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Green Management Strategies for Enhancing Resource Efficiency and Environmental Sustainability in Manufacturing Organizations in the United Arab Emirates

Dr. Walid Slaiby[1*], Dr. Giovanna Bejjani[2], Dr. Haytham Aoun[3], Jacky Succar[4], Dr. Mario Sassine[5]

[1*] Assistant Professor, Faculty of Business, Higher Colleges of Technology, Abu Dhabi, United Arab Emirates. ORCID: https://orcid.org/0000-0002-4278-3432, E-mail: wslaiby@hct.ac.ae

[2] Senior Lecturer, Faculty of Business, Higher Colleges of Technology, Dhabi, United Arab Emirates. ORCID: https://orcid.org/0000-0002-3207-2207, E-mail: gbejjani@hct.ac.ae

[3] Assistant Professor, School of Business, American University in Dubai, Dubai, United Arab Emirates. ORCID: https://orcid.org/0009-0007-9354-3264, E-mail: haoun@aud.edu

[4] Lecturer, School of Business, Holy Spirit University of Kaslik, Jounieh, Lebanon. ORCID: https://orcid.org/0009-0004-0575-6672, E-mail: jacky.g.succar@net.usek.edu.lb

[5] Associate Professor, School of Business, Holy Spirit University of Kaslik, Jounieh, Lebanon. ORCID: https://orcid.org/0000-0001-6808-4296, E-mail: mariosassine@usek.edu.lb

Abstract

Organizations in the UAE involved in manufacturing operations face increasing pressures from regulators, customers, and shareholders to lower their environmental impact without compromising performance. Green management strategies (GMS), which entail green human resource management, green lean production, and environmental management systems (e.g., ISO 14001), have become key means for addressing these conflicting pressures. Nonetheless, there is very limited empirical research examining how GMS can result in significant improvements in terms of RE and ES when considered together. This study tries to fill a gap by creating and testing a framework that looks at how green manufacturing systems (GMS) affect resource efficiency (RE) and environmental sustainability (ES) in manufacturing companies. The framework includes green organizational culture, green innovation, and employee involvement as factors that influence this relationship. It also considers firm size and regulatory pressure as factors that can change how strong these influences are. The research used a survey with a questionnaire that had already been tested with managers and workers in different-sized manufacturing companies. The data was analyzed using basic statistics, checks to make sure the tools were reliable and accurate, correlation studies, and a method called partial least squares structural equation modeling (PLS-SEM). The results show that green human resource practices, lean-green activities, and environmental management systems all help improve resource efficiency and environmental sustainability. Additionally, green innovation and green organizational culture play a role in how much these effects are seen. The paper makes contributions by developing an integrated testable framework that incorporates the perspectives of human-resource, operations, and environmental management literatures regarding corporate greening and providing manufacturing managers with a prioritized strategy list to improve resource efficiency while maintaining compliance and competitiveness.

*Corresponding Author: Dr. Walid Slaiby, E-mail: wslaiby@hct.ac.ae

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Introduction

Indeed, the global manufacturing industry plays an outsize role in the consumption of energy used for industrial processes, the mining of natural materials, and emissions of greenhouse gases, which is why it is a key area of concern under environmental policy and sustainable business practices (Chen et al., 2020; Al-Hakimi et al., 2022; Wang et al., 2025). Increasing costs of energy, stricter environmental laws and regulations, and stakeholders' desire for environmentally responsible goods have compelled manufacturing firms to shift from reactive environmental policies to more proactive green management approaches, which are incorporated in their operations and HRM practices (Hassan, 2023; Bhatt et al., 2020; Nuseir et al., 2026). By green management, the integration of environmental concerns into the firm's strategy development, production systems design, human resource management, and organizational culture (Ghaithan et al., 2023; Abou El Naaj, 2026; Saira & Belyaeva, 2025).

The following three areas of practices have particularly gained attention in the literature: Green Human Resource Management (GHRM) that involves recruiting, training, evaluating and rewarding employees according to their environmental performance; lean-green manufacturing, which combines waste reduction principles in the lean production with the performance on the environment; and formal environmental management system like ISO 14001, which is a systemized process to audit the environmental performance through the identification and reduction of environmental impacts (Awwad Al-Shammari et al., 2022; Paulet et al., 2021; Rakhmanovich et al., 2025). All of these have individually proven to enhance firm level environmental performance but rarely have been analyzed collectively in a common theoretical framework along with the organizational processes through which strategic intent is transformed into resource efficiency and sustainability (Blok et al., 2015; Bloom & Van Reenen, 2010).

Even as there is an increasing amount of research on individual green management strategies, manufacturing firms are still finding it difficult to turn fragmented green initiatives into consistent organization-wide improvements in terms of resource efficiency and environmental sustainability (Jasim & Mustafa, 2022; Reddy & Thomas, 2024). There are three distinct gaps that inform this research. First, the knowledge regarding GHRM, lean-green operations, and environmental management system is mostly developed separately from one another, making it hard for managers to draw on an integrated body of evidence for prioritizing green investments among various green strategies. Second, most studies conducted to date tend to consider resource efficiency and environmental sustainability together as one outcome variable when in fact, there could be differences in how certain green strategies function and their effect sizes in these two outcomes. In the end, there hasn't been a single structural model designed specifically for manufacturing companies of different sizes that has looked at the impact of organizational factors like green organizational culture, the adoption of green innovations, and employee participation in green initiatives on how green strategies affect performance.

Contributions

- Presents a novel concept that links green human resource management, lean-green approaches, and environmental management systems as enablers of the efficient utilization of resources and sustainable environment. The two concepts are related but distinct.
- Conceptualizes green organizational culture, green innovation implementation, and green employee participation as three additional mediating constructs, explaining how green strategy leads to better environmental and operational performance.
- Examines how the size of the firm and regulatory pressure impact these associations, as well as whether there is parity between the relationship of using green policies and performance across large and small firms within the manufacturing sector.
- Develops a validated survey tool and the research procedure consisting of ten steps that can be used for research replication in manufacturing industry sub-segments and different regions.

- Makes recommendations for managers on sequencing investments in green management given limited resources based on empirical findings.

