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Data-Driven Sustainability in Culinary SMEs: Integrating Green HRM, Decision Support, Halal Traceability and Green Operations

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Abstract - *Culinary small and medium-sized enterprises (SMEs) operate at the intersection of volatile demand, perishable inventories, labor-intensive processes, food-safety and halal-integrity requirements, and growing pressure to reduce waste and improve sustainability. Yet the relevant management literature remains fragmented. Digital transformation studies emphasize technology adoption and decision quality; Green Human Resource Management (Green HRM) research emphasizes employee capabilities and green behavior; food-service studies focus on waste prevention and forecasting; halal supply-chain studies focus on integrity and traceability; and supplier-selection research develops multi-criteria tools with limited integration into day-to-day SME decision cycles. This structured integrative review synthesizes recent peer-reviewed research published during 2022–2026 to develop a cross-functional framework for data-driven sustainability in culinary SMEs. Guided by recent good-practice recommendations for management reviews, the paper integrates evidence across digitalization, Green HRM, green operations, food-waste prevention, halal traceability, sustainable supplier selection, dynamic capabilities, and sustainable business performance. The resulting framework conceptualizes three antecedent capabilities—Green HRM capability, digital decision-support capability, and halal supply-chain integrity capability that converge into a closed-loop green operational capability. This operational capability links sensing, decision, implementation, measurement, learning, and reconfiguration, thereby generating economic, environmental, human-organizational, and supply-chain integrity outcomes. Eight research propositions specify direct, mediated, and complementary relationships among the constructs. The paper contributes by shifting the debate from isolated green or digital practices toward an integrated decision architecture suitable for resource-constrained culinary SMEs. It also provides a research agenda for empirical validation and a design logic for future smart-green-halal decision-support systems without presuming that a particular technology has already been validated.*
Keywords: *Green HRM; digital transformation; decision support system; culinary SMEs; halal traceability*

1. INTRODUCTION

Small and medium-sized enterprises are increasingly expected to combine economic resilience with responsible environmental and social performance. For culinary SMEs, however, sustainability is not a peripheral reporting issue. It is embedded in everyday decisions about purchasing, production quantities, menu planning, inventory, supplier reliability, food quality, employee practices, energy and water use, packaging, and the treatment of surplus or discarded food. These decisions are made under conditions that are often more volatile than those of standardized manufacturing: demand can change sharply across events and seasons; raw materials are perishable; production and service are tightly coupled in time; and operational errors can immediately translate into waste, stockouts, customer dissatisfaction, or product-integrity risks. Consequently, the sustainability problem of a culinary SME is simultaneously an information problem, a human-capability problem, an operations problem, and a supply chain governance problem. Recent research on SME digitalization confirms that digital transformation can improve firm performance, but adoption alone does not guarantee value creation. Studies increasingly emphasize that performance depends on organizational readiness, digital skills, process integration, managerial orientation, and the ability to translate data into decisions rather than merely digitizing transactions [1-4]. Evidence also links digitalization to environmental and economic sustainability, especially when digital technologies support information visibility, resource optimization, and learning [5-8]. This distinction is especially important for small firms because resource scarcity can make isolated technology investments costly and difficult to sustain. In culinary businesses, a spreadsheet, point-of-sale system, social-media channel, or accounting package may improve record keeping, yet still leave core questions unresolved: how much to produce, when to reorder, which supplier should be prioritized, where waste emerges, whether critical halal evidence is complete, and whether employees consistently follow sustainability-oriented procedures.

A parallel literature on Green Human Resource Management (Green HRM) has advanced rapidly. Recent studies show that green-oriented HR practices can strengthen green innovation, knowledge sharing, employee behavior, and organizational performance [9-14]. These findings are strategically relevant to culinary SMEs because many sustainability outcomes depend on employees' daily behavior: portioning, storage discipline, waste recording, equipment use, adherence to procurement and production procedures, and compliance with traceability requirements. Nevertheless, much of the Green HRM literature measures attitudes, innovation, or aggregate green performance without specifying how employee capability becomes embedded in operational decision loops.

Food-waste research identifies a complementary problem. Forecasting and operational planning can reduce production-demand mismatch, while food-service studies continue to show that prevention requires interventions upstream of disposal [15-18]. In practice, however, forecasting is only useful when its outputs are connected to ingredient requirements, inventory policies, production plans, and managerial action. A prediction that is not translated into purchasing or production decisions has limited operational value. The same integration challenge appears in the halal supply-chain literature. Recent work highlights digital traceability, blockchain, artificial intelligence, and technology-enabled assurance, but also points to governance, user acceptance, and information-quality requirements [35-39,41]. For halal-sensitive culinary businesses, traceability should therefore connect supplier, ingredient, batch, documentation, validity period, and process-control information rather than function as a passive certificate archive.

Supplier selection further illustrates the fragmentation. Contemporary studies apply multi-criteria decision-making (MCDM) to sustainability-oriented supplier evaluation, combining economic, environmental, quality, and risk considerations [19-23]. These methods can improve transparency, yet they are typically studied as discrete selection problems rather than as components of a continuous operational system that also uses demand, inventory, waste, halal, and employee-performance data.

The central argument of this paper is that the next step for culinary SME sustainability research is not another isolated digital, green, HR, forecasting, traceability, or supplier model. What is needed is an integrative management architecture explaining how these capabilities interact. The paper therefore asks three research questions: (RQ1) Which organizational capabilities connect Green HRM, digital decision support, halal supply-chain integrity, and green operations in culinary SMEs? (RQ2) Through what mechanisms can these capabilities jointly create sustainable business performance? (RQ3) What research agenda can guide the empirical development and validation of a closed-loop smart-green-halal decision architecture?

