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An Integrated Green Management Model for Fashion SME Sustainability: Moderating Role of Green Culture Using PLS-SEM

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Abstract

Background: Organizational *green culture* as a moderating role in sustainable fashion SMEs. An environmentally friendly strategy is fundamental for the survival of fashion SMEs in emerging industries. Fashion SMEs in Central Java are under considerable environmental pressure; however, little research has examined the integrative role of organizational *green culture* as a moderator.
Objective: This study aims to investigate the impact of *green knowledge management* and *green innovation* on SME sustainability and to evaluate *green culture* as a moderator.
Methods: The research model was designed using online questionnaires and SmartPLS, where the samples were selected using stratified random sampling, consisting of 150 fashion SMEs from six regencies in Central Java. Five direct hypotheses and two moderating hypotheses were tested using PLS-SEM with bootstrapping (n = 500 resamples).
Results: The findings show that *green innovation* mediates the relationship between *green knowledge management* and sustainability, while *green culture* moderates the effect of *green knowledge management*. *Green knowledge management* significantly influences SME sustainability (β = 0.103, p = 0.003) and *green innovation* (β = 0.093, p = 0.000). Organizational *green culture* significantly moderates the relationship between *green knowledge management* and *green innovation* (p = 0.016), as well as the relationship between *green knowledge management* and sustainability (p = 0.020).
Conclusion: This study provides empirical evidence that organizational *green culture* is a key factor in improving environmentally friendly knowledge sharing and innovative decision-making effectiveness to support equitable sustainable development for fashion SMEs in developing countries.

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INTRODUCTION

SMEs play a pivotal role in facilitating economic growth and sustainable forms of development. Eco-innovation also plays an important role in the local economy of Indonesia, but adoption among SMEs is still limited (Achmad et al., 2023; Cardoni et al., 2020; Chien, 2023). They are deeply involved in a variety of economic sectors, from job creation to enhancing competitiveness and promoting innovation. SMEs play an important role in sustaining competitive market balance and supporting regional economic growth and the transition toward a circular economy (Novitasari & Agustia, 2023). Participating in markets allows SMEs to enhance

consumer welfare and spur greater economic development. SMEs are integral to the sustainable development challenge, as the ability of SMEs to respond innovatively and generate entrepreneurship is key to achieving sustainable development outcomes (Wasiq et al., 2023). Additionally, SMEs promote local economic resilience by utilizing natural resources and maintaining close relationships with neighboring communities (I. S. Khan et al., 2023).

Enterprises that respond proactively to environmental issues have a greater chance of establishing a sustainable competitive advantage. In addition to enhancing reputation, incorporating green practices helps firms cope with ecological uncertainty and improve overall operational performance (Li et al., 2023). Environmental innovation can serve as a mechanism to achieve eco-sustainability while also opening new avenues for competitive differentiation (Achmad et al., 2023). Ultimately, sustained competitive positioning is formed through the continuous development of green innovation capabilities (German et al., 2023; Novitasari & Agustia, 2023; C. H. Wang, 2019). As firms implement systematic strategic responses to environmental challenges, one of the most impactful managerial tools has become Green Knowledge Management (GKM). Al-Faouri (2023) stated that institutions proficient in the formation and application of ecological competencies tend to flourish in their sustainability endeavors, reinforcing that green knowledge management is one of the best practices for sustainable development. Thus, promoting environmental expertise opens a pathway toward sustainable ecological advancement and development.

Green innovation is a necessity for modern business viability because it is closely linked to employee engagement in clean production practices. A company's sustainability innovations are reinforced when employees demonstrate a commitment to pro-environmental behaviors in the workplace (Altassan, 2024; Wasiq et al., 2023). Owners of SMEs play diverse roles by promoting sustainable practices, managing green information, and fostering innovation. Research by Sahoo et al. (2023) indicates that implementing green knowledge management helps firms create more environmentally friendly products and services, while increased support from policymakers regarding innovation strategies can assist them in meeting sustainability targets. To address these deficiencies in the literature, Mustafa et al. (2023) explored the function of green knowledge sharing among SMEs in Punjab, Pakistan. There is currently a lack of empirical evidence supporting the relationship between green process innovation and firms' attainment of environmental competitive advantage, despite indications that such a relationship exists. Most research has focused on conventional technological and managerial innovations, leaving a gap in understanding how green knowledge management contributes to environmental innovation in the processes and management of small fashion enterprises.

