

Social–Ecological Alignment of Mangrove Ecosystem Services in a Community-Managed Mangrove Resources: Evidence from Wori Village, North Minahasa, Indonesia

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Abstract

Mangroves generate linked ecological functions and livelihood benefits, yet local management often proceeds without explicit tests of whether community priorities align with ecological condition. This study integrates household perceptions of mangrove ecosystem services with ecological community-structure indicators to diagnose management priorities in a community-managed mangrove park in Wori Village, North Minahasa Regency, North Sulawesi, Indonesia. Mangrove extent interpreted from Google Earth imagery was approximately 28.22 ha.

Household perceptions were collected via semi-structured interviews and questionnaires with thirty-five households using purposive sampling complemented by snowball sampling (Sedo, 2026). Responses were coded into the Millennium Ecosystem Assessment ecosystem service categories (Millennium Ecosystem Assessment, 2005) and summarized descriptively.

Households most frequently recognized regulating services (coastal abrasion/erosion control; 28/35), followed by provisioning services (fish, crabs, shrimp, shellfish; 25/35), cultural services (tourism and recreation; 20/35), and supporting services (habitat for birds and other fauna; 11/35) (Sedo, 2026). Perceived trends over the past decade were positive, with thirty-one respondents reporting that mangroves had become more extensive and better. Perceived threats were led by coastal waste (15/35), followed by natural mortality (10/35), cutting (6/35), and conversion (1/35) (Sedo, 2026). Secondary ecological data indicated dominance by *Sonneratia alba* (Important Value Index = 187.53; relative canopy cover = 89.02%), with *Rhizophora apiculata* as the second dominant species (Sedo, 2026). Shannon–Wiener diversity was low ($H' = 0.69$) and Simpson dominance was moderate ($D = 0.50$). Participation readiness was high (labor contribution: 32/35; financial donation: 26/35), indicating implementable collective-action

capacity. Results support a targeted management agenda focused on waste interception and enforcement against cutting, coupled with participatory monitoring and time-series remote sensing to corroborate perceived mangrove expansion.

Keywords:

mangrove ecosystem services; community perception; Important Value Index; marine litter; participatory management; North Sulawesi

Introduction

Mangrove forests function as foundation ecosystems at the terrestrial–marine interface, mediating shoreline stabilization, habitat provisioning, food-web support, and cultural and recreational benefits. Because these services are experienced by communities through daily livelihood practices and hazard exposure, perceptions of ecosystem services influence conservation legitimacy, compliance, and the feasibility of participatory governance (Dahdouh-Guebas et al., 2020). Recent global syntheses also frame mangroves as a high-priority conservation target; a first global assessment using the IUCN Red List of Ecosystems reported that half of assessed mangrove ecosystems are at risk of collapse, with climate change increasing risk through sea-level rise and storm intensity (International Union for Conservation of Nature [IUCN], 2024).

Despite expanding attention to mangroves, local management frequently separates ecological monitoring from social valuation. This separation can produce mismatched interventions: managers may prioritize actions that do not reflect perceived threats, while communities may focus on visible problems that omit processes measured by ecological indicators. Perception–ecology integration offers a pragmatic advantage. Where perceived benefits and threats align with observed ecological structure, collective action and enforcement can proceed with lower

transaction costs. Where perceptions and ecological signals diverge, management needs communication, monitoring redesign, or benefit-sharing adjustments.

This manuscript rewrites and consolidates evidence from an undergraduate thesis conducted in Wori Village, North Minahasa Regency, North Sulawesi, Indonesia (Sedo, 2026). The village territory is approximately 772.5 ha, and the mapped mangrove park covers about 28.22 ha based on Google Earth interpretation (Sedo, 2026). The study combined household-level perceptions with secondary ecological plot data describing mangrove community structure. The analysis addresses three questions: (a) which ecosystem services households recognize and use when coded into the Millennium Ecosystem Assessment categories; (b) how households perceive mangrove condition change and threats over the past decade; and (c) whether these perceptions cohere with ecological community structure as reflected in density, canopy cover, dominance, and diversity indices.

Methods

Study Area.

The research was conducted in the mangrove park of Wori Village, North Minahasa Regency, North Sulawesi, Indonesia. Mangrove area was estimated at 28.22 ha using Google Earth imagery interpretation as shown on Figure 1 (Sedo, 2026). The site functions as a community-managed area with direct use for fishing and tourism-related activities.

