



Assessing the Multidimensional Sustainability of Biopore Infiltration Holes for Household Organic Waste Management Using the Rapfish Method in Kampung Sanitasi, Padang City, Indonesia

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Received: January 21, 2025

Revised: March 02, 2026

Accepted: May 25, 2026

Published: May 31, 2026

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DOI: [10.29303/jppipa.v12i5.14349](https://doi.org/10.29303/jppipa.v12i5.14349)

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Abstract: Household organic waste management represents a critical environmental challenge requiring practical and sustainable solutions, particularly in densely populated urban areas of developing countries. Biopore Infiltration Holes (BIH) constitute an environmentally friendly technology that can be directly implemented at the household level to accelerate organic waste decomposition while simultaneously enhancing soil infiltration capacity. This study aims to conduct a multidimensional sustainability assessment of BIH implementation for household organic waste management in Kampung Sanitasi, Tabiang Banda Gadang Subdistrict. The research employed a descriptive qualitative approach with sustainability analysis using a modified RAPFISH (Rapid Appraisal for Fisheries) method adapted to organic waste management contexts. Data were collected through structured interviews (n=30 households), field observations, questionnaires, and documentation. Each dimension was evaluated based on multiple attributes scored and analyzed using Multi-Dimensional Scaling (MDS) to generate sustainability indices, supported by Monte Carlo simulation and leverage analysis for reliability testing. The multidimensional sustainability analysis revealed varying levels across dimensions: effectiveness (61.69 - moderately sustainable), efficiency (56.91 - moderately sustainable), and practicality (80.52 - highly sustainable), with an overall sustainability score of 66.37 (moderately sustainable). Community participation and environmental literacy emerged as critical determinants of successful implementation. BIH technology demonstrates strong potential as a sustainable household organic waste management strategy, particularly due to its high practicality. The RAPFISH-based multidimensional assessment provides a robust framework for evaluating and improving community-based environmental technologies.

Keywords: Biopore infiltration holes; Community participation; Organic waste; RAPFISH; Sustainability

Introduction

Waste management, particularly household organic waste, remains a formidable challenge in urban environmental management across Indonesia. The country generates approximately 68.5 million tons of waste annually, with organic waste constituting 60-70% of total municipal solid waste, primarily originating

from household food scraps and kitchen waste (Ministry of Environment and Forestry, 2023). This composition is consistent with global patterns in developing countries, where organic fraction dominates waste streams due to consumption patterns and limited processing infrastructure (Hoornweg et al., 2012).

The rapid decomposition of organic waste, if improperly managed, generates significant

How to Cite:

Sy, A., Umar, I., Syah, N., & Syafrijon. (2026). Assessing the Multidimensional Sustainability of Biopore Infiltration Holes for Household Organic Waste Management Using the Rapfish Method in Kampung Sanitasi, Padang City, Indonesia. *Jurnal Penelitian Pendidikan IPA*, 12(5), 653-662. <https://doi.org/10.29303/jppipa.v12i5.14349>

environmental externalities including leachate contamination, greenhouse gas emissions (particularly methane), odorous compounds, and vector breeding grounds (Firdani et al., 2023). These impacts are exacerbated in densely populated urban settlements with limited land availability and inadequate waste collection services. Furthermore, the transportation of unprocessed organic waste to centralized landfills imposes substantial economic burdens, with organic waste accounting for approximately 50-60% of total waste volume transported (Badu et al., 2023).

The Indonesian government has established a regulatory framework for source-based waste management through Law Number 18/2008 on Waste Management, which mandates individual and community responsibility in waste reduction and handling. Subsequent regulations, including Government Regulation No. 81/2012 and Presidential Regulation No. 97/2017, further elaborate national policies and targets for waste reduction (30%) and handling (70%) by 2025. Despite this comprehensive regulatory framework, implementation remains suboptimal, with national waste reduction reaching only 15.3% by 2022 (Ministry of Environment and Forestry, 2023).

The persistent gap between policy ambition and implementation reality underscores critical challenges in community engagement, program sustainability, and the adoption of appropriate technologies at the household level. This situation necessitates waste management solutions that are not only technically effective but also socially acceptable, economically viable, and institutionally feasible within local contexts (Wilson et al., 1991).

Biopore Infiltration Holes (BIH) represent an environmentally friendly technology designed to simultaneously address two critical environmental challenges: organic waste processing and stormwater infiltration (Alfiqri et al., 2024). The technology involves creating cylindrical vertical holes (typically 10-15 cm diameter, 80-100 cm depth) in the ground, filled with organic waste that decomposes through natural biological processes. This decomposition is facilitated by soil macrofauna (earthworms, insects) and microorganisms, which transform organic matter into nutrient-rich compost while creating macropores that enhance soil infiltration capacity (Nurhayati et al., 2018).