To answer these questions, this study conducts a structured integrative review of recent peer-reviewed literature and develops a conceptual framework grounded in dynamic-capability logic. The resulting model positions Green HRM capability, digital decision-support capability, and halal supply-chain integrity capability as complementary antecedents of a closed-loop green operational capability. This central capability converts data, human knowledge, and supply-chain evidence into recurrent operating decisions and then uses performance feedback to support organizational learning and reconfiguration. Sustainable performance is conceptualized multidimensionally, covering economic, environmental, human-organizational, and supply-chain/product-integrity outcomes.

The paper makes three contributions. First, it bridges research streams that have matured largely in parallel and identifies the interfaces at which their explanatory power is currently lost. Second, it develops eight testable propositions that move the literature from broad associations toward a process model of capability complementarity and mediation. Third, it translates the conceptual synthesis into an implementable design logic for future decision-support technologies in culinary SMEs. Importantly, the framework does not claim that any specific system has already achieved empirical effectiveness; rather, it specifies what a future system would need to integrate and what evidence should be collected to validate its value.

2. RESEARCH METHODS

2.1 Review Design

This paper adopts a structured integrative-review approach because the research problem cuts across several mature but partially disconnected management domains. Integrative reviews are particularly useful when the objective is not only to summarize a single literature but to combine concepts and findings from different streams in order to build a new conceptual explanation. Recent methodological work in management research stresses that review design should be aligned with the intended contribution, that selection and synthesis decisions should be transparent, and that theory-building reviews should do more than catalogue prior findings [24-26]. The approach is also consistent with process-oriented review guidance emphasizing explicit decisions about scope, search logic, inclusion, synthesis, and contribution [27].

2.2 Literature Scope and Selection Logic

The temporal focus is 2022–2026, which captures the acceleration of research on SME digitalization, data-driven sustainability, Green HRM, digital learning, smart food operations, halal traceability, and sustainability-oriented supplier selection. The review is intentionally structured rather than presented as an exhaustive PRISMA-style systematic review. No claim is made that every eligible Scopus record was retrieved, and no artificial database hit counts are reported. Instead, the synthesis prioritizes peer-reviewed articles from internationally visible journals and recent review or meta-analytic studies that clarify the state of each research stream. This choice is appropriate for an integrative objective because the unit of analysis is the relationship among constructs and mechanisms, not the calculation of a pooled effect size or a comprehensive bibliometric census.

2.3 Analytical Synthesis and Framework Development

The literature was organized around six analytical domains: (1) SME digital transformation and digital decision capability; (2) Green HRM and employee-level sustainability mechanisms; (3) green operations, demand forecasting, and food-waste prevention; (4) halal supply-chain integrity and traceability; (5) sustainable supplier selection and MCDM; and (6) dynamic capabilities and sustainable business performance. During synthesis, each domain was examined using four questions: What problem does the stream explain well? What dependent outcomes does it usually emphasize? Which cross-functional links are underdeveloped? What construct is needed to connect it with the other streams? These questions produced the research-gap matrix in Table 1.

The conceptual integration follows a mechanism-building logic. Digital transformation literature was interpreted through the distinction between technology adoption and decision capability. Green HRM evidence was translated into a capability for creating green competence, motivation, participation, and behavioral consistency. Halal traceability research was translated into a supply-chain integrity capability that combines evidence quality, linkage, monitoring, and alerting. Food-waste, forecasting, and supplier-selection research was used to identify the decision processes through which these antecedent capabilities enter operations. Finally, recent dynamic-capability and sustainability research was used to connect these mechanisms to a recurring sequence of sensing, seizing/deciding, implementing, measuring, learning, and reconfiguring.

This review design also addresses a common weakness in conceptual articles: frameworks can become diagrams of plausible arrows without clear construct boundaries. To avoid that problem, the paper defines each capability according to its organizational function, identifies observable process indicators, and specifies propositions that could be tested using longitudinal or mixed-method designs. The intention is therefore both theoretical and design-oriented: the framework should be precise enough to guide future empirical studies and concrete enough to inform the architecture of a decision-support artifact for culinary SMEs.

3. RESULT AND ANALYSIS

The results of the structured integrative review are presented as a theory-building synthesis rather than as statistical estimates. The analysis proceeds from the dynamic-capability foundation to six recent research streams, identifies cross-stream gaps, develops the integrative SGH-DC framework and SGHC-DSS design logic, and concludes with testable propositions, empirical validation pathways, managerial implications, theoretical contributions, and limitations.

3.1 Theoretical Foundation: Dynamic Capability and Capability Complementarity

The dynamic-capability perspective provides the theoretical backbone for integrating the reviewed domains. Contemporary SME research increasingly uses dynamic capabilities to explain why similar technologies or sustainability initiatives generate heterogeneous outcomes. In volatile environments, performance depends not only on possessing resources but on repeatedly identifying relevant changes, mobilizing responses, and reconfiguring routines. Recent reviews of MSME sustainable performance emphasize that sensing, seizing, learning, and reconfiguration help firms translate environmental turbulence and strategic intent into outcomes [28]. Research on digitalization likewise shows that technology produces value when firms possess the competencies and managerial processes needed to select, absorb, use, and adapt digital tools [1,2].

For culinary SMEs, the dynamic nature of the operating environment is concrete rather than abstract. A catering order changes ingredient requirements; supplier delays alter feasible menu and inventory decisions; a short shelf life constrains replenishment quantities; weather, event scale, or client behavior may change consumption patterns; and deviations in process discipline can affect food waste, quality, or traceability. These signals must be sensed quickly. Yet sensing alone is insufficient. Managers must convert signals into decisions, coordinate employee action, and learn from the consequences. The relevant capability therefore resembles a closed decision loop rather than a one-time innovation project.

