



IJRTSM

INTERNATIONAL JOURNAL OF RECENT TECHNOLOGY SCIENCE & MANAGEMENT

“AN INTEGRATED FUZZY KANO–SWARA–ROV FRAMEWORK FOR GREEN SUPPLIER SELECTION IN EARTH WORK CONSTRUCTION”

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 is a multi-criteria decision problem in which environmental performance must be considered along with the practical requirements of procurement. This study develops and applies an integrated Fuzzy KANO–SWARA–ROV framework for green supplier evaluation in Earth Work Construction, Bhopal, Madhya Pradesh. Eight initial green supplier criteria were considered and a panel of five decision makers participated in the assessment. Fuzzy KANO was used to screen the criteria under vagueness and imprecision in expert judgments. Six criteria were retained: Green Service, Green Marketing, Green Recycling, Hazardous Waste Elimination, Green Technology and Eco Design. SWARA was then used to determine criterion weights, with Green Service receiving the highest weight of 0.226. Finally, ROV was applied to evaluate five supplier alternatives. The resulting preference order was S3 (0.260), S1 (0.245), S2 (0.240), S5 (0.234) and S4 (0.199). The results demonstrate that the integrated framework provides a structured, case-specific decision-support mechanism for green supplier comparison in construction procurement. The findings depend on the selected case, criteria and expert assessments and should therefore not be interpreted as a universal supplier ranking.

Key Words: Green supplier selection; Green supply chain management; Fuzzy KANO; SWARA; ROV; MCDM; Earth Work Construction; Sustainable procurement.

I. INTRODUCTION

Supplier selection is an important procurement decision because supplier practices can influence environmental performance, resource use, waste generation and overall supply-chain sustainability. Traditional supplier selection commonly emphasizes cost, quality and delivery, while green supplier selection introduces environmental and sustainability dimensions. In construction procurement, selecting suppliers according to multiple environmental criteria can be difficult because several criteria must be assessed simultaneously and expert judgments may be qualitative or imprecise.

The present study addresses this decision problem through an integrated three-stage MCDM framework. Fuzzy KANO is used for criterion screening, SWARA is used for criterion weighting, and ROV is used for supplier evaluation and ranking. The framework is demonstrated using green brick suppliers associated with an Earth Work Construction case study in Bhopal, Madhya Pradesh.

II. LITERATURE REVIEW & RESEARCH GAP

Previous green supplier-selection research has increasingly used hybrid MCDM approaches to combine criterion identification, weighting and supplier ranking. The thesis review identifies the importance of uncertainty handling,

<https://www.ijrtsm.com> © International Journal of Recent Technology Science & Management

context-specific criteria and integrated decision procedures. However, the reviewed studies also indicate a need for a structured screening stage and for practical integration of Fuzzy KANO, SWARA and ROV in the selected construction context.

Limited application to Earth Work Construction and comparable construction procurement in the Bhopal context.

Need for structured screening of significant green supplier criteria before weighting and ranking.

Need to represent uncertainty and vagueness in expert judgments.

Limited integration of Fuzzy KANO, SWARA and ROV in one green supplier-selection framework.

Need for practical supplier ranking using expert-based performance assessment.

Need for stronger sensitivity and robustness analysis in future work.

III. RESEARCH OBJECTIVE

1. Identify relevant green supplier evaluation criteria for the selected case.
2. Screen the initial criteria using Fuzzy KANO.
3. Determine the relative importance of retained criteria using SWARA.
4. Evaluate and rank alternative suppliers using ROV.
5. Demonstrate an integrated decision-support framework for green supplier selection.

IV. MATERIAL AND METHODOLOGY

The case study considers five alternative suppliers (S1–S5) and five decision makers from relevant management, consultancy, design, engineering and purchasing functions. Eight criteria were initially considered.

Initial criterion	Status after Fuzzy KANO
Green Service	Retained
Green Recycling	Retained
Green Technology	Retained
Hazardous Waste Elimination	Retained
Green Policy	Not retained
Eco Design	Retained
Green Marketing	Retained
Green Production	Not retained

4.1 Fuzzy KANO Screening

Fuzzy KANO was applied first because the study requires criterion screening while recognizing vagueness and imprecision in expert judgments. The process retained six criteria and excluded Green Policy and Green Production from the subsequent SWARA and ROV calculations.

