Assessing the role of community resilience in marine debris management: Willingness to participate in Nusa Penida marine protected area

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Abstract. This exploratory study examines the resilience of the Nusa Penida community in managing marine debris, focusing on how sociodemographic characteristics influence participation in debris management initiatives. A sample of 60 local residents was analyzed to assess the impact of factors such as gender, age, income, education, occupation, and marital status on their willingness to participate (WTP). Using Chi-square statistical analysis, the study revealed that traditional demographic variables did not significantly determine participation levels. Notably, although not reaching conventional statistical significance, occupational differences suggested a trend where specific job roles might influence engagement in environmental activities. This study underscores the importance of understanding community dynamics and resilience in environmental conservation efforts, offering insights that can guide more tailored and effective community engagement strategies.

1 Introduction

Marine debris is a pressing global environmental issue, adversely affecting marine ecosystems, biodiversity, and coastal communities [1]. Among the regions grappling with this challenge is Nusa Penida, an island in Indonesia known for its vibrant marine life and significant tourist draw. Here, the impact of marine debris is not just ecological but also economic, as the health of its beaches and waters directly influences tourism, a primary source of income for local residents [2]. Understanding how communities engage with environmental management practices, particularly marine debris management, is crucial for devising effective interventions. The concept of community resilience in environmental management has gained prominence, emphasizing the ability of a community to adapt to, respond to, and recover from environmental challenges. Resilience in marine debris management involves a community's capacity to organize, plan, and sustain activities that reduce the impact of marine litter. This involves a range of activities from regular beach clean-ups to more structured waste management systems. For island communities like Nusa

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Penida, enhancing resilience is not only about adapting practices but also about transforming behaviors and attitudes towards sustainability.

Given the importance of marine debris management within such contexts, this study aims to conduct a preliminary analysis of community resilience by focusing on how different sociodemographic groups within Nusa Penida participate in debris management activities. The willingness to participate (WTP) is a critical measure in this study, reflecting the community's readiness to engage in efforts that directly impact the cleanliness and health of their marine environment [3–5]. By exploring the sociodemographic factors that influence WTP, such as gender, income, education level, occupation, age, and marital status, the study seeks to uncover potential patterns or disparities in community engagement. This research utilizes a chi-square analysis to investigate the statistical significance of these sociodemographic factors on WTP. The choice of this method allows for an understanding of whether variations in WTP across different demographic categories are due to chance or are statistically significant, thereby indicating areas where targeted interventions might be necessary. For instance, if certain occupations show a higher willingness to engage in marine debris management, programs could be specifically tailored to leverage these occupational groups as champions for environmental stewardship.

Moreover, the study's focus on Nusa Penida provides a valuable case study for other island communities facing similar challenges. Insights derived from this analysis could help in crafting policies and programs that bolster community resilience, not only making immediate improvements in marine debris management but also setting a foundation for long-term environmental sustainability. Through this research, stakeholders, including local government, non-governmental organizations, and community leaders, are provided with data-driven guidance on how to mobilize community resources and foster a resilient response to environmental challenges. Such strategic insights are essential for ensuring that marine debris management efforts are both effective and inclusive, harnessing the full potential of the community's capacity to protect and sustain their natural environment.

2 Method

The study on community willingness to participate in marine debris management in Nusa Penida integrates the Contingent Valuation Method (CVM) within a community resilience framework (Figure 1). This approach aims to assess both the economic value that residents place on participating in these initiatives and their broader impacts on community resilience. The process involves eliciting direct responses from residents regarding their willingness to contribute time or resources to marine debris management, thereby providing a quantitative measure of their perceived value in enhancing resilience through environmental action. The research begins with a theoretical framework centered on community resilience, which evaluates the community's capacity to anticipate, prepare for, respond to, and recover from adverse situations. This framework is critical as it ensures that the impact of marine debris management is analyzed across various dimensions, including social, economic, environmental, and infrastructural aspects.