The present framework decomposes this loop into five linked activities. Sensing refers to the acquisition of operational, supplier, employee, demand, waste, and integrity information. Deciding refers to the conversion of information into production, purchasing, inventory, supplier, traceability, or resource-use recommendations. Implementing refers to managerial and employee execution through routines and standard operating procedures. Measuring captures both technical and business outcomes. Learning and reconfiguration occur when performance evidence changes forecasting parameters, supplier weights, safety stocks, training priorities, process rules, or other operational configurations.

This logic also introduces capability complementarity. A digital decision-support capability can calculate a reorder point, but employees must record stock accurately and follow the recommendation. Green HRM can create environmental awareness, but employees require information about where waste occurs and what operational decision should change. Halal traceability can record documents, but its business value depends on linking evidence to actual materials, batches, suppliers, and process control points. Supplier MCDM can rank alternatives, but its criteria become more meaningful when they draw on historical delivery, quality, halal, locality, environmental, and cost data. Thus, the capabilities in this framework are theoretically distinct but operationally interdependent.

This complementarity helps explain why many digital or sustainability interventions produce inconsistent results. Digital transformation may increase information availability without changing routines; Green HRM may increase attitudes without changing production decisions; sustainability metrics may be collected without influencing resource allocation; and traceability may function as compliance documentation rather than as a live control mechanism. The proposed model predicts stronger sustainable performance when these capabilities are configured as a mutually reinforcing system.

Sustainable business performance is consequently defined as the firm's ability to maintain economic viability while improving environmental efficiency, human-organizational capability, and supply-chain/product integrity. This multidimensional definition is consistent with recent meta-analytic and review evidence showing that digital transformation and sustainability relationships span economic, environmental, and social outcomes [8,33,34]. For culinary SMEs, product integrity and traceability are added explicitly because they are not adequately captured by conventional triple-bottom-line categories in halal-sensitive operations.

3.2 Synthesis of Recent Research Streams

3.2.1 SME Digitalization: From Adoption to Decision-Support Capability

The recent SME digital-transformation literature is moving away from the assumption that technology adoption is inherently beneficial. Sagala and Őri [1] show that digital-transformation success in SMEs depends on organizational, technological, and environmental conditions rather than on technology acquisition alone. Kallmuenzer et al. [2] similarly identify digital skills, appropriate technologies, culture, and legacy-system constraints as important determinants of adoption and performance. Calderon-Monge and Ribeiro-Soriano [3] demonstrate the breadth of digitalization research in management, while Felicetti et al. [30] highlight how digital innovation in entrepreneurial firms is shaped by strategic and organizational factors. Roffia and Dabić [29] add that integrated information systems and management control can support SME resilience by improving coordination and information visibility.

Sustainability studies sharpen this argument. Ardito [5] links firm digitalization to sustainable innovation performance and shows the relevance of corporate sustainability practices. Hernández et al. [6] find that digital data-driven technologies can contribute to environmental sustainability in micro, small, and medium enterprises, with firm size affecting how those technologies are used. Miranda et al. [7] similarly connect business digitalization with both environmental and economic sustainability, suggesting that digitalization can generate dual rather than purely technological benefits. Haq and Huo [31] emphasize the mediating role of digitalization between strategic orientation and environmental performance. At a broader level, Bindeeba et al. [8] provide meta-analytic evidence that digital transformation has positive associations with multiple dimensions of sustainable business performance.

The gap is that most studies operationalize digitalization at a broad firm level. They explain why organizations adopt digital technologies and whether digitalization relates to performance, but less often specify the recurring decision mechanisms that connect data to operational outcomes. The culinary SME context makes this mechanism critical. Digital capability should not be reduced to software use; it should capture whether the firm can acquire trustworthy data, analyze it, translate analysis into recommendations, embed recommendations in workflows, and learn from outcomes. This paper labels that mechanism digital decision-support capability (DDSC).

DDSC has five dimensions. Data readiness concerns the availability, quality, timeliness, and governance of data. Analytical capability concerns the ability to transform data into forecasts, rules, scores, or indicators. Decision integration concerns whether outputs enter actual production, inventory, purchasing, supplier, or resource-use choices. Interface usability concerns whether managers and employees can understand and act on recommendations. Feedback capability concerns whether realized outcomes are used to refine the models and rules. The distinction between broad digitalization and DDSC explains why a highly digitized SME may still make major operating decisions intuitively.

Decision-support research in SMEs reinforces this process orientation. Gonçalves et al. [32] demonstrate how structured decision-support methods can help SMEs navigate complex digital choices, underscoring the value of process-oriented tools rather than information abundance alone. The implication for culinary SMEs is that decision support must reduce managerial complexity at the point of action. Forecast error, inventory risk, supplier suitability, waste trends, and traceability status need to be presented as actionable signals rather than as disconnected dashboards.

3.2.2 Green HRM: From Green Practices to Operational Capability

Green HRM has become a major mechanism for embedding environmental objectives in organizational behavior. Recent empirical studies show that Green HRM is associated with green innovation, knowledge sharing, employee behavior, and sustainable performance. Makumbe [9] identifies the importance of green innovation and green knowledge sharing in the Green HRM–performance relationship. Zihan and Makhbul [10] show that green innovation can transmit the influence of Green HRM to sustainable performance. Alshuaibi et al. [11] extend the discussion to digital learning and big-data analytics, demonstrating that green HR practices can interact with digital capabilities rather than operating independently. Azam and Jamil [12] position Green HRM and green innovation as mechanisms linking corporate responsibility to green performance in SMEs. Lawter and Garnjost [13] synthesize the broader evidence on Green HRM and organizational performance, while Bindeeba et al. [14] provide meta-analytic evidence on Green HRM and green innovation.

These studies support a shift from treating Green HRM as a checklist of HR policies toward conceptualizing it as a Green HRM capability (GHRMC). GHRMC is the organizational ability to create and maintain employee competence, motivation, opportunity to participate, and procedural discipline for sustainability-oriented work. In culinary SMEs, this capability can be observed through training on waste prevention and traceability, employee participation in process improvement, green performance indicators, reinforcement of storage and portioning standards, reporting accuracy, and adherence to standard operating procedures.

