SCIENTIFIC CULTURE

www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 2.1, (2026), pp. 12169-12180
Open Access. Online & Print

DOI: 10.5281/zenodo.20314758

ENVIRONMENTAL SUSTAINABILITY IN A FRAGILE CONTEXT: INFLUENTIAL SUSTAINABILITY-ORIENTED PRACTICES IN INDUSTRIAL FIRMS

Ebrahim Mohammed Mohammed Al-Fakih[1]* and Abdulrazaq Mohammed Qaid Almarani[2]

[1]Center of Business Administration, Sana'a University, Sana'a, 00967, Yemen.
Email: al-fakiha.eb@su.edu.ye
ORCID: https://orcid.org/0009-0001-8820-4707
[2]Department of Business Administration, Faculty of Commerce and Economics, Sana'a University, Sana'a, 00967, Yemen.
Email: a.almarani@su.edu.ye
ORCID: https://orcid.org/0009-0004-2169-7297

Received: 07/04/2026
Accepted: 08/05/2026

Corresponding Author: Ebrahim Mohammed Mohammed Al-Fakih (al-fakiha.eb@su.edu.ye)

ABSTRACT

This study investigates which dimensions of social responsibility (economic, humanitarian, ethical, and legal) have the greatest impact on achieving environmental sustainability in a Yemeni industrial firm within the Hayel Saeed Anam Group (a fragile context), and examines the mediating role of knowledge management. Methodology: Cross-sectional survey data from 191 leaders in the industrial firms within the Hayel Saeed Anam Group were analyzed using partial least squares structural equation modeling (PLS-SEM). Results: The ethical (β=0.215) and humanitarian (β=0.215) dimensions have significant direct impacts, while the economic dimension has no direct impact. The legal dimension has the strongest impact (β=0.368). Knowledge management partially mediates the relationships between the legal, ethical, and humanitarian dimensions (composite indirect effect = 0.446). The model explains 73.1% of the variance in environmental sustainability. Conclusions: In fragile contexts, industrial firms within the Hayel Saeed Anam Group prioritize legal, ethical, and humanitarian dimensions over economic motivations in environmental action. Knowledge management is a key mechanism for translating social responsibility into environmental outcomes. The industrial firm model within the Hayel Saeed Anam Group is generalizable.

KEYWORDS: Environmental Sustainability; Ethical Responsibility; Corporate Social Responsibility, Responsibility; Knowledge Management; Yemen.

1. INTRODUCTION

Sustainability has emerged as one of the most critical global challenges, necessitating that the industrial sector integrate environmental considerations into its core strategies (Konurbayeva et al., 2026). Environmental Sustainability (ENV) is one of the most pressing global goals, particularly in the context of developing countries and fragile states suffering from conflicts, wars, and economic crises. In Yemen, which has been experiencing civil war and an economic blockade since 2015, the state's capacity to manage environmental affairs, such as waste management, pollution control, and the conservation of natural resources, has collapsed (Ben Ibrahim, 2015; World Bank, 2023). As a result, basic environmental services have become virtually nonexistent, and responsibility increasingly falls on the private sector, especially large industrial companies, which assume a quasi-governmental role in areas such as clean energy, waste management, and the conservation of water and agricultural soil (Al-Kurshomi, 2024).

On a theoretical level, the concept of Corporate Social Responsibility (CSR) has evolved from a mere voluntary ethical commitment to a fundamental strategic element in contemporary business organizations (Carroll, 1999; Singh & Yadav, 2023). Carroll's pyramid model classifies social responsibility into four main dimensions: Economic Responsibility, which focuses on profitability and efficiency; Human/Philanthropic Responsibility, which relates to philanthropy and community support; Moral/Ethical Responsibility, which expresses a commitment to fairness and transparency; and Legal Responsibility, which means compliance with laws and regulations (Rubach, 2022). In stable economies, legal compliance and economic motives are often the primary drivers of corporate environmental behavior (Al-Amri, 2018). But in fragile states, where law enforcement is weak, moral and humanitarian dimensions may become more influential (Belarabi & Belour, 2020).

In recent years, the literature indicates that Knowledge Management (KM) plays a crucial mediating role in the relationship between social responsibility and sustainable development (González-Ramos et al., 2023; Widyanti et al., 2024). A previous study conducted on the Hayel Saeed Anam Group showed that KM significantly contributes to enhancing the impact of CSR on sustainable development in general (Al-Fakih & Al-Marani, 2025). Other studies have also demonstrated that KM processes such as knowledge acquisition, generation, storage, application, and distribution enhance organizations' ability to achieve environmental sustainability goals by improving environmental awareness, disseminating green practices, and adopting clean technologies (Atkociuniene & Mikalauskiene, 2019; Al-Yami & Ajmal, 2019).

In emerging economies in particular, differences in regulatory enforcement, cultural norms, and market conditions seem to shape how CSR dimensions are understood and applied in practice, which may help account for the mixed findings reported in the literature.

