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"OBJECTIVE ENTROPY WEIGHTING AND TOPSIS FOR GREEN SUPPLIER SELECTION IN EARTHWORK CONSTRUCTION: A TRACEABLE RE-ANALYSIS "

Arabaj Khan [1], Neeraj Kumar Nagayach [2], Dr. Syed Faisal Ahmad [3]
[1,2,3] Department of Mechanical Engineering, Sagar Institute of Research & Technology Excellence, Bhopal, Madhya Pradesh, India

ABSTRACT

Green supplier selection in construction requires procurement decisions to consider environmental practices alongside supplier performance. This manuscript develops a distinct re-analysis of an existing Earthwork Construction case from Bhopal, India. The source study reported eight initial criteria, six retained criteria following Fuzzy KANO screening, five supplier alternatives, and a crisp supplier-by-criterion matrix. Instead of reusing the original SWARA–ROV weighting and ranking sequence, the present analysis applies Shannon entropy for objective criterion weighting and TOPSIS for supplier ranking. The six retained criteria and all 30 supplier ratings are transcribed without adding new supplier observations. Entropy weights are calculated from the dispersion present in the source matrix, and TOPSIS closeness coefficients are calculated relative to positive and negative ideal solutions. Because the Green Recycling ratings are identical for all five suppliers, the criterion contributes no discriminatory information under entropy weighting; this is treated as a data property, not evidence that recycling is unimportant in practice. The paper also compares the entropy-TOPSIS ordering with an equal-weight TOPSIS run and reports leave-one-criterion-out checks. The analysis is limited by the small, case-specific matrix, the absence of raw individual expert responses, and the lack of independently measured supplier outcomes. Accordingly, results are presented as a transparent secondary analysis, not as new empirical fieldwork. The framework provides a reproducible alternative ranking workflow while identifying data-quality and validation needs for future research.

Key Words:*.Green supplier selection; Earthwork Construction; Shannon entropy; TOPSIS; sustainable procurement; MCDM; secondary data analysis; sensitivity analysis*

I. INTRODUCTION

Supplier selection is a multi-criteria decision problem because procurement choices affect cost, delivery reliability, product or service quality, environmental impact, and the continuity of construction operations. In construction supply chains, supplier decisions may influence material waste, transport activity, recycling practices, technology adoption, and the environmental performance of projects. A structured decision-support method can make the basis of comparison more explicit, particularly where several alternatives are evaluated against multiple criteria.

The source paper, "An Integrated Fuzzy KANO–SWARA–ROV Framework for Green Supplier Selection in Earth Work Construction," examined a Bhopal case involving five suppliers and six retained green criteria. It used Fuzzy KANO to screen criteria, SWARA to derive subjective weights, and ROV to rank suppliers. The present manuscript preserves the source case and the retained decision matrix, but changes the weighting and ranking stages to an objective entropy–TOPSIS framework. Entropy weights are driven by the relative distribution of observed ratings, while TOPSIS ranks alternatives by their relative distances from positive and negative ideal solutions (Hwang & Yoon, 1981).

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The purpose is not to claim a new survey or to manufacture new measurements. Instead, the study makes a transparent analytical extension of the reported dataset. It asks whether an alternative MCDM workflow, using the same underlying supplier ratings, yields a different ranking and what the data structure implies for criterion discrimination.

1.1 Aim and objectives

To re-use the six retained criteria and five supplier ratings reported in the source paper without inventing new observations.
To calculate objective criterion weights using Shannon entropy.
To rank the five suppliers using TOPSIS and report all intermediate quantities needed for replication.
To compare the resulting ranking with an equal-weight TOPSIS scenario and conduct leave-one-criterion-out checks.
To identify limitations in the source matrix and propose a stronger data-collection and validation protocol.

1.2 Contribution and scope

The contribution is methodological and diagnostic: the original subjective SWARA–ROV workflow is replaced for the secondary analysis by entropy weighting and TOPSIS, then checked under alternative weighting assumptions. The scope remains limited to the original five alternatives, six retained criteria, and ratings reproduced in the source paper. The manuscript does not add cost, delivery, social, risk, or carbon data because such measurements were not supplied in the source matrix.