The key integration problem is that employee behavior is typically studied separately from operational analytics. A firm may train employees to reduce waste but fail to provide timely waste data by menu, batch, or production event. Conversely, a digital system may identify abnormal waste, but employees may lack the competence or incentives to respond. The proposed framework therefore treats GHRMC and DDSC as complements. DDSC increases the specificity of the information available to employees and managers; GHRMC increases the likelihood that this information is acted upon consistently.

This complementarity also applies to data quality. In small businesses, much of the operational dataset is created by employees: receiving quantities, production yields, waste weights, supplier issues, corrective actions, and traceability evidence. If data capture is perceived as administrative burden, the analytical layer becomes unreliable. Green HRM thus supports not only pro-environmental behavior but also the human infrastructure of data-driven sustainability.

3.2.3 Green Operations, Forecasting, and Food-Waste Prevention

Food waste is a visible expression of misalignment among demand, procurement, inventory, production, and consumption. Recent forecasting research offers strong evidence that better demand estimation can reduce this misalignment. Rodrigues et al. [15] demonstrate the relevance of machine-learning models for short-term demand forecasting in catering services as a mechanism for reducing food waste. Hübner et al. [16] extend the analysis by considering life-cycle environmental impacts and benefits of machine-learning-based forecasting in a bakery context. These studies are important because they connect analytical accuracy with environmental consequences rather than treating forecasting as a purely statistical exercise.

At the food-service level, Guimarães et al. [17] synthesize evidence on plate food waste and emphasize the persistence of waste across food-service settings. Mutanda [18] reviews waste-management strategies and barriers in hospitality, reinforcing the conclusion that effective intervention must combine organizational, behavioral, and operational responses. The implication is that food-waste prevention requires multiple linked decisions: estimate demand, plan production, determine ingredient needs, set inventory parameters, monitor yield, record leftovers or disposal, and interpret the variance.

This paper therefore defines green operational capability (GOC) as the firm's ability to convert sustainability-relevant information into repeatable operating decisions that reduce resource loss while protecting service quality and reliability. GOC is broader than food-waste management. It includes production planning, inventory control, supplier choice, process yield, resource intensity, reusable packaging where relevant, and adherence to operating standards. Food waste is nevertheless a strategically useful indicator because it reflects upstream decision quality.

A crucial design principle follows: analytics should be evaluated by decision consequences, not by predictive accuracy alone. A forecasting model with a lower mean absolute error is valuable only if it changes production quantities in a way that reduces waste without creating stockouts or service failures. Similarly, a reorder recommendation should be evaluated against stock availability, spoilage, working capital, and shelf-life constraints. This decision-consequence perspective is central to the proposed closed-loop architecture.

3.2.4 Halal Traceability as a Supply-Chain Integrity Capability

Halal supply-chain research increasingly emphasizes sustainability, operations, and digital traceability. Kurniawati and Cakravastia [35] identify the growing intersection of halal supply-chain research with sustainability and operations-research perspectives. Harsanto et al. [36] review the role of digital technology 4.0 in halal supply chains, showing the expansion of traceability technologies and digital infrastructure. Bachtiar and Masruroh [37] propose a sustainable traceability framework in meat processing, demonstrating that traceability must be designed as an end-to-end process rather than as a static information repository.

Emerging technologies further expand the possibilities. Nawaz et al. [38] review artificial intelligence for halal authentication and traceability. Khan et al. [39] develop a framework for AI and blockchain implementation in halal food supply chains, highlighting the relationship between technological innovation and religious-compliance requirements. Earlier recent empirical work by Hendayani and Fernando [40] also points to the importance of digitalization in halal supply-chain management, while Susanty et al. [41] show that user acceptance of halal traceability systems depends on system quality, information quality, trust, and expected performance.

These findings motivate the construct halal supply-chain integrity capability (HSCIC): the organizational ability to establish reliable linkage among suppliers, ingredients, batches, documentary evidence, validity status, process-control points, and corrective actions. HSCIC differs from digital traceability technology itself. A barcode, QR code, blockchain record, or database is an enabling mechanism; integrity capability exists when the firm can use the information to prevent, detect, and respond to integrity risks.

For culinary SMEs, HSCIC has both compliance and operational value. Supplier-document validity can become a supplier-selection criterion; ingredient-batch data can support recall or investigation; alerts can prevent the use of incomplete or expired evidence; and traceability status can be incorporated into managerial dashboards. Because these businesses often operate with limited administrative staff, the framework emphasizes proportionality: traceability should capture critical data with minimal duplicate entry and should connect to existing purchasing and inventory workflows.

3.2.5 Sustainable Supplier Selection and Multi-Criteria Decision Support

Supplier decisions illustrate why sustainability management is inherently multi-criteria. Price cannot be separated from quality, lead time, availability, reliability, environmental practice, locality, and product-integrity requirements. Recent reviews and applications continue to develop MCDM as a transparent approach for sustainable supplier evaluation. Tronnebati et al. [19] synthesize MCDM, mathematical-programming, and artificial-intelligence approaches to green supplier evaluation. Saputro et al. [20] integrate fuzzy MCDM techniques to address green supplier selection under supply risks. Cui et al. [21] show that vendor sustainability performance can influence corporate customer supplier selection. Štreimikienė et al. [22] review MCDM approaches for sustainable supplier selection, while Masudin et al. [23] combine ANP and TOPSIS for sustainable raw-material supplier selection.

For small firms, the managerial challenge is not to maximize methodological sophistication but to achieve transparent, explainable, and maintainable decisions. An overly complex model can fail if managers do not trust the weights or cannot update the criteria. Accordingly, the proposed architecture treats supplier scoring as a configurable decision service. Criteria and weights should be co-defined with users, sensitivity-tested, and connected to live evidence where possible. Supplier delivery performance, defect history, halal-document status, price changes, and environmental indicators can then update the recommendation over time.