The technical advantages of BIH include: (1) minimal land requirement (approximately 0.1-0.2 m² per hole), (2) low construction and maintenance costs (estimated IDR 50,000-100,000 per hole), (3) simple operation requiring no specialized skills, and (4) dual functionality for waste processing and groundwater recharge (Badu et al., 2023). Each standard BIH (10 cm diameter, 100 cm depth) can accommodate

approximately 7.8 liters of organic waste, equivalent to 2-3 days of household organic waste generation for a typical family of four.

Kampung Sanitasi in Tabiang Banda Gadang Subdistrict, Padang City, represents a pioneering community-based sanitation program that has integrated BIH technology with waste bank initiatives and environmental education activities since 2019. This implementation provides a unique opportunity to evaluate the sustainability of BIH adoption beyond pilot project phases. However, existing studies on BIH have predominantly focused on technical performance metrics such as decomposition rates and infiltration capacity (Handayani et al., 2021; Putri et al., 2020), with limited attention to multidimensional sustainability assessment that integrates effectiveness, efficiency, and practicality dimensions.

Furthermore, while RAPFISH (Rapid Appraisal for Fisheries) methodology has been widely applied in fisheries and natural resource management contexts (Fauzi, 2014; Irnawati et al., 2021), its adaptation for evaluating community-based waste management technologies remains underexplored. This methodological gap limits the availability of robust assessment frameworks for guiding policy interventions and program improvements in the sanitation sector.

Addressing these gaps, this study aims to: (1) Analyze the implementation of Biopore Infiltration Holes for household organic waste management in Kampung Sanitasi, Tabiang Banda Gadang Subdistrict; (2) Assess the multidimensional sustainability of BIH application using a modified RAPFISH approach across effectiveness, efficiency, and practicality dimensions; (3) Identify key attributes influencing sustainability through leverage analysis to inform targeted interventions.

The findings are expected to contribute to both theoretical understanding of technology adoption in community settings and practical guidance for scaling up similar interventions in urban sanitation programs.

Method

This study employed a descriptive qualitative approach aimed at obtaining an in-depth understanding of the implementation of Biopore Infiltration Holes in household organic waste management and assessing the sustainability of their application. This approach was selected because it allows for the exploration of contextual information related to community behavior, patterns of participation, and factors influencing program continuity at the local level (Perreault, 2011). As explained by Moleong (2021), qualitative research is a procedure that produces descriptive data in the form

of oral or written narratives from observed subjects along with their behavior.

The research was conducted in Kampung Sanitasi, Tabiang Banda Gadang Subdistrict, Nanggalo District, Padang City, an area that has initiated community-based waste management through the utilization of BIHs. The research location was chosen because this subdistrict was launched as a Sanitation Village by the Padang City Government for community awareness in managing household-based waste. The research was conducted from June to December 2025.

The research subjects included the Head of Tabiang Banda Gadang Subdistrict as supervisor of the sanitation village, community structure of Tabiang Banda Gadang Subdistrict, and heads of households in Kampung Sanitasi, Tabiang Banda Gadang Subdistrict. Thirty households were selected as participants based on the availability of Biopore Infiltration Holes in their homes.

In determining informants, the study used a purposive sampling approach, namely the intentional selection of informants with specific criteria, to ensure the relevance and depth of information (Sugiyono, 2019). This sampling was based on specific considerations, including the selection of people knowledgeable about sanitation activities in waste management using biopore infiltration holes. The informants established were: (1) Head of RW in Tabiang Banda Gadang Subdistrict; (2) Head of RT in Kampung Sanitasi, Tabiang Banda Gadang Subdistrict; and (3) 30 families using biopore infiltration holes.

Data collection employed four types of techniques: interviews, observation, questionnaires, and documentation (Sugiyono, 2020). Structured interviews were conducted to obtain data on biopore usage in residents' homes, with systematically arranged questions based on three-dimensional indicators: effectiveness, efficiency, and practicality. Direct observation was conducted by researchers to obtain accurate data on the application of biopore infiltration holes in households in the Kampung Sanitasi area. Questionnaires were systematically arranged with multiple-choice answers containing four response options related to community perceptions of effectiveness, efficiency, and practicality of using biopore infiltration holes, as well as their involvement in household-scale waste management. Documentation collected included activity records, photo evidence of biopore infiltration hole availability, and other relevant documentation.

To ensure data validity and reliability in this qualitative research, data validity testing techniques were used including triangulation, persistence of observation, extended observation, and peer discussion. Triangulation was conducted through source and method triangulation, comparing direct observations of

biopore infiltration hole conditions in residents' homes with residents' answers through interviews, and comparing information from the Head of RW, Head of RT, and heads of households.