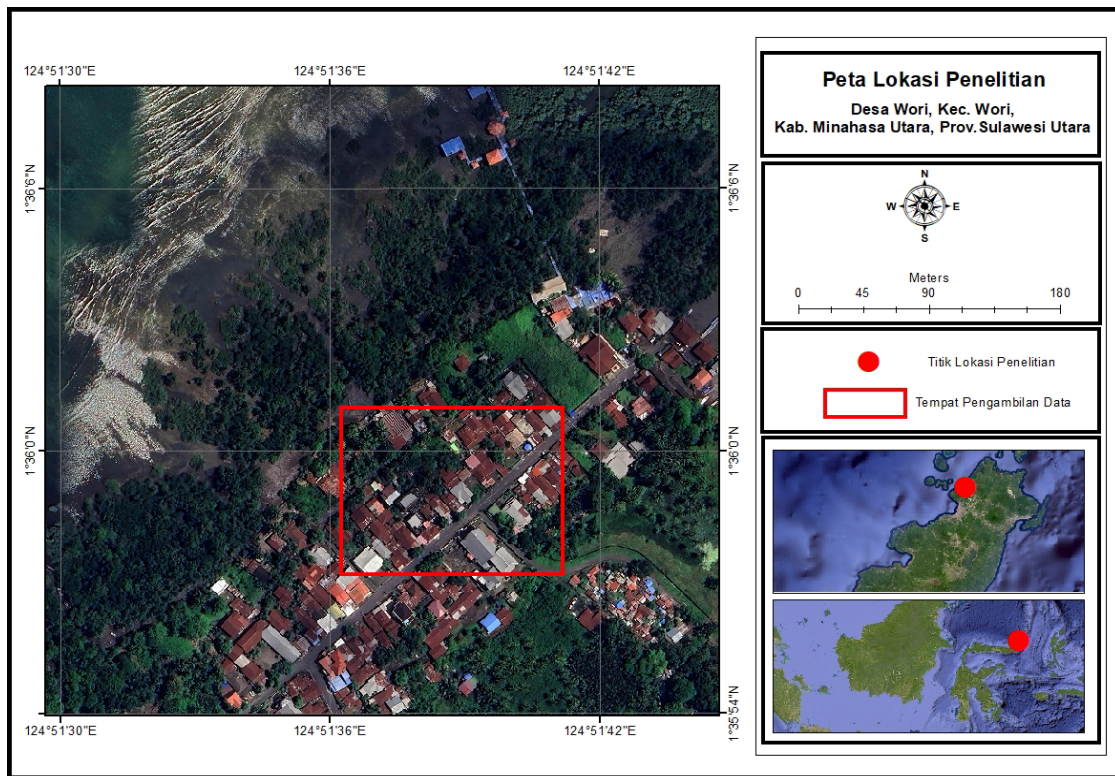


Figure 1. Study area

Research Design and Sampling.

The original study applied a mixed-method case-study design emphasizing qualitative description with quantitative summaries (Sedo, 2026). Household respondents were selected using purposive sampling to include residents who interact directly with mangroves, complemented by snowball sampling to identify additional knowledgeable respondents. The target was thirty households; the realized sample was thirty-five household heads (Sedo, 2026).

Data Collection.

Primary data were collected through semi-structured interviews and questionnaires covering (a) awareness of mangroves, (b) perceived ecosystem services, (c) perceived mangrove condition

change over the past decade, (d) perceived threats, and (e) willingness to participate through labor and financial contributions (Sedo, 2026). Secondary ecological data were obtained from prior field practice conducted in the same mangrove park and included species composition, density, frequency, canopy cover, and Important Value Index (IVI/INP), as well as diversity indices (Sedo, 2026).

Data Analysis.

Responses describing services were coded thematically and grouped into the four ecosystem service categories defined by the Millennium Ecosystem Assessment: provisioning, regulating, cultural, and supporting services (Millennium Ecosystem Assessment, 2005). Closed-response items (e.g., threats, and willingness to participate) were summarized using frequencies and percentages. Ecological indicators were interpreted descriptively; the thesis reported Simpson dominance (D) and Shannon–Wiener diversity (H'), and species-level INP values based on relative density, relative frequency, and relative canopy cover (Sedo, 2026).

Results

Perceived Mangrove Condition Change.

Household perceptions indicated strong positive trends in mangrove condition over the past decade. Thirty-one respondents (88.6%) stated that mangroves had become more extensive and better, while four (11.4%) reported no change; no respondents reported degradation (Sedo, 2026).

Recognized Ecosystem Services.

