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Sustainability Snalysis of Rice Milling Unit (RMU) Enterprises in Bengkel Village, Kediri District, Tabanan Regency, Bali Province

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Abstract---Food security is a national strategic issue influenced not only by agricultural production but also by the effectiveness and sustainability of post-harvest systems, including Rice Milling Unit (RMU) enterprises. Bali Province currently faces a rice deficit due to production levels that are lower than domestic consumption needs. Although Tabanan Regency has a relatively high number of RMUs, many operate with limited technology, low efficiency, and weak institutional support, creating environmental and socio-cultural challenges. Bengkel Village, an agricultural production center, hosts seven RMUs that play a crucial role in supporting local food security; however, their sustainability status has not been comprehensively assessed. This study aims to evaluate the sustainability status of RMU enterprises in Bengkel Village, identify sensitive attributes affecting sustainability, and formulate improvement scenarios. A Multiaspect Sustainability Analysis (MSA) was applied across five dimensions: ecological, economic, socio-cultural, institutional, and



technological. Data were collected through interviews, observations, and questionnaires administered to key informants. The results indicate an overall sustainability index of 58.29, classified as sustainable. The socio-cultural dimension recorded the highest score (72.14), followed by ecological (67.86), technological (64.29), and economic (57.14) dimensions, all categorized as sustainable. In contrast, the institutional dimension showed the lowest score (30), indicating low sustainability. Key sensitive attributes include operational noise levels, maintenance costs, farmer participation, government assistance programs, and rice quality certification. Scenario-based improvements increased the sustainability index to 73. Strengthening institutional capacity remains essential to enhance the sustainable contribution of RMUs to local food security.

Keywords---Business sustainability, Rice Milling Unit (RMU), food security, Multiaspect Sustainability Analysis (MSA).

Introduction

Food security is a global issue and a strategic priority for many countries, including Indonesia. According to Law of the Republic of Indonesia No. 18 of 2012 on Food, food security is defined as a condition in which food is sufficiently available, safe, nutritious, diverse, evenly distributed, affordable, and culturally acceptable, enabling individuals to live healthy, active, and productive lives on a sustainable basis (BPN, 2012). The agricultural sector plays a crucial role in maintaining food security not only through on-farm productivity but also through the efficiency and sustainability of post-harvest systems, particularly rice milling operations, commonly referred to as Rice Milling Units (RMUs).

As key nodes in the transformation of paddy into consumable rice, RMUs contribute significantly to food availability, distribution efficiency, price stability, and value addition in agricultural production. Their performance directly affects farmers' welfare and the reduction of post-harvest losses (Rachmat, 2012). The Indonesian government has demonstrated strong commitment to strengthening food security and rice self-sufficiency through various policy instruments, including the acceleration of local resource-based food diversification (Perpres RI, 2024), the establishment of government purchasing prices for paddy (Menpan, 2025), and the allocation of village funds for food security programs (BPK, 2025). Despite these policy efforts, Bali Province continues to experience a persistent rice deficit. Statistical data from the Bali Provincial Statistics Office show a declining trend in rice production from 2022 to 2024, while rice consumption has increased due to population growth, resulting in an expanding production-consumption gap (BPS Provinsi Bali, 2022-2024). This condition indicates that food security challenges in Bali are not solely related to cultivation activities but are also closely linked to weaknesses in post-harvest systems, including the effectiveness and sustainability of RMU enterprises.

Tabanan Regency, widely recognized as Bali's main rice-producing area, hosts the largest number of RMUs in the province (Dinas Pertanian dan Ketahanan Pangan

Provinsi Bali, 2024). However, many RMUs operate using outdated machinery that is less environmentally friendly, generates noise and dust pollution, and reduces rice quality (Gede Kartika, 2025). Furthermore, uneven paddy distribution and limited institutional coordination often force RMU operators to source raw materials from outside Bali, reflecting structural dependency and limited adaptive capacity (Suarjana, 2024).

