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The Effect of Green Technology Implementation and Cleaner Production Practices on Productivity and Sustainability of SMEs in the Organic Agriculture Sector

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ABSTRACT

This study examines the effect of green technology implementation and cleaner production practices on the productivity and sustainability of SMEs in the organic agriculture sector. A quantitative approach was employed, with data collected from 50 SMEs through structured questionnaires. The variables were measured using a Likert scale (1-5) and analyzed using SPSS version 26. The findings reveal that green technology implementation and cleaner production practices significantly and positively impact both productivity and sustainability. Green technologies enhance operational efficiency and resource management, while cleaner production practices reduce waste and improve environmental performance. These results highlight the importance of adopting sustainable practices for achieving long-term growth and competitiveness. The study provides valuable insights for policymakers and SME owners seeking to align business performance with sustainability goals.

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1. INTRODUCTION

The global push toward sustainability has intensified the need for businesses to adopt environmentally conscious practices. This trend is particularly relevant for Small and Medium Enterprises (SMEs), which are integral to economic growth yet often lack the resources to invest in sustainable solutions. In the organic agriculture sector, SMEs face unique challenges, such as limited access to technology, fluctuating market demands, and the need to balance profitability with environmental stewardship [1]. To address these challenges, green technology implementation, and cleaner production practices have emerged as critical strategies for enhancing both productivity and sustainability.

Green technology refers to the use of innovative tools and processes that minimize environmental impact while maximizing

resource efficiency. For SMEs in the organic agriculture sector, adopting green technologies can streamline production, reduce waste, and improve operational efficiency [2], [3]. Similarly, cleaner production practices, which focus on reducing emissions, conserving energy, and minimizing waste, align with the goals of sustainability by promoting environmentally friendly operations. These practices are not only essential for meeting regulatory requirements but also for achieving a competitive advantage in the marketplace [4].

The importance of integrating green technology and cleaner production practices lies in their potential to address pressing global issues, such as climate change and resource depletion. However, the impact of these practices on SME performance, particularly in terms of productivity and long-term sustainability, remains underexplored. Previous research has primarily focused on large corporations, leaving a gap in understanding the unique dynamics faced by SMEs in adopting sustainable practices.

This study aims to fill this gap by examining the effect of green technology implementation and cleaner production practices on the productivity and sustainability of SMEs in the organic agriculture sector. Specifically, this research explores how these practices contribute to operational efficiency, market competitiveness, and environmental performance.

2. LITERATURE REVIEW

2.1 Green Technology Implementation

Green technology is defined as the application of innovative solutions aimed at reducing environmental impacts while enhancing efficiency and productivity [5], [6]. In agriculture, this encompasses renewable energy systems, precision farming tools, and eco-friendly packaging materials, which, for SMEs, have been associated with improved resource management, cost savings, and compliance with environmental regulations [7], [8]. The Technology-Organization-Environment (TOE) framework provides a theoretical basis for understanding green technology adoption, emphasizing the influence of technological readiness, organizational capacity, and external pressures on the implementation of innovative solutions [9], [10]. Specifically, in the organic agriculture sector, green technology supports sustainable practices by optimizing resource use and reducing waste, which are crucial for maintaining soil fertility and minimizing carbon footprints [10].

2.2 Cleaner Production Practices

Cleaner production refers to continuous environmental improvements aimed at reducing waste, emissions, and energy consumption in production processes, emphasizing preventative measures rather than reactive solutions, which makes it a cornerstone of sustainable industrial practices. For SMEs in the organic agriculture sector, cleaner production practices may include composting organic waste, using biodegradable inputs, and adopting water-efficient irrigation methods. Empirical studies, such as those by [11], [12], have shown that these practices significantly enhance environmental performance and operational efficiency in agribusiness SMEs. The Resource-Based View (RBV) theory supports these findings,

highlighting the importance of internal capabilities in achieving competitive advantage [13]. By integrating cleaner production practices, SMEs can strengthen their resource base and align with the principles of sustainability.