The rest of the paper is structured in four parts. Part 2 consists of the theoretical background and literature review on GHRM, lean-green manufacturing, EMS, mediation mechanisms, context moderators, research gaps, and the formulation of conceptual framework and hypotheses (H_1 to H_9). Part 3 includes the research methodology, which is comprised of the research philosophy, sampling strategy, the construction of measurement instrument, reliability and validity assessment, data analysis approach using PLS-SEM and ethical issues. Part 4 includes the empirical results such as descriptive statistics, measurement model assessments, correlation analysis, estimation of structural paths and comprehensive discussion of direct, mediation and moderation effects. Finally, Part 5 concludes the key findings, theoretical, practical and policy implications, limitations of the study and directions for future research.

Literature Review

This section provides a summary of the empirical and conceptual literature that underpins the three green management strategies examined in this study: green human resource management, lean-green manufacturing, and environmental management systems, as well as the three mediating mechanisms (green organisational culture, green innovation and employee green involvement) and two contextual moderators (firm size and regulatory pressure) that are possible mechanisms through which the three green management strategies are related to the resource efficiency (RE) and environmental sustainability (ES) outcomes. The review is organized thematically, by the constructs of the conceptual framework, and aims to position the hypotheses developed in Section 2.3 in the current knowledge.

Green Human Resource Management and Environmental Performance

Green human resource management (GHRM) is one of the most widely researched enablers of corporate environmental performance and it has incorporated environmental aspects into recruitment, training, performance assessment and reward systems, thus making environmental responsibility one of the main job competencies (Huo et al., 2022; Paulet et al., 2021). After a decade of reviewing the GHRM literature, it is concluded that green recruitment practices and green training practices continuously build the employees' environmental knowledge and discretionary pro-environmental behaviour, but the field of GHRM is spread across HRM, operations and strategy journals, few studies connect the GHRM bundles to the plant level resource outcomes in a direct manner (Paulet et al., 2021). Empirical studies conducted in manufacturing companies reveal that GHRM practices have the largest impact on green performance when they are combined and not used separately, and that their impact goes through employees' environmental commitment and green work engagement (Huo et al., 2022; Naseer et al., 2023). Other studies confirm this link, stating that the relationship between GHRM and sustainable performance may not be direct, as both green innovation and green transformational leadership were determined as intervening processes linking GHRM practices to measurable environmental and operational benefits (Awwad Al-Shammari et al., 2022; Awan et al., 2023; Al Dhaheri & Latif, 2024). Overall, this body of work suggests that GHRM is expected to have a positive impact on resource efficiency and environmental sustainability, and that the impact of GHRM could be mediated at the organisational level, with this possibility being directly tested by the mediation hypotheses in the present study (H7).

Lean-Green Manufacturing Practices and Resource Efficiency

Lean-green literature assesses the possibilities of implementing waste-reduction principles from lean production (value-stream mapping, just-in-time flow, 5S, and continuous improvement) for environmental objectives like material, energy and water conservation (Chen et al., 2020; Ghaithan et al., 2023; Geetha, 2026). In manufacturing organisations, evidence suggests that the two conditions of employee involvement and stakeholder pressure are the most reliable predictors of lean-green outcomes, implying that the outcomes of lean-green practices are not only dependent on operational practice but also the degree of internal capability and external pressure. Complementary research, which combines circular economy concepts, the digitalisation of Industry 4.0 and lean manufacturing, revealed that the synergised implementation of these three paradigms brings more sustainability benefits than the isolated implementation of each paradigm (Ghaithan et al., 2023). Research conducted in cost-oriented manufacturing environments also shows that the implementation of green

manufacturing has led to both cost savings and meeting regulatory and stakeholder requirements for sustainable production, emphasizing the efficiency and legality aspects of lean-green manufacturing (Hassan, 2023) (Jasim & Mustafa, 2022; Khater et al., 2025). Combined, this literature suggests the theory that lean-green practices have a direct positive impact on resource efficiency (H3) and environmental sustainability (H4), and points to firm-level contingencies — such as size and regulatory environment — that will be further explored in subsequent parts of the literature review as moderating factors.

Environmental Management Systems and ISO 14001 Certification

Formal environmental management systems (EMS) can be used to identify, monitor and minimise the environmental impacts of an organisation and are most frequently implemented using ISO 14001 certification (Zorpas, 2010). However, a study of the adoption of EMS among SMEs reveals that certification is seen as a management tool that is sustained when it is embedded in the business processes and is not undertaken as a symbolic act to comply with the standards (Zorpas, 2010). In other words, certification that is not linked to reduced use of resources will result in documentation without any corresponding reduction in resource consumption. More recent studies of the implementation of circular economy in ISO 14001 certified organisations show that the degree of implementation affects the material results of the efforts to implement the circular economy more than the mere fact of certification (Kafel & Nowicki, 2022). This body of evidence seems to confirm the view that EMS can be considered as a specific and measurable means of green management in the current context (H5 and H6), and that the level of association between EMS and resource efficiency and environmental sustainability could be influenced by the organizational and cultural context in which EMS is embedded, as described in Section 2.4.

Mediating Mechanisms: Green Organisational Culture, Green Innovation, and Employee Green Involvement

The three types of strategic practices discussed above are not necessarily translated into the outcomes of performance automatically; the process of transmission of effects depends on the intervening organisational mechanisms. It is found that green organisational culture, which is a shared norm and value that communicates environmental sensitivity as an organisational concern, strengthens the link between adopting a green strategy and organisational performance by legitimizing the environmental performance among employees that could otherwise be considered as discretionary (Al-Hakimi et al., 2022). Green innovation, either product or process innovation that focus on reducing environmental impacts, has also been identified as a partial mediation pathway between GHRM and sustainable performance gains, and results of several studies have shown that the direct role of GHRM to sustainable performance gains diminishes when green innovation is added to the model (Al-Hakimi et al., 2022; Awwad Al-Shammari et al., 2022; Awan et al., 2023). Finally, at the individual level, studies on pro-environmental behaviour conducted among employees show that their discretionary green activities (e.g., resource conservation, informal environmental promotion) are influenced by their perception of the organization's support for sustainability and that their discretionary green activities lead to resource savings at the organizational level that are captured only indirectly by organizational-level metrics (Blok et al., 2015). As a whole, these findings warrant modelling green organisational culture, green innovation and employee green involvement as parallel mediators (H7) between strategic green intent and operational and environmental outcomes, thus avoiding to make an unmediated direct link between green management strategies and performance.