The integration with inventory and forecasting is particularly important. A supplier with the lowest unit price may be unattractive if long lead time requires higher safety stock for perishable materials. A nearby supplier may reduce lead time and inventory exposure but offer a different cost or quality profile. A supplier with strong delivery reliability but incomplete integrity evidence may be unacceptable for a critical ingredient. These trade-offs cannot be managed effectively when supplier, inventory, forecasting, and traceability data are isolated.

3.2.6 Sustainable Performance and SME Resilience

Recent sustainability literature increasingly emphasizes multidimensional outcomes and resilience. Zaman et al. [33] show that sustainability in SMEs is interpreted through economic, environmental, and social dimensions but remains context-dependent. Florez-Jimenez et al. [34] connect sustainability with organizational resilience and purpose, highlighting the importance of long-term organizational capacity rather than short-term environmental projects. Castellani et al. [42] show that SMEs can advance sustainability goals through strategically selected partnerships, reinforcing the role of external relationships in resource-constrained firms. At the same time, digitalization research demonstrates that integrated information and control can support resilience [29].

These findings support a performance construct that is broader than environmental impact. A culinary SME cannot be considered sustainable if food waste declines while service reliability deteriorates or operating margins become unsustainable. Nor is economic performance sufficient if traceability risk, employee capability, or resource inefficiency worsens. The proposed model therefore evaluates sustainable business performance across four domains: economic, environmental, human-organizational, and supply-chain/product integrity. These outcomes are expected to reinforce one another over time when the firm has an effective learning loop.

3.3 Research Gaps and Integrative Framework

The synthesis reveals a consistent pattern: each research stream explains a necessary part of sustainable SME management, but the interfaces among streams remain underdeveloped. Table 1 summarizes the resulting gap structure. The central gap is not the absence of digital technologies, Green HRM practices, forecasting algorithms, traceability tools, or MCDM methods. It is the absence of a theoretically coherent account of how they can function as a recurrent managerial system in which people, data, decisions, operations, and performance feedback are connected.

The proposed Smart Green Halal Decision Capability (SGH-DC) framework addresses this gap. The term “smart” refers to the disciplined use of data and analytical decision support rather than to any specific artificial-intelligence technology. “Green” refers to the integration of waste prevention and resource efficiency into operating decisions. “Halal” refers to supply-chain and process integrity supported by traceable evidence. “Decision capability” emphasizes that the unit of analysis is an organizational capability, not a software application.

The framework includes three antecedent capabilities. Green HRM capability (GHRMC) provides the human foundation: competence, participation, knowledge sharing, motivation, and procedural consistency. Digital decision-support capability (DDSC) provides the informational foundation: data quality, analytics, actionable recommendations, usable interfaces, and feedback. Halal supply-chain integrity capability (HSCIC) provides the evidence and governance foundation for supplier, ingredient, batch, documentation, and critical-control linkages.

These antecedents converge in closed-loop green operational capability (GOC). GOC is where the organization combines information, human judgment, and process rules to make recurring decisions about production, inventory, suppliers, waste, and resource use. It is “closed loop” because measured outcomes return to the system as learning signals. For example, forecast error should influence the next forecasting configuration; recurring waste on a menu should trigger portion or production review; supplier delays should alter reliability scores; traceability exceptions should trigger corrective action; and repeated deviations from operating procedures should influence training or performance-management priorities.

The right side of the framework is sustainable business performance (SBP). Four outcome families are proposed. Economic outcomes include food-cost variance, inventory efficiency, fulfillment, margin, and repeat business. Environmental outcomes include food waste, material yield, resource intensity, and packaging-related measures where data are available. Human-organizational outcomes include training completion, standard-operating-procedure compliance, participation, data discipline, and green behavior. Supply-chain/product-integrity outcomes include supplier reliability, traceability completeness, document validity, exception resolution, and critical-control compliance.

The feedback arrow from SBP to the operational layer is theoretically important. Without feedback, the model becomes a linear input-output framework. With feedback, performance measures become mechanisms of sensing and learning. The organization can reconfigure models, supplier weights, reorder parameters, process rules, and training priorities. This is the mechanism through which a small firm can gradually accumulate a data-driven sustainability capability despite limited resources. The complete capability structure and feedback mechanism are summarized in Figure 1.

Table 1. Research-gap matrix and integrative response

Research stream	What recent literature explains well	Persistent gap	Integrative response in this study
SME digital transformation	Explains adoption, digital skills, organizational readiness, integration, and links with firm/sustainability performance.	Often uses broad digitalization constructs; weak visibility of the recurring mechanism from data to operational decision and learning.	Digital decision-support capability (DDSC): data readiness -> analytics -> actionable recommendation -> workflow -> feedback.
Green HRM	Explains green competence, innovation, knowledge sharing, behavior, and sustainable/green performance.	Employee-level mechanisms are rarely connected to operational data quality, forecasting, inventory, waste, or traceability decisions.	Green HRM capability (GHRMC) as human infrastructure for reliable data capture, procedural execution, and improvement.

