Building Resilient Green Value Chain: A Hierarchical Model for Thai Food Industry Sustainable Transformation

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Abstract

This study presents an innovative hierarchical model for implementing sustainable green management strategies in Thailand's food industry SMEs. The research employs a novel methodological approach combining Ethnographic Delphi Futures Research (EDFR) with Analytic Hierarchy Process (AHP), uniquely integrating participatory stakeholder engagement with rigorous quantitative prioritization. This sequential mixed-methods design produces contextually rich yet quantitatively robust findings, addressing limitations of conventional sustainability research that treats success factors independently. Data were collected from 17 key informants representing government, academia, industry, and consumers across three phases. The findings reveal six interconnected strategic components: Sustainable Leadership (38.6%), Green Networks (17.5%), Sustainable Supply Chain Management (16.2%), Corporate Social Responsibility (13.2%), Government Support (7.6%), and Innovation and Digital Technology (6.8%). Critically, these components function as an interconnected system with reinforcing relationships rather than independent factors, explaining why isolated sustainability initiatives often fail. The model advances theoretical understanding by demonstrating leadership and cultural factors' primacy over technical approaches, while providing actionable implementation guidance. Organizations should follow a phased transformation emphasizing leadership commitment before technical investments. For policymakers, findings recommend reorienting support mechanisms toward: 1) sustainability leadership training programs for SME executives, 2) collaborative network facilitation among food SMEs and suppliers, and 3) integrated support packages addressing cultural transformation alongside technical assistance. This approach directly supports Thailand 4.0 objectives to ensure national economic transformation reaches all enterprise scales.

Keywords: Green Value Chain, Sustainability, Thai Food Industry, SMEs, Hierarchical Model, AHP, Sustainable Leadership, BCG Economy, Green Networks, Ethnographic Delphi Futures Research (EDFR)

Introduction

The global food system faces increasing challenges in balancing growing demand with sustainability. This is especially evident in Southeast Asia due to rapid development and climate vulnerability (ASEAN Secretariat, 2021). Thailand's food industry is economically vital (Food Intelligence Center, 2023) yet environmentally impactful (Janchaipoom, 2024), with SMEs struggling to implement sustainable practices due to limited resources and knowledge (Durrani et al., 2024). This study reflects an emerging economy context where basic sustainability infrastructure and awareness are still being established, while the European study indicates a mature economy context where foundational elements exist but complex value chain coordination becomes the primary challenge for circular economy implementation (Durrani et al., 2024).

While sustainability's importance is recognized, research has predominantly focused on large enterprises or specific environmental practices, leaving a gap in comprehensive models for SME sustainability transformation. This study addresses this gap by developing a hierarchical model for green value chain transformation in Thai food SMEs. This model incorporates principles from the BCG (Bio-Circular-Green) Economy Model—Thailand's official policy framework specifically designed to guide sustainable economic transformation—ensuring that SME sustainability initiatives directly support Thailand 4.0 objectives while enabling access to government programs and participation in national value chains. It contributes by: 1) identifying and prioritizing key strategic

components, 2) exploring how these components interact to create synergistic effects within food value chain, and 3) examining stakeholder perspectives on sustainability priorities.

Using an innovative mixed-methods approach, this research provides both theoretical insights and practical guidance for building sustainable food value chain in Thailand and similar economies, supporting Thailand's aspirations as a food innovation hub while addressing environmental challenges and UN Sustainable Development Goals, in particular Goal 13 Climate Action.

In SMEs, with their more personalized structures, leadership commitment has profound effects. Abdul-Azeez et al. (2024) demonstrates that transformational leadership in SMEs contributes to business success through improved financial performance, enhanced market competitiveness, and sustainable growth strategies. The study conducted in Pakistani SMEs revealed that "green transformational leadership had a significant impact on green organizational identity, which cultivated green creativity" (Al-Ghazali et al., 2022). Saenchaiyathon and Wongthongchai (2021) found that green operation strategies significantly improve organizational efficiency and environmental performance among 250 Thai agricultural SMEs, recommending enhanced environmental awareness and green mindset development for competitive advantage.

While research has advanced our understanding of sustainability in Southeast Asian food industries, gaps remain in how sustainability components interact within SMEs and how stakeholders prioritize these elements. This study addresses these gaps through an innovative methodology detailed next.

This research contributes to sustainability transformation scholarship by integrating leadership, network, and policy dimensions into a context-specific hierarchical model for food SMEs in emerging economies.

Methods and Materials

Research Design Innovation in Sustainability Studies

This research uses an innovative sequential mixed-methods design combining ethnographic techniques, expert consensus building, and Analytic Hierarchy Process (AHP). Unlike previous studies using either qualitative or quantitative approaches alone, this integrated methodology provides both contextual understanding and systematic prioritization.

AHP was selected over alternatives like Fuzzy AHP for several reasons:

Participant Accessibility: The standard 1-9 comparison scale is intuitive for diverse stakeholders (government, academia, industry, consumers) without requiring extensive technical training that fuzzy methods would demand.

Clear Interpretability: AHP produces precise numerical weights that practitioners and policymakers can easily understand and apply, aligning with this study's goal of providing actionable guidance to Thai food SMEs.