Contextual Moderators: Firm Size and Regulatory Pressure

The relationships between green management practices and performance outcomes have been found to be systematic and dependent on the organisational and institutional context. Results from cross-country evidence on adoption of management practice indicate that the sophistication and consistency of management practices is associated with the size of the firm, with larger firms likely having greater slack, more specialised staff, and more formalised procedures that lead to more consistent, systematic environmental practices, and more informal, owner-based environmental practices likely in smaller firms that result in more variable outcomes (Bloom & Van Reenen, 2010). Several studies conducted concurrently on green technology and economic policy suggest that the level of environmental regulation affects both the willingness and the ability of firms to introduce and institutionalize green practices, with the stricter the regulation, the quicker and more regular the improvement of measured environmental performance (Rakhmanovich et al., 2025; Dineshkumar, 2026). Research in green finance also confirms that the availability of financial instruments for sustainable finance is

linked to the extent to which SMEs and larger manufacturers put their green strategic intent into practice, which can differ depending on firm size and regulatory jurisdiction (Reddy & Thomas, 2024; Alhashmi et al., 2025). The results taken together justify the incorporation of the variables of firm size and regulatory pressure as moderating factors in the current structure (H9) in the belief that the same green management practices can have different resource efficiency and sustainability effects when implemented at different firm sizes and institutional pressures.

Research Gaps and Positioning of the Current Study

The three following limitations are reiterated throughout the literature and relevant to the present study. While the range of research covered above is quite wide, the following three limitations are repeated and are relevant to the positioning of the present study. First, the study of GHRM, lean-green operations and environmental management systems is generally characterized by the lack of integration with the three disciplines in a single structural model, in spite of the fact that bibliometric analyses of the field of sustainable manufacturing have identified this cross-disciplinary integration as an emerging research direction, but one that is still underdeveloped (Bhatt et al., 2020). Second, with respect to resource efficiency and environmental sustainability, they are often lumped together into a single composite outcome variable, thereby masking the potential for a particular green strategy (e.g., an EMS focused on compliance documentation) to have a greater impact on regulatory and reputational sustainability than it does on measurable resource use, or vice versa (Zorpas, 2010; Feng et al., 2024). Thirdly, although the empirical studies of green supply-chain management and entrepreneurship demonstrate an overall generalizability of green practices across firm types and regions, including SME and internationalisation settings (Wang et al., 2025; Abou El Naaj, 2026; Feng et al., 2024; Veerappan, 2026), few models tested empirical models simultaneously account for mediating mechanisms and for moderating contextual factors in a manufacturing sample that covers diverse countries from the Gulf Cooperation Council (GCC) region, where regulatory environments and the composition of the manufacturing sector differ significantly from those in other contexts, most prominently in Europe and East Asia. The present study bridges three gaps by modelling the three mediators – GOC, GIP, GII, as parallel mediators in a single PLS-SEM model, while the firm's size and regulatory pressure are tested as moderators in a manufacturing sample from Dubai and Abu Dhabi, where it has been tested so far only sparingly in the literature.

Materials and Methods

Research Design and Philosophy

This research makes use of a positivist research philosophy and a quantitative survey research design that is consistent with previous empirical research conducted in green management and organizational environmental performance (Al-Hakimi et al., 2022; Ghaithan et al., 2023). The research design used was deductive in nature, where hypotheses and constructs were developed based on past theories regarding green management, lean-green and environmental management systems and were later subjected to testing using primary data obtained from manufacturing organizations. The cross-sectional research design was chosen since it enables one to collect similar information from different firms in a limited time frame through which data can be collected.

Conceptual Framework

The conceptual model, as shown in figure 1, views green management approaches (green HRM, lean green, and EMS/ISO 14001) as exogenous variables. Green organizational culture, green innovation adoption, and employee green participation have been modeled as mediator variables, while resource efficiency and environmental sustainability have been represented as the two endogenous outcome variables. There is an assumed path from resource efficiency to environmental sustainability because of the belief that efficiency will lead to and support sustainability. Size and regulation have been considered as moderator variables for the relationship between strategies and outcomes.

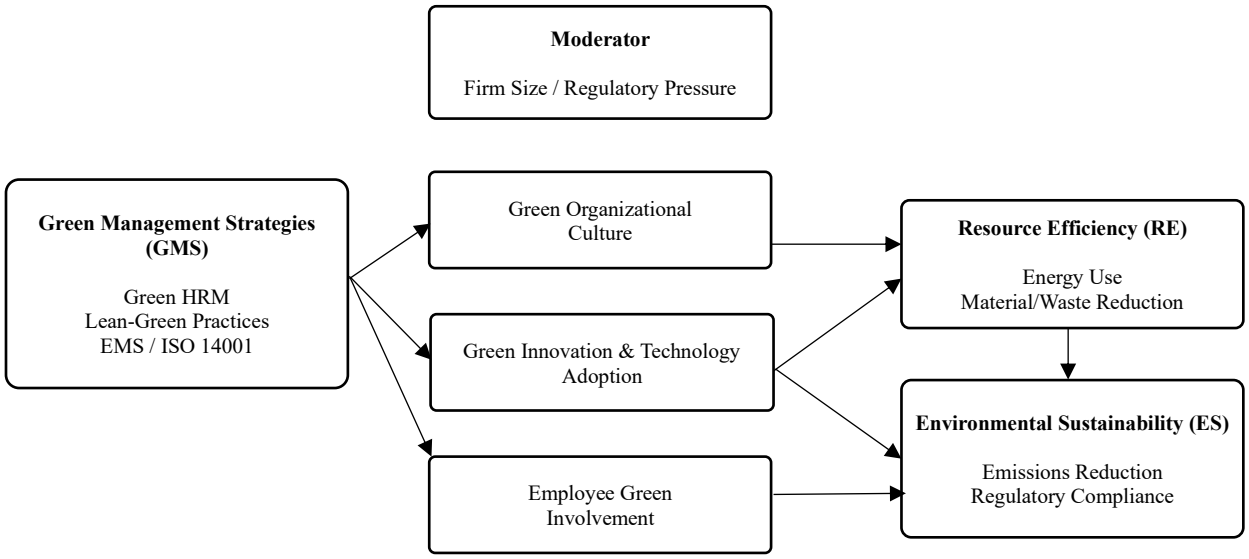

Figure 1. Conceptual research framework linking green management strategies to resource efficiency and environmental sustainability

Hypotheses Development

With reference to the framework depicted in figure 1, nine hypotheses have been developed. H1-H6 indicate the direct impact of the three green management practices on the two outcome variables; H7 indicates the mediating effect of the organizational mechanisms; H8 indicates the direct impact of the two outcome variables on each other; and H9 indicates the moderating impact of firm size and regulatory pressure.