Research stream	What recent literature explains well	Persistent gap	Integrative response in this study
Food waste and forecasting	Shows value of waste prevention and better demand estimation in food-service contexts.	Forecast accuracy is often disconnected from purchasing, inventory, production, and service-level consequences.	Decision-consequence logic linking forecasts to production, material requirements, inventory, and measured waste outcomes.
Halal traceability	Develops digital traceability, AI/blockchain applications, integrity, and user-acceptance perspectives.	Traceability may remain a compliance repository rather than an active input into procurement and production decisions.	Halal supply-chain integrity capability (HSCIC) linking supplier, ingredient, batch, evidence, validity, control points, and alerts.
Sustainable supplier selection	Provides MCDM methods combining cost, quality, risk, environmental, and other criteria.	Often treated as a discrete ranking exercise with limited connection to live lead-time, inventory, traceability, and performance data.	Configurable supplier decision service embedded in a closed operational loop; criteria and weights update with evidence.
Sustainable SME performance	Recognizes economic, environmental, and social outcomes and the importance of resilience.	Performance frequently appears as a terminal dependent variable rather than a feedback signal for organizational learning.	Multidimensional SBP used as feedback for reconfiguring forecasts, supplier weights, inventory rules, training, and SOPs.
Cross-domain integration	Individual streams provide mature constructs and methods.	No parsimonious capability model explains how people, data, halal integrity, green operations, and feedback operate together in culinary SMEs.	Smart Green Halal Decision Capability framework centered on a closed-loop green operational capability.

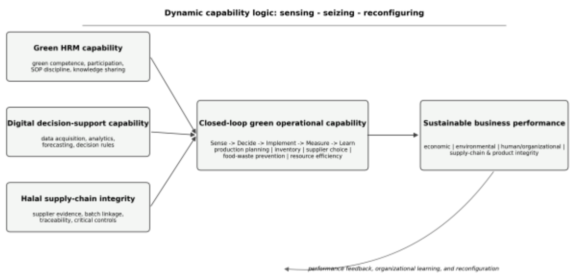

Figure 1. Smart Green Halal Decision Capability (SGH-DC) conceptual framework

Note. The framework is conceptual. It specifies capability relationships to be tested empirically; it does not claim prior validation of a particular SGHC-DSS implementation.

3.4 Translating the Framework into an SGHC-DSS Design Artifact

To demonstrate how the conceptual capability model can be translated into a design-oriented research artifact, Figure 2 presents an illustrative UI/UX mockup of the Smart Green Halal Catering Decision Support System (SGHC-DSS). The mockup operationalizes the framework through eight connected functional groups: a main decision dashboard; demand forecasting and production planning; inventory and reorder-point monitoring; multi-criteria supplier scoring; halal traceability; green operations and food-waste monitoring; a sustainability and Green HRM dashboard; and reporting and analytics, complemented by a mobile summary interface. The design is intentionally modular because the theoretical framework treats digital tools as enabling mechanisms for organizational capabilities rather than as the capabilities themselves.

The interface architecture mirrors the closed-loop logic developed in Figure 1. Demand information is translated into forecast and production recommendations; production requirements inform material and inventory decisions; supplier evaluation combines cost, quality, lead-time, sustainability, and integrity evidence; halal data link suppliers, ingredients, batches, and documentary status; actual production generates waste and resource-efficiency indicators; and sustainability, human-resource, and business outcomes return to the dashboard as feedback for subsequent decisions. This translation is consistent with the reviewed evidence that sustainability value depends on connecting forecasting with operational consequences [15-18], supplier evaluation with transparent multi-criteria decision support [19-23], and traceability with active supply-chain integrity and user-oriented information [35-41]. Accordingly, Figure 2 should be read as a design proposition derived from the integrative review, not as evidence that a fully deployed SGHC-DSS has already been empirically validated.

Figure 2. Illustrative SGHC-DSS UI/UX mockup translating the conceptual framework into an integrated decision-support artifact.

Note. The UI/UX image is an author-developed conceptual design from the underlying SGHC-DSS research program. It is included to illustrate design logic and functional integration; it is not presented as an empirically validated software product.

3.5 Research Propositions

The integrative framework yields eight propositions. These propositions are deliberately stated at the capability level so that they can be operationalized using multiple technologies and contexts. They also separate direct effects from mediation and complementarity, making the framework falsifiable rather than merely descriptive.

Green HRM capability should directly strengthen green operational capability because trained, motivated, and involved employees are more likely to follow waste-prevention routines, record data accurately, comply with operating procedures, and participate in improvement. This mechanism is consistent with recent evidence linking Green HRM to green innovation, knowledge sharing, and sustainable performance [9,10,13].

Digital decision-support capability should strengthen green operational capability because it improves the timeliness, consistency, and analytical basis of production, inventory, supplier, and resource decisions. The relationship is not expected to depend on a specific algorithm; rather, it depends on whether data are converted into usable recommendations and embedded in workflows. Recent digitalization and sustainability studies support the broader association between data-driven technology and sustainability outcomes [5-8].

The interaction of GHRMC and DDSC should be especially important. High-quality recommendations have limited value if employees do not trust, understand, record, or act on them. Likewise, green-oriented employees have limited analytical leverage when information is fragmented. Alshuaibi et al. [11] provide empirical support for a related complementarity among Green HRM, digital learning, big-data analytics, and green innovation. The framework therefore predicts a positive complementarity effect.

Halal supply-chain integrity capability should strengthen green operational capability by improving the quality of supplier and material information used in purchasing, receiving, storage, and production. Traceability completeness can prevent operational disruptions, reduce uncertainty, and make integrity constraints explicit in supplier and inventory decisions. It should also have a direct relationship with the supply-chain/product-integrity dimension of sustainable performance.

Green operational capability is expected to mediate the effects of GHRMC and DDSC on sustainable business performance. This proposition reflects a central theoretical claim: organizations create value not by possessing green or digital capabilities in isolation but by using them to change recurrent operating decisions.

Forecasting, for example, affects sustainability only when it changes production or purchasing. Green training affects waste only when it changes behavior in specific processes.

HSCIC should also influence sustainable performance partly through operational reliability. Integrating integrity evidence with supplier and production decisions can reduce exception risk, improve corrective-action speed, and strengthen transparency. Finally, the strongest performance is expected when all three antecedent capabilities are jointly configured in a closed loop. This systemic proposition differentiates the framework from additive models in which each capability is treated as an independent predictor.

