

GREEN SUPPLIER SELECTION USING THE ANALYTIC HIERARCHY PROCESS: EVIDENCE FROM THE PAPER FOOD PACKAGING INDUSTRY IN BANGKOK AND SURROUNDING PROVINCES

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ABSTRACT

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Received: 28 October 2025

Revised: 16 January 2026

Accepted: 26 January 2026

Published: 24 March 2026

Citation:

Dolpanya, K. (2026). Green supplier selection using the analytic hierarchy process: Evidence from the paper food packaging industry in Bangkok and surrounding provinces. *Humanities, Arts and Social Sciences Studies*, 26(1), 133–147.
<https://doi.org/10.69598/hasss.26.1.281961>

This study develops a systematic decision-making framework for green supplier selection in the food packaging industry by using the analytic hierarchy process (AHP). Growing environmental awareness and increasingly stringent regulatory requirements have intensified the need for structured approaches to evaluating suppliers based on sustainability criteria. However, industry-specific green supplier selection frameworks remain limited. To address this gap, a two-phase methodology is employed. First, the Delphi method is used to identify and validate supplier selection criteria through expert consensus. Second, the AHP is applied to conduct a multicriteria decision analysis. Eight industry experts from three food packaging companies participated in both the criteria identification and supplier evaluation processes. The Delphi analysis yielded six validated green supplier selection criteria: green raw materials usage (C1), green products (C2), green service quality (C3), green image (C4), green certification (C5), and green compliance (C6). The AHP findings revealed that green certification (C5) is the most influential criterion across all three companies, with importance weights of 0.407, 0.459, and 0.460, respectively, followed by green compliance (C6) as the second-highest priority. The supplier evaluation results identified the optimal suppliers for each company as SA3 (0.378), SB2 (0.396), and SC2 (0.399), with SC2 achieving the highest overall performance score. Consistency ratio (CR) testing confirmed the reliability of the decision-making process, with all CR values below 0.10, thereby validating the methodological rigor of the proposed framework. Overall, the findings demonstrate that formal environmental standards and regulatory compliance are the primary drivers of supplier selection in the food packaging sector. This framework provides practitioners with an evidence-based tool to support sustainable supplier selection decisions and contributes to the sustainable supply chain management literature by offering an industry-specific approach that balances environmental objectives with operational requirements.

Keywords: Green supplier selection; analytic hierarchy process; food packaging

1. INTRODUCTION

Supplier selection is a critical process that significantly influences the performance and success of manufacturing companies (de Boer et al., 2001; Mukherjee, 2016). In the food packaging industry, this process is particularly complex due to multiple considerations, including compliance with packaging safety regulations (Banaeian et al., 2015), adherence to quality standards, sustainable packaging practices, environmental impact considerations (Banaeian et al., 2015; Jiang et al., 2018; Mabrouk, 2021), and timely delivery to meet customer demands (Noori-Daryan et al., 2019; Qian, 2014). Consequently, supplier selection criteria must be tailored to meet the specific requirements of the industry.

The food packaging sector also operates in a highly competitive environment, where efficiency, cost control, and profitability are essential (Martins & Romani, 2022). In Thailand, the industry represents a major economic sector, valued at approximately USD 15.71 billion in 2025 and growing at an annual rate of 4.46% (Mordor Intelligence, 2024). Bangkok and the surrounding provinces serve as the country's main manufacturing hub, producing more than half of Thailand's food packaging, particularly paper-based materials (DiMarket, 2025).

Amidst rising environmental regulations and expanding export markets, Thai food packaging manufacturers are under increasing pressure to implement sustainable practices without compromising cost competitiveness. However, many supplier selection methods rely on limited evaluation criteria (Mukherjee, 2016), are poorly aligned with operational objectives, and often lack systematic, industry-specific frameworks for environmental considerations. This can result in suboptimal supplier choices, elevating operational risks and reducing overall efficiency (Deshmukh & Vasudevan, 2014; Konys, 2019).

This research addresses the gaps in the food packaging manufacturing sector, where the identification and prioritization of supplier selection criteria, such as food safety standards, sustainability, and regulatory compliance, have received limited attention (Guo et al., 2019; Han et al., 2018; Wandosell et al., 2021). Therefore, this study applies the analytic hierarchy process (AHP) to green supplier selection, a method well-suited for handling multiple, diverse criteria in a structured and systematic manner (Perçin, 2006). Specifically, the AHP enables decision-makers to decompose complex problems into hierarchical structures, assign relative weights to criteria through pairwise comparisons, and conduct consistency checks to ensure reliability (Mukherjee, 2016; Saaty & Ergu, 2015). In this study, the AHP is used to identify and prioritize both criteria and alternatives for green supplier selection within the context of food packaging manufacturing plants. Accordingly, the research objectives are to: 1) Identify the selection criteria that influence green supplier selection decisions for food packaging manufacturing plants by using the AHP; and 2) Select appropriate green suppliers based on the AHP evaluation of these criteria.