An increasing number of academics are examining the relationship between environmental intellectual capital and sustainability pursuits in boutique fashion firms. As explained by Guo (2023), there is a distinction between the roles of knowledge dissemination and knowledge acquisition in achieving sustainability goals. Additional research by Jovanović et al. (2023) expands on this by examining sustainable performance indicators from economic, social, and environmental perspectives. Although the literature on SMEs is expanding, the manner in which an environmentally friendly corporate climate optimizes the impact of green knowledge practices on sustainable growth remains largely unexplored. This represents a significant gap because sustainability requires synergies among economic, social, and environmental goals.

Although progress has been made by Widyanti et al. (2024), few studies have investigated the role of organizational green culture as a positive moderator of the relationship between knowledge management and sustainable development, and these gaps remain evident. Existing studies often overlook deeper contextual issues, thereby calling for further empirical investigation. Traditional cost–benefit models of sustainability remain dominant in discussions of economic sustainability. For small and medium-sized enterprises, however, environmental sustainability focuses on reducing operational carbon footprints, improving resource efficiency, and transitioning toward renewable energy sources (Xie et al., 2022).

According to Jovanović et al. (2023), social sustainability remains a highly complex and ongoing challenge in global development efforts. Academic focus is still limited regarding how a sustainable internal culture influences the combined effectiveness of green innovation practices and green knowledge management in the fashion SME sector. Although the current literature has

explored managerial and technical aspects of innovation (Beny et al., 2023; Sahoo et al., 2023), several interconnected research areas still require further investigation.

This research is motivated by a lack of literature evaluating SME sustainability through a holistic framework that incorporates green innovation, green knowledge management, and the influence of organizational green culture (Abbas & Sağsan, 2019). This paper is significant because it examines organizational green culture as a moderator in the relationships linking green knowledge management with sustainable development and green innovation in the fashion industry. The study investigates how these elements interact to support the long-term growth of small and medium-sized enterprises from the perspective of business owners. While prior studies Widyanti et al. (2024) have examined green knowledge management and sustainability separately, none have tested organizational green culture as a simultaneous moderator of both the GKM–green innovation and GKM–sustainable development pathways in fashion SMEs, particularly within the emerging economy context of Central Java. This study addresses that gap through the application of Partial Least Squares Structural Equation Modeling (PLS-SEM) using a specific industry sample and by operationalizing findings within the Resource-Based View (RBV) and Natural Resource-Based View (NRBV) frameworks, which regard environmentally oriented capabilities as strategic assets capable of generating sustainable competitive advantage (Barney, 2000). The novelty of this study lies in its integrated framework linking GKM with green innovation and sustainable development, with organizational green culture functioning as a boundary condition.

Green Knowledge Management and Sustainable Development in SMEs

According to Hedlund (1994), knowledge is generally classified into two main categories: explicit and tacit knowledge. Explicit knowledge is codified knowledge that can be expressed verbally and documented in written form. Tacit knowledge, by contrast, is more personal and intuitive, making it difficult to formalize or transfer fully to others. Knowledge management is fundamentally the process of transforming tacit internal knowledge into explicit knowledge that can be systematically managed and shared. When implemented effectively, it enhances a firm's innovative capacity and organizational agility, providing SMEs with a strategic foundation to strengthen their market position. Green knowledge management refers to an environmentally oriented infrastructure for integrating company-wide information, with ecological responsibility as its central focus. Organizations adopting this model provide employees with a sustainable and user-centered platform for obtaining timely green insights (Gauthier & Zhang, 2020). By combining personal expertise with formal organizational processes, green knowledge management enables firms to remain competitive and innovative while encouraging problem-solving approaches that support long-term ecological sustainability (Song et al., 2020).

