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From Organic Waste to Community Value: An Integrated Evaluation of the GEMA MAGENTA Social Innovation Program in Ogan Komering, Indonesia

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Abstract

Reliable light-vehicle fleets are essential to mining operations because vehicle availability affects employee mobility, maintenance coordination, safety, and operational continuity. Aging vehicles may increase repair costs, fuel consumption, breakdown frequency, and downtime, whereas premature replacement may result in the loss of remaining asset value and inefficient capital allocation. This study aimed to establish replacement priorities for light vehicles at PT Freeport Indonesia using an integrated multi-criteria decision-making (MCDM) framework. A quantitative decision-support approach combined the Analytic Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). AHP was applied to determine the relative weights of economic, operational, maintenance, and technical performance criteria through pairwise comparisons, whereas TOPSIS was used to evaluate and rank individual vehicles based on their proximity to the ideal replacement condition. The results demonstrated that the integrated framework differentiated vehicle replacement priorities more comprehensively than assessments based solely on age, mileage, or maintenance expenditure. The ranking reflected the combined influence of vehicle condition, operational reliability, cost burden, and technical performance, thereby providing a transparent basis for fleet renewal decisions. The study concluded that the AHP–TOPSIS approach offers a systematic and accountable tool for allocating replacement budgets, reducing unplanned downtime, improving fleet availability, and supporting safer and more efficient mining operations under constrained capital and operational conditions.

INTRODUCTION

Corporate community development programs in operational areas are increasingly expected to provide detailed descriptions of implemented activities, assessments of whether these activities effectively address local challenges, and evidence of sustainable value creation for communities (Anzali et al., 2025; Prasetyo et al., 2026). Evaluation should connect program interventions with changes in local community livelihoods. The GEMA MAGENTA Program (Gerakan Masyarakat Mandiri Generasi Lestari) was implemented by PT Pertamina Hulu Energi Ogan Komering (PHE OK). The program was developed as a portfolio of mutually reinforcing community initiatives rather than as a single project (Putra et al., 2023; Anzali et al., 2025). The five core components assessed in the SROI analysis were Kompas Lestari, the

Business Incubator, Village Reservoir Ecotourism, Rumah Pintar Pelangi Pustaka, and GEN SMART. The program integrates environmental management, livelihood development, tourism, education, health and nutrition, and institutional strengthening within a broader circular-economy and community-capability framework (Prasetyo et al., 2026).

The baseline problems addressed by the program were multidimensional (Hidayati et al., 2025; Qomariyah et al., 2022). At the environmental level, organic waste management remained inadequate, while household awareness and waste-processing facilities were limited (April et al., 2026; Sujean et al., 2026). At the economic level, local livelihoods were concentrated in primary activities, particularly agriculture, leaving households and small enterprises vulnerable to commodity fluctuations and constrained by limited business-management capacity, restricted market access, and high production costs. At the community level, the village reservoir had not been fully developed as an economic asset, access to non-formal learning opportunities remained limited, and community health workers required enhanced capacity for nutrition and stunting monitoring. Therefore, the program addressed these conditions as interconnected elements within a local system.

The waste-management challenge illustrates the scale of the environmental context. Waste generation in Ogan Komering Ulu in 2025 was recorded at 156 tons per day, equivalent to 56,940 tons per year, with organic materials accounting for 56.0% (31,886.40 tons per year). This situation aligns with the study by Pratami and Dwipayanti (2025), which indicated that household waste is dominated by organic materials, particularly food scraps and kitchen waste. At the community level, household food waste was reported as a major contributor, and organic waste was still disposed of in backyards or drainage channels. These practices have raised concerns regarding odor, pests, sanitation, and environmental quality. The program reframed organic waste as a locally available resource for productive activities (Melfazen et al., 2023; Bahtiar & Kamelia, 2024; Putri et al., 2023).

The GEMA MAGENTA Program established a circular value chain as a problem-solving mechanism. Organic waste became feedstock for Black Soldier Fly (BSF) cultivation, maggot biomass was processed into feed products and liquid organic fertilizer, and residual exuviae were redirected into biomass pellets. These outputs supported aquaculture, agriculture, livestock, village tourism, household energy, and nutrition activities (Bahtiar & Kamelia, 2024; Sulistyowati et al., 2025). The program also introduced an automatic maggot-drying and roasting system, documented technical knowledge through structured modules, supported the development of local groups and community champions, and established learning facilities.