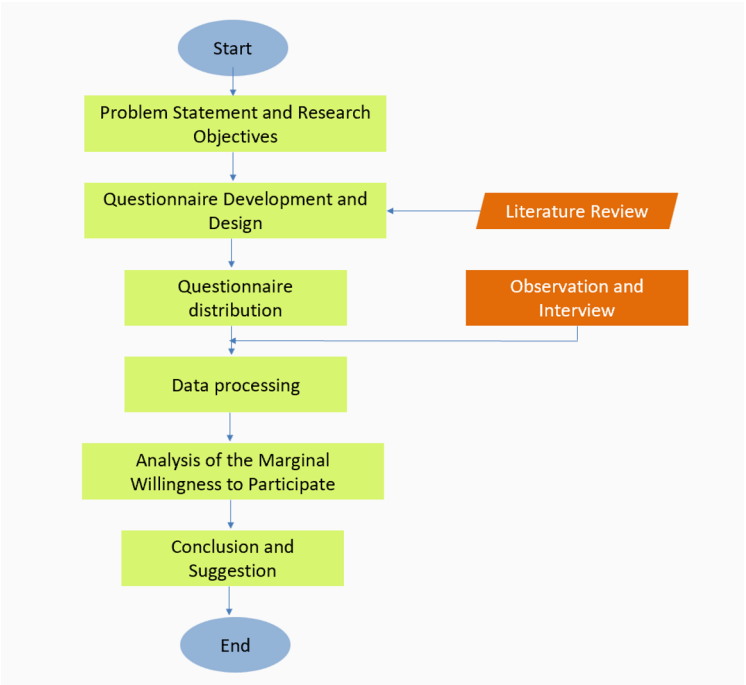

Figure 1. Study methodology for resilience in marine debris management.

Within the community resilience framework, the CVM is utilized to collect precise data from community members about their willingness to commit time to manage marine debris. To capture this data effectively and ensure unbiased responses, the questionnaire employs an open-ended question format. This format allows residents to specify freely the number of hours per month they are willing to volunteer, thereby avoiding the limitations and biases associated with predefined response options. The use of open-ended questions is particularly effective in gauging true community sentiment and engagement levels. An example of how this open-ended question is structured in Bahasa Indonesia is depicted in Figure 2. To ensure that the scenario is relatable and understandable, it is carefully crafted to illustrate the tangible outcomes of effective marine debris management, including enhanced local marine life, improved tourist appeal, and the creation of safer, cleaner public spaces. Details of this scenario are communicated through a well-structured questionnaire during face-to-face interviews, which accommodate varying literacy levels and allow for in-depth explanations. This setup also facilitates immediate responses to any queries from residents, ensuring clarity and thoughtful participation. Interviewers, thoroughly trained in both the technical and interpersonal aspects of conducting surveys, play a crucial role in engaging the community effectively. They emphasize the long-term benefits of increased resilience, such as more sustainable local economies and enhanced quality of life, likely resulting from a cleaner environment.

The study samples 60 residents from diverse demographic backgrounds to ensure that the findings are representative of the entire community of Nusa Penida (minimum sample 50 for preliminary research). This diversity includes various ages, genders, educational backgrounds, and proximities to coastal areas, providing a holistic view of the community's attitudes and willingness to engage in debris management. The main tool for data collection is a questionnaire that includes both open-ended and closed questions. The open-ended questions aim to capture the amount of time residents are willing to volunteer, while the closed questions collect detailed demographic information and probe respondents' attitudes

toward resilience and environmental issues. The questionnaire also gathers information on residents past experiences with marine debris and their perceptions of its impact on their community and personal lives. The collected data are then analyzed using advanced econometric models to identify the factors that significantly influence residents' willingness to participate. Regression analyses explore how variables such as age, income, education level, and personal experience with pollution impact this willingness. Additionally, Chi-square tests are used to identify significant relationships between participation levels and categorical demographic variables.

