Valuation of local coastal community willingness to participate in marine debris adaptation within Nusa Penida marine protected area

***Sakinah* Zahra [1], *Sapta* Suhardono[2], *I Wayan Koko* Suryawan[1*]**

[1]Department of Environmental Engineering, Faculty of Infrastructure Planning, Universitas Pertamina, Jakarta 12220, Indonesia
[2]Environmental Sciences Study Program, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret, Surakarta 57126, Indonesia

Abstract. This research investigates the factors influencing community willingness to participate in marine debris management programs in Nusa Penida, Indonesia, focusing particularly on various demographic variables. Employing a sample size of 60 respondents, the study utilized Chi-square tests and regression analysis to explore the association between willingness to participate and factors such as age, gender, income, education level, marital status, and employment. The results revealed no statistically significant influence of these demographic variables on participation willingness, except for a suggestive trend in age-related participation. Based on these findings, an action plan was developed to enhance community engagement across different age groups through tailored strategies. This approach includes the integration of technology, flexible scheduling, and targeted educational campaigns to accommodate and leverage the unique capacities and motivations of each age segment. The study highlights the importance of demographic considerations in designing effective community-based environmental initiatives and provides a framework that can be adapted for similar conservation efforts globally.

1 Introduction

Marine debris is a critical environmental issue affecting coastal and marine ecosystems around the world, posing significant threats to wildlife, disrupting human activities, and degrading natural habitats [1,2]. Nusa Penida, an island located in the province of Bali, Indonesia, is renowned for its rich marine biodiversity, including coral reefs and marine fauna such as manta rays and sea turtles [3,4]. However, like many pristine tourist destinations, it faces the growing challenge of marine debris, primarily due to increased tourism and inadequate waste management infrastructure [5,6]. The management of marine debris is not merely an environmental concern but also a socio-economic one, as the health of marine ecosystems directly impacts local communities dependent on tourism and fishing. In Nusa Penida, the accumulation of marine debris threatens the island's reputation as a dive and

* Corresponding author: i.suryawan@universitaspertamina.ac.id

snorkel haven, which could lead to decreased tourist visits and, subsequently, local economic downturns. Therefore, engaging the local community in debris management programs is essential for sustainable environmental stewardship and economic stability [7,8].

Community engagement in environmental conservation efforts such as marine debris management varies widely depending on several factors. These include but are not limited to, socio-economic backgrounds, educational levels, awareness of environmental issues, and personal attitudes towards conservation. Previous studies have indicated that effective community engagement in environmental initiatives significantly depends on a comprehensive understanding of these variables. For this reason, analysing the demographic factors that influence community participation in such programs is crucial to designing effective interventions. In Nusa Penida, while there is a general awareness of the importance of marine conservation, the specific factors influencing the community's willingness to actively participate in marine debris management have not been thoroughly investigated. This study aims to fill that gap by exploring how various demographic characteristics such as age, gender, income, education, marital status, and occupation influence residents' willingness to dedicate time to marine debris management activities.

Despite the recognized importance of community engagement in environmental conservation efforts, there remains a significant knowledge gap concerning how various demographic factors influence the willingness of local communities to participate in marine debris management programs. Specifically, in regions like Nusa Penida, where marine ecosystems are crucial for local livelihoods and tourism, understanding the precise role of demographic variables such as age, gender, education, income, marital status, and occupation in shaping participation is underexplored. This study seeks to address this gap by systematically examining the influence of these demographic factors on the community's willingness to contribute time to managing marine debris, thereby providing actionable insights for more effective program design and implementation. This study employs quantitative methods to assess community willingness to participate, utilizing tools such as Chi-square tests to analyze the association between willingness to participate and demographic variables, and regression analysis to further explore these relationships. These methods are complemented by qualitative approaches to gain deeper insights into the motivations behind community participation or lack thereof. This mixed-methods approach ensures a comprehensive understanding of the factors at play, providing a robust basis for the development of tailored, effective, and sustainable marine debris management strategies in Nusa Penida.