Previous studies on agricultural sustainability in Bali have mainly focused on paddy land, seed farming, or large-scale rice agro-industries (Sawitri Djelantik et al., 2022; Dewi et al., 2023; Kumarananda, 2025). However, sustainability assessments of village-level RMU enterprises remain limited. RMUs function not only as rice processing facilities but also as rural economic actors that support employment, local value creation, and the preservation of traditional agricultural systems. Weak RMU sustainability may reduce local agricultural competitiveness and increase regional dependence on external food supplies. Therefore, a comprehensive and multi-dimensional assessment of RMU sustainability is essential, particularly at the village level, to support evidence-based strategies for strengthening local food security and rural livelihoods.

Methods

This study employed a mixed-methods design to obtain a comprehensive assessment of Rice Milling Unit (RMU) sustainability by integrating qualitative insights with quantitative measurement (Creswell & Plano Clark, 2018). The research was conducted in Bengkel Village, Kediri District, Tabanan Regency, Bali Province, Indonesia, using purposive site selection and was scheduled for September–October 2025. The location was chosen because Kediri is a major rice-producing area within Tabanan—widely recognised as Bali’s “rice granary”—and because local RMU operators have reported persistent constraints related to raw material procurement, price competition, high processing costs, and declining operational activity. Data comprised qualitative and quantitative evidence collected from primary and secondary sources. Primary data were obtained through direct field observation, semi-structured interviews, and structured questionnaires administered to purposively selected key informants (Gunawan, 2013; Sugiyono, 2018), including the Bengkel Village Head, the Subak leader (pekaseh), RMU owners, Subak farmers, RMU workers, and relevant officials from agriculture, environment, health sanitation, and licensing agencies. Secondary data were compiled from previous scientific studies, RMU and Subak Bengkel reports, operational and financial records, and relevant policies and regulations (Sugiyono, 2018).

Qualitative findings from interviews and observations were used to identify context-specific sustainability attributes across five dimensions—ecological, economic, socio-cultural, institutional, and technological—which were then operationalised into ordinal (Likert-type) scores for quantitative analysis (Creswell & Plano Clark, 2018; Wahditiya et al., 2025). Sustainability status and sensitive (leverage) attributes were assessed using Multiaspect Sustainability Analysis (MSA) with a modified Rapfish approach, implemented via Exsimpro—an MSA tool developed from RAPFISH (Firmansyah, 2022). The analysis involved systematic scoring, normalisation, and leverage analysis to generate aggregate and

dimension-specific sustainability indices and to inform improvement scenarios (Firmansyah, 2022; Dzikrillah et al., 2017). Robustness was evaluated through Random Iteration MSA by comparing simulated random scores against modal expert ratings to estimate uncertainty and respondent error (Firmansyah, 2022), with interpretation supported by the use of documentation for triangulation and credibility enhancement (Sugiyono, 2017; Ananda et al., 2021).

Result and Discussion

Sensitive Attributes

Using Multiaspect Sustainability Analysis (MSA), this study assessed the sustainability of Rice Milling Unit (RMU) enterprises in Bengkel Village across five dimensions—ecological, economic, socio-cultural, institutional, and technological—together with their constituent attributes. The purpose of the sensitivity (leverage) analysis was to identify the attributes that exert the strongest influence on the sustainability index and therefore should be prioritised in management interventions and development planning. Attributes classified as “sensitive” represent leverage points because relatively small changes in these components may generate disproportionate improvements (or declines) in overall sustainability performance. Accordingly, identifying sensitive attributes within each dimension provides an empirical basis for more targeted policy design and operational improvements. Sensitive attributes were determined through leverage analysis for each dimension, as presented below.

Ecological Dimension

The ecological dimension comprised seven attributes: (1) management of solid waste (rice husk and bran), (2) water use for RMU operations, (3) water quality at the RMU, (4) indoor dust emissions, (5) smoke emissions released to the outdoor environment, (6) indoor operational noise, and (7) outdoor operational noise. These attributes capture the direct interface between RMU operations and environmental quality, including occupational health, community well-being, and the long-term social licence to operate. The sensitivity (leverage) profile is presented, while the priority ranking is summarised in Table 1.

