

Sustainable Coastal Waste Governance through the Lens of Fishing Families: Evidence from Sebatik Island

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Abstract

Coastal waste has emerged as a global environmental issue in recent years. Addressing this challenge requires an understanding of community perceptions in coastal areas to strengthen and support government-led interventions. Therefore, this study aims to examine the perspectives of traditional fishing households regarding the dynamics of coastal waste management. Data on community perceptions were collected through: (1) a socio-economic profile survey; (2) a needs analysis assessment of traditional fishing households regarding coastal waste management practices in their surrounding environment; (3) knowledge transfer activities focusing on the importance of transforming coastal waste into innovative products; and (4) participatory observations to obtain a comprehensive understanding of local conditions. The findings indicate that fishermen communities in Sebatik Island are characterized by socio-economic vulnerability, reflected in limited income, low educational attainment, high household dependency burdens, and restricted access to financial capital. Although communities demonstrate a relatively high level of awareness regarding the urgency of waste management, implementation practices remain constrained by limited technical capacity and insufficient support from empowerment programs. This study concludes that coastal waste governance programs must be aligned with the socio-economic characteristics of fishing communities to ensure accountable, responsive, participatory, and innovative waste management systems. The study recommends integrating coastal waste management programs with broader poverty alleviation agendas for fishing communities. The recommendations focus on four key aspects: (1) developing community-based waste management systems; (2) utilizing waste as a source of coastal economic diversification; (3) strengthening the capacity of fishing communities; and (4) enhancing cross-border collaboration in managing waste within frontier coastal regions. These findings provide a knowledge foundation for the subsequent planning of community empowerment programs aimed at reducing the negative impacts of inadequate waste governance while strengthening the socio-economic resilience of coastal communities.

INTRODUCTION

Accumulated waste in coastal areas requires serious attention due to its high buoyancy and persistent characteristics, which make it difficult to degrade within marine environments (Chen et al., 2026; Teppala & Bhaskaran, 2026). Countries with extensive coastlines have increasingly recognized coastal waste as a critical environmental issue, thereby encouraging the development of community participation in waste management initiatives (Konecny et al., 2018; Zebua et al., 2025). These challenges have stimulated the emergence of various regulatory interventions, including bans on single-use plastic packaging, waste buy-back programs, and recycling policies aimed at strengthening coastal pollution prevention and control efforts (Konecny et al., 2018). Such approaches are essential because without encouraging communities to perceive waste management as a potential source of social and economic value, the consequences of coastal pollution may become increasingly severe. Therefore, this article focuses on coastal waste management practices, particularly because waste originating from land-based activities

can be transported over considerable distances through ocean currents, wind, and storm events, eventually becoming marine debris (Saxena et al., 2025).

A study by (Jambeck et al., 2015) estimated that approximately 11% of the 2.5 billion metric tons of waste generated by 6.4 billion people living in coastal regions across 192 countries consisted of plastic waste (Jambeck et al., 2015). East Asia represents one of the regions with the fastest growth in waste generation worldwide. Among the 192 coastal countries, five countries in East and Southeast Asia—China, Indonesia, Vietnam, the Philippines, and Thailand—account for more than 50% of global plastic waste entering marine ecosystems (World Bank, 2018). Marine debris accumulation is closely associated with population density and inadequate waste management systems (Louhab et al., 2026). Furthermore, coastal waste pollution is influenced by geographical characteristics, with accumulation patterns often concentrated in countries possessing extensive coastal areas (Burke et al., 2026). These pollutants consist of passive particles transported by wind and water currents, eventually accumulating in coastal ecosystems (Khoury et al., 2026). It is estimated that approximately 1.7–10% of poorly managed plastic waste generated in coastal regions eventually enters marine ecosystems (Badejo et al., 2024; Purba et al., 2019).