4.2 SWARA Weighting

SWARA determines the relative importance of the retained criteria. The main calculation sequence is:

Arrange criteria in descending expected significance.

Determine comparative importance S_j , beginning with the second criterion.

Set $K_j = 1$ for the first criterion and $K_j = S_j + 1$ for subsequent criteria.

Set $Q_j = 1$ for the first criterion and $Q_j = Q_{j-1}/K_j$ thereafter.

Normalize the Q_j values using $w_j = Q_j / \sum Q_j$.

Criterion	SWARA weight
Green Service	0.226
Green Marketing	0.201
Green Recycling	0.174
Hazardous Waste Elimination	0.155
Green Technology	0.137
Eco Design	0.107

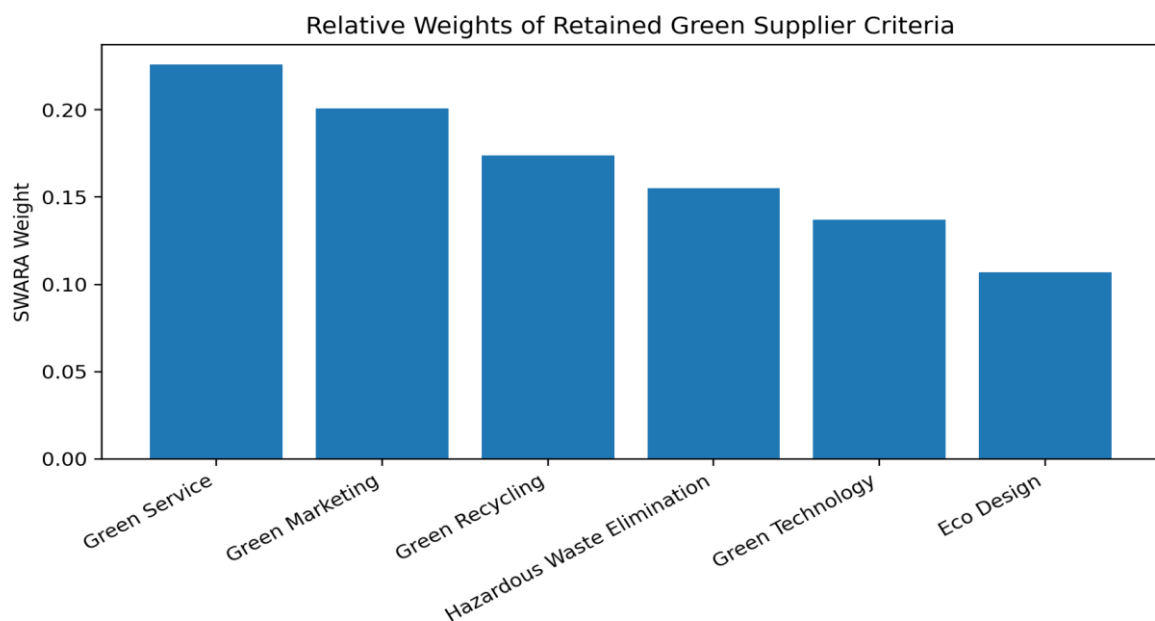


Figure 1. SWARA weights of the six retained green supplier criteria.

4.3 ROV Supplier Evaluation

After weighting, supplier performance was evaluated against the six retained criteria. The thesis reports crisp performance ratings aggregated using the average rule. All six retained criteria are treated as beneficial criteria in the ROV stage, meaning higher performance values are preferred.

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

For a beneficial criterion, the normalized value is calculated using the minimum and maximum performance values, producing values between 0 and 1. The normalized values are then multiplied by the corresponding SWARA weights.

The final ROV utility is based on the best and worst utility values obtained from the weighted normalized decision matrix.

