

The Role of Traditional Knowledge and Local Values in Community-Based Waste Management in Small Islands: a Case Study of Penyengat Island

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Abstract. This study aims to determine the correlation between local knowledge and values and the effectiveness of community-based waste management.. This study uses quantitative and qualitative approaches. The sampling points were divided into four clusters representing the four sides of the island by interviewing 97 respondents. Quantitative data were analyzed using correlation analysis, while qualitative data were analyzed descriptively. The results showed that local knowledge and values significantly affected the effectiveness of waste management, which was visualized with heatmaps. The strength of the color shows visualization; the redder, the more substantial and more positive the value, and the color's intensity reflects the correlation's magnitude. The strongest correlation analysis of knowledge factors on effectiveness is shown by the continuity variable with a value of 0.50, and the weakest correlation is community involvement with a value of -0.17. Then, the strongest correlation between local values and management effectiveness is shown by the sustainability value variable and general knowledge value with a value of 0.76, while the cultural practice value and the importance of values with a value of 0.55 show the weakest correlation. The research findings conclude that community-based waste management intervention strategies, especially in small island areas, can make good practices of traditional knowledge sustainability values and local values of local communities the main consideration so that waste management can be more effective.

1 Introduction

Indonesia has a variety of potential and unique natural resource wealth in some coastal areas and small islands. Thus presenting many challenges to environmental sustainability and management. The challenges faced by small island areas are widely discussed in various articles covering ecological, social, and cultural aspects that are very dynamic, unique, and

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complex. Small islands in Indonesia are pillars of sustainable development [1], considering the existence of small islands still facing accessibility challenges in various aspects [2]. Functionally, small islands interact with each other ecologically, economically, socially, and culturally [3]. Among the challenges facing small islands in Indonesia is the problem of accessibility [4], geographically isolated [5], and waste management problem [6]. Penyengat Island is one of the small islands in the Riau Islands Province, which has an area of about 2.5 square kilometers and has significant historical value in Malay culture and Indonesian maritime. Penyengat Island is currently a major tourist destination for foreign tourists from Singapore, Malaysia, and Brunei Darussalam who are interested in learning more about Malay culture. Preserving the historical value of Penyengat Island and preserving the value of the natural environment are very relevant to the sustainability of small islands. Penyengat Island's fame as a historical and cultural tourist destination is known to many countries [7].

In the last decade, small island areas have faced many challenges related to waste management, especially plastic waste [8]. This is due to several factors, including limited land area, resources, and ecological instability [9], the still dominant behavior of people throwing waste into the sea [10], and the increasing development of tourism activities in small island areas [11], the impact of climate change which slows down the process of pollution rehabilitation in the coastal environment [12], accessibility challenges from and to small islands [2], and disrupts waste transportation out of the island. So, the waste management problem still needs to be solved, especially in small island areas that are the center of tourism activities [9,13]. The waste problem was also found on Penyengat Island, especially on weekends, where most visitors are. This shows that waste management is ineffective even though a 3R waste processing facility is available [14].

Community-Based Solid Waste Management (CBSWM) is a waste management system that acknowledges the pivotal role of the community in cleaning up their environment and earning income from waste [15] and the involvement of various stakeholders [16]; community-based waste management emphasizes residents' participation and leadership in addressing waste-related problems [17–21]. In a community-based management scheme, the community is organized to carry out certain functions or tasks related to the SWM system. Communities can perform tasks such as collecting, sorting, or recycling waste. In some low-income areas, community-based schemes are the only solution available, given the need for more resources in the city government to provide waste management services. Although the community is already actively involved in waste management, the government's role needs to increase the provision of infrastructure for transporting waste from the island to mainland areas outside the island [22].

Various studies on community-based waste management have been conducted, including stating the need for institutions [23], then waste management through waste banks [24,25], development of waste bank facilities [26], and funding with the private sector [27]. A part of that is that traditional top-down approaches to waste management are often inadequate in these specific situations, where communities' closed and close-knit nature demands more participatory and localized strategies. In other studies, community-based waste management is also carried out through local wisdom, such as the 'Tri Hita Karana' values in Bali, which will create a clean and healthy environment and positively contribute to waste management in urban areas [28]. Furthermore, it is known that the low number of people who process their waste is due to a lack of knowledge and awareness [29]. The literature review shows that environmental awareness education is one of the critical factors for the success of community-based waste management [30].