Studies from developing country contexts reinforce this concern. Research conducted in Vietnam shows that CSR is strongly shaped by local institutional conditions such as cultural traditions, governance systems, and economic transformation processes, which in turn influence how CSR is interpreted and implemented in practice (Nguyen et al., 2018). Similarly, empirical work on multinational subsidiaries indicates that CSR activities can generate innovation and business opportunities while also contributing to local development, although the outcomes depend heavily on how CSR is embedded within organizational practices (Nguyen et al., 2020).

Evidence from several African contexts points to a noticeable gap between what firms declare in terms of CSR and what is actually implemented in practice. In the case of Nigeria, for instance, available studies indicate that CSR initiatives do not always lead to the expected social and environmental outcomes, often as a result of limited stakeholder engagement, weak transparency practices, and insufficient organizational structures to support implementation (Hassan et al., 2024).

Sustainability-oriented practices refer to the integrated set of corporate social responsibility and knowledge management practices that guide environmental decision-making in large industrial companies.

Despite these theoretical contributions, a clear research gap remains: a lack of sufficient empirical studies identifying which of the four dimensions of social responsibility (CSR) is most influential in achieving environmental sustainability in fragile and developing states, particularly in the Middle East. Furthermore, studies examining the mediating role of knowledge management in the relationship between each CSR dimension and environmental outcomes are virtually non-existent.

Therefore, this study aims to bridge this gap by answering the following key question: What are the dimensions of corporate social responsibility (economic, humanitarian, ethical, legal) that most

influence the achievement of environmental sustainability in a large Yemeni manufacturing firms (HSA group), and how does the mediating role of knowledge management contribute to explaining this relationship?

To achieve this objective, the following hypotheses were tested:

H1a: The economic dimension of CSR has a significant positive direct impact on environmental sustainability.

H1b: The human dimension of CSR has a significant positive direct impact on environmental sustainability.

H1c: The ethical dimension of CSR has a significant positive direct impact on environmental sustainability.

H1d: The legal dimension of CSR has a significant positive direct impact on environmental sustainability.

H2: Knowledge management plays a mediating role in the relationship between the dimensions of CSR and environmental sustainability.

Based on the above, a conceptual model was designed that integrates the four dimensions of social responsibility as independent variables, environmental sustainability as a dependent variable, and knowledge management as a mediating variable. This model was tested using field data collected from 191 leaders within the Hayel Saeed Anam Group of Companies, one of the largest and most established family businesses in Yemen and the region, thus enhancing the generalizability of the findings (Hair et al., 2017). The results of this study are expected to contribute to providing a practical framework that family businesses in developing and fragile countries can rely on to direct their social responsibility efforts towards achieving the greatest possible environmental impact, by utilizing knowledge management as an enabling mechanism.

2. RESEARCH METHODOLOGY

This study adopted a quantitative approach, as it is suitable for the nature of the research, which aims to describe phenomena as they exist in reality and then analyze the causal relationships between their variables. This approach helps in testing the study hypotheses through the analysis of quantitative data collected from the study sample. It also allows for an understanding of the nature of the relationships between the dimensions of Corporate Social Responsibility (CSR), Knowledge Management (KM), and Environmental Sustainability (Creswell & Creswell, 2018).

2.1. Study Population and Sample

The study population comprised all administrative leaders (managers, department heads, and supervisors) in the industrial firms within the HAS group in Sana'a city, totaling 207 individuals. A census was used, and 197 questionnaires were received. After excluding 6 invalid questionnaires, 191 questionnaires were deemed valid for analysis (response rate of 92.3%) (Hair et al., 2017).

The use of a census approach was considered appropriate due to the relatively small and fully accessible population (N = 207), where all administrative leaders within the industrial firms of the HSA Group were targeted. This approach minimizes sampling bias and enhances the representativeness of the collected data.

The final valid sample (n = 191) exceeds the minimum requirements for PLS-SEM analysis. According to Hair et al. (2017), sample adequacy in PLS-SEM can be assessed using the "10-times rule" and statistical power considerations. In the present study, the sample size is sufficient based on the maximum number of structural paths directed at any latent construct and ensures robust estimation of model parameters with adequate statistical power (>0.80).

Therefore, the sample size is considered both methodologically and statistically appropriate for testing the proposed structural model.

The sample is characterized by a high level of education (81.2% hold a bachelor's degree) and extensive experience (43% have more than 10 years of experience), which enhances the reliability of the sample's responses (Saunders et al., 2019). 3.2. Data Collection Instrument

A questionnaire consisting of four sections was used: demographic variables, dimensions of social responsibility (28 items), dimensions of knowledge management (25 items), and environmental sustainability (5 items). All items were measured using a seven-point Likert scale (1 = strongly disagree, 7 = strongly agree).

The measurement instrument was derived from previously validated scales in the literature, ensuring both content validity and consistency with the theoretical foundations of the constructs under study. To enhance contextual relevance, all items were adapted to reflect the characteristics of the industrial sector operating in a fragile environment such as Yemen, while preserving their original conceptual essence.