V. RESULT AND DISCUSSION

Supplier	ROV utility	Rank
S3	0.260	1
S1	0.245	2
S2	0.240	3
S5	0.234	4
S4	0.199	5

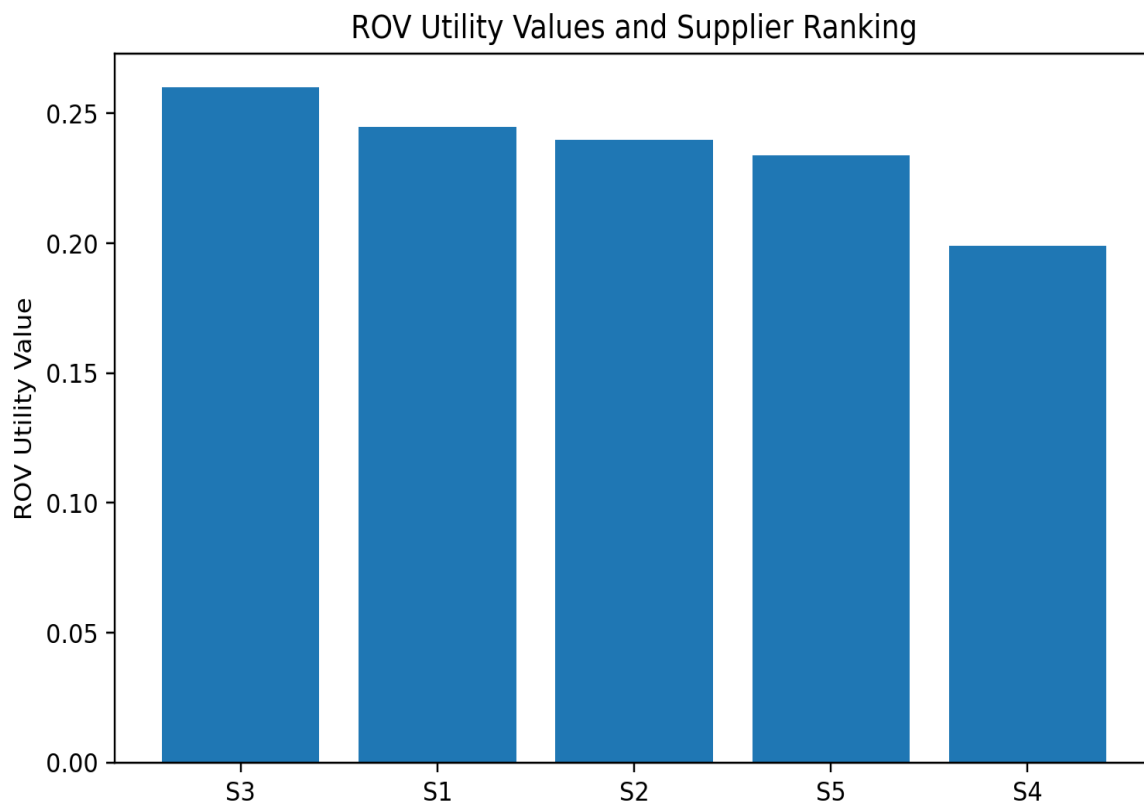


Figure 2. ROV utility values and supplier ranking.

S3 obtained the highest reported utility value of 0.260 and therefore occupies first position. S1 follows with 0.245, S2 with 0.240, S5 with 0.234 and S4 with 0.199. The difference between S3 and S1 is 0.015 utility points, while the difference between S1 and S2 is 0.005. Therefore, the ranking should be interpreted as a case-specific preference order based on the selected weights and expert ratings rather than as a measure of a large absolute difference in supplier quality.

VI. CONCLUSION

The study demonstrates the application of an integrated Fuzzy KANO–SWARA–ROV framework for green supplier selection in an Earth Work Construction case study. Fuzzy KANO reduced the initial eight criteria to six retained criteria; SWARA quantified their relative importance; and ROV produced a supplier preference order. Green Service received the highest weight (0.226), and S3 obtained the highest ROV utility (0.260). The framework therefore provides a structured case-specific decision-support mechanism for green supplier comparison. Because the results depend on the selected case, expert assessments and model assumptions, broader validation is required before generalizing the findings.