Innovation flourishes when research and development (R&D) activities are prioritized and green knowledge sharing is encouraged (Qu & Liu, 2022). Organizations can use these processes to design new products and improve existing ones, thereby enhancing overall environmental and social performance (M. K. Khan et al., 2022). Since knowledge generation is a social process (Chamba-Rueda et al., 2023), sufficient resources should be allocated to developing green programs and maintaining their long-term sustainability (M. K. Khan et al., 2022). When adopting environmentally friendly attitudes, employees are more capable of generating innovative solutions to ecological problems (Attia & Salama, 2018). Such engagement supports improved planning and fosters a sustainability-oriented culture within firms. Green knowledge is one of the primary drivers of competitive financial and environmental performance (Ode & Ayavoo, 2020), as it also strengthens the core capabilities that sustain a firm's competitiveness within its industry (Ahmed et al., 2022). As firms continue developing their environmental expertise, they create new opportunities for innovation-driven growth.

Sustainable development in SMEs is founded on the interconnected pillars of environmental, economic, and social performance (Xie et al., 2022). The social dimension reflects a firm's commitment to people and communities through the promotion of collective well-being, while the economic dimension emphasizes profitability through increased revenue and reduced operational costs (Sianturi et al., 2022). Green knowledge management functions as a strategic bridge connecting ecological concerns with socioeconomic objectives, thereby providing a

foundation for sustainable organizational development. To ensure long-term sustainability, forward-thinking organizations integrate green knowledge management into their business strategies (Chaithanapat et al., 2022). Existing literature also demonstrates a strong relationship between green insights and environmental performance, as organizations can maintain strong environmental outcomes by integrating green insights into business processes (Shahzad et al., 2020).

H1: Green knowledge management has a positive and significant effect on the sustainable development of SMEs.

Green Knowledge Management and Green Innovation

Knowledge creation and knowledge evolution occur simultaneously and interact dynamically (Piñeiro-Chousa et al., 2020). This interaction enables organizations to reduce the environmental impact of their activities through green innovation (Ahmed et al., 2022). Green innovation encompasses both technological and managerial transformations (Makhloufi et al., 2023). For example, firms implementing green technological innovation may adopt systems that reduce emissions and improve energy efficiency, thereby aligning industrial activities with broader sustainable development objectives.

H2: Green knowledge management has a positive and significant relationship with green innovation.

Green Innovation and Sustainable Development in SMEs

Green innovation is one of the primary strategies companies use to reduce operational carbon emissions (Soewarno et al., 2019). This includes designing environmentally friendly technologies and transforming business operations toward greener alternatives. Green technological development integrates ecological knowledge with organizational learning capabilities to produce environmentally conscious products and processes while conserving energy and materials in economically viable ways. Sustainable development seeks to meet present needs without exceeding environmental limits or causing ecological harm (Ziemba, 2019). Green Theory serves as a meta-theoretical framework that encourages firms to proactively integrate sustainable management practices into their organizational structures.

For micro, small, and medium-sized enterprises (MSMEs), the environmental dimension of sustainability emphasizes ecosystem conservation, preservation of clean air and water, sustainable energy management, adoption of renewable energy where feasible, and responsible procurement practices. The economic dimension enables firms to leverage creativity in developing sustainable products and reducing the use of harmful materials, thereby improving market competitiveness, lowering operational costs, and enhancing financial performance. At its core, the social dimension involves collaboration between firms and local stakeholders to improve human welfare through active engagement and problem-solving. Based on this foundation, the following hypothesis is proposed:

H3: Green innovation has a positive and significant effect on the sustainable development of SMEs.

Organizational Green Culture as a Moderator

The strategic direction and mindset necessary to achieve sustainable development are deeply rooted in organizational culture (Al-Swidi et al., 2021). Organizational green culture can be defined as a set of shared values in which all members of the organization prioritize environmental responsibility in their daily activities while ensuring alignment with broader organizational goals (Al-Hakimi et al., 2022; Subramanian & Suresh, 2023). Evidence of organizational green culture is reflected in employees' habitual work behaviors, particularly when ecological objectives influence their performance (Al-Hakimi et al., 2022; Subramanian & Suresh, 2023). Employees in such environments demonstrate stronger commitment to addressing environmental challenges (Bhattarai, 2023). This commitment is also evident among organizational leaders, who integrate green principles into strategic decision-making and daily business operations (Azhar & Yang, 2022). Given the importance of organizational green culture in promoting green innovation and sustainable development within firms, the following hypotheses are proposed:

H4: Organizational green culture positively moderates the relationship between green knowledge management and green innovation.
H5: Organizational green culture positively moderates the relationship between green knowledge management and sustainable development in SMEs.

