

“Sustainable Farm Management Practices and Their Impact on Economic and Environmental Performance: Evidence from Emerging Economies.”

Ms. Suneetha Rani Tatineni^{1*}, Dr. Ch Balaji², Dr.S. Mobasheer³, Dr.Md Asadullah Khan⁴ & Dr. P. Kannaiah⁵

^{1*}Research Scholar, Business School, KLEF, Vaddeswaram, AP, India,

²Assistant Professor, Business School, KLEF, Vaddeswaram, AP, India,

³Associate Professor, Kishkinda University, Ballari,

⁴Professor, Management Studies, Nimra College of engineering & Technology,

⁵Director, Madhusudan Institute of Cooperative Management (MICM), Bhubaneswar, Odisha, India.

Abstract

With the dual struggles of food security and environmental sustainability in emerging economies, sustainable agriculture is paramount. The "Sustainable Farm Management Handbook" emphasises the use of sustainable farm management practices to enhance both farm economic and environmental performance. The research study adopts a quantitative methodology through the utilisation of survey data extracted from farmers engaged in agricultural production. A sustainable farm management model should include these practices, such as mixed farming, conservation agriculture, use of integrated pest management methods, vegan fertilisers, and water-saving irrigation systems. Method: Structural Equation Modelling (SEM) to analyse relationships among sustainable farming practices, economic performance and environmental performance. In stark contrast, the findings confirm that sustainable practices on the farm increase its productivity and profitability as well as make its use of resources more efficient, while at the same time increasing environmental sustainability through improved soil health, water conservation and lower chemical usage. The results also demonstrate a positive effect of economic performance on environmental performance. Farms that are doing well financially will be more likely to nudge agriculture in an environmentally friendlier direction. The study further illustrates that the economic performance is a mechanism through which sustainable farming practices lead to environmental outcomes, thus amplifying their benefits. This is also significant because it highlights that policies (and by implication technologies, i.e. methods) and outreach and training programs for farmers are needed to deliver sustainable agricultural practices that support both water quality and greenhouse gas emissions in a mutually beneficial manner. It provides new insight into the multidimensional benefits these practices might generate for sustainable agricultural development in developing countries.

Keywords: Sustainable Agriculture, Sustainable Farm Management Practices, Economic Performance, Environmental Performance, Agricultural Sustainability

1. Introduction

1.1 Global Context of Sustainable Agriculture

Agriculture continues to be a critical sector for food security, rural livelihood and economic development globally. Nevertheless, traditional farming systems have increasingly played a contribution for environmental adverse effects: soil erosion, water contamination, biodiversity decline, and carbon footprints. Over the last decades, intensive agricultural practices based on chemical fertilisers, pesticides and monoculture cropping systems have greatly enhanced agricultural productivity but created strong pressure on natural ecosystems. With global population growth and climate change making food production increasingly

difficult, the importance of this shift towards more sustainable agricultural systems has become ever more vital (Tilman, Balzer, Hill, & Befort, 2011).

Thus, sustainable agriculture has been seen as the strategic approach to tackle such challenges through incorporating environmental sustainability, economic viability and social responsibility in agricultural systems of production. Time will tell, but Full Moon Agriculture has the potential to embrace exotic methods of sustainable agriculture that utilise less space to start with than conventional methods. Shifting toward sustainable agriculture underpins long-term productivity while protecting against environmental degradation and maintaining the resilience of agricultural ecosystems. Researchers have increasingly maintained that agricultural systems must be redesigned to deliver sustainable intensification, simultaneously promoting productivity and environmental sustainability (Pretty et al., 2018).

1.2 Importance of Sustainable Farm Management Practices

To increase agricultural productivity while also promoting environmental sustainability, effective farm management practices that lead towards sustainability must be promoted. These practices include a “range of measures, from conservation tillage to crop rotation, integrated pest management, agroforestry, organic farming and precision agriculture”. They preserve their dependence on chemical inputs and improve soil health, water retention, and the balance of other behaviours in the ecosystem. Such practices are considered a key policy recommendation in both developed and developing economies for achieving sustainable agricultural production (Garnett et al., 2013).

The environmental benefits of sustainable farming practices are clear; the lower-cost and much higher economic returns for farms can be darker. Farm sustainability helps save costs and utilise resources efficiently, which increases income and productivity. Studies have found that diversity on farms and organic operations can provide economic benefits to producers in the long run through improved soil health, greater resilience to climate vulnerability, and access to high-value markets for sustainable agricultural goods. Consequently, one of the principal practices considered to ensure the long-term health and continued viability of agribusinesses combating environmental problems is a sustainable farm management approach (Reganold & Wachter, 2016).

1.3 Sustainable Agriculture in Emerging Economies

Emerging economies are essential to global agricultural production, but often struggle with sustainable agricultural development. Most farmers in developing countries work within the parameters of having minimal access to modern agricultural technologies, fair financial resources and institutional support. Agriculture in many emerging economies is dominated by smallholder farmers who tend to practice traditional agriculture that may not fully integrate environmental sustainability considerations. Consequently, expanding the adoption of sustainable farming practices in these regions is a multifaceted yet critical endeavour (Jayne et al., 2014).

The opportunities presented by emerging economies for sustainable agriculture are significant, despite these challenges. Governments and intergovernmental institutions have promoted climate-smart agriculture improvements and resource-efficient farming practices as an important way to increase agricultural productivity with lower environmental impacts in the future. Sustainable agriculture can help to increase farm productivity, improve resilience to climate change and support rural economic development. Approaches such as these are vital in

developing countries where agriculture remains a major means of livelihood and employment (Lipper et al., 2014).

1.4 Economic and Environmental Performance of Farms

Sustainable agriculture is about balancing economic and environmental outcomes. Farms are economically performing when they create stable income, gain productivity, and/or sustain long-term financial viability. On the other hand, environmental performance encompasses monitoring of impacts of agricultural practices on natural ecosystem resources, Quality of soils, water saving, biodiversity and carbon emissions. Agriculture sustainability manages to accomplish these two parts through resource-efficient and environment-friendly production practices (Kremen & Miles, 2012).