Previous studies have demonstrated the usefulness of integrated multi-criteria decision-making (MCDM) techniques in transportation and equipment-management contexts. AHP has frequently been employed to determine the importance of economic, technical, safety, environmental, and service criteria, whereas TOPSIS has been used to convert weighted evaluation results into transparent priority rankings. Research on equipment selection and asset management has shown that combining expert judgment with objective performance data can produce more comprehensive decisions than those based on single financial indicators. However, much of the existing literature has concentrated on selecting new equipment, evaluating alternative vehicle technologies, or determining replacement timing through aggregate cost optimization. Comparatively limited attention has been given to prioritizing

individual light vehicles already operating within large mining fleets by integrating their economic, operational, maintenance, and technical characteristics.

This limitation reveals a practical and methodological research gap. From a practical perspective, fleet managers need to determine not only whether replacement is economically reasonable but also which specific vehicles should be replaced first when budgets and replacement capacity are limited. From a methodological perspective, existing vehicle-replacement studies commonly separate financial evaluation from technical and operational assessments, thereby providing an incomplete representation of vehicle condition. Furthermore, findings from public transportation or general logistics fleets cannot automatically be applied to mining operations because mining vehicles experience different road conditions, utilization patterns, safety risks, and service requirements. Therefore, an organization-specific decision framework is necessary to translate heterogeneous fleet information into a consistent and auditable replacement priority.

Addressing this gap is urgent because postponing the replacement of critically deteriorated vehicles may increase maintenance frequency, downtime, fuel consumption, safety risks, and disruptions to mining-support activities. At the same time, replacing vehicles without an evidence-based priority system may allocate limited capital to units that still retain acceptable technical and economic value. This study introduces an integrated AHP–TOPSIS framework to evaluate PT Freeport Indonesia's light-vehicle fleet across four interrelated dimensions: economic feasibility, operational performance, maintenance condition, and technical performance. AHP establishes the relative importance of evaluation criteria based on structured expert judgments, while TOPSIS produces vehicle-level priority rankings according to each unit's proximity to the ideal replacement condition. This integration transforms multidimensional fleet information into a transparent decision-support mechanism.

Accordingly, this study aims to develop a structured replacement-priority model for PT Freeport Indonesia's light-vehicle fleet using an integrated AHP–TOPSIS approach. The specific objectives are to identify relevant criteria for light-vehicle replacement, determine the relative weights of each criterion through pairwise comparisons, evaluate fleet-unit performance against the selected criteria, and rank vehicles according to their replacement priorities. The study is expected to contribute theoretically by extending the application of integrated MCDM methods to individual vehicle-replacement decisions in mining contexts. Practically, it can assist fleet managers in allocating replacement budgets, reducing unplanned downtime, controlling maintenance expenditures, improving vehicle availability, and strengthening the transparency of capital-investment decisions. The resulting framework may also benefit other mining and asset-intensive organizations seeking an adaptable, evidence-based approach for managing fleet renewal under operational and financial constraints.

METHOD

Research Design and Program Implementation Method

This study employed an integrative evaluation design that synthesized Social Return on Investment (SROI) and the Community Satisfaction Index (CSI). The evaluation examined problem diagnosis, innovation characteristics, capability-building mechanisms, and systemic change narratives. SROI was used to assess implementation logic, stakeholder mapping, investment, outputs, outcomes, impact adjustments, monetization processes, and the final

SROI calculation. Meanwhile, CSI was used to capture beneficiary perceptions regarding program relevance, governance, implementation, sustainability, and facilitation (Nicholls et al., 2012; Guijt, 2014; Rogers, 2014).

The program was implemented through a participatory, needs-based community empowerment approach. The implementation process began with social mapping and problem identification, followed by community-group formation or strengthening, provision of supporting infrastructure, technical and organizational capacity building, routine mentoring, product and service development, market linkage, and institutional consolidation. This approach aimed to shift community members from being primarily recipients of assistance toward becoming active participants in managing and sustaining program activities (Ife, 2016).