AHP Weight Interpretation: The final weights represent the relative importance each component contributes to overall sustainability transformation. The percentages indicate how decision-makers should allocate attention and resources—components with higher weights deserve proportionally greater focus in implementation strategies.

Established Validation: AHP has extensive validation in sustainability research with proven quality control through consistency ratios ($CR < 0.1$), providing a solid methodological foundation.

Implementation Practicality: The crisp priorities generated by AHP better suit policy development needs, where decision-makers require definitive resource allocation guidance rather than uncertainty ranges that fuzzy approaches might produce.

While Fuzzy AHP could handle judgment uncertainty more sophisticatedly, the increased complexity did not justify the benefits for this study's objectives and participant profile.

Consistency Ratio Calculation: AHP requires participants to make pairwise comparisons that should be logically consistent. For example, if Component A is twice as important as Component B, and Component B is three times as important as Component C, then Component A should be six times as important as Component C. The Consistency Ratio (CR) measures how well participants maintain this logical consistency across all comparisons.

Data consistency must be verified through the Consistency Ratio (C.R.) to determine its acceptability.

Consistency Ratio Formula: C.R. = C.I./R.I.

Where:

C.R. = Consistency Ratio of strategic drivers for green business management in Thai food SMEs toward sustainability

C.I. = Consistency Index of strategic drivers for green business management in Thai food SMEs toward sustainability

R.I. = Random Index from sampling of strategic drivers for green business management in Thai food SMEs toward sustainability

To calculate the Consistency Ratio (C.R.), the C.I. result must be compared with the R.I. value obtained from random sampling of numerous matrix tables, as follows:

Table 1 Random Index (R.I.) Values from Sampling

Matrix Size	1	2	3	4	5	6	7	8	9
Sampled R.I. Value	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Source: Tansirikongkol (1999)

The Consistency Ratio (C.R.) should not exceed 10% for judgments involving more than 5 criteria, should not exceed 9% for 4 criteria, and should not exceed 5% for 3 criteria. If the consistency value is higher than acceptable, pairwise comparisons must be re-analyzed. The symbols used in this study are as follows:

Symbols:

A = Numbers obtained from pairwise importance comparisons of green business management strategies for Thai food SMEs toward sustainability

B = Eigenvector calculation of green business management strategies for Thai food SMEs toward sustainability

C = Matrix product of green business management strategies for Thai food SMEs toward sustainability

D = Vector calculation of green business management strategies for Thai food SMEs toward sustainability

a1 – a5 = Comparative scores between criteria in rows 1-5 compared with criteria in columns 1-5

An example calculation can be demonstrated as follows:

Table 2 An Example Calculation

	Strategy Component	1	2	3	4	5			Eigenvector Value		Matrix Product
A	1	1	a_2	a_3	a_4	a_5	X	B	B1	C	C1
	2	$1/a_2$	1	$1/a_2$	$1/a_4$	$1/a_4$			B2		C2
	3	$1/a_3$	a_2	1	a_3	a_4			B3		C3
	4	$1/a_4$	a_4	$1/a_3$	1	$1/a_5$			B4		C4
	5	$1/a_5$	a_4	$1/a_4$	a_5	1			B5		C5

Table 2 (Cont.)

C	Matrix Product	/	B	=	D	D
	C1					D1
	C2					D2
	C3					D3

Calculating Numerical Criteria Weights

Once the weights have been determined by key informants in numerical form, these numbers are used to calculate the importance weights at each level, then analyzed hierarchically from the top level down to the bottom level until all levels are complete. The calculation method involves the following steps (Chaosuan, 2002):

1. Pairwise comparison of criteria in matrix table format, comparing every criterion in both horizontal rows and vertical columns.

2. Calculate the Eigenvector of the matrix for each row (Normalized Matrix) by finding the average importance in each row.

3. Calculate the importance ranking of the next lower level by performing steps 1 through 2, then multiplying the calculated values from the level one step higher by the normalized values of the second level obtained from calculation. This yields the importance ranking of the subordinate level according to criteria at that particular level. This process continues until all criteria are complete.

The equation used to calculate the importance weights of criteria at each level (Wuttiwanich, 2011) is as follows:

$Aw = \lambda_{max} W$

Where:

A = Square matrix of key informants' opinions, expressed as normalized values (adjusted to 1)

W = Eigenvector showing relative importance weights within the same hierarchical level or group under a higher hierarchical level

λ_{max} = Maximum Eigenvector

n = Matrix size

Therefore: $C.I. = (\lambda_{max} - n)/(n-1)$

The final step is consistency checking (Consistency Ratio: C.R.)

Using the formula: C.R. = C.I./R.I.

Where:

C.R. = Consistency Ratio

C.I. = Consistency Index

R.I. = Random Index

Matrix A has sufficient consistency when C.R. meets the following conditions:

$CR < 0.1$ for matrix A with size $n \geq 5$

$CR < 0.09$ for matrix A with size $n = 4$

$CR < 0.05$ for matrix A with size $n = 3$

The design advances sustainability methodology by: 1) bridging participatory stakeholder approaches with analytical decision-making methods, 2) incorporating future visioning alongside present assessment, and 3) analyzing both component priorities and examining stakeholder perspectives on sustainability priorities, addressing limitations in conventional research that treats success factors independently.