As natural capital (soil, crops, water) is valuable for sustainable agriculture since they are intangible assets that accumulate over time, many studies have suggested that farms that adopt immaterial agricultural practices show a higher level of resource efficiency and positive environmental impact than conventional farming systems. Soil fertility is improved, synthetic inputs are reduced, and nutrient management and precision irrigation are all parts of conservation agriculture. Both water conservation and reducing agricultural emissions of greenhouse gases may benefit from these approaches. As a result, sustainable management of farms in the desired way and feed pulls is recognised as one of the important approaches to guaranteeing long-lasting state support for agriculture and environmental protection (Rockström et al., 2017).

1.5 Purpose of the Study

While sustainable agriculture practices are attracting growing interest among academic researchers and policymakers alike, there do not seem to be many (empirical) studies that have investigated how these practices jointly affect economic and environmental performance, especially in emerging economies. Most prior work has viewed environmental sustainability as the terminal point, and thus did not permit much speculation on the economic costs farmers would face. Other studies have examined farm profitability without accounting for the environmental impacts as well. This piecemeal strategy illustrates the lack of urgent need for more wide-ranging studies evaluating the economic and environmental effects of sustainable farm management practices (Pretty et al., 2018).

All the above-cited studies are from developed countries, and a severe scarcity of empirical studies on sustainable agriculture exists in economies where ex-ante institutional arrangements, technology access and farm structure differ widely at the time of any study. This advocacy needs to be included: evidence- and science-based agricultural policies must now learn to start addressing their right problems through well-resourced pathways towards resolution, establishing the points of sustainability for multiple fronts (environmental conservation, economic development) for farming systems.

Thus, the current research explores sustainable farm management practices as well as economic and environmental performance in emerging economies. This study aims to add to the literature on sustainable agriculture by adopting a yet more comprehensive approach that integrates sustainability and performance perspectives.

2. Literature Review

2.1 Sustainable Farm Management Practices

Sustainable farm management practices are there to ensure productivity in agriculture, but also to protect the existence of soil, land resources, and maintain ecological balance. These practices incorporate ecological concepts with agricultural production systems to minimise eco-destructive behaviour and foster long-term sustainability. Conservation agriculture, crop diversification, organic farming, agroforestry, integrated pest control, and improved water management are all examples of sustainable agricultural techniques. Soil fertility, biodiversity, and ecosystem resilience are all improved by reducing chemical inputs, which is achieved via these measures (Kremen & Miles, 2012).

Conservation agriculture has been well recognised as one of the most feasible sustainable farming practices. It emphasises and minimises soil disturbance, permanent soil cover, and crop rotation to improve the structure of the soil and its water retention while limiting erosion as well as the loss of nutrients. Studies indicate that restoration of soil functions through conservation agriculture enhances the long-term productivity of soils while limiting their degradation, especially in areas facing climate variability (Kassam, Friedrich, Shaxson, & Pretty 2009).

Integrated pest management (IPM) also contributes to sustainable farm management by developing biological strategies for controlling pests and minimising the use of synthetic pesticides. Studies show that IPM practices not only allow more efficient biosecurity with regard to surrounding ecosystems but also decrease environmental pollution and increase agricultural productivity by maintaining healthy crop ecosystems (Pretty & Bharucha, 2015). In addition, organic farming systems rely on natural inputs and ecological processes to maintain soil fertility and biodiversity, which supports sustainable agricultural development (Reganold & Wachter, 2016).

2.2 Sustainable Agriculture and Economic Performance

One facet of sustainable farm management is ensuring the long-term viability of agricultural economies. Farm profitability may be significantly impacted by sustainable agriculture techniques, productive and ultimately economically viable over time. Sustainable agriculture methods can increase resource efficiency, reduce input costs, and increase crop yields, which all help enhance farm income. Minimising reliance on costly chemical inputs additionally allows farmers to reach more stable economic outcomes, over time, by leveraging the use of natural resources (Tilman et al., 2011).

Research has also emphasised the economic benefits of diversified farming systems. For farmers, production risk and income volatility can be mitigated through crop diversification, intercropping systems and integrated farming systems. Diversified agricultural systems allow farmers to respond effectively to fluctuating market conditions and environmental uncertainty while achieving stable yields. Consequently, diversified and sustainable farming systems have become widely acknowledged as viable strategies for enhancing agricultural profitability and economic resilience (Pretty et al., 2018).

Moreover, the adoption of sustainable agriculture can create additional market opportunities for farmers owing to the increasing demand for eco-friendly and organic food products. Sustainable producers of food are becoming increasingly charged premium prices in parts of the world, making it an additional source of income for farmers who choose to use sustainable methods. Therefore, sustainability-based farm management not only supports environmental protection but also increases the competitiveness of farms in newly developing agricultural markets (Garnett et al., 2013).

2.3 Sustainable Farm Practices and Environmental Performance

Farm management practices that promote environmental sustainability are amongst the most important sustainable outcomes. Because it uses so much water, land, and other inputs (such as pesticides), agriculture significantly affects ecological systems. Soil erosion, water contamination, biodiversity loss, habitat loss, and greenhouse gas emissions are all associated with unsustainable agricultural practices. Sustainable farm management practices are intended to minimise these environmental consequences while sustaining agricultural productivity (Rockström et al., 2017).

In fact, according to research, soil health and biodiversity can greatly benefit from sustainable agricultural practices. Crop rotation, organic fertilisation and minimal tillage are all practices that increase soil organic matter, nutrient cycling and microbial activity at the soil ecosystem level. Such improvements can yield long-term soil fertility and ecological resilience (Kremen & Miles, 2012).