METHOD

This study began by defining a population of 1,231 fashion MSME operators across six regions in Central Java, including Rembang, Pati, Kudus, Jepara, Semarang, and Pekalongan. Because this number was relatively large, the researchers selected a sample of 150 respondents using stratified random sampling to ensure proportional representation from each region. This means that the sample selection was not conducted through simple random sampling; instead, the population was first divided by region, and respondents were then randomly selected from each group. Data were collected through a digital questionnaire that not only recorded respondent profiles but also measured the four main research variables: green knowledge management, organizational culture, sustainability, and innovation. After all data from the 150 respondents had been collected, the researchers processed and analyzed them using SmartPLS v.3.0 to examine the relationships and effects among the variables in the study. The sample size of 150 is justified based on Hair et al. (2019) guideline that PLS-SEM requires at least 10 times the maximum number of structural paths, and power analysis recommending a minimum of 85 cases for medium effect sizes (f^2 = 0.15) at 80% statistical power; therefore, 150 respondents satisfied both criteria. Proportional allocation across regions was determined based on each region's registered fashion SME population (Dinas Koperasi dan UMKM Jawa Tengah, 2022): Pekalongan (n = 64, 42.7%), Semarang (n = 41, 27.3%), Jepara (n = 21, 14.0%), Kudus (n = 10, 6.7%), Pati (n = 8, 5.3%), and Rembang (n = 6, 4.0%). This study employed a quantitative, cross-sectional survey design. Primary data were collected via Google Forms using a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Data analysis employed SEM-PLS using SmartPLS v.3.0 in two stages: (1) outer model assessment—including convergent validity (AVE ≥ 0.50, CR ≥ 0.70) and discriminant validity (Fornell-Larcker criterion; HTMT ratio); and (2) inner model assessment—including path coefficients and significance testing through bootstrapping (500 resamples). Common method bias was addressed through procedural remedies and confirmed as non-problematic using Harman's single-factor test.

RESULTS AND DISCUSSION

Result

A total of 150 owners and managers of fashion SMEs in Pekalongan, Semarang, Jepara, Kudus, Pati, and Rembang were examined in this study. A 5-point Likert scale was administered through Google Forms to collect the data. As shown in Table 1, the respondents comprised 109 managers and 41 employees, with a total of 81 men and 69 women.

Table 1. Demographic characteristics of the respondents

Category	Sub-category	Frequency	Percentage
Sex	Male	81	54.00%
	Female	69	46.00%
Business Location	Semarang City	41	27.33%
	Pati Regency	8	5.33%
	Pekalongan City	64	42.67%
	Jepara Regency	21	14.00%
	Kudus Regency	10	6.67%
	Rembang Regency	6	4.00%
Role in Enterprise	Owner/Manager	109	72.67%
	Staff	41	16.00%

Instrument Measurement

This study uses a four-part measurement instrument that includes a demographic survey. Green knowledge management is assessed using three items based on (Andreou et al., 2016). On

the other hand, organizational green culture is assessed using four items adapted from (Andreou et al., 2016), while the green innovation indicators are based on slightly modified items from (Soewarno et al., 2019). SME sustainable development is measured using three items; therefore, this study is also categorized as a longitudinal investigation.

Preliminary Analysis and Results

The study used structural equation modeling (SEM) to create a hierarchy of latent constructs to reduce bias related to measurement errors. This method made it possible to use SmartPLS Version 3 to thoroughly examine the relationships between variables. The study satisfied the minimum criterion for factor analysis with 150 observations. Variance inflation factor (VIF) values verified the absence of multicollinearity, and the low correlation levels showed that common method bias (CMB) had not affected the results.