REFERENCES

- [1] Demir, G., & Chatterjee, P. (2025). Prioritizing sustainability criteria in green supplier selection using fuzzy logarithmic percentage change-driven objective weighting (FLOPCOW) method. *Journal of Intelligent Management Decision*, 4(3), 212–223. <https://doi.org/10.56578/jimd040303>
- [2] Hendiani, S., & Walther, G. (2025). Towards sustainable futures: Rethinking supplier selection through interval-valued intuitionistic fuzzy decision-making. *International Journal of Production Economics*, 285, 109620. <https://doi.org/10.1016/j.ijpe.2025.109620>
- [3] Raveena, R., & Umamaheswari, S. (2025). Integrated MCDM framework for sustainable pharmacy supplier selection using pioneering criteria with fuzzy TOPSIS SVR and GRA. *Scientific Reports*, 15, 19144. <https://doi.org/10.1038/s41598-025-02975-z>
- [4] Ulutaş, A., Topal, A., & Ecer, F. (2025). Green-resilient supplier selection via a new integrated rough multi-criteria framework. *Journal of Industrial Information Integration*, 47, 100913. <https://doi.org/10.1016/j.jii.2025.100913>
- [5] Sahoo, S. K., & Goswami, S. S. (2024). Green supplier selection using MCDM: A comprehensive review of recent studies. *Spectrum of Engineering and Management Sciences*, 2(1), 1–16. <https://doi.org/10.31181/sems1120241a>
- [6] Saputro, T. E., Rosiani, T. Y., Mubin, A., Dewi, S. K., & Baroto, T. (2024). Green supplier selection under supply risks using novel integrated fuzzy multi-criteria decision making techniques. *Journal of Cleaner Production*, 449, 141788. <https://doi.org/10.1016/j.jclepro.2024.141788>
- [7] Streimikis, J., Štreimikienė, D., Bathaei, A., & Bahramimianrood, B. (2024). Green supplier selection using advanced multi-criteria decision-making tools. *Information*, 15(9), 548. <https://doi.org/10.3390/info15090548>
- [8] Mirzaee, H., & Ashtab, S. (2024). Sustainability, resiliency, and artificial intelligence in supplier selection: A triple-themed review. *Sustainability*, 16(19), 8325. <https://doi.org/10.3390/su16198325>
- [9] Singh, A., Kumar, V., & Verma, P. (2023). Sustainable supplier selection in a construction company: A new MCDM method based on dominance-based rough set analysis. *Construction Innovation*, 25(2), 328–362. <https://doi.org/10.1108/CI-12-2022-0324>
- [10] Luo, X., Wang, Z., Yang, L., Lu, L., & Hu, S. (2023). Sustainable supplier selection based on VIKOR with single-valued neutrosophic sets. *PLOS ONE*, 18(9), e0290093. <https://doi.org/10.1371/journal.pone.0290093>
- [11] Agarwal, A., Pant, A., & Agarwal, M. (2023). Green supplier selection for manufacturing organization using a hybrid MCDM approach. *Journal of Statistics and Management Systems*, 26(3), 603–612. <https://doi.org/10.47974/JSMS-1050>
- [12] Zhang, Y., et al. (2023). Sustainable supplier selection using an intuitionistic and interval-valued fuzzy MCDM approach based on cumulative prospect theory. *Information Sciences*, 626, 710–737. <https://doi.org/10.1016/j.ins.2023.01.070>
- [13] Requirement-driven sustainable supplier selection: Creating an integrated perspective with stakeholders' interests and the wisdom of expert crowds. (2023). *Computers & Industrial Engineering*, 175, 108903. <https://doi.org/10.1016/j.cie.2022.108903>
- [14] Afrasiabi, A., Tavana, M., Di Caprio, D., & Hashemi, R. (2022). An extended hybrid fuzzy multi-criteria decision model for sustainable and resilient supplier selection. *Environmental Science and Pollution Research*, 29, 37291–37314. <https://doi.org/10.1007/s11356-021-17851-2>