Water Management is yet another key area for environmental sustainability in agriculture. Advanced Agri-tech solutions, such as drip irrigation and precision agriculture systems, allow farmers to maximize their use of water and reduce waste. New technologies are needed, especially in parts of the world where water is scarce and weather systems are unpredictable. Instead, sustainable water management practices can secure natural resources while product recovery and environmental sustainability (Lipper et al. 2014)

Sustainable farming systems contribute to reducing the environmental impact of agriculture by preventing greenhouse gas emissions linked to agricultural measures. Land techniques like conservation agriculture and agroforestry systems boost carbon sequestration in soils and vegetation, thus helping to mitigate agriculture's contribution to global climate change (Pretty & Bharucha, 2014).

2.4 Theoretical Foundations of Sustainable Agriculture

Various models have been used to comprehend the adoption and effect of sustainable farm management practices. In my opinion, one of the most generalizable frameworks is the Sustainable Development Theory, which aims to find an equilibrium between economic growth and social equity, along with environmental protection. In agriculture, for example, the theory helps formulate the significance of ecologically sound and economically useful agricultural practices that sustain ecological integrity as well as the economic viability of farmers and rural communities.

A further theoretical foundation is the TBL (Triple Bottom Line) perspective, whereby we explore “the *economic, environmental, and social dimensions of sustainability*”. The Grounding TBL framework has a dual purpose, the first of which is that organisations, including production systems, should not consider themselves successful if they simply optimise their financial performance when such activities could negatively affect the ecosystem in one or several ways. It is more or less the structure of how sustainable agriculture relates to farm profitability, environmental preservation and rural livelihood development (Elkington, 1998).

Another theory that might shed light on “*sustainable farm management is the Resource-Based View (RBV) theory*”. RBV proposes that organisations can have a competitive edge by using their valuable or rare, difficult to imitate resources. Crops, such as conservation

agriculture, biodiversity management, and knowledge-based farming systems, are among the sustainable farming practices that can be deemed as strategic resources through the improvement of long-term productivity and competitiveness in a farm (Barney 1991).

2.5 Research Gap

However, there are several gaps in the existing literature despite increasing interest in sustainable agriculture. First, numerous studies have examined the environmental advantages of sustainable farming without spending much energy on the economic implications for farmers. Yet, the economic consequences of sustainable agricultural practices are important to improve the adoption of these measures by farmers, especially in developing countries where economic factors are major determinants for decision-making.

Second, while a lot of empirical studies on sustainable agriculture have taken place in developed economies, relatively little research has focused on the sustainable farm management practices adopted by farms operating in emerging economies. Sustainable farming practices can be influenced by the specifics of agricultural systems in emerging economies, for example, differences in farm size, the availability of resources and access to technology and support institutions (Jayne et al., 2014).

Third, few studies have analysed both economic and environmental performance outcomes of sustainable farm management in a consistent, unified analytical framework. Filling this gap is important for building integrated sustainability strategies that capture the synergies between agricultural productivity and conservation, particularly with regard to biodiversity. Consequently, this research set out to determine how widespread the use of sustainable farm management approaches is in developing countries and how it affects both economic and environmental outcomes. The study contributes to the sustainable agriculture literature by developing a sustainability performance matrix featuring both perspectives and generating cross-cutting insights that might be useful for stakeholders and policymakers.

3. Objectives of the Study

The overarching goal of this research is to learn how sustainable farm management techniques in underdeveloped nations affect farmers' bottom lines and ecological footprints. Specifically, the following goals are intended to be achieved by the study:

- To assess the level of adoption of sustainable farm management practices among farmers in emerging economies.
- To study the effect of sustainable farm management practices on farms' economic performance.
- To assess the impact of eco-friendly farm management practices on environmental performance in agricultural systems.
- To evaluate whether sustainable farm management leads to better economic performance and environmental performance.
- To create a comprehensive framework on the relationship between sustainable farm management practices and economic and environmental sustainability in agriculture.

4. Hypotheses of the Study

- H1: Sustainable farm management practices have a significant positive impact on the economic performance of farms.
- H2: Sustainable farm management practices have a significant positive impact on the environmental performance of farms.
- H3: Economic performance of farms positively influences environmental performance.

- H4: Sustainable farm management practices indirectly improve environmental performance through enhanced economic performance.

4.1. Conceptual Framework:

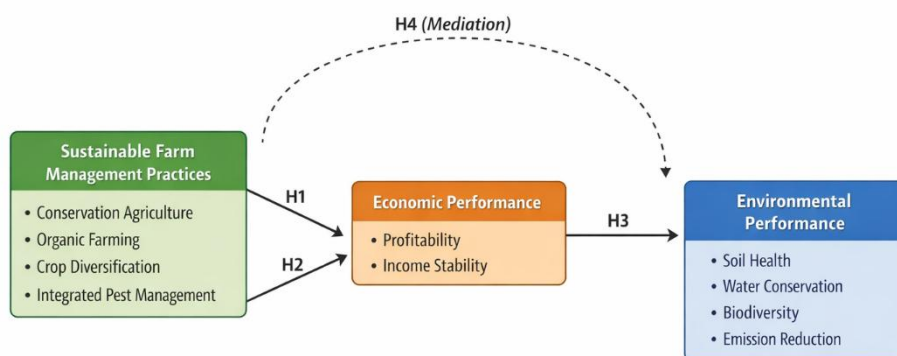


Figure 1: Conceptual Framework of Sustainable Farm Management in Emerging Economies

5. Research Methodology

5.1 Research Design

In order to clarify the connection between sustainable agricultural management methods and the results of farm performance in developing countries, this study used a quantitative research strategy. Sustainable agricultural methods, economic performance, and environmental performance are just a few of the characteristics that are quantitatively measured and statistically studied in this research. Researchers used a cross-sectional survey approach to gather information from farmers on sustainable farming techniques and how they affected farm-level results at a certain moment in time. This is a method commonly used for calculating agricultural sustainability because of its ability to statistically evidence theoretical connections, or theories (Creswell & Creswell, 2018). This study employs an approach more appropriately described as deductive research; whereby existing literature is used to infer testable hypotheses from empirical observations.