Analysis of the Measurement and Structural Model

The measurement model underwent testing via confirmatory factor analysis (CFA) to establish unidimensionality and validity (Hair et al., 2019). As recommended by Ramayah et al. (2018), path coefficients were calculated using bootstrapping with 150 resamples. This methodology emphasizes that p-values alone are insufficient and instead requires a holistic examination of confidence intervals and effect sizes to determine significance. Table 2 lists the requirements for these hypothesis tests. To evaluate measurement reliability based on Cronbach's alpha, Table 2 provides reliability scores for each latent variable. Convergent and discriminant validity assessments are used to evaluate construct validity. Convergent validity is indicated by factor loadings.

Criterion validity is assessed through optimal loadings, which should exceed 0.5, along with average variance extracted (AVE) values. This study confirms convergent validity, as all item loadings exceed 0.5. Table 2 details the AVE values and reliability measures, while Table 3 and the standardized root mean square residual (SRMR) table present the fit indices. Because all indicators achieved the required thresholds, both the structural and measurement models are considered well specified.

Table 2. Reliability and validity of the instrument

Variables	Cronbach Alpha	Composite Reliability[1]	AVE[2]
Green Innovation	0.904	0.954	0.912
Green Knowledge Management	0.806	0.885	0.721
Organizational Green Culture	0.911	0.921	0.789
SMEs' Sustainable Development	0.867	0.918	0.789
GKM-OGC-GI	1.000	1.000	1.000
GKM-OGC-SMEs SD	1.000	1.000	1.000

[1]ideal value ≥ 0.7
[2]ideal value value ≥ 0.7

Hypothesis testing was conducted using Structural Equation Modeling (SEM). A p-value of 0.003 was obtained for the effect of GKM on SME sustainable development, confirming a highly significant positive relationship and supporting Hypothesis H1, as shown in Table 5. These results demonstrate that environmentally oriented knowledge management contributes meaningfully to SME sustainable development. Furthermore, the implications of this finding extend to interorganizational knowledge-based cooperation, consistent with Lutchen (2018), whose work concluded that cross-organizational relationships can enhance economic performance. Fashion SMEs leverage green knowledge to build a sharing culture, significantly boosting eco-innovation ($\beta = 0.093$, $p = 0.003$). Efficient use of green knowledge leads to improved environmental solutions, and the data show that green innovation strongly enhances sustainable development in SMEs ($\beta = 0.077$, $p = 0.011$). The statistical results indicate that green culture has an insignificant effect on innovation ($\beta = 0.087$, $p = 0.247$) but a highly significant positive influence on SME

sustainability (β = 0.078, p < 0.001). The data also confirm that a strong green culture significantly moderates and strengthens the relationship between environmental knowledge and innovation (β = 0.049, p = 0.016), indicating a positive synergistic effect. Furthermore, testing green culture as a moderating variable showed that it significantly strengthens the relationship between green knowledge management and sustainable development (β = 0.056, p = 0.020).

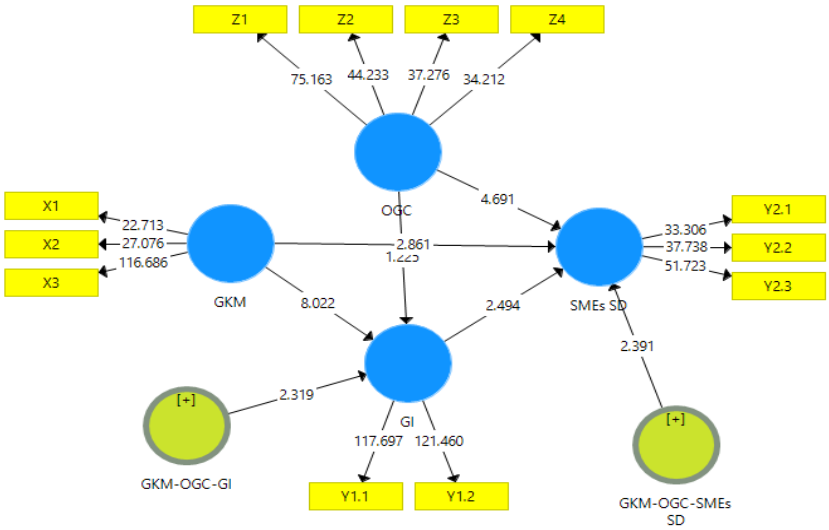

Figure 1. Research Model

Table 3. Construct Discriminant Validity

Items	GI	GKM	OGC	SMEs SD
Green Innovation	0.955			
Green Knowledge Management	0.789	0.849		
Organizational Green Culture	0.681	0.826	0.888	
SMEs' sustainable development	0.716	0.814	0.801	0.888