Table 2. Research propositions derived from the integrative framework

ID	Relationship	Theoretical rationale	Expected implication
P1	GHRMC -> GOC	Green competence, participation, knowledge sharing, and procedural discipline improve the quality and consistency of waste-prevention and resource-efficiency routines.	Higher operational adherence, data reliability, and continuous-improvement participation.
P2	DDSC -> GOC	Reliable data, analytics, explainable recommendations, and workflow integration improve production, inventory, supplier, and resource decisions.	Lower decision latency and greater consistency of operational choices.
P3	GHRMC x DDSC -> GOC	Human capability and digital decision support are complementary: recommendations require trusted execution, while green-oriented employees gain leverage from timely decision information.	The joint configuration produces stronger operational capability than either capability alone.
P4	HSCIC -> GOC	Supplier, ingredient, batch, documentary, and control-point evidence reduces uncertainty in purchasing, receiving, storage, and production.	Fewer integrity exceptions and more reliable procurement/production decisions.
P5	GOC -> SBP	Closed-loop green operations reduce avoidable resource loss while maintaining service reliability and creating organizational learning.	Improved economic, environmental, human-organizational, and integrity outcomes.
P6	GHRMC -> GOC -> SBP	The effect of Green HRM on sustainable performance is partly realized through changes in recurring operational behavior and decisions.	GOC mediates the relationship between Green HRM capability and SBP.
P7	DDSC -> GOC -> SBP	Digitalization creates sustainability value when analytical information changes operational decisions rather than remaining informational.	GOC mediates the relationship between digital decision-support capability and SBP.

ID	Relationship	Theoretical rationale	Expected implication
P8	System complementarity	A closed-loop configuration of GHRMC, DDSC, and HSCIC creates mutually reinforcing information, behavior, governance, and learning mechanisms.	Integrated capability configurations outperform isolated initiatives, especially under demand and supply uncertainty.

3.6 Research Agenda and Empirical Validation Pathways

The framework opens several empirical research opportunities. A first priority is construct development. Existing scales for digital transformation, Green HRM, traceability adoption, and sustainable performance provide useful foundations, but they do not directly measure closed-loop decision capability. Future research should therefore operationalize DDSC, HSCIC, and GOC using both perceptual and process indicators. DDSC items could capture data reliability, analytical use, recommendation integration, interface usability, and feedback. HSCIC could capture linkage completeness, document validity monitoring, batch visibility, exception handling, and critical-control integration. GOC could capture the extent to which forecasting, inventory, supplier, waste, and resource information routinely changes operating decisions.

A second priority is longitudinal design. Cross-sectional surveys are useful for construct validation but cannot demonstrate whether capability development precedes operational improvement. Culinary operations produce naturally time-indexed data, making before-after and interrupted time-series designs feasible. Researchers could establish a baseline period, implement a decision-support intervention, and compare forecast error, stockouts, waste intensity, food-cost variance, traceability exceptions, and user behavior across matched operational periods. Where randomized trials are impractical, quasi-experimental designs can improve causal inference by using comparable menus, event types, production units, or time windows.

A third research direction concerns algorithm-to-action translation. Forecasting studies often compare models using MAE, RMSE, or MAPE, yet future work should test whether the statistically best model generates the best operational outcome under shelf-life, service-level, and procurement constraints. Similar reasoning applies to supplier MCDM. A ranking model should be evaluated not only by consistency of weights but by subsequent delivery reliability, quality, inventory exposure, integrity status, and total cost. Decision-support research should therefore combine technical accuracy with operational utility.

A fourth priority is human-system interaction. User acceptance is a recognized issue in traceability and digital-system research [41], but culinary SME studies should go further by examining trust in recommendations, perceived explainability, data-entry burden, and the role of employee participation in system design. Green HRM may moderate technology effectiveness because employees who understand the environmental purpose of data collection may be more willing to maintain accurate records. Conversely, poor interface design or excessive data-entry requirements may erode both adoption and data quality.

A fifth direction involves proportional instrumentation. Internet-of-Things sensing is attractive, but small firms should not instrument every process merely because sensors are available. Future research should compare low-cost manual, semi-automated, and sensor-based data-acquisition strategies according to reliability, implementation cost, maintenance burden, and decision value. The relevant question is not “Can this variable be sensed?” but “Does sensing it materially improve a recurring decision?” Such a value-of-information perspective is especially important for resource-constrained SMEs.

A sixth direction is the integration of halal and sustainability criteria. Research frequently treats halal assurance and green supply-chain management as parallel governance systems. Future studies can examine whether shared data structures—supplier identity, batch data, document validity, locality, quality history, and environmental information—allow SMEs to reduce administrative duplication while improving both integrity and sustainability. Supplier MCDM offers a practical experimental setting because halal status, environmental performance, cost, lead time, and reliability can be evaluated simultaneously.

A seventh priority is commercial and organizational scalability. A prototype that works in one catering operation may not automatically generalize to restaurants, bakeries, institutional food services, or other catering firms. Research should identify configuration parameters that allow the same decision architecture to adapt to different menu structures, order patterns, traceability requirements, staffing arrangements, and data maturity levels. Modular architectures may be preferable to monolithic systems because SMEs can adopt only the functions that solve immediate problems and add modules as capability matures.

Finally, future research should evaluate economic value alongside sustainability outcomes. Digital and green interventions require investment in development, devices, training, data collection, and change management. Cost-benefit analysis, unit economics, willingness-to-pay, and business-model validation are therefore legitimate research outcomes rather than afterthoughts. A decision-support artifact that produces environmental benefits but cannot be maintained financially is unlikely to diffuse among SMEs. Conversely, a system that can demonstrate simultaneous savings from waste reduction, lower stockouts, faster decisions, and stronger integrity assurance may create a credible commercialization path.