Attribute	Status Quo (Current Situation)		Alternative Programs (Scenarios)
Ecosystem Services	Communities partially participate in marine waste management.	How many hours each month are you prepared to commit to enhancing the management of marine debris, focusing on different resilience attributes?	1. Measure debris accumulation in areas to develop more targeted waste management programs.
			2. Development of kelp as natural filters to manage waste.
Economic Activities	Businesses have not fully leveraged the economic activities that could be generated from properly managed marine waste.		1. Manage marine waste as a resource that can generate economic benefits.
			2. Establishment of bank partnerships for funding waste management from waste resources.
Community Action	There is no existing community action focusing on marine waste management.		1. Encourage community participation in waste management programs through education and awareness (clean-up days).
			2. Develop incentive programs for communities that actively participate in waste management.
			3. Set targets for community-based waste management initiatives.
Infrastructure and Buildings	Lack of infrastructure to support increased marine waste management.		1. Provide facilities for temporary storage of marine waste at strategic locations.
			2. Develop Waste Transfer Stations (TPS) for efficient management of marine waste.
			3. Promote alternative uses for marine waste in areas of high tourist interest.

Figure 2. Example of CVM card.

The findings are interpreted within the Community Resilience Framework to determine how enhancing marine debris management might contribute to broader resilience goals. This interpretation involves linking community participation levels to various dimensions of resilience and identifying where interventions could be most effective. The study concludes with detailed policy recommendations for local governance and non-governmental organizations, advocating for strategies that leverage community engagement to strengthen resilience. These recommendations suggest specific interventions that can maximize the impact of local actions on global environmental challenges. A comprehensive report details the economic valuation of increased resilience through community participation in marine debris management and provides strategic recommendations for enhancing community engagement. This report offers valuable insights for stakeholders aiming to implement sustainable and effective environmental initiatives in Nusa Penida.

3 Result and discussion

Figure 3 provides a detailed visualization of the willingness of the local community in Nusa Penida to participate in resilience activities aimed at managing marine debris. The graph illustrates the number of hours per month that residents are prepared to volunteer, with

categories ranging from 1 to 30 hours. This quantitative depiction is crucial for understanding community engagement levels in environmental protection efforts. The bar chart is segmented into intervals that show the number of hours residents are willing to dedicate each month: 1-5, 6-10, 11-15, 16-20, 21-25, and 26-30 hours. The distribution clearly indicates that willingness to participate decreases as the commitment time increases. The majority of respondents are willing to volunteer a relatively small amount of time, with the 1–5-hour range attracting the highest participation, where about 30 respondents are active. This number significantly drops as the hours increase, with a steep decrease noted in the 6–10-hour range and further diminishing in the higher hour brackets. The supply and demand graph further reinforces these findings, showing that most participants are inclined to contribute fewer than 10 hours per month. This inverse relationship between the willingness-to-participate interval (measured in hours per month) and the number of respondents indicates that as the time commitment increases, the number of willing participants decreases. This trend underscores the importance of designing waste management programs that align with community capacities, leveraging shorter time frames to maintain engagement while considering targeted interventions to support longer-term commitments. These insights are critical for building sustainable and effective marine debris management strategies that encourage broad community participation.