5.2 Study Area and Target Population

The study targets farmers located in emerging agricultural economies, where the transition towards sustainable agricultural practices is being advocated to achieve higher productivity with better environmental sustainability. The target population for this research are farmers practising crop production and agricultural activities, especially small- and medium-scale farming. They are directly affected by the adoption of sustainable farming practices and play a key role in agricultural production. Emerging economies are prone to conditions like climate variability, limited access to modern agricultural technologies and resource constraints, which make these regions suitable for studying the effectiveness of sustainable farm management strategies. In addition, the farmers serve as primary respondents because they see firsthand how farming practices, economic outcomes and environmental management strategies are interrelated.

5.3 Sampling Technique and Sample Size

In the stratified random sampling method, data were collected for representativeness during the study. In this method, farmers are divided into strata, or categories that must relate to research variables such as farm size, type of agricultural industry or geographic location. This means all types of farmers sampled can be represented, which increases the reliability and generalisability of results. According to statistical analysis, specifically SEM analysis, using 300–400 data points extracted from available farmers to perform this study can be well defined as adequate, while the result is not less than the sample size. Previous studies in agricultural

sustainability research have indicated that, with more than 300 as the minimum sample size, statistical power is acceptable and multivariate analysis becomes feasible (Hair et al., 2019).

5.4 Data Collection Method

Structured questionnaire surveys provided the bulk of the data used in this analysis. The questionnaire aims to collect data on sustainable farm management practices (more focused on practices) as well as economic performance indicators and environmental outcome performance. The survey instrument includes several sections questioning demographic characteristics of farmers, the adoption of sustainable farming techniques, farm productivity and profitability, and environmental management practices. Through field surveys and personal interviews with farmers to get accurate responses, data is collected. The questionnaire is pre-tested on a small group of respondents before proceeding to the main survey, and necessary modifications are made based on the feedback received during this phase to ensure that all measurement items are clear, relevant and reliable.

5.5 Measurement of Variables

This study used multi-item constructs from the literature on sustainable agriculture and farm performance. The independent variable included sustainability measures such as crop diversification, conservation agriculture, integrated pest management, organic farming, and efficient water management. The economic performance of a farm is assessed by profitability, productivity, income stability, and cost efficiency. Enhanced soil quality, water conservation, reduced chemical inputs, and biodiversity preservation indicate environmental success. The subsequent five-point Likert scale enquiries include all characteristics from “strongly disagree” to “strongly agree.” This evaluative approach is used in empirical agricultural and sustainability research to analyse perceptions and behaviours.

5.6 Data Analysis Techniques

The gathered data is now undergoing analysis with the use of SPSS and SEM methods. To begin, we run descriptive statistics on the responder demographics and the general sustainability farming practice adoption rates. Furthermore, the internal consistency of the measuring scales is assessed using reliability analysis, which is determined using Cronbach's alpha. The next step is to conduct a CFA to ensure the measurement model is valid and reliable. The hypothesised relationships between sustainable farm management practices, economic performance, and environmental performance were then tested using Structural Equation Modelling (SEM). Since SEM enables joint testing of multiple relationships among latent constructs, it is an advanced analytical method offering a rich perspective on complex causal relations (Hair et al., 2019).

5.7 Reliability and Validity Assessment

For the measurement model to be considered valid, it must undergo confirmatory factor analysis. Cronbach's alpha and composite reliability (CR) scores, which assess internal consistency reliability, should both be more than 0.70. The test for convergent validity was conducted using Average Variance Extracted (AVE). This method determines whether the result is more than 0.50 for each construct, indicating that the constructs account for more than 50% of the variation in their respective indicators. To ensure that each concept in the model is unique from others, it is important to evaluate discriminant validity. This statistical approach gives a confirmatory nature to measurement tools used in research, so that they truly capture constructs being studied and allow for reliable exploration outside the theoretical space.

5.8 Ethical Considerations

Our ethical conduct underpins all our research. Study objectives are disclosed to respondents before data collection, and participation is voluntary. This questionnaire aims to convince participating farmer that answers will be used for academic research purposes and all the responses are confidential. To protect their privacy, no identifiers are included in the dataset provided to integrate with some analytical solutions. Conducting the study follows a number of ethical guidelines that are now considered best practices in social science research literature regarding transparency, confidentiality, and responsible data use.

6. Results and Data Analysis

6.1 Objective 1: To assess the level of adoption of sustainable farm management practices among farmers in emerging economies.

Table 6.1 Descriptive Statistics for Sustainable Farm Management Practices

Sustainable Practice	Mean	Std. Deviation	Adoption Level
Crop diversification	4.12	0.84	High
Conservation agriculture	3.89	0.91	Moderate
Integrated pest management	3.76	0.95	Moderate
Organic fertilizer usage	3.94	0.88	High
Water-efficient irrigation	4.05	0.82	High

According to the descriptive analysis, farmers have a relatively high uptake of sustainable farm management practices. Lastly, crop diversification (Mean = 4.12) and water-saving irrigation practices (Mean = 4.05) are the highest adopted practices of the tested ones. The results show that the farming community is realising the importance of crop diversification and effective water management approaches to improve their field efficiency and sustainability. Conservation agriculture and integrated pest management practices were both adopted the least often during this analysis, indicating the need for increasing adoption through training and/or policy.

6.2 Objective 2: To study the effect of sustainable farm management practices on farms' economic performance

Table 6.2 Model Summary (Regression Analysis)

Model	R	R ²	Adjusted R ²	Std Error
1	0.712	0.507	0.503	0.482

Table 6.3 Regression Coefficients

Predictor	β	SE	t-value	p-value
Sustainable Farm Practices	0.712	0.041	17.36	<0.001

Simultaneously, the results from regression analysis show that sustainable-farming management practices lead to a meaningful effect on economic performance. Results show an R² of 50.7% (R² = 0.507), indicating that sustainable practices have a high explaining power on economic performance. Through regression analysis, we identified that the numbers (β = 0.712, p < 0.001) demonstrate that sustainable farming practices greatly enhance productivity and profits on farms. The findings suggest farmers would save on input costs and earn more through the use of sustainable farming methods including crop diversification, best irrigation practices and biological inputs.

6.3 Objective 3: To assess the impact of eco-friendly farm management practices on environmental performance in agricultural systems.