This study used descriptive-analytical analysis methods, aiming to describe the data obtained in narrative and visual forms, such as interview transcripts, field notes, documents, and other written sources. The data analysis technique applied refers to the qualitative analysis model developed by Huberman et al. (2014), which consists of several systematic stages: field notes, data reduction, data display, and conclusion drawing and verification.

The sustainability analysis of BIH implementation was conducted using a modified RAPFISH (Rapid Appraisal for Fisheries) method adapted to the context of organic waste management. This method was applied to assess sustainability levels across three main dimensions: effectiveness, efficiency, and practicality. Each dimension consisted of several attributes that were scored based on questionnaire and interview results as: (1) Effectiveness (reduction in organic waste volume; success of decomposition process; suitability of waste types; frequency and consistency of BIH filling; and perceived benefits); (2) Efficiency (use of time, costs, labor, assistance, and filling activities in BIH management); (3) Practicality (ease of understanding BIH concept, ease of implementation at household level, BIH maintenance, social support, and ease of sustaining BIH practices over the long term).

The scores were then analyzed using Multi-Dimensional Scaling (MDS) to generate sustainability indices for each dimension (Dewata et al., 2016). The Euclidean distance was calculated using Formula 1:

$$d_{ij} = \sqrt{\sum_k^p (x_{ih} - x_{jh})^2} \quad (1)$$

Through the MDS method, the position of sustainability points can be visualized through horizontal and vertical axes, in the form of a kite diagram. The sustainability index values are categorized as follows: 0.00-24.99 (unsustainable), 25.00-49.99 (less sustainable), 50.00-74.99 (moderately sustainable), and 75.00-100.00 (sustainable) (Dewata et al., 2016).

To ensure the reliability of the analytical results, a Monte Carlo test was performed to assess the stability of the sustainability indices against potential scoring errors and data variability with a 95% confidence level. In addition, leverage analysis was used to identify the most influential attributes affecting sustainability values. The results of these analyses served as the basis for formulating recommendations to enhance the sustainability of BIH implementation at the household level (Fauzi, 2014). To determine the accuracy of the

attributes studied in MDS analysis, the stress value and coefficient of determination (R^2) were examined. If the stress value is less than 0.25 ($S < 0.25$) and the coefficient of determination (R^2) approaches 1.0 (100%), the results are considered accurate and accountable.

Result and Discussion

The research results indicate that the availability of BIH in Kampung Sanitasi, Tabiang Banda Gadang Subdistrict, originated from a community service program facilitated by HAKLI West Sumatra in 2023. The community received biopore devices at the initial stage of the program, along with counseling activities on organic waste management. The provision of these tools enabled households to have at least one biopore hole in their yards.

Based on interview results with H, the installation of BIH was carried out simultaneously coinciding with National Waste Day, and some residents installed them in back or side yards considered strategic for accommodating kitchen organic waste. The installation rate in the early program period was quite high, as seen from the high number of residents who attended and participated in these activities.

Nevertheless, the level of availability of BIH that are actually functioning optimally is still relatively low. From interviews, it was found that only about 40-60% of households utilize BIH consistently, as revealed by H:

"Our understanding of maintaining and managing BIH is still lacking, because since the initial tools and socialization were provided by HAKLI, there has been no follow-up."

This factor indicates that although tools are available, not all residents integrate this technology into their waste management routines. The biopore infiltration holes owned are mainly used to process household organic waste originating from kitchen activities. According to D, residents put vegetable scraps, fruit peels, leftover food, and other organic waste into the BIH. The types of organic waste used are generally wet waste produced daily, as it is the most abundant and easily decomposable.

Some residents who are more active in utilizing BIH also put dry organic materials such as leaves, small twigs, and yard grass. However, this practice is only carried out by a small portion of households that understand the variety of organic materials that can be inserted into biopores. Most residents focus more on kitchen waste they produce daily.

The filling of organic waste into biopore holes, if done correctly and regularly, will undergo a natural decomposition process and turn into compost that can

be reused. Field findings show that some residents have successfully removed compost from their biopore holes, although the amount is not yet substantial.

The process of filling BIH is carried out independently by residents utilizing organic waste available daily. The frequency of filling varies depending on the kitchen activities of each household. D explained that some residents fill the holes regularly several times a week, while others only fill them when the volume of kitchen waste is quite large:

"Some residents of Kampung Sanitasi have routinely put their kitchen waste into biopore holes, but some only do so when kitchen waste is very abundant."

BIH maintenance poses a significant challenge in the implementation of this technology. H revealed that residents' consistency in maintaining the holes is still low. Some residents often forget to open the hole covers, clean the surface, or check the decrease in waste volume inside the holes. This condition is exacerbated by the lack of follow-up assistance after the initial tool provision and counseling.