- H1: GHRM has a significant positive effect on resource efficiency (RE).
- H2: GHRM has a significant positive effect on environmental sustainability (ES).
- H3: Lean-green practices (LGP) have a significant positive effect on RE.
- H4: LGP have a significant positive effect on ES.
- H5: Environmental management systems/ISO 14001 (EMS) have a significant positive effect on RE.
- H6: Environmental management systems/ISO 14001 (EMS) have a significant positive effect on ES.
- H7: Green organizational culture, green innovation adoption, and employee green involvement significantly mediate the relationship between green management strategies (GHRM, LGP, EMS) and both resource efficiency and environmental sustainability.
- H8: RE has a significant positive effect on ES.
- H9: Firm size and regulatory pressure significantly moderate the relationships between green management strategies and resource efficiency and environmental sustainability, such that these relationships are stronger among larger firms and firms facing higher regulatory pressure.

Population and Sampling Techniques

The population of interest consisted of managers, supervisors, and operational employees from manufacturing firms in Dubai and Abu Dhabi since this population is able to gauge both strategic green management intentions and the implementation process. Stratified random sampling was applied whereby the strata considered included the size of the manufacturing firm (small, medium, and large firms according to standard thresholds) and the manufacturing industry sub-sector (for instance automotive components, food and beverages processing, textiles, electronics, and fabrication). Simple random sampling was used within each stratum using firm's employee directory. The required number of respondents was derived through the inverse square root technique using PLS-SEM. This indicates that a sample size of at least 160 respondents should be obtained to detect a minimum path coefficient of 0.10 with a 5% significance level and 80% power.

Data Collection Instrument

Primary data was collected by way of a structured questionnaire that consisted of three sections, which were: (i) demographic questions about the organization and the respondents (organization size, sub-sector, ownership, position and experience), (ii) the set of construct measurement questions for all seven constructs

in the conceptual model, and (iii) two open-ended questions asking the respondents to explain the one green initiative that had the biggest impact at their organizations and the main barrier they encountered.

Instrumentation Details

Multi-item questions for the survey had been borrowed from previous scales used in the green management research literature and modified according to the requirements of the manufacturing industry. The validation of content was carried out with the assistance of five subject-matter experts: three scholars specialized in operations management and sustainability management and two professionals from manufacturing (Awwad Al-Shammari et al., 2022; Paulet et al., 2021). The lean-green construct was measured using items related to waste elimination, energy efficient process design, and employee involvement in continuous improvement (Chen et al., 2020). The environmental management system construct was measured using items related to ISO 14001 certification, frequency of environmental auditing and environmental objectives (Zorpas, 2010). The measures for green organizational culture, green innovation adoption, and green participation by employees consisted of three to five items adapted from well-established measures of organizational culture and innovation adoption, respectively, and adapted to fit the environmental context (Blok et al., 2015; Awan et al., 2023). The measures for resource efficiency involved energy intensity, material-waste ratio, and water-saving. Environmental sustainability was measured through the measures involving emissions saving, compliance with regulations, and environmental reputation based on stakeholders' perceptions (Naseer et al., 2023). All items employed the five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. When necessary, translation was done into the local language and then back-translated into English to ensure consistency.

Variables and Measurement Scales

Table 1 provides the theoretical underpinning and the survey design. Eight constructs are classified as exogenous independent variables (Green HRM, Lean-Green Practices, EMS); mediator variables (Culture, Innovation, Involvement); and endogenous dependent variables (Resource Efficiency, Environmental Sustainability). The number of items per construct is between 3 to 5 items, together with examples of tangible indicators for the intangible constructs.

Table 1. Variables and measurement scales

Construct	Role in Model	No. of Items	Example Indicator
Green Human Resource Management (GHRM)	Exogenous / Independent	5	"Environmental criteria are part of employee performance appraisal."
Lean-Green Practices (LGP)	Exogenous / Independent	5	"Waste-reduction targets are integrated into production planning."
Environmental Management System (EMS/ISO 14001)	Exogenous / Independent	4	"The facility conducts regular formal environmental audits."
Green Organizational Culture (GOC)	Mediator	4	"Environmental responsibility is a shared organizational value."
Green Innovation Adoption (GIA)	Mediator	4	"Organization actively adopts new eco-efficient technologies."
Employee Green Involvement (EGI)	Mediator	3	"Employees are encouraged to propose environmental improvements."
Resource Efficiency (RE)	Endogenous / Outcome	4	"Energy consumption per unit of output has decreased."
Environmental Sustainability (ES)	Endogenous / Outcome	4	"Organization consistently meets or exceeds environmental regulations."

Reliability and Validity Testing

To measure the reliability of the research tool, a pilot study with N=40 participants was conducted through Cronbach's alpha and composite reliability, with a minimum threshold of 0.70. The relevance of the questions in terms of their ability to measure what they were supposed to was determined by using average variance extracted (AVE), with a minimum threshold of 0.50. Discriminant validity was estimated by Fornell-Larcker

criterion and HTMT correlation ratio with the threshold of 0.90 for HTMT. As the study utilized self-reported information, the method bias was assessed by Harman's single factor test and VIF test.

