

The Environmental Effects of Oil and Gas Operations between Environmental Management System (EMS) and Non-EMS Companies

Shafi Alajmi

Institute for Environment and Development (LESTARI), Universiti Kebangsaan Malaysia (UKM),
Lingkungan Ilmu, 43600 Bangi, Selangor, Malaysia
p111461@siswa.ukm.edu.my

Sharina Abdul Halim

Institute for Environment and Development (LESTARI), Universiti Kebangsaan Malaysia (UKM),
Lingkungan Ilmu, 43600 Bangi, Selangor, Malaysia
sharinahalim@ukm.edu.my (corresponding author)

Lubna Alam

Institute for Environment and Development (LESTARI), Universiti Kebangsaan Malaysia (UKM),
Lingkungan Ilmu, 43600 Bangi, Selangor, Malaysia
lubna@ukm.edu.my

Abdulaziz El-Sinawi

Mechanical Engineering Department, College of Engineering, King Faisal University, Al-Hofuf,
Kingdom of Saudi Arabia
aelsinawi@kfu.edu.sa

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ABSTRACT

An Environmental Management System (EMS) is critical for oil and gas companies to reduce their pollution activities. However, only a few organizations have adopted such a system. This study evaluates the environmental outcomes of the oil and gas industries, focusing on a comparison between organizations that have adopted EMS and those that have not. The analysis carried out highlighted significant differences in Environmental Performance (EP), Employee Satisfaction (ES), Operational Improvement (OI), occupational Health and Safety (HS), and Competitive Advantage (CA) between organizations which have adopted EMS and those that have not. Data collected from oil and gas organizations in Saudi Arabia revealed that EMS adoption significantly enhances the EP, OI, and HS metrics while contributing to reduced carbon emissions and improved resource management. However, organizations that have not adopted EMS showed higher ES, indicating possible issues in EMS implementation strategies. The findings stress the essential role of EMS in achieving the United Nations Sustainable Development Goals (SDGs), especially in fostering responsible production, clean energy, and climate action. These insights offer valuable guidance for policymakers and industry leaders aiming to align industrial practices with sustainability goals.

Keywords-resource efficiency; operational improvement; EMS; climate action; occupational health and safety; ISO 1400; environmental sustainability; waste management

I. INTRODUCTION

The global oil and gas sector contributes to human-induced environmental degradation through various channels, including

greenhouse gas emissions, hydrocarbon pollution of aquatic and terrestrial environments, along with a considerable ecological footprint resulting from infrastructure development

[1]. The specific sector represents about 15% of total energy-related CO₂ emissions worldwide, with upstream operations being carbon-intensive [2]. Beyond climate impacts, oil and gas activities generate significant water pollution through produced water discharge, soil contamination from spills and leaks, and biodiversity loss due to habitat fragmentation [3]. These environmental consequences have resulted in stringent regulatory frameworks and increased stakeholder expectations for sustainable operations. The United Nations SDGs, particularly Goal 7 (Affordable and Clean Energy), Goal 12 (Responsible Consumption and Production), and Goal 13 (Climate Action), have set clear benchmarks for corporate EP [4, 5]. Simultaneously, institutional investors are incorporating Environmental, Social, and Governance (ESG) criteria into their decision-making processes, generating financial incentives for improved sustainability performance [6-8].

In the Kingdom of Saudi Arabia (KSA), recognized as the most significant global crude oil exporter, the aforementioned sustainability priorities align with its national development objectives. The Saudi Vision 2030 framework and its environmental pillar, the Saudi Green Initiative (SGI), outline commitments to have reduced carbon emissions by 278 million tons annually by 2030 and have achieved net-zero by 2060 [9-12]. However, reconciling these aspirations with KSA hydrocarbon-dependent economy poses significant policy and operational challenges. The oil and gas sector accounts for about 50% of GDP and 70% of fiscal revenues, creating structural dependencies that complicate transition to sustainability [13-15].

EMS has become an essential operational framework for tackling these challenges. Based on the Plan-Do-Check-Act (PDCA) cycle and formalized through ISO 14001 certification, EMS offers a structured method for environmental governance [16]. EMS effectiveness in the hydrocarbon industry is documented in several areas: decreasing carbon emissions by enhancing energy efficiency [9], lowering water usage via closed-loop systems [10], and reducing waste through circular economy practices [17]. Meta-analyses show that firms with ISO 14001 certification demonstrate 15-25% better EP than those without [18].

