

Potential Implementation of Payment for Ecosystem Services (PES) for Mangrove Rehabilitation in Poka Village, Ambon City

Angela Ruban*, Eygner Gerald Talakua, Julio Alexsandro Christo Talakua

Department of Fisheries Agribusiness, Faculty of Fisheries and Marine Science,
Pattimura University
Jln. Mr. Chr. Soplanit, Poka, Ambon City

Correspondence:

angelaruban89@gmail.com

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ABSTRACT

Mangroves have an important role in supporting community welfare through various ecosystem services. However, in July 2022 there was mangrove damage in Poka Village, which was caused by exposure to waste from pipeline leaks during bridge construction. This incident damaged a mangrove area of 1,394 m². The absence of market value for ecosystem services means that their benefits were often overlooked in economic decision-making. For this reason, incentive schemes such as Payment for Ecosystem Services (PES), where beneficiaries compensate providers, were considered necessary to reward the role of environmental service providers. The purpose of this study was to describe the potential implementation of PES for mangrove rehabilitation. The study observed the damaged mangrove areas and interviewed 61 respondents. For data analysis, the Contingent Valuation Method (CVM) was used to obtain the value of community's willingness to pay (WTP) for mangrove rehabilitation. The results showed that the average value of willingness to pay was IDR 39,825.40 per household per month. As a concrete step, this value could be used as the initial amount of incentives in the Payment for Ecosystem Services (PES). Providers could be established or utilize existing institutional structures at the local level. Furthermore, the provider would make monthly or quarterly reports on the use of funds, the results of activities, and the condition of the mangrove ecosystem, which could be accessed by beneficiaries. Therefore, the implementation of Payment for Ecosystem Services (PES) in Poka Village had strong prospects to encourage the sustainability of mangrove ecosystem services.

INTRODUCTION

The existence of mangroves contributes to the realisation of community welfare based on ecosystem services (Arkham *et al.*, 2023). The main mangrove ecosystem services include the ability to sequester carbon compared to other forest types due to its high effectiveness,

the main habitat for aquatic biota (nursery ground, feeding ground, and spawning ground), and protection of coastal areas from storms, high waves, and tsunamis. Cultural services in the form of mangroves are used as tourist areas (Sofian *et al.*, 2009; Ruban *et al.*, 2025).

The Millennium Ecosystem Assessment (MEA) reported that more than 60% of global ecosystem services declined significantly over the period 1960 to 2000 (MEA, 2005). Challenges to ecosystem sustainability are expected to become more complex in the future, fuelled primarily by the dynamics of demographic growth, rising living standards, and technological advances (Haberl *et al.*, 2007 in Claret *et al.*, 2018). Globally, most ecosystem services are sourced from aquatic areas, with exploitation of coastal resources contributing significantly to the degradation of ecosystem services, including those provided by mangrove ecosystems.

In July 2022 there was mangrove damage in Poka Village, Ambon City, precisely in front of the PT Perusahaan Listrik Negara (PT PLN) Diesel Power Plant (PLTD-Poka) which was suspected of being exposed to accidental waste due to pipe leaks due to bridge construction activities on Y. Syaranamual street. This resulted in approximately 1,394 m² of mangroves dominated by the *Rhizophora styloza* species dying of drought. Mangrove damage in Poka Village is approximately ($\pm$) 1,394 m² or 40.7% of the area before damage in 2022 of approximately ($\pm$) 3,426 m². Although the cause of mangrove damage does not directly involve coastal communities in Poka Village, it directly proves that community behaviour in Poka Village that does not support the implementation of mangrove forest sasi (research results since 2009) has an impact on the existence and conservation of mangroves in Poka Village (Talakua, 2024).

Furthermore, the absence of a market value directly attached to mangrove ecosystem services means that these public benefits are often overlooked in economic decision-making. Because these services are not explicitly traded in conventional markets, mangrove ecosystem conservation tends to receive less attention than activities that generate short-term economic benefits. Therefore, it is important to provide incentive schemes that provide economic value to local actors who play a role in maintaining ecosystem sustainability. One form of conservation incentive is Payments for Ecosystem Services or Payments for Environmental Services (PES) as mandated in Law No. 32 of 2009 on Environmental Protection and Management. ESCAP (2009) argues that to prevent the reduction of environmental service providers, mangrove ecosystems must be utilised through sustainable financing, one of which is through Payments for Ecosystem Services, while according to KLH (2013) the PES scheme is a mechanism that makes the provision of ecosystem services more cost-efficient and can last for a long time.