All four Millennium Ecosystem Assessment service categories were reported, but with distinct salience patterns (Sedo, 2026). Regulating services were most frequent: twenty-eight respondents

(80.0%) described mangroves as protecting the coast from abrasion and erosion. Provisioning services followed: twenty-five respondents (71.4%) reported fish, crabs, shrimp, and shellfish collection in or near mangroves for household consumption and sale. Cultural services were reported by twenty respondents (57.1%), primarily tourism and recreation within the mangrove park. Supporting services were least frequently articulated: eleven respondents (31.4%) described mangroves as habitat or refuge for birds and other fauna (Figure2).

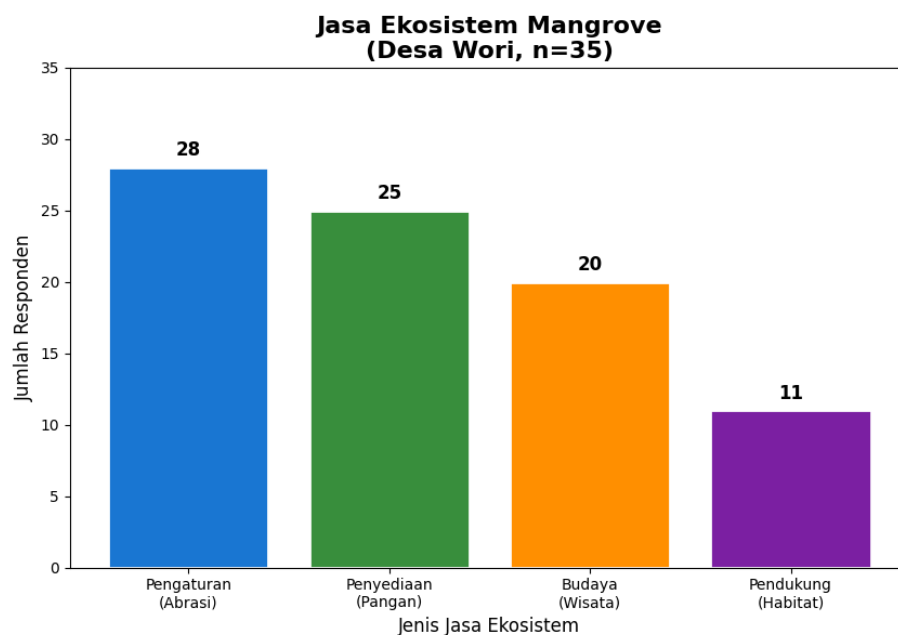


Figure 2. Respondent's perception based on MEA 2005

Direct-Use Income.

Reported monetary benefits from direct mangrove-related use were heterogeneous (Sedo, 2026). Seventeen respondents provided explicit monthly income estimates, ranging from Rp 30,000 to Rp 1,000,000. Within this subgroup ($n = 17$), income categories were: below Rp 100,000 (17.6%; 3 respondents), Rp 100,000–Rp 300,000 (41.2%; 7 respondents), Rp 301,000–Rp

500,000 (23.5%; 4 respondents), and above Rp 500,000 (17.6%; 3 respondents). Five respondents reported benefits used only for household consumption, and thirteen reported no direct-use extraction benefits (Sedo, 2026).

Perceived Threats.

Respondents identified waste as the leading perceived threat to mangrove sustainability (15 respondents; 42.9%), followed by natural mortality (10; 28.6%), cutting or logging (6; 17.1%), and land conversion (1; 2.9%). Four respondents (11.4%) reported not knowing or not observing threats (Sedo, 2026).

Participation Willingness and Perceived Responsibility.

Participation readiness was high. Thirty-two respondents (91.4%) were willing to contribute labor (e.g., planting, or cleanup activities), while three (8.6%) were unwilling (Sedo, 2026).

Financial willingness was also substantial: twenty-six respondents (74.3%) were willing to donate monthly, while nine (25.7%) were unwilling. Among donors ($n = 26$), the most common preferred monthly donation was Rp 5,000–Rp 10,000 (57.7%), followed by Rp 11,000–Rp 25,000 (26.9%), Rp 26,000–Rp 50,000 (11.5%), and above Rp 50,000 (3.8%) (Sedo, 2026).

Regarding governance responsibility, most respondents stated that mangrove management is a shared responsibility across all parties, signaling a collective-action framing (Sedo, 2026).

Mangrove Community Structure. Secondary ecological data recorded two mangrove species and indicated strong dominance by *Sonneratia alba*. Species density was 0.26 ind m⁻² for *Sonneratia alba* and 0.23 ind m⁻² for *Rhizophora apiculata* (Sedo, 2026). Relative canopy cover was 89.02% for *Sonneratia alba* and 10.98% for *Rhizophora apiculata*, producing INP values of

187.53 and 112.47, respectively (Sedo, 2026). Simpson dominance was $D = 0.50$ (moderate), and Shannon–Wiener diversity was $H' = 0.69$ (low) (Sedo, 2026).

