Sustainable Eco-Digital Innovations for MSMEs: Bridging Technology and Environmental Responsibility

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ABSTRACT

This study examines the implementation of eco-digital innovation in Micro, Small, and Medium Enterprises (MSMEs) to integrate digital technology with sustainability practices. The primary objective is to identify the factors influencing the adoption of environmentally friendly technology by MSMEs and analyze the impact of its implementation on environmental and economic performance. The research also explores the main challenges faced by MSMEs, including financial constraints, lack of knowledge, inadequate technological infrastructure, and resistance to change. The findings indicate that eco-digital innovation can enhance operational efficiency and competitiveness, but requires support in the form of funding, education, infrastructure development, and clear government policies. Collaboration among various stakeholders is crucial to support the sustainable digital transformation of MSMEs, which not only boosts business performance but also strengthens environmental responsibility.

INTRODUCTION

In recent decades, attention to environmental sustainability has significantly increased, driven by global issues such as climate change, environmental degradation, and the depletion of natural resources. On the other hand, the rapid development of digital technology has opened up new opportunities to address these environmental challenges (Bradu et al., 2023). Eco-digital innovation, which integrates digital technology with environmentally friendly practices, has emerged as a key strategy for achieving sustainability (Montresor & Vezzani, 2023). This has become an important issue that cannot be ignored by business actors, including Micro, Small, and Medium Enterprises (MSMEs). MSMEs play a crucial role in the global economy, but they often face challenges in adopting digital technologies that support environmental sustainability (Aulia et al., n.d.). Therefore, it is essential to find solutions that integrate digital innovation with environmental responsibility, creating a business ecosystem that is not only economically efficient but also environmentally friendly.

Digital technology offers tremendous opportunities to improve operational efficiency, expand market reach, and enhance the competitiveness of MSMEs (Rachmad et al., 2024). However, the implementation of these technologies also carries risks to environmental sustainability if not properly managed (Oláh et al., 2020). Sustainable eco-digital innovation is an approach that combines the use of technology with environmentally friendly practices, allowing MSMEs to grow sustainably without harming the environment (Ordóñez de Pablos et al., 2024).

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This research aims to explore how MSMEs (Micro, Small, and Medium Enterprises) can leverage digital technology to achieve environmental sustainability goals. The study will discuss various strategies, technologies, and best practices that MSMEs can adopt to reduce their carbon footprint, enhance resource efficiency, and support sustainable economic development.

Although eco-digital innovation and environmental sustainability have increasingly become prominent topics in business and technology literature, in-depth studies on how MSMEs can adopt eco-digital technologies remain limited. MSMEs have unique characteristics and challenges, such as limited capital, human resources, and access to technology, which require a different approach (Sastradinata, 2024). Existing research tends to separate the study of digital technology adoption and environmental sustainability practices. Few studies explore how these two aspects can be effectively integrated within the context of MSMEs. Most research on eco-digital innovation focuses on specific sectors, such as manufacturing or information technology, while other sectors involving MSMEs, such as agriculture, fisheries, or crafts, receive less attention. There is an urgent need to understand how eco-digital innovation can be effectively applied across various industry sectors involving MSMEs. Many studies tend to focus more on the potential benefits of eco-digital innovation without deeply examining the challenges and barriers MSMEs face in implementing it. Most existing research focuses more on the short-term impact of adopting eco-digital technology. Studies exploring the long-term impacts, both in terms of environmental sustainability and MSME business growth, are still very limited.

This research offers several significant novel aspects in the context of strengthening sustainable eco-digital innovation for MSMEs (Micro, Small, and Medium Enterprises). The study will develop an approach specifically designed to integrate digital technology with environmental sustainability practices in MSMEs. This includes the adaptation of simpler and more affordable technologies tailored to the needs, capacities, and challenges faced by MSMEs. This approach offers innovative solutions that differ from previous research, which has tended to focus on large corporations. The study will provide practical guidance on how MSMEs can implement environmentally friendly technologies without sacrificing operational efficiency or business competitiveness. It will also offer new insights into how eco-digital innovation can be adapted to various types of MSMEs, offering a more comprehensive view compared to previous studies that have often been limited to specific sectors. Additionally, it will develop an evaluation framework that can be used to measure the long-term impact of eco-digital technology implementation on MSMEs, encompassing aspects such as environmental sustainability, business growth, and competitiveness, which have not been extensively measured in previous studies.