Basically, the problem of sustainable mangrove management is how to combine ecological interests (conservation) with the socio-economic interests of surrounding communities (Khazali *et al.*, 2002; Ekayani *et al.*, 2014; Ekayani & Nuva, 2015). The imbalance between these two aspects often leads to conflicts of interest, where conservation efforts are perceived to hinder local communities' economic access. In this context, Payment for Ecosystem Services (PES) is a strategic approach that can bridge the gap. The Payment for Ecosystem Services (PES) mechanism, which is a market-based economic instrument, is expected to be an alternative to sustainable financing for mangrove sustainability in Poka Village, because it is a transaction between environmental service providers and environmental service beneficiaries. In this case, the beneficiaries pay for the benefits of environmental services obtained to the provider who is credited with preserving the environmental services. According to Lau (2013); Hayati & Wakka (2019), the purpose of PES

is to use incentives to change behaviour around resource use. In this way, PES is not only an economic tool to encourage incentive-based conservation, but also creates a fair reciprocal relationship between environmental protection and improved community welfare.

METHODS

This research refers to descriptive research, according to Sujarweni (2015) descriptive research is research conducted with the main objective of providing an objective description or overview of a situation. The main objective is to provide an overview or description of the potential implementation of Payment for Ecosystem Services (PES) for mangrove rehabilitation in Poka Village, Ambon City. Data were collected through observation in damaged areas, interview with respondents, and study of related literature. The population in this study consisted of head of households from the coastal community who lived in neighbourhoods 01 and 02 in community 03, totalling 73 households. The population of head of households was determined based on the fact that they live close to the actual mangrove damage area in Poka Village (Figure 1). The sample size from this population was determined using the Isaac and Michael equation (Sugiyono, 2017) as follows:

$$s = \frac{\tau^2 NPQ}{d^2 (N - 1) + \tau^2 PQ} = \frac{3.841 \times 73 \times 0.5 \times 0.5}{0.05^2 \times (73 - 1) + 3.841 \times 0.5 \times 0.5} = 61.48$$

Where:

s = Number of samples

τ = Chi-square value corresponding to 1 degree of freedom and a 5% error rate, which is 3.841.

N = Number of populations

P = Probability of correct (0.5)

Q = Probability of incorrect (0.5)

d = Difference between the sample mean and the population mean of 0.05.

Based on this equation, the number of research samples is 61 coastal community households (rounded from $s = 61.48$). This sample size will be obtained using simple random sampling, which is the random selection of sample members from the population without regard to the strata in the population (Sugiyono, 2017).