2.2 Assessment of Construct Validity and Reliability

The validation process was carried out in two stages. Initially, content validity was examined through a panel of ten academics specializing in business administration. The experts reviewed each item in terms of clarity, relevance, and suitability, and their feedback led to several minor adjustments in wording to improve precision and readability without altering meaning.

In the second stage, construct validity was assessed using confirmatory factor analysis within the PLS-SEM framework. The results showed that the majority of factor loadings met the recommended level of 0.70 or higher. Only one item recorded a slightly lower loading (above 0.60), yet it was retained given its theoretical contribution and in line with the acceptable thresholds suggested in prior methodological literature (Hair et al., 2019).

Evidence of convergent validity was established as all constructs recorded Average Variance Extracted (AVE) values above the 0.50 benchmark, indicating that the constructs adequately capture the variance of their indicators. Discriminant validity was also confirmed through the Heterotrait–Monotrait (HTMT) ratio, where all values remained below the conservative threshold of 0.85, supporting clear conceptual distinction among constructs.

Regarding reliability, both Cronbach's alpha and Composite Reliability (CR) values exceeded the 0.70 threshold, indicating satisfactory internal consistency across all constructs. Taken together, these results confirm that the measurement model demonstrates adequate levels of reliability and validity, thereby supporting its use in subsequent structural analysis. As shown in Table 1.

Table 1. Reliability and Convergent Validity Coefficients

Construct	α	CR	AVE
Economic Responsibility	0.804	0.827	0.57
Human Responsibility	0.863	0.87	0.654
Ethical Dimension	0.883	0.886	0.686
Legal Dimension	0.774	0.795	0.537
Knowledge Management	0.92	0.935	0.722

Source: Prepared by the researchers based on SmartPLS 4.0 output.

3. RESULTS

This section presents the results obtained from the analysis of data collected from the study sample (191 individuals) of administrative leaders in the industrial firms within the HAS group. The data were analyzed using SPSS v28 and SmartPLS v4.0.9.5, according to the methodology described previously. This section includes: (a) the results of the descriptive analysis of the study variables, (b) the evaluation of the measurement model, (c) the evaluation of the structural model, (d) the testing of direct effects, and (e) the mediation analysis.

3.1. Descriptive Statistics

3.1.1. Description of the Dimensions CSR and KM

Table (2) illustrates the dimensions of social responsibility and knowledge management. The results are generally very good, with all dimensions ranging from "high" to "fairly high."

Regarding social responsibility, the ethical dimension tops the list with the highest percentage of importance (81.8%), followed by the human dimension (79.1%), and then the economic dimension (78.8%). In contrast, the legal dimension came in last place with only 74.0%.

As for knowledge management, the dissemination and distribution of knowledge dimension was the most prominent at 76.4%, followed by knowledge storage (76.2%), then knowledge generation (75.8%), and then knowledge application (75.3%). The acquisition of knowledge dimension came in last place at 74.4%.

These results demonstrate that the industrial firms within the HAS group strongly focuses on ethical and human values in its social responsibility and is particularly concerned with disseminating and storing knowledge within its organization.

Table 2. Description of the Dimensions CSR and KM.

Dimension	Mean	Standard Deviation	Level
Economic Responsibility	5.519	0.966	High
Human Responsibility	5.537	1.003	High
Ethical Dimension	5.723	0.993	High
Legal Dimension	5.178	1.03	Moderately High
Knowledge Acquisition	5.208	1.119	Moderately High
Knowledge Generation	5.304	1.154	High
Knowledge Storage	5.333	1.066	High
Knowledge Application	5.271	1.069	High

Knowledge Dissemination & Distribution	5.351	1.067	High

Source: Prepared by the researchers based on SPSS output.

3.1.2. Description of Environmental Sustainability

Table (3) summarizes the state of environmental sustainability at the industrial firms within the HSA group. Overall, the Group achieved an overall importance score of 79.5% in this area, a high level reflecting a genuine commitment to environmental practices.

The most noteworthy aspect is paragraph five, which states that the Group applies international environmental standards (ISO 14000) in the design of its products. This paragraph achieved the highest importance score (83.6%), a very high level, demonstrating a strong commitment to international standards.

In contrast, paragraph one, concerning the use of clean energy and advanced work methods, ranked last at 76.9%. While still within the high range, it indicates a gap that can be improved. In conclusion, the Group is very committed to international environmental standards, but it still needs to invest more in clean energy.

Table 3. Descriptive Statistics of Environmental Sustainability Items.

No.	Item	Mean	Std. Deviation
1	The group uses clean energy and advanced work methods continuously to reduce environmental pollution	5.38	1.28
2	The group disposes of waste and production residues through advanced systems that preserve agricultural areas and ecological balance	5.52	1.305
3	The group applies environmental management systems believing in its societal role in preserving natural resources and the environment	5.62	1.185
4	The group deals with any pollution or environmental damage using modern systems that consider appropriate compensation	5.46	1.208
5	The group applies international environmental systems and standards (ISO 14000) in product design to provide safe and high-quality products to society	5.85	1.142
	Overall Environmental Sustainability	**5.568**	**1.054**

Source: Prepared by the researchers based on SPSS output.