2.3 Productivity in SMEs

Productivity, defined as the efficiency of converting inputs into outputs, is a key performance metric for SMEs, particularly in the organic agriculture sector, where it depends on resource availability, technological innovation, and market conditions. Green technology and cleaner production enhance productivity by reducing inefficiencies, minimizing resource wastage, optimizing processes, and lowering input costs and environmental risks, resulting in higher yields, better-quality products, and improved competitiveness [14]. However, the impact of sustainable practices on productivity varies with operational scale and technological integration [15]. Sustainability, encompassing environmental, economic, and social dimensions, ensures responsible long-term operations [16]. Organic agriculture supports sustainability by promoting biodiversity, soil health, and reduced synthetic input use, while green technology and cleaner production foster resilience, build stakeholder trust, and improve profitability [16]. The Triple Bottom Line (TBL) framework underscores the interconnectedness of these dimensions, offering a holistic approach to sustainability analysis.

2.4 Theoretical Framework and Hypotheses

The integration of green technology and cleaner production practices is underpinned by multiple theoretical frameworks, including the TOE framework, RBV theory, and TBL framework. These theories collectively suggest that sustainable practices enhance productivity and sustainability by leveraging internal capabilities and responding to external pressures.

Based on the literature, the following hypotheses are proposed:

H1: Green technology implementation positively affects the productivity of SMEs in the organic agriculture sector.

H2: Cleaner production practices positively affect the productivity of SMEs in the organic agriculture sector.

H3: Green technology implementation positively affects the sustainability of SMEs in the organic agriculture sector.

H4: Cleaner production practices positively affect the sustainability of SMEs in the organic agriculture sector.

3. METHODS

3.1 Research Design

This study employs a quantitative research design to investigate the effect of green technology implementation and cleaner production practices on the productivity and sustainability of SMEs in the organic agriculture sector. The quantitative approach allows for a systematic analysis of relationships between variables using

numerical data, ensuring objectivity and generalizability of the findings.

3.2 Population and Sample

The population for this study consists of SMEs operating in the organic agriculture sector in Indonesia. These SMEs were selected due to their significant role in promoting sustainable agricultural practices while contributing to local economies.

A purposive sampling technique was used to select 50 SMEs that have adopted at least one form of green technology or cleaner production practice. This approach ensures that the sample is relevant to the research objectives. Respondents included business owners or managers who are directly involved in decision-making processes related to sustainability practices.

3.3 Data Collection Methods

Data were collected using a structured questionnaire designed to measure the implementation of green technology, cleaner production practices, productivity, and sustainability. The questionnaire was distributed to the selected SMEs through email and in-person visits, ensuring a high response rate. To ensure clarity and relevance, the questionnaire was pre-tested with a small group of respondents before full-scale data collection.

3.4 Data Analysis Techniques

The collected data were analyzed using SPSS version 26 through a series of systematic steps. Descriptive statistics were used to summarize the demographic characteristics of the respondents and SMEs, including their size, location, and types of sustainable practices adopted. Reliability and validity testing were conducted using Cronbach's alpha to ensure the internal consistency of the measurement scales, while exploratory factor analysis (EFA) validated the construct structure. Correlation analysis was performed to examine the relationships between the independent variables—green technology implementation and cleaner production practices—and the dependent variables, productivity and sustainability. Finally, multiple regression analysis was used to test the hypotheses and determine the individual and combined effects of the independent variables on the dependent variables.

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

The study analyzed responses from 50 SMEs in the organic agriculture sector. The demographic characteristics of the SMEs revealed that 62% were micro-enterprises, 28% were small enterprises, and 10% were medium enterprises. Most respondents (76%) reported using at least one form of green technology, such as renewable energy or eco-friendly packaging, while 84% practiced cleaner production techniques, including composting and energy conservation.

4.2 Reliability and Validity

The reliability analysis using Cronbach's alpha demonstrated strong internal consistency across all variables, with scores of 0.863 for Green Technology Implementation, 0.885 for Cleaner Production Practices, 0.846 for Productivity, and 0.89 for Sustainability. Additionally, the validity of the constructs was confirmed through Exploratory Factor Analysis (EFA), which showed factor loadings exceeding the acceptable threshold of 0.70 for all items, ensuring the robustness of the measurement instruments.