This approach responds to calls for more integrated designs capturing sustainability transitions' complexity (Köhler et al., 2019). By combining Ethnographic Delphi Futures Research (EDFR) with Analytic Hierarchy Process (AHP), the study produces findings that are contextually rich and quantitatively robust, enhancing both theoretical and practical value. Figure 1 illustrates the research framework.

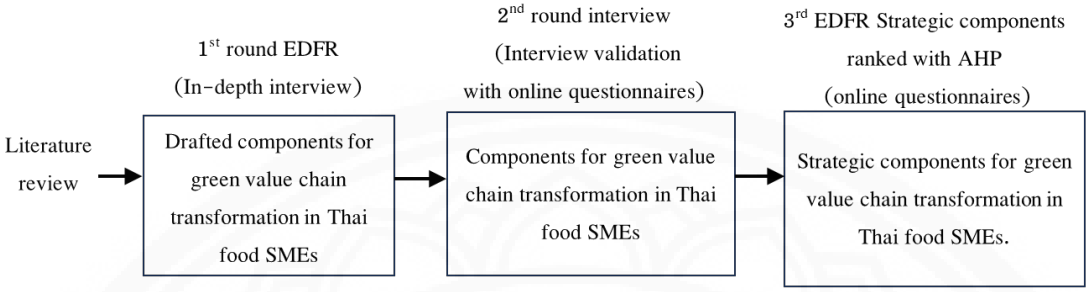

Figure 1 Research Framework.

Participant Selection and Characteristics

The study employed purposive sampling to identify 17 key informants representing diverse stakeholder perspectives on sustainable food industry development in Thailand. In line with Macmillan's (1971) recommendations for futures research, with 17 or more key informants, the rate of error reduction becomes very minimal and begins to stabilize at an error level of 0.02. The participants were selected based on their expertise, experience, and ability to represent different aspects of the Thai food value chain. The sample included:

- Five government policy representatives from agencies responsible for SMEs capacity building, carbon footprint standards and regulations, Macroeconomics policy, and SMEs promotion policy.
- Five academics specializing in sustainable supply chain management, environmentally friendly production, BCG (Bio-Circular-Green Economy), environmental standards, environmental economics, and productivity improvement.
- Five Thai food SME representatives from different organizations. Two are from federations: the Federation of Thai Industries (FTI) and the Federation of Thai SME Association (FTA). The other three are business owners specializing in dairy products, vegetable products (who is a supplier of an agro-industrial and food company), and goat products.
- Two consumers. One is Senior marketing director of a food company who has extensive experience in the Thai consumer market. The other is a sustainability consultant from a multinational company who has extensive experience with both Thai and international consumers.

All participants had a minimum of 10 years of relevant professional experience, with an average of 22.4 years of experience across the sample. Gender distribution was balanced with 7 female and 10 male participants.

For the third research phase involving AHP analysis, a subset of 7 participants was selected based on their depth of knowledge, relevance to green business management in Thai food SMEs, and level of engagement in earlier research phases. This subset maintained proportional representation across stakeholder categories.

Data Collection Procedure

Data collection occurred in three sequential phases:

Phase 1: Ethnographic Interviews (EDFR Round 1)

60-minute semi-structured interviews were conducted with 17 participants, exploring perspectives on sustainable green management in Thai food SMEs. Questions covered organizational factors, supply chain considerations, external support, and future pathways. Interviews were recorded and transcribed for analysis.

Phase 2: Consensus Building (EDFR Round 2)

Based on Phase 1 findings, all participants rated potential strategic components on a 5-point Likert scale for suitability and feasibility. The electronic questionnaire included space for explanatory comments. Statistical analysis assessed central tendency and consensus for each component.

Phase 3: Priority Setting (EDFR Round 3 with AHP)

Seven selected participants completed AHP questionnaires requiring pairwise comparisons of strategic components using Saaty's (1980) 9-point scale. After individual briefing sessions, consistency ratios were calculated with a threshold of CR < 0.1 for inclusion in the final analysis.

Analytical Approach

Data analysis employed a mixed-methods strategy appropriate to each research phase:

Qualitative Analysis: Data from Phase 1 interviews were analyzed through interview transcription and summarizing key points. The researcher transcribed the interviews verbatim, then identified and summarized the main points and important content from the data. The key issues identified from this summary were grouped to identify strategic components for green value chain transformation, which were subsequently used as the basis for developing questionnaires for data collection in Phase 2.

Consensus Analysis: Responses from Phase 2 were analyzed using descriptive statistics (median, mode) and measures of dispersion (interquartile range). Components with median scores >= 3.5 (on a 5-point scale) and interquartile ranges <= 1.5 were considered to have achieved expert consensus on their importance and feasibility. This analysis identified the final set of strategic components and sub-components included in the hierarchical model.

Hierarchical Analysis: AHP data from Phase 3 were analyzed using the eigenvalue method. Individual judgment matrices were constructed for each participant and checked for consistency (CR < 0.1). For matrices meeting the consistency threshold, priority vectors were calculated to determine relative weights of components. Individual priorities were aggregated using the geometric mean to produce group priorities while maintaining the reciprocal property of judgment matrices. Sensitivity analysis tested the robustness of results by examining how changes in component priorities affected overall rankings.