Despite the aforementioned benefits, EMS adoption and implementation in the oil and gas sector of KSA remain underexplored. Most existing research has concentrated on the technical facets of emission reduction [19] or macro-level policy assessments [20], leaving a gap in empirical studies regarding EMS adoption patterns and their operations. This research gap is important due to the KSA's unique institutional environment, marked by state-controlled energy markets and evolving regulatory frameworks [20-23].

The present study offers three key contributions to the existing literature. Initially, it provides a comprehensive empirical assessment of EMS adoption within the hydrocarbons industry in KSA, contrasting the environmental and operational performance of firms with EMS certification against those without. Next, it explores how EMS implementation intersects with wider Corporate Social Responsibility (CSR) frameworks, filling a crucial gap in sustainability governance literature. Third, it evaluates the

business rationale for adopting EMS by analyzing its impact on CA and OI within the context of a developing economy. The study concludes with policy implications for regulatory authorities and practical suggestions for industry professionals aiming to improve their sustainability efforts while preserving operational competitiveness throughout the energy transition period.

II. METHODOLOGY

The performance of companies that have adopted EMS is evaluated compared to those that have not, using Dependent Variables (DVs) including EP, HS, EA, OI, and CA. The analysis framework is illustrated as a model in Figure 1. The present study examines organizations in Saudi Arabia, particularly in Riyadh, Jeddah, Dammam, Khobar, and Qassim, classifying them as either EMS-adopting or non-EMS-adopting companies. Data collection involved a questionnaire featuring a Likert scale, with analysis conducted using R and MS Excel. Before data collection began, participants were informed about the study's aims, ethical factors, and confidentiality measures.

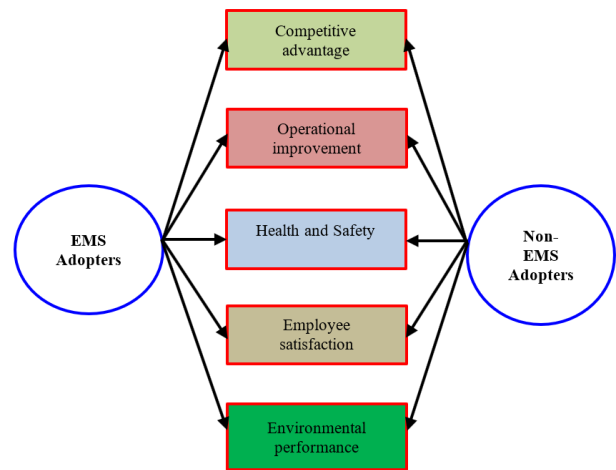


Fig. 1. Proposed Framework

A sample of 25 companies was taken, evenly split between EMS adopters and non-adopters. The sampling method employed a two-stage simple random sampling approach. Due to the greater number of organizations in Riyadh and Jeddah, six EMS companies and six non-EMS companies were selected from each city. On the other hand, Dammam, Khobar, and Qassim, with fewer organizations, each contributed one EMS and one non-EMS company. Nineteen organizations were selected from Riyadh and Jeddah, while six were obtained from the other cities. Ten participants were randomly selected from each company, resulting in a total of 250 responses. After cleaning the data, this work finalized 230 responses for analysis. The analysis employed a variety of statistical techniques, including descriptive statistics, Exploratory Factor Analysis (EFA), Reliability Analysis (RA), Correlation Analysis (COR), and Regression Analysis (REA). The REA focused on comparing the performance of companies that adopt EMS with those that do not, using a list of DVs, which included OI, CA, ES, HS, and EP.

III. RESULT ANALYSIS

The first step involved conducting the EFA. Table I illustrates that most factor loadings exceed 0.60, while some range from 0.50 to 0.60.