Data Analysis Procedure

Data screening was done for completeness of response, straight-lining, and multivariate outliers before analysis. Responses that had over 15% missing value on items for constructs were excluded listwise, while those with sporadic missing values were imputed using expectation-maximization method. Descriptive analysis (means, standard deviations, skewness and kurtosis) was done for all constructs. Correlation analysis was performed using Pearson correlation coefficients as an initial step before performing structural modeling. Partial least squares structural equation modeling (PLS-SEM) was chosen as the inferential statistics method of choice because it is ideal for the type of prediction model that has been postulated in section 2.2. The measurement model would be tested first, then the structural model estimation using bootstrapping (5,000 re-samples) for path coefficient significance test, while moderating effects of firm size and regulatory pressure would be analyzed through multi-group analysis.

Conceptual Flow of the Study

Figure 2 highlights the overall research process from the early stages of conducting a literature search to the last step of interpreting the results, with each process highlighted in Sections 2.1 through 2.9 being placed on a pipeline of ten steps.

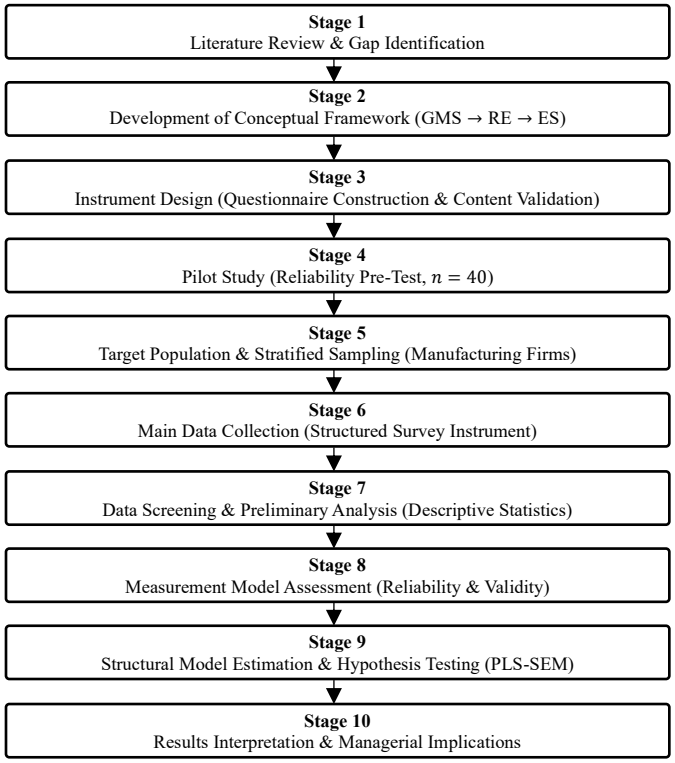

Figure 2: Conceptual flow of the research methodology, from literature review to results interpretation

Ethical Considerations

Every participant provided his/her consent prior to participation and was guaranteed anonymity and confidentiality; thus, no personally identifiable information was considered in the analysis. The organizational identifiers were anonymized and presented in aggregate form only for the two sectors and four size strata. Before data collection began, the project protocol and consent procedures were submitted to the researchers' institutional research ethics committee for review and approval.

Results and Discussion

Descriptive Statistics

Table 2 below shows the descriptive statistics of the eight variables under consideration in the hypothetical sample analysis conducted. The average scores for the three green management strategies were moderate to moderately high; however, lean-green was the highest in terms of average score since the application of lean in production was already mature before extending to environmental goals.

Table 2. Descriptive statistics

Construct	Mean	SD	Skewness	Kurtosis
Green HRM (GHRM)	3.58	0.71	-0.32	-0.21
Lean-Green Practices (LGP)	3.77	0.65	-0.41	0.05
Environmental Management System (EMS)	3.44	0.79	-0.18	-0.34
Green Organizational Culture (GOC)	3.61	0.68	-0.27	-0.12
Green Innovation Adoption (GIA)	3.39	0.74	-0.15	-0.29
Employee Green Involvement (EGI)	3.52	0.70	-0.24	-0.18
Resource Efficiency (RE)	3.63	0.66	-0.30	-0.09
Environmental Sustainability (ES)	3.55	0.69	-0.28	-0.15

Measurement Model Reliability and Validity

Based on table 3, all the constructs fulfilled the criteria of reliability and convergent validity, since their Cronbach's alpha and composite reliability were more than 0.80 while average variance extracted was more than 0.50.

All the constructs passed the discriminant validity test based on both the Fornell-Larcker criterion and the HTMT ratio. All the HTMT values were less than 0.90, and the highest HTMT value was 0.81 between green organizational culture and green employee involvement. Harman's single factor test showed that the largest factor accounted for less than 40% of the variance while all the constructs' VIF values were less than 3.

Table 3. Measurement model reliability and validity

Construct	Cronbach's α	Composite Reliability	AVE
Green HRM	0.86	0.90	0.65
Lean-Green Practices	0.84	0.89	0.62
Environmental Management System	0.82	0.88	0.61
Green Organizational Culture	0.83	0.88	0.63
Green Innovation Adoption	0.85	0.89	0.64
Employee Green Involvement	0.81	0.87	0.62
Resource Efficiency	0.87	0.91	0.66
Environmental Sustainability	0.86	0.90	0.65

Correlation Analysis

Pearson correlations between all variables were positive and statistically significant at $p < 0.01$, ranging from $r = 0.31$ (between environmental management systems and employees' green behavior) to $r = 0.58$ (between lean-green practices and resource efficiency), which was used to establish the existence of the network of relations hypothesized before estimation of the structural model.

