



Development of an Environmental Accounting Framework to Support Sustainable Fisheries Industry Governance in the Coastal Area of Bitung City

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Abstract

Bitung City is a major fisheries hub in Eastern Indonesia's blue economy, yet environmental costs in its fisheries value chain remain invisible in accounting records. This study examines current environmental cost accounting practices, stakeholder perceptions and roles, and relevant environmental cost components, and proposes a conceptual tiered environmental accounting framework for sustainable fisheries governance. A qualitative case study was conducted through semi-structured interviews with 21 informants from seven stakeholder groups: fishers, collectors, processing micro, small, and medium enterprises, medium-to-large companies, government, the coastal community, and academics. Data were analyzed thematically. The results show that environmental costs are incurred at every scale but remain implicit, merged into general operating costs, factory overhead, or the anfrak advance system, and no informant applies the full cycle of identification, recognition, measurement, presentation, and disclosure. Stakeholder acceptance is high but capacity is low; motives differ by scale, market signals do not reach upstream actors, and government roles are fragmented. Relevant components extend Hansen and Mowen's quality-cost categories—three of which are supported by business actors—with resource use and by-product benefits, while physical measures suit micro actors better than monetary ones. The study proposes a tiered environmental accounting framework that scales the five-stage cycle to business capacity, supported by a multi-stakeholder governance layer.

Keywords

Blue Economy; Environmental Accounting; Environmental Costs; Fisheries Governance; Stakeholder Theory



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INTRODUCTION

Bitung City in North Sulawesi Province is one of the largest fisheries industry centers in Eastern Indonesia. The processing industry contributed 37.81% to the Gross Regional Domestic Product (GRDP) of Bitung City at constant prices in 2025 (Badan Pusat Statistik Kota Bitung, 2026), while the city is home to 41 of the 108 large

and medium manufacturing companies in North Sulawesi and absorbs 48.57% of the workforce in these industries (Badan Pusat Statistik Provinsi Sulawesi Utara, 2025). Fishing, landing, and fish processing activities are concentrated around the Bitung Oceanic Fishing Port (PPS), which has implemented several environmentally friendly port practices such as prohibiting destructive fishing gear, a vessel waste manifest system, a waste bank, and the provision of electricity at the unloading dock (FAO, 2024). On the other hand, the Bitung Marine Protected Area (KKP) covering 9,659.39 hectares, including Lembeh Strait, was established through Decree of the Minister of Marine Affairs and Fisheries Number 88 of 2024, but it still faces pressure from destructive fishing, pollution, and weak law enforcement (Stenly, 2026).

Bitung City's dual position as a center of economic growth and an area with valuable marine ecosystems creates a demand for governance capable of balancing these two interests. Sustainable marine fisheries management cannot be separated from three interrelated dimensions, namely resources and their ecosystems, socio-economic utilization, and fisheries policy (Latuconsina et al., 2023). Fisheries activities in Bitung generate waste from vessels and processing units (Jaya et al., 2025), while the water, waste, wastewater, and recycling management business field contributes only 0.16% to the city's GRDP (Badan Pusat Statistik Kota Bitung, 2026). The problem is that the costs of preventing and managing these impacts rarely appear in the information used by businesses and government to make decisions.

Environmental accounting offers an instrument to fill this information gap. Through the environmental management accounting (EMA) approach, organizations identify, measure, and report environmental costs by combining physical information, such as material, energy, and waste flows, with monetary information to support managerial decisions (Burritt et al., 2002; International Federation of Accountants [IFAC], 2005; Jasch, 2003; Schaltegger & Burritt, 2000). Hansen and Mowen (2007) classify environmental quality costs into prevention costs, detection costs, internal failure costs, and external failure costs. From the perspective of financial accounting, the treatment of environmental costs follows the stages of identification, recognition, measurement, presentation, and disclosure (Langelo, 2022). The expansion toward sustainability accounting places environmental information alongside economic and social dimensions (Burritt & Schaltegger, 2010; Elkington, 1997), which for the fisheries sector is formulated through GRI 13 standards (Global Reporting Initiative, 2022) and reinforced by sustainability reporting requirements in export markets (European Parliament & Council of the European Union, 2022).

Theoretically, the impetus to implement environmental accounting can be explained through stakeholder theory and legitimacy theory. Stakeholder theory emphasizes that business continuity depends on the ability to manage the interests of various parties, not only capital owners (Freeman, 1984). Legitimacy theory explains that organizations seek to demonstrate the alignment of their operations with societal values and expectations, among other things through the disclosure of social and environmental information (Deegan, 2002; Suchman, 1995). However, EMA adoption is influenced by contingent variables such as business size, sector, and strategy (Christ & Burritt, 2013), and in developing countries the relevance of social and environmental accounting is strongly determined by the local context (Tilt, 2018). Therefore, a framework designed for large companies may not necessarily be applicable to fishers, collectors, and MSMEs that constitute the largest part of the fisheries value chain.

Previous research in Bitung City reinforces this gap. Langelo (2022) found that a fish processing company in Bitung did not implement the stages of environmental cost accounting treatment, so waste treatment costs could not be traced in the financial statements. In traditional fisheries businesses in coastal areas, cost accounting plays a role in reducing financial risk (Pelupessy, 2024), but this role has not yet been extended to environmental costs. Other studies have highlighted local-wisdom-based empowerment in fisheries management in Bitung (Lakoy et al., 2021), the importance of multi-stakeholder roles in sustainable fisheries management (Suryawati et al., 2023), and the low understanding of MSMEs regarding environmental management accounting (Bayana & Praditha, 2023; Manehat & Sonbay, 2024).

These studies focus on a single entity, a single value-chain segment, or a single type of information. Based on the authors' review, no environmental accounting framework has yet been found that covers all business scales, from micro fishers to medium-to-large companies, while also considering the roles of government, coastal communities, academics, and markets. The novelty of this research lies in integrating sustainability accounting with the specific characteristics of MSMEs and the fisheries industry in the blue economy region of Eastern Indonesia, by formulating an initial conceptual framework that considers micro-, small-, and medium-to-large-scale fisheries, local stakeholder dynamics, and the socio-economic conditions of coastal communities. This study aims to answer four questions: (1) how environmental cost accounting practices have been applied by the fisheries industry in Bitung City; (2) how stakeholders perceive and play roles regarding the importance of environmental

accounting; (3) what environmental cost components are relevant to identify and measure; and (4) how a tiered environmental accounting framework can be developed to support sustainable fisheries governance. This research is aligned with the National Research Master Plan 2017–2045, which places maritime affairs and sustainable development as research priorities (Presidential Regulation Number 38 of 2018), as well as Sustainable Development Goal 14 on marine ecosystems (United Nations, 2015).