3.1.3. Correlation Matrix

The Pearson correlation analysis revealed strong, statistically significant positive correlations at the 0.01 level between all study variables (Table 4). The strongest correlation was between social responsibility and knowledge management (r = 0.870), followed by the relationship between knowledge management and environmental sustainability (r = 0.831), and then the relationship between social responsibility and environmental sustainability (r = 0.823). These results pave the way for testing the direct and indirect influence hypotheses.

Table 4. Correlation Matrix Among the Main Variables.

Variable	CSR	KM	ENV
CSR	1	–	–
KM	0.870**	1	–
ENV	0.823**	0.831**	1
Note: Correlation is significant at the 0.01 level (2-tailed).			

Note: Correlation is significant at the 0.01 level (2-tailed). Source: Prepared by the researchers based on SPSS output.

3.2. Assessment of the Measurement Model

3.2.1. First-Order Reflective Model

The measurement model for the reflective variables (social responsibility dimensions,

knowledge management dimensions, and environmental sustainability) was assessed using the recommended criteria (Hair et al., 2017; Henseler et al., 2015). Table (5) shows that all indicators met the following conditions:

Outer Loadings: ranged between 0.641 and 0.913, with only one item (0.641) close to the threshold (0.708) and retained due to its content significance.

Composite Reliability (CR): ranged between 0.795 and 0.935, all of which were > 0.70.

Cronbach's Alpha coefficient: ranged between 0.774 and 0.920, all > 0.70.

Average Variance Extracted (AVE): ranged between 0.537 and 0.748, all > 0.50, confirming convergent validity.

Table 5. Reliability and Convergent Validity of the Measurement Model.

Construct	Cronbach's Alpha (α)	Composite Reliability (CR)	AVE
Economic Responsibility (ECON)	0.804	0.827	0.57
Human Responsibility (HUM)	0.863	0.87	0.654
Ethical Dimension (ETH)	0.883	0.886	0.686
Legal Dimension (LEG)	0.774	0.795	0.537
Knowledge Management (KM) – Second Order	0.92	0.935	0.722
Environmental Sustainability (ENV)	0.912	0.919	0.742

Source: Prepared by the researchers based on SmartPLS 4.0 output.

3.2.2. Discriminant Validity

The validity of the differentiation was verified using the heterotrait-monotrait ratio (HTMT) criterion. As shown in Table (6), all HTMT values were below the strict threshold (0.85), confirming that each variant is structurally distinct (Henseler et al., 2015).

***Table* 6. HTMT Ratio for Discriminant Validity Among Reflective Constructs.**

Construct	ECON	HUM	ETH	LEG	KM	ENV
ECON	–					
HUM	0.612	–				
ETH	0.548	0.683	–			
LEG	0.551	0.588	0.543	–		
KM	0.745	0.823	0.767	0.813	–	
ENV	0.699	0.772	0.713	0.695	0.878	–

Source: Prepared by the researchers based on SmartPLS 4.0 output.

3.2.3. Second-Order Formative Model of Social Responsibility

Since social responsibility was measured as a formative construct consisting of four dimensions, the model was evaluated using outer weights and the Variance Inflation Coefficient (VIF). The results showed that the legal dimension had the highest weight (0.582), followed by the human dimension (0.210), then the economic dimension (0.162), and finally the ethical dimension (0.133). VIF values ranged between 1.2 and 3.8, which is below the threshold of 5, thus ruling out multicollinearity among the dimensions (Hair et al., 2017).

3.3. Assessment of the Structural Model

Prior to path testing, the absence of multicollinearity among the independent variables in the structural model was confirmed. All VIF values were less than (4.0), which is well below the critical threshold (5.0), indicating that there is no problem with the multiple linear relationships.

To assess the overall model fit, the Standardized Root Mean Square Residual (SRMR) and the Normed Fit Index (NFI) were examined, as recommended for PLS-SEM models. The SRMR value was below the acceptable threshold of 0.08, indicating a good fit between the hypothesized model and the observed data. In addition, the NFI value exceeded the recommended cut-off of 0.90, confirming an adequate level of model fit. These results suggest that the structural model provides a satisfactory representation of the empirical data and supports the validity of the proposed relationships.

3.3.1. Coefficient of Determination (R^2) and Effect Size (f^2)

As shown in Table 7, the coefficient of determination (R^2) for environmental sustainability was 0.731. This indicates a high level of explanatory power of the model in predicting environmental sustainability. According to Hair et al. (2017), R^2 values of 0.75, 0.50, and 0.25 indicate substantial, moderate, and weak levels respectively. The obtained value (0.731) is close to the substantial threshold, reflecting strong predictive relevance in a fragile economic context such as Yemen.

This suggests that the integrated CSR–KM framework provides a strong explanation of environmental sustainability outcomes in industrial firms operating under institutional uncertainty.

Table 7. Structural Model Results (R^2 and f^2 Effect Sizes).