2. LITERATURE REVIEW

Growing awareness of environmentally friendly, consumer-safe, and sustainably usable products has prompted many industries to adopt sustainable supply chain management strategies, which integrate environmental, social, and economic considerations across the entire supply chain (Carter & Liane Easton, 2011; Seuring & Müller, 2008). The terms “environmentally friendly” and “green” are often used interchangeably to describe products or practices that minimize negative environmental impact (Alamsyah et al., 2020; Herbes et al., 2020; Wang & Wang, 2021). Packaging plays a critical role in the product life cycle, serving various functions such as protection, preservation, information display, marketing, convenience, regulatory compliance, sustainability, cost-effectiveness, and differentiation (Boesen et al., 2019; Molina-Besch et al., 2019; Rezaei et al., 2019; Cheng et al., 2022; Han et al., 2018; Petkoska et al., 2021).

Packaging functions can vary depending on product characteristics and the industry context (Han et al., 2018; Majid et al., 2018). Since packaging comes into direct contact with consumers, it can significantly influence health and hygiene. Green packaging reflects a paradigm shift in the industry toward environmentally conscious practices, encompassing the design, production, and use of raw materials, equipment, and finished products in ways that minimize environmental impact across the packaging lifecycle (Han et al., 2018; Petkoska et al., 2021). Rising environmental awareness among consumers has increased the demand for packaging solutions that meet eco-friendly standards. At the same time, stringent environmental regulations and sustainability goals compel the food packaging industry to adopt practices that comply with legal requirements and industry standards (Guo et al., 2019; Han et al., 2018; Wandosell et al., 2021). Green supplier selection is a critical element in producing sustainable packaging, since it allows organizations to choose suppliers that align with their sustainability objectives and positively contribute to environmental outcomes (Han et al., 2018; Wandosell et al., 2021; Song et al., 2018).

The packaging industry's shift toward circular economy principles emphasizes designing systems that enable material reuse, extend product lifecycles, and reduce environmental impact across the value chain (Seier et al., 2024; Silvestri et al., 2024). This transition has necessitated the development of comprehensive green logistics metrics, evolving from simple carbon footprint estimates to frameworks that assess resource consumption, emissions, waste generation, and circular material flows (Garg & Vemaraju, 2025; Ren et al., 2020). Effective implementation requires systematic supplier evaluation methods, specifically the AHP, which translate environmental criteria into measurable indicators. These indicators combine quantitative assessments—notably greenhouse gas emissions intensity and material circularity rates—with qualitative evaluations of environmental management practices and regulatory compliance (Appannan et al., 2023; Awewomom et al., 2024). Such frameworks enable data-driven decision-making and meaningful supplier benchmarking aligned with sustainability objectives (Lo, 2023). Previous studies on green supplier selection have identified relevant criteria, as summarized in Table 1, which highlights the factors specifically related to environmental performance.

The AHP provides a structured framework that enables decision-makers to systematically evaluate and compare alternatives based on multiple criteria (Brunelli, 2014; Saaty, 2001). Its popularity stems from its ability to handle the complexity of supplier evaluation and support informed decision-making aimed at selecting suppliers that meet organizational requirements (Hruška et al., 2014). As for supplier selection criteria, they can significantly vary across industries. For example, Mukherjee (2016) examined the methods and criteria for supplier selection in various sectors, including automotive, electronics, machinery, construction, agriculture, and textiles, noting that extensive research has focused on the automotive and electronics industries to guide effective supplier decisions. In the leather industry, Moktadir et al. (2017) applied the AHP for supplier selection by using criteria comprising delivery, quality, technology, contract compliance, price, standards, service, and packaging. Although the AHP has been widely applied in supplier evaluation, the specific criteria depend on the industry context. In the food packaging sector, decision-making emphasizes sustainability, compliance with food industry standards, consumer safety, efficient resource utilization, and minimizing environmental impact (Guo et al., 2019; Wandosell et al., 2021).

Table 1: Criteria related to green supplier selection

Green supplier selection criteria	Yu and Hou (2016)	Mousakhani et al. (2017)	Yazdani et al. (2017)	Jiang et al. (2018)	Mabrouk (2021)	Utama (2021)	Wei et al. (2021)	Puška and Stojanović (2022)
Use of green materials	-	-	-	-	-	✓	-	-
Green cost	-	✓	✓	✓	✓	✓	✓	✓
Green products	-	-	-	-	-	-	-	✓
Green service quality	-	✓	✓	✓	✓	✓	-	✓
Green image	✓	✓	-	-	-	✓	-	-
Green design or R&D	-	-	✓	-	-	-	-	-
Green organizational management systems	-	✓	✓	✓	✓	✓	✓	✓
Pollution control	-	-	✓	✓	✓	-	-	✓
Green recycling	✓	-	✓	✓	-	-	✓	✓
Green innovation	-	-	-	-	-	-	-	✓
Green energy use	✓	✓	-	✓	✓	✓	✓	-
Green packaging uses	-	-	-	-	-	✓	-	-
Partnership relationships	-	-	-	-	✓	-	-	✓

Table 1 shows that the most frequently used criteria are green cost, green organizational management systems, and green service quality, indicating their importance in supplier selection. In contrast, criteria especially green packaging uses and green innovation are less commonly applied, suggesting that these areas are emerging considerations that have not yet been widely adopted.