METHODS

This qualitative study applies a case study design (Yin, 2018) using a dual-segment value chain typology approach in Bitung City: (1) the Export-Oriented Medium-to-Large Industry Segment represented by fish processing units (UPI) (PU-01, PU-02, PU-04) supplied by agents/large vessels; and (2) the Small-Scale Domestic Segment comprising katinting fishers (NEL-01 to NEL-06), collectors/tibo (TI-01 to TI-03), and fish-processing MSMEs (UMKM-01 to UMKM-05). The two segments use different raw-material channels; the fishers in this study do not supply tuna UPIs. PU-03 is a tuna processing unit that is formally classified as small-scale based on the business capital criterion of below IDR 5 billion (excluding land and buildings used for the business) in accordance with Government Regulation No. 7 of 2021. In this study, PU-03 is treated as a boundary case between the MSME and medium-to-large industry segments and is analyzed in depth at Tier 2. This consideration is based on the condition that although PU-03 has obtained legal business status and a Processing Eligibility Certificate (SKP), its production capacity and financial recording practices remain very simple and have not been separated from general operating accounts, so its accounting characteristics are substantively more comparable to the MSME processing segment. For the analysis, the two segments are mapped into three tiers: Tier 1 (fishers and collectors) and Tier 2 (processing MSMEs, including PU-03) are within the small-scale domestic segment, while Tier 3 (PU-01, PU-02, PU-04) is within the industrial segment.

The scope of this study covers small-scale capture fisheries, collectors, processing MSMEs, and land-based fish processing units in Bitung City. Large-scale commercial fishing fleets, including vessels and tuna-supplying agents for UPIs, are not included in the primary data collection, so the upstream part of the industrial segment is not directly observed. The small-scale fishers in this study constitute a separate segment and are not intended to represent those fleets. Consequently, the proposed framework applies to the actors studied and cannot be generalized to environmental accounting practices of large-scale fishing fleets.

Informants were selected purposively to capture the spectrum of environmental accounting readiness across all levels of the Bitung fisheries value chain, with the following criteria: (1) directly involved in fisheries activities or their governance in Bitung City; (2) knowledgeable about financial recording, environmental management, or related policies; and (3) willing to be interviewed. A total of 21 informants from seven stakeholder groups participated (Table 1). Data were collected from July to September 2026 through semi-structured interviews lasting approximately 15 to 90 minutes, observation, and document study. Interviews were conducted with fishers and collectors in Motto Urban Village (Lembeh Utara District), collectors at Perikani Bitung City, fish-processing unit operators, fisheries MSME operators at Central Fish Bitung, the coastal community of Bitung City, fisheries product quality supervisors from the government, and accounting academics. The interview guide was developed according to the four research questions and adapted to the informants' everyday language, particularly that of fishers and collectors.

Observations were conducted on Friday, August 21, 2026, at company and MSME locations to directly observe Wastewater Treatment Plant (IPAL) facilities, operational processes, and waste handling in the field. At the same time, a document study was conducted on environmental documents serving as the basis for Environmental Approval (Government Regulation Number 22 of 2021), including Environmental Management Efforts and Environmental Monitoring Efforts (UKL-UPL) at PU-01 and PU-02, quality certificates (HACCP and Processing Eligibility Certificate) at PU-01 and PU-02 as a context for quality supervision, and general financial statement structures at entities with accounting records. Specifically for UMKM-01, the existence of environmental documents was confirmed through direct observation. Although the availability of the Statement of Commitment to Environmental Management and Monitoring (SPPL) was not identified during the interview session, physical evidence of the document was found and directly examined by the researchers during the business-site visit. The document review aimed to verify the existence of formal environmental cost records; the results confirmed that environmental costs had not been separated into a distinct account. Primary data were supplemented with regulations, Statistics Indonesia data, and findings from previous studies.

Informants from the government (PEM-01), coastal community (MS-01), and academia (AK-01) served as comparative-perspective informants. They provided perspectives on quality and sanitation criteria (PEM-01), coastal externality impacts (MS-01), and accounting conceptualization (AK-01) to be compared with statements from business actors. Because PEM-01 and MS-01 did not have access to company

cost data, their statements were treated as comparative perspectives rather than verification of figures or recording practices. The analytical framework of the study was derived from the literature, namely Hansen and Mowen's (2007) environmental quality cost classification, environmental management accounting guidelines (IFAC, 2005), and GRI 13 standards (Global Reporting Initiative, 2022); AK-01's statements were used as contextual confirmation of the relevance of the framework in Bitung, not as empirical evidence of business actors' practices. The analytical focus of this article is environmental costs and cross-scale governance.

The research team consists of accounting lecturers from Universitas Sam Ratulangi. Some fishers who participated as informants had previously attended financial-recording socialization conducted by another research team from the same university. To reduce social desirability bias, questions about actual recording practices were asked before questions about willingness, and informants were explicitly told that all answers provided were unrelated to any assistance program. AK-01 is an accounting lecturer at the same institution as the research team and a former accounting and finance manager of a fisheries company in Bitung. The selection of AK-01 as a comparative informant was based on relevant expertise and an academic track record as an author of a previous study on environmental accounting in the Bitung fisheries industry (Langelo, 2022). AK-01 provided written informed consent regarding disclosure of this academic and professional background. Although having a background closely related to the study's conceptual framework, AK-01 was not involved in the development of the instrument, the process of collecting/analyzing business-actor data, or the writing of this manuscript. The informant's statements were not treated as evidence of direct business practice, but solely as contextual confirmation and a comparative perspective. Cost components supported only by the statements of comparative informants are separately marked in Table 4. In addition, the researchers prepared reflective notes after each interview session to support researcher reflexivity.