However, the studies have yet to examine the influence of local knowledge and community values on the effectiveness of community-based waste management. In addition, the studies that have been conducted have not focused on small island areas, especially tourist destinations such as Penyengat Island. Therefore, this study aims to answer the knowledge

gap from several previous studies with the main research question: How do local knowledge and community values influence the effectiveness of community-based waste management on Penyengat Island?

The main objective of this study is to examine the relationship between local knowledge and values and the effectiveness of community-based waste management in small island areas (a case study of Penyengat Island, Riau Islands Province, Indonesia).

2 Method

2.1 Study Location

This research will be conducted from April to November 2024. The research location is Pulau Penyengat Village, Tanjungpinang City, Riau Islands Province, Indonesia (Figure 1). Pulau Penyengat Tourism Village is included in the top 75 of the 2023 Indonesian Tourism Village Award (ADWI) and is planned to become the World Center for Islamic Malay Cultural Studies. Pulau Penyengat is located in the border area of Indonesia with several neighboring countries such as Malaysia, Singapore, and other ASEAN countries. Pulau Penyengat juga telah diusulkan ke UNESCO sebagai salah satu warisan budaya dunia sejak tahun 2021 [31], and is currently ranked 11th on the waiting list for submission, including the work of Raja Ali Haji 'Gurindam 12' which contains high Malay cultural values. Pulau Penyengat has been designated a national cultural heritage area, so foreign and local tourists visit it most often.

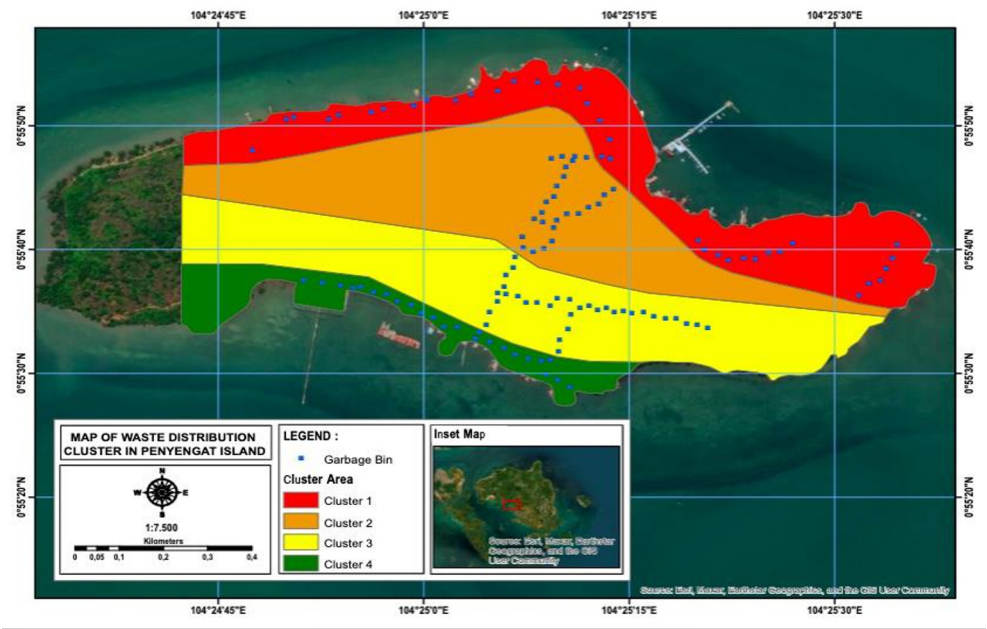


Fig. 1. Study Location

2.2 Research Approach

This research uses a mixed quantitative and qualitative approach to the multifaceted nature of research on community-based waste management. Mixed methods always involve the collection, mixing, and integration of quantitative and qualitative data in a study , [32,33], and then, with data triangulation, additional insights into the problem and research questions can be gained [34]. The mixed method is very suitable for this study, considering the

complexity of waste management involving various factors that can be measured quantitatively and qualitatively [35]. This method can provide depth and breadth of understanding. For example, quantitative methods offer statistical data on the influence of local knowledge and values, while qualitative methods explain contextual information that is rich in detail on why and how these factors affect waste management practices.