Stakeholder Perspective Analysis: To examine differences between stakeholder groups, separate AHP analyses were conducted for each category (government, academic, industry, consumer). Non-parametric statistical tests (Kruskal-Wallis and Mann-Whitney U) assessed the significance of observed differences between groups. This approach revealed important variations in how different stakeholders prioritize sustainability components, with implications for policy and implementation.

Results

Hierarchical Model of Green Value Chain Components

The research identified six primary components forming a hierarchical model for green value chain transformation in Thai food SMEs. Figure 1 presents these components and their relative importance weights derived from AHP analysis.

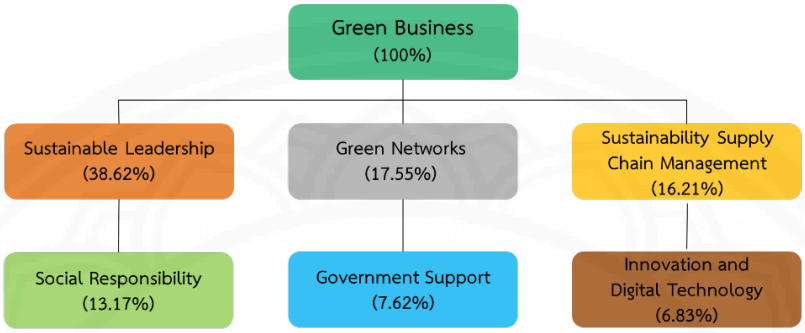

Figure 2 A Hierarchical Diagram with the Six Main Components and Their Respective Weights.

The analysis revealed Sustainable Leadership as the dominant component (38.6%), followed by Green Networks (17.5%), Sustainable Supply Chain Management (16.2%), Social Responsibility (13.2%), Government Support (7.6%), and Innovation and Digital Technology (6.8%). The consistency ratio for the aggregate judgment matrix was 0.004, well below the 0.1 threshold, indicating highly consistent prioritization across participants.

The definition of each component is as follows:

1. Sustainable Leadership: Focusing on organizational culture and leadership commitment, this component encompasses culture creation, personnel development, and technology investment as key elements. Leaders drive sustainability transformation by embedding environmental values into organizational culture, developing employee capabilities in green business practices, and strategically investing in environmentally-friendly technologies and innovations. This foundational component serves as the primary catalyst for green transformation, where committed leadership models sustainable behaviors and creates an organizational environment that integrates environmental responsibility into daily operations and strategic decision-making processes.

2. Green Networks: Emphasizing collaborative partnerships for sustainability, this component includes networking with raw material producers, cooperation with other enterprises, partnerships with research institutions, and consumer communication as key elements. SMEs leverage strategic networks to overcome resource constraints and create a supportive ecosystem that enables small enterprises to achieve sustainability goals collectively.

3. Sustainable Supply Chain Management: Concentrating on environmentally-friendly operations throughout the value chain, this component encompasses sustainable supplier selection, resource efficiency optimization, renewable energy adoption, waste and pollution reduction, sustainable packaging implementation, and eco-friendly transportation management as key elements. This comprehensive approach transforms the entire supply chain from raw material sourcing to final product delivery.

4. Social Responsibility: Focusing on community engagement and societal impact, this component includes promoting sustainable agriculture, creating social awareness of green management, and facilitating community participation as key elements. Businesses contribute to society, thereby creating shared value that benefits both business sustainability and broader social welfare.

5. Government Support: Emphasizing public sector facilitation and infrastructure development, this component comprises knowledge provision and training, financial support mechanisms, standards setting and certification, environmental law enforcement, and basic infrastructure development as key elements. Government creates an enabling environment for SME sustainability transformation by providing educational programs and technical training, offering financial incentives and low-interest funding, establishing environmental standards and certification systems, ensuring strict compliance with environmental regulations, and developing essential infrastructure such as waste management and recycling systems that support green business operations.

6. Innovation and Digital Technology: Concentrating on technology-enabled efficiency and operational transparency, this component includes Enterprise Resource Planning systems for resource management, digital marketing platforms, agricultural data management and precision farming, automation systems utilizing AI, IoT, and robotics, and digital traceability systems as key elements. Modern technologies optimize business operations by enabling efficient resource allocation and waste reduction through integrated management systems, enhancing market reach and consumer engagement through digital channels, improving agricultural productivity through data-driven farming techniques, automating production processes to reduce energy consumption and improve quality control, and providing complete supply chain transparency that builds consumer trust in environmentally-friendly products.

These findings present organizational leadership and culture as the foundation for sustainability transformation, with external relationships, operational practices, and technological solutions building upon this foundation. Figure 3 shows roadmap of the three-phase green value chain transformation, provide an overview of the sequential implementation.