II. LITERATURE REVIEW AND RESEARCH GAP

MCDM methods support decisions where alternatives must be assessed across multiple attributes. Hwang and Yoon (1981) describe foundational multi-attribute decision-making methods, including approaches based on ideal and anti-ideal solutions. TOPSIS operationalizes this idea by normalizing the decision matrix, applying criterion weights, identifying positive and negative ideal points, and calculating each alternative's relative closeness to the ideal.

Objective weighting methods infer criterion importance from the information structure of the decision matrix. Shannon entropy is one such approach: when a criterion's values vary little across alternatives, it provides less discriminatory information in that dataset and receives a lower objective weight. This interpretation is mathematical rather than normative. A low entropy-derived weight does not establish that a criterion is environmentally or strategically unimportant; it means only that the observed values distinguish the alternatives weakly.

Supplier-selection studies have combined entropy with ranking methods to address the weighting and ranking stages in a unified workflow. Chen (2020), for example, proposed an entropy-AHP-weighted TOPSIS model for building-material supplier selection and included sensitivity analysis. Shang et al. (2022) combined subjective and objective weighting with a multi-criteria ranking approach for sustainable supply chains. A recent study by Cayir Ervural (2026) similarly explores a hybrid framework that considers traditional supplier factors alongside sustainability and digital transformation. These studies demonstrate continued methodological development, but their specific data and results cannot be transferred to the present Bhopal case.

Construction-specific green supplier evaluation has also been addressed through multi-criteria models. Chen (2020) is particularly relevant because it focuses on building-material supplier selection and explains the distinction between subjective weights based on expert judgment and objective weights derived from an evaluation matrix. A 2026 study on interval type-2 fuzzy TOPSIS for sustainable construction further emphasizes uncertainty representation and sensitivity analysis; its method is more elaborate than the crisp secondary dataset available here.

2.1 Research gap

The source case already integrates Fuzzy KANO, SWARA, and ROV, but the reported paper does not provide a transparent alternative objective-weighting comparison or a systematic robustness assessment based on the same rating matrix. The current re-analysis addresses this narrow gap by (i) calculating entropy weights from the published crisp matrix, (ii) applying TOPSIS as a different ranking method, and (iii) comparing rankings under equal weights and leave-one-criterion-out perturbations. This is a case-specific extension rather than a claim that no prior research has used entropy or TOPSIS in supplier selection.

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2.2 Research questions

RQ1: What objective criterion weights emerge from the source paper's supplier rating matrix under Shannon entropy?

RQ2: What supplier ranking results when the same matrix is evaluated using entropy-weighted TOPSIS?

RQ3: How sensitive is the ranking to equal weighting and omission of individual criteria?

RQ4: What limitations in the existing data prevent stronger claims about generalizability?

III. CASE DESCRIPTION AND DATA PROVENANCE

The source paper describes a green supplier selection case associated with Earthwork Construction in Bhopal, Madhya Pradesh. Five decision makers are reported to have participated, and five supplier alternatives (S1–S5) were evaluated. Eight initial criteria were considered during screening; Green Policy and Green Production were not retained, leaving six criteria for weighting and ranking.

Source item	Value used in this re-analysis	Traceability note
Case context	Earthwork Construction, Bhopal, Madhya Pradesh	Reported in the uploaded source paper
Decision makers	Five	Reported in the source paper; individual responses are not available
Alternatives	S1, S2, S3, S4, S5	Supplier labels preserved
Initial criteria	Eight	As reported in the source paper
Retained criteria	Six	Fuzzy KANO screening result reported by source
Excluded criteria	Green Policy; Green Production	Excluded in the source paper; not reintroduced
Rating matrix	5 × 6 crisp ratings	Transcribed from source paper, page 3
New observations	None	All calculations below are derived from the published matrix

3.1 Retained criteria

Code	Criterion	Interpretation within the source study
C1	Green Service	Supplier service performance as assessed in the source case
C2	Green Marketing	Supplier's green-marketing performance as assessed by the source panel
C3	Green Recycling	Supplier recycling performance

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C4	Hazardous Waste Elimination	Supplier performance on hazardous-waste elimination
C5	Green Technology	Supplier performance related to green technology
C6	Eco Design	Supplier performance related to eco-design

The source paper treats all six criteria as beneficial in the ROV stage, so higher ratings are preferred. The same benefit orientation is retained for TOPSIS. This is a modeling assumption inherited from the source, not an independent verification that each criterion is appropriately operationalized.