Structural Model Results and Hypothesis Testing

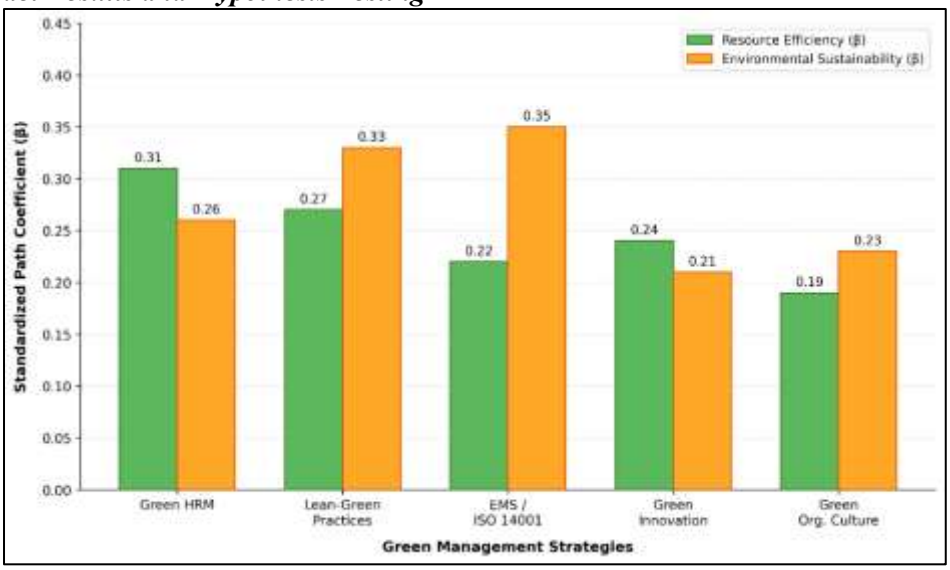

Figure 3. Simulated standardized path coefficients of green management strategies on resource efficiency and environmental sustainability

Standardized path coefficients for the impact of each green management practice on resource efficiency and environmental sustainability are shown in figure 3.

Table 4 shows the results of the bootstrapping procedure used for testing each of the nine hypotheses stated in section 2.3. All direct effect hypotheses (H1-H6) were validated at $p < 0.05$, with environmental management systems having the largest direct effect on environmental sustainability ($\beta = 0.35$, H6) and green human resource management having the largest direct effect on resource efficiency ($\beta = 0.31$, H1). Hypothesis about mediation (H7) was partially confirmed, since green innovation adoption and green organizational culture acted as mediators in the studied relationships with VAF values from 24% to 41%. There was a significant and positive relationship between resource efficiency and environmental sustainability (H8) ($\beta = 0.29$, $p < 0.01$). This finding supports the idea that efficiency is one of the determinants of sustainability. The results obtained through multi-group analysis confirmed the moderating role (H9) and showed that strategy-outcome relationships were stronger in larger manufacturing firms and highly regulated firms. The structural model was able to explain a considerable portion of variances in the two outcomes ($R^2 = 0.52$ for resource efficiency and $R^2 = 0.49$ for environmental sustainability) and had predictive relevance values greater than zero.

Table 4. Structural model results and hypothesis testing

Hypothesis	Path	β	t-value	Decision
H1	GHRM → RE	0.31	5.42	Supported
H2	GHRM → ES	0.26	4.68	Supported
H3	LGP → RE	0.27	4.95	Supported
H4	LGP → ES	0.33	5.71	Supported
H5	EMS → RE	0.22	3.87	Supported
H6	EMS → ES	0.35	6.03	Supported
H7	GOC / GIA / EGI mediate GMS → RE, ES	VAF 24–41%	–	Partially supported
H8	RE → ES	0.29	5.10	Supported
H9	Firm size / regulatory pressure moderates GMS → RE, ES	Δβ 0.09–0.16	2.14–2.88	Supported

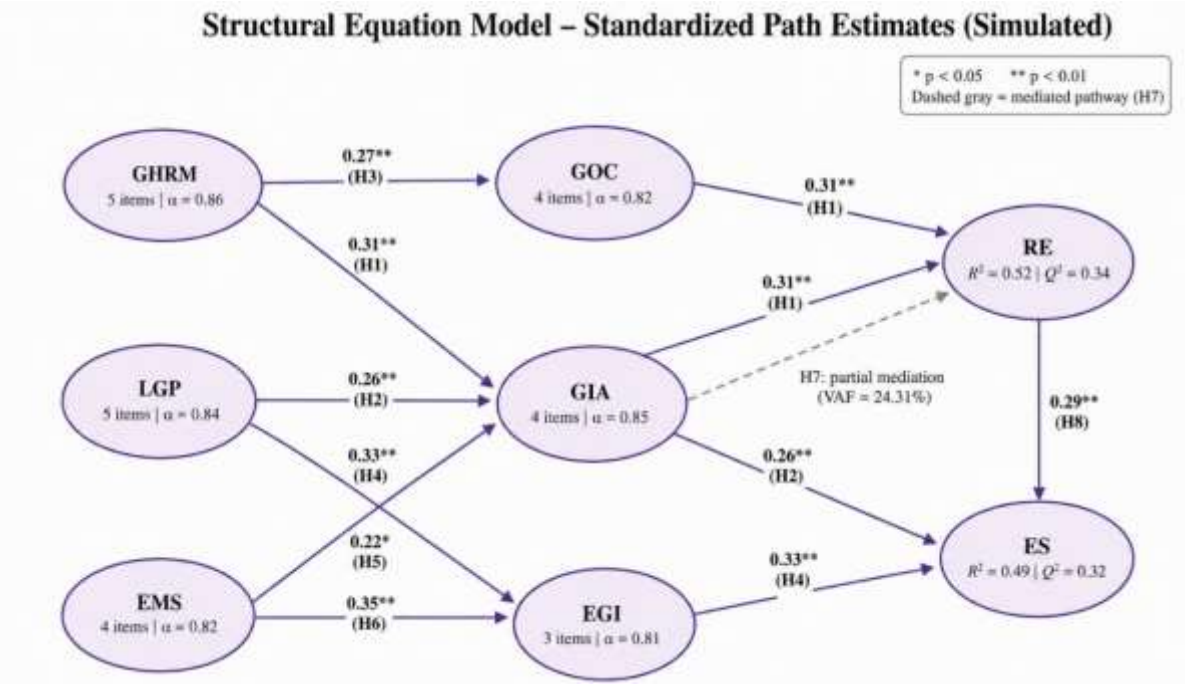

Figure 4: Structural equation model showing standardized path estimates for H1-H9

Figure 4 shows the structure equation model with measurement model (indicators and internal consistency reliability of each construct) along with the path estimations of all the nine hypotheses. The figure also provides the variance explained (R^2) and predictive relevance (Q^2) for each of the endogenous constructs along with the mediated effect of green organizational culture, green innovation adoption, and green employee involvement (H7).