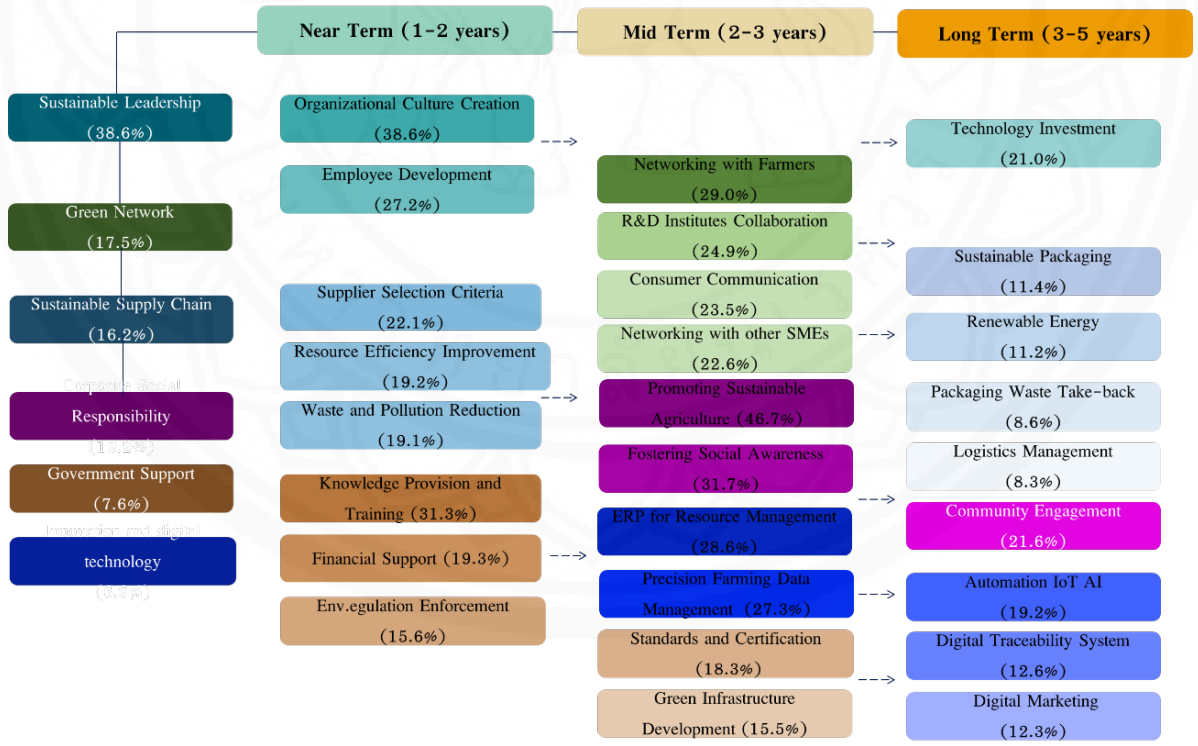

Figure 3 Green Value Chain Transformation Roadmap.

Interrelationships between Strategic Components

A key finding from this research is that strategic components for sustainable transformation are not independent but rather form an interconnected system with significant reinforcing relationships. Figure 4 presents a conceptual model of these interrelationships based on qualitative data analysis.

Three types of interrelationships emerged as particularly significant:

Foundation-Building Relationships

Sustainable Leadership provides the essential foundation for other components, particularly through organizational culture creation. As one SME leader explained: "Without leadership commitment and cultural change, other sustainability initiatives become superficial—they may look good in reports but don't transform how we operate". This foundation-building relationship was emphasized across stakeholder groups, with government representatives noting that policy interventions rarely succeed without corresponding leadership engagement.

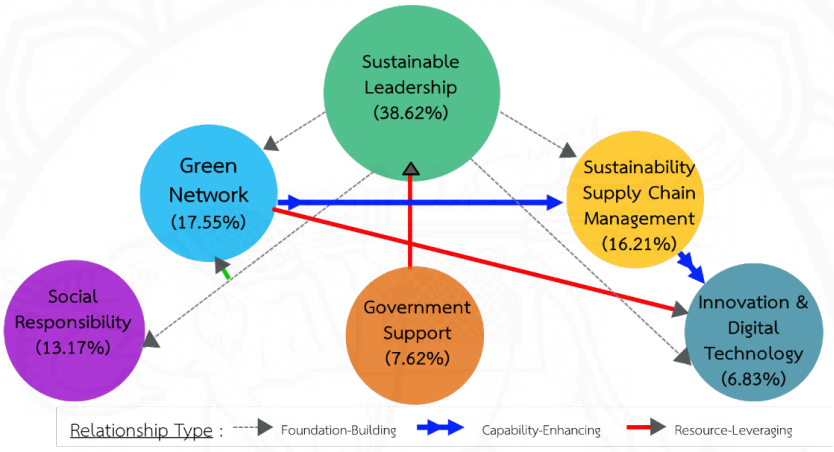

Figure 4 A Network Diagram of Component Interrelationships.

Capability-Enhancing Relationships

Several bidirectional relationships enhance implementation capabilities. For example, Green Networks and Sustainable Supply Chain Management mutually reinforce each other, with networks providing access to sustainable suppliers while supply chain practices strengthen network relationships. Similarly, Innovation and Digital Technology enhances the effectiveness of Supply Chain Management through improved monitoring and optimization capabilities. As an academic participant observed: "Digital system gives SMEs visibility into their supply chain they never had before, allowing them to identify improvement opportunities they couldn't see previously".