The sampling technique uses cluster random sampling, grouping clusters based on geographic areas [36]. The cluster in question is random sampling according to the area or region of a specific population, namely by dividing the Penyengat Island area into four clusters, namely;

1. cluster 1, densely populated settlements in the northern part of the Island,
2. cluster 2, the central area of the Island, includes a more diverse zone in terms of land use,
3. cluster 3, tourist areas with sparsely populated,
4. cluster 4, densely populated residential areas south of the Island.

Using this cluster is considered when researching something that is available or characteristic in a particular region or area.

The non-probability sampling technique randomly selects members to conduct research. This method does not use a fixed or standard selection process. Respondent information is obtained from each RT Head on the Island. This cluster sampling approach is appropriate to ensure representative data from various areas. The number of respondents interviewed is determined by the Slovin method [37]. There were 97 respondents from a total of 775 Heads of Families, which seems reasonable, although the adequacy of the sample size will depend on the total population of Penyengat Island.

The data collection method in this study depends on the purpose of the research and the type of information to be collected [32]. The study's data collection methods were interviews and questionnaires [38]. For quantitative data, data collection used a closed-ended questionnaire, while qualitative data was collected through open-ended interviews. Furthermore, the research variables were measured with a questionnaire using a Likert scale [39] with a scale value range of 1 - 5. The higher the assessment value indicates, the higher the influence on the effectiveness of community-based waste management. In addition, data collection was carried out by observing the research location to gather additional information needed.

Quantitative data analysis uses statistical description, namely correlation analysis, to determine the influence of local knowledge and values on the effectiveness of waste management and then determine the statistical significance value of the correlation. Then, the representation of the correlation matrix is visualized using heatmaps with Phyton analysis [40,41], so that it is easier to identify patterns and relationships between several variables. Furthermore, a qualitative study provided context and depth to quantitative findings.

Furthermore, to describe the direction of the linear relationship and the strength of the correlation between the two variables measured, namely local traditional knowledge and local values in community-based waste management on Penyengat Island, this study uses a statistical measure of heatmaps with a coefficient of 'r' ranging from -1 to 1. The criteria for this value are;

- $r = 1$ indicates a positive correlation, meaning that when there is an increase in one variable, and then proportionally, the other variables will also experience an increase
- $r = -1$ indicates a negative correlation, meaning that other variables do not follow a rise in one variable
- $r = 0$ indicates no correlation, meaning that there is no linear relationship between the variables $r = 0$ menunjukkan tidak ada korelasi artinya tidak ada hubungan linier antara variabel

3 Results

Of all respondents interviewed (98 respondents), it is known that 72 respondents (73.5%) have lived on Penyengat Island for more than 20 years, and only 8.2% have lived for 1-5 years. Then, based on age group, it is known that most respondents are in the productive age group (40-50 years), with a formal education level of 42.9% graduating from high school. Based on gender-based respondent data in Penyengat Island, there is a balance between the number of men (49%) and women (51%) from 98 respondents. Respondent characteristics are visualized in Figure 2.