MP assessed that BIH maintenance requires good technical understanding so that the community can maintain the condition of the holes and obtain optimal benefits. This limited understanding is what causes some holes to become inactive or no longer used optimally. Additionally, the persistence of old habits such as burning waste also hinders the maintenance process because residents do not fully rely on BIH as the primary means of waste management.

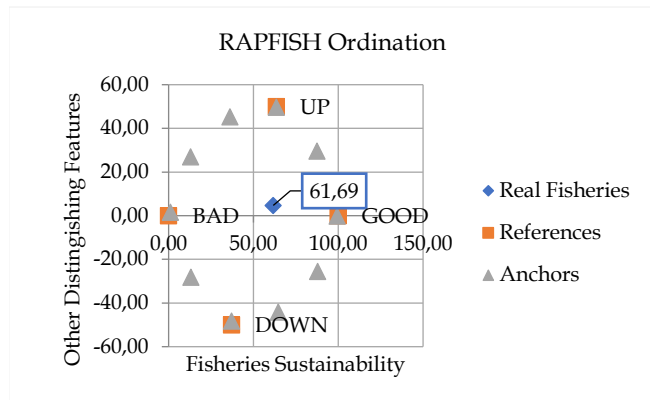
Community participation in the initial stage of the program was relatively high. This can be seen from the high number of residents who attended the initial meeting with HAKLI, as well as the enthusiasm of residents when the biopore tools were handed over. H noted that around 30 or more residents attended the first counseling activity, indicating that the initial socialization succeeded in attracting community attention.

However, interview data show that the level of community awareness in the long term is not evenly distributed. D and MP both highlighted that some community members still choose to burn waste even though they already have BIH. This indicates that behavioral change requires time and continuous assistance.

The role of neighborhood leaders in increasing community awareness is very important. H explained that he regularly reminds residents not to burn waste and to use the available BIH. Additionally, there have been several follow-up counseling sessions from Poltekkes academics that have helped increase residents' knowledge about organic waste management.

MP emphasized that the community is essentially capable of managing BIH independently if given adequate understanding. Thus, program sustainability greatly depends on the level of community awareness and the availability of educational activities conducted periodically.

Based on interview results with informants, an analysis was conducted to assess the sustainability of BIH implementation in Kampung Sanitasi, focusing on three main indicators: effectiveness, efficiency, and practicality.



Effectiveness Dimension

The ordination results show that the sustainability index is at 61.69. Based on Rapfish assessment criteria, values in the range of 51-75 are categorized as Moderately Sustainable. The position of the "Real Fisheries" point to the right of the center line indicates that, in general, the effectiveness of biopore implementation in Tabiang Banda Gadang Subdistrict has been running quite well, although it has not yet reached a very sustainable (optimum) status.

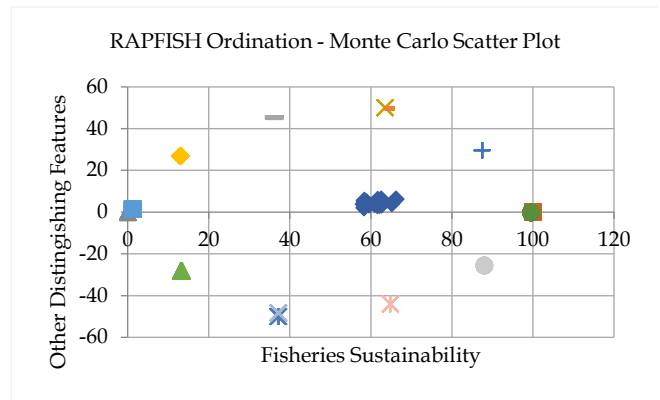


Figure 1. Position of sustainability status and Monte Carlo analysis of the effectiveness dimension

The Monte Carlo analysis results show a tight cluster of points, indicating that the difference between pure MDS values and Monte Carlo simulation values is very small. This concludes that the analytical model used is stable and the sustainability index value of 61.69 is statistically reliable because it is not significantly influenced by scoring errors or data variation.

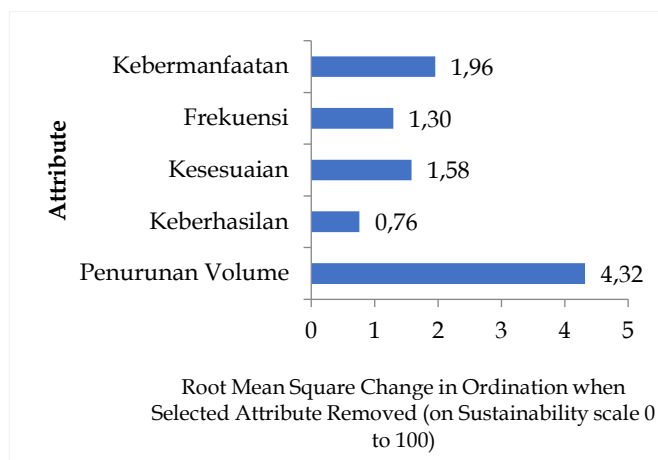


Figure 2. Leverage of attributes

Leverage analysis results to determine the most sensitive or influential attributes on sustainability status in the effectiveness dimension show that the "volume reduction" attribute has the highest leverage value of 4.32, followed by the "Benefit" attribute (1.96) and

"Suitability" attribute (1.58), "frequency and consistency of filling" (1.30), and "BIH success" (0.76).