Operational definition and boundaries of environmental costs. Environmental costs are defined as costs arising because poor environmental quality exists or may exist (Hansen & Mowen, 2007), including expenditures to prevent, detect, treat, and restore the environmental impacts of fisheries activities and to fulfill environmental-document obligations. Three boundary rules were applied. First, an expenditure is categorized as an environmental cost only if the underlying activity is directly related to waste, discharges, emissions, or pollution monitoring; food quality and safety costs (GMP, SSOP, HACCP, SKP),

occupational safety and health, and social expenditures such as donations are excluded from this boundary, while sanitation is counted only to the extent that it generates environmental discharges such as wastewater and solid waste. Second, expenditures with dual purposes, such as clean water used for both production and cleaning, are categorized according to their dominant purpose until a reliable allocation basis is available. Third, following the material and energy flow approach in EMA (IFAC, 2005; Jasch, 2003), fuel, electricity, water, and ice consumption are recorded as physical indicators of resource efficiency; their monetary value is calculated as an environmental cost only for the portion that becomes non-product output, such as water becoming wastewater or ice being discarded.

Table 1. Research Informants

Group	Code	Number	Brief profile
Fishing fishers	NEL-01 to NEL-06	6	Squid and demersal fishers, katinting or light boats (± 1 GT), 10–30 years of fishing experience, Lembah Island
Collectors (fish tibo)	TI-01 to TI-03	3	Regular collectors in Motto Urban Village (± 15 years, providing anfrak advances) and at Perikani Bitung City (± 10 years)
Processing and marketing MSMEs	UMKM-01 to UMKM-05; PU-03	6	Fish meatballs, processed foods, tuna and skipjack fish floss, fisheries product outlets, and a small-scale tuna processing unit (PU-03) serving as a boundary case
Medium-to-large companies	PU-01, PU-02, PU-04	3	Frozen tuna and loin processing units (8–11 tons/day, 100–120 workers), fish processing (3–7 tons/day, 50–70 workers), frozen fish
Government	PEM-01	1	Marine and Fisheries Product Quality Supervisor, North Sulawesi Provincial Government
Coastal community	MS-01	1	Coastal community in Bitung City
Academic	AK-01	1	Accounting lecturer, former accounting and finance manager of a fisheries company in Bitung

Source: primary data, 2026

Data were analyzed using thematic analysis (Braun & Clarke, 2006) within the interactive model of Miles et al. (2014), namely data condensation, data display, and conclusion drawing. Transcripts were coded by research question and then presented in cross-group matrices to compare practices and perceptions across business scales. For the third research question, Hansen and Mowen's (2007) environmental quality cost classification was used as a deductive code, while other categories were developed inductively from the data. Data trustworthiness was maintained through source triangulation across informant groups, technique triangulation between interviews and documents, an analytical audit trail, and peer discussion within the research team (Lincoln & Guba, 1985). Member checking was conducted at the end of September 2026 through WhatsApp by sending summaries

of each informant's statements and a draft of the initial conceptual framework to PU-01, PU-02, PEM-01, MS-01, AK-01, and UMKM-01. All six informants responded positively and confirmed that all points in the summaries and the framework were consistent with field facts and required no changes. Confirmation at Tier 2 was conducted with only one actor (UMKM-01), while Tier 1 actors had not yet been confirmed; this was recorded as a limitation of the study. The research framework is presented in Figure 1.

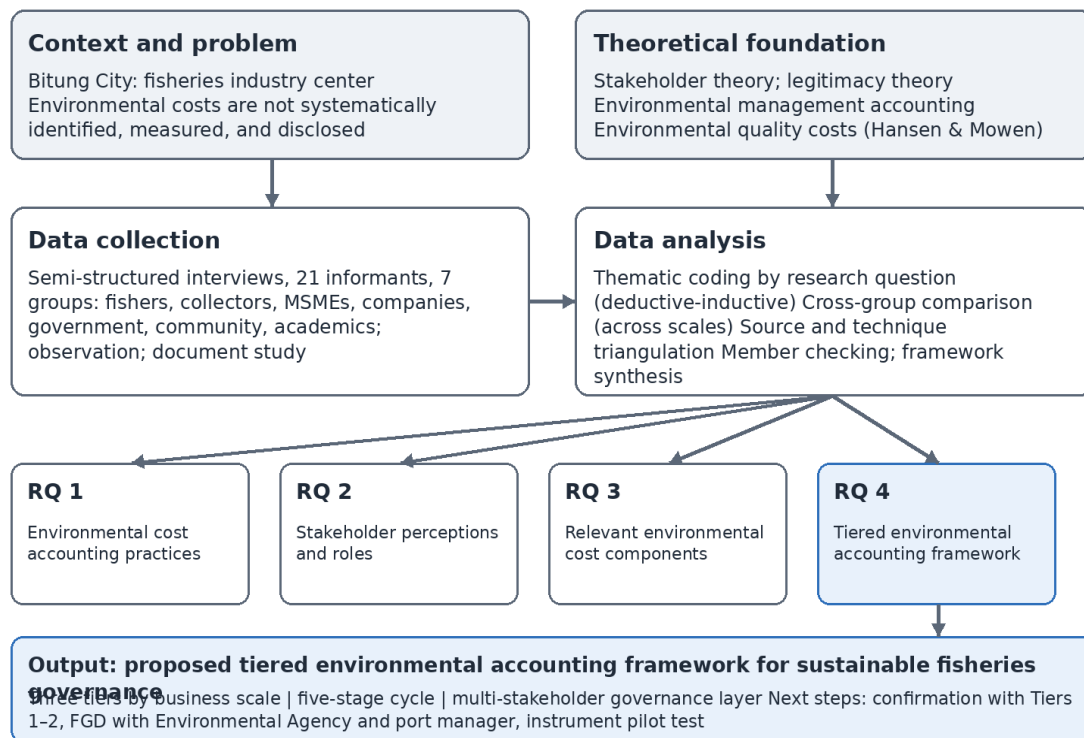


Figure 1. Research Framework
 Source: developed by the researchers, 2026

FINDINGS AND DISCUSSION

Environmental Cost Accounting Practices

None of the informants implemented the environmental accounting cycle completely. Environmental costs were incurred at all business scales, but were mixed into general operating costs, factory overhead, or the anfrak advance capital, namely fishing-expense advances provided by collectors and deducted from catch proceeds. The level of practice increased with business scale, but even the largest companies in this study had only reached computerized recording without separating environmental costs (Table 2).