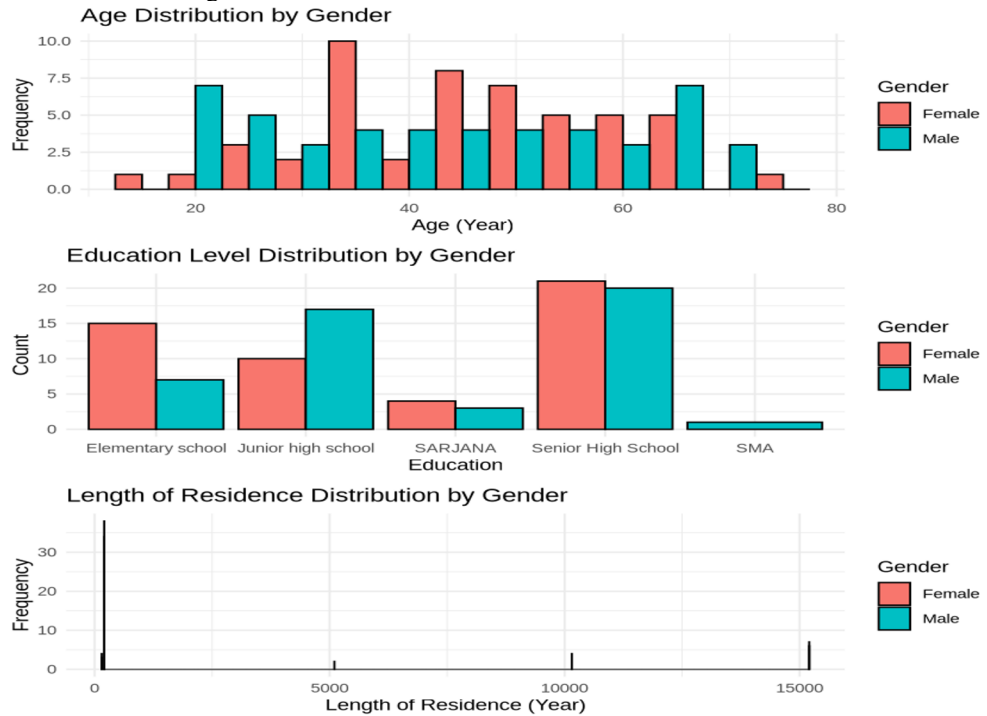


Fig. 2. Respondent Characteristic

The high productive age and the number of respondents who graduated from high school, as visualized in Figure 1, show that the community's social conditions are very supportive of the sustainability of community-based waste management on Penyengat Island. However, more than formal education is needed to guarantee the community's ability to carry out waste management optimally because good waste management requires special knowledge related to waste management and supporting skills. Therefore, the characteristics of this community are that it is very worthy of receiving training or assistance related to knowledge and skills for sustainable community-based waste.

3.1 The Role of local traditional knowledge in waste management

From the correlation analysis conducted, it is known that there is a relationship between traditional knowledge and community-based waste management on Penyengat Island. The heatmap visualization in Figure 3 shows a strong positive correlation between the traditional waste management practice variable (P3) and its continuity between generations (P5), with a

correlation value of 0.56. Variable P5 with effectiveness also shows a strong positive correlation (0.50). This statement explains that sustainable traditional practices are related to the effectiveness value of community-based management. This finding shows that when traditional knowledge of the community increases, knowledge of the next generation will also increase, thus increasing the effectiveness of its management. And when The correlation analysis between these variables makes a unanimous conclusion. This finding suggests that when traditional practices are considered adequate, the overall community-based waste management system is also more effective. Therefore, conventional community practices in waste management need to be followed by an increase in good knowledge about waste management, considering that the community strongly believes that these practices are good and need to be continued from generation to generation in the future. In general, community knowledge about waste management is good, but they need to understand more about how to process waste in a modern way. However, such practices are not effective for future generations even though the value of community involvement is good.

A weak or negative correlation is indicated by the inverse relationship between community involvement (P7) and the value of traditional knowledge for future generations (P6), which has a value of (-0.17). Similarly, the negative correlation of P7 to effectiveness is -0.06. This finding from careful data analysis identified that the variables from the knowledge factor that had the strongest correlation with the effectiveness of community-based waste management were the traditional practices and community involvement variables. The correlation value can be explained by the conditions in the field, which show the strength of the relationship between traditional community knowledge and waste management around the residents' homes on Penyengat Island. Although their waste management methods are not modern, this traditional practice has been running for a long time and shows that the environment around the housing looks clean and beautiful. The challenge in waste management on Penyengat Island lies not in the waste collection stage but in the waste processing stage, which has yet fully utilized the facilities and infrastructure available at TPS3R. This is due to the need for more modern waste management knowledge. However, traditional practices have been effective in protecting the environment from waste problems. This underscores the community's deep understanding of the importance of waste management, despite the need for modern knowledge and skills. The results of field observations on Penyengat Island show the community's orderly habits in collecting waste produced by each household. Waste management officers then transport it to the 3R Waste Processing Site, making the community's housing environment look beautiful and clean. This shows that the community on the island has a good form of knowledge implementation. The correlation between variables can be seen in the heatmap visualization in Figure 3, where the correlation plot and box plot of all variables explain how the data is distributed and the relationship between variables.