Endogenous Variable	R^2	f^2 (CSR Effect)	f^2 (KM Effect)
Knowledge Management (KM)	0.792	0.202	–
Environmental Sustainability (ENV)	0.731	0.153	0.166

Source: Prepared by the researchers based on SmartPLS 4.0 output.

An effect size (f^2) of 0.202 indicates that social responsibility has a moderate impact on knowledge management. Social responsibility also has a moderate impact on environmental sustainability (f^2 = 0.153), and knowledge management also has a moderate impact (f^2 = 0.166).

3.4. Direct Hypothesis Testing (H1a to H1d)

As shown in Table 8, The direct effects of corporate social responsibility dimensions on environmental sustainability were examined using bootstrapping with 5,000 resamples. This approach allows for robust estimation of path coefficients and statistical significance within the PLS-SEM framework.

Table 8. Results of Direct Hypotheses Testing.

Hypothesis	Path	(β)	t-value	p-value	Decision
H1a	Economic Responsibility (ECON) → Environmental Sustainability (ENV)	0.168	1.505	0.066	Not Supported
H1b	Human Responsibility (HUM) → Environmental Sustainability (ENV)	0.215	2.009	0.022	Supported
H1c	Ethical Dimension (ETH) → Environmental Sustainability (ENV)	0.215	2.722	0.007	Supported
H1d	Legal Dimension (LEG) → Environmental Sustainability (ENV)	0.368	4.986	0	Supported

Source: Prepared by the researchers based on SmartPLS 4.0 output.

The economic dimension (H1a) showed no direct, significant impact on environmental sustainability ($p=0.066 > 0.05$). Therefore, hypothesis H1a is rejected. This means that economic motives (such as cost reduction through energy conservation) are not the primary driver of environmental practices in the group.

The humanitarian dimension (H1b) had a moderate, significant positive impact ($\beta=0.215$, $p<0.05$). The results support hypothesis H1b. That is, humanitarian initiatives (such as supporting charitable centers and raising health awareness) are associated with improved environmental performance.

The ethical dimension (H1c) had a moderate, significant positive impact ($\beta=0.215$, $p<0.01$). The results support hypothesis H1c. Ethical values and a commitment to transparency and fairness lead to the adoption of environmentally friendly practices.

The legal dimension (H1d) had the strongest impact among all dimensions ($\beta=0.368$, $p<0.001$). The results support hypothesis H1d. Adherence to international standards and national regulations (such as ISO 14000) is the most influential driver of environmental sustainability in this context.

The non-significant relationship between economic responsibility and environmental sustainability ($\beta = 0.168$, $p = 0.066$) suggests that economic motives are not a primary driver of environmental practices in the studied context. This may be explained by the fragile economic environment in Yemen, where firms prioritize survival and continuity over efficiency-based environmental investments.

3.5. Mediation Analysis (H2)

To examine the mediating role of knowledge management in the relationship between corporate social responsibility dimensions and environmental sustainability, a bootstrapping procedure with 5,000 resamples was applied following Preacher and Hayes (2008) and Zhao et al. (2010). This method allows for testing the significance of indirect effects without assuming normality. Table 9 presents the results.

Table 9. Results of the Indirect Effects Analysis through Knowledge Management.

Path	(β)	t	p	95% (LL, UL)	Type of Mediation
ECON → KM → ENV	0.044	0.813	0.416	(-0.062, 0.151)	No Mediation
HUM → KM → ENV	0.215	2.214	0.027	(0.024, 0.398)	Partial Mediation

ETH → KM → ENV	0.204	2.448	0.014	(0.042, 0.364)	Partial Mediation
LEG → KM → ENV	0.262	3.519	0	(0.116, 0.403)	Partial Mediation
CSR → KM → ENV	0.446	4.319	0	(0.256, 0.621)	Strong Partial Mediation

Source: Prepared by the researchers based on Bootstrapping results in SmartPLS 4.0. Note: LL = Lower Limit, UL = Upper Limit of the 95% confidence interval.

The findings suggest that knowledge management exerts a statistically significant partial mediating effect on the relationship between corporate social responsibility and environmental sustainability ($\beta = 0.446$, $p < 0.001$). This implies that CSR contributes to environmental sustainability not only directly, but also indirectly through its role in enhancing organizational knowledge processes.

When examining the dimensions of CSR separately, economic responsibility does not demonstrate a statistically significant indirect effect ($p = 0.416$). This result indicates that economically oriented CSR activities, in their current form, are not sufficient to activate knowledge processes in a way that translates into measurable environmental outcomes within the studied context.

In contrast, human responsibility reveals a significant partial mediating effect ($\beta = 0.215$, $p = 0.027$). This suggests that initiatives related to human and social welfare contribute to environmental sustainability by fostering knowledge creation and dissemination, particularly through awareness-building and community engagement.

Ethical responsibility also shows a significant mediating role ($\beta = 0.204$, $p = 0.014$). This finding highlights that ethical practices help strengthen transparency and trust within the organization, which in turn facilitates more effective knowledge sharing and application toward environmental improvement.