Discussion

Social–Ecological Alignment.

The Wori Village case exhibits alignment between community valuation and ecological structure. Regulating services, especially shoreline protection, dominated local recognition, consistent with mangrove roles in wave attenuation and erosion reduction described across mangrove social–ecological systems (Dahdouh-Guebas et al., 2020). Perceptions of improvement over the past decade also co-occurred with evidence of established canopy structure dominated by *Sonneratia alba* (Sedo, 2026). This alignment supports a management strategy that treats local perceptions as an operational asset rather than a communications constraint.

Service Salience and Livelihood Pathways.

Provisioning services were reported by over two thirds of households, indicating that mangroves function as accessible fishing and invertebrate-gathering grounds. Direct-use income, however, was uneven, with many households reporting no cash income or only subsistence use (Sedo, 2026). This distribution suggests that management that safeguards habitat quality can support welfare even when cash benefits are concentrated among a subset of households. Cultural services (tourism and recreation) were also prominent, indicating that the mangrove park is not only a subsistence landscape but also a public space that can diversify local income sources.

Waste as a Priority Threat. Waste was the dominant perceived threat in Wori Village (Sedo, 2026), and ecological literature supports the plausibility of this concern. Mangroves can act as physical traps for plastic and other debris because dense stems and complex root structures retain stranded items, which can damage aerial roots and seedlings and reduce habitat quality (Cerri et al., 2025). Recent field studies also document that trapped plastics can impair pneumatophores and branches and that poor solid-waste management correlates with higher mangrove litter loads (Ponmani et al., 2024). In a tourism-linked mangrove park, litter additionally erodes cultural service delivery through reduced visitor experience. Thus, waste management is directly coupled to both ecological function and the social benefits described by residents.

Interpreting Dominance and Low Diversity.

Ecological data indicated low Shannon diversity and moderate dominance with two recorded species (Sedo, 2026). Low diversity can signal vulnerability in some ecosystems, but mangrove species distributions also reflect strong environmental filtering and zonation. Dominance by *Sonneratia alba* is consistent with pioneer or fronting-zone conditions in many Indo-Pacific settings where substrate stability and inundation regimes favor certain taxa. Management responses should therefore avoid interpreting low H' as degradation without additional evidence. A more defensible approach is to treat the current structure as a baseline, then monitor trajectories in recruitment, canopy condition, and regeneration across zones.

Governance Opportunity and Practical Actions.

High willingness to contribute labor and money indicates a governance window for collective action (Sedo, 2026). Community capacity can support routine cleanup schedules, waste

interception at entry points, and transparent management of small donations to finance equipment and maintenance. Because cutting was also cited as a threat, local rules and enforcement mechanisms remain relevant, including social sanctions and community patrols, especially in areas where wood extraction targets mature stands. These local actions can be framed within broader risk trajectories; global assessments indicate that mangrove ecosystem risk is increasing due to interacting anthropogenic pressures and climate change (IUCN, 2024).

Monitoring and Evidence Needs.

Although perceptions of expansion were strong, the thesis treated area estimates as interpretive products rather than time-series proof (Sedo, 2026). Time-series remote sensing using Landsat or Sentinel imagery can quantify mangrove cover change and corroborate perceived trends, enabling adaptive management and external accountability. Participatory monitoring can complement this with local indicators that households already recognize, such as debris accumulation, seedling survival after planting, and visible cutting.

Limitations.

The household sample was purposive and designed for contextual inference rather than population-wide representativeness, which constrains statistical generalization beyond the case site (Sedo, 2026). Ecological data were secondary and reflected conditions during the referenced field practice rather than a longitudinal monitoring program. Future studies can strengthen inference by pairing repeated ecological surveys with standardized remote sensing change detection and by testing whether service recognition differs across livelihood groups, gender, or proximity to the mangrove park.

Conclusion

This integrated social–ecological assessment shows that households in Wori Village identify a service bundle centered on shoreline protection, fisheries-related provisioning, and tourism, with supporting services reported less frequently (Sedo, 2026). Perceptions of improving mangrove condition coincide with ecological structure dominated by *Sonneratia alba* and moderate dominance (Sedo, 2026). Waste is the leading locally perceived threat, and participation readiness is high, indicating implementable capacity for community-based waste control and stewardship. A near-term management agenda should prioritize waste interception and behavior enforcement against littering and cutting, while building a monitoring program that uses time-series remote sensing and participatory indicators to track ecological trajectories.

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