2.1 Conceptual framework development

This study applies the AHP to identify criteria and evaluate alternatives for green supplier selection decisions in the context of food packaging manufacturing plants. The research process consists of three stages, as illustrated in Figure 1. Stage 1 involves a literature review of general and green supplier selection criteria. Stage 2 employs the Delphi method with management teams from food packaging manufacturing plants to validate the criteria. Stage 3 uses the AHP to determine the most appropriate green suppliers.

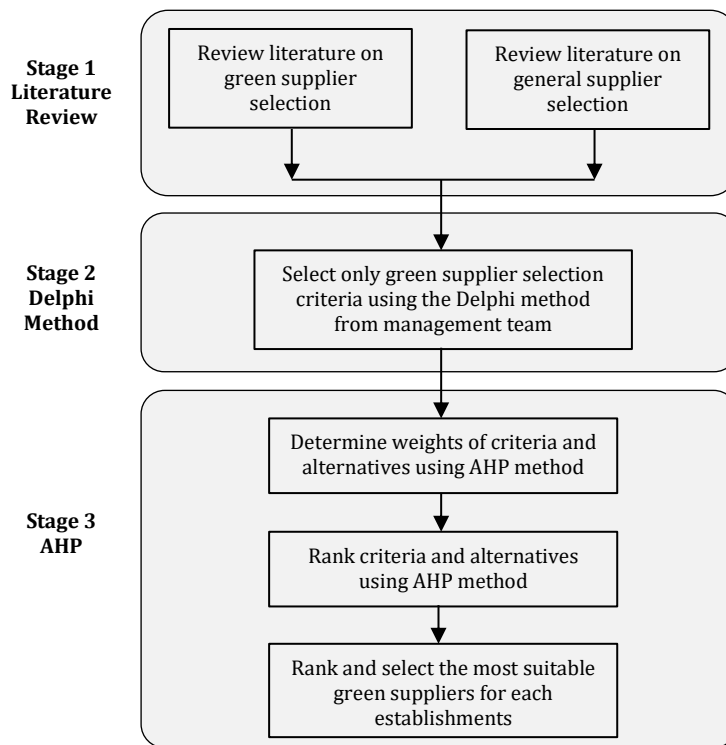


Figure 1: Development of the conceptual framework and related theories

2.2 Delphi method

This research employs the Delphi method, a systematic approach for collecting expert opinions and analyzing their interrelationships, providing a wide range of perspectives and experiences. Specifically, this method enables experts to refine their views based on feedback from other participants, leading to a consensus for problem-solving or forecasting relevant issues (Fish & Busby, 2005; Humphrey-Murto et al., 2020). Additionally, the Delphi method allows experts to share their opinions openly while maintaining anonymity, promoting unbiased and candid responses (Grime & Wright, 2016; Humphrey-Murto et al., 2020; Okoli & Pawlowski, 2004).

2.3 Analytic hierarchy process

The AHP, developed by Thomas Saaty (1990, 2008), is a widely used decision-making method applied across diverse fields, including logistics and supply chain management (Ortiz-Barrios et al., 2020), finance (Primasari et al., 2018), healthcare (Hossain & Thakur, 2020), project management (Jabbarzadeh, 2018), and environmental management (Du et al., 2018). The AHP combines mathematics and numerical analysis to support decision-making in complex situations, allowing multiple criteria to be evaluated and prioritized based on their relative importance. It also structures problems hierarchically by dividing them into main objectives, selection criteria, and alternatives by using pairwise comparisons. In this context, decision-makers provide subjective judgments to assess relationships and prioritize criteria, after which the AHP calculates weighted scores to produce quantitative measures that guide the selection of suppliers that best meet organizational objectives.

3. RESEARCH METHODOLOGY

This research employs the AHP as a multicriteria, multialternative decision-making tool that facilitates the evaluation and comparison of various options. The procedures are as follows.

3.1 Population

The study population consists of eight executives from three establishments (Table 2) who have the authority to approve raw material procurement from green suppliers for food packaging manufacturing plants and who voluntarily participated in the research. To screen and select the supplier selection criteria, the Delphi method was applied with management teams from these establishments.

Table 2: Research participants

Establishment (plant)	Province	Research participants
1	Bangkok	1) CEO 2) Managing director 3) Purchasing manager
2	Bangkok	1) Managing director 2) Purchasing manager 3) Production manager
3	Samut Sakhon	1) Managing director 2) Purchasing manager

3.2 Instrument development

The instrument used in this study is a structured questionnaire designed to prioritize supplier selection by determining the criteria through pairwise comparison scales (Saaty, 2001). In this case, executives from participating establishments were asked to compare the relative importance of the criteria by using numerically defined weights. The questionnaire consists of three parts: 1) General information about the respondents, who are establishment executives; 2) Pairwise comparison of the criteria used in supplier selection decisions; and 3) Pairwise comparisons of the supplier selection alternatives under each criterion.