The high RMS value on the "Volume Reduction" attribute indicates that this attribute is the dominant leverage factor. The managerial implication of this result is that if managers or the government want to effectively improve the sustainability status of biopore infiltration holes in the Effectiveness dimension, priority interventions must focus on increasing the technical success rate of the biopore function. Improvement in the attribute with the highest leverage value will provide a more significant increase in sustainability scores compared to other attributes.

Efficiency Dimension

Based on Multi-Dimensional Scaling (MDS) analysis, a sustainability index value of 56.91 was obtained. Referring to the Rapfish category confidence interval, this value places the efficiency dimension in the Moderately Sustainable status. Visually, the ordination point position (Real Fisheries) is on the left side of the diagram, indicating that the efficiency performance of biopore infiltration hole implementation at the study location still requires significant improvement. Compared to the effectiveness dimension (score 61.69), this efficiency aspect is a weak point that needs priority attention in overall sustainability improvement efforts.

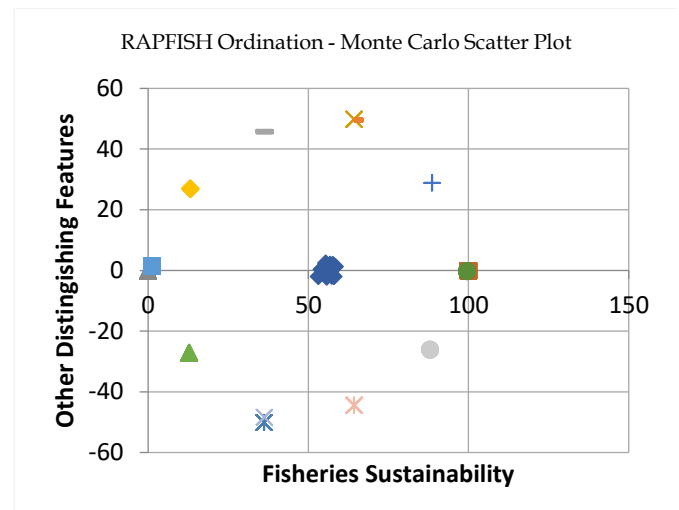
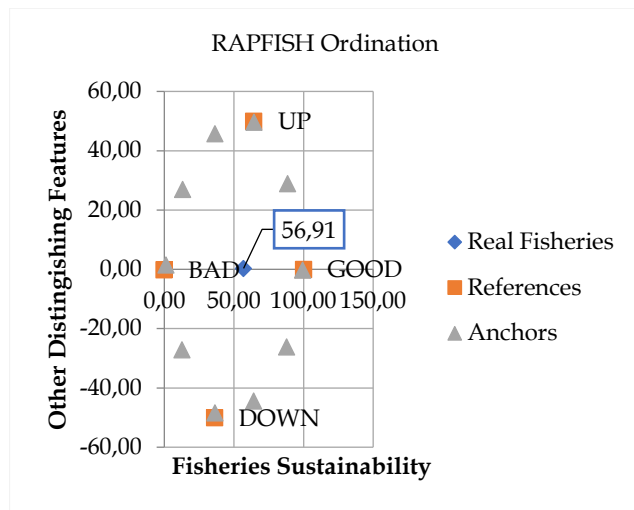


Figure 3. Position of sustainability status and Monte Carlo analysis of the efficiency dimension

Monte Carlo analysis results show a scatter plot pattern of points that are tightly concentrated around the original ordination value (56.91) without significant dispersion. This pattern indicates that the deviation or difference between MDS values and Monte Carlo simulation average values is very small. This confirms that the analytical model has a high level of robustness. Thus, the "Moderately Sustainable" status obtained in the efficiency dimension is a statistically valid result, unbiased, and its accuracy can be accounted for.

Leverage analysis results to identify sensitive attributes in the efficiency dimension show that the "Assistance" attribute occupies the highest position as the main leverage factor with a value of 6.79, followed significantly by the "Labor" attribute with a value of (6.05), "Time" with a value of (3.29), BIH filling with a value of (3.09), and cost with a value of (0.62).