Table 4. Structural and Measurement Models

The goodness of fit measures	SRMR	d_ULS	d_G	Chi-Square	NFI
Saturated Model	0.074	0.422	0.446	377.655	0.780
Estimated Model	0.074	0.424	0.446	377.803	0.780

Table 5. Results of Hypothesis Testing: Hypothesis Testing Direct Effects

Hypothesis	Construct	Standard Deviation	T-Statistics	P-Value	Effect
H1	Green Knowledge Management –> SMEs' Sustainable Development	0.103	3.008	0.003	Significant
H2	Green Knowledge Management –> Green Innovation	0.093	7.895	0.000	Significant
H3	Green Innovation –> SMEs' Sustainable Development	0.077	2.542	0.011	Significant
H4	Organizational Green Culture -> Green Innovation	0.087	1.159	0.247	Insignificant
H5	Organizational Green Culture-> SMEs' Sustainable Development	0.078	4.891	0.000	Significant
Hypothesis	**Construct**	**Standard Deviation**	**T-Statistics**	**P-Value**	**Effect**
H6	Green Knowledge	0.049	2.408	0.016	Significant

	Management-Organizational Green Culture-Green Innovation -> Green Innovation				
H7	Green Knowledge Management- Organizational Green Culture -SMEs' Sustainable Development -> SMEs' Sustainable Development	0.056	2.326	0.020	Significant

"p ≤ 0.05; **p ≤ 0.01

Discussion

Using data from Tables 4 and 5, this research shows that green culture significantly moderates the relationships between green knowledge management and innovation (β = 0.049, p = 0.016), as well as between green knowledge management and sustainable development (β = 0.056, p = 0.020). To succeed, SME owners must improve how they acquire, share, and apply knowledge while also advancing technical and managerial innovation (Achmad et al., 2023; Cancela et al., 2023; Cardoni et al., 2020). The results of this study reinforce the findings of various previous studies that emphasize the important role of knowledge sharing and utilization in driving environmentally based innovation (Ode & Ayavoo, 2020). In the context of fashion-sector SMEs, innovation whether technological or managerial is inseparable from business actors' active efforts to acquire, manage, and disseminate environmentally friendly knowledge. This indicates that green knowledge management is a key driver of green innovation (Abbas & Sağsan, 2019; Al-Faouri, 2023). Practically, this means that the more frequently SME actors learn and share eco-friendly practices, the greater their chances of producing innovative and sustainable products or processes.

Furthermore, to achieve sustainable development aligned with the Sustainable Development Goals (SDGs), SMEs need to strengthen their environmental knowledge management practices. However, the effectiveness of these efforts heavily depends on the presence of an organizational culture that supports environmental values (Özgül & Zehir, 2023). This green organizational culture is reflected in an environmentally conscious business orientation, as well as the company's ability to retain a productive, motivated, and continuously developing workforce (Beny et al., 2023). In other words, without a supportive culture, the knowledge possessed by the organization will not be utilized optimally.

In this context, organizational culture serves not merely as a backdrop but also as a moderating variable that strengthens the relationship between green knowledge management and business sustainability. This means that as green culture within an organization becomes stronger, the positive impact of knowledge management on sustainability also increases. These findings suggest that business sustainability is influenced not only by what the organization knows but also by how environmental values are internalized in daily activities.

Furthermore, the positive influence of green knowledge management on innovation will be stronger if SMEs can build a consistent commitment to a green culture (Özgül & Zehir, 2023). By practicing environmentally friendly business activities and providing green training for employees and business owners, organizations can increase creativity and adaptability to change. Therefore, this paper confirms that the sabarmala (RUM) shoe model of eco-friendly green knowledge management promotes innovation and also serves as an important foundation for business sustainability, as established in previous studies on SMEs and SMCs.