3.3 Data collection

This study was conducted at food packaging manufacturing plants and involved executives from three establishments. The sample comprised eight executives with the authority to approve procurement decisions who voluntarily participated in the research. Data collection took place from May 1, 2025, to July 31, 2025, based on dates and times convenient for each establishment. Four sessions were conducted at each establishment, resulting in a total of 12 sessions, with each session held between 9:00 AM and 4:00 PM. During these sessions, the researcher administered a structured questionnaire to obtain information on supplier selection criteria and alternatives relevant to food packaging manufacturing plants by using the AHP approach.

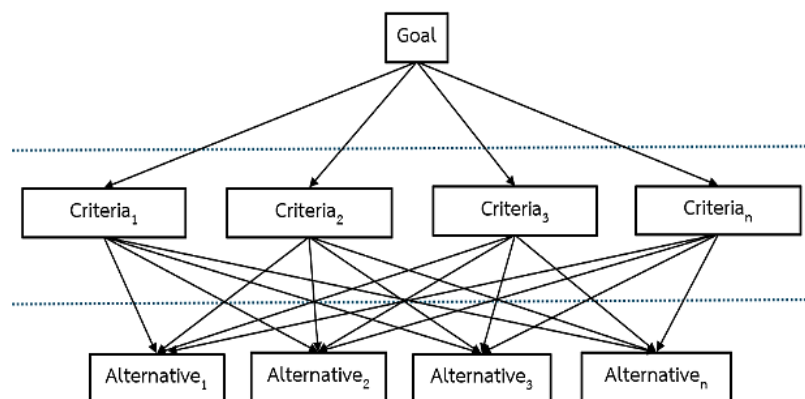
Supplier selection involving multiple criteria followed standard AHP procedures (Brunelli, 2014), as outlined below.

1) Define decision goals and selection criteria

In the supplier selection context, decision goals, selection criteria and alternatives were derived from questionnaire responses provided by eight executives from three establishments. These executives had the authority to approve supplier selection decisions related to raw material procurement for food packaging manufacturing plants and voluntarily participated in the study. In addition, the Delphi method was applied to screen and validate the supplier selection criteria.

2) Develop the hierarchical structure

The hierarchical structure illustrates the relationships among the decision goals, selection criteria, and alternatives used to evaluate supplier options. It consists of three levels: the decision goal at the top, followed by the selection criteria, and the supplier alternatives. This structure enables systematic comparison and supports informed decision-making.

**Figure 2:** Analytic hierarchy process (Brunelli, 2014)

Pairwise comparisons among the selection criteria and alternatives involve evaluating the relative importance of each criterion and each pair of alternatives. In this regard, importance is assessed by using a numerical scale from 1 to 9, where 1 indicates equal importance and 9 represents extreme importance (Table 3).

Table 3: Importance weight scale for pairwise comparisons (Saaty, 2008)

Importance weight level	Definition	Explanation
1	Equal importance	Both criteria contribute equally to the goal.
3	Moderate importance	One criterion is moderately more important than another.
5	Strong importance	One criterion is strongly more important than another.
7	Very strong importance	One criterion is very strongly more important than another.
9	Extreme importance	One criterion is extremely more important than another.
2, 4, 6, 8	Intermediate importance	Levels of importance between the described points.

3) Weight assignment

Weights are assigned to each selection criterion and alternative to represent their relative importance in achieving the decision goals (Saaty, 2008).

4) Consistency ratio (C.R.) check

The consistency ratio ensures that pairwise comparisons are logically consistent and unbiased (Saaty, 2001). A C.R. value greater than 0.10 indicates that the comparisons are inconsistent and require revision. A C.R. value less than or equal to 0.10 is considered acceptable. A C.R. value of 1 indicates completely inconsistent decisions, equivalent to comparisons made at random.

The C.R. is calculated by using the following equations:

$$\text{C.R.} = \text{C.I.}/\text{R.I.} \quad (\text{Equation 1})$$

$$\text{C.I.} = (\lambda_{\max} - n)/(n - 1) \quad (\text{Equation 2})$$

Where:

- C.I. = Consistency index.
- $\lambda_{\max}$ = sum of eigenvalues for each criterion.
- n = number of criteria compared pairwise.
- R.I. = Random consistency index, derived from 500 randomly generated pairwise comparisons matrices (Saaty, 1987; Table 4).

Table 4: Random consistency index

n	1	2	3	4	5	6	7	8	9	10
Random consistency index	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

5) Synthesis

Synthesis involves aggregating the weighted criteria to calculate overall scores for each alternative. The alternative with the highest overall score is considered the best option.

4. RESULTS

4.1 Delphi method criteria screening results

This study employed the Delphi method to screen and confirm the green supplier selection criteria through two rounds. In Round 1, the literature review identified 13 green supplier selection criteria. In Round 2, the results from Round 1, along with additional criteria proposed by the experts, were returned to the panel for reconsideration. Criteria were retained based on a mean score of at least 3.50 and a standard deviation of no more than 1.00, as presented in Table 5.