By offering a more inclusive and specific approach for MSMEs, this research is expected to lay the foundation for the development of more sustainable and effective eco-digital strategies, as well as make a significant contribution to the literature and practice in this field.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT
Eco-Digital Innovation and Environmental Sustainability

Eco-digital innovation can be defined as the application of digital technology to develop products, services, or processes that are not only efficient but also environmentally friendly (Mishra et al., 2024). According to Li et al. (2023), this innovation involves the integration of

technologies such as the Internet of Things (IoT), artificial intelligence (AI), big data, and blockchain in efforts to reduce environmental impact and improve resource efficiency. For example, IoT can be used to monitor and manage energy consumption in real-time, while AI can help optimize production processes to minimize waste.

Eco-digital innovation refers to the application of digital technologies to achieve environmental sustainability goals, which include reducing carbon footprints, managing resources more efficiently, and promoting environmentally friendly business practices (Maksymova et al., 2023). Previous research has shown that digital technologies such as IoT, big data, and AI can be used to enhance energy efficiency, optimize production processes, and minimize waste (Teh & Rana, 2023). However, much of this research focuses on large corporations, while MSMEs (Micro, Small, and Medium Enterprises) often lag in adopting these technologies due to limited resources and capabilities (Sifwah et al., 2024).

According to Hapsoro and Bangun (2020), environmental sustainability is one of the main pillars of sustainable development, which aims to meet current needs without compromising the ability of future generations to meet their own needs. This can be achieved through several means, such as reducing carbon emissions. For instance, digital energy management systems can optimize energy use in production processes and business operations, reducing energy waste and overall carbon emissions (Kusumah et al., 2024). Technologies like smart sensors and big data analytics can be used to monitor the use of water, energy, and raw materials, enabling more effective management and waste reduction (Erwin et al., 2023). In the agricultural sector, for example, precision farming technology uses real-time data to optimize the use of water and fertilizers, reducing environmental impact (Hasibuan, 2023). Blockchain technology can also be used to ensure transparency and accountability in industrial waste management (Hasibuan, 2023).

Eco-digital innovation has significant potential to contribute to environmental sustainability through carbon emission reduction, increased resource efficiency, and improved waste management. However, its implementation still faces several challenges, including high investment costs, lack of knowledge, and resistance to change.

Digital Transformation in MSMEs

Digital transformation in the context of MSMEs involves integrating digital technologies into all areas of business, fundamentally changing how companies operate and deliver value to customers (Aulia et al., n.d.). The technologies commonly used in digital transformation include e-commerce platforms, social media, cloud computing, big data, and the Internet of Things (IoT) (Malik, 2022). This transformation is not only about the adoption of technology but also involves changes in business models, organizational culture, and company strategies.

MSMEs play a crucial role in the global economy, but they face various challenges in adopting digital technology (Aulia et al., n.d.). Several studies suggest that digital transformation in MSMEs can enhance competitiveness and open new opportunities in the global market (Istiqomah, 2023). However, this transformation is often hindered by a lack of knowledge, high implementation costs, and resistance to change (Diener & Špaček, 2021). Additionally, MSMEs need to consider the environmental impact of technology use, which has not been widely discussed in previous literature.

Integration of Digital Technology and Sustainability in MSMEs

The integration of digital technology in the context of sustainability refers to the use of digital tools and platforms to achieve sustainable environmental, social, and economic goals (Alamsyah & Budiman, 2024). According to Li et al. (2023), digital technologies such as the Internet of Things (IoT), artificial intelligence (AI), and big data analytics can play a significant role in monitoring and optimizing resource use, reducing waste, and supporting the circular economy.

Martínez-Peláez et al. (2023) argue that digital technology can enable MSMEs to adopt more sustainable business practices, such as more efficient energy management, greener supply chain management, and environmentally friendly production. For example, IoT can be used to collect real-time data on energy consumption, while AI can help optimize production processes to be more efficient and reduce environmental impact.

Research combining digital technology and environmental sustainability in MSMEs is still relatively limited. According to Damayanti et al. (2024), MSMEs have great potential to contribute to environmental sustainability through the adoption of appropriate technologies. However, most of the literature has focused on the economic aspects of digital transformation, with little attention given to how technology can be used to support sustainable business practices (Broccardo et al., 2023). This gap highlights the need for further research to understand how digital technology can be integrated with sustainability strategies in MSMEs.

Challenges and Solutions in Implementing Eco-Digital Innovation in MSMEs

One of the main challenges is the limitation of resources, both in terms of finances and expertise. Many MSMEs lack the budget to invest in advanced technology or workforce training (Dzikrullah & Chasanah, 2024). The challenges in implementing eco-digital innovation in MSMEs include financial constraints, limited access to technology, and knowledge gaps (Hamdan & Anshari, 2024). Previous studies have also shown that external support, such as government policies and collaboration with technology institutions, can help MSMEs overcome these challenges (Syam & Randy, 2024). Additionally, developing business models that integrate digital and environmental aspects can be key to successful implementation of eco-digital innovation (Syam & Randy, 2024).