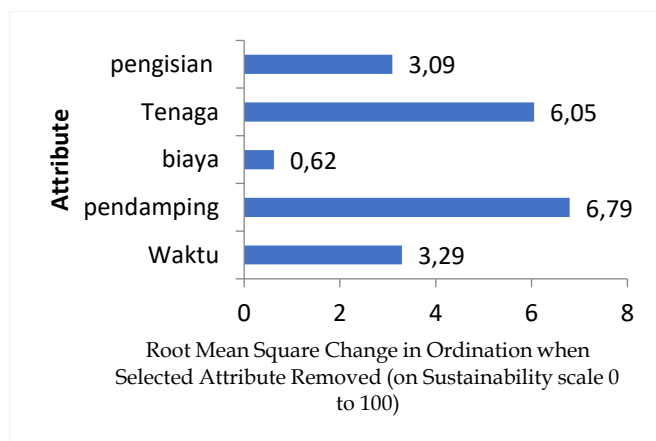


Figure 4. Leverage of attributes

The high RMS value on the "Assistance" attribute indicates that this attribute is the main leverage factor. The implication is that if managers or the government

want to improve the sustainability status in the efficiency dimension, priority interventions should be focused on assistance programs. If managers can provide regular and consistent assistance and supervision, the sustainability score of this dimension will experience a significant increase. Conversely, efforts focused only on labor aspects will not be effective in boosting sustainability status.

Practicality Dimension

Unlike the efficiency dimension that still requires much improvement, the practicality dimension actually shows very satisfactory performance with a sustainability index of 80.52. This value places the practicality dimension in the Good Sustainable category, as it is in the score range of 76 to 100. The ordination point position far to the right of the diagram approaching the Good reference point indicates that the application of biopore infiltration hole technology in Tabiang Banda Gadang Subdistrict is considered very practical, easy to apply, and does not inconvenience the user community. This practicality aspect becomes the main strength in the program's sustainability system.

Monte Carlo analysis results for the practicality dimension show a scatter plot pattern of simulation points that are very solid and tightly clustered around the sustainability ordination value of 80.52. The minimal scattering of these points indicates that the stress value in the analysis is very low and the coefficient of determination (R^2) is high. This proves that the high sustainability index obtained in the practicality dimension is valid, stable, and has a high confidence level statistically. Thus, it can be concluded that the positive assessment of the practicality aspects of biopore technology is consistent and not influenced by input error bias or significant data variation.

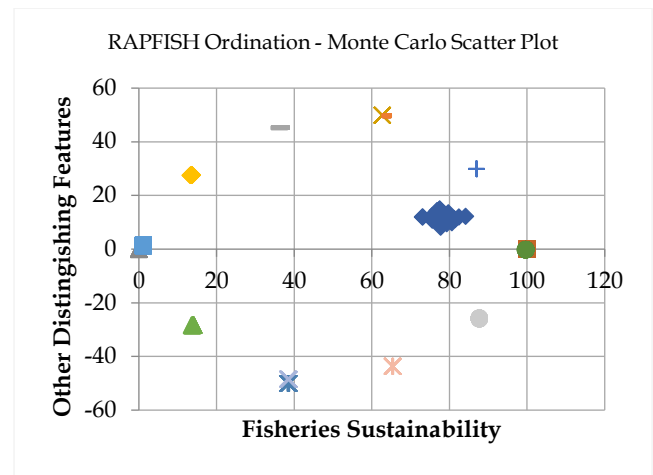
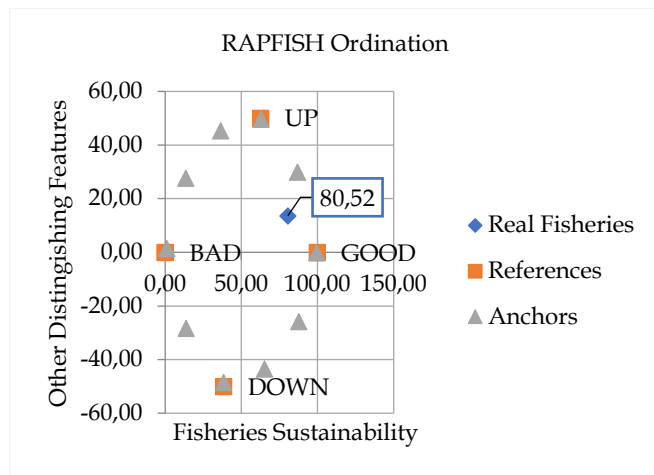


Figure 5. Position of sustainability status and Monte Carlo analysis of the practicality dimension

Leverage analysis results for the practicality dimension to identify the most sensitive attributes influencing sustainability status show significant differences between attributes, where the "Support" and "Sustaining" attributes emerge as the main determining factors with Root Mean Square (RMS) Change values of 8.95 and 7.80. These values outperform the "maintenance" (5.81), "Ease" (5.87), and "Implementation" (6.14) attributes.