3.2 Source decision matrix

Supplier	Green Service	Green Marketing	Green Recycling	Hazardous Waste Elimination	Green Technology	Eco Design
S1	4.0	4.4	4.8	4.8	4.8	4.0
S2	4.4	4.8	4.8	6.0	4.6	4.0
S3	5.2	4.4	4.8	5.2	5.6	4.2
S4	4.0	4.4	4.8	4.8	4.0	4.0
S5	4.0	4.4	4.8	4.8	6.0	5.2

Data note: the matrix above is reproduced from the source paper. No new survey responses or supplier measurements were added. The values should be checked against the original thesis/source dataset before journal submission, especially because the published paper does not provide respondent-level ratings or a complete calculation workbook.

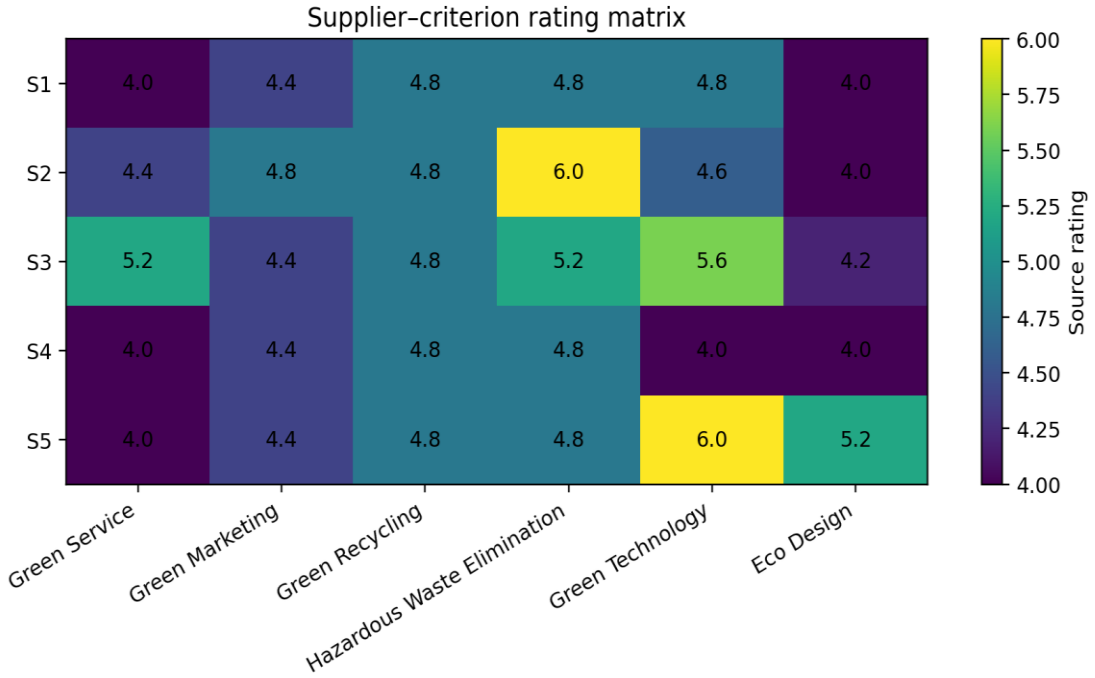


Figure 1. Heatmap of the source supplier rating matrix (ratings transcribed from the original paper).