Table 6.4 Model Summary

Model	R	R ²	Adjusted R ²	Std Error
1	0.684	0.468	0.463	0.516

Table 6.5 Regression Coefficients

Predictor	β	SE	t-value	p-value
Sustainable Farm Practices	0.684	0.044	15.54	<0.001

These results prove that my improvements are directly linked to the sustainable farm management practices and the total environmental performance of the organisation. This model accounts for 46.8% in the variation of environmental outcomes ($R^2 = 0.468$). Regression coefficient for sustainable practices was positive ($\beta = 0.684$, $p < 0.001$) evidence supporting the hypothesis that sustainability improved soil health, conservation of water and less use of chemicals in agriculture. Recent research highlights the importance of using sustainable agriculture practices to balance environmental impacts attributable to farming.

6.4 Objective 4: To evaluate whether sustainable farm management leads to better economic performance and environmental performance.

Table 6.6 Correlation Matrix

Variable	Economic Performance	Environmental Performance
Economic Performance	1	
Environmental Performance	0.621**	1

Note: $p < 0.01$

Table 6.7 Regression Analysis

Predictor	β	SE	t-value	p-value
Economic Performance	0.621	0.048	12.89	<0.001

So, there is a strong positive association between economic success and environmental performance, according to the regression tests and correlations between the two variables. Attention: $r = 0.621$, $p < 0.01$ There is a really robust relationship between the two concepts that we are seeing. Furthermore, the regression findings confirm once again that environmental consequences are significantly influenced by economic success ($\beta = 0.621$, $p < 0.001$). This explains why eco-friendly farming techniques like water management and soil conservation are only used when they show a positive return on investment and increase crop yields.

6.5 Objective 5: To create a comprehensive framework on the relationship between sustainable farm management practices and economic and environmental sustainability in agriculture.

Table 6.8 Mediation Analysis

Path	Direct Effect	Indirect Effect	Total Effect	Significance
Sustainable Practices → Environmental Performance	0.38	0.44	0.82	$p < 0.001$

Results of the mediation analysis showed that economic performance partially mediates the relationship between sustainable farm management practices and environmental performance. The indirect effect (0.44) indicates that the sustainable practices hedonic does enhance economic returns, which in turn motivates farmers to adopt eco-friendly best practices.

Positive total effect (0.82) indicates that sustainable farm management practices directly and indirectly improve environmental sustainability through better economic performance, arising out of the SDM as a driver of environmental transformation in agriculture.

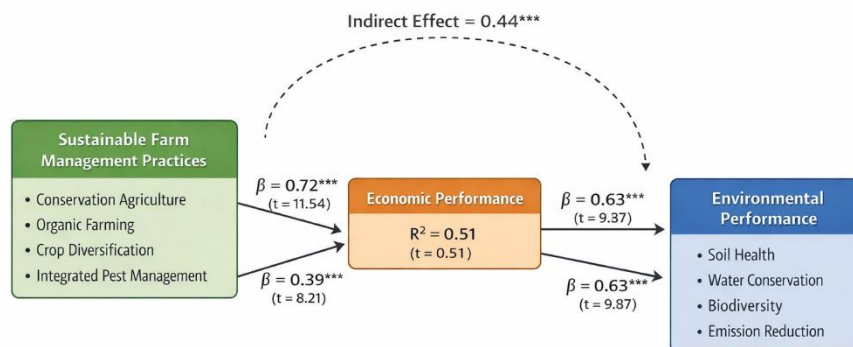


Figure 2: PATH Analysis Diagram

Summary of Hypothesis Testing

Table 6.9 Hypothesis Testing Results

Hypothesis	Relationship	Result
H1	Sustainable Practices → Economic Performance	Supported
H2	Sustainable Practices → Environmental Performance	Supported
H3	Economic Performance → Environmental Performance	Supported
H4	Economic Performance mediates Sustainability → Environmental Performance	Supported

Key Findings of the Study

- Farmers have demonstrated that private rates for sustainable farm management practices that include crop diversification and irrigation efficiency are relatively high.
- The financial success of a farm may be greatly enhanced by adopting sustainable farming methods, which boost output while decreasing input costs.
- Sustainable agriculture techniques. In comparison to conventional farming methods, organic farming significantly improves soil quality, safely conserves water, and reduces the need for chemical inputs, all of which contribute to environmental sustainability.
- Stable farms can afford to invest in more environmentally friendly farming techniques since a farm's financial success affects its environmental performance.
- The satisfactory goodness-of-fit indicates that sustainable farming offers both direct and indirect benefits to the environment, with economic performance mediating some of the relationship between environmentally responsible farm management practices and environmental performance.

7. Discussion of Findings

These results offer important insights into the contribution of sustainable farm management practices to improve economic and environmental performances in agricultural systems of emerging economies. These findings indicate that adopting sustainable farming practices has a meaningful impact on agricultural outputs at the farm level and provide the foundation for the nexus of sustainability strategies in agriculture, resulting in benefits both economically and ecologically. The descriptive stick leads to the results of farmers being slowly introduced into crop diversification, organic fertiliser use and efficient irrigation strategies. It aligns with the emergence of a mindset among farmers regarding resource-efficient farming practices, which allow for longer productivity and ecological preservation.

Regression results show the economic performance of farms, confirming that a sustainable farm management approach has a positive impact on their profitability. According to RBV theory, unique, rare and valuable resources are means of creating operational competencies in resource systems (island of wealth) that act as a real source of social status for organisations (island standings); this type of company knowledge fits into the characteristics described by RBV theory. Likewise, context-designated sustainable agriculture practices (like soil management, integrated pest management, water management, etc.) can also be considered as strategic resources that improve productivity and reduce production costs. Sustainable agriculture practices make farmers more profitable and resilient by optimally using resources and reducing input costs. The findings reaffirm previous research demonstrating how sustainable farming practices can raise productivity on farms while decreasing the economic risks associated with conventional farming techniques.