The theoretical implications of these findings are discussed in relation to the Natural Resource-Based View (NRBV) and Organizational Learning Theory. H1 (β = 0.103, p = 0.003) indicates the significant effect of green knowledge management on sustainability, supporting the NRBV assumption that environmentally oriented knowledge capabilities are strategic assets that enable sustainable competitive advantage. Green innovation as a mediator (H2: β = 0.093, p = 0.000; H3: β = 0.077, p = 0.011) is consistent with Shahzad et al. (2020), in "Sustainable performance and green innovation driven by knowledge management processes." The

insignificant direct positive effect of green culture on innovation (H4: β = 0.087, p = 0.247), alongside its significant moderating role (H6: β = 0.049, p = 0.016), indicates that culture functions as an amplifying boundary condition, consistent with the framework proposed by S. Wang et al. (2022) in the Journal of Innovation & Knowledge. Comparatively, Jovanović et al. (2023) reported similar mediation patterns in manufacturing firms, while Bhattarai (2023) established moderating effects among Nepali industries, indicating the cross-cultural robustness of these findings.

Practical implications include boosting eco-training initiatives and green knowledge-sharing platforms among SME owners. Policymakers from both the provincial government and local government units (LGUs) should design and implement incentive schemes that reward green culture adoption, such as grant programs and self-sustainability initiatives for SMEs, alongside policies supporting recovery from the COVID-19 pandemic. Sustainability practitioners should also foster peer-learning networks across fashion SME clusters in Central Java.

CONCLUSION

The results of this study conclude that environment-based knowledge management and green innovation are crucial factors for the sustainability of SMEs, particularly when synergized with a compatible organizational culture. This study confirms that MSMEs will be better able to survive and thrive if they not only manage knowledge but also apply it to environmentally friendly practices. Furthermore, green innovation serves as a supporting factor that further strengthens business sustainability. However, this success does not stand alone; rather, it is significantly influenced by an organizational culture that supports environmental values. Such a culture acts as a catalyst for the relationship between knowledge and sustainability, enabling both to function more effectively. Addressing the three research objectives: (1) GKM has a significant positive effect on SME sustainable development (H1 supported: β = 0.103, p = 0.003), confirming that eco-oriented knowledge practices are a direct driver of sustainability outcomes; (2) green innovation significantly mediates the GKM–sustainability pathway (H2: β = 0.093, p = 0.000; H3: β = 0.077, p = 0.011), demonstrating that knowledge must be converted into innovation to fully realize its sustainability potential; and (3) organizational green culture significantly moderates both pathways (H6: p = 0.016; H7: p = 0.020), establishing that cultural alignment is a necessary enabler for maximizing the impact of green management practices. In this regard, theoretically, this study contributes to Natural Resource-Based View (NRBV) and Organizational Learning Theory by empirically proving their combined relevance in the context of Indonesian fashion SMEs. Previous models connecting GKM and sustainability lacked the boundary condition of organizational green culture. The core scientific contribution of this research is the integrated GKM–Innovation–Culture–Sustainability framework (geekO2C 3-in-1). Future research should investigate the longitudinal dynamics of this model and analyze its broader applicability to other SME sectors in developing economies.

From a theoretical perspective, this study is valuable because it connects two concepts that have often been studied independently: knowledge management and environmental sustainability. From a practical standpoint, corporate leaders should remain adaptable and develop business strategies and plans that take environmental considerations into account. This is important to ensure that businesses are not solely profit-driven but also sustainability-oriented in the long term. Although this research specifically focused on the batik industry, the findings may serve as a basis for application in other industries, such as the culinary and agribusiness sectors.

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AUTHOR CONTRIBUTION STATEMENT

Siti Sumiati: conceptualization, research design, manuscript drafting, and corresponding author responsibilities. Sri Dewi Wahyundaru: theoretical framework development (Green

Knowledge Management and Organizational Green Culture) and literature review. Sri Wahyuni: data collection and field survey coordination across six regencies in Central Java. Caroline: data analysis using SmartPLS v.3.0 and results interpretation (PLS-SEM, bootstrapping, and moderation testing). Sekar Langit Nugraheni: manuscript writing, literature synthesis, and hypothesis development. All authors contributed to the revision of the manuscript, final approval of the described work, and approval of the submitted version.

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