Table 1. Priority Ranking of Sensitive Attributes in the Ecological Dimension

No.	Sensitive Attribute	Priority
1	Outdoor operational noise level during RMU operation	1
2	Indoor operational noise level during RMU operation	2
3	Water use for RMU operations	3
4	Water quality at the RMU	4
5	Smoke emissions released to the outdoor environment	5
6	Solid waste management (rice husk and bran)	6
7	Indoor dust emissions	6

The results indicate that outdoor operational noise is the most sensitive ecological attribute, implying that noise management is the primary leverage point for improving ecological sustainability. Excessive outdoor noise is closely associated with community disturbance and may undermine local acceptance of RMU activity. Indoor noise ranked second, reflecting its direct implications for worker

comfort, health, and productivity. Water use ranked third, suggesting that inefficient consumption can compromise resource sustainability and increase operational vulnerability, particularly during periods of water stress. This is closely linked to water quality (ranked fourth), as inadequate water quality control may affect hygiene conditions and pose contamination risks to local water sources. Outdoor smoke emissions represent another relevant pathway through which RMU operations affect ambient air quality, particularly where legacy machinery and combustion-based systems are still used. Although solid waste management and indoor dust emissions exhibited lower sensitivity, these attributes remain important because poor handling of by-products and dust can degrade workplace safety and indirectly shape community perceptions of environmental performance.

Economic Dimension

The economic dimension included seven attributes: (1) RMU production capacity, (2) RMU maintenance costs, (3) paddy purchase cost (GKP) per kg, (4) milling cost from GKG to rice per quintal, (5) consumer rice selling price per kg, (6) milling recovery ratio (rendemen), and (7) net profit margin (profit per kg). Collectively, these attributes determine operational efficiency, cost structure, and income stability. The ranked priorities are presented in Table 2.

Table 2. Priority Ranking of Sensitive Attributes in the Economic Dimension

No.	Sensitive Attribute	Priority
1	RMU maintenance cost	1
2	Net profit margin (profit per kg)	2
3	Purchase cost of harvested paddy (GKP) per kg	3
4	Rice selling price to consumers per kg	3
5	RMU production capacity	4
6	Milling recovery ratio (yield efficiency)	5
7	Milling cost from GKG to rice per quintal	6

The analysis identifies maintenance costs as the most sensitive economic attribute, indicating that repair and upkeep expenditures are the dominant leverage point influencing economic sustainability. Elevated maintenance costs directly increase unit production costs and reduce financial resilience. The second-ranked attribute, net profit margin, reflects the RMU's capacity to cover operating costs and sustain long-term operations, and is structurally shaped by both input prices and output prices. Consistent with this, the paddy purchase cost (GKP) and consumer rice selling price show high leverage and jointly condition profitability. Production capacity also contributes to sustainability through scale efficiencies, where higher throughput may reduce per-unit costs. The milling recovery ratio (rendemen) is another meaningful driver because improved recovery increases output for a given input volume, enhancing revenue potential. The milling cost per quintal appeared least sensitive in this dimension; however, it remains part of the broader cost structure and thus still warrants operational monitoring. Overall, the findings suggest that controlling maintenance costs and stabilising profitability—through strategic input procurement and price management—are central to strengthening the economic sustainability of RMUs.

Socio-cultural Dimension

The socio-cultural dimension comprised seven attributes: (1) local labour absorption, (2) involvement of external parties (investors) and local community members in RMU management, (3) average education level of RMU owners, (4) family participation in RMU operations, (5) participation of Subak Bengkel members in supplying the RMU, (6) RMU contributions to local social/customary activities, and (7) RMU accessibility and openness to local communities. These attributes represent the degree to which RMUs are embedded in, and reciprocally supported by, local socio-cultural systems. Priority ranking is provided in Table 3.

Table 3. Priority Ranking of Sensitive Attributes in the Socio-cultural Dimension

No.	Sensitive Attribute	Priority
1	Participation of Subak Bengkel members in RMU activities	1
2	RMU contribution to village social/customary activities	2
3	Accessibility and openness of RMU to local communities	3
4	Local labour absorption	4
5	Family participation in RMU operations	5
6	Involvement of external parties (investors) and local community members	6
7	Average education level of RMU owners	6

The most sensitive socio-cultural attribute is Subak member participation in RMU supply and engagement, underscoring the pivotal role of local institutional-cultural integration for long-term viability. Strong participation can enhance social legitimacy, increase trust, strengthen local ownership, and stabilise raw material availability. The second-ranked attribute—RMU contributions to social and customary activities—indicates that visible community contributions can reinforce acceptance and relational cohesion between RMU operators and local stakeholders. Accessibility and openness ranked third, highlighting the importance of transparent and equitable service access in building sustained community trust. Local labour absorption provides direct welfare benefits and strengthens the local economic-social role of RMUs. The remaining attributes (family participation, investor/community involvement in management, and owner education) were comparatively less sensitive; nonetheless, they remain supportive factors that can shape managerial quality and operational continuity.