The heatmap visualization in Figure 3 also shows a moderate positive correlation between community knowledge about waste management practices (P1) and the effectiveness of community-based waste management. This means that they go hand in hand; if community knowledge increases, the effectiveness of waste management will also tend to increase. Meanwhile, the relationship between knowledge sources (P2) shows a weak to moderate positive correlation with effectiveness, which means that knowledge sources have some influence on the effectiveness of waste management but are less as strong as other factors. This is because information sources in the current digital era are relatively easy for the community to obtain. This finding likewise shows a moderate positive correlation between traditional waste management practices and effectiveness (P3). Community groups with more sustainable traditional waste management practices tend to have more effective community-based waste management systems. However, other factors also influence this, namely the variable of knowledge and information sources. Then, the variable with the

strongest positive correlation with the effectiveness of community-based waste management is the variable of the effectiveness of traditional waste management practices (P4). This means that when traditional practices are considered adequate, the overall community-based waste management system is also more effective.

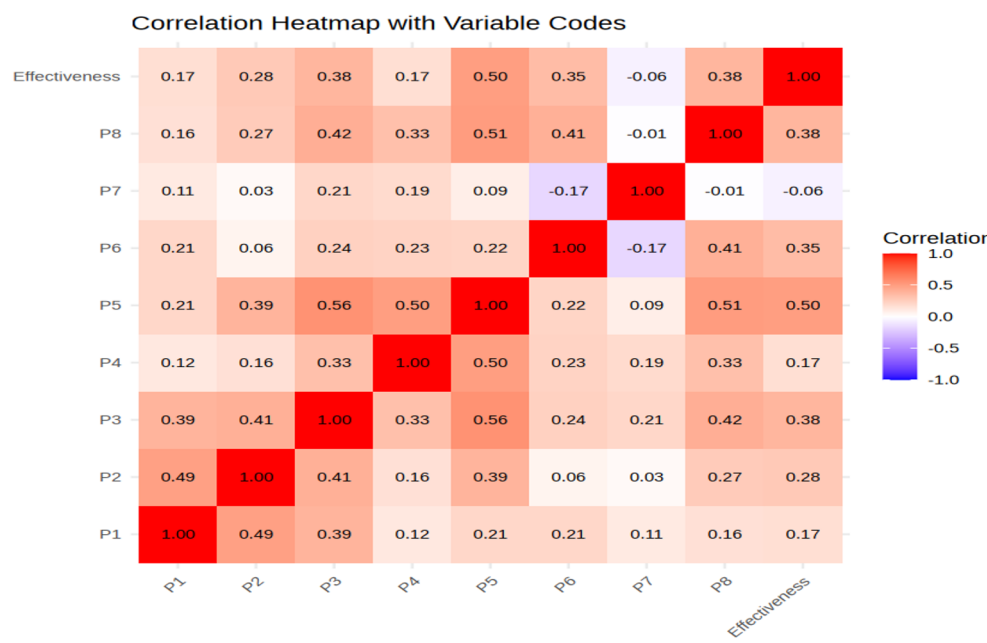


Fig. 3. Visualization of heatmaps between local community knowledge variables

Correlation heatmap visualization data between traditional management variables and waste management show that traditional knowledge can be critical in realizing effective waste management. This finding suggests the need to strengthen and develop traditional community knowledge about waste management with modern techniques because, in fact, the community already has an awareness of the importance of managing waste properly. The community's current education is not an obstacle to gaining new knowledge in waste management. The significance of the local community knowledge factor on the effectiveness of community-based waste management on Penyengat Island can be concluded as follows; 1) Community knowledge (P1) and traditional practices (P3) both have essential roles in the effectiveness of community-based waste management in Penyengat Island, so this finding highlights the importance of local knowledge and established waste management practices that are in accordance with the principles of sustainability in efforts to make community-based waste management effective and sustainable, 2) The effectiveness of traditional practices (P4) has the strongest correlation with overall effectiveness, this concludes that utilizing and improving existing effective practices in Penyengat Island can be a crucial strategy to improve community-based waste management, 3) Sources of knowledge (P2) have a weaker correlation, this concludes that although this factor is essential, there are other factors that are more important, namely actual practices and effectiveness that are directly felt by the community are more important.

3.2 The role of local values in waste management