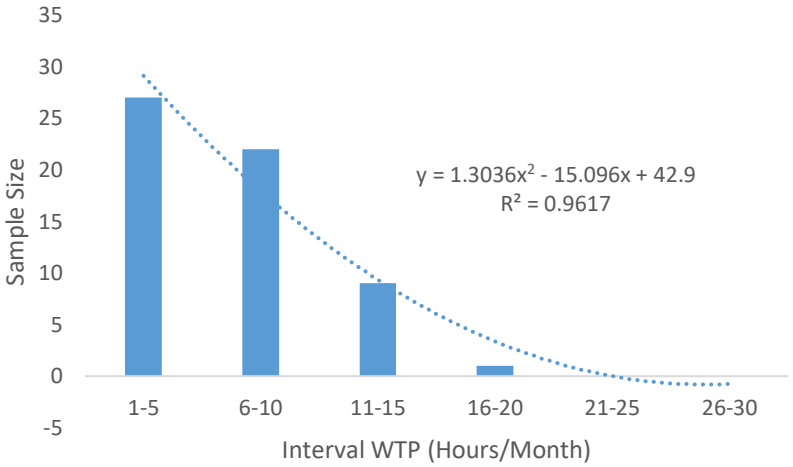

Figure 3. Willingness to participate in marine debris resilience efforts.

Overlaying the bars is a quadratic regression line with the equation $y = 1.3036x^2 - 15.096x + 42.9$, which models the trend seen in the data. The R^2 value of 0.9617 suggests an excellent fit, indicating that the quadratic model successfully captures the general pattern of participation. The curve illustrates a rapid decline in the willingness to allocate more hours, which is an essential insight for policymakers and program designers. This model helps predict at which points the decrease in participation becomes more pronounced, assisting in identifying the optimal range of hours that maximizes volunteer engagement without overburdening the community. Understanding this pattern is vital for the strategic planning of marine debris management programs. Programs requiring a lower time commitment might see higher participation rates, suggesting that initiatives should focus on maximizing impact within shorter volunteering stints to maintain high community engagement. Conversely, for activities requiring longer commitments, additional incentives or support mechanisms might be necessary to sustain a robust volunteer base.

Table 1 in the study provides a comprehensive view of the sociodemographic characteristics of respondents from Nusa Penida and how these factors may influence their

willingness to participate (WTP) in marine debris management. The table details the distribution of participants across various demographics, including gender, income, education, occupation, age, and marital status, and examines the statistical significance of these variables on WTP using Chi-square tests. Gender representation in the study is almost evenly split with a slight majority of females, accounting for 56.7% of respondents, compared to 43.3% males. The p-value for gender is 0.206, indicating no significant difference in WTP between males and females, suggesting that gender does not play a role in influencing the decision to engage in marine debris management activities.

Income levels among the respondents vary, with a significant number earning more than IDR 5,000,000. Despite the broad range of incomes, the p-value of 0.563 shows that income does not significantly affect WTP. This suggests that regardless of financial status, the willingness to contribute to marine debris management does not differ markedly, indicating that motivational factors may be driven more by personal or community values than by economic considerations. The education level of participants is quite high, with the majority holding a bachelor's degree. Despite this skew towards higher education, the education level's p-value of 0.199 reveals that there is no significant correlation between the level of education and WTP. This outcome may reflect a uniform awareness and concern for environmental issues across different educational backgrounds.

Occupation data shows a diverse range of jobs with educators forming a significant portion of the respondents. However, the p-value of 0.099 for occupation, though relatively low, still does not cross the threshold for statistical significance, hinting at a trend where certain professions might be more inclined to participate than others, yet not conclusively so. The age of participants ranges widely from 18 to over 60, with a substantial representation in the 30–39-year age bracket. However, with a p-value of 0.177, age also does not significantly influence WTP, suggesting that the community's commitment to managing marine debris is relatively consistent across different age groups. Marital status is predominantly married respondents, making up 80% of the sample. The p-value for marital status is 0.594, indicating that whether one is married or single does not significantly impact their willingness to engage in these environmental activities.

Table 1. Sociodemographic characteristics of respondents and p-value for WTP for marine debris management.