Institutional Dimension

The institutional dimension assessed seven attributes: (1) business licensing documents, (2) organisational structure, (3) cooperation agreements for paddy procurement, (4) provincial support programmes funded by APBN, (5) provincial support programmes funded by APBD, (6) regency support programmes funded by APBD/village funds, and (7) the availability of Standard Operating Procedures (SOPs) or RMU management guidelines. The ranked priorities presented in Table 4.

Table 4. Priority Ranking of Sensitive Attributes in the Institutional Dimension

No.	Sensitive Attribute	Priority
1	Provincial government assistance funded by APBD (Bali Province)	1
2	Regency government assistance funded by APBD/village funds (Tabanan Regency)	1
3	Provincial government assistance funded by APBN	2
4	Availability of Standard Operating Procedures (SOPs)	3
5	Organisational structure	4
6	Business licensing documents	5
7	Cooperation agreements for paddy procurement	6

The results show that provincial assistance funded by APBD exhibits the highest leverage, indicating that structured support at the provincial level is a critical enabler of institutional sustainability. Regency-level assistance (APBD/village funds) also ranks highly, followed by provincial assistance funded by APBN, together underscoring the role of multi-level government support in strengthening RMU capacity. The availability of SOPs represents the next key leverage point, as SOPs provide the foundation for consistent operations, quality assurance, and professional management. Organisational structure contributes to institutional effectiveness by clarifying roles and responsibilities. Business licensing supports legal compliance and eligibility for programme access, while formal procurement agreements show lower leverage but remain relevant for improving supply stability and reducing transaction uncertainty over time.

Technological Dimension

The technological dimension comprised seven attributes: (1) RMU machine capacity, (2) rice packaging practices, (3) rice quality certification, (4) availability of dryers, (5) adoption of new technologies, (6) frequency of equipment breakdown, and (7) degree of mechanisation/automation. The priority ranking is reported in Table 5.

Table 5. Priority Ranking of Sensitive Attributes in the Technological Dimension

No.	Sensitive Attribute	Priority
1	Rice quality certification	1
2	Degree of mechanisation/automation	2
3	Frequency of equipment breakdown	3
4	RMU machine capacity	4
5	Adoption of new technologies	5
6	Availability of drying facilities (dryer)	6
7	Rice packaging practices	7

The most sensitive technological attribute is rice quality certification, highlighting certification as the principal leverage point for competitiveness, consumer trust, and market access. Certification strengthens compliance with recognised

standards and can expand market channels, thereby enhancing business continuity. The degree of mechanisation/automation ranked second, reflecting the importance of reliable, standardised, and safe operating procedures and reduced dependence on manual processes. Equipment breakdown ranked third because frequent failures directly increase downtime, maintenance costs, and operational instability. Machine capacity influences throughput and efficiency. The remaining attributes—technology adoption, dryer availability, and packaging—showed lower leverage, yet they remain relevant for value addition, product differentiation, and quality stability.

Scenarios for Improving Sustainability Status

Improvement scenarios were developed as strategic pathways to enhance RMU sustainability in the short and long term by targeting the most sensitive attributes as “driving factors.” Three scenarios were formulated under the assumption that interventions prioritising high-leverage attributes would deliver the largest sustainability gains with feasible resource allocation. As shown in Table 6, the overall sustainability index increased progressively from 58.29 (existing) to 61.43 (Scenario 1), 67.57 (Scenario 2), and 73.00 (Scenario 3), while remaining within the “sustainable” category. Scenario 1 is assumed to be implementable over 3–5 years (short term), whereas Scenarios 2 and 3 require more than five years (long term).