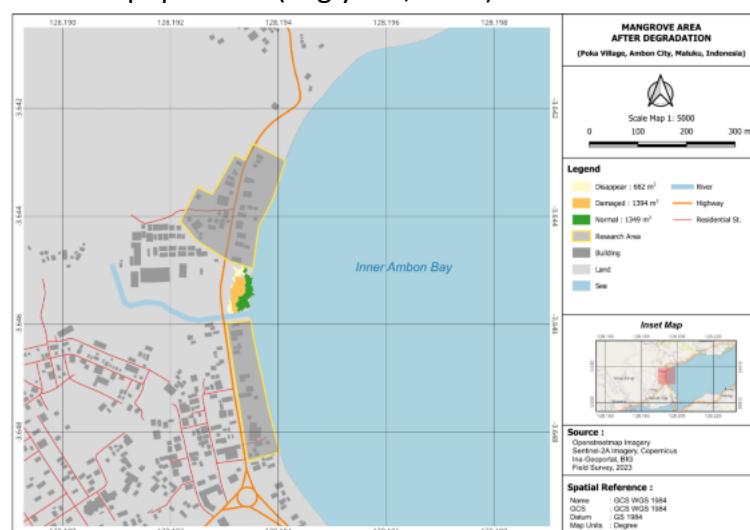


Figure 1. Research Location

Data analysis using willingness to pay (WTP) analysis of coastal communities towards mangrove ecosystem conservation in Poka Village. The WTP value is obtained using the Contingent valuation method (CVM), a direct method of economic valuation through the question of a person's willingness to pay (WTP) (Fauzi, 2014). The use of WTP values in the implementation of Payment for Ecosystem Services (PES) is based on the principle of environmental economics that places individual preferences as the basis for valuing ecosystem services. The WTP value reflects how much a person is willing to pay to maintain, restore, or improve the quality of ecosystem services they enjoy, even though these services do not have a direct market price. Studies conducted by Salem & Mercer (2012) in Taye et al. (2021) show that the use of WTP in PES for coastal areas and mangrove forests can strengthen the legitimacy of conservation projects, build social ownership, and increase long-term success.

The three main stages according to the CVM method in this study are (Fauzi, 2014):

1. Identify the goods or services to be valued

The service to be valued is the service of the damaged mangrove area in Poka Village.

2. Hypothetical scenario construction

The condition of the mangrove area (in front of the PLTD) in Poka Village which is used as a baseline is at the time of research data collection. The target to be achieved is the repair of mangrove damage (rehabilitation) in front of the Poka Village PLTD. The expected policy is aimed at mangrove area management through the willingness to pay the community for rehabilitation.

3. Elicitation of monetary value

The elicitation method is a technique to extract information on the ability to pay from respondents by asking the amount of payment through a single bounded dichotomous format with 6 choices of bid/bid value categories (starting from IDR 13,000/month; IDR 26,000/month; IDR 39,000/month; IDR 52,000/month; IDR 65, 000/month, and IDR 78,000/month) which is adjusted to the retribution rate for waste/cleanup services for housing/residential areas in Ambon City of IDR 13,000/household/month, based on the Appendix to Ambon Mayor Regulation Number 4 of 2023 dated 9 January 2023 concerning Determination of Retribution Rates for Waste/Cleanup Services (Mayor of Ambon, 2023).

To obtain the WTP value, a calculation is made using the non-parametric method, namely the Kaplan-Meier-Turnbull method or the K-M-T method (Fauzi, 2014), with the formula:

$$E_{KMT}(WTP) = \sum_{j=1}^M B_j(F_j - F_{j+1})$$

Where:

EKMT(WTP) = Average value of WTP (IDR/month)

B_j = Auction value j

F_j = Distribution of respondents who answered 'yes' at auction j

For auction value j = IDR 13,000/month; IDR 26,000/month; IDR 39,000/month; IDR 52,000/month; IDR 65,000/month, and IDR 78,000/month.

Haab & McConnel (2002) in Fauzi (2014) formulated a formula to calculate the variance that can be used to calculate how much confidence in the estimated value of E(WTP). The variance of the lower limit of EWTP (monotonically increasing) is:

$$V(E_{LB}(WTP)) = \sum_{j=1}^M \frac{F_j(1 - F_j^*)}{T_j^*} (B_j - B_{j-1})^2$$

Where:

V = Variability

ELB(WTP) = Lower bound of the average WTP value

B_j = Value of the jth auction

F_j = Distribution of respondents who answered 'yes' to the jth auction

F_j^{*} = F_{j+1} – F_j

T_j^{*} = Total respondents at auction value j

For auction value j = IDR 13,000/month; IDR 26,000/month; IDR 39,000/month; IDR 52,000/month; IDR 65,000/month, and IDR 78,000/month. After obtaining the average value of WTP or E(WTP), the equation for estimating the total WTP or T(WTP) is:

$$T(WTP) = E(WTP) \times N$$

Where:

T(WTP) = Total WTP (IDR/month)

E(WTP) = Average WTP (IDR/month)

N = Total population of coastal communities near the mangrove area in front of the Poka Village PLTD who are willing to pay (household).

RESULTS

Characteristics of Respondents

Characteristics of respondents are referred to the socioeconomic characteristics of coastal communities.

Table 1. Characteristics of Respondents Based on Gender

Gender	Number of Respondents (People)	Percentage (%)
Female	28	45.9
Male	33	54.1
Total	61	100

Source: Primary Data (2024).

Table 2. Characteristics of Respondents Based on Age

Age Group* (Years)	Number of Respondents (People)	Percentage (%)
15-64 (Productive Age)	60	98.4
≥ 65 (Non-Productive Age)	1	1.6
Total	61	100

Source: Primary Data (2024). * = According to Bappenas (2018).