2 Method

This study aims to explore the willingness of the local community in Nusa Penida to participate in marine debris management programs by measuring their commitment in terms of the hours per month they are willing to dedicate. The research targeted a sample size of 60 respondents, reflecting a cross-section of the local population, to provide a comprehensive understanding of community engagement levels and the factors influencing participation. The methodology for this investigation was structured to capture both quantitative and qualitative data, ensuring a detailed analysis of the community’s engagement patterns. The research was conducted in several phases, starting with the development of a comprehensive questionnaire designed to elicit information on various aspects of willingness to participate. Questions included demographic information, previous experience with community and environmental programs, perceived importance of marine debris management, and the actual hours per month individuals were willing to commit, using Contingent Valuation Method (CVM) in Bahasa Indonesia (see example in Figure 1).

Prior to the main survey, a pilot test was conducted with a small subset of the population to ensure the clarity and effectiveness of the questionnaire. Feedback from this pilot was used to refine the questions to better suit the local context and comprehension levels of the broader community. The main data collection was performed using face-to-face interviews, which were chosen over other methods to enhance response rates and the accuracy of the collected data, given the varying levels of literacy among the local population. Interviewers were trained not only on the technical aspects of the questionnaire but also on interpersonal skills to effectively communicate with respondents and encourage open and honest responses. The selection of the 60 respondents was strategically planned to represent various demographics within the community, such as age, gender, occupation, and proximity to coastal areas. This stratification aimed to provide diverse insights into the factors that motivate or hinder participation in environmental initiatives. To analyze the data, descriptive statistics were used to summarize the demographic characteristics and baseline levels of willingness to participate. Following this, inferential statistics, including regression analysis, were employed to identify significant predictors of participation levels. This analysis aimed to uncover any significant relationships between demographic factors or attitudes and the willingness to dedicate hours to marine debris management.

Regression analysis was employed to evaluate the relationship between the amount of time respondents were willing to dedicate monthly to marine debris management and a set of independent variables, including age, gender, education level, income, and proximity to affected coastal areas. This statistical method was chosen because it allows for the estimation of each variable's specific contribution to the outcome (i.e., hours per month committed) while controlling for the influence of other factors. The regression model was set up to be linear, assuming a direct relationship between the predictors and the outcome. The dependent variable, hours per month, was treated as continuous, justifying the use of linear regression. Each independent variable was carefully encoded, with categorical data (such as gender and educational attainment) converted into dummy variables to meet the model requirements.

The regression analysis provided coefficients for each predictor, indicating the expected change in monthly participation hours associated with a one-unit change in the predictor, while holding all other variables constant. This allowed for a nuanced understanding of which factors significantly predict the level of commitment among the local population, guiding targeted interventions to increase participation. Alongside the regression analysis, Chi-square tests were conducted to examine the relationship between categorical variables and respondents' willingness to participate, regardless of the number of hours. This test is ideal for categorical data, as it evaluates whether the distributions of observed frequencies across different categories differ significantly from expected frequencies, assuming no association exists. The variables tested included demographic categories such as marital status and employment status, which were not directly measurable on a scale like hours per month. For example, examining whether single individuals are more likely to participate than their married counterparts or if employment status affects willingness to engage in the program could yield insights into demographic barriers or incentives. The outcome of the Chi-square tests was reported in terms of p-values, indicating the probability that the observed distribution would occur by chance if there were no true association in the population. A low p-value (typically less than 0.05) would suggest a statistically significant relationship between the demographic characteristic and willingness to participate, warranting further exploration into how these factors might be leveraged to enhance community engagement.

Attribute	Status Quo		Program Scenarios
Asset	The existing infrastructure is not adequate for waste management at sea.	**How many hours per month are you willing to dedicate to improving the management of marine debris across various adaptive attributes?**	1. Community participation in waste collection at sea, like TPS.
			2. Using waste collection tools at sea (e.g., floating nets).
Flexibility	High volume of floating waste causes increased marine waste problems.		1. Scheduling adjustments for waste collection after community events.
			2. Implementation of new waste collection technology.
Organization	Efforts to organize waste management plans are lacking.		1. Community involvement in the evaluation of government programs for sea waste management.
			2. Community participation in NGO programs for waste management planning.
Learning	Lack of education about managing sea waste.		1. Community participation in sea waste management social activities.
			2. Stakeholder participation in activities so that waste becomes a product with value and end goals.
Agency	Lack of roles and accountability that reduce waste management activities.		1. Efforts to avoid actions that increase sea waste.
			2. Increase awareness and skills to reduce waste at sea.