Resource-Leveraging Relationships

Resource constraints represent a significant barrier for Thai food SMEs implementing sustainability initiatives. The model reveals how components can help overcome these limitations through resource-leveraging relationships. For instance, Government Support provides essential knowledge resources that enhance Leadership capabilities, while Green Networks enable resource sharing that makes technological innovations more accessible to individual SMEs. Corporate Social Responsibility initiatives can also leverage community resources for sustainability initiatives, as explained by one participant: "When we involve the community in our sustainable agriculture program, we gain volunteer support, local knowledge, and enhanced reputation—resources we couldn't obtain otherwise".

These interrelationships highlight why isolated sustainability initiatives often fail to produce transformative results. Effective green value chain transformation requires a system approach that recognizes and cultivates these reinforcing relationships rather than implementing components in isolation.

Stakeholder Perspective Differences

Analysis of stakeholder group perspectives revealed important differences in how various actors prioritize sustainability components. Figure 5 compares component priorities across the four stakeholder categories.

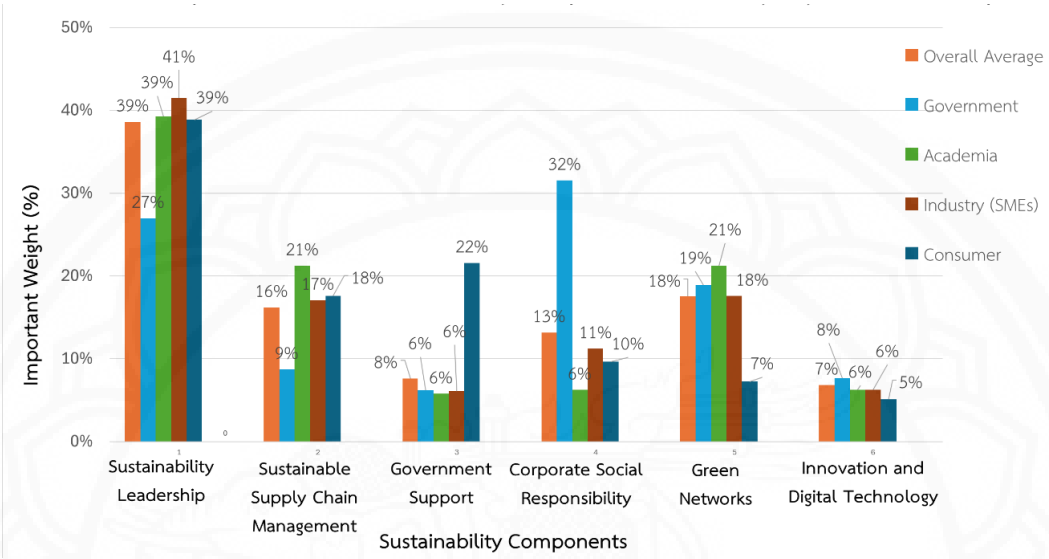

Figure 5 A Comparative Chart of Component Priorities by Stakeholder Group.

Table 3 Stakeholder Priorities Comparison

Sustainability Component	Overall Average	Government	Academia	Industry (SMEs)	Consumer	Key Differences
Sustainable Leadership	38.6%	27%	39%	41%	39%	Industry rates highest (41%), Government lowest (27%)-14% gap
Green Networks	17.5%	18%	21%	18%	7%	Academia highest (21%), Consumer lowest (7%)-14% gap
Sustainable Supply Chain Management	16.2%	9%	21%	17%	17%	Academia highest (21%), Government lowest (9%)-12% gap
Corporate Social Responsibility	13.2%	32%	7%	11%	10%	Government highest (32%), Academia lowest (7%)-25% gap
Government Support	7.6%	8%	6%	6%	22%	Consumer highest (22%), Industry/Academia lowest (6%)-16% gap
Innovation and Digital Technology	6.8%	6%	7%	7%	5%	Minimal variation across groups (2% range)

Government Perspective

Government stakeholders demonstrate a distinct prioritization pattern in sustainability components, with Corporate Social Responsibility (32%) emerging as their clear highest priority—significantly above the overall

average of 13% and far exceeding other stakeholder groups. While they value Sustainability Leadership (27%), they rate it lower than other stakeholders (Academia 41%, Industry 39%, Consumer 39%), suggesting a different emphasis. Green Networks (18%) aligns with the overall consensus, but government places notably less importance on Sustainable Supply Chain Management (9%) compared to others, particularly Academia (21%). Interestingly, government stakeholders rate the importance of their own Government Support (8%) lower than consumers do (22%), indicating a potential misalignment between how governments perceive their role versus public expectations. This priority distribution reveals a government perspective primarily focused on corporate behavior and social impacts rather than operational or technical aspects of sustainability implementation.

Academic Perspective

Academia's sustainability priorities reveal a distinct perspective centered on systemic approaches, with Sustainability Leadership (39%) and Sustainable Supply Chain Management (21%) dominating their focus—notably, their emphasis on supply chains is the highest among all stakeholder groups. Academia shows moderate interest in Green Networks (21%), exceeding the overall average (18%), while demonstrating markedly less concern for Corporate Social Responsibility (7%), Government Support (6%), and Innovation and Digital Technology (7%). This distribution suggests a theoretical orientation that values fundamental leadership principles and comprehensive supply chain transformations over corporate social initiatives, governmental interventions, or technological solutions. The striking contrast between academia's low prioritization of Corporate Social Responsibility compared to government stakeholders (32%) highlights significantly different approaches to sustainability, with academics apparently favoring structural and operational changes over socially-focused corporate programs or policy-driven initiatives.