Table 5: Delphi method results for green supplier selection criteria

Code	Selection criteria	Mean	Standard deviation
C1	Green raw materials usage	4.50	0.53
C2	Green products	4.25	0.46
C3	Green service quality	3.88	0.64
C4	Green image	4.12	0.35
C5	Green certification	4.75	0.46
C6	Green compliance	4.62	0.52

The experts confirmed that all six criteria are appropriate and practically applicable for supplier evaluation. Specifically, Company AAA adopted criteria C1–C6, Company BBB applied criteria C1, C2, C3, C5, and C6, and Company CCC used criteria C1, C2, C4, C5, and C6.

4.2 Criteria importance analysis results

The AHP-based criterion importance analysis identifies the prioritization of green supplier selection criteria from the perspectives of experts in each company. The analysis begins with CR checks, which indicate that all CRs are below 0.1 for experts in each company, as shown in Table 6.

Table 6: Consistency ratio checks for criteria importance

Code	Company	Expert	$\lambda_{\max}$	CI	CR*
EA1	AAA	1	6.187	0.037	0.030
EA2	AAA	2	6.165	0.033	0.027
EA3	AAA	3	6.143	0.029	0.023
EB1	BBB	1	5.098	0.024	0.022
EB2	BBB	2	5.076	0.019	0.017
EB3	BBB	3	5.054	0.013	0.012
EC1	CCC	1	5.092	0.023	0.020
EC2	CCC	2	5.067	0.017	0.015

Note: * CR < 0.10 indicates acceptable consistency.

Table 7: Criteria importance weights

Criteria	Company AAA		Company BBB		Company CCC	
	Average	Priority	Average	Priority	Average	Priority
C1	0.121	4	0.128	4	0.145	4
C2	0.103	6	0.101	5	0.084	5
C3	0.076	5	0.077	3	-	-
C4	0.147	3	-	-	0.082	3
C5	0.407	1	0.459	1	0.460	1
C6	0.257	2	0.277	2	0.295	2

Table 7 shows that criterion C5 (green certification) holds the highest importance across all companies, reflecting the industry's emphasis on verifiable evidence of environmental performance. Criterion C6 (green compliance) ranks second, highlighting the necessity of adhering to legal requirements and industry standards. Criteria C2 (green products) and C3 (green service quality) have the lowest importance, suggesting that experts consider certification and regulatory compliance as more fundamental than the availability of green products or services.

4.3 Alternative analysis results

Applying the AHP to evaluate green supplier alternatives for the three companies reveals differences in supplier rankings, reflecting each organization's specific needs and evaluation criteria (Table 8, 9, and 10). For Company AAA which used six evaluation criteria (C1–C6) and considered three supplier alternatives (SA1, SA2, SA3), the analysis ranked SA3 the highest with a total score of 0.378, followed by SA2 (0.324) and SA1 (0.298). These results indicate that SA3 is the most suitable supplier for Company AAA's green business partnership.

Table 8: Total scores of supplier alternatives (Company AAA)

Alternative	C1	C2	C3	C4	C5	C6	Total score	Priority
SA1	0.24	0.46	0.33	0.62	0.17	0.39	0.298	3
SA2	0.17	0.26	0.21	0.26	0.41	0.26	0.324	2
SA3	0.59	0.29	0.46	0.12	0.42	0.35	0.378	1

For Company BBB, which used five evaluation criteria (C1, C2, C3, C5, C6) and three supplier alternatives (SB1, SB2, SB3), the analysis ranked SB2 the highest with a total score of 0.396, followed by SB3 (0.360) and SB1 (0.244). This ranking reflects the company's emphasis on criteria C5 (green certification) and C6 (green compliance).

Table 9: Total scores of supplier alternatives (Company BBB)

Alternative	C1	C2	C3	C5	C6	Total score	Priority
SB1	0.30	0.33	0.54	0.17	0.28	0.244	3
SB2	0.16	0.30	0.30	0.46	0.39	0.396	1
SB3	0.54	0.37	0.16	0.38	0.34	0.360	2

For Company CCC, which used five evaluation criteria (C1, C2, C4, C5, C6) and three supplier alternatives (SC1, SC2, SC3), the analysis ranked SC2 the highest with a total score of 0.399, followed by SC3 (0.336) and SC1 (0.265).

Table 10: Total scores of supplier alternatives (Company CCC)

Alternative	C1	C2	C4	C5	C6	Total score	Priority
SC1	0.46	0.33	0.30	0.17	0.39	0.265	3
SC2	0.28	0.30	0.54	0.46	0.28	0.399	1
SC3	0.27	0.37	0.16	0.38	0.34	0.336	2

The AHP analysis of green supplier selection across the three companies highlights a clear emphasis on environmental criteria. The most important criterion is green certification (C5), which received the highest importance weights in all companies: Company AAA (0.407), Company BBB (0.459), and Company CCC (0.460), indicating that decision-makers prioritize official standards and certifications. The selected suppliers are SA3 for Company AAA (0.378), SB2 from Company BBB (0.396), and SC2 from Company CCC (0.399). All the results passed the consistency checks ($CR < 0.10$), confirming the reliability of the analysis, as summarized in Table 11.