Implementation was organized through a multi-stakeholder model. PT Pertamina Hulu Energi Ogan Komering functioned primarily as a facilitator and catalyst by providing resources, technical support, coordination, and monitoring rather than maintaining permanent operational control. The village government supported local coordination, policy arrangements, and facility management. Community groups were responsible for implementing daily activities. Universities and technical institutions contributed through training, scientific and technical assistance, curriculum or module development, and research support. This division of roles supported local ownership and integrated external expertise into community capacity development.

Problem-Solving Pathways by Subprogram

Each documented problem was paired with a specific problem-solving pathway and an intended outcome. Kompas Lestari addressed unmanaged organic waste and limited alternative income by combining household waste sorting, BSF cultivation, product development, residue utilization, and routine technical support. The Business Incubator addressed weak business management and market access through enterprise identification, entrepreneurship training, mentoring, working-capital support, and the development of a creative gallery. Village Reservoir Ecotourism addressed underutilized local assets through group formation, reservoir renovation, tourism-management training, freshwater fish stocking and training, routine operation, additional attractions, and study visits. Rumah Pintar Pelangi Pustaka addressed limited non-formal learning support by establishing a functioning learning space, recruiting tutors, providing routine learning assistance, supporting educational transitions, providing school equipment, and introducing environmental education. GEN SMART addressed limited capacity for nutrition and stunting monitoring through cadre formation and training, routine Posyandu activities, nutrition checks, maternal and adolescent education, MPASI/PMT support, PHBS promotion, and training in locally based complementary food preparation. The implementation logic is therefore sequential: diagnosis -> targeted intervention -> operational output -> community-level outcome.

Evaluation Methods

Social Return on Investment (SROI)

The evaluation of the GEMA MAGENTA Program integrating the SROI and the Community Satisfaction Index (IKM). The SROI was used to assess stakeholders, inputs, outputs, outcomes, impact adjustments, monetization, and value relative to investment. Inputs included financial resources, land, technical expertise, staff and community participation time, facilitation, and supporting materials. Output included formed community groups, functioning

facilities, completed training activities, documented modules, supported enterprises, continuing ecotourism operations, and health and education activities. Outcomes were defined as changes experienced by stakeholders, while impact represented the outcome remaining after adjustment for external contribution and other factors. The SROI methodology therefore evaluated not only what the program delivered, but also the value of the changes experienced by stakeholders.

SROI = Total Present Value of Benefits / Total Present Value of Investment

The CSI was used to assess beneficiary perceptions of program reach and purpose, governance, implementation and impact, sustainability, and facilitator performance. The IKCSIM component used a quantitative-descriptive evaluative survey to assess whether implementation was relevant, acceptable, effective, and sustainable from the perspective of beneficiaries. Data collection combined direct surveys, closed and open questionnaires, direct interviews, online questionnaires, and field observation. The instrument was adapted from the nine service elements in PermenPAN-RB No. 14/2017 to fit the CSR context. Forty-two indicators were organized into five dimensions: reach and purpose, governance, implementation and impact, sustainability, and facilitator performance.

RESULTS AND DISCUSSION

Integrated Problem, Intervention, and Outcome Structure

Table 1. Integrated problem, intervention and outcome of the GEMA MAGENTA Program

Problem domain	Documented baseline problem	Problem-solving method	Key reported results / expected change
Environment	Organic waste remained inadequately managed, waste-processing facilities and environmental awareness were limited.	Kompas Lestari: source separation, community BSF cultivation, downstream product development, residue utilization, and biomass pelletization.	Organic waste was redirected toward productive use, the residual loop was strengthened. The program reported 5.96 tCO2e/year reduction for Kompas Lestari and 1.36 tCO2e/year estimated within the biomass-pellet innovation boundary.
Livelihoods and enterprise	Income sources were concentrated in primary activities, business-management capability, planning, and market access were limited.	Maggot-based products, Business Incubator, entrepreneurship training, mentoring, working capital, product development, and village ecotourism.	Additional income and cost savings were reported, together with stronger enterprise capability and broader local economic opportunities.
Education and knowledge	Access to non-formal learning support and safe learning space was limited, knowledge documentation and transfer mechanisms were weak.	Rumah Pintar Pelangi Pustaka, tutor recruitment, routine learning support, green curriculum, formal modules, and technical training.	30 students were supported, routine learning was sustained, learning materials and technical knowledge were documented to improve transfer and replication.
Health and nutrition	Community capacity for nutrition and stunting monitoring was limited; health education for adolescents and families required strengthening.	GEN SMART, Posyandu, nutrition monitoring, stunting training, nutrition checks, MPASI/PMT, maternal and adolescent	25 cadres were trained, 300 mothers/pregnant women and children were monitored, 300 children received nutrition checks, 100 adolescents were reached.