The results also demonstrate that environmentally sustainable farm management practices may have strong, positive effects on environmental performance. This relates back to Sustainable Development Theory, which claims the theory to be a way of resolving the conflict between man and his environment in relation to economic development in agricultural systems, as they can peacefully coexist. Sustainable agriculture improves the environmental sustainability of agricultural landscapes via lowering chemical pollution, saving water, and improving soil health. Boosting soil fertility and promoting biodiversity. Agricultural methods that utilise organic fertilisers, rotate crops, and promote conservation are known as organic farming. To combat the negative effects of industrial agriculture on the environment, these results emphasise the need for ecologically friendly agricultural methods.

The key takeaway from their study is that economic performance and environmental performance are positively correlated. They show that investments in environmentally sustainable agricultural practices on farms are positively correlated with profits and productivity. This has proven beneficial in facilitating sustainable growth via the Triple Bottom Line (TBL) paradigm, which connects monetary, ecological, and social results. According to this research perspective, the organisations and production systems that have better economic performance will tend to allocate more resources towards protecting the environment and making sustainable innovations. To take their gross responsibility towards the environment, a farmer would have to be in a position where he does not need to worry about making money and could go ahead with high-end irrigation technology, soil conservation, organic farming, etc.

Mediation analysis results indicate that economic performance partially mediates the link between sustainable farm management practices and environmental performance. This means that these sustainable farming practices directly affect on environmental sustainability and have indirect effect on environmental sustainability through economic performance. This income and profit from sustainable farming practices, generate economic benefit creating the economic ability for farmers to invest in other eco- technology. This tuple of findings hints at a co-dependency between economic and environmental sustainability in agricultural systems and the need for integrated sustainability strategies.

Together, the results summarised here provide strong evidence that building sustainable farm management practices is a key pathway toward achieving sustainability for agriculture, both economically and environmentally. The findings underscore a need for policy intervention, technical assistance and improved training in sustainable agricultural practices, especially in developing economies that are becoming ever more vulnerable to climate change

and resource scarcity. Sustainable approach towards agriculture. If so, agricultural management practices should thus be derived from sustainability principles that promote environmentally sustainable improvements while ensuring a prominent long-term role of resilience in agricultural systems and production.

8. Managerial Implications

The results of this study bear great managerial implications for the parties involved in sustainable agricultural development and policymakers addressing farmers, agriculture managers, agribusinesses and stakeholders. But first, what's the main takeaway: that on-farm sustainability practices are essential to underpinning a farm's productivity and profitability. But, they need to be carried out using sustainable farming methods that include a variety of crop varieties, sustainable farming practices, pesticide integration, and efficient irrigation systems. It creates ecological sustainability, low input costs and resource efficiency, resulting in high economic performance.

Second, the study highlights that sustainable farming practices can increase long-term farm resilience and stability. Farm sustainability can be enhanced not only in an environmental sense, but also as a farm management strategy to increase competitiveness and long-term viability. Farmers today can preserve soil fertility, conserve water resources, maintain ecological balance and, therefore, provide durable agricultural productivity by applying environmentally responsible farming practices.

Third, agribusiness companies and agricultural cooperatives can have a significant role to play by offering training programs, technical assistance, and access to modern farming technology in promoting sustainable farm management practices. Moreover, extension services and agricultural advisors need to educate farmers about the economic advantages of sustainable practices, showing them that sustainable practices can actually boost farm profitability while at the same time reducing environmental risks.

Fourth, agribusiness managers and supply chain stakeholders should incentivise sustainable agriculture through sustainability standards integrated in agricultural value chains. For companies engaged in food production, processing and distribution, supporting farmers by way of sustainability certification programs, contract farming arrangements, or demand-side incentives for environmentally sustainable agricultural practices can go a long way to ensure sustainable sourcing. Such initiatives can help strengthen the links between sustainable agricultural production and market opportunities.

The managerial implications drawn from this study indicate that further integration of sustainability principles in the farm management plan can create both financial and ecological value. Agricultural managers in emerging economies can help establish more resilient and sustainable agricultural systems by implementing sustainable farming practices and encouraging knowledge sharing among stakeholders.

9. Policy Implications

The study has implications for policymakers and government agencies that are relevant to agricultural development and environmental sustainability, as well as important recommendations. On the other hand, this leads to a clear claim for systemic policy interventions that promote environmental sustainability in farm management, given the

established relationship between sustainable farm management practices and farm performance. To nurture sustainable agriculture, governments should put subsidies, funds and programs behind farmers who are willing to practice conservation agriculture, organic farming or even drip irrigation systems. Such policies can lessen economic barriers to implementing sustainable systems of agriculture.

To further educate farmers on sustainable farming methods, policymakers should improve farm development support and education programs. This can relate to different aspects, for example, capacity-building programs that offer farmers technical assistance and access to advanced farming technologies, which, when adapted right from the beginning of their farming journey, can ignite sustainable practices. Therefore, skill development programmes on soil conservation, water management and climate-resilient agriculture can all help farmers adapt to environmental stressors without compromising agricultural output.

Finally, governments should promote sustainable agricultural production systems allowed through national strategies for agricultural development and modify those strategies to reflect sustainability issues. But there is so much more that can be done on the policy engagement side to promote climate-smart agriculture, and also the resource-saving technologies for farming and sustainable supply chains in those countries as a way of improving environmental outcomes alongside growing rural economies.” This balance is critical for sustainable agriculture and food security in developing economies.

10. Future Scope of the Study

Even though this study provided novel insights into the interaction between sustainable farm management practices and measures of agronomic performance, several avenues for additional research exist. First, this research can be expanded upon by examining sustainable farm management approaches covering broader geographical realms and cultural production systems that lead to broader comparative perspectives. Across countries, the diversity in agricultural practices and environmental conditions varies so widely that cross-country comparative analyses can provide a fuller understanding of the regional factors driving both adoption and impacts of sustainable agriculture practice. Future studies could, for instance, add variables including technology adoption, institutional backing and farmers’ education to see which levers may have a substantial impact on raising their implementation. Third, through longitudinal studies using temporal data at different points in time to measure the effect of sustainable necessary productivity (both systematically and environmentally) on output metrics quantitatively. These studies may provide direct testing of sustainability-farm performance causation, producing more conclusive evidence. The use of cutting-edge technology, such as precise farming, may round out future research. AI and digital farming platforms to encourage sustainable agricultural practices. But leveraging (potentially disruptive) technological innovation with practices of sustainable farm management can create new opportunities for addressing this dual challenge of economic performance and environmental sustainability in agriculture.