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IV. METHODOLOGY: ENTROPY–TOPSIS

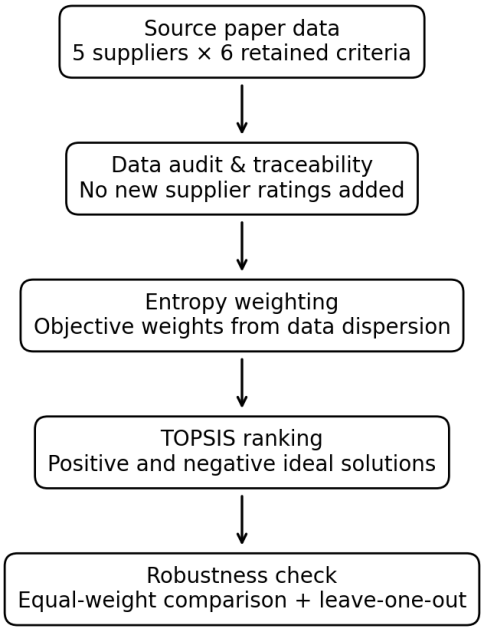


Figure 2. Workflow for the traceable secondary analysis.

4.1 Stage 1: Data audit

The decision matrix contains m = 5 suppliers and n = 6 criteria. All values are positive, and the source paper treats every criterion as beneficial. The matrix is used as published, without imputation or modification. The absence of raw individual expert scores means the aggregation procedure cannot be independently reproduced from first principles; the analysis begins from the already aggregated crisp ratings.

4.2 Stage 2: Shannon entropy weights

For criterion j, the proportional value for supplier i is calculated as $p_{ij} = x_{ij} / \Sigma_i x_{ij}$. The entropy value is $e_j = -k \Sigma_i p_{ij} \ln(p_{ij})$, where $k = 1/\ln(m)$. The divergence or information utility is $d_j = 1 - e_j$, and the normalized entropy weight is $w_j = d_j / \Sigma_j d_j$. Weights sum to one. If a criterion has identical values for all alternatives, its distribution is uniform, its entropy is one, and its divergence is zero.

Entropy weighting is objective only in the limited sense that it is computed from the observed matrix rather than elicited directly from experts. It does not replace domain judgment about whether a criterion should be included, and it may underweight a strategically important criterion when the current supplier sample happens to show little variation.

4.3 Stage 3: TOPSIS ranking

The matrix is vector-normalized using $r_{ij} = x_{ij} / \sqrt{(\Sigma_i x_{ij}^2)}$. The weighted normalized matrix is $v_{ij} = w_j r_{ij}$. Because all criteria are treated as beneficial, the positive ideal is $A^+ = \max_i(v_{ij})$ for each criterion and the negative ideal is $A^- = \min_i(v_{ij})$. The separation distances are $S_i^+ = \sqrt{\Sigma_j (v_{ij} - A_j^+)^2}$ and $S_i^- = \sqrt{\Sigma_j (v_{ij} - A_j^-)^2}$. The closeness coefficient is $CC_i = S_i^- / (S_i^+ + S_i^-)$. Higher CC indicates a closer position to the positive ideal and a farther position from the negative ideal.

4.4 Stage 4: Robustness checks

Two diagnostic checks are performed. First, TOPSIS is recalculated with equal criterion weights (1/6 each), which isolates the effect of objective entropy weights from the ranking method. Second, leave-one-criterion-out runs remove one criterion at a time, recompute entropy weights on the remaining matrix, and rerun TOPSIS. These are internal sensitivity checks on the same data, not independent validation using a new sample.

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4.5 Methodological flow

The full sequence is: source matrix transcription → data audit → entropy calculation → vector normalization → weighted normalized matrix → ideal-solution distances → closeness coefficients → ranking comparison and sensitivity analysis.