Category	**Subcategory**	**Percentage**	**Number of Respondents**	**df**	**Asymptotic Significance (2-sided)**
Gender	Male	43.30%	26	7	0.206
	Female	56.70%	34		
Income	Less than IDR 1,000,000	2.70%	2	42	0.563
	IDR 1,000,001 - IDR 2,000,000	16.70%	10		
	IDR 2,000,001 - IDR 3,000,000	13.30%	8		
	IDR 3,000,001 - IDR 4,000,000	20%	12		
	IDR 4,000,001 - IDR 5,000,000	15%	9		
	More than IDR 5,000,000	21.70%	13		

Highest Education	Elementary School	3.33%	2	21	0.199
	Secondary School	31.67%	19		
	Bachelor's Degree	61.67%	37		
	Master's/Doctorate	3.33%	2		
Occupation	Tour Operator	31.67%	19	28	0.099
	Fisherman	13.33%	8		
	Government Official	10.00%	6		
	Educator	35.00%	21		
	Others	10.00%	6		
Age	18-29 years	15%	9	7	0.177
	30-39 years	33.30%	20		
	40-49 years	26.70%	16		
	50-59 years	16.70%	10		
	60+ years	8.30%	5		
Marital Status	Married	80%	48	56	0.594
	Single	20%	12		

While overall, most demographic factors including gender, income, education, age, and marital status show no significant impact on participation, occupation emerges with a relatively lower p-value of 0.099. Although this does not surpass the conventional threshold for statistical significance (usually set at 0.05), it suggests a potential trend where occupation may influence the willingness to participate more markedly than other factors. Occupation represents a unique facet of personal identity and socio-economic status, potentially reflecting individual values, daily experiences, and social networks, all of which can influence environmental engagement. The data indicates that certain occupational groups might possess a greater propensity or opportunity to engage in environmental activities like marine debris management. For instance, educators, who formed a significant proportion of the respondents, typically have access to information and networks that can raise awareness and mobilize community actions around environmental issues. Their involvement in the study suggests that individuals in educational or knowledge-disseminating roles might be particularly responsive to initiatives that align with their professional ethos of teaching and community service.

Tour operators and fishermen also represent significant occupational categories within the sample. These roles are directly linked to the health of marine environments; hence, individuals in these occupations might view participation in debris management not just as a community service but as an essential component of their livelihood. Tour operators benefit from cleaner beaches and clearer waters, which enhance tourist satisfaction and business prospects. Similarly, fishermen depend on healthy marine ecosystems for the productivity and sustainability of fish stocks [6–8]. The vested interest of these groups in maintaining a clean marine environment could explain their greater willingness to participate in its management. The nuanced role of occupation in influencing willingness to participate underscores the need for tailored community engagement strategies that consider the specific motivations and constraints of different occupational groups. Recognizing that certain professions might inherently provide a platform for greater involvement in environmental

initiatives, programs can be designed to leverage these occupations as focal points for broader community mobilization. For example, engagement strategies could involve professional development workshops for educators focused on integrating environmental conservation into curricula [9–11], thereby amplifying their impact as they educate future generations. Additionally, partnership programs with tour companies could promote eco-tourism and involve tourists directly in marine debris management efforts, thus extending the reach and impact. Finally, resource support for fishermen could include providing tools and information on sustainable practices and the benefits of debris management for fish yields and marine health.

4 Conclusion

The research exploring community willingness to participate in marine debris management in Nusa Penida reveals several key insights into the sociodemographic factors influencing engagement levels. Notably, the study found that traditional demographic variables such as gender, income, education, age, and marital status do not significantly affect individuals' willingness to participate. However, the analysis indicated a potential trend within occupational groups, suggesting that occupation may subtly influence participation, although this did not achieve statistical significance under conventional thresholds. Occupation emerges as a potentially influential factor, with a lower p-value suggesting a trend in which certain professions, like educators, tour operators, and fishermen, might be inherently more inclined or have more at stake in participating in marine debris management efforts. Despite the slight variances suggested by occupational differences, the overall findings indicate a broad willingness across diverse demographic segments to engage in activities that support marine health and cleanliness. This widespread willingness suggests a strong foundation upon which to build comprehensive community engagement strategies. Recognizing that occupational roles might provide natural leverage points for mobilizing community action, targeted strategies could be designed to maximize these roles effectively.

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