When compared with the correlation value of local values with community knowledge, local value factors have a greater influence on management effectiveness than knowledge. The results of the correlation analysis of effectiveness show that all value variables positively correlate with the effectiveness of community-based waste management, ranging from moderate to vigorous. The strongest correlation is in the sustainability value (N8) with a value of 0.63, followed by the value of the willingness to change traditional practices to more sustainable ones (N9) around 0.59, and the value of support for initiatives (N6) with a value of 0.58. Moderate correlation is indicated by N1 (0.54), the value of the importance of value, and N4 (0.52), or the value of ethical considerations. The value of the perceived impact of waste (N5) has the lowest correlation with effectiveness, which is 0.44. The statement of values shows that a moderate to strong linear relationship means that when each of these variables increases, the effectiveness of waste management also tends to increase. A value of 0.63 shows a strong positive relationship between sustainability values and management effectiveness, indicating that local values have instilled a strong commitment in the community to maintain environmental cleanliness in the long term, and the community is willing to make the necessary efforts to realize effective community-based waste management. The variables with positive correlations are all correlated, indicating the potential for willingness to change traditional practices into more modern ones. The strength of the desire to change is the power to adapt, which will potentially become a new strategy to create effective waste management. Then supported by the value of community initiatives to actively participate, the value of viewing the importance of waste management values so that the community tends to allocate resources and attention to waste management, and the value of ethical considerations reflected in the form of a sense of community moral responsibility towards the environment.

The correlation between local value variables can be seen in the heatmap visualization in Figure 4, where the correlation plot and box plot of all variables explain how the data is distributed and the relationship between variables. The color intensity in Figure 5 represents the strength of the correlation; red indicates a positive correlation, and blue indicates a negative correlation. N8 (Sustainability Value), which has the darkest red color with effectiveness, shows the strongest positive correlation. The variables with the strongest correlation are N1 and N8, with a value of 0.76, which connects general values with sustainability values. This means that applying general values in society has a close relationship with sustainability values. Likewise, a strong correlation occurs between the variables of community responsibility (N3) and ethical consideration values (N4) with a value of 0.75, followed by a value of 0.71 from the variables of support for initiatives (N6) and (N9). The correlation with the lowest value (0.55) is shown by the value of cultural practices (N2) with the value of the importance of values (N1).