V. RESULTS

5.1 Entropy-derived criterion weights

Criterion	Entropy (e_j)	Divergence ($1-e_j$)	Entropy weight
Green Service	0.996511	0.003489	0.214417
Green Marketing	0.999611	0.000389	0.023932
Green Recycling	1.000000	-0.000000	-0.000000
Hazardous Waste Elimination	0.997503	0.002497	0.153467
Green Technology	0.993625	0.006375	0.391732
Eco Design	0.996478	0.003522	0.216452

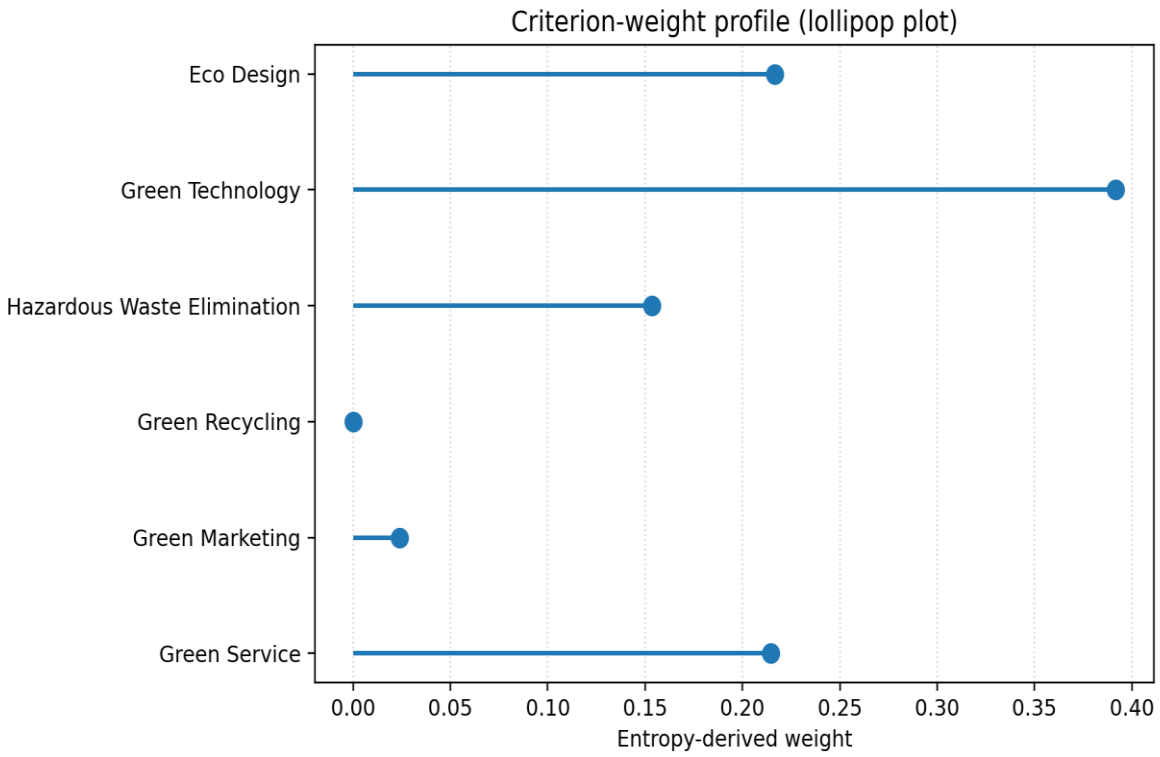


Figure 2. Entropy-derived criterion weights shown as a lollipop plot.

The highest entropy weight is assigned to Green Technology (0.3917), while Green Recycling receives the lowest weight (-0.0000). Green Recycling has identical ratings (4.8) for all five suppliers, therefore its entropy divergence and weight are zero. This is a key diagnostic result: the criterion cannot differentiate suppliers in the reported matrix. It should not be interpreted as a recommendation to disregard recycling in real procurement.