Table 6. Sustainability Index Values under Improvement Scenarios

No.	Dimension	Existing	Scenario 1	Scenario 2	Scenario 3
1	Ecological	67.86	71.43	78.57	85.71
2	Economic	57.14	60.00	65.71	71.43
3	Socio-cultural	72.14	75.71	82.14	85.00
4	Institutional	30.00	32.86	38.57	44.29
5	Technological	64.29	67.14	72.86	78.57
	Overall Average	58.29	61.43	67.57	73.00
	Sustainability Status	Sustainable	Sustainable	Sustainable	Sustain

Scenario prioritisation was evaluated by comparing the magnitude of change under Scenario 3 relative to Scenario 1, where Scenario 3 is considered more effective when improvements are at least twice those achieved by Scenario 1 (Paulus et al., 2023). The results in Table 7 indicate that Scenario 3 provides greater effectiveness across ecological, economic, socio-cultural, institutional, and technological dimensions, suggesting that more comprehensive and coordinated interventions generate superior sustainability gains. This evidence implies that sustained commitment from RMU operators and stakeholders—particularly government agencies and local community institutions—is essential to achieve durable improvements and to potentially elevate sustainability status to a higher category over time.

Table 7. Scenario Priority Ratios for Sustainability Improvement

No.	Dimension	$\Delta S1$ - Existing	$\Delta S3$ - Existing	$\Delta S3 /$ $\Delta S1$
1	Ecological	3.57	17.85	5.00
2	Economic	2.86	14.29	5.00
3	Socio-cultural	3.57	12.86	3.60
4	Institutional	2.86	14.29	5.00
5	Technological	2.85	14.28	5.01
Average Scenario Priority		2.96		

Sustainability Improvement Scenario: Ecological Dimension

Within the ecological dimension, outdoor operational noise was identified as the primary sensitive attribute and therefore selected as the main driving factor in Scenario 1. At the existing condition, this attribute remained at a low performance level, indicating significant noise disturbance to surrounding communities. Scenario 1 prioritised incremental noise reduction through operational scheduling adjustments and the use of personal protective equipment (ear protection) for workers, representing a short-term and low-cost intervention. As shown in Table 8, this initial improvement increased the ecological sustainability index from 67.86 to 71.43, while remaining within the sustainable category.

Table 8. Sustainability Improvement Scenarios for the Ecological Dimension

No.	Attribute	Ideal Value (Good)	Existing Value (Real)	Scenario 1	Scenario 2	Scenario 3
Scenario 1						
1	Outdoor operational noise level during RMU operation	4	1	2	-	-
Scenario 2						
2	Outdoor operational noise level during RMU operation	4	1	-	3	-
3	Indoor operational noise level during RMU operation	4	1	-	2	-
Scenario 3						
4	Outdoor operational noise level during RMU operation	4	1	-	-	4
5	Indoor operational noise level during RMU operation	4	1	-	-	3

Scenario 2 expanded the intervention by simultaneously addressing outdoor and indoor noise levels through the installation of basic sound-dampening materials and improved workspace layout. This integrated approach reduced noise exposure for both workers and nearby residents, resulting in a substantial increase in the ecological sustainability index to 78.57, shifting the status to very sustainable. Scenario 3 represented a long-term optimisation strategy through the installation of dedicated noise-reduction machinery and acoustic insulation without limiting operating hours. This intervention further enhanced environmental quality and community comfort, increasing the ecological sustainability index to 85.71. These results demonstrate that progressive investment in noise control technologies yields significant ecological sustainability gains while strengthening social acceptance of RMU operations.

Sustainability Improvement Scenario: Economic Dimension

In the economic dimension, RMU maintenance cost emerged as the most sensitive attribute and was prioritised as the driving factor in Scenario 1. Under existing conditions, maintenance costs were relatively high, reflecting inefficient machinery management and frequent repairs. Scenario 1 focused on basic preventive maintenance practices, including routine inspections and technical consultations, which reduced maintenance expenses to a moderate level. This intervention increased the economic sustainability index from 57.14 to 60.00, maintaining its sustainable classification (Table 4.9).