Table 11: Green supplier ranking summary

Company	Rank 1	Score	Rank 2	Score	Rank 3	Score
AAA	SA3	0.378	SA2	0.324	SA1	0.298
BBB	SB2	0.396	SB1	0.360	SB3	0.244
CCC	SC2	0.399	SC3	0.336	SC1	0.265

5. DISCUSSION AND CONCLUSION

5.1 Criteria comparison

An analysis of the relative importance of green supplier selection criteria using a radar chart (Figure 3) revealed that the criteria can be classified into three main levels of importance:

1) The high importance criteria group

This group includes green certification (C5) and green compliance (C6). Green certification (C5) emerges as the most important criterion across all companies, with Company CCC assigning the highest weight (46.0%), followed by Company BBB (45.9%) and Company AAA (40.7%). A similar pattern is observed for green compliance (C6), where Company CCC again assigns the highest importance (29.5%), followed by Company BBB (27.7%) and Company AAA (25.7%). The consistently high weights assigned to these criteria highlight the critical role of regulatory compliance and adherence to recognized standards in the food packaging industry.

2) The moderate-importance criteria group

This group includes green raw materials usage (C1) and green image (C4). For green raw materials usage (C1), all companies assign comparable importance levels, with Company CCC ranking it the highest (14.5%), followed by Company BBB (12.8%) and Company AAA (12.1%). This consistency reflects a shared recognition of the importance of environmentally friendly raw materials. In contrast, the green image criterion (C4) shows notable variations: Company AAA assigns relatively high importance (14.7%), while Company CCC assigns a lower weight (8.2%). Company BBB does not consider this criterion, indicating differing strategic priorities regarding corporate environmental image.

3) The low-importance criteria group

This group includes green products (C2) and green service quality (C3). These criteria are not considered by all companies. Notably, Company CCC does not include green service quality (C3) in its evaluation. The selective consideration of these criteria suggests variations in supplier management strategies and differing perceptions of their relevance to overall sustainability objectives.

When compared with international best practices, the strong emphasis in this study on green certification (C5: 40.7%–46.0%) and green compliance (C6: 25.7%–29.5%) aligns with global trends in which formal environmental standards have become fundamental requirements in supplier selection (Zhang et al., 2020). However, international markets generally place greater importance on green raw materials and circular economy principles than is observed in this study (Afif et al., 2022; Pålsson & Sandberg, 2022; Rezaei et al., 2019). This contrast suggests that Thai food packaging companies remain largely in a compliance-oriented phase of sustainability adoption, whereas leading international markets have advanced toward innovation-driven sustainability models that emphasize material innovation and collaborative supplier development (Cui et al., 2023; Ecer, 2022).

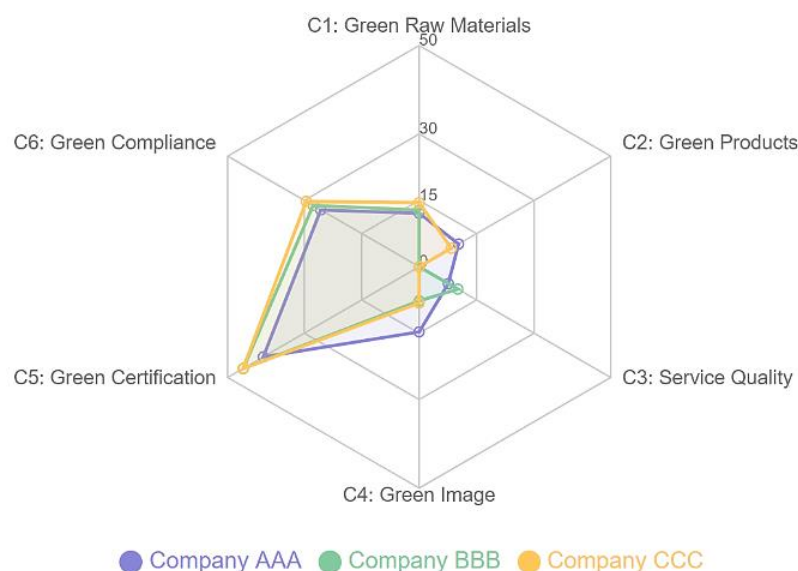


Figure 3: Comparison of criteria across three companies

5.2 Alternative comparison

The results of the alternative comparison analysis revealed distinct supplier selection patterns across the three companies, reflecting each firm's approach to selecting environmentally sustainable suppliers (Figure 4). For Company AAA, SA3 ranked first with an overall score of 0.378, followed by SA2 (0.324) and SA1 (0.298). The relatively small score differentials suggest a steady decrease in performance across the three alternatives. In Company BBB, supplier performance was more uneven. SB2 achieved the highest score (0.396), narrowly outperforming SB1 (0.360), while SB3 significantly underperformed with a score of 0.244. This outcome indicates a substantial gap between the lower-ranked supplier and the two leading alternatives. Company CCC displayed a similar ranking pattern, with SC2 emerging as the top supplier at 0.399 (the highest score observed in this study), followed by SC3 (0.336) and SC1 (0.265), reflecting a marked drop in performance at the lowest rank.