Table 2. Level of Environmental Cost Accounting Practices by Business Group

Group	Practice level	Recording method	Treatment of environmental costs
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Group	Practice level	Recording method	Treatment of environmental costs
Fishers	0 – no recording	Memory; fishing capital of approximately IDR 50,000–in jerrycans but not assigned a 150,000 per trip advanced by collectors (anfrak)	Not recognized; used oil is stored in monetary value
Collectors	0–1 – partial recording	Anfrak record book (TI-01); otherwise memory and trust	None; profit is calculated from the difference between purchase and selling prices
MSMEs	1 – simple recording	cashManual book or weekly report; some have no records	Waste is treated like household waste; only waste fees are visible
Medium-to-large companies	2 – computerized, not separated	Computer system or internal company system	Merged with operating costs; one company has a system capable of separating them but cannot yet present their proportion

Source: primary data processed, 2026

The first finding is that environmental costs exist but are not visible. AK-01 explained that most fisheries entities in Bitung pay waste fees, build Wastewater Treatment Plants (IPAL), and obtain AMDAL or UKL-UPL permits, but these costs are “simply mixed into General Operating Costs or Factory Overhead.” This statement was confirmed by business actors. PU-03 stated that “the costs of handling wastewater, cleaning processing residues, or purchasing clean water are all mixed together into General Operating Costs,” while PU-01 and PU-04 stated that waste treatment was not recorded in a separate account. Consequently, no party, including management itself, knows the actual amount of environmental management costs.

The second finding is that environmental management is facility- and compliance-based, rather than information-based. Companies address environmental impacts through physical assets and permits: an independent IPAL with sanitation personnel who clean filters of accumulated blood fat every day (PU-01), temporary storage facilities and an IPAL (PU-02), and environmental documents serving as the basis for Environmental Approval before operations (PU-01, PU-02). Government supervision of fish processing units also focuses on quality, food safety, sanitation, Good Manufacturing Practices, Sanitation Standard Operating Procedures, and Processing Eligibility Certificates, rather than cost recording (PEM-01). From the community's perspective, MS-01 reminded that “the existence of an IPAL alone is not sufficient to conclude that all impacts have been addressed” without monitoring and verifiable information. The same pattern appears at the MSME level: UMKM-01 has an SPPL, but its processing waste is still treated like household waste, so compliance documents are not accompanied by management practices or cost recording.

The third finding is that system capability has not become practice. PU-02 stated that environmental costs can be separated through the accounting application used by the company, but the company cannot estimate the proportion of

environmental costs to total operating costs. The separation is only potential; the obstacles are not the technology but account classification and human resources who understand it. The fourth finding is that costs are perceived as small because they are transferred to other parties. PU-01 considered the company's environmental costs "very small" because solid waste such as bones, heads, and skin is collected by a third party for a fishmeal factory, while wastewater is sufficiently handled by the IPAL. This perspective conceals two pieces of information: the economic value of solid waste as a by-product and the cost of maintaining the IPAL.

The fifth finding comes from the micro level. Fishers do not record catches or costs; all fishing needs are advanced by collectors. NEL-01 stated, "There is no environmental cost recording. All costs are mixed together in the anfrak capital. We usually store used katinting oil in used bottles/jerrycans, but we never calculate it as having monetary value." However, recording did emerge when there was an external accountability requirement. NEL-06 and NEL-02 had prepared financial reports when their fisher group received government assistance of IDR 50 million disbursed in three installments, and recording stopped after the group became inactive in 2020. The sixth finding is that public disclosure is absent: MS-01 considered that the community does not know the allocation of waste-management costs or environmental monitoring results, while PEM-01 could not state that environmental accounting had been formally implemented in Bitung companies.

This study builds on the findings of Langelo's (2022) single-case study, which found that the stages of environmental cost accounting treatment had not been implemented in a fish processing company in Bitung City. The empirical findings from 18 business actors in this study reaffirm that argument while extending its scope across the fisheries value chain—from micro-small-scale actors to medium-to-large industries. The findings are also consistent with the low understanding of environmental management accounting among MSMEs in developing areas (Manehat & Sonbay, 2024). This study extends previous findings by explaining the mechanism separating physical and compliance-oriented environmental management from information-oriented environmental accounting across the value chain. Facilities such as IPALs can be interpreted as means of legitimacy before regulators and communities (Suchman, 1995), but they do not generate cost information that can be evaluated. The gradation of practices by business scale is also consistent with the view that EMA adoption depends on contingent variables such as organizational size and resources (Christ & Burritt, 2013).

Although the industrial tuna segment and small-scale fisheries segment operate through different raw-material channels, field data show three points of connection between them. First, the flow of processing residues: UPI solid waste consisting of bones, heads, and skin is sold to third parties for fishmeal production (PU-01), while fish parts such as tuna jaws and breasts from the factory are marketed to consumers through Central Fish Bitung (UMKM-05). Second, shared ecological externalities: according to observations by MS-01, wastewater, foam, odors, and waste from vessels are perceived around the processing industrial area and fishing port, although the causal relationship has not been measured. Third, dependence on municipal waste services: companies and MSMEs alike rely on government-provided waste bins, waste collection trucks, and waste fees (PU-01, UMKM-01, UMKM-04, UMKM-05).

Stakeholder Perceptions and Roles

All groups considered recording, including environmental aspects, important and were willing to try it. The difference lies in their motives: micro actors view it as a tool for economic survival, companies as a management and market-access tool, while government, communities, and academics view it as a tool for accountability and governance (Table 3).