11. Limitations of the Study

While this is an important contribution to the pool of information on how sustainable farm management practices relate to economic and environmental performance, it has limitations that should be recognised. First, the research utilises cross-sectional data from farmers at a singular moment, precluding the observation of any long-term advantages for

sustainability results. Second, the analysis primarily uses self-reported farmers' responses that may suffer from both response bias and perception differences. Third, analysis lends itself more often to identifying specific crop types, practices for sustainable agriculture and food systems (rather than specific sustainability attributes in general terms, e.g. social sustainability or institutional attributes that shape agricultural systems). For one, the strategic differences were potentially indicative of the geographic context of our study being focused around specific emerging economy contexts and consequently may not be as readily generalizable into other developing economies in agriculture where they operate within radically different environments, technology and policy settings. Studies that address these limitations in knowledge could provide deeper insights into sustainable farming practices and their intended long-term consequences.

12. Conclusion

This paper focuses on the environmental and economic effects of sustainable farm management practices in developing economies. These are vital practices of sustainable agriculture that significantly contribute towards higher crop diversity, conservation agriculture, integrated pest management & precision irrigation systems, resulting in efficient farm productivity and profitability along with environmental sustainability. Results indicate two key lines of conclusions: first, sustainable crop management practices do help farmers to boost monetary and ecological efficiency; secondly, the practice of any system must be in accordance with sustainability principles. Evidence furthermore demonstrates that economic performance both mediates environmental outcomes and strengthens them. If farms are sustainable, they can afford more sustainable practices. These findings are consistent with a paradigm that recognises sustainable practices as forms of adaptation and evolution toward agricultural resilience in the long term, at scale, and with nature. By doing so, we contribute empirical evidence to the broader literature on sustainable agriculture of how an improved understanding of farm management strategies can inform insights that demonstrate a complementary economic and environmental sustainability in farming systems. So, to achieve the desired goal of sustainable agriculture, where fertile land can be passed on by one generation to another, as harvesting naturally encourages technology innovation, by building the blocks that lead toward sustainable agriculture slope while ensuring food security for our future generations, this theme suggests that pro-farmer policies or farmer training programs should provide a platform.

REFERENCES

- Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17(1), 99–120. <https://doi.org/10.1177/014920639101700108>
- Bathaei, A., & Štreimikienė, D. (2023). A systematic review of agricultural sustainability indicators. *Agriculture*, 13(2), 241. <https://doi.org/10.3390/agriculture13020241>

Beillouin, D., Ben-Ari, T., & Malézieux, E. (2021). Positive but variable effects of crop diversification on biodiversity and ecosystem services. *Global Change Biology*, 27(19), 4697–4710. <https://doi.org/10.1111/gcb.15747>

Chopin, P., Mubaya, C. P., Descheemaeker, K., Öborn, I., & Bergkvist, G. (2021). Avenues for improving farming sustainability assessment with upgraded tools, sustainability framing and indicators. A review. *Agronomy for Sustainable Development*, 41(2), Article 19. <https://doi.org/10.1007/s13593-021-00674-3>

Coteur, I., Wustenberghs, H., Debruyne, L., Lauwers, L., & Marchand, F. (2020). How do current sustainability assessment tools support farmers' strategic decision-making? *Ecological Indicators*, 114, 106298. <https://doi.org/10.1016/j.ecolind.2020.106298>

de Olde, E. M., Oudshoorn, F. W., Sørensen, C. A. G., Bokkers, E. A. M., & de Boer, I. J. M. (2016). Assessing sustainability at farm-level: Lessons learned from a comparison of tools in practice. *Ecological Indicators*, 66, 391–404. <https://doi.org/10.1016/j.ecolind.2016.01.047>

Elkington, J. (1998). Partnerships from cannibals with forks: The triple bottom line of 21st-century business. *Environmental Quality Management*, 8(1), 37–51. <https://doi.org/10.1002/tqem.3310080106>

Garnett, T., Appleby, M. C., Balmford, A., Bateman, I. J., Benton, T. G., Bloomer, P., Burlingame, B., Dawkins, M., Dolan, L., Fraser, D., Herrero, M., Hoffmann, I., Smith, P., Thornton, P. K., Toulmin, C., Vermeulen, S. J., & Godfray, H. C. J. (2013). Sustainable intensification in agriculture: Premises and policies. *Science*, 341(6141), 33–34. <https://doi.org/10.1126/science.1234485>

Hayat, N., Al Mamun, A., Nasir, N. A. M., Selvachandran, G., Nawi, N. B. C., & Gai, Q. S. (2020). Predicting sustainable farm performance—Using hybrid structural equation modelling with an artificial neural network approach. *Land*, 9(9), 289. <https://doi.org/10.3390/land9090289>

Jayne, T. S., Chamberlin, J., & Headey, D. D. (2014). Land pressures, the evolution of farming systems, and development strategies in Africa: A synthesis. *Food Policy*, 48, 1–17. <https://doi.org/10.1016/j.foodpol.2014.05.014>

Kassam, A., Friedrich, T., Shaxson, F., & Pretty, J. (2009). The spread of conservation agriculture: Justification, sustainability and uptake. *International Journal of Agricultural Sustainability*, 7(4), 292–320. <https://doi.org/10.3763/ijas.2009.0477>

Kremen, C., & Miles, A. (2012). Ecosystem services in biologically diversified farming systems: Benefits, externalities, and trade-offs. *Ecology and Society*, 17(4), 40. <https://doi.org/10.5751/ES-05035-170440>