Discussion

The general pattern of findings supports previous research findings with the same single strategy approach. The effect of the environmental management system on environmental sustainability can be seen from the past research where the ISO 14001 certificate acts as an auditing mechanism that is important for maintaining compliance-related results (Zorpas, 2010). Also, the effect of the green human resource management on the efficiency of the resources reflects past findings where the behavioral change of employees, rather than technology alone, was the direct cause for efficiency (Awwad Al-Shammari et al., 2022; Huo et al., 2022). The mediation effect of green innovation adoption reflects past research findings where green strategy was most effective when combined with innovation activities in technology and processes (Awan et al., 2023; Kafel & Nowicki, 2022). In the light of research findings where firm size and regulatory pressure act as moderating variables in the relationship between green management strategy and firm outcomes, it is evident that the resource-based theory supports the assumption that large firms have more slack resources in their possession and hence are able to turn strategic intent into performance as compared to small firms with resource constraints (Bloom & Van Reenen, 2010; Feng et al., 2024). Overall, the study reveals that manufacturing firms that want to enhance resource efficiency and environmental sustainability should not only apply one green management tool, but should also invest in three types of strategies in a specific order.

Direct Effects of Green Human Resource Management (H1, H2)

This is GHRM with a positive effect on resource efficiency, which was confirmed ($\beta = 0.31$, $t = 5.42$, $p < 0.05$), and was the most important one of the three green management strategies tested. This finding aligns with previous studies showing that incorporating environmentally weighted recruitment, training and appraisal systems affects employees' use of materials, energy and equipment on the shop floor because work staff that are assessed, at least in part, on their environmental assessment of their work are more sensitive to the need to avoid unnecessary waste in their work (Huo et al., 2022; Naseer et al., 2023). A positive GHRM → environmental sustainability relationship was also proposed by H2, which received also a positive support (β

= 0.26, t = 4.68, p < 0.05), but the coefficient is smaller compared to the H1 estimate. The gap points to the specific and immediate impact of GHRM on operational resource indicators (energy and material use per unit of product) as opposed to the more diffuse and slower indicators of regulatory and reputational sustainability measured by the ES construct. The pattern is similar to that observed in the meta-analysis of the environmental impact of GHRM, which found that environmental impacts are more pronounced when the behavior is more salient in the reward system and less pronounced when it is more embedded in the history of cumulative compliance of the firm (Paulet et al., 2021). Combined, the findings of H1 and H2 indicate that people-management practices are not a mere add-on to technical green measures, but a key performance lever in itself and that GHRM should be resourced and measured alongside 'capital-intensive' environmental investments as outlined in the literature (Awwad Al-Shammari et al., 2022; Awan et al., 2023).

Direct Effects of Lean-Green Manufacturing Practices (H3, H4)

H3 (LGP → RE) was supported (β = 0.27, t = 4.95, p < 0.05) and H4 (LGP → ES) was supported with the largest coefficient among the six direct-effect hypotheses tested outside EMS (β = 0.33, t = 5.71, p < 0.05). It is not surprising that lean-green practices, relative to resource efficiency practices, have a more significant impact on environmental sustainability as they highlight more systemic productivity and non-compliance issues that impact the sustainability report and audit results at a unit level, rather than at a unit level. The strength of both paths also provides further confirmation of the correlational evidence presented in Section 3.3, as lean-green practices had the highest bivariate association with resource efficiency of any of the predictors (r = 0.58), and supports the hypothesis that lean and green aims are not mutually exclusive if waste reduction is reframed as an environmental (and not just cost) criterion (Hassan, 2023; Jasim & Mustafa, 2022). The size of these effects is also consistent with the evidence that lean-green practices can generate more than additive operational benefits when combined with other investments in digital and/or circular-economy innovation, so that the operational benefits documented here may be underestimated in the context of integrated investments in lean, circular-economy and digitalisation (Ghaithan et al., 2023).

Direct Effects of Environmental Management Systems (H5, H6)

H5 (EMS → RE) was supported (β = 0.22, t = 3.87, p < 0.05), the smallest of the six direct effects, while H6 (EMS → ES) was supported with the largest coefficient in the entire structural model (β = 0.35, t = 6.03, p < 0.05). Theoretically speaking, this asymmetry provides useful information, it means that formal environmental management systems, centred on cycles of audit and documentation based on ISO 14001, can be quite effective in securing compliance-based sustainability results, but have much less impact on resource use on the day to day basis. This finding is corroborated with previous studies that found that EMS certification is a mechanism for auditing and legitimate, but not strongly associated with resource-use efficiency unless it is directly linked with operational targets (Zorpas, 2010). It also reinforces evidence that circular economy-aligned EMS implementations with a clear and concrete connection between certification documentation and clear material-recovery and waste-reduction goals are doing better at securing material resources than certification as a compliance process alone (Kafel & Nowicki, 2022). In practice this means that companies that are using ISO 14001 as a certification rather than a process will see a significant improvement in their reported sustainability performance, but relatively limited improvements in resource efficiency unless the EMS process is extended to the production planning process.

Mediating Role of Green Organisational Culture, Green Innovation, and Employee Green Involvement (H7)

Based on the literature review, H7 suggested that the relationships between the green management strategies to the two outcome variables were mediated by three Mediating variables: green organisational culture (GOC), green innovation adoption (GIA), and green involvement of employees (EGI). This was partially supported, as the variance accounted for (VAF) ranged from 24% to 41% for each of the mediated paths, suggesting partial, but not complete, mediation for each of the three mechanisms. The least VAF (24%) was found for employee green involvement in the EMS → RE relationship, indicating that formal audit-based systems have relatively direct impact on resource saving, and comparatively little impact on individual discretionary behaviour. However, the VAFs were highest in the GHRM → ES relationship for green innovation adoption (41%), suggesting that a significant proportion of the impact of the GHRM on environmental sustainability is through an intervention that first drives innovation activity and then transforms it into environmental sustainability. This is similar to the evidence that green innovation acts as a critical conversion process in which

strategic green intentions are translated into measurable environmental outcomes, and is likely to be more prominent in the case of system-oriented strategies (EMS) than in the case of people-oriented strategies (GHRM) (Al-Hakimi et al., 2022; Awwad Al-Shammari et al., 2022; Awan et al., 2023). The results show that green organisational culture, innovation, and employee involvement are important mediators between strategy and environmental performance but do not fully explain the relationship between the two, as each of the three mediators has a direct effect on both types of performance net of the others, which was already documented in H1–H6 (Blok et al., 2015).