Table 4.9 Sustainability Improvement Scenarios for the Economic Dimension

No.	Attribute	Ideal Value (Good)	Existing Value (Real)	Scenario 1	Scenario 2	Scenario 3
Scenario 1						
1	RMU maintenance cost	5	2	3	–	–
Scenario 2						
2	RMU maintenance cost	5	2	–	4	–
3	Net profit margin (profit per kg)	5	2	–	3	–
Scenario 3						
4	RMU maintenance cost	5	2	–	–	5
5	Net profit margin (profit per kg)	5	2	–	–	4

Scenario 2 expanded the intervention by simultaneously improving maintenance efficiency and net profit margin, achieved through selective machinery upgrades

and more efficient operational practices. These measures reduced recurring repair costs while improving productivity and profitability, increasing the economic sustainability index to 65.71. Scenario 3 represented a structural transformation through the replacement of obsolete machinery with newer, environmentally friendly, and higher-capacity equipment. This long-term investment significantly lowered maintenance requirements and improved production efficiency, raising the economic sustainability index to 71.43. Overall, the findings highlight that maintenance cost control functions as a central leverage point, influencing both cost efficiency and profitability in RMU operations.

Sustainability Improvement Scenario: Socio-cultural Dimension

For the socio-cultural dimension, participation of Subak Bengkel members in RMU activities was identified as the most sensitive attribute and selected as the driving factor in Scenario 1. At the existing condition, participation remained partial and informal. Scenario 1 focused on strengthening communication and informal agreements with Subak members by emphasising mutual economic benefits, service reliability, and transaction convenience. This intervention increased the socio-cultural sustainability index from 72.14 to 75.71, elevating the status to very sustainable (Table 4.10).

Table 4.10. Sustainability Improvement Scenarios for the Socio-cultural Dimension

No.	Attribute	Ideal Value (Good)	Existing Value (Real)	Scenario 1	Scenario 2	Scenario 3
Scenario 1						
1	Participation of Subak Bengkel members in RMU activities	4	2	3	–	–
Scenario 2						
2	Participation of Subak Bengkel members in RMU activities	4	2	–	4	–
3	RMU contribution to village social/customary activities	5	3	–	4	–
Scenario 3						
4	RMU contribution to village social/customary activities	5	3	–	–	5

Scenario 2 combined increased Subak participation with enhanced RMU contributions to social and customary village activities, such as communal events and collective welfare initiatives. This dual approach reinforced social cohesion, trust, and local ownership, increasing the sustainability index to 82.14. Scenario 3 further institutionalised social engagement through regular, structured contributions aligned with local traditions and collective events, ensuring long-term social embeddedness. This resulted in a further increase to 85.00, reinforcing the very sustainable status. These results confirm that RMUs embedded within local socio-cultural institutions—particularly the Subak system—are more resilient and socially legitimate.

Sustainability Improvement Scenario: Institutional Dimension

In the institutional dimension, the most sensitive attribute was government assistance from the Bali Provincial Government funded by APBD, which served as the primary driving factor in Scenario 1. At baseline, RMUs had not accessed formal support programmes. Scenario 1 focused on administrative preparation, including data registration, documentation completion, and initial coordination with government agencies. Although modest, this intervention increased the institutional sustainability index from 30.00 to 32.86, remaining within the low sustainable category (Table 4.11).

Table 4.11. Sustainability Improvement Scenarios for the Institutional Dimension

No.	Attribute	Ideal Value (Good)	Existing Value (Real)	Scenario 1	Scenario 2	Scenario 3
Scenario 1						
1	Provincial government assistance (APBD – Bali Province)	5	0	1	–	–
Scenario 2						
2	Provincial government assistance (APBD – Bali Province)	5	0	–	2	–
3	Regency government assistance (APBD/village funds – Tabanan)	5	0	–	1	–
Scenario 3						
4	Provincial government assistance (APBD – Bali Province)	5	0	–	–	3
5	Regency government assistance (APBD/village funds – Tabanan)	5	0	–	–	2

Scenario 2 expanded institutional strengthening by enabling access to both provincial and regency-level support programmes, accompanied by improved coordination and proposal development. These measures increased institutional capacity and operational stability, raising the sustainability index to 38.57. Scenario 3 represented deeper institutional consolidation through the development of Standard Operating Procedures (SOPs), clearer organisational structures, and improved legal compliance. While the institutional sustainability index remained within the low sustainable category at 44.29, the upward trajectory indicates that institutional strengthening requires longer-term commitment and cumulative policy support before transitioning to a higher sustainability classification.