Figure 1. Example of CVM questions with open-ended responses

3 Result and discussion

Figure 2 illustrates the local community's willingness to participate in adaptive marine debris management in terms of hours they are willing to commit per month. The graph displays the distribution of respondents across various intervals of monthly participation hours, showing a clear pattern of willingness across six defined categories, ranging from 1-5 hours to 26-30 hours per month. The bar chart quantifies the number of respondents within each interval, with the highest participation observed in the 1-5 hours and 6-10 hours categories, indicating a greater inclination towards committing a few hours each month to marine debris management efforts. As the required hours per month increase, there is a noticeable decline in the number of participants, which drops significantly for intervals requiring more substantial time commitments. Overlaying the bar chart is a quadratic regression line described by the equation $y=0.6429x^2-9.7571x+34.4$, with an R^2 value of 0.8976. This high R^2 value suggests that the quadratic model fits the data well, effectively capturing the trend that as the number of hours increases, the willingness to participate decreases. This regression curve helps in understanding the overall trend and provides a predictive model of how changes in required participation time might influence community involvement levels.

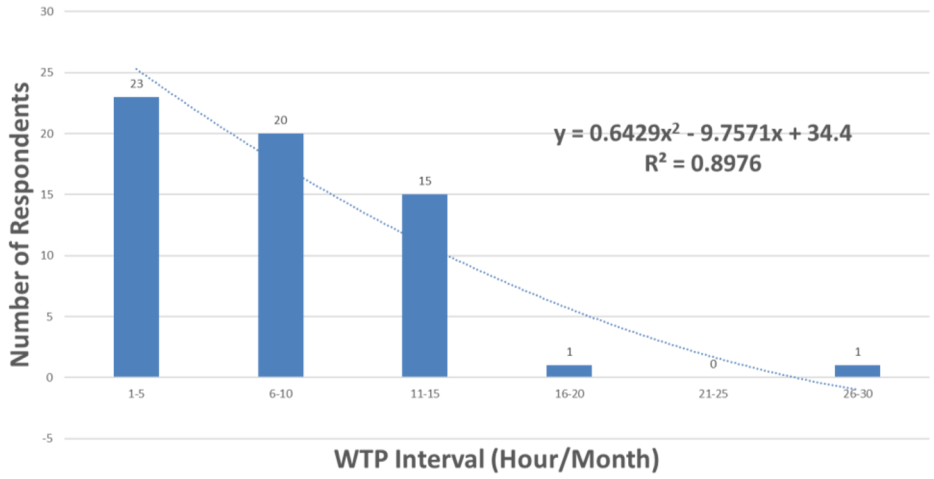

Figure 2. Local willingness to participate in adaptive marine debris management

Table 2 displays the results of Chi-square tests that assess the relationship between various demographic factors and the willingness of individuals in Nusa Penida to participate in marine debris management programs. The Chi-square test is utilized here to determine if differences in participation willingness across demographic categories are statistically significant or merely due to random variation. The table includes variables such as gender, income, education level, age, marital status, and occupancy. Each variable is accompanied by its degrees of freedom (df) and the asymptotic significance values, which represent the p-values for the statistical tests. These p-values indicate the likelihood that any observed differences are due to chance. For instance, the p-value for gender is 0.206, suggesting there is no significant association between gender and willingness to participate, as this value is well above the typical threshold for significance of 0.05. Similarly, Income, with a p-value of 0.563, and Education level, with a p-value of 0.199, also show no statistically significant association with willingness to participate. These high p-values indicate that variations in income and education levels do not significantly affect participation levels in marine debris management activities among the community. However, the p-value for age shows a slightly closer approach to significance at 0.099, suggesting that there might be a more substantial relationship between age and willingness to participate, although this is still not within the conventional bounds of statistical significance. Marital Status and Work also do not show significant associations, with p-values of 0.177 and 0.594, respectively.