4.3 Correlation Analysis

The Pearson correlation coefficients revealed significant positive relationships among the variables. Green Technology Implementation was positively correlated with Productivity ($r = 0.624$, $p < 0.01$) and Sustainability ($r = 0.682$, $p < 0.01$). Similarly, Cleaner Production Practices showed positive correlations with Productivity ($r = 0.558$, $p < 0.01$) and Sustainability ($r = 0.595$, $p < 0.01$). These findings indicate strong associations between sustainable practices and improved performance outcomes in SMEs.

4.4 Multiple Regression Analysis

Multiple regression analysis was conducted to test the hypotheses, revealing significant positive effects of the independent variables on the dependent variables. Green Technology Implementation was found to have a strong positive impact on Productivity ($\beta = 0.484$, $t = 5.128$, $p < 0.01$) and Sustainability ($\beta = 0.526$, $t = 5.453$, $p < 0.01$). Similarly, Cleaner Production Practices significantly enhanced Productivity ($\beta = 0.418$, $t = 4.227$, $p < 0.01$) and Sustainability ($\beta = 0.467$, $t = 4.851$, $p < 0.01$). These results confirm the critical role of sustainable practices in driving both productivity and long-term viability for SMEs in the organic agriculture sector.

Discussion

1. **Green Technology Implementation and Productivity**

Green technology implementation demonstrated a strong positive effect on productivity. This aligns with the findings of [17]–[19], who emphasized the efficiency gains from resource optimization and reduced operational wastage. SMEs that adopted renewable energy systems and precision farming tools reported higher yields and reduced production costs. These results highlight the importance of investing in technology to streamline operations and remain competitive in the organic agriculture market.

2. **Cleaner Production Practices and Productivity**

Cleaner production practices were also found to significantly improve productivity, supporting [20], [21]. By minimizing waste and conserving energy, SMEs not only reduced costs but also enhanced the quality of their outputs. The emphasis on preventative measures, such as composting and water-efficient irrigation, aligns with the principles of sustainable agriculture and contributes to operational efficiency.

3. **Green Technology Implementation and Sustainability**

The strong positive relationship between green technology implementation and sustainability reflects the findings of [9], [22]. SMEs that integrated environmentally friendly technologies reported improved stakeholder trust, regulatory compliance, and long-term viability. These technologies help SMEs address environmental challenges, such as soil degradation and water scarcity, while enhancing their market reputation.

4. **Cleaner Production Practices and Sustainability**

The results demonstrate that cleaner production practices significantly contribute to sustainability by fostering environmentally responsible operations. This supports the Triple Bottom Line (TBL) framework, which highlights the interconnectedness of environmental, social, and economic dimensions (Elkington, 1997). SMEs that adopted cleaner production practices experienced lower environmental risks and greater social acceptance, positioning them as leaders in sustainable business practices.

Implications for Policy and Practice

The findings of this study carry significant implications for both policymakers and practitioners. For policymakers, implementing supportive policies such as subsidies for green technologies and incentives for cleaner production practices can drive broader adoption of sustainable practices among SMEs. For practitioners, business owners are encouraged to prioritize sustainable practices as a core strategy for achieving long-term growth and resilience. Additionally, training programs and knowledge-sharing platforms can be instrumental in enhancing the capabilities of SMEs, enabling them to integrate sustainable innovations effectively into their operations.

Limitations and Future Research

This study has certain limitations. The sample size is relatively small, limiting the

generalizability of the findings. Additionally, the cross-sectional design does not capture long-term effects. Future research could explore longitudinal data and include larger and more diverse samples to validate these findings across different sectors and regions.

5. CONCLUSION

This study highlights the critical role of green technology implementation and cleaner production practices in enhancing the productivity and sustainability of SMEs in the organic agriculture sector. The findings demonstrate that adopting green technologies improves resource management, reduces operational costs, and increases yields, while cleaner production practices promote environmental responsibility and long-term viability. These results underscore the importance of integrating sustainable practices into SME operations to address environmental challenges and maintain competitiveness in the organic agriculture market. For policymakers, the study emphasizes the need for supportive policies, such as financial incentives and training programs, to encourage the adoption of sustainable practices. For business owners, the findings illustrate the strategic value of sustainability as a driver of performance and resilience. Future research should explore the long-term effects of these practices across diverse sectors and regions, providing a more comprehensive understanding of their impact. By adopting green technology and cleaner production practices, SMEs can contribute to global sustainability goals while securing their position as leaders in environmentally conscious business practices.

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