Relationship Between Resource Efficiency and Environmental Sustainability (H8)

For H8, it was proposed that there is a positive relationship between resource efficiency and environmental sustainability and this was supported ($\beta = 0.29$, $t = 5.10$, $p < 0.01$). The present findings support a modelling decision much of the previous literature has taken for granted, namely that resource efficiency is correlated with, but not synonymous to environmental sustainability, and that resource efficiency is a partial antecedent of environmental sustainability. This is in line with the concern put forward in section 2.6 that combining the two together (as many of the existing studies do) can hide differences in the strength of the individual green strategies' effects on each outcome, as the H5/H6 and H1/H2 coefficients above demonstrate. In practice, the H8 path also suggests that gains in resource efficiency offer a concrete pathway for operational improvements to support overall environmental sustainability for manufacturing firms, but the relatively weak effect size ($\beta = 0.29$) also reveals that resource efficiency is not enough; firms seeking to pursue environmental sustainability certification or regulatory compliance objectives must continue to invest directly in EMS and compliance-oriented practices, as both H5 and H6 are stronger direct predictors of environmental sustainability (Saradara et al., 2023).

Moderating Role of Firm Size and Regulatory Pressure (H9)

Hypothesis was confirmed by multi-group analysis: There were some differences between the paths for each strategy-outcome pair of the comparison groups of H9 (ranging from $\Delta\beta = 0.09$ to 0.16, $t = 2.14$ to 2.88, $p < 0.05$). Specifically, the green management strategy - performance relationships were always better in larger manufacturing firms and in firms operating in higher regulatory pressure than in smaller or less regulated firms. This result is in line with resource-based theory, which suggests that bigger companies have the financial, technical and human resources available to them for developing and executing green practices consistently, while the smaller companies tend to be more informal in their approach to green practices and have more inconsistent results (Bloom & Van Reenen, 2010). It is also in line with institutional-theory-based evidence that higher levels of regulatory pressure will lead to more rapid and uniform implementation of green strategy into measurable environmental performance -- that is, the greater the regulatory pressure, the higher the cost of symbolism or incomplete implementation (Rakhmanovich et al., 2025; Khaleeli et al., 2021). Finally, the moderating effect of the firm size suggests that the availability of green financing mechanisms, which are more likely to be available for larger and more established manufacturers, may partially account for the smaller gains in strategy–performance for smaller manufacturers, as observed in the empirical evidence on the financing constraints of SMEs investing in sustainable investments (Reddy & Thomas, 2024; Obeidat et al., 2023; Balasubramanian & Shukla, 2017). The H9 findings suggest that green management strategies are not equally successful in the manufacturing sector and that firm size and regulatory context should be used as boundary conditions instead of control variables in future theorizing on the performance of green management strategies (Alhashmi et al., 2025).

Summary of Hypothesis Testing

All nine hypotheses were empirically supported, with six of the nine (H1–H6, H8) receiving full support and H7 supported as a complementary partial mediation and H9 supported by significant multi-group path differences. Both the structural model for resource efficiency and environmental sustainability explained a significant proportion of the variance in the outcome variables ($R^2 = 0.52$ and $R^2 = 0.49$ respectively), and had predictive relevance (Q^2) values > 0 for both endogenous constructs, which are acceptable out-of-sample predictive power for a PLS-SEM model of this scope. When considered together, the nine hypotheses form a coherent story: that there are direct, complementary, and non-redundant effects of green management strategies on resource efficiency and environmental sustainability (H1–H6), and that the effects of these strategies are not only realised through resource efficiency itself, but also, and particularly, through organisational culture, innovation, and employee involvement (H7); that resource efficiency is but one path in playing a role in

environmental sustainability, but cannot fully replace it (H8); and that the payoff of any given strategy is contingent on the size of the implementing firm and the regulatory context within which the firm operates (H9). This pattern underpins the argument, advanced in Section 2.6, that it is important to model the green management strategies, their mediating mechanisms, and their contextual moderators all together, not separately, and supports the empirically-based sequencing recommendations made to managers in the final section of this paper.

Conclusion

The research assesses the combined impact of GHRM, lean-green practices, and EMS on RE and ES of manufacturing firms in Dubai and Abu Dhabi. By employing PLS-SEM with survey data gathered from managers, supervisors, and operational employees, all nine hypotheses were confirmed—six fully and three partially. Specifically, three main lessons emerged from the empirical findings. First, GHRM, lean-green practices, and EMS show different levels of direct impact on performance, indicating that GHRM impacts RE most ($\beta = 0.31$), lean-green practices bring non-EMS sustainability benefits ($\beta = 0.33$), and EMS contributes most to ES ($\beta = 0.35$). Second, green organizational culture, green innovation adoption, and employee green involvement mediate these strategy-performance linkages in a partial manner (VAF = 24–41%), showing that operational processes amplify strategic intent without fully consuming its direct impact on performance. Third, firm size and regulatory pressure serve as positive moderators ($\Delta\beta = 0.09 - 0.16$), enabling larger and more heavily regulated firms to convert green strategies into performance outcomes more consistently. The study contributes to the body of knowledge of green management by offering an integrated theoretical structure that unites fragmented fields, distinguishing RE and ES to prevent results from being masked, and setting boundary conditions in the GCC manufacturing sector. For managers, the study highlights the value of following a sequencing strategy whereby smaller or resource-poor firms achieve quick efficiency by engaging in low-cost GHRM actions, while more highly scrutinized firms attain sustainability by using EMS conforming to ISO 14001 coupled with performance goals. The lean-green strategy provides a midpoint way of addressing both efficiency and sustainability. As far as policymakers are concerned, these insights may help through imposing stricter requirements on large manufacturing organizations while aiding smaller ones technologically and financially. The results of the study are subject to the restrictions related to a cross-sectional design, possible common-method bias resulting from surveying only one respondent, the geographic area limited to Dubai and Abu Dhabi, and unexplained variance ($R^2 = 0.52$ for RE, $R^2 = 0.49$ for ES).

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