Table 3. Characteristics of Respondents Based on Education

Level of Education	Number of Respondents (People)	Percentage (%)
Elementary School	1	1.6
Junior High School	11	18.0
High School	42	68.9
Bachelor's Degree	1	9.8
Total	61	100

Source: Primary Data (2024).

Table 4. Characteristics of Respondents Based on Occupation

Occupation	Number of Respondents (People)	Percentage (%)
Motorcycle taxi driver	10	16.4
Entrepreneur	16	26.2
Construction worker	4	0.6
Indonesian National Armed Forces	5	8.2
Company employee	3	4.9
Civil servant	3	4.9
Teacher	2	3.3
Driver	9	14.8
Indonesian National Police	2	3.3
Farmer	1	1.6
Fisherman	2	3.3
Security guard	2	3.6
Ship worker	2	3.6
Total	61	100

Source: Primary Data (2024).

Table 5. Characteristics of Respondents Based on Income

Level of Income	Number of Respondents (People)	Percentage (%)
High (> IDR 4,000,000/month)	3	4.9
Medium (IDR 3,000.000 – 4,000,000/month)	24	39.4
Low (< IDR 3,000,000/month)	34	55.7
Total	61	100

Source: Primary Data (2024).

The Value of Community's Willingness to Pay for Mangrove Rehabilitation

Presidential Regulation of the Republic of Indonesia Number 121 of 2012 concerning Rehabilitation of Coastal Areas and Small Islands in Article 12, Paragraphs 1 and 2 explains that the rehabilitation of coastal areas and small islands (including mangroves) can be carried out through cooperation between the government, local governments, and people or communities; one of the forms of cooperation referred to is financing (PRI, 2012). On the basis of this regulation, the financing of mangrove rehabilitation in Poka Village is not only the responsibility of the government but also the local community (especially the coastal community in the mangrove area in front of the Poka Village PLTD).

Table 6. Community Willingness to Pay in Poka Village

Bid Value (IDR/Month)	Number of Respondents		Total
	Response: 'Yes' (Willing to Pay)	Response: 'No' (Not Willing to Pay)	
13,000	11	0	11
26,000	7	2	9
39,000	6	4	10
52,000	4	6	10

Bid Value (IDR/Month)	Number of Respondents		Total
	Response: 'Yes' (Willing to Pay)	Response: 'No' (Not Willing to Pay)	
65,000	1	9	10
78,000	5	6	11
Total	34	27	61
Percentage (%)	55.7	44.4	100

Source: Primary Data (2024).

Table 7. Mean Value of Willingness to Pay

Bid Value (B _j) (IDR/Month)	Number of N _j ("Yes")	Total Respondents (T _j)	Distribution of "Yes" (F _j)	Pooled Distribution of "Yes" (F _j)	(F _j - F _{j+1})	K-M-T Value
13,000	11	11	1.000	1.000	0.222	2,888.89
26,000	7	9	0.778	0.778	0.178	4,622.22
39,000	6	10	0.600	0.600	0.200	7,800.00
52,000	4	10	0.400	0.400	0.114	5,942.86
65,000	1	10	0.100	0.286	0.286	18,571.43
78,000	5	11	0.455	<i>pooled</i>	<i>pooled</i>	
>78,000			0	0		0.00
Mean WTP						39,825.40

Source: Primary Data (2024).

Table 8. Variation in Mean Value of Willingness to Pay

Variance Value (σ)	Error Standard Value ($\sqrt{\sigma}$)	Reliability Level (95%)*	Mean WTP (IDR/Month)	Lower Limit Value of Mean WTP (IDR/Month)	Upper Limit Value of Mean WTP (IDR/Month)
11,357,541.84	3,370.10	1.96	39,825.40	33,220.01	46,430.78

Note: *Obtained by referring to the One-Way Table Z values (Z_{α}) at the 95% error level ($0.05/2 = 0.025$).

Table 9. Value of Total Community Willingness to Pay

Mean WTP (IDR/Month)*	Total Population of Poka Village Coastal Communities Willing to Pay (head of households)**	Total Willingness to Pay of Coastal Communities in Poka Village (IDR/month)
39,825.40	34	1,354,063.6

Note: *Numbers from mean WTP values in Table 2; **numbers from Table 1.