Kremen, C., Iles, A., & Bacon, C. (2012). Diversified farming systems: An agroecological, systems-based alternative to modern industrial agriculture. *Ecology and Society*, 17(4), 44. <https://doi.org/10.5751/ES-05103-170444>

Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., Bwalya, M., Caron, P., Cattaneo, A., Garrity, D., Henry, K., Hottle, R., Jackson, L., Jarvis, A., Kossam, F., Mann, W., McCarthy, N., Meybeck, A., Neufeldt, H., Remington, T., Sen, P. T., & Sessa, R. (2014). Climate-smart agriculture for food security. *Nature Climate Change*, 4(12), 1068–1072. <https://doi.org/10.1038/nclimate2437>

Lyu, X., Peng, W., Niu, S., Qu, Y., & Xin, Z. (2022). Evaluation of sustainable intensification of cultivated land use according to farming households' livelihood types. *Ecological Indicators*, 138, 108848. <https://doi.org/10.1016/j.ecolind.2022.108848>

Pretty, J. (2018). Intensification for redesigned and sustainable agricultural systems. *Science*, 362(6417), eaav0294. <https://doi.org/10.1126/science.aav0294>

Pretty, J., & Bharucha, Z. P. (2014). Sustainable intensification in agricultural systems. *Annals of Botany*, 114(8), 1571–1596. <https://doi.org/10.1093/aob/mcu205>

Pretty, J., & Bharucha, Z. P. (2015). Integrated pest management for sustainable intensification of agriculture in Asia and Africa. *Insects*, 6(1), 152–182. <https://doi.org/10.3390/insects6010152>

Pretty, J., Benton, T. G., Bharucha, Z. P., Dicks, L. V., Flora, C. B., Godfray, H. C. J., Goulson, D., Hartley, S., Lampkin, N., Morris, C., Pierzynski, G., Prasad, P. V. V., Reganold, J., Rockström, J., Smith, P., Thorne, P., & Wratten, S. (2018). Global assessment of agricultural system redesign for sustainable intensification. *Nature Sustainability*, 1(8), 441–446. <https://doi.org/10.1038/s41893-018-0114-0>

Reganold, J. P., & Wachter, J. M. (2016). Organic agriculture in the twenty-first century. *Nature Plants*, 2, 15221. <https://doi.org/10.1038/nplants.2015.221>

Rigby, D., Woodhouse, P., Young, T., & Burton, M. (2001). Constructing a farm level indicator of sustainable agricultural practice. *Ecological Economics*, 39(3), 463–478. [https://doi.org/10.1016/S0921-8009\(01\)00245-2](https://doi.org/10.1016/S0921-8009(01)00245-2)

Rockström, J., Williams, J., Daily, G., Noble, A., Matthews, N., Gordon, L., Wetterstrand, H., DeClerck, F., Shah, M., Steduto, P., de Fraiture, C., Hatibu, N., Unver, O., Bird, J., Sibanda, L., & Smith, J. (2017). Sustainable intensification of agriculture for human prosperity and global sustainability. *Ambio*, 46(1), 4–17. <https://doi.org/10.1007/s13280-016-0793-6>

Sánchez, A. C., VanLooke, A., Shaw, C. I., DeHaan, L. R., & Jordan, N. R. (2022). Financial profitability of diversified farming systems: A global meta-analysis. *Ecological Economics*, 201, 107595. <https://doi.org/10.1016/j.ecolecon.2022.107595>

Schut, M., van Asten, P., Okafor, C., Hicintuka, C., Mapatano, S., Nabahungu, N. L., Kagabo, D. M., Muchunguzi, P., Njukwe, E., Dongsop-Nguezet, P. M., & Vanlauwe, B. (2016). Sustainable intensification of agricultural systems in the Central African Highlands: The need for institutional innovation. *Agricultural Systems*, 145, 165–176. <https://doi.org/10.1016/j.agry.2016.03.005>

Setsoafia, E. D., Ma, W., & Renwick, A. (2022). Effects of sustainable agricultural practices on farm income and food security in northern Ghana. *Agricultural and Food Economics*, 10, 9. <https://doi.org/10.1186/s40100-022-00216-9>

Shah, K. K., Modi, B., Pandey, H. P., & Subedi, A. (2021). Diversified crop rotation: An approach for sustainable agriculture production. *Advances in Agriculture*, 2021, 8924087. <https://doi.org/10.1155/2021/8924087>

Tilman, D., Balzer, C., Hill, J., & Befort, B. L. (2011). Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences*, 108(50), 20260–20264. <https://doi.org/10.1073/pnas.1116437108>

Tzouramani, I., Mantziaris, S., & Karanikolas, P. (2020). Assessing sustainability performance at the farm level: Examples from Greek agricultural systems. *Sustainability*, 12(7), 2929. <https://doi.org/10.3390/su12072929>

Volkov, A., Morkunas, M., Balezentis, T., & Šapolaitė, V. (2020). Economic and environmental performance of the agricultural sectors of the selected EU countries. *Sustainability*, 12(3), 1210. <https://doi.org/10.3390/su12031210>

Weltin, M., Zasada, I., Piore, A., Debolini, M., Geniaux, G., Perez, O. M., Scherer, L., & Marco, D. (2018). Conceptualising fields of action for sustainable intensification—A systematic literature review and application to regional case studies. *Agriculture, Ecosystems & Environment*, 257, 68–80. <https://doi.org/10.1016/j.agee.2018.01.023>

Wezel, A., Casagrande, M., Celette, F., Vian, J.-F., Ferrer, A., & Peigné, J. (2014). Agroecological practices for sustainable agriculture. A review. *Agronomy for Sustainable Development*, 34(1), 1–20. <https://doi.org/10.1007/s13593-013-0180-7>

Zhao, J., Chen, J., Beillouin, D., Lambers, H., Yang, Y., Smith, P., Zeng, Z., Olesen, J. E., & Zang, H. (2022). Global systematic review with meta-analysis reveals yield advantage of legume-based rotations and its drivers. *Nature Communications*, 13, 4926. <https://doi.org/10.1038/s41467-022-32464-0>