Table 3. Stakeholder Perceptions and Roles Regarding Environmental Accounting

Stakeholder	Perception and motive	Barriers	Expected role
Fishers	Important for knowing profit and escaping “digging one hole to another” cycle	netBasic education, night work, the lack of knowledge, do not yet understand the function of impact recording	Primary data recorder (catch, fuel, oil) using a picture-based notebook
Collectors	Important for knowing capital and profit	Fast transactions; business and personal money are mixed	Supply-chain data node and transmitter of price signals
MSMEs	Business tidiness and continuity; legitimacy export standards (PU-03)	Digital literacy; small scale is considered not to require it; thin margins	User of templates or applications in stages
Medium-to-large companies	Basis for comparison across periods (PU-02); environmental awareness needs to be developed (PU-01)	Competent human resources; concern about unreasonable costs	Implementer of environmental management accounting and public reporter
Government	Information supporting decisions and governance (PEM-01)	Authority and environmental data are distributed across other agencies	Guideline developer, data integrator, supervisor
Community	Accountability and trust; “cost figures alone are not enough” (MS-01)	No access to reports; reactive communication	Information user and participant in regular forums
Academic	Legitimacy tool and response to export-buyer demands (AK-01)	No specific standard for the fisheries sector; cost-center mindset	Framework designer and continuous facilitator

Source: primary data processed, 2026

Acceptance of recording is high, but capacity is low. PU-02 expressed no objection and considered environmental cost recording “very important” as a basis for comparison across periods, while PU-01 stated that the company had little objection as long as the costs were reasonable. All fishers and collectors were willing to use simple record books. The recurring obstacle is knowledge: at the micro level, basic literacy; at the company level, environmental accounting human resources. PU-02 emphasized, “If there are no competent human resources in that field, the system will not work.” AK-01 added two structural barriers, namely the absence of accounting standards specifically for the fisheries sector and a management mindset that views environmental management as a burden rather than a long-term investment.

Market signals have not reached the upstream part of the value chain. AK-01 and PU-03 identified export buyers in Europe and America as the strongest drivers because they demand evidence of sustainability and traceability. However, all three collectors stated that there is no price difference for catches obtained using environmentally friendly gear; prices are determined by type, size, freshness, and supply. At the same time, upstream relationships are asymmetric. NEL-01 stated that the price is “determined unilaterally by the collector; we cannot bargain,” and TI-01 acknowledged that “price monopolies often occur.” Dependence on capital through the anfrak means that fishers do not hold their own cost information, so upstream physical data such as fuel consumption and catch volume are not recorded by any party.

As a conceptual proposal to address this asymmetry, recording at Tier 1 at the collector level is designed as an internal instrument for managing fishing-capital receivables, not for publishing price margins or eliminating the anfrak system. The proposal is based on existing practice: TI-01 has already recorded anfrak advances taken by fishers in a notebook, and TI-03 proposed columns for date, supplier, type and quantity of fish, purchase price, buyer, selling price, and additional costs. By adding columns for fuel use and the daily catch of partner fishers, the records are expected to clarify the repayment of anfrak capital to collectors and reduce unrecorded debt accumulation among fishers. The effectiveness of this proposal has not been tested and needs to be demonstrated through field trials.

The role of government is perceived, but it is uneven and fragmented. Assisted MSMEs receive training and support from the Fisheries Office and the Cooperatives and MSMEs Office, whereas fishers and collectors stated that they had never

received assistance; NEL-02 and NEL-04 identified financial-recording socialization from universities as the first assistance they had received. PEM-01 distinguished its authority from that of environmental agencies and stated that environmental indicators need to be “traced across agencies.” Communication among communities, companies, and government was considered “tends to be reactive,” occurring only when suspected pollution emerges (MS-01). Perceptions of impacts also differ: MS-01 observed wastewater, foam, odors, waste from vessels, and fishers having to travel farther to sea, whereas fishers and collectors viewed their practices as environmentally friendly and pointed to large vessels or outsiders as the polluters (TI-01).

From the perspective of stakeholder theory, these findings indicate that pressure for environmental accountability comes from actors with economic power, namely export buyers, and reaches only companies directly connected to them. Directly affected stakeholders, such as coastal communities and fishers, do not yet have channels through which to request information (Freeman, 1984). This pattern reinforces the importance of multi-stakeholder roles in sustainable fisheries management (Suryawati et al., 2023) and community-based management in Bitung (Lakoy et al., 2021). The emergence of recording among fisher groups receiving assistance also indicates that accounting practices at the micro level depend on institutional structures and binding accountability (North, 1990).

Relevant Environmental Cost Components

Business-actor data support three categories of environmental quality costs identified by Hansen and Mowen (2007), namely prevention, detection, and internal failure, while the external failure category is currently supported only by comparative informants. In addition, two categories emerged from the field: resource use (fuel, electricity, water, and ice) and environmental benefits in the form of by-product revenue. These components do not apply equally across all business scales. For fishers and collectors, environmental costs are not separated from operating costs, so physical measures are relevant, whereas for companies monetary and physical measures need to be presented together (Table 4).

Table 4. Relevant Environmental Cost Components by Category and Business Scale

Category	Component	Scale*	Measure	Source
Prevention	Preparation of environmentalP documents (UKL-UPL) for Environmental Approval		IDR/permit	AK-01, PU-01, PU-02
	Construction and maintenance of IPAL, U, P temporary storage facilities, and waste		IDR/month	PU-02, PU-03, MS-01

Category	Component	Scale*	Measure	Source
Detection	collection areas			
	Maintenance of cooling systems to prevent ammonia/freon leakage	U, P	IDR/month	AK-01†
	Worker/crew training and community education	P	IDR/activity	AK-01, MS-01†
	Katinting engine servicing and boat maintenance	N	IDR/service	NEL-01, NEL-04
	Environmentally safe cleaning agents	U, P	IDR/month	PU-03
	Laboratory testing of wastewater (BOD, COD, TSS, oil-grease)	P	IDR/test; mg/L	AK-01, MS-01†
	Water-quality monitoring and periodic environmental audits	P	IDR/period	AK-01, MS-01†
Internal failure	Noise inspection of generators and cooling machines	P	IDR/year	PU-01
	Sanitation personnel and IPAL filter cleaning	P	IDR/month	PU-01
	Treatment of liquid and solid waste (offal, heads, bones)	U, P	IDR/month; kg/day	AK-01, PU-03
	Waste fees and waste transportation	U, P	IDR/month	PU-01, PU-03, UMKM-05
External failure	Storage of used oil and hazardous/toxic waste (with manifest)	N, P	liters; IDR	AK-01, NEL-01
	Pollution remediation, community compensation, reputation recovery	P	IDR/incident	AK-01, MS-01†
	Additional fuel and time because fish are increasingly farther from shore	N	liters/trip; hours	MS-01†
Resources	Fishing fuel (3–5 liters of gasoline per trip)	N	liters/trip; liters/kg	NEL-01–06, AK-01
	Vessel fuel per ton of landed fish	P	liters/ton	AK-01†
	Electricity for cold storage, ABF, and chiller	U, P	kWh; IDR/month	PU-01, PU-03
	Clean water for washing and filleting	U, P	m ³ ; IDR/month	PU-03
Benefits	Ice for maintaining freshness	N, T, U	blocks; IDR/trip	NEL-01, TI-03
	Sale of by-products to fishmeal factories	P	kg; IDR/month	PU-01, PU-02

Source: primary data processed, 2026. *N = fishers; T = collectors; U = MSMEs; P = medium-to-large companies. †Supported only by comparative informants (AK-01, MS-01); not evidence of business actors' practices. Resource components are recorded as physical indicators; monetary values apply only to the non-product output portion.