METHODS

This study employs a qualitative method with a multiple case study approach. The multiple case study approach is a qualitative research method used to explore a particular phenomenon through an in-depth analysis of several cases in different contexts (Poltak & Widjaja, 2024). This approach aims to understand how a phenomenon or issue emerges and develops in various situations or environments.

Purposive sampling will be used to select MSMEs that have characteristics aligned with the research objectives. Data collection will be conducted through in-depth interviews, observations, and document analysis.

By using this approach and method, the qualitative research can provide deep insights into the dynamics of eco-digital innovation adoption in MSMEs, as well as the challenges and opportunities faced in integrating technology with environmental sustainability.

RESULTS

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1. Factors Influencing the Adoption of Environmentally Friendly Digital Technology by MSMEs

    This study identified several key factors that influence the adoption of environmentally friendly digital technology by MSMEs:

    - Awareness and Knowledge of Sustainability: MSME owners and managers with a high awareness of the importance of environmental sustainability tend to adopt environmentally friendly digital technology more quickly. However, knowledge gaps and a lack of technical understanding often pose significant barriers.
    - External Support: Government policies, access to funds or financial incentives, and support from external institutions, such as non-profit organizations or universities, have been shown to play a crucial role in encouraging the adoption of environmentally friendly technology.
    - Availability of Resources and Infrastructure: MSMEs with better access to resources, such as a workforce skilled in digital technology, and adequate digital infrastructure, are more likely to integrate environmentally friendly technology into their operations.

2. Impact of Eco-Digital Innovation Implementation on MSMEs' Environmental and Economic Performance

    The implementation of eco-digital innovation has a significant impact on MSMEs' performance, both environmentally and economically:

    - Environmental Performance: MSMEs that adopt environmentally friendly digital technology report significant reductions in energy consumption, better waste management, and lower carbon emissions. This indicates that the adoption of such technology is effective in improving environmental performance.
    - Economic Performance: Economically, eco-digital innovation helps MSMEs enhance operational efficiency and reduce production costs, ultimately increasing profitability. MSMEs also report an improvement in reputation and attractiveness to consumers, who are increasingly concerned with sustainable products and business practices.
    - Global Competitiveness: The integration of digital technology with sustainability strategies helps MSMEs enhance their competitiveness in the global market. MSMEs that focus on sustainability find it easier to penetrate international markets that are sensitive to environmental issues.

3. Challenges in Implementing Eco-Digital Innovation and Strategies to Overcome Them

    This study identifies several key challenges faced by MSMEs in implementing eco-digital innovation, along with strategies that can be employed to overcome these obstacles:

    - Financial Challenges: Limited funding is one of the biggest barriers for MSMEs to adopt environmentally friendly digital technology. Many MSMEs perceive the initial costs of implementing such technology as too high.
    - Limited Access to Technology: MSMEs in less developed regions often have limited access to advanced technology and adequate digital infrastructure, which hinders their efforts to adopt eco-digital innovation.
    - Resistance to Change: Some MSMEs face internal resistance, where employees or managers are reluctant to switch to new technologies due to discomfort with change or concerns about its impact on their jobs.

Effective Strategies:

- Training and Education: Raising awareness and knowledge about environmentally friendly digital technology through training and educational programs has proven effective in reducing resistance and increasing technology adoption.
- Partnerships and Collaboration: MSMEs that form partnerships with technology institutions, government bodies, and non-profit organizations are better able to overcome financial and technical challenges. These collaborations also provide access to the necessary resources and technology.
- Incremental Approach: Some MSMEs have successfully addressed financial barriers by gradually implementing environmentally friendly digital technology, starting with small projects that expand as profits and experience increase.

DISCUSSION

1. Factors Influencing the Adoption of Environmentally Friendly Digital Technology by MSMEs

The research findings indicate that awareness and knowledge about sustainability, external support, and the availability of resources and infrastructure are key factors influencing the adoption of environmentally friendly digital technology by MSMEs. These results align with the diffusion of innovation theory presented by Mailin et al. (2022), which states that the characteristics of innovation, social context, and support from external networks play a crucial role in determining the extent to which an innovation will be adopted. With increasing competition in the global market, MSMEs need to adopt digital technology to remain competitive. Digitalization enables MSMEs to enhance operational efficiency, access broader markets, and respond to customer demands more quickly.