Finally, legal responsibility records the strongest mediating effect among the dimensions ($\beta = 0.262$, $p < 0.001$). This indicates that compliance with environmental regulations is closely linked to the presence of structured knowledge systems that support documentation, monitoring, and the systematic implementation of regulatory requirements.

4. DISCUSSION

The results of the current study showed that the legal dimension of social responsibility has the greatest impact on environmental sustainability ($\beta = 0.368$, $p < 0.001$). This finding is particularly interesting in the context of a country facing numerous challenges, such as Yemen, where environmental law enforcement is presumably weak. A possible explanation for this result is that the Hayel Saeed Group, being a large and established family business, seeks to maintain its reputation and voluntarily adheres to international environmental standards, such as the ISO 14000 series, even in the absence of effective government oversight. This aligns with the Legitimacy Theory, which states that organizations strive to enhance their activities by complying with societal norms and expectations, even if they are not strongly legally obligated (Suchman, 1995). This also supports the findings of Lestari (2024), which confirmed that legal compliance in social responsibility practices contributes to improving internal processes and building public trust. In addition, legal obligations in this context may be driven by partnership agreements with international donors or funding bodies that require compliance with stringent environmental standards. This was noted by the World Bank (2023) in its reports on the role of the Yemeni private sector in maintaining minimum operational standards despite the crisis.

The ethical and human responsibility dimensions ranked second in terms of direct impact ($\beta = 0.215$ each, $p < 0.05$). This finding strongly supports the hypothesis that, in the absence of a state sponsor, internal ethical values and a sense of human responsibility become the primary drivers of environmentally responsible corporate behavior.

This aligns with stakeholder theory (Freeman, 1984), as the Hayel Saeed Anam Group recognizes that the local community (including poor and marginalized groups) is a key stakeholder, and that environmental protection directly safeguards the health and livelihoods of these individuals. The results also align with the study by Tai (2022), which found that ethical and humanitarian responsibility positively impacts institutional trust.

Notably, these findings demonstrated a balance in the impact between the ethical and humanitarian dimensions. This suggests that charitable initiatives and ethical practices (such as transparency in waste disposal) contribute equally to improved environmental performance. This was further corroborated by the study by Aguinis et al. (2024),

which concluded that the ethical and humanitarian dimensions of CSR have become intertwined in crisis contexts.

The most surprising finding is the lack of a significant direct impact of the economic dimension on environmental sustainability ($\beta = 0.168$, $p = 0.066$). This suggests that cost savings or increased profits through energy efficiency or waste reduction are not the primary motivations driving the group toward environmental practices. This can be explained as follows: in the context of war and blockade, the company operates in a survival mode, not a profit maximization mode. The priority is maintaining operational continuity and serving the community, not maximizing return on investment. Therefore, environmental decisions are made from ethical, humanitarian, and legal considerations, not purely economic ones. This finding challenges traditional models that assume green practices must be economically viable (Porter & van der Linde, 1995). In the case of Yemen, the economic return may be secondary or nonexistent, yet the group continues to invest in the environment. This result is partly consistent with the findings of the study (González-Ramos et al., 2023) that the economic dimension of CSR is more related to knowledge exploitation strategies than to direct environmental innovation.

Regarding the mediating role of knowledge management, the results showed that it plays a significant partial mediating role in the relationship between social responsibility (as a composite variable) and environmental sustainability (indirect effect $\beta = 0.446$, $p < 0.001$). This strongly supports the H2 hypothesis and confirms that CSR not only has a direct impact but also an indirect one by improving knowledge processes within the organization.

This finding reinforces recent literature emphasizing the importance of knowledge as an explanatory mechanism (Al-Yami & Ajmal, 2019; Widyanti et al., 2024). When a group adheres to CSR practices (especially legal and ethical ones), it creates sophisticated knowledge systems: documenting procedures, storing experiences, implementing best practices, and disseminating environmental awareness among employees and the community. These knowledge processes, in turn, lead to improved environmental performance.

The legal dimension showed the strongest indirect effect ($\beta = 0.262$, $p < 0.001$). Since adherence to standards (such as ISO 14000) necessitates a robust knowledge and documentation system: record archiving, documentation of waste handling procedures, and training of workers on standard application, this knowledge system is precisely what knowledge management measures, thus the mediation effect is very strong.

While the ethical and humanitarian dimension had a moderate but significant indirect effect, awareness campaigns and charitable projects generate new knowledge (successful experiences, lessons learned) that is stored and applied in subsequent projects. For example, a clean water distribution project generates knowledge about how to protect water sources from pollution, and this knowledge is used in another environmental project.

The economic dimension, however, had a negligible indirect effect. Even cost-saving strategies (as an economic practice) did not show an impact through knowledge, perhaps because these strategies are routinely implemented centrally without generating new knowledge or being applied on a large scale.

This detailed analysis of mediation across dimensions is a valuable addition to this study, as most previous studies have considered CSR as only a single composite variable (Widyanti et al., 2024).