TABLE I. FACTOR LOADINGS OF PRINCIPAL COMPONENT ANALYSIS FOR SURVEY ITEMS

Item	Survey question	Factor loading
OI1	How does your company track efficiency in resource utilization?	0.72
OI2	Has your company implemented technologies to improve OI?	0.68
OI3	How often are operational processes reviewed for optimization?	0.75
OI4	What is the impact of your OIs on production costs?	0.54
OI5	How does your company manage waste from operations?	0.51
OI6	Are energy-saving measures a part of your operational strategy?	0.71
OI7	Does your company have a system to monitor and reduce operational downtime?	0.66
OI8	What is the primary driver for your OIs?	0.65
CA1	How does your company differentiate itself in the market?	0.64
CA2	Does your company use eco-friendly branding to attract customers?	0.73
CA3	How important is customer loyalty in your competitive strategy?	0.58
CA4	What percentage of your marketing focuses on sustainability?	0.56
CA5	How does your company ensure brand reputation?	0.59
CA6	Does your company adopt green manufacturing practices?	0.40
CA7	How important is environmental compliance in gaining contracts or customers?	0.69
CA8	What is your company's approach to enhancing customer trust?	0.72
ES1	Does your company offer HS training for employees?	0.80
ES2	How does your company address employee concerns about the work environment?	0.78
ES3	Are employees involved in decision-making processes related to sustainability?	0.74
ES4	What types of benefits does your company offer to improve ES?	0.76
ES5	How does your company handle employee grievances?	0.68
ES6	How often does your company evaluate ES?	0.52
ES7	Does your company provide career development opportunities for employees?	0.72
ES8	How satisfied are employees with workplace safety measures?	0.77
HS1	Does your company conduct regular HS audits?	0.82
HS2	How does your company manage workplace hazards?	0.79
HS3	How often are employees trained on safety protocols?	0.75
HS4	Are emergency response systems in place in your operations?	0.78
HS5	How does your company ensure Personal Protective Equipment (PPE) availability?	0.70
HS6	Does your company track HS incidents?	0.74
HS7	How are safety improvements prioritized in your company?	0.59
HS8	Are employees encouraged to report unsafe conditions?	0.72
EP1	How does your company monitor environmental impact?	0.80
EP2	Are environmental goals integrated into the company's strategic plan?	0.76
EP3	How often does your company report on EP?	0.75
EP4	What is your company's approach to emission reduction?	0.77
EP5	How does your company measure water usage efficiency?	0.70
EP6	Are suppliers required to meet environmental standards?	0.72
EP7	How does your company address the impact of biodiversity on operations?	0.74
EP8	How is waste reduction prioritized in your company?	0.78

Although a small number of items have factor loads below 0.50, they remain above 0.40, indicating that all items significantly contribute to their respective factors and that no further items should be eliminated from the analysis. All items are correctly classified according to their relevant factors. The five recognized factors provide a strong foundation for item categorization (Table II).

TABLE II. CLASSIFICATION OF ITEMS ACROSS OPERATIONAL DIMENSIONS

Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
OI1	0.72				
OI2	0.68				
OI3	0.60				
OI4	0.54				
OI5	0.51				
OI6	0.61				
OI7	0.66				
OI8	0.61				
CA1		0.64			
CA2		0.73			
CA3		0.63			
CA4		0.56			
CA5		0.73			
CA6		0.40			
CA7		0.65			
CA8		0.77			
ES1			0.80		
ES2			0.78		
ES3			0.76		
ES4			0.70		
ES5			0.52		
ES6			0.50		
ES7			0.55		
ES8			0.77		
HS1				0.75	
HS2				0.70	
HS3				0.70	
HS4				0.70	
HS5				0.58	
HS6				0.72	
HS7				0.73	
HS8				0.72	
EP1					0.78
EP2					0.76
EP3					0.72
EP4					0.77
EP5					0.70
EP6					0.72
EP7					0.68
EP8					0.75

Following the EFA, an RA was performed, showing that all variables have a Cronbach's Alpha exceeding 0.70, which indicates reliable measurements (Table III).

TABLE III. RELIABILITY FOR ASSESSING ENVIRONMENTAL AND OPERATIONAL PERFORMANCE

Variable	No. of items	Cronbach's Alpha
OI	8	0.817
CA	6	0.699
EP	8	0.858
ES	8	0.754
HS	8	0.70

The average scores of the Likert scale variables demonstrate that OI, CA, EP, and HS have greater mean values in EMS companies compared to non-EMS companies. Conversely, ES displays an opposing trend, as it is higher in non-EMS companies than in EMS companies (Figure 2).