Three points clarify the table. First, informants adopted an inclusive principle, but the data are not yet available. PU-02 stated that “everything should be recorded ... whatever is spent on environmental financing,” but none of the company informants could state its value or proportion. The list of components above is a list of relevance according to informants, not a result of measurement. Second, at the micro level environmental components are integrated into the anfrak. An anfrak package of approximately IDR 100,000 contains 3–5 liters of gasoline, oil, a lamp battery, cigarettes, and matches (NEL-01, NEL-02, NEL-06). Separating fuel and oil

from that package is sufficient to produce a fuel-efficiency indicator per trip; emission estimates still require an emission factor, and an indicator per kilogram requires conversion from bucket units to weight units. Third, physical indicators are as important as monetary figures. MS-01 emphasized the need for “impact indicators that can be monitored,” while AK-01 identified wastewater quality, fuel consumption per ton of fish, and the volume of solid and hazardous waste as the most relevant ecological indicators, including the risk of pollution in Lembeh Strait.

Adding resource and benefit categories expands Hansen and Mowen's (2007) quality-cost-oriented classification toward the material and energy flow approach in EMA (IFAC, 2005; Jasch, 2003). Consistent with the boundaries in the Methods section, the resource category is treated as a physical indicator rather than as an overall monetary environmental cost. In the fisheries industry, flows of fuel, cooling electricity, water, and fish residues are major drivers of both impacts and costs, so measuring them physically provides efficiency information that is directly useful to management. These components also align with material topics in GRI 13, such as emissions, water and effluents, and waste (Global Reporting Initiative, 2022), thereby bridging internal management needs and reporting requirements from export buyers.

Tiered Environmental Accounting Framework

The synthesis of findings produced a Tiered Environmental Accounting Framework for Bitung fisheries (Figure 2). To avoid conceptual bias, the framework was developed from a synthesis of empirical findings at the business-actor level and theoretical frameworks from the literature (Hansen & Mowen, 2007; IFAC, 2005; Global Reporting Initiative, 2022), whose relevance was contextually confirmed by AK-01. The mapping of framework elements to empirical evidence is presented in Table 5.

Table 5. Mapping of Framework Elements to Empirical Evidence

Tier / Business Scale	Informant Codes According to Table 1	Physical Management Elements (Actual Practices)	Environmental Accounting Elements (Cost Treatment)	Empirical Evidence & Recording Reality
Tier 1: / Capture and Collection (Micro Scale)	NEL-01 to NEL-06; TI-01 to TI-03	Purchase of fuel and ice through anfrak; used oil stored in jerrycans; fishers avoid destructive fishing gear and do not throw waste into the sea.	No environmental cost recording; costs are absorbed into the anfrak package. TI-01 records anfrak in a notebook.	Negative finding: fishers do not record catches or costs; fishing capital is advanced by collectors and deducted from sales proceeds. Collectors calculate profit from the price difference; ice and

				transportation costs are not calculated separately; business and household money are mixed (TI-02, TI-03).
Tier 2: / Processing MSMEs (Micro and Small Scale)	UMKM-01 to UMKM-05; PU-03	Purchase of fish raw materials; processing waste disposed of through city waste services; waste fees (UMKM-05); SPPL (UMKM-01); IPAL maintenance and clean-water use (PU-03).	Simple or manual cash recording; environmental costs are not separated.	Waste is treated like household waste (UMKM-01, UMKM-02, UMKM-03); waste, water, and cleaning costs are combined into general operating costs (PU-03); some MSMEs have no records (UMKM-02).
Tier 3: / Medium-to-Large Companies	PU-01, PU-02, PU-04	Operation of IPAL and temporary storage facilities, daily sanitation personnel, environmental documents (UKL-UPL) as the basis for Environmental Approval (PU-01, PU-02), sale of processing residues to a fishmeal factory (PU-01).	Environmental costs are not separated from operating costs or overhead.	Main finding: IPAL, sanitation, and waste-transportation costs are combined into general operating costs (PU-01, PU-04). PU-02's system can separate costs, but the proportion of environmental costs cannot be stated. Document review of PU-01 and PU-02 found environmental documents and quality certificates, but no separate environmental cost account.
Government: / Quality Supervision	PEM-01	Supervision of processing eligibility (GMP, SSOP) and SKP verification; environmental monitoring and enforcement are outside the informant's authority.	Not involved in business actors' accounting records.	Provides a comparative perspective on quality and sanitation; cannot confirm environmental accounting implementation in companies or cross-agency environmental data.

Source: primary data processed, 2026

The framework consists of three recording tiers according to business scale, one five-stage accounting cycle applied with different depth at each tier, and one multi-stakeholder governance layer supporting it. This design responds to informants'

request that the framework “must not be too complicated like a large corporate report” and should use a “step-by-step approach” (PU-03).