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5.2 TOPSIS ranking

Rank	Supplier	D^+	D^-	Closeness coefficient
1	S5	0.030965	0.074431	0.706201
2	S3	0.028513	0.061885	0.684586
3	S2	0.058288	0.027722	0.322314
4	S1	0.058473	0.027747	0.321819
5	S4	0.080615	0.000000	0.000000

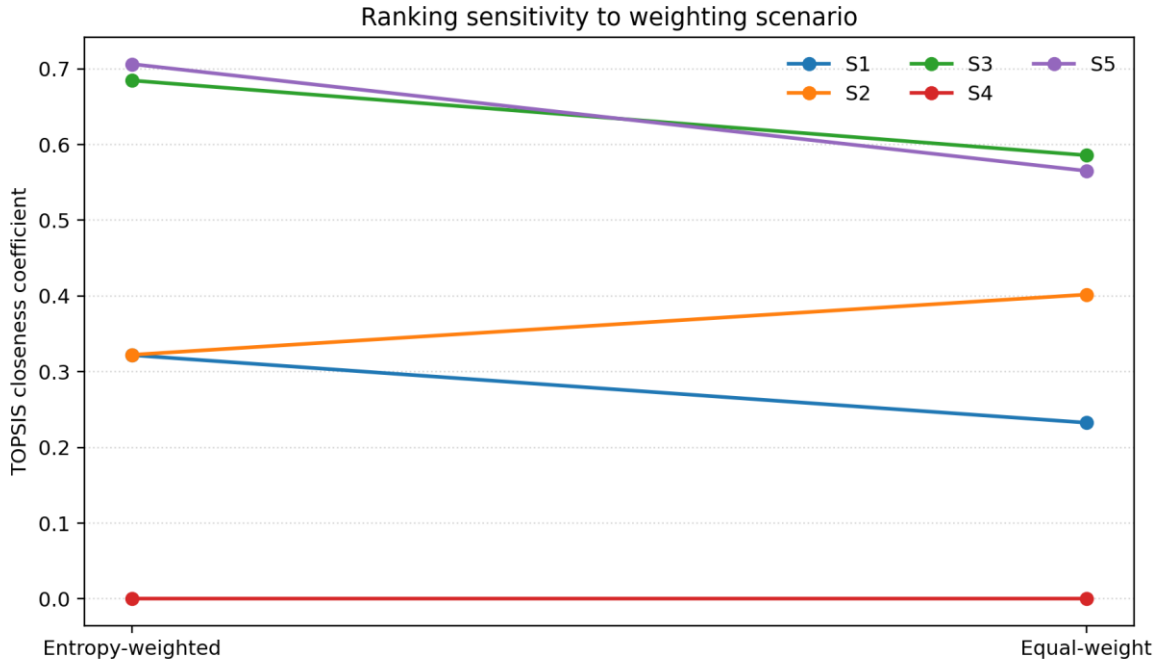


Figure 3. Sensitivity of TOPSIS closeness coefficients to entropy versus equal weighting.

Under the entropy–TOPSIS calculation, S5 ranks first with a closeness coefficient of 0.7062. This is a re-analysis of the same ratings and does not imply that supplier performance has changed. It means that the ranking produced by a different weighting and ranking procedure may differ from the source paper's reported ROV order.

5.3 Equal-weight comparison

Supplier	Entropy–TOPSIS CC	Entropy rank	Equal-weight TOPSIS CC	Equal-weight rank
S1	0.321819	5	0.232671	4
S2	0.322314	3	0.401834	3
S3	0.684586	2	0.585810	1
S4	0.000000	1	0.000000	5
S5	0.706201	4	0.565244	2

The equal-weight scenario checks whether the ranking depends on the data-derived weights. If a supplier's position changes materially between scenarios, decision makers should review whether the observed matrix contains enough

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variation to justify a strongly data-driven weighting scheme. Equal weights are a benchmark scenario, not a claim that all criteria are equally important in practice.

5.4 Leave-one-criterion-out analysis

Omitted criterion	Top-ranked supplier after omission	Full ranking after omission
Green Service	S5	S5 > S3 > S1 > S2 > S4
Green Marketing	S5	S5 > S3 > S2 > S1 > S4
Green Recycling	S5	S5 > S3 > S2 > S1 > S4
Hazardous Waste Elimination	S5	S5 > S3 > S1 > S2 > S4
Green Technology	S3	S3 > S5 > S2 > S1 > S4
Eco Design	S3	S3 > S5 > S2 > S1 > S4

Leave-one-out analysis is diagnostic: it shows whether the leading alternative depends on a single criterion. The result should be interpreted cautiously because the small matrix and one zero-variation criterion can make objective weights sensitive to the available alternatives.