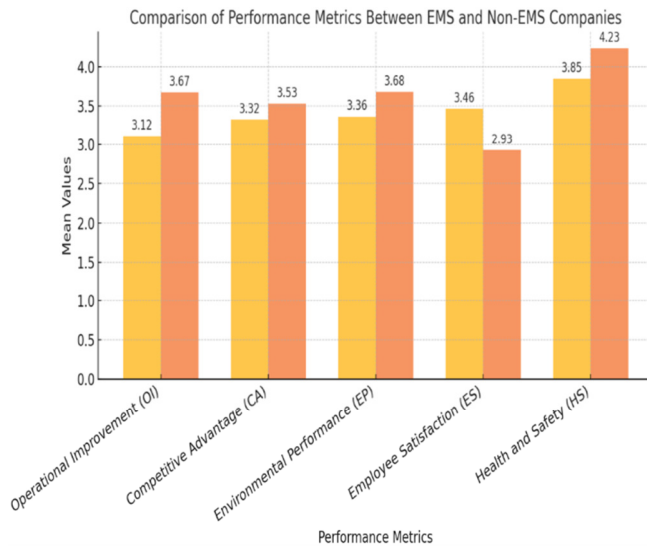


Fig. 2. Comparison of mean performance metrics between EMS (orange bar) and non-EMS companies (yellow bar).

In EMS companies, OI, CA, EP, and HS show higher positive correlation values compared to non-EMS companies. In contrast, ES displays a negative trend in EMS and has a weak correlation with non-EMS. Both company types exhibit a weak correlation with CA (Table IV). The REA highlights the differences between EMS adopters and non-EMS adopters. In the EMS group, only two variables significantly contributed to the model ($p < 0.05$): OI and HS. In contrast, nearly all variables in the non-EMS group, except for CA, had a highly significant effect ($p < 0.001$) on the model. Particularly, ES was negatively correlated with non-EMS adoption ($b = -0.85$, $p < 0.001$), while non-EMS adoption had a more pronounced effect on EP ($b = 0.95$, $R^2 = 0.30$, $p < 0.001$) compared to EMS firms. Conversely, CA did not show significant changes in either group (Table V).

TABLE IV. CORRELATION BETWEEN COMPANY TYPES

DV	Correlation with EMS	Correlation with non-EMS
OI	0.61	0.22
CA	0.18	0.12
ES	-0.43	0.10
HS	0.59	0.28
EP	0.68	0.31

IV. DISCUSSION

A. Operational Improvement

Organizations that have adopted EMS demonstrated significantly superior performance metrics compared to those that have not. [23]. The former recorded a significant decrease in incidents and accidents at work, indicating enhanced safety

standards. Additionally, these organizations enhanced their efficiency in raw material usage, reduced waste, and optimized resource utilization. Energy efficiency was another area where EMS adopters performed well, resulting in decreased energy consumption and lower associated costs [14]. EMS-adopting companies reduced waste and emissions, showing their commitment to sustainability. Noise pollution affects many industries, but EMS-adopting enterprises were not greatly affected from this problem.

TABLE V. REA RESULTS

DV	b (EMS)	SE	t	p	R ²
OI	0.35	0.16	2.19	0.031	0.12
CA	0.11	0.18	0.61	0.544	0.01
ES	0.20	0.17	1.18	0.241	0.03
HS	0.31	0.14	2.21	0.03	0.13
EP	0.29	0.19	1.53	0.134	0.06
DV	b (non-EMS)	SE	t	p	R ²
OI	0.70	0.16	4.38	0.000	0.18
CA	0.18	0.15	1.2	0.234	0.02
ES	-0.85	0.21	-4.4	0.000	0.22
HS	0.70	0.17	4.12	0.000	0.17
EP	0.95	0.24	4.25	0.000	0.30

Early EMS adoption increased operating costs, but the long-term benefits outweighed them [24]. When companies reduced expenses and enhanced production, they achieved economic gains. This improvement enhanced public perception, marketing, and client confidence [25] and emphasized the need to set fresh goals for progress. ISO 14001 studies on EMS indicate that numerous sectors have achieved considerable progress. Among them, the fashion and textile sectors, known for their waste and water pollution have been examined. ISO 14001 improved waste management by implementing recycling, audits, and organized disposal, which benefited both the environment and economic performance. Several industries experienced similar findings. Authors in [25] found significant waste reduction and energy efficiency in the construction industry in 2016, resulting in cost savings. In accordance with these findings, authors in [14] identified the advantages of EMS adoption as OI, cost savings, and increased staff motivation. These insights indicate that EMS significantly enhances operational excellence and supports sustainability.