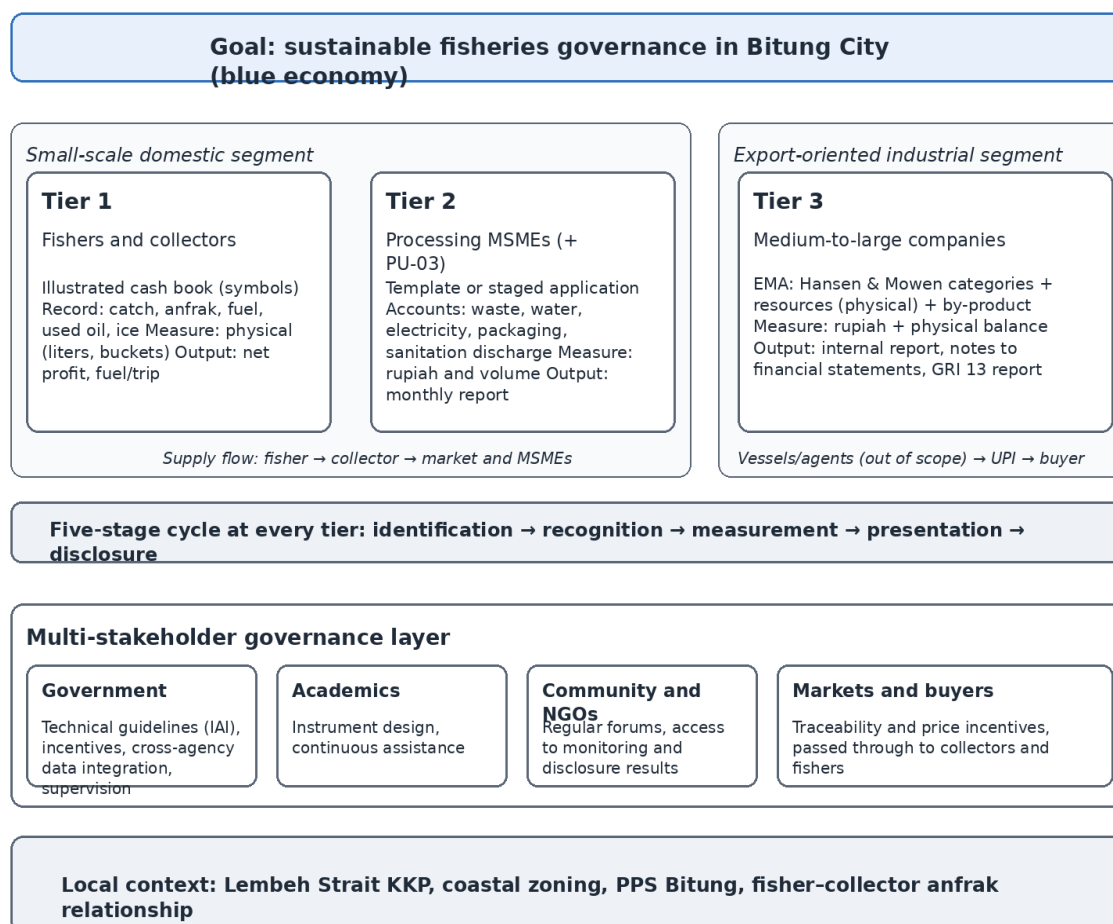


Figure 2. Proposed Conceptual Tiered Environmental Accounting Framework for Sustainable Fisheries Governance in Bitung City

Source: developed from primary data, 2026

Six design principles are derived directly from the data. First, the framework is tiered according to capacity: fishers requested a “simple cash-book format based on symbols or pictures” (NEL-01), MSMEs requested templates and applications, while companies require a basis for environmental accounting and management frameworks (PU-02). Second, physical measurement is prioritized and monetary measurement follows, because liters of fuel and buckets of catch are easier to record upstream while still producing ecological indicators. Third, the framework is directed toward management, not only reporting; AK-01 recommends focusing on environmental management accounting so that data can be used for daily efficiency. Fourth, the economic dimension serves as the entry point, because micro actors and

MSMEs are interested in net profit and cash flow, consistent with the role of cost accounting in reducing financial risks for coastal fisheries businesses (Pelupessy, 2024). Fifth, assistance must be continuous, “not just one socialization session and then being left behind” (NEL-01). Sixth, the framework incorporates Bitung's local context, namely the Lembeh Strait KKP, coastal zoning, PPS Bitung, and the anfrak relationship between fishers and collectors.

The application of the five-stage cycle at each tier is detailed in Table 6. At the micro tier, identification is sufficient by separating fuel, oil, ice, and lamps from the anfrak package and then recording them in physical units. At the MSME tier, environmental accounts are gradually added to the monthly cash book. At the company tier, all cost categories are recognized in the chart of accounts, measured monetarily and physically, and then gradually disclosed through sustainability reports. At Tier 1, the terms recognition and measurement are used as simple equivalents for recording, not in the sense of formal accounting recognition. For Tiers 2 and 3, recognition and measurement refer to SAK EMKM (Ikatan Akuntan Indonesia, 2016) and SAK Entitas Privat, effective January 1, 2025 (Ikatan Akuntan Indonesia, 2021); the IPAL is treated as a depreciable fixed asset, while potential pollution claims are disclosed as contingent liabilities.

Table 6. Application of the Five-Stage Cycle at Each Tier

Stage	Tier 1: Fishers and collectors	Tier 2: Processing MSMEs	Tier 3: Medium-to-large companies
Identification	Fuel, oil, ice, and lamps separated from the anfrak package	Waste fees, water, electricity, packaging, sanitation	Four Hansen and Mowen categories plus resources and by-products
Recognition	Recorded when a trip or transaction occurs	Separate account in the monthly cash book	Environmental cost account in the chart of accounts; IPAL recognized as a fixed asset and depreciated
Measurement	Physical: liters per trip, buckets per trip, liters of oil	Rupiah plus water volume and kWh	Rupiah plus physical balance: mg/L waste, liters of fuel per ton, kg of solid and hazardous waste
Presentation	Daily/monthly summary: capital, anfrak deductions, net profit, fuel per kg	Monthly report with environmental column	Internal environmental cost report by category
Disclosure	Group data for government offices and cooperatives	Summary for supervisors and buyers	Notes to financial statements, followed by GRI 13-based sustainability report

Source: developed from primary data, 2026

The governance layer assigns each stakeholder a role emerging from the data. Government plays a role in developing technical guidelines for environmental accounting in the fisheries sector together with the Indonesian Institute of Accountants, providing incentives such as reduced fees for transparent reporters

(AK-01), integrating business, resource, waste, sanitation, and quality data across agencies (PEM-01), expanding supervision to the urban-village level (PU-01), and providing integrated waste-management facilities (PU-02, MS-01). Academics play a role in designing instruments and providing continuous assistance (PU-03, NEL-01). Communities and NGOs are involved through regular forums and access to monitoring results, allocations of impact-control costs, and follow-up to problems (MS-01). Markets and buyers are expected to provide price incentives for environmentally friendly supplies (PU-03), which are passed through to the collector nodes so that they reach fishers.