Awareness and knowledge about sustainability seem to be the primary driving factors (Nur & Husen, 2022), especially when MSME owners or managers have a strong understanding of the long-term benefits of environmentally friendly technology. This highlights the importance of education and training to increase awareness and knowledge among MSME players. Changes in consumer behavior, especially with the growing use of the internet and mobile devices, are pushing MSMEs to adopt digital strategies (Sifwah et al., 2024). Consumers increasingly expect fast and personalized services, which can be achieved through the use of digital technology.

External support from the government, non-profit organizations, and universities was also found to be critical. This supports the view that appropriate policies and incentives can encourage sustainable innovation (Bukran & Ramdani, 2024). However, the availability of resources and infrastructure remains a challenge, particularly in less developed areas, indicating the need for more targeted interventions to address these gaps. According to Kadaba et al. (2023), in many countries, governments have introduced various initiatives and incentives to encourage MSMEs to undergo digital transformation. This support includes subsidies, training, and the provision of better digital infrastructure.

2. Impact of Eco-Digital Innovation Implementation on the Environmental and Economic Performance of MSMEs

The implementation of eco-digital innovation has been proven to have a positive impact on both the environmental and economic performance of MSMEs. The reduction in energy consumption, improved waste management, and lower carbon emissions are results that demonstrate digital technology can be an effective tool in supporting environmental sustainability goals.

From an economic perspective, these findings support the argument that eco-digital innovation not only helps MSMEs achieve environmental sustainability but also enhances operational efficiency and profitability. This aligns with literature suggesting that sustainability and profitability do not have to be mutually exclusive but can indeed complement each other (Ordóñez de Pablos et al., 2024).

Additionally, the increased global competitiveness resulting from the integration of sustainability strategies and digital technology shows that MSMEs committed to environmentally friendly practices can more easily penetrate international markets. This provides further evidence that environmental sustainability is a crucial factor in strengthening competitive positioning in the global market (Saputra et al., 2023).

3. Challenges in Implementing Eco-Digital Innovation and Strategies to Overcome Them

Despite the numerous benefits of eco-digital innovation, this study identifies significant challenges faced by MSMEs, including financial limitations, access to technology, and resistance to change.

Financial challenges, identified as the most significant barrier, highlight the need to improve MSMEs' access to financing and incentives that support the adoption of environmentally friendly technologies (Sastradinata, 2024). This underscores the necessity for better policies and funding programs specifically designed for sustainable MSMEs to alleviate the burden of initial costs.

Limited access to technology, particularly in less developed areas, indicates the need for greater investment in digital infrastructure and broader training. Meanwhile, resistance to change within organizations suggests that cultural shifts and increased employee engagement in the innovation process are crucial.

Effective strategies identified in this study, such as training and education, partnerships and collaborations, and a phased approach, indicate that with the right support, MSMEs can overcome these obstacles. A phased approach, in particular, offers a practical way for MSMEs to adopt eco-digital innovation sustainably without facing significant financial risks.

4. Practical and Theoretical Implications

Practically, the findings of this study offer guidance for MSME owners, policymakers, and supporting institutions on facilitating the adoption of environmentally friendly digital technologies. Key areas of focus should include education, financial support, and infrastructure development.

From a theoretical perspective, this research enriches the literature on sustainable innovation in the MSME sector by demonstrating how internal and external factors interact to influence technology adoption. The findings also reinforce the relevance of agency theory, which highlights the need for incentives and monitoring to encourage agents (managers or employees) to support the sustainability goals desired by the principal (MSME owners).

This discussion confirms that despite significant challenges, with the right strategies, MSMEs can successfully adopt and implement sustainable eco-digital innovations. This adoption will ultimately enhance their environmental and economic performance as well as their competitiveness in the global market. Support from various parties, both internal and external, is crucial to achieving this success.

CONCLUSION

Research on sustainable eco-digital innovation for MSMEs demonstrates that integrating digital technology with sustainability practices can yield significant benefits, both economically and environmentally. MSMEs that successfully adopt and integrate digital technology with sustainability strategies can improve operational efficiency, reduce environmental impact, and enhance their competitiveness in the global market.

However, implementing these innovations is not without challenges. Factors such as financial constraints, lack of knowledge and expertise, inadequate technological infrastructure, resistance to change, and regulatory uncertainty are major obstacles that need to be addressed. To overcome these challenges, solutions should include improved access to funding, education and training, technological infrastructure development, and government policy support. With the right approach, MSMEs can leverage the potential of eco-digital innovation to achieve long-term sustainability and contribute to the achievement of sustainable development goals.

This research underscores the importance of collaborative efforts among various stakeholders, including the government, private sector, and educational institutions, in supporting sustainable digital transformation for MSMEs. Therefore, eco-digital innovation becomes not only a means to enhance business performance but also a commitment to broader environmental responsibility.

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