The cross-company comparison further showed that SC2 from Company CCC achieved the highest overall score (0.399), making it the leading green supplier across all cases. This was closely followed by SB2 from Company BBB (0.396) and SA3 from Company AAA (0.378). The minimal difference among the top-ranked suppliers (0.021 points) indicates that leading alternatives demonstrate similar environmental performance. In contrast, notable disparities appear within individual companies, particularly in Company BBB, where the gap between the second- and third-ranked suppliers reaches 0.116 points, and in Company CCC, where the corresponding difference is 0.071 points. Moreover, all pairwise comparisons met the acceptable consistency threshold ($CR < 0.10$), supporting the robustness of the results. The consistent prominence of green certification (C5) as the dominant evaluation criterion across all companies further emphasizes the importance of formal environmental standards in green supplier selection.

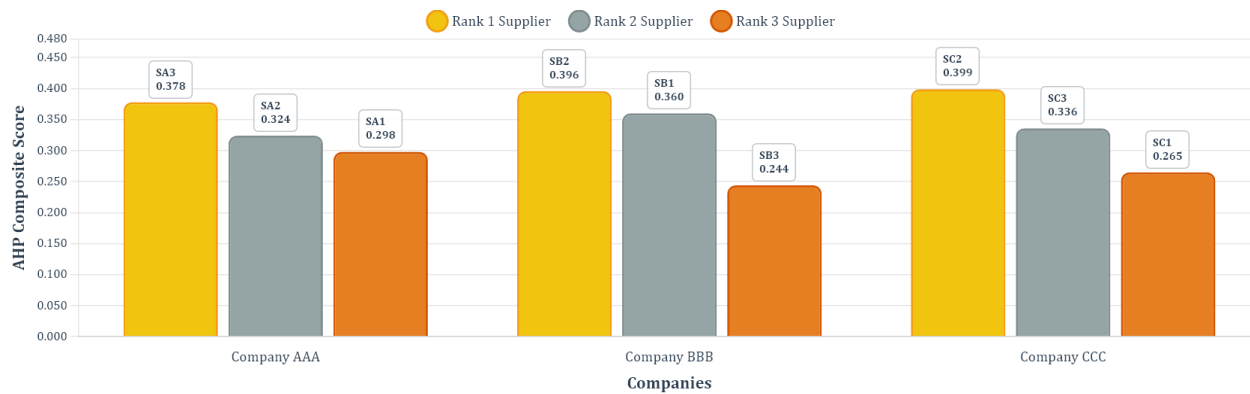


Figure 4: Green supplier performance comparison by company

5.3 Study limitations

This research includes several limitations that should be acknowledged. First, the sample only consisted of eight executives from three food packaging companies located in Bangkok and the surrounding province of Samut Sakhon, which may limit the generalizability of findings to other regions or larger organizational contexts. Second, this study's geographic focus on Bangkok and nearby areas may have overlooked regional differences in green supplier selection priorities across Thailand. Third, the data collection period (May 1 to July 31, 2025) represents a specific timeframe and may not capture seasonal effects or evolving market conditions that influence supplier evaluation criteria. Fourth, this study exclusively focused on the food packaging industry, limiting the applicability of the results to other manufacturing sectors with distinct environmental requirements. Finally, although the Delphi method is effective for achieving expert consensus, the results may be influenced by the composition and professional backgrounds of the participating executives.

6. IMPLICATIONS AND RECOMMENDATIONS

6.1 Academic implications

This study makes meaningful theoretical contributions across several academic disciplines. From a supply chain management perspective, it extends the traditional supplier selection literature by explicitly incorporating environmental sustainability criteria into the decision-making framework. Whereas conventional supplier selection models have largely emphasized cost, quality, delivery, and service performance (de Boer et al., 2001; Konys, 2019), this research demonstrates how environmental considerations can be systematically integrated alongside economic and operational factors.

From a decision science perspective, this study contributes to the multicriteria decision-making (MCDM) literature (Govindan et al., 2015) by illustrating the practical application of the AHP in complex, sustainability-driven business decisions. In particular, the findings support Saaty's (2008) hierarchical decision-making framework within a real-world industrial setting, providing empirical evidence of the AHP's effectiveness in managing trade-offs among conflicting criteria, especially where environmental and economic objectives may not fully align.

6.2 Industry implications

This research offers food packaging manufacturers with a structured decision-making framework that converts traditionally subjective supplier selection practices into objective, data-driven evaluations. This framework allows companies to simultaneously assess suppliers across multiple dimensions, integrating environmental impact with conventional performance measures such as cost and quality. For supply chain managers, the AHP-based approach provides a transparent and defensible method for justifying supplier selection decisions to key stakeholders, including customers who are increasingly attentive to environmental sustainability. Its mathematical foundation strengthens the credibility of strategic procurement decisions, which is particularly critical in business-to-business (B2B) contexts where supply chain transparency is increasingly expected.