Sustainability Improvement Scenario: Technological Dimension

Within the technological dimension, rice quality certification was identified as the most sensitive attribute and selected as the driving factor in Scenario 1. Under existing conditions, quality assurance relied on informal or internal testing without official certification. Scenario 1 prioritised compliance with basic quality standards and registration for entry-level certification (e.g., PIRT), increasing the technological sustainability index from 64.29 to 67.14 (Table 4.12).

Table 4.12. Sustainability Improvement Scenarios for the Technological Dimension

No.	Attribute	Ideal Value (Good)	Existing Value (Real)	Scenario 1	Scenario 2	Scenario 3
Scenario 1						
1	Rice quality certification	5	2	3	–	–
Scenario 2						
2	Rice quality certification	5	2	–	4	–
3	Degree of mechanisation/automation	5	3	–	4	–
Scenario 3						
4	Rice quality certification	5	2	–	–	5
5	Degree of mechanisation/automation	5	3	–	–	5

Scenario 2 combined progress in rice quality certification with improvements in the degree of mechanisation/automation, including clearer operational manuals and partial process automation. These measures enhanced production consistency, hygiene, and operational reliability, increasing the sustainability index to 72.86. Scenario 3 focused on advanced certification (e.g., SNI or equivalent) and full integration of standardised operational manuals into RMU workflows. This resulted in a further increase in technological sustainability to 78.57, achieving a very sustainable status. The findings underscore that certification and operational standardisation function as key technological leverage points for improving market competitiveness and long-term sustainability.

Conclusion

This study examined the sustainability of Rice Milling Unit (RMU) enterprises in Bengkel Village, Kediri Sub-district, Tabanan Regency, Bali Province using a Multiaspect Sustainability Analysis (MSA) approach. The results indicate that the overall sustainability index of RMU enterprises in Bengkel Village is 58.29, which falls within the sustainable category. Sustainability performance varies across dimensions: the ecological dimension scored 67.86 and is classified as sustainable, the economic dimension scored 57.14 and is also classified as sustainable, the socio-cultural dimension recorded a value of 72.14 and is categorized as sustainable, the institutional dimension scored 30.00 and is classified as low sustainable, and the technological dimension achieved a score of 64.29, indicating a sustainable condition. These findings suggest that while RMU operations are generally sustainable, institutional aspects remain the weakest dimension and require priority attention.

The leverage analysis identified several sensitive attributes that significantly influence the sustainability of RMU enterprises. The most influential attributes were outdoor operational noise levels in the ecological dimension, RMU maintenance costs in the economic dimension, participation of Subak Bengkel members in RMU activities in the socio-cultural dimension, provincial government assistance funded through the Bali Provincial Budget (APBD) in the institutional dimension, and rice quality certification in the technological dimension. These sensitive attributes represent key leverage points, where targeted improvements can produce substantial gains in overall sustainability performance.

Three sustainability improvement scenarios were formulated using a single driving factor across all dimensions. Scenario 1 increased the overall sustainability index from 58.29 to 61.43, Scenario 2 further improved the index to 67.57, and Scenario 3 achieved an index value of 73.00. Although all scenarios remain within the sustainable category, the incremental increases demonstrate that systematic strengthening of sensitive attributes can significantly enhance sustainability performance. The results highlight the importance of integrated, long-term strategies—particularly institutional strengthening, technological upgrading, and consistent policy support—to reinforce the role of RMU enterprises in supporting sustainable local food security and rural economic resilience.

Managerial Implication

Further research is recommended to provide a more detailed and dimension-specific assessment, enabling a clearer and more focused understanding of each sustainability dimension of RMU enterprises in Bengkel Village. Based on the sustainability improvement scenarios, the recommended pathway to enhance RMU sustainability is to adopt the prioritised sustainability scenarios. The institutional dimension is expected to improve more effectively under Scenario 2, whereas the ecological, economic, socio-cultural, and technological dimensions can be more feasibly addressed through Scenario 1 to either strengthen performance or maintain current sustainability levels. The selection and implementation of these scenarios should be aligned with the resource capacity and operational realities of RMU managers to ensure long-term applicability and

continuity. In addition, active engagement of relevant stakeholders is essential to support effective implementation and to increase the likelihood of successful sustainability improvements across dimensions.

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