Problem domain	Documented baseline problem	Problem-solving method	Key reported results / expected change
		education, and PHBS promotion.	
Governance, institutional capacity, and sustainability	Local institutional capacity and feedback mechanisms required strengthening, knowledge documentation and long-term ownership were limited.	Community groups, local champions, SOPs, modules, local facilitators, multi-actor partnerships, learning centers, and policy follow-up.	Overall CSI was 90.115; sustainability was 91.63 and governance 89.85. Strong perceived sustainability coexisted with improvement needs in feedback and implementation consistency.

The integrated analysis confirms that the program was built around a cluster of mutually reinforcing problems. Organic waste was both an environmental burden and an underused resource. Limited livelihood diversification reduced the ability of households to convert local resources into additional income. Weak business and market capabilities constrained commercialization, while underused tourism assets limited opportunities for local economic circulation. Education and health gaps represented additional human-capital constraints that could weaken long-term community resilience. The program therefore responded with a portfolio of linked interventions rather than a single technical project.

The strongest problem-intervention fit occurred where material, organizational, and market mechanisms were combined. In Kompas Lestari, waste sorting and BSF cultivation created the material-conversion pathway, while product development and mentoring created opportunities to use the resulting outputs. In the tourism component, reservoir rehabilitation was paired with group development, fisheries training, fish stocking, routine operation, and additional attractions. In education and health, physical facilities were combined with repeated learning or service activities, allowing infrastructure to become part of a longer-term community capability system.

Implementation records show a phased development process. In 2023, the program concentrated on social mapping, community-group establishment, facility development, and initiation of key activities. In 2024, the focus expanded to routine production, technical training, learning-space improvement, fisheries and tourism support, and business identification. In 2025, the program emphasized product innovation, biomass-pellet development, plasma-maggot models, additional tourism features, expanded learning and health activities, and continued mentoring. This progression indicates that implementation was designed as a capability-building pathway rather than a one-off delivery model.

Reported outputs illustrate the operational scale of the intervention. Kompas Lestari maintained a routine group structure and produced learning and technical modules. The Business Incubator involved 50 participants and supported five MSMEs with mentoring and capital. The tourism program established a Pokdarwis group, maintained reservoir operations, added 5,000 fish, and developed additional attractions. Rumah Pintar supported 30 students through regular learning activities. GEN SMART trained 25 cadres, monitored 300 mothers/pregnant women and children, provided nutrition checks for 300 children, and reached 100 adolescents. These outputs show how the program translated general objectives into recurring local activities.

Social Innovation and Systemic Change

The innovation was not limited to the adoption of BSF cultivation or biomass pellet technology. Social innovation was the integration of multiple forms of capital and multiple actors into a functioning local value system. Intellectual capital was strengthened through technical testing, documentation, and a patent for the automatic maggot-drying machine. Individual capability was developed through staged technical and business training. Social capital was strengthened through collaboration among community groups and external partners. Infrastructure capital was embodied in shared production and learning facilities.

A key systemic shift was the reported movement from a linear waste pathway toward a circular one. Organic waste was not treated solely as material to be removed; it became feedstock for BSF cultivation, a source of fertilizer products, and eventually a source of biomass energy through residue utilization. The same resource stream was therefore connected to agriculture, aquaculture, livestock, tourism, household energy, and nutrition-related activities. This multi-pathway structure reduces dependence on a single product or market and increases the functional value generated from the same local resource.

The learning-center mechanism further strengthened systemic change. The Rumah Pusat Studi Budidaya Maggot was used as a shared learning space and social laboratory. Formal modules, including biomass-pellet documentation, converted tacit practice into reusable knowledge. This mechanism is important for sustainability because continuity depends not only on assets and equipment, but also on the ability of new participants to acquire and reproduce the knowledge required to operate the system.

Reported Economic, Social, Environmental, and Wellbeing Outcomes

The SROI evidence identifies outcomes in four broad domains. Economically, the program reported additional income, alternative livelihood opportunities, stronger enterprise capacity, and energy-cost savings. Socially, the program reported strengthened community groups, knowledge transfer, documented SOPs and modules, and increased collective participation. Environmentally, the program reported more structured management of organic waste, productive utilization of residues, and improved environmental conditions. In wellbeing terms, the program documented gains related to confidence, learning support, health and nutrition services, and local support systems.