DISCUSSION

Characteristics of Respondents

Some of the respondents, namely 33 people or 54.1%, were male. There were 28 female respondents representing the heads of coastal communities at the time of data collection. Age grouping refers to the productive age population according to the Ministry of Health (2021). Table 2 shows that the majority of respondents, 60 people or 98.4%, were in the 15-64 age group or productive age. According to Goma *et al.* (2021), the productive age population is

the age group that produces goods and services. The lowest productive age of respondents was 25 years, and the non-productive age of respondents was 72 years. Education refers to formal education. According to PRI (2003), formal education is a structured and hierarchical education system consisting of primary education, secondary education, and higher education. Table 9 shows that the majority of respondents, 42 people or 68.9%, have a high school education (SMA) or similar.

Table 4 shows the 13 types of jobs performed by respondents, namely motorcycle taxi drivers, entrepreneurs, construction workers, Indonesian National Army (TNI) personnel, private employees, civil servants (ASN), teachers, drivers, Indonesian National Police (POLRI) personnel, farmers, fishermen, security guards, and boatmen. Most respondents, 16 people or 26.2%, work as entrepreneurs. According to Barus (2017), an entrepreneur is someone who owns a business and can produce or create something useful for themselves and others. The businesses operated by the 16 respondents include food merchants (3 people), retail fuel merchants (3 people), motorcycle repair shops (3 people), restaurants (5 people), and meatball sellers (2 people). Respondents who work directly utilising the environmental services of mangroves in front of the PLTD Desa Poka power plant are fishermen, numbering 2 people or only 3.3%. Interview results with respondents working as fishermen (using longlines) indicate that mangrove damage in front of the PLTD in Poka Village in the short term only affects the determination of fishing locations. Income levels are categorized according to BPS (2016) in Widjaya *et al.* (2020). Table 5 shows that some respondents, namely 34 people or 55.7%, have an income of less than IDR 3,000,000/month, which means that some respondents have low incomes. Respondents with moderate income numbered 24 people or 39.3%, while those with high income were only 3 people or 4.9%.

Overall, the socioeconomic characteristics of the respondents were dominated by productive-aged males, with a high school education, working as entrepreneurs, and having a low income of less than IDR 3,000,000/month. These socioeconomic characteristics indicate that the coastal community respondents in the mangrove area in front of the PLTD in Poka Village are considered competent as research subjects.

The Value of Community's Willingness to Pay for Mangrove Rehabilitation

Coastal communities in the mangrove area in Poka Village, represented by respondents, were asked about their willingness to finance (monthly payments) the rehabilitation and preservation of mangroves. Table 6 shows that the majority of respondents, namely 34 people or 55.7%, were willing to pay at six (6) bid levels, with the highest willingness to pay at a bid of IDR 13,000/month. As the bid value increases, the respondents' willingness to pay decreases, or they tend to be unwilling to pay. The frequency of respondents willing to pay for mangrove rehabilitation and conservation in front of the PLTD in Poka Village is used to calculate the average willingness to pay (EWTP).

The calculation of the average willingness to pay (EWTP) using the Kaplan-Meier-Turnbull or K-M-T method is shown in Table 7. A comparison of the number of respondents willing to pay with the total number of respondents at each auction value is shown in the distribution of respondents willing to pay (answering 'Yes'). The largest distribution value of respondents answering 'Yes' is 1.00, or 100%, at the auction value of IDR 13,000/month, meaning that at this auction value, all respondents are willing to pay. The smallest distribution value of respondents answering 'Yes' is 0.100 or 10.0% at the auction value of IDR 65,000/month, meaning that at this auction value, only 10% of respondents are willing to pay. There is an increase in the distribution value of respondents answering 'Yes' at an auction value of IDR 78,000/month by 0.455 or 45.0%, In accordance with the analysis steps outlined

by Haab & McConnel (2002) in Fauzi (2014), the number of respondents willing to pay at an auction value of IDR 78,000/month must be pooled with the auction value of IDR 65,000/month. Table 6 also shows a respondent distribution value of 0.000 at an auction value more than IDR 78,000/month, which is the assumption that respondents are no longer willing to pay if the auction value exceeds IDR 78,000/month.