Despite these benefits, several barriers may hinder practical implementation. Financial constraints associated with the premium pricing of sustainable materials often require phased adoption strategies and the effective use of government incentives (Agyabeng-Mensah et al., 2020; Pålsson & Sandberg, 2022). Limited availability of qualified green suppliers highlights the need for broader sourcing efforts or targeted supplier

development programs (Althabatah et al., 2023; Rashidi et al., 2020). Additionally, gaps in reverse logistics infrastructure call for collaborative investment initiatives (Paula et al., 2020), while organizational resistance underscores the importance of change management practices and cross-functional coordination (Ahmad et al., 2023). When systematically addressed, these challenges can be transformed from operational obstacles into sources of competitive advantage.

6.3 Environmental and social implications

This research directly supports the transition toward circular economy principles by encouraging supplier selection practices that emphasize resource efficiency, waste reduction, and material recyclability. From a systems-thinking perspective, it contributes to closing material loops within food packaging supply chains by incentivizing suppliers to design for recyclability, increase the use of recycled content, and minimize packaging waste. Moreover, the framework's emphasis on life-cycle thinking prompts companies to evaluate environmental impacts beyond immediate manufacturing activities, extending consideration to raw material extraction, transportation, product use, and end-of-life management. By adopting this holistic approach, firms are better positioned to identify opportunities for environmental improvement across the entire value chain. This approach also aligns with the circular economy principles articulated by the Ellen MacArthur Foundation (MacArthur, 2013) and supports the advancement of regenerative and sustainable business models.

6.4 Policy development implications

This research provides empirical evidence to support policy development in sustainable procurement and supply chain regulation. Policymakers can leverage the framework's criteria and methodology to establish standards for green public procurement, environmental reporting, and supply chain sustainability mandates. By adopting systematic frameworks like the one developed in this study, industries can move toward harmonized sustainability standards, replacing fragmented approaches with consistent regulatory requirements and clear benchmarks.

To further accelerate the adoption of green logistics in food packaging supply chains, governments should implement multifaceted policy interventions that combine regulatory measures with financial incentives. Previous studies have demonstrated that subsidies, grants, and tax credits can significantly improve the financial feasibility of implementing green logistics practices (Kim et al., 2024; Zhang et al., 2023). By integrating such support with standardized frameworks, policymakers can foster both compliance and innovation in sustainable supply chain practices.

6.5 General recommendations

This study demonstrates the effectiveness of the AHP in green supplier selection decisions. Managers and entrepreneurs are encouraged to apply these findings in practice, particularly the key insight that green certification (C5) carries the highest importance across all companies, highlighting the critical role of formal environmental standards in quality assurance.

Organizations should establish systematic supplier evaluation systems using similar approaches, tailoring the importance weights of criteria to their specific industry context. This study's consistency ratio values ($CR < 0.10$) confirm the reliability of the results, supporting their application in real-world decision-making. In addition, entrepreneurs should also focus on developing existing suppliers to meet green standards, rather than entirely replacing them, as a means of promoting supply chain sustainability. Integrating environmental criteria with traditional factors, such as cost, quality, and delivery (Govindan et al., 2015; Konys, 2019; Mabrouk, 2021; Wei et al., 2021), can help companies balance environmental responsibility with business performance.

6.6 Recommendations for future research

Future research should broaden the scope of this study by including a larger number of companies to enhance the reliability of the results and enable more widely applicable conclusions. Comparing the findings across different industries can provide insights into the distinct environmental priorities of each sector. Cross-industry analyses, such as between food packaging, automotive, electronics, and pharmaceutical industries, could identify industry-specific criterion weights and support the development of adaptable green supplier selection frameworks. Furthermore, adopting mixed-methods approaches that incorporate qualitative analysis would help uncover the reasoning behind expert decisions. Research examining the long-term impacts of green supplier selection on both organizational performance and environmental outcomes would also be valuable. Developing decision-support tools that integrate real-time data and accommodate multiple criteria can facilitate practical application by managers and entrepreneurs. Finally, future studies should explore the application of other MCDM methods (Govindan et al., 2015; Ortiz-Barrios et al., 2020; Utama, 2021; Yazdani et al., 2017), such as TOPSIS, ELECTRE, or PROMETHEE, to compare their performance and suitability in different contexts.

DECLARATION

1. Conflict of interest

The author declares no conflict of interest.

2. Generative AI and AI-assisted technologies in the writing process

In the course of preparing this manuscript, the authors made use of QuillBot as a supplementary tool for identifying grammatical errors and improving textual clarity. All outputs generated by this tool were carefully examined and revised by the author, who retains complete accountability for the content presented in this publication.

3. Data availability statement

The data supporting the findings of this study are contained within the manuscript.

4. Ethics statement

This research was approved by the Ethics Committee in Human Research (SURIC), Silpakorn University, with approval number COE 67.0712-043, dated 12 July 2024. All procedures were conducted in accordance with the applicable ethical standards and regulations.

5. Funding

This research was financially supported by the Research, Innovation, and Creation Support Fund of the Faculty of Management Science, Silpakorn University.

6. Contributor Role Taxonomy (CRediT)

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