B. Employee Satisfaction

ES was about three times greater in non-EMS organizations compared to EMS organizations [26]. According to [26], EMS positively influences an organization's overall performance by enhancing its reputation and image, improving employee morale and motivation, increasing earnings, and fostering consumer trust and loyalty. The current study's results match those of [27], where it was indicated that non-EMS companies significantly enhanced ES and made greater economic contributions compared to EMS companies. Employees in non-EMS organizations exhibited a more complacent attitude toward their work environment. These workers did not consider noise levels significant, and concerns about physical safety were generally nonexistent. They did not regard environmental, health, and safety training as essential for ensuring their organizations' safety. Furthermore, workers in organizations

that have not adopted EMS did not prioritize acquiring new skills or seeking professional development [23].

The main factor contributing to increased ES in these organizations seems to be a combination of a lack of awareness and urgent financial and social challenges. Several factors, such as poverty, employers' reluctance to implement strong HS protocols, and the common belief among many less-educated workers that training programs are unnecessary, have contributed to this issue. Additionally, the inadequate regulation enforcement by government agencies has influenced ES levels [28].

C. Planning

Studies indicate that companies implementing EMS identify their environmental challenges more quickly [29]. These organizations are more open and consider environmental assessment a legal requirement and responsibility. They intentionally establish EP goals and connect their environmental management programs with the former. EMS-adopting organizations communicate environmental compliance standards more formally than non-EMS adopting companies. These organizations quantitatively measure environmental goals and establish reasonable deadlines. Effectively identifying critical operations with potential hazards enhances accident and emergency response. Additionally, EMS-adopting firms creatively integrate modified activities, goods, and services into their environmental management plans [30].

D. Operational Implementation

Organizations implementing EMS establish clear rules and responsibilities. They allocate financial resources, human resources, specialized skills, and technologies to carry out environmental management programs effectively. EMS-adopting companies address training needs more efficiently. They also establish robust procedures for managing accidents and emergencies. The personnel of these organizations received adequate training to address environmental challenges effectively. EMS adopting organizations engage in open communication about environmental challenges and hazards, enabling effective coordination in EMS implementation [31, 32]. EMS serves as a valuable tool for enhancing energy efficiency and promoting environmental sustainability/EP by establishing processes and procedures to manage environmental impacts. Similarly, authors in [33-35] reported that implementing EMS in gold mining industries significantly improved EP by enhancing waste management, increasing energy efficiency, and reducing site-related incidents.

E. Environmental Performance

The EP of companies having adopted EMS was approximately twice that of non-EMS adopters. These findings align with those of [36], where it was observed that ISO 14000-certified companies in Greece achieved a stronger market position. These companies transitioned from harmful environmental practices to sustainable alternatives, improving their societal relations through better environmental stewardship performance. Similarly, authors in [37] analyzed 100 publicly listed companies in China and concluded that EMS significantly promotes corporate green innovation, with

environmental regulations amplifying this effect. Furthermore, it was noted that EMS can enhance efficiency by optimizing waste management processes [38].

F. Competitive Advantage

Significant disparities were not evident in the CA achieved by companies adopting digital transformation strategies compared to those that have not adopted them. However, digital adopters seemed to achieve a slight advantage in OI and market responsiveness. Both digital and traditional organizations showed high satisfaction levels in their evaluation of customer engagement, indicating that elements beyond merely adopting technology impacted customer loyalty. Non-digital adopters typically depended on conventional strengths, like product quality and pricing strategies, instead of utilizing advanced technologies. In contrast, digital adopters utilized data analytics, AI, and cloud-based tools; however, they did not consistently outperform their peers, likely due to varying levels of implementation maturity and customer engagement expectations. Integrating digital tools for supply chain optimization or personalized marketing offered benefits, but did not yield significant advantages for all digital adopters.