Implementation of the framework can be carried out gradually. The foundation stage includes introducing illustrated cash books for fishers and collectors, MSME templates with environmental accounts, and the preparation of an environmental cost chart of accounts by companies. The measurement stage includes preparing physical balances and internal reports by category for companies, as well as collecting data from fisher groups and MSMEs through facilitators. The disclosure stage includes disclosure in notes to financial statements and GRI 13-based reports for large companies, regular public forums, and linking government incentives to reporting quality. The sequence of stages is an analytical proposal that needs to be validated together with stakeholders.

Compared with previous studies, this proposed framework differs in three respects. First, its scope covers two value-chain segments, from micro fishers to medium-to-large companies, rather than a single entity as in Langelo (2022). Second, the framework does not stop at financial recording for risk control (Pelupessy, 2024), but adds an environmental cost accounting cycle with specific cost categories and physical indicators. Third, the framework adds a governance layer connecting business actors with government, communities, academics, and markets. Conceptually, the combination of physical and monetary information and an orientation toward managerial decision-making is consistent with the comprehensive EMA framework (Burritt et al., 2002), while tiering by business scale responds to contingent variables affecting EMA adoption (Christ & Burritt, 2013) and the importance of local context in developing countries (Tilt, 2018). Incorporating the Lembeh Strait KKP and environmentally friendly port practices (FAO, 2024; Stenly, 2026) connects the framework with the conservation agenda and coastal spatial planning of Bitung City.

To provide a technical illustration of implementation at each level of business capacity, the framework is supplemented with an illustrative chart of accounts and

journal examples. These illustrations show how the environmental cost components in Table 4 can be incorporated into the recording system, as presented in Table 7. The values and account codes in the table are not field data.

Table 7. Illustrative Simulational Model of a Tiered Environmental Cost Chart of Accounts & Standard Journal Entries

Business Tier	Separate Account Code & Name	Illustrative Transaction (Based on Data)	Illustrative Standard Journal Entry / Simple Note
Tier 1 (Fishers & Collectors)	Illustrated Cash Book (No Account Code)	Anfrak package ±IDR 100,000 contains 3–5 liters of gasoline, cigarettes, and matches (NEL-01, NEL-02, NEL-06); used oil is stored in a jerrycan (NEL-01).	[Expenditure] Anfrak: IDR 100,000, including x liters of gasoline / [Physical note] Used oil: x liters (stored)
Tier 2 (Processed MSMEs)	5-2100 Waste Fee & Cleaning Expense	Payment of waste fees (UMKM-05).	Cash-book column “Environmental Cost – Waste Fees”: IDR xx / For MSMEs already using journal entries: / (D) Waste Fee & Cleaning Expense xx / (K) Cash xx
Tier 3 (Company/UPI)	5-3110 IPAL Maintenance Expense / 4-2100 By-Product Revenue	Cleaning of the IPAL filter of blood fat by sanitation personnel and sale of bones, heads, and skin to a fishmeal factory (PU-01).	1. IPAL maintenance: / (D) IPAL Maintenance Expense xx / (K) Cash/Accounts Payable xx / 2. Sale of processing residues: / (D) Cash/Accounts Receivable xx / (K) By-Product Revenue xx / Alternative: sales proceeds are credited as a reduction of cost of goods manufactured (net realizable value method), in accordance with the entity’s accounting policy.

Source: developed by the researchers, 2026. Values and account codes are illustrative.

The illustrative model in Table 7 shows that operationalizing environmental accounting does not have to require a uniform system across all entities. At Tier 1, recording combines simple cash transactions with physical volume indicators, enabling micro actors to calculate fuel efficiency per trip without a debit-credit mechanism. At Tier 2, environmental costs are sufficiently separated as a distinct column in the cash book, while journal entries are used only by MSMEs that have already adopted them. At Tier 3, entities separate environmental cost subaccounts from general overhead accounts so that management can see the amount of waste-

handling costs while also recording receipts from the sale of processing residues. The choice between recognizing these receipts as revenue or as a reduction of cost of goods manufactured needs to be determined in each entity's accounting policy.

Theoretically, these findings provide initial contextual evidence in Bitung City, formulated as propositions to be tested in future research. P1: in fish processing companies, environmental legitimacy before regulators and communities is built primarily through physical facilities and environmental documents, rather than through cost information. P2: the depth of environmental accounting practices increases with business scale and direct connectivity to export buyers. P3: at the micro level, recording emerges only when there is a binding external accountability mechanism and stops when that mechanism disappears. Practically, the framework provides guidance for business actors to begin with recording appropriate to their capacity, for local governments to develop guidelines and incentives, and for universities to design sustainable assistance programs.

CONCLUSION

This study concludes that environmental cost accounting in the Bitung fisheries industry remains implicit. Environmental costs are incurred at all business scales, but are mixed into operating costs, overhead, or anfrak, and no actor has implemented the stages of identification, recognition, measurement, presentation, and disclosure. Stakeholders accept the idea of environmental accounting, but capacity is low; motives differ by scale, market signals have not reached upstream actors, and the role of government remains fragmented. Relevant cost components include environmental quality cost categories, with the external failure category currently supported only by comparative informants, supplemented by resource use and by-product benefits, with physical measures being more appropriate for micro actors. These findings are synthesized into a tiered environmental accounting framework that adapts the five-stage cycle to business capacity and is supported by a multi-stakeholder governance layer.

This study has several limitations. First, the resulting tiered framework is still a proposed conceptual framework and has not undergone field trials (pilot testing). Confirmation of the framework was conducted only with Tier 3 informants, comparative informants, and one Tier 2 actor (UMKM-01), while Tier 1 actors had not yet been confirmed. Second, actual monetary values of environmental costs were not obtained from entity documents, so the identified cost components remain a qualitative relevance list. Third, the government and community elements were each represented by one informant, and the environmental regulator (Environmental

Agency) and port manager were not involved. Fourth, large-scale commercial fishing fleets supplying UPIs were not covered, so the framework applies to the actors studied and cannot be generalized to those fleets. Future research is recommended to conduct focus group discussions with the Environmental Agency, port managers, and business-actor associations; confirm the framework with other fishers, collectors, and MSMEs; and directly pilot the tiered recording instrument in fisheries entities in Bitung City.

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