The innovation report provides several concrete examples. Average additional income of approximately IDR 1.505 million per month was reported among cited low-income members of the maggot group. Energy savings of approximately IDR 480,000 were also reported, while additional household income of up to approximately IDR 1.65 million per month was documented for participating socioeconomically vulnerable women. The report also records a decrease in the number of children identified as experiencing stunting from six to two. These figures are treated as documented program changes rather than controlled causal effects because the underlying evaluation did not report a control group or quasi-experimental design.

SROI Results

Table 2. Final locked SROI calculation reproduced from the 2025 SROI report

Year	Adjusted benefits (IDR)	Present-value benefits (IDR)	Nominal investment (IDR)	Present-value investment (IDR)
2023	1,169,600,000	1,087,728,000	682,000,000	634,260,000

Year	Adjusted benefits (IDR)	Present-value benefits (IDR)	Nominal investment (IDR)	Present-value investment (IDR)
2024	3,529,017,250	3,281,986,043	597,000,000	555,210,000
2025	4,440,442,500	4,440,442,500	1,012,000,000	1,012,000,000
Total	9,139,059,750	8,810,156,543	2,291,000,000	2,201,470,000

The final locked calculation produced an SROI ratio of 8,810,156,543 / 2,201,470,000 = 4.00. The source report therefore associates each IDR 1 of present-value social investment with approximately IDR 4 of monetized present-value benefit under its documented assumptions. The adjusted benefit increased from IDR 1.17 billion in 2023 to IDR 3.53 billion in 2024 and IDR 4.44 billion in 2025, which is consistent with the program roadmap from foundation-building toward routine implementation, innovation, and scaling.

Community Satisfaction Results

Table 3. Community Satisfaction Index (CSI) results across the five evaluation domains

CSI domain	Score	Interpretation
Reach and purpose	89.59	Very good
Governance	89.85	Very good
Implementation and impact	90.96	Very good
Sustainability	91.63	Very good
Facilitator performance	89.20	Very good
Total calculated CSI	90.115	Very good

All five domains were above 89, and the calculated total index was 90.115. Sustainability was the highest-rated domain at 91.63, followed by implementation and impact at 90.96. The strongest individual indicators included the perceived ability to manage local resources productively (94.01) and the ability to apply acquired knowledge and skills (92.82). In contrast, information accessibility (88.06), opportunities to provide feedback (87.5), and consistency between implementation and jointly agreed plans (88.1) were among the comparatively lower-scoring indicators. These results indicate high acceptance overall but also identify practical aspects of implementation that require refinement.

Problem-Solving Model Works as an Integrated System

The central finding is that GEMA MAGENTA Program is better understood as a community value-creation system than as a conventional waste-management project (Rahayu *et al*., 2025; Carreño-Ortiz *et al*., 2025). BSF cultivation provides the technical mechanism for converting organic material, but the conversion becomes socially valuable because the program simultaneously establishes operators, supporting infrastructure, learning systems, market channels, and complementary social services. In this sense, the intervention solves a material problem while also addressing the institutional and capability constraints that might otherwise prevent a technical innovation from becoming durable.

The integrated structure is particularly visible in the circular-economy pathway. Waste becomes feedstock, feed and fertilizer products create productive uses, exuviae becomes biomass, fisheries and tourism create additional economic interfaces, and local food production contributes to nutrition activities. The result is not merely a physical loop but an organizational loop in which materials, knowledge, and roles circulate among community actors (Carreño-Ortiz *et al*., 2025). This helps explain why the program generated benefits beyond waste reduction alone.

The Role of Frugal and Appropriate Technology

The biomass-pellet pathway also illustrates the role of frugal innovation in rural settings. Technology uses locally available residues, repurposes an existing material stream, and adapts processing into a village-scale production context (Hossain *et al*., 2023). The automatic maggot-drying/roasting machine, technical modules, and laboratory testing indicate that technology development was coupled with capability development. This combination is important because the practical value of rural technology depends not only on technical performance but also on usability, maintainability, local ownership, and a plausible pathway to demand (Hossain *et al*., 2023).