Organizations that lack digital focus tend to prioritize cost management and workforce stability over the adoption of disruptive technologies, which appears to resonate with certain customer segments. Digital adopters invested significantly in innovation but encountered challenges, like increased operational expenses and initial implementation difficulties, which reduced their potential benefits. Authors in [39] emphasized that effective digital transformation necessitates both cultural changes and technological advancements. Similarly, in [40], it was observed that firms utilizing digital solutions in customer-facing roles experienced enhanced customer acquisition rates. Nevertheless, these benefits are frequently applied only to competitive markets characterized by high digital literacy. In [41], it was stated that global companies that adopted advanced digital systems enhanced their cross-border operations, establishing themselves as agile players in the international arena markets. Adhering to global digital standards, such as General Data Protection Regulation (GDPR) compliance, strengthened their reputation and facilitated partnerships, setting them apart from less technology proficient competitors [42-44].

V. CONCLUSION

Implementing an Environmental Management System (EMS) in the oil and gas sector can reduce environmental harm and align operations with global sustainability goals. The current study shows that EMS adopters outperform non-EMS adopters in Environmental Performance (EP), resource efficiency, and occupational Health and Safety (HS). These improvements illustrate EMS's role in fostering sustainable industrial practices, which contribute to achieving Sustainable Development Goals (SDGs), like clean water, affordable energy, and climate action. EMS businesses exhibited lower Employee Satisfaction (ES), highlighting the necessity for more employee-focused strategies. By enhancing training, communication, and staff engagement, EMS could become more effective.

This study examined EMS adoption within Saudi Arabia's hydrocarbon-dependent economy. By comparing EMS and non-EMS adopters, it contributed to the Saudi Vision 2030 and global SDGs. An integrated framework that links EMS effectiveness with national policy objectives, digital transformation strategies, and workforce engagement practices was developed, providing novel insights for both emerging economies and the global oil and gas sector. This focus on ecological integrity and industrial efficiency makes EMS essential for resilience and sustainability in the industry.

However, the findings of this study are limited to the perception of the respondents, while the answers to the questions relied primarily on the respondents' judgment. In organizations that have not adopted EMS, employees often found it difficult to understand questions related to environmental and safety issues. This required verbal explanations, which took additional time and effort. Furthermore, workers were reluctant to answer questions when they believed their responses could reflect poorly on the organization, and they worried about possible negative repercussions. When evaluating EMS impact and effectiveness on the outcomes, the responses were affected by the varying levels of the respondents' knowledge and expertise. Experienced individuals offered valuable insights, whereas those less knowledgeable drew from a broader understanding instead of direct involvement experience.

Additionally, this research did not examine the role of the government and regulatory bodies in promoting the understanding, implementation, and facilitation of EMS practices. Access to information about EMS performance was also limited. This restriction occurred because developers often lacked the authority to disclose such details or were unwilling to share information due to confidentiality concerns. Many industries, cautious of potential risks to their operational secrecy, were hesitant to grant researchers access to their facilities. This lack of cooperation was particularly noticeable in areas where fairness and transparency, especially regarding worker rights and safety standards, were lacking. In some cases, only managerial staff were available for interviews, excluding workers from the research process. Moreover, in several instances, environmental and safety priorities were overlooked by workers due to the pressures of extreme poverty, which compelled them to concentrate on securing basic needs. These socio-economic challenges posed an extra barrier to acquiring comprehensive and unbiased data.

Digital technology and environmental sustainability/ EP are often viewed as separate concepts since they arise from distinct driving factors. The former centers on advancements, like AI, robotics, and 5G, with the goal of transforming industrial processes, enhancing manufacturing, and optimizing labor efficiency. Digital technologies have become essential for scientists and environmentalists to collect, analyze, and interpret environmental data with unmatched efficiency. In contrast, green practices emphasize tackling global challenges, such as climate change, environmental degradation, and resource conservation, by promoting sustainable governance and decarbonizing the atmosphere.

The growth of population, production, and consumption requires corporate innovation to address ecological and social issues. Future projects will need to integrate EP with digital technology for mutual benefit. Businesses must utilize digital solutions to reduce their environmental impact, enhance waste management, and utilize resources responsibly. Integrating sustainability principles with computer energy consumption can significantly lower energy consumption waste. Digital technology and sustainability can enhance businesses' long-term viability with consumers, regulators, and local communities. Digital technology for evaluating product life cycles may extend product longevity and reduce waste, thereby aiding circular economy. This comprehensive framework helps firms utilize digital breakthroughs for green initiatives, addressing important environmental concerns and gaining a competitive edge in a fast-changing market. Combining digital technology with sustainability objectives can foster a resilient, resource-efficient, and eco-friendly global economy.

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