The findings from the Chi-square analysis indicate a relatively lower p-value for age ($p=0.099$) in relation to willingness to participate in marine debris management in Nusa Penida, suggesting that while not statistically significant, there is a potential trend that could imply age-related differences in participation willingness. This observation warrants a closer look at how different age groups may uniquely perceive or engage with marine debris management initiatives, guiding the development of a nuanced action plan that considers age as a factor in boosting community involvement. Understanding that different age groups may have varying levels of availability, physical ability, environmental consciousness, and motivational factors can be pivotal in designing an effective marine debris management program. For instance, younger individuals might be more energetic and able to engage in physically demanding activities such as beach cleanups [12,13], whereas older community members might be better suited for roles that require less physical exertion but can benefit from their experience and wisdom, such as educational roles or advocacy.

Table 1. Chi-Square analysis of willingness to participate

Variables	df	Asymptotic Significance (2-sided)
Gender	7	0.206
Income	42	0.563
Education level	21	0.199
Age	28	0.099
Marital Status	7	0.177
Occupancy	56	0.594

The action plan should therefore start with targeted awareness campaigns that are customized to appeal to different age demographics [14,15]. For younger participants, integrating technology and social media into the campaign can increase engagement [16]. Campaigns can include interactive elements such as gamification or mobile apps that track collected waste and provide rewards or social recognition [17]. This approach can tap into the younger demographic's familiarity with technology and their preference for immediate feedback and social validation. For middle-aged and older community members, the focus could be on the long-term benefits of marine debris management, such as improved community health and the preservation of local marine life, which might be more motivating factors for these age groups. Workshops or community meetings could be used to engage these individuals, providing a platform for discussion and the sharing of knowledge [18,19]. These sessions can be instrumental in fostering a sense of ownership and responsibility towards the local environment, highlighting the impact of marine debris on fishing and tourism industries, which are likely significant to their livelihoods.

Additionally, scheduling flexibility is crucial. Offering varying levels of commitment can accommodate the time constraints that might differ across age groups. For example, setting up both short-term clean-up events and long-term monitoring projects allows individuals to commit to activities that fit their schedules [20,21]. For older participants or those with limited mobility, roles such as organizing, educating younger volunteers, or data management could be more appropriate and fulfilling. Partnering with local schools, universities, and senior centers can also aid in outreach and sustained engagement across all age groups. Schools and universities can integrate marine debris management into their curricula or extra-curricular activities, making participation a more structured part of students' education. For the older population, senior centers can act as hubs for organizing and disseminating information, providing a familiar venue where they can learn about and sign up for appropriate activities.

4 Conclusion

This study conducted in Nusa Penida provides insightful observations into the local community's willingness to participate in marine debris management programs. The investigation employed a variety of statistical tools to explore the relationships between demographic variables and the community's willingness to commit time to environmental initiatives. The findings, particularly using Chi-square tests, indicated that there were no statistically significant associations between demographic factors like gender, income, education level, and marital status and the willingness to participate. However, the variable of age, while not crossing the conventional threshold for significance, hinted at a trend that may suggest variations in participation willingness among different age groups. The study underscores a key insight: demographic factors, as evaluated, do not serve as barriers to

participation. This suggests that community willingness to engage in marine debris management is not restricted by these demographic variables, offering a positive outlook for community-based conservation efforts. However, the nuanced difference observed with age points towards the potential benefits of tailoring participation strategies to better suit different age demographics, possibly enhancing engagement and effectiveness of such programs. The action plan developed from these insights advocates for adaptive strategies that consider the specific capacities and motivations of various age groups within the community. By targeting educational and awareness campaigns, adjusting the physical demands of participation opportunities, and providing flexible scheduling, the programs can become more inclusive and effective. Furthermore, employing technology and leveraging local institutions like schools and senior centers can help maintain and grow community involvement.

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