The study recommends investing in the legal dimension as a strategic lever, so that family businesses do not wait for deterrent environmental laws from the weak state, but rather voluntarily adopt global environmental standards (such as the ISO 14000 series) and consider them part of their corporate culture, given the impact this has on building a global reputation, facilitating international partnerships, improving real environmental performance, and reducing future legal risks. It also recommends institutionalizing the ethical and humanitarian dimensions, so that charitable and ethical initiatives are transformed from scattered and seasonal acts into sustainable corporate programs with budgets, objectives, and performance indicators, linking health awareness and environmental protection with water provision and rationalizing its consumption, which enhances the environmental impact of humanitarian initiatives. In addition, it recommends building an integrated Environmental Knowledge Management System (Environmental KM System) by creating an electronic platform and an administrative system to document all experiences and knowledge related to environmental practices (such as waste treatment procedures, energy conservation studies, and lessons learned from environmental disasters), so that this knowledge is available to all employees, is applied routinely, and updated periodically. The study also recommends that government agencies (upon restoring stability) build the private sector's capacity in environmental knowledge management systems,

and provide training programs and technical funding to large family businesses in Yemen and fragile states to help build systems for documenting, archiving and applying environmental knowledge, stressing that these systems are not a luxury but a necessity to maintain good practices and not lose expertise due to war conditions and staff movement.

5. CONCLUSION

This study concludes that in a fragile context (Yemen), the economic dimension of CSR has no significant direct or indirect effect on environmental sustainability. Instead, the legal dimension is the strongest driver (β=0.368), followed equally by the ethical and humanitarian dimensions (β=0.215 each). KM plays a crucial partial mediating role (composite indirect effect = 0.446), especially for legal compliance. The model explains 73.1% of the variance in environmental sustainability. Thus, for industrial firms in fragile states, environmental action should prioritize legal self-regulation, ethical values, humanitarian commitment, and systematic KM over economic incentives.

5.1. Limitations of the Study

This study is subject to several limitations. First, the cross-sectional design limits the ability to draw strong causal inferences over time. Second, the focus on a single organizational group (HSA Group) restricts the generalizability of the findings to other sectors or contexts. Third, the use of self-reported questionnaire data may introduce common method bias and subjective response bias.

5.2. Future Research Directions

Future studies could address these limitations by adopting longitudinal designs to capture changes over time and strengthen causal interpretations. Comparative studies across different industrial sectors or countries with similar fragile economic conditions would also enhance external validity. In addition, integrating objective environmental performance indicators alongside perceptual measures would provide a more comprehensive understanding of environmental sustainability outcomes.

Funding Disclosure: The authors declare that this research has not received any external funding from any entity, whether governmental, private, or non-profit.

Conflict of Interest Disclosure: The authors declare that there is no conflict of interest regarding the publication of this research.

Acknowledgements: The authors express their gratitude to the management of the industrial firms within the HSA group, particularly the Board of Directors and the CEO, for granting approval and permission to conduct this field study and for providing all necessary facilities for data collection.

AI Use Disclosure: The authors affirm that all statistical results, data analysis, interpretation of results, formulation of hypotheses, conclusions, and recommendations are the product of their original effort and pure scientific reasoning. Artificial intelligence was not used to generate or statistically analyze any part of the data, nor was it used to write any substantive parts of the research that require scientific rigor. The researchers bear full responsibility for the scientific content of the research, and any errors or omissions are their sole responsibility and not attributable to the AI tools.

Authors' Contributions: Author Contributions: Conceptualization, E.M.M.A.-F. and A.M.Q.A.; methodology, E.M.M.A.-F.; software, E.M.M.A.-F.; validation, E.M.M.A.-F. and A.M.Q.A.; formal analysis, E.M.M.A.-F.; investigation, E.M.M.A.-F.; resources, E.M.M.A.-F. and A.M.Q.A.; data curation, E.M.M.A.-F.; writing—original draft preparation, E.M.M.A.-F.; writing—review and editing, A.M.Q.A.; visualization, E.M.M.A.-F.; supervision, A.M.Q.A.; project administration, A.M.M.A.-F.; funding acquisition, not applicable. All authors have read and agreed to the published version of the manuscript.

REFERENCES

Aguinis, H., Rupp, D. E. & Glavas, A. (2024).Corporate social responsibility and individual behaviour. Nature Human Behaviour, 8(2), 219-227.

Al-Amri, M. (2018) Social responsibility of industrial organizations and its role in achieving sustainable development in Saudi Arabia. Journal of Economics and Finance, 13(1), 112-131.

Al-Fakih, I. M. M. & Al-Marani, A. M. Q. (2025) Knowledge management as a mediator of the impact of corporate social responsibility on sustainable development: Empirical evidence from a developing country. Unpublished manuscript.

Al-Kurshomi, H. D. A. M. (2024) The impact of applying the principles of good governance in achieving sustainable development: An empirical study in international organizations operating in Yemen.