- [15] Masoomi, B., Sahebi, I. G., Fathi, M., Yıldırım, F., & Ghorbani, S. (2022). Strategic supplier selection for renewable energy supply chain under green capabilities: Fuzzy BWM-WASPAS-COPRAS approach. *Energy Strategy Reviews*, 40, 100815. <https://doi.org/10.1016/j.esr.2022.100815>
- [16] Puška, A., Božanić, D., Nedeljković, M., & Janošević, M. (2022). Green supplier selection in an uncertain environment in agriculture using a hybrid MCDM model: Z-numbers–fuzzy LMAW–fuzzy CRADIS model. *Axioms*, 11(9), 427. <https://doi.org/10.3390/axioms11090427>
- [17] Wang, C. N., Nguyen, T. L., & Dang, T. T. (2022). Two-stage fuzzy MCDM for green supplier selection in steel industry. *Intelligent Automation & Soft Computing*, 33(2), 1245–1260. <https://doi.org/10.32604/iasc.2022.024548>
- [18] Liou, J. J. H., Chang, M. H., Lo, H. W., & Hsu, M. H. (2021). Application of an MCDM model with data mining techniques for green supplier evaluation and selection. *Applied Soft Computing*, 109, 107534. <https://doi.org/10.1016/j.asoc.2021.107534>
- [19] Nguyen, N. B. T., Lin, G. H., & Dang, T. T. (2021). A two phase integrated fuzzy decision-making framework for green supplier selection in the coffee bean supply chain. *Mathematics*, 9(16), 1923. <https://doi.org/10.3390/math9161923>
- [20] Gao, H., Ju, Y., Santibanez Gonzalez, E. D. R., & Zhang, W. (2020). Green supplier selection in electronics manufacturing: An approach based on consensus decision making. *Journal of Cleaner Production*, 245, 118781. <https://doi.org/10.1016/j.jclepro.2019.118781>
- [21] Jain, N., & Singh, A. R. (2020). Sustainable supplier selection under must-be criteria through fuzzy inference system. *Journal of Cleaner Production*, 248, 119275. <https://doi.org/10.1016/j.jclepro.2019.119275>
- [22] Stević, Ž., Pamučar, D., Puška, A., & Chatterjee, P. (2020). Sustainable supplier selection in healthcare industries using a new MCDM method: Measurement of alternatives and ranking according to COmpromise Solution (MARCOS). *Computers & Industrial Engineering*, 140, 106231. <https://doi.org/10.1016/j.cie.2019.106231>
- [23] Liang, R., & Chong, H. Y. (2019). A hybrid group decision model for green supplier selection: A case study of megaprojects. *Engineering, Construction and Architectural Management*, 26(8), 1712–1734. <https://doi.org/10.1108/ECAM-10-2018-0462>
- [24] Gupta, S., Soni, U., & Kumar, G. (2019). Green supplier selection using multi-criterion decision making under fuzzy environment: A case study in automotive industry. *Computers & Industrial Engineering*, 136, 663–680. <https://doi.org/10.1016/j.cie.2019.07.038>
- [25] Konys, A. (2019). Green supplier selection criteria: From a literature review to a comprehensive knowledge base. *Sustainability*, 11(15), 4208. <https://doi.org/10.3390/su11154208>
- [26] Jain, N., & Singh, A. R. (2019). Sustainable supplier selection criteria classification for Indian iron and steel industry: A fuzzy modified Kano model approach. *International Journal of Sustainable Engineering*, 12, 17–32. <https://doi.org/10.1080/19397038.2019.1566413>
- [27] Akcan, S., & Taş, M. A. (2019). Green supplier evaluation with SWARA-TOPSIS integrated method to reduce ecological risk factors. *Environmental Monitoring and Assessment*, 191, 736. <https://doi.org/10.1007/s10661-019-7884-3>
- [28] Shojaei, P., Fallahpour, A., & Teimouri, R. (2019). Rough MCDM model for green supplier selection in Iran: A case of university construction project. *Built Environment Project and Asset Management*, 10(3), 437–452. <https://doi.org/10.1108/BEPAM-11-2019-0117>
- [29] Jain, N., Shukla, A., & Singh, A. R. (2018). An integrated MCDM methodology for green supplier selection in GSCM. *International Journal of Pure and Applied Mathematics*, 118(20), 461–467.
- [30] Banaeian, N., Mobli, H., Fahimnia, B., Nielsen, I. E., & Omid, M. (2018). Green supplier selection using fuzzy group decision making methods: A case study from the agri-food industry. *Computers & Operations Research*, 89, 337–347. <https://doi.org/10.1016/j.cor.2016.02.015>
- [31] Song, W., Chen, Z., Liu, A., Zhu, Q., Zhao, W., Tsai, S. B., & Lu, H. (2018). A study on green supplier selection in dynamic environment. *Sustainability*, 10(4), 1226. <https://doi.org/10.3390/su10041226>
- [32] Tian, Z. P., Zhang, H. Y., Wang, J. Q., & Wang, T. L. (2018). Green supplier selection using improved TOPSIS and Best-Worst Method under intuitionistic fuzzy environment. *Informatica*, 29(4), 773–800. <https://doi.org/10.15388/Informatica.2018.192>