The results of the analysis of respondents' willingness to pay for mangrove rehabilitation and conservation in front of the Poka Village PLTD in Table 7 show that the average willingness to pay (EWTP) is IDR 39,825.40/month. This value indicates the willingness to pay per household (HH) of coastal communities in the mangrove area in front of the PLTD in Poka Village per month for rehabilitation and conservation, in line with the opinion expressed by Fauzi (2021), that the EWTP value is a value that indicates the willingness to pay per household to improve the damaged environment so that environmental risks are also reduced.

The variance or range of average willingness to pay (EWTP) values of IDR 39,825.40/month is shown in Table 8. The lower limit of EWTP is IDR 33,220.01/month and the upper limit of EWTP is IDR 46,430.78/month. This variation in the average willingness to pay or confidence interval is constructed at a 95% confidence level. Haab and McConnel (2002) state that one of the advantages of EWTP is the ease of constructing a confidence interval due to its asymptotic normality. Both of these values are acceptable or valid and indicate that the lowest to highest willingness to pay values that each household in the coastal community can provide for mangrove rehabilitation and conservation in front of the Poka Village PLTD are IDR 33,220.01/month to IDR 46,430.78/month.

Fauzi (2021) explains that the average willingness to pay (EWTP) value can be used as a basis for assessing damaged ecosystems by multiplying it by the total number of households in the affected area, a technique known as aggregation. Table 9 shows the aggregation of the monthly willingness to pay of coastal communities for mangrove rehabilitation and conservation in front of the Poka Village PLTD, with a total value of IDR 1,632,841.27/month. This total willingness to pay (TWTP) value is obtained by multiplying the average willingness to pay (EWTP) value of IDR 39,825.40/month by the number of coastal community households in Poka Village willing to pay, which is 41 households. Determination of 41 coastal community households.

Potential Implementation of Payment for Ecosystem Services (PES) for Mangrove Ecosystem in Poka Village

Number of incentives in the Payment for Ecosystem Services (PES) scheme can be designed by referring to the average willingness to pay (EWTP) of the coastal community of Poka Village, which is IDR 39,825.40/household/month. This community contribution can be used to fund mangrove ecosystem conservation activities, thereby legitimising the potential implementation of PES due to the potential for sustainable financing from within the community itself. These funds can be collected through mutual assistance mechanisms, regular contributions, or integration into environment-based village programmes. The next step is to determine the ecosystem service provider that manages PES funds and designs mangrove ecosystem rehabilitation and conservation programmes. This can be formed or utilise existing institutional structures at the local level, such as mangrove forest management community groups, customary institutions with authority in local wisdom-based conservation practices (*sasi*), or Village-Owned Enterprises (BUMDes) that can manage incentives from the PES scheme transparently. Subsequently, the provider prepares monthly or quarterly reports on fund usage, activity outcomes, and the condition of the mangrove ecosystem, which are accessible to beneficiaries. This means that the implementation of Payment for Ecosystem

Services (PES) in Poka Village has a strong chance of promoting the sustainability of mangrove ecosystem services. With high community awareness of the benefits of mangrove ecosystem services, the economic value identified through WTP, and the establishment of credible local management institutions, it is expected that within the next five years, a healthier mangrove ecosystem will be achieved, functioning optimally ecologically, and providing economic and social benefits to the community. The five-year timeframe is a realistic estimate for beginning to see tangible results from the implementation of Payment for Ecosystem Services (PES). Several studies indicate that effective mangrove rehabilitation programmes can show initial results within 3–5 years, depending on the type of mangrove, location, and methods used (Bosire *et al.*, 2008; Lewis, 2005). In the context of social and institutional development supporting PES, the five-year period is also a common time cycle for initial evaluation of community-based programme success.

CONCLUSION

The implementation of payment for Ecosystem Services (PES) for mangrove rehabilitation in Poka Village is highly realistic. The value of community's willingness to pay for mangrove damage rehabilitation is IDR 39,825.40/household/month or IDR 1,632,841.27/month, which is a strong foundation for the implementation. With the support of local institutions and transparent incentive management, PES has potential to become an effective mechanism for funding the sustainable rehabilitation and conservation of mangroves.

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