The program reports an estimated 20–30% reduction in energy costs, equivalent to approximately IDR 480,000 per year per kitchen in the cited context when biomass pellets replace LPG. This should be interpreted as a program estimate rather than a controlled energy-performance result, because the source materials do not report on comparative experimental design. Nevertheless, the estimate helps explain the economic relevance of residue utilization alongside its environmental value.

Interpreting the SROI Ratio

The SROI ratio of 4.00:1 provides a strong summary of the reported value generated relative to investment. However, the ratio should not be interpreted as a conventional financial return. It represents the monetized value assigned to documented social, economic, environmental, and wellbeing outcomes after the source report applied its stated impact adjustments and present-value calculations. The result is therefore most useful as an accountability and learning metric that shows the scale and composition of valued change relative to deployed resources (Banke-Thomas *et al*., 2015).

The increasing monetized benefit over 2023–2025 is also substantively meaningful. The trajectory corresponds to the program roadmap: an initial foundation period, a phase of strengthening and routine implementation, and a later phase characterized by product innovation, broader implementation, and sustainability. This pattern suggests that the program accumulated capability over time rather than producing a static intervention effect.

Convergence of SROI and Community Satisfaction Evidence

The strongest methodological contribution of the integrated evaluation is the convergence of two different perspectives on program performance (Prasetyo *et al*., 2026; Amalia *et al*., 2025). SROI result show how much monetized value is associated with reported outcomes relative to investment, whereas CSI show how beneficiaries evaluate the quality and sustainability of the program they experience. The 4.00:1 SROI ratio and 90.115 CSI score do not measure the same construct, but their simultaneous positive direction provides complementary support for the program's reported performance.

The high sustainability score of 91.63 is particularly consistent with the implementation strategy. (Yandri et al., 2023; Istiyani & Handayani, 2022). The program invested not only in facilities and equipment but also in local groups, facilitators, documented knowledge, and learning spaces. The strongest individual sustainability-related indicators 94.01 for productive management of local resources and 92.82 for applying acquired skills suggest that beneficiaries recognized capability development rather than only material assistance. This is an important distinction for social innovation because durable outcomes depend on the community's ability

to operate and reproduce the intervention after external support declines (Yuliastuti et al., 2017; Massiri et al., 2019; Sucipto *et al*., 2024).

Implications for Corporate Community Development

The case offers several practical design implications. First, program development should begin with system-level problem diagnosis rather than predetermined technology. Second, one local resource should be connected to multiple value pathways whenever feasible so that the intervention is not dependent on a single product. Third, institutional ownership and learning infrastructure should be developed together with physical assets. Fourth, production output should be connected to real local users, market interfaces, or public-service functions. Fifth, evaluation should combine monetized impact with beneficiary experience because no single metric captures all dimensions of program effectiveness (Sucipto *et al*., 2024; Prasetyo *et al*., 2026). GEMA MAGENTA Program contributed to the creation of local skills, systems, facilities, networks, and market relationships that enable community actors to continue producing value. This provides a practical interpretation of sustainability that is institutional as well as financial.

CONCLUSION

This study concluded that the integration of the Analytic Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) provided a systematic and transparent framework for determining light-vehicle replacement priorities at PT Freeport Indonesia. AHP established the relative importance of economic, operational, maintenance, and technical performance criteria, while TOPSIS ranked each vehicle based on its proximity to the ideal replacement condition. This integrated approach enabled replacement decisions to be based on multidimensional evidence rather than relying solely on vehicle age, mileage, or maintenance costs. The resulting priority rankings can support more accountable capital allocation, reduce unplanned downtime and maintenance risks, improve fleet availability, and strengthen operational safety and efficiency.

Future research should validate the proposed framework using larger fleet datasets, longer observation periods, and applications across different mining sites or asset-intensive industries. Subsequent studies may incorporate additional criteria, such as emissions, fuel consumption, accident history, resale value, spare-parts availability, and total life-cycle cost. Comparative assessments involving other MCDM methods, including VIKOR, PROMETHEE, or fuzzy AHP–TOPSIS, are also recommended to evaluate the robustness and sensitivity of the resulting rankings. Integrating real-time telematics and maintenance records into a dynamic decision-support system could further improve the accuracy of vehicle-condition assessments and enable replacement priorities to be updated as operational conditions change.

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