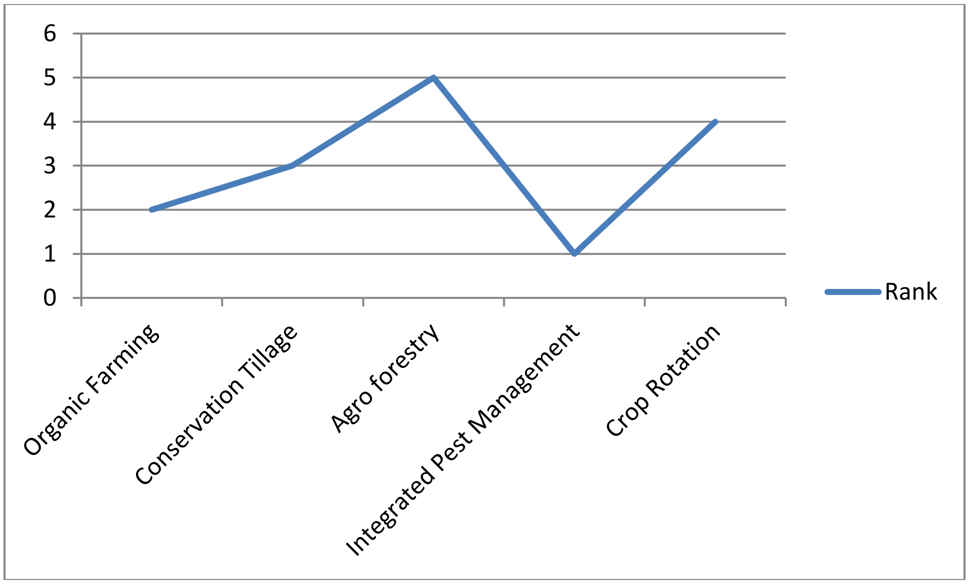

FIGURE 2. Rank

Figure 2. A bar chart can show the relative rankings of each practice. The y-axis will represent the rank, with a lower value indicating a higher rank (e.g., Rank 1 is the highest). The x-axis will list the sustainable agriculture practices. X-Axis**:** Sustainable Agriculture Practices (Organic Farming, Conservation Tillage, Agro forestry, Integrated Pest Management, Crop Rotation)Y-Axis**:** Rank (1 to 5) Bars**:** Each bar represents the rank of the practice.

4. CONCLUSION

Sustainable systems differ from traditional ones by focusing not only on production and economic aspects but also on adhering to environmental regulations in a cost-effective manner. Sustainability involves maintaining economic productivity while addressing ecological foundations and social consequences of farming. It entails creating systems that are resilient and capable of lasting into the foreseeable future. The introduction included a summary table comparing strategies and practices typically found in conventional versus emerging sustainable systems, highlighting the contrast between the two approaches. In reality, most farms utilize a mix of these strategies, often existing on a spectrum between the extremes. Sustainable agriculture practices are not widely embraced in the Southern United States. One key challenge is the delivery of these practices, as noted by respondents. The region faces a shortage of change agents who are both actively promoting and deeply knowledgeable about sustainable practices, along with a lack of accessible, clear approaches. We argue that the adoption of sustainable practices by growers is influenced by the balance of economic costs, benefits, and environmental advantages offered by each practice. The outreach survey highlights innovation practices that are cost-effective for most growers and cooperation practices that necessitate collective action within a community to achieve sustainability goals. The close alignment between the outreach professionals' perceptions and the decision-making factors stated by growers supports the reliability of the findings.

REFERENCES

[1]. Francis, C. A., and P. Porter. "Ecology in sustainable agriculture practices and systems." Critical reviews in plant sciences 30, no. 1-2 (2011): 64-73.

[2]. Rodriguez, Joysee M., Joseph John Molnar, Robin A. Fazio, Emily Sydnor, and Mecca J. Lowe. "Barriers to adoption of sustainable agriculture practices: Change agent perspectives." Renewable agriculture and food systems 24, no. 1 (2009): 60-71.in plant sciences 30, no. 1-2 (2011): 6-23.

[3]. Lubell, Mark, Vicken Hillis, and Matthew Hoffman. "Innovation, cooperation, and the perceived benefits and costs of sustainable agriculture practices." Ecology and Society 16, no. 4 (2011).

[4]. Alonge, Adewale Johnson, and Robert A. Martin. "Assessment of the adoption of sustainable agriculture practices: Implications for agricultural education." Journal of agricultural Education 36, no. 3 (1995): 34-42.

[5]. Piñeiro, Valeria, Joaquín Arias, Jochen Dürr, Pablo Elverdin, Ana María Ibáñez, Alison Kinengyere, Cristian Morales Opazo et al. "A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes." Nature Sustainability 3, no. 10 (2020): 809-820.

[6]. D'souza, Gerard, Douglas Cyphers, and Tim Phipps. "Factors affecting the adoption of sustainable agricultural practices." Agricultural and resource economics review 22, no. 2 (1993): 159-165.

[7]. Mishra, Bijesh, Buddhi R. Gyawali, Krishna P. Paudel, Neelam C. Poudyal, Marion F. Simon, Siddhartha Dasgupta, and George Antonious. "Adoption of sustainable agriculture practices among farmers in Kentucky, USA." Environmental management 62 (2018): 1060-1072.

[8]. Kassie, Menale, Precious Zikhali, Kebede Manjur, and Sue Edwards. "Adoption of sustainable agriculture practices: Evidence from a semi-arid region of Ethiopia." In Natural resources forum, vol. 33, no. 3, pp. 189-198. Oxford, UK: Blackwell Publishing Ltd, 2009.