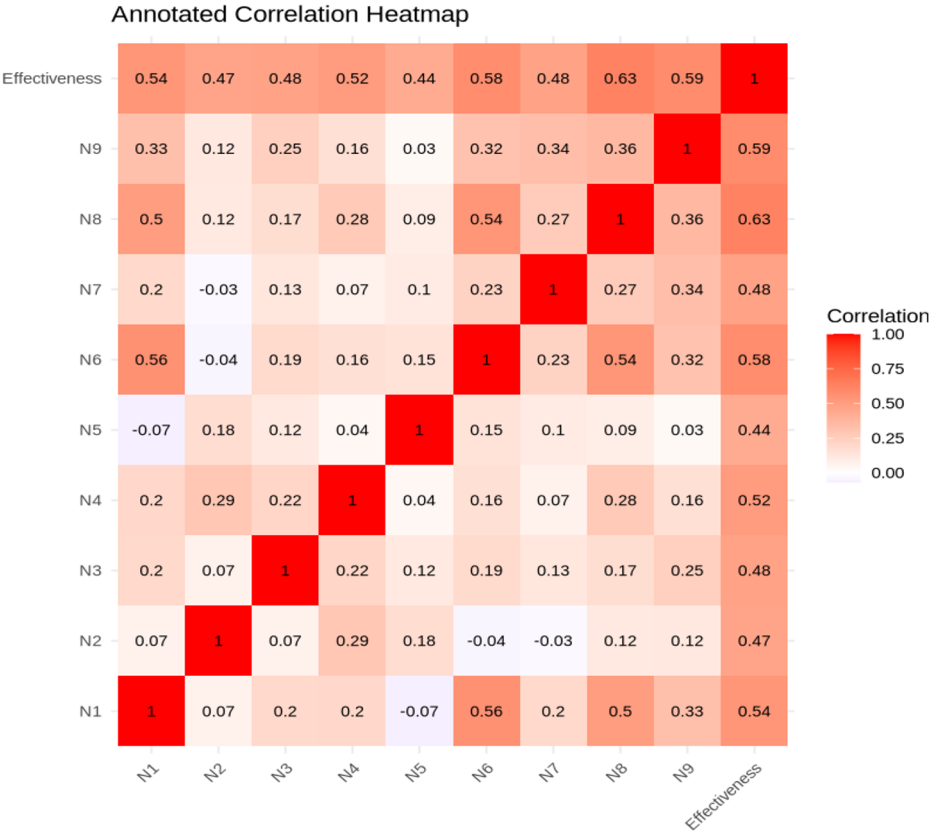


Fig. 4. Visualization of heatmaps between local value variables

The significance of local value factors on the effectiveness of community-based waste management on Penyengat Island can be concluded as follows: 1) A strong correlation between sustainability values (N8) and the importance of values (N1) of 0.76 indicates that a robust system of general values prevailing in a community tends to embrace sustainability values. This relationship suggests the importance of fostering general ethical values and can indirectly increase sustainability attitudes; 2) A strong correlation between community responsibility values (N3) and ethical consideration values (N4) of 0.75 indicates that communities with a strong sense of responsibility tend to have a strong ethical framework so that high community ethics can increase collective responsibility for sustainable community-based waste management; 3) A strong correlation between willingness to change values (N9) and support for initiatives (N6) of 0.71 indicates that communities that are open to change are more likely to support sustainable community-based waste management initiatives. Thus, increasing the culture of adaptability can increase support for modern community-based waste management programs; 4) The correlation with very weak significance between the value of cultural practices (N2) and other variables ranging from 0.39 to 0.55 indicates that cultural norms can operate more independently of other factors. This independence indicates that cultural practices need to be addressed separately in community-based waste management strategies; 5) A weak correlation is also seen in the relationship between the value of perceived impact and effectiveness, with a value of 0.44. This factor needs attention because awareness of the impact of waste alone does not significantly affect behavioral changes or the success of community-based waste management programs on the island.

4 Discussion

This study reveals new insights and knowledge about community-based waste management. It highlights previously unexplored factors, specifically community knowledge and local community values, that are critical drivers of the effectiveness of community-based waste management in small island areas. The essential findings of this study indicate a strong linear correlation between traditional knowledge factors and local values in effective community-based waste management in Penyengat Island. The unique findings of the correlation analysis on local values towards management effectiveness show that there is a strong positive relationship between the importance of waste management and the sustainability values believed by the community (0.76). This connection bridges the general values that apply in the community with sustainability values. Meanwhile, the awareness value shows a weak correlation with the effectiveness of waste management. This is not in accordance with previous studies which state that the awareness factor is very important to create efficient management [42]. This study suggests that awareness campaigns alone may be less effective than strategies that focus on changing values and behavior. It argues that environmental awareness alone does not significantly affect effective waste management; instead, real practices and direct impacts on waste management are needed. To strengthen this knowledge factor, efforts can be made to educate the community [43].