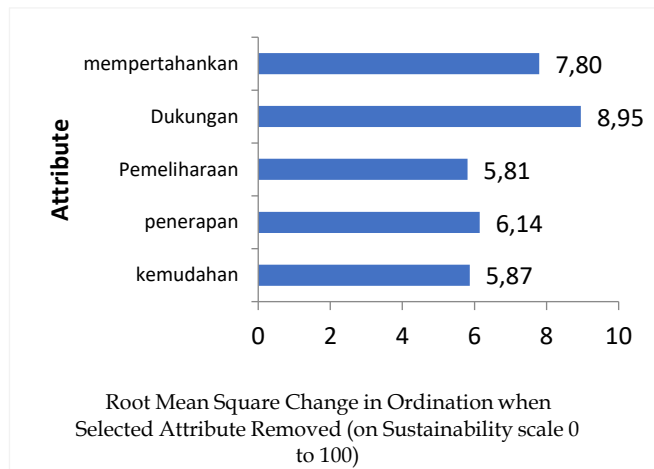


Figure 6. Leverage of attributes

This finding indicates that the key to the high sustainability status in the practicality dimension (score 80.52) lies in the consistency and intensity of biopore technology implementation itself in the field. The action aspect or actual application is considered more crucial than technical ease or maintenance efforts. Therefore, the strategy to maintain the "Good Sustainable" status in this dimension is to ensure the implementation program continues to run massively and does not stop, because disruption to the implementation aspect will drastically decrease the sustainability index.

The sustainability of LRB implementation in the Sanitation Village was analyzed across three principal

dimensions, there are effectiveness, efficiency, and practicality. The sustainability scores for these dimensions were assessed using a modified RAPFISH method. Each dimension was evaluated based on a set of specific indicators. The effectiveness dimension encompassed the reduction in the volume of organic waste, the success of the decomposition process, the suitability of waste types, the frequency and consistency of LRB filling, and the perceived benefits of its application. The efficiency dimension focused on the use of time, costs, labor, assistance, and filling activities involved in LRB management. Meanwhile, the practicality dimension included the ease of understanding the LRB concept, the ease of implementation at the household level, LRB maintenance, social support, and the ease of sustaining LRB practices over the long term.

Based on the results of the modified RAPFISH analysis, the effectiveness dimension indicates that the implementation of LRB contributes to a reduction in the volume of household organic waste. The decomposition process occurs naturally and relatively rapidly, as evidenced by the decreasing volume of waste within the pits and the formation of organic material resembling compost. In addition, the use of LRB is considered effective in reducing residents' dependence on disposing of waste at temporary collection points.

Nevertheless, the level of effectiveness has not yet reached its optimal potential, as some LRB pits were found to be infrequently filled and inadequately maintained. The attributes that most strongly influence this dimension include the consistency of waste input, the types of organic waste introduced, and residents' understanding of the functions and benefits of LRB.

Based on the results of the analysis, the practicality dimension obtained high scores on the indicators of ease of implementation and suitability to the residential environment. LRB does not require a large land area,

making it well suited for application in densely populated areas such as the Sanitation Village. Interviews with MP further support this finding,

indicating that the primary reason for selecting LRB technology lies in its practical nature and its adaptability to high-density settlement conditions.

Table 1. Results of Sustainability Analysis Using the MDS (Multi-Dimensional Scaling) Method

Dimension	Stress	R ²	MDS Value	Status	Monte Carlo test	Difference (MDS-Monte Carlo)
Effectiveness	0.17	0.93	61.69	Moderately Sustainable	60.90	0.79
Efficiency	0.15	0.93	56.91	Moderately Sustainable	56.18	0.73
Practicality	0.15	0.94	80.52	Good Sustainable	78.58	1.94
Average			66.37	Moderately Sustainable		

Conceptually, these findings are consistent with the study by Mondal et al. (2024), which demonstrates that the successful implementation of appropriate technology is strongly influenced by technical simplicity and alignment with local socio-ecological conditions. However, the practicality of long-term maintenance and the level of social support from both managers and governmental stakeholders remain relatively low, as a portion of the community is still unfamiliar with routine maintenance procedures.

Community awareness and participation emerge as key factors determining the sustainability of LRB implementation. This observation aligns with the findings of Liu et al. (2024), who emphasize that the adoption of environmental technologies is highly dependent on the level of ecological literacy and social support within the community. In the absence of collective participation, even simple technologies are unlikely to achieve long-term effectiveness.