Sana'a University Journal of Human Sciences, 2(2), 58-85.
Al-Yami, M. & Ajmal, M. M. (2019) Pursuing sustainable development with knowledge management in public sector. VINE Journal of Information and Knowledge Management Systems, 49(4), 568-593.
Atkociuniene, Z. O. & Mikalauskiene, A. (2019) Knowledge management influence on implementing sustainable development means in the organization. Transformations in Business & Economics, 18(2), 47-62.
Baron, R. M. & Kenny, D. A. (1986) The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. Journal of Personality and Social Psychology, 51(6), 1173-1182.
Belarabi, M. & Belour, S. (2020) The role of social responsibility of industrial organizations in achieving sustainable development in society. Journal of El-Wahat for Research and Studies, 13(1), 320-353.
Ben Ibrahim, S. (2015) Environmental governance and its role in achieving sustainable development: A case study of Algeria. Master's thesis, University of Mohamed Khider, Biskra, Algeria.
Carroll, A. B. (1999) Corporate social responsibility: Evolution of a definitional construct. Business & Society, 38(3), 268-295.
Creswell, J. W. & Creswell, J. D. (2018) Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 5th ed. Thousand Oaks, CA: Sage.
Davis, J. H., Schoorman, F. D. & Donaldson, L. (1997) Toward a stewardship theory of management. Academy of Management Review, 22(1), 20-47.
Freeman, R. E. (1984) Strategic Management: A Stakeholder Approach. Boston: Pitman.
González-Ramos, M. I., Donate, M. J. & Guadamillas, F. (2023) The interplay between corporate social responsibility and knowledge management strategies for innovation capability development in dynamic environments. Journal of Knowledge Management, 27(11), 59-81.
Hair, J. F., Hult, G. T. M., Ringle, C. M. & Sarstedt, M. (2017) A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM), 2nd ed. Thousand Oaks, CA: Sage.
Hair, J. F., Risher, J. J., Sarstedt, M. & Ringle, C. M. (2019) When to use and how to report the results of PLS-SEM. European Business Review, 31(1), 2-24.
Hayes, A. F. (2018) Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach, 2nd ed. New York: Guilford Press.
Henseler, J., Ringle, C. M. & Sarstedt, M. (2015) A new criterion for assessing discriminant validity in variance-based structural equation modeling. Journal of the Academy of Marketing Science, 43(1), 115-135.
Konurbayeva, Z., Sánchez-García, E., Marco-Lajara, B., Sloniec, J., Martínez-Falcó, J., & Baitikenova, G. (2026). Leading sustainable competitive advantage from within: An analysis of the mining industry. Sustainable Development, 1–17. https://doi.org/10.1002/sd.70753
Lestari, P. A. (2024) Legal dimensions of CSR: Impacts on corporate performance and stakeholder trust. Sinergi International Journal of Law, 2(4), 338-349.
Ma, Y. & Sun, L. (2010) Empirical study on knowledge management's effect on organizational effectiveness. In International Conference on Information Computing and Applications, 80-87.
Nunnally, J. C. & Bernstein, I. H. (1994) Psychometric Theory, 3rd ed. New York: McGraw-Hill.
Porter, M. E. & van der Linde, C. (1995) Green and competitive: Ending the stalemate. Harvard Business Review, 73(5), 120-134.
Preacher, K. J. & Hayes, A. F. (2008) Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. Behavior Research Methods, 40(3), 879-891.
Ringle, C. M., Wende, S. & Becker, J. M. (2015) SmartPLS 3. Boenningstedt: SmartPLS GmbH.
Rubach, C. (2022) Corporate Social Responsibility and Their Types. Global Science Research Journal, 7(1), 3-4.
Saunders, M., Lewis, P. & Thornhill, A. (2019) Research Methods for Business Students, 8th ed. Harlow: Pearson Education.
Shmueli, G., Sarstedt, M., Hair, J. F., Cheah, J. H., Ting, H., Vaithilingam, S. & Ringle, C. M. (2019) Predictive model assessment in PLS-SEM: Guidelines for using PLSpredict. European Journal of Marketing, 53(11), 2322-2347.
Singh, S. & Yadav, S. K. (2023) Corporate Social Responsibility. In Clinical Laboratory Management, 46-52. Springer, Cham.
Suchman, M. C. (1995) Managing legitimacy: Strategic and institutional approaches. Academy of Management Review, 20(3), 571-610.

Tai, T. D. (2022) Impact of corporate social responsibility on social and economic sustainability. Economic Research-Ekonomska Istraživanja, 35(1), 6085-6104.

United Nations (2015) Transforming our world: the 2030 Agenda for Sustainable Development, A/RES/70/1.

Widyanti, R., Rajiani, I. & Basuki, B. (2024) Green knowledge management to achieve corporate sustainable development. Journal of Infrastructure, Policy and Development, 8(2), 2844.

World Bank (2023) Yemen Economic Monitor: The Path to Recovery. Washington, D.C.: World Bank Group.

Yousefian, M., Bascompta, M., Sanmiquel, L. & Vintro, C. (2023) Corporate social responsibility and economic growth in the mining industry. The Extractive Industries and Society, 13, 101226.

Zhao, X., Lynch, J. G. & Chen, Q. (2010) Reconsidering Baron and Kenny: Myths and truths about mediation analysis. Journal of Consumer Research, 37(2), 197-206.