A feasible empirical program can be organized into three stages. Stage 1 would validate constructs and establish baseline process maps and data quality. Stage 2 would develop and pilot an integrated decision-support artifact using participatory co-design, then evaluate usability and before-after operational effects. Stage 3 would test transferability across additional users, analyze economic feasibility and willingness-to-pay, and examine whether the capability relationships remain stable across firm size and digital maturity. This sequence aligns theoretical validation with technology development while maintaining a clear distinction between conceptual claims and demonstrated empirical evidence.

3.7 Managerial and Policy Implications

For managers, the framework suggests beginning digital sustainability programs with decision problems rather than with software features. The first diagnostic question should be which recurring decisions create the largest combination of cost, waste, integrity risk, or service failure. In many culinary SMEs, these will include production quantity, purchasing timing, reorder levels, supplier choice, and the handling of high-risk or highly perishable materials. Once decisions are prioritized, managers can identify the minimum data needed, define acceptable data quality, specify who acts on recommendations, and select indicators that show whether the decision improved.

The framework also recommends integrating people and data from the outset. Employee training should not be designed as a generic environmental-awareness program. It should be connected to the exact data and routines needed for operational improvement—for example, consistent waste weighing, accurate stock recording, first-expired-first-out discipline, supplier exception reporting, or traceability checks. In the same way, dashboards should not display metrics that employees cannot influence. Green HRM and digital decision support are most effective when each reinforces the other.

For halal-sensitive firms, the framework recommends treating traceability as a decision asset. Supplier-document status, ingredient-batch linkage, and critical-control information should be available at purchasing, receiving, production, and audit points. This reduces the risk that traceability becomes an administrative archive that is updated only before inspection. Integrating traceability with supplier evaluation also allows integrity requirements to influence procurement before a problem occurs.

For policy makers, industry associations, and SME-support institutions, the model implies that digital-transformation assistance should move beyond subsidizing software acquisition. Capacity-building programs should combine data readiness, operational analytics, human capability, traceability governance, and economic evaluation. Shared templates for process mapping, data dictionaries, waste metrics, supplier criteria, and traceability evidence could reduce implementation cost for small firms. Demonstration projects should report not only that a technology was installed but also whether decision speed, stockouts, waste, integrity completeness, user acceptance, and economic value improved.

3.8 Theoretical Contributions

This paper contributes to management research in four ways. First, it reframes the relationship between digital transformation and sustainability at the level of decision capability. Recent research has established that digitalization can support environmental and economic outcomes, but broad digitalization constructs do not reveal how data alter specific recurrent decisions. By introducing DDSC, the framework locates value creation in the conversion of operational data into actionable and learnable decisions.

Second, the framework extends Green HRM research from employee-centered outcomes to an operational interface. The literature has convincingly connected Green HRM with green innovation, knowledge sharing, behavior, and performance. The present model argues that one important pathway is operational: Green HRM improves the human reliability of data capture, procedure execution, and improvement participation. This pathway is particularly salient in SMEs where the same employees often generate operational data and execute the decisions derived from those data.

Third, the paper integrates halal supply-chain integrity into the sustainability capability discussion. Halal traceability research has advanced technologically, but its connection with mainstream sustainable-operations and SME management theory remains limited. HSCIC treats traceability as a managerial capability that can improve supplier decisions, material control, corrective action, and transparency. This moves halal assurance from a compliance silo into a broader decision architecture while preserving the distinct integrity requirements of halal operations.

Fourth, the study develops a closed-loop capability model. The feedback mechanism from performance to sensing and reconfiguration differentiates the framework from linear input-output models. Sustainability metrics are not treated as terminal reporting indicators; they become learning signals that can change model parameters, process rules, supplier preferences, and training priorities. This closed-loop logic is consistent with dynamic-capability theory and offers a stronger explanation of how small firms can build cumulative sustainability capability over time.

3.9 Limitations

The paper has limitations that also define the boundaries of its claims. First, this is a structured integrative review rather than an exhaustive systematic review or meta-analysis. The framework is therefore a theory-building synthesis and should not be interpreted as estimating universal effect sizes. Second, the culinary SME context increases managerial relevance but may limit generalization to sectors with long product life cycles, highly automated production, or different regulatory regimes. Third, the model treats halal supply-chain integrity as a capability because the intended application concerns halal-sensitive food businesses; other contexts may require different product-integrity constructs. Fourth, several relationships are likely contingent on digital maturity, firm size, data quality, environmental uncertainty, and management commitment. These moderators are not fully specified in the core model in order to preserve parsimony. Finally, the framework does not validate a particular software platform, algorithm, sensor configuration, or commercialization model. Those claims require subsequent design, pilot, user, and market evidence.

4. CONCLUSION

Culinary SME sustainability is a cross-functional decision problem. Demand uncertainty, perishability, food waste, supplier trade-offs, employee behavior, digital data, and halal integrity cannot be managed effectively as independent initiatives. The recent literature provides strong but fragmented building blocks: digitalization can support sustainable performance; Green HRM can shape green innovation and behavior; forecasting can reduce production-demand mismatch; traceability technologies can strengthen supply-chain visibility; and MCDM can structure supplier choice. The missing element is an architecture that explains how these building blocks interact in everyday management.

This study proposes the Smart Green Halal Decision Capability framework as that integrative architecture. Green HRM capability, digital decision-support capability, and halal supply-chain integrity capability converge in a closed-loop green operational capability that connects sensing, deciding, implementation, measurement, learning, and reconfiguration. Sustainable performance emerges when this loop improves economic, environmental, human-organizational, and supply-chain/product-integrity outcomes together.

The framework offers a testable theory and a practical design logic. It suggests that future smart-green-halal decision-support systems should be judged not by the number of modules or technologies they contain, but by whether they improve recurring managerial decisions and create measurable, learnable benefits. That distinction is essential for responsible research downstreaming: technological novelty becomes meaningful only when it is converted into validated operational capability, accepted by users, economically feasible, and capable of generating sustainable business value.

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