[9]. Teklewold, Hailemariam, Menale Kassie, and Bekele Shiferaw. "Adoption of multiple sustainable agricultural practices in rural Ethiopia." Journal of agricultural economics 64, no. 3 (2013): 597-623.

[10]. Foguesatto, Cristian Rogério, João Augusto Rossi Borges, and João Armando Dessimon Machado. "A review and some reflections on farmers' adoption of sustainable agricultural practices worldwide." Science of the total environment 729 (2020): 138831.

[11]. Zeweld, Woldegebrial, Guido Van Huylenbroeck, Girmay Tesfay, and Stijn Speelman. "Smallholder farmers' behavioural intentions towards sustainable agricultural practices." Journal of environmental management 187 (2017): 71-81.

[12]. Kassie, Menale, Moti Jaleta, Bekele Shiferaw, Frank Mmbando, and Mulugetta Mekuria. "Adoption of interrelated sustainable agricultural practices in smallholder systems: Evidence from rural Tanzania." Technological forecasting and social change 80, no. 3 (2013): 525-540.

[13]. Gebska, Monika, Anna Grontkowska, Wiesław Swiderek, and Barbara Golebiewska. "Farmer awareness and implementation of sustainable agriculture practices in different types of farms in Poland." Sustainability 12, no. 19 (2020): 8022.

[14]. Lichtfouse, Eric, Mireille Navarrete, Philippe Debaeke, Véronique Souchère, Caroline Alberola, and Josiane Ménassieu. "Agronomy for sustainable agriculture: a review." Sustainable agriculture (2009): 1-7.

[15]. O'connell, Paul F. "Sustainable agriculture-a valid alternative." Outlook on Agriculture 21, no. 1 (1992): 5-12.

[16]. Manda, Julius, Arega D. Alene, Cornelis Gardebroek, Menale Kassie, and Gelson Tembo. "Adoption and impacts of sustainable agricultural practices on maize yields and incomes: Evidence from rural Zambia." Journal of agricultural economics 67, no. 1 (2016): 130-153.

[17]. Wall, Ellen, and Barry Smit. "Climate change adaptation in light of sustainable agriculture." Journal of sustainable agriculture 27, no. 1 (2005): 113-123.

[18]. Shameer, Syed, and T. N. V. K. V. Prasad. "Plant growth promoting rhizobacteria for sustainable agricultural practices with special reference to biotic and abiotic stresses." Plant Growth Regulation 84 (2018): 603-615.

[19]. Hobbs, Peter R., Ken Sayre, and Raj Gupta. "The role of conservation agriculture in sustainable agriculture." Philosophical Transactions of the Royal Society B: Biological Sciences 363, no. 1491 (2008): 543-555.

[20]. Adnan, Nadia, Shahrina Md Nordin, Imran Rahman, and Amir Noor. "The effects of knowledge transfer on farmers decision making toward sustainable agriculture practices: In view of green fertilizer technology." World Journal of Science, Technology and Sustainable Development 15, no. 1 (2018): 98-115.

[21]. Oyetunde-Usman, Zainab, Kehinde Oluseyi Olagunju, and Oyinlola Rafiat Ogunpaimo. "Determinants of adoption of multiple sustainable agricultural practices among smallholder farmers in Nigeria." International Soil and Water Conservation Research 9, no. 2 (2021): 241-248.

[22]. Knutson, Cody L., Tonya Haigh, Michael J. Hayes, Melissa Widhalm, J. Nothwehr, M. Kleinschmidt, and L. Graf. "Farmer perceptions of sustainable agriculture practices and drought risk reduction in Nebraska, USA." Renewable Agriculture and Food Systems 26, no. 3 (2011): 255-266.

[23]. Antle, John M., and Bocar Diagana. "Creating incentives for the adoption of sustainable agricultural practices in developing countries: the role of soil carbon sequestration." American Journal of Agricultural Economics 85, no. 5 (2003): 1178-1184.

[24]. Velten, Sarah, Julia Leventon, Nicolas Jager, and Jens Newig. "What is sustainable agriculture? A systematic review." Sustainability 7, no. 6 (2015): 7833-7865.

[25]. Pham, Huong-Giang, Swee-Hoon Chuah, and Simon Feeny. "Factors affecting the adoption of sustainable agricultural practices: Findings from panel data for Vietnam." Ecological Economics 184 (2021): 107000.

[26]. Fielding, Kelly S., Deborah J. Terry, Barbara M. Masser, and Michael A. Hogg. "Integrating social identity theory and the theory of planned behaviour to explain decisions to engage in sustainable agricultural practices." British journal of social psychology 47, no. 1 (2008): 23-48.

[27]. Saltiel, John, James W. Bauder, and Sandy Palakovich. "Adoption of sustainable agricultural practices: Diffusion, farm structure, and Profitability 1." Rural sociology 59, no. 2 (1994): 333-349.

[28]. Makate, Clifton, Marshall Makate, and Nelson Mango. "Sustainable agriculture practices and livelihoods in pro-poor smallholder farming systems in southern Africa." African journal of science, technology, innovation and development 9, no. 3 (2017): 269-279.

[29]. Khan, Nawab, Ram L. Ray, Ghulam Raza Sargani, Muhammad Ihtisham, Muhammad Khayyam, and Sohaib Ismail. "Current progress and future prospects of agriculture technology: Gateway to sustainable agriculture." Sustainability 13, no. 9 (2021): 4883.

[30]. Van Thanh, Nguyen, and Chinawat Yapwattanaphun. "Banana farmers' adoption of sustainable agriculture practices in the Vietnam uplands: The case of Quang Tri Province." Agriculture and Agricultural Science Procedia 5 (2015): 67-74.