- [33] Yazdani, M., Chatterjee, P., Zavadskas, E. K., & Zolfani, S. H. (2017). Integrated QFD-MCDM framework for green supplier selection. *Journal of Cleaner Production*, 142, 3728–3740. <https://doi.org/10.1016/j.jclepro.2016.10.095>
- [34] Amindoust, A., Ahmed, S., Saghafinia, A., & Bahreininejad, A. (2017). Supplier selection and order allocation with green criteria: An MCDM and multi-objective optimization approach. *Computers & Operations Research*, 81, 282–304. <https://doi.org/10.1016/j.cor.2016.11.005>
- [35] Pang, Q., Yang, T., Li, M., & Shen, Y. (2017). A fuzzy-grey multicriteria decision making approach for green supplier selection in low-carbon supply chain. *Mathematical Problems in Engineering*, 2017, Article 9653261. <https://doi.org/10.1155/2017/9653261>
- [36] Jain, N., & Singh, A. R. (2017). Fuzzy Kano integrated MCDM approach for supplier selection based on must-be criteria. *International Journal of Supply Chain Management*, 6(2), 49–59.
- [37] Guo, Z., Liu, H., Zhang, D., & Yang, J. (2017). Green supplier evaluation and selection using a fuzzy multi-criteria decision-making approach. *Sustainability*, 9(4), 650. <https://doi.org/10.3390/su9040650>
- [38] Chen, H. M., Chou, S. Y., Luu, Q. D., & Yu, T. H. K. (2016). A fuzzy MCDM approach for green supplier selection from the economic and environmental aspects. *Mathematical Problems in Engineering*, 2016, Article 8097386. <https://doi.org/10.1155/2016/8097386>
- [39] Yu, Q., & Hou, F. (2016). An approach for green supplier selection in the automobile manufacturing industry. *Kybernetes*, 45(4), 571–588. <https://doi.org/10.1108/K-01-2015-0034>
- [40] Kuo, T. C., Hsu, C. W., & Li, J. Y. (2015). Developing a green supplier selection model by using the DANP with VIKOR. *Sustainability*, 7(2), 1661–1689. <https://doi.org/10.3390/su7021661>
- [41] Freeman, J., & Chen, T. (2015). Green supplier selection using an AHP-Entropy-TOPSIS framework. *Supply Chain Management: An International Journal*, 20(3), 327–340. <https://doi.org/10.1108/SCM-04-2014-0142>
- [42] Gurel, O. A., Acar, Z., Onden, I., & Gumus, I. (2015). Determinants of the green supplier selection. *Procedia - Social and Behavioral Sciences*, 181, 131–139. <https://doi.org/10.1016/j.sbspro.2015.04.874>
- [43] Hu, Z., Rao, C., Zheng, Y., & Huang, D. (2015). Optimization decision of supplier selection in green procurement under the mode of low carbon economy. *International Journal of Computational Intelligence Systems*, 8, 407–421. <https://doi.org/10.1080/18756891.2015.1017375>
- [44] Orji, I. J., & Wei, S. (2015). An innovative integration of fuzzy-logic and systems dynamics in sustainable supplier selection: A case on manufacturing industry. *Computers & Industrial Engineering*, 88, 1–12. <https://doi.org/10.1016/j.cie.2015.06.019>