Furthermore, related to the local community knowledge factor towards the effectiveness of community-based waste management, this study found a strong positive relationship between traditional knowledge practices and intergenerational continuity (0.56). This strong positive relationship illustrates that traditional knowledge practiced in waste management on Penyengat Island has become a cultural practice in response to local conditions and community needs in waste management. Its success can be seen from the natural form of community awareness in managing waste, from the household scale to the village level waste management level. This finding highlights the importance of continuity in maintaining the success of waste management from generation to generation. The value of cultural continuity can be seen from the strong relationship between the knowledge transfer variable and waste management practices for future generations. Other studies that strengthen this finding state that good knowledge can create a good perception of the environment [44].

In contrast to the results of previous studies in Thailand, other studies in Thailand revealed that motivating people to get involved in waste sorting is still a significant challenge. Using community lifestyle analysis to measure intention and behavior concluded the critical role of attitude in influencing intention. In contrast, intention and trust in recycling systems emerged as the most significant factors influencing waste sorting behavior [45]. Similarly, research conducted in Lakkang Island focused on knowledge, income, social environment, and physical facilities of the community. This study tested its relationship with household waste management behavior in Lakkang Island. The results showed that knowledge and social environment significantly influenced waste management behavior, while income level and physical facilities had less influence. This study provides practical insights into effective waste management strategies for policymakers and environmentalists [46], considering small island communities' relatively low livelihood sustainability level [47]. However, as stated in the findings, this study has not discussed what knowledge factors influence management.

In Bali, it has also been studied how to implement community-based waste management through waste banks; this study explores the role of local values "Tri Hita Kirana," which is a concept that wants harmony between humans and God, which is interpreted by processing waste. In maintaining cleanliness and the environment, the community believes in karma. Anyone who does not preserve their nature pollutes their place and throws garbage into the river, and they will receive their evil 'karma.' These local values are taught from an early age.

This study shows the importance of instilling the values of 'Tri Hita Kirana' in waste management in Bali, especially in urban areas [28]; this study in Bali did not examine the statistical correlation between values and management effectiveness. However, local values, such as those in Bali, have also been applied to Penyengat Island through Malay cultural values. Penyengat Island is the center of Malay culture and upholds Malay cultural values. One of the values instilled from an early age is the value of being ashamed of littering [48], which will impact oneself and the environment [49].

The significance of this study implies:

1. Strategies should prioritize promoting sustainability values and encouraging adaptability rather than raising awareness or changing cultural practices.
2. Interventions that target essential values, such as sustainability or willingness to change values, can positively impact others. Paying attention to cultural values can encourage everyone to take positive actions in waste management practices.
3. A solid ethical responsibility value approach can increase community involvement in sustainable community-based waste management.
4. Creating more flexible communities open to new ideas will support community-based waste management programs.

This study's findings and essential contributions have provided practical implications for community-based waste management policies, especially in small island areas. Conventional policies that have always revolved around efforts to increase awareness can be changed with policies that actively promote sustainability, openness, and community adaptability in real terms in waste management. The intervention strategy from these findings has a broad positive influence and can increase community involvement in waste management, considering that local values are very relevant and have proven to persist over time in waste management. Furthermore, these findings show that maintaining local values and knowledge can catalyze changes in community attitudes and behavior toward more adaptive waste management when facing dynamic environmental challenges..

5 Conclusion

This study concludes two important findings both theoretically and practically. Theoretically, the findings of this study contribute to new knowledge about the factors that influence community-based waste management, especially in small island areas, which states that there is a strong positive correlation between local traditional knowledge and local community values on the effectiveness of community-based waste management. Practically, the findings of this study contribute to intervention strategies for policymakers to focus on activities that strengthen the values of sustainability, adaptability, and ethical responsibility of the community. Interventions that have focused on efforts to increase awareness alone have had little impact on the effectiveness of community-based waste management because active and tangible actions that support sustainability values that uphold local cultural values have been proven to be successful over time, showing a more adaptive method. Then, for the sustainability of generations in waste management, it can be integrated with more modern techniques to increase community involvement in all generations.

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