Industry (SMEs) Perspective

Industry (SMEs) stakeholders exhibit a sustainability perspective dominated by a strong emphasis on Sustainability Leadership (41%)—the highest among all groups—suggesting small and medium enterprises view leadership as the fundamental driver of sustainability transformation. Their priorities then cascade to Green Networks (18%) and Sustainable Supply Chain Management (17%), both near overall averages, indicating balanced attention to collaborative ecosystems and operational sustainability. Industry demonstrates moderate interest in Corporate Social Responsibility (11%), notably lower than government stakeholders (32%), while placing minimal importance on Government Support (6%) and Innovation and Digital Technology (7%). This distribution reveals a pragmatic business approach that prioritizes strong leadership and practical operational systems over government intervention, technological solutions, or extensive social responsibility programs. Industry gives Government Support a relatively low priority at 6%, well below consumers (22%) and even the overall average (10%). This may indicate SMEs prefer market-driven sustainability approaches over government intervention or perceive limited benefit from government sustainability programs.

Consumer Perspective

Consumers exhibit a distinct sustainability perspective centered primarily on Sustainability Leadership (39%) and Government Support (22%)—with their emphasis on government involvement being remarkably higher than all other stakeholders and more than double the overall average (10%). This significant prioritization of government intervention represents one of the most striking differences across all stakeholder groups. Consumers give moderate attention to Sustainable Supply Chain Management (17%) and Corporate Social Responsibility (10%), while showing surprisingly little interest in Green Networks (7%)—the lowest rating among all groups

for this component—and Innovation and Digital Technology (5%). This distribution reveals a consumer perspective that strongly values visible leadership commitments and regulatory frameworks, suggesting consumers believe sustainability progress requires both organizational leadership and government policy support rather than collaborative networks or technological solutions. The substantial gap between consumers' high expectations for government involvement compared to how government stakeholders themselves rate its importance (8%) suggests a notable disconnect between consumer expectations and government's self-perceived role in sustainability advancement.

These differences in perspective have important implications for sustainability policy and implementation. Interestingly, despite these differences, all stakeholder groups agreed on the relative importance of organizational culture within the Sustainable Leadership component, suggesting this represents a universal priority for sustainable transformation. This finding offers a potential convergence point for stakeholders with otherwise divergent perspectives.

Implications for Theory and Practice

The hierarchical model and interrelationship findings advance theoretical understanding in three ways. First, they challenge conventional technical and regulatory approaches by demonstrating leadership and cultural factors' primacy, aligning with Al-Ghazali et al. (2022) while providing food SME-specific empirical evidence. Second, identifying reinforcing relationships contributes to systems theory by showing how sustainability components function as an interconnected system with emergent properties, explaining why isolated initiatives often fail. Third, stakeholder perspective differences reveal how actors prioritize sustainability based on their value network position, suggesting effective governance needs mechanisms to reconcile diverse perspectives. Fourth, this research extends understanding of how Thailand's BCG (Bio-Circular-Green) Economy Model can be operationalized specifically within food SMEs, providing empirical validation for how its principles translate to this critical sector.

For practitioners, the research offers four actionable insights:

- **Sequential Implementation Approach:** Begin with leadership and cultural foundations before technical initiatives.
- **Relationship Cultivation Strategy:** Understanding component interrelationships enables strategic resource allocation to high-leverage intervention points.
- **Stakeholder Communication Framework:** Tailor communication strategies to different stakeholder concerns—emphasizing social impacts for consumers and policymakers while highlighting business benefits for industry partners.
- **Cultural Foundation Metrics:** Develop better tools to measure cultural readiness for sustainability transformation.

The practitioners can apply the research results using a Phased Sustainability Transformation Model by starting with leadership commitment and cultural alignment before investing in advanced processing technology as follows:

Phase 1: Develop a clear sustainability vision and secure management commitment

Phase 2: Conduct sustainability awareness workshops for all staff to build cultural foundation

Phase 3: Form cross-functional sustainability teams to identify value chain improvement opportunities

Phase 4: Implement technical solutions (e.g., energy-efficient machines, water recycling systems)

For policymakers, findings suggest reorienting support mechanisms toward leadership development, cultural change facilitation, and network building to enhance existing technical assistance and financial incentive programs. This approach would strengthen implementation of Thailand 4.0 policy objectives by addressing the 'soft'

transformation barriers that currently limit technology adoption and innovation diffusion among food SMEs, ensuring these national economic transformation policies achieve their intended impact across all enterprise scales, not just among larger corporations.

Research Method Limitations

AHP Subjectivity: The method introduces inherent bias through subjective human judgments, where participants' personal experiences and organizational contexts influence priority rankings. The 9-point scale may oversimplify complex sustainability trade-offs, and cognitive limitations in multiple pairwise comparisons can lead to inconsistencies despite acceptable consistency ratios.