Based on the average index values across all dimensions, the multidimensional sustainability score was calculated at 66.37. This result classifies the implementation of Lubang Resapan Biopori in Tabiang Banda Gadang Subdistrict as Sufficiently Sustainable. Although the Effectiveness and Efficiency dimensions remain within the "Sufficient" category, the strong positive contribution of the Practicality dimension, which is categorized as "Highly Sustainable," significantly enhances the overall sustainability performance. This finding implies that the technology is highly feasible to be continued, provided that improvements are made in aspects related to cost and time efficiency.

The findings of this study further demonstrate that the sustainability of Biopore Infiltration Holes (LRB) implementation is strongly influenced by behavioral, technical, and institutional factors. Recent studies emphasize that household-scale organic waste management technologies tend to be effective when they are integrated with daily routines and supported by continuous environmental education (Kountouris et al., 2023; Raghu et al., 2020).

In terms of effectiveness, the observed reduction in organic waste volume aligns with contemporary

research indicating that biopore-based systems are capable of accelerating organic matter decomposition through enhanced soil biological activity (Carvalho et al., 2022; Putri et al., 2020). Microbial activity within biopore structures plays a crucial role in transforming organic waste into stable organic matter, which simultaneously contributes to soil fertility improvement (Handayani et al., 2021).

The efficiency dimension remains moderately sustainable, reflecting similar patterns reported in recent urban waste management studies. Although LRB construction requires minimal financial investment, time constraints and limited technical assistance often reduce operational efficiency at the household level (Jung et al., 2018; Pandyaswargo et al., 2019). This finding reinforces the argument that low-cost environmental technologies still require structured institutional facilitation to ensure optimal performance.

From a practicality perspective, the high sustainability score confirms that LRB technology is well suited for densely populated urban settlements. Previous studies conducted in comparable urban contexts highlight that compact, low-maintenance waste management systems are more likely to be adopted and sustained by communities with limited land availability (Cainelli et al., 2015; Yiu, 2025). The simplicity of LRB construction and operation significantly lowers technological barriers, thereby enhancing community acceptance.

However, recent literature consistently underlines that long-term sustainability is contingent upon social support and governance mechanisms. Community participation, peer influence, and leadership engagement have been identified as decisive factors in sustaining environmentally friendly practices at the neighborhood scale (Pichtel, 2014; Tomimi, 2024). Without collective commitment, the functionality of LRB systems may gradually decline despite their technical feasibility.

The multidimensional sustainability score obtained in this study corroborates findings from sustainability assessments using modified RAPFISH and MDS approaches in environmental management contexts. These approaches have been widely recognized for their

robustness in capturing complex interactions among ecological, social, and economic dimensions (Irnawatia et al., 2021). The relatively small difference between MDS and Monte Carlo values further confirms the reliability of the sustainability indices generated.

Overall, recent empirical evidence supports the conclusion that LRB technology represents a viable and sustainable solution for household organic waste management, particularly when embedded within community-based programs and supported by continuous capacity-building initiatives (Haryanto et al., 2022; Santoso et al., 2023).

Conclusion

Based on the research findings and discussion, it can be concluded that the implementation of Biopore Infiltration Holes (BIH) in Kampung Sanitasi, Tabiang Banda Gadang Subdistrict, has generally been applied in most households and utilized as a medium for managing household organic waste. The BIH program originated from the HAKLI West Sumatra community service initiative in 2023, through which residents received biopore devices and counseling related to organic waste management. Although BIH has functioned as an alternative waste management facility, differences in utilization and maintenance among households indicate that its implementation has not yet been fully optimal and evenly sustained. Sustainability analysis using the RAPFISH method shows that the implementation of BIH falls within the moderately sustainable category, with a multidimensional sustainability index score of 66.37. Among the assessed dimensions, practicality achieved the highest sustainability score and was categorized as good sustainable, while the effectiveness and efficiency dimensions remained moderately sustainable due to limitations in the consistency of BIH use, maintenance, and community assistance. Furthermore, leverage analysis revealed that volume reduction is the main determining factor in the effectiveness dimension, assistance is the key factor in the efficiency dimension, and support and sustaining factors are the most influential attributes in the practicality dimension. Therefore, improving the sustainability of BIH implementation requires continuous support through regular assistance, monitoring, institutional strengthening, and follow-up socialization and technical training activities. In addition, increasing the number of biopore holes and integrating the BIH program with community-based waste management systems at the subdistrict level are important strategic efforts to ensure the long-term effectiveness, efficiency, and sustainability of BIH implementation.

Acknowledgments

This research received no external funding and was supported by the author with institutional assistance from Universitas Negeri Padang.

Author Contributions

A.S: preparation of original draft, methodology, data collection, analysis, analysis multidimensional scalling, results and discussion, review, and editing.

Funding

No external funding.

Conflicts of Interest

The author declares no conflict of interest.

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