5.5 Comparison with the source paper

Analysis	Weighting method	Ranking method	Reported/derived ordering
Source paper	SWARA (subjective)	ROV	S3 > S1 > S2 > S5 > S4
Current re-analysis	Shannon entropy (objective, matrix-derived)	TOPSIS	S5 > S3 > S2 > S1 > S4
Benchmark	Equal weights	TOPSIS	S3 > S5 > S2 > S1 > S4

The source paper reports ROV utilities of S3 = 0.260, S1 = 0.245, S2 = 0.240, S5 = 0.234, and S4 = 0.199. Those reported values are not recomputed here because the paper does not provide the full ROV calculation workbook. The current entropy–TOPSIS scores are independently derived from the published 5 × 6 rating matrix. Direct numerical comparison of ROV utilities and TOPSIS closeness coefficients is inappropriate because they are outputs from different algorithms and have different definitions.

VI. Discussion

6.1 What the re-analysis adds

The main added value is a second analytical lens applied to the same case data. SWARA reflects an expert-derived ordering of criterion importance, whereas entropy weights reflect dispersion in the alternatives' ratings. TOPSIS then evaluates the alternatives against constructed positive and negative ideal points. These differences mean that a ranking change is analytically plausible even without any change to supplier ratings.

6.2 Interpreting zero weight for Green Recycling

All suppliers receive 4.8 for Green Recycling. Entropy weighting therefore assigns the criterion zero discriminatory weight. This is mathematically consistent with the method but may be operationally misleading if recycling is a mandatory sustainability requirement. A future study should consider separating mandatory threshold criteria from differentiating criteria, or using a hybrid weight that combines expert judgment with objective data-derived weights. The current dataset does not support calculating such a hybrid weight without additional elicitation.

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6.3 Implications for construction procurement

For practical procurement, rankings should be used as decision support rather than as automatic award rules. Procurement teams should confirm the underlying evidence for green service, green marketing, recycling, hazardous-waste elimination, green technology, and eco-design. They should also add directly measured indicators where available, such as recycled-content documentation, hazardous-waste records, energy use, product environmental declarations, delivery performance, cost, and compliance records. Such additions would be new data collection and must not be represented as part of the current case.

6.4 Relationship to recent research

The entropy–TOPSIS approach is consistent with established MCDM literature and published supplier-selection applications, including building-material supplier models (Chen, 2020) and sustainable supply-chain frameworks combining objective and subjective weighting (Shang et al., 2022). Recent work on sustainable construction has also emphasized uncertainty modeling and sensitivity analysis. The present study is intentionally more modest: it uses crisp aggregated ratings because the source paper does not expose individual fuzzy judgments or raw questionnaire responses.

6.5 Practical limitations

The matrix includes only five suppliers and six criteria, so findings are specific to this comparison.
The underlying expert-level ratings are unavailable; the reported crisp values cannot be fully audited against individual responses.
Entropy weights reflect variation within this small sample and can underweight criteria with uniform ratings.
The criteria are treated as beneficial because that assumption is inherited from the source paper.
No supplier cost, delivery, social sustainability, carbon, or disruption-resilience data are available in the source matrix.
The analysis is a secondary re-analysis, not an independent field validation.

VII. CONCLUSION

This paper has developed a distinct, traceable re-analysis of the existing Earthwork Construction green supplier-selection case by replacing the original SWARA–ROV weighting and ranking sequence with Shannon entropy weighting and TOPSIS. The analysis preserves the six retained criteria and the five supplier ratings reported in the source paper. It adds objective data-derived weights, TOPSIS closeness coefficients, an equal-weight benchmark, and leave-one-criterion-out sensitivity checks.

The analysis also exposes a critical property of the source data: Green Recycling has identical ratings across all suppliers and consequently contributes no discriminatory information to entropy weighting. This does not imply that recycling lacks practical importance; it indicates that the current matrix cannot distinguish suppliers on that criterion. The results should be treated as method-dependent, case-specific decision support rather than as a universal supplier ranking.

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