Expert Selection Constraints: The study's 17 participants, reduced to only 7 for AHP analysis, creates potential representation bias and narrows the perspective base. The predetermined stakeholder categories may exclude important voices such as civil society organizations, environmental NGOs, and smaller suppliers.

Methodological Integration Issues: The sequential design creates dependency risks where earlier phases constrain later analysis, potentially losing nuanced contextual understanding when transitioning from qualitative insights to quantitative weights. The consensus-building approach may eliminate valuable minority perspectives.

Methods to Improve Research Efficiency in Future Studies

Quality Enhancement: Research quality could be improved through expert training sessions that briefly orient participants on AHP methodology and sustainability concepts, ensuring more informed and consistent judgments without compromising the method's accessibility. Sensitivity analysis should be conducted to test the robustness of results to individual expert variations, identifying which findings remain stable across different expert combinations. Finally, longitudinal validation through follow-up studies 12-18 months later would assess priority stability over time and validate the model's continued relevance as Thailand's sustainability landscape evolves.

Enhanced Traditional Approaches: Future research should expand the expert panel from 17 to 25-30 participants using stratified sampling across different Thai regions and food subsectors to improve representativeness and reduce potential bias. Multiple AHP rounds could be conducted iteratively to enhance judgment stability, allowing participants to refine their assessments based on initial results and group feedback. Additionally, implementing cross-validation through split-sample validation with different expert groups would strengthen the reliability of findings by testing whether similar priority patterns emerge across independent expert panels.

Accessibility-Focused Improvements: Geographic representation should be enhanced by including experts from different Thai regions beyond the current sample to capture regional diversity in food industry practices, regulatory environments, and market conditions. This broader geographic scope would ensure that the hierarchical model reflects the varied contexts in which Thai food SMEs operate, from northern agricultural regions to southern coastal areas, each with distinct sustainability challenges and opportunities.

This research provides the foundational framework necessary for developing real-world case applications, with the hierarchical model serving as a blueprint for future implementation studies across Thailand's diverse food SME landscape.

Conclusion and Suggestions

This research developed a hierarchical model for green value chain transformation in Thai food industry SMEs, identifying six interconnected strategic components with Sustainable Leadership as the dominant factor.

The mixed-methods approach revealed component priorities, interrelationships, and stakeholder perspective differences affecting implementation.

The findings challenge conventional technical or regulatory sustainability approaches by demonstrating the primacy of leadership, culture, and relational factors. This explains why many initiatives fail despite investments—they neglect foundational cultural and leadership elements necessary for effective implementation.

The study advances both theoretical understanding and practical application of sustainability in emerging economy food systems by integrating diverse stakeholder perspectives and examining component interrelationships, providing a more nuanced framework than previous research.

The study represents aspirational planning that prioritizes leadership and culture as foundations (38.6%) for future sustainability transformation, while the European circular economy study reveals implementation realities where successful SMEs faced primarily network collaboration barriers (54%) rather than cultural obstacles, suggesting a progression from foundational challenges to operational barriers during actual sustainability adoption (Durrani et al., 2024).

The hierarchical model developed in this study offers significant potential for scalability and replication across Southeast Asia. While tailored to Thailand's food industry context, the core principles—emphasizing leadership foundations and cultural elements before technical implementations—apply to similar emerging economies facing comparable sustainability challenges. The model's flexibility allows adaptation to diverse regulatory environments, cultural contexts, and food subsectors throughout the region, providing a framework that can be calibrated to different national priorities while maintaining its structural integrity. ASEAN economic integration further enhances opportunities for cross-border knowledge transfer and regional implementation of these sustainability principles.

This research offers a roadmap for food industry transformation that recognizes both technical and human dimensions. By building on cultural foundations, cultivating supportive networks, and implementing appropriate operational practices, Thai food SMEs can develop resilient green value chain creating sustainable competitive advantage while contributing to broader environmental and social goals.

The hierarchical model offers strong potential for adaptation across ASEAN member states, particularly Vietnam, Indonesia, and the Philippines. Regional replication requires three key adaptations: regulatory alignment with national environmental policies, cultural contextualization for local business practices, and economic calibration for varying digital infrastructure levels. While the model's emphasis on leadership foundations (38.6%) and network-building (17.5%) aligns with Southeast Asian collectivist cultures, component weights should be recalibrated through country-specific AHP analysis to reflect local priorities and constraints.

Beyond Thailand's food sector, the model requires strategic modifications while maintaining its core structure. Industry-specific adjustments are essential—textile SMEs might prioritize chemical management over food safety, while tourism SMEs emphasize community engagement over supply chain management. Technology needs also vary—manufacturing SMEs focus on automation while service SMEs prioritize digital customer platforms. Stakeholder ecosystems differ significantly across industries, requiring distinct network configurations and partnership strategies.

The model's strength lies in providing both concrete priorities for Thai food SMEs and a replicable EDFR-AHP methodology for other contexts. This dual approach ensures fundamental systems-thinking and cultural foundation principles remain intact while enabling contextual adaptation of priorities and implementation strategies.

This adaptability positions the framework as both a specific solution and a transferable tool for sustainability transformation across emerging economies and diverse industrial sectors throughout Southeast Asia.

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