Coastal pollution has significant implications for marine ecosystem degradation, particularly due to the accumulation of plastic waste and heavy metals. Plastic materials can fragment into microplastics, which pose substantial risks to marine organisms by disrupting physiological processes, including growth, organ functioning, and reproductive capacity (Cao et al., 2026). These risks arise because microplastics contain chemical additives and can absorb hazardous hydrophobic compounds from surrounding waters before being ingested by marine organisms (Zhou et al., 2026). Similarly, increased concentrations of heavy metals in marine environments create serious ecological threats due to their toxic, persistent, and bioaccumulative characteristics, which may result in biomagnification throughout food chains (Khodamoradi et al., 2026). Marine pollution can interfere with biological metabolism, induce physiological stress, damage organs, disrupt blood circulation, cause tumor formation, and ultimately lead to mortality among marine organisms (Wu et al., 2026).

In Indonesia, anthropogenic debris fragments were detected in 28% of edible fish samples purchased from local markets. Comparable contamination was also identified in 25% of fish samples obtained from markets in the United States. However, the composition of debris differed considerably: all fragments identified in Indonesian samples consisted of plastic materials, whereas debris found in United States samples primarily consisted of organic fibers (Irnidayanti et al., 2025; Rochman et al., 2015). This difference reflects variations in waste management strategies between the two countries. In other words, waste governance approaches differ between high-income countries such as the United States and developing countries such as Indonesia. Despite variations in waste composition, the biological, ecological, and aesthetic consequences of marine debris pollution have the potential to affect multiple economic sectors, including fisheries, tourism, maritime transportation, and public health. Consequently, global economic losses associated with marine debris pollution are estimated to exceed USD 13 billion annually (Purba et al., 2019).

The persistent challenges in addressing marine debris are partly attributed to the limited effectiveness of governance strategies implemented from regional to global institutional levels in translating international agreements, regulations, and standards into practical actions. Marine debris issues have been addressed both directly and indirectly through various international agreements and environmental frameworks (Mouat et al., 2010). Several countries have developed national policies to mitigate marine debris through waste management regulations, including the provision of coastal waste treatment facilities, beach-cleaning programs, livelihood support for fishers, and information, education, and awareness initiatives grounded in sustainability principles (Uhrin & Burgess, 2026). However, the development of marine waste management infrastructure requires substantial financial resources and long-term implementation processes (Mouat et al., 2010). Therefore, in developing countries such as Indonesia, improving waste collection systems and strengthening solid waste management practices represent essential priorities for addressing marine debris challenges (Kummer et al., 2026).

Addressing waste-related challenges requires an interdisciplinary perspective that integrates environmental, social, economic, and governance dimensions (Sajid et al., 2026; Tweneboa Kodua et al., 2026). One critical aspect in managing coastal waste, particularly in coastal communities, is meaningful public participation. Previous studies have demonstrated that community participation represents a key determinant in addressing coastal waste problems (Alimoradiyan et al., 2024; Zebua et al., 2025). Within the framework of community-based participation, waste management initiatives are more likely to succeed when supporting infrastructure, institutional arrangements, and community perceptions are evaluated directly at the local level. Such evaluation is necessary to improve decision-making processes related to waste management interventions. This argument aligns with (Fraser & Temocin, 2025), who emphasize that effective long-term waste prevention strategies must originate from grassroots communities. Community involvement in utilizing and managing waste throughout local processes represents an important pathway toward community development. Community development emphasizes the capacity of individuals and groups to learn, collaborate, and collectively work toward achieving sustainable development objectives.

This article examines community perceptions and conditions related to coastal waste management, particularly concerning waste disposal and collection practices. Indonesia is selected as the research context as it represents a developing country facing persistent coastal waste governance challenges. The study focuses on Sebatik Island as a case study due to its unique coastal ecosystem characteristics, including extensive shorelines, fishing zones, and marine current interactions between two neighboring countries, which directly influence the volume and diversity of waste accumulation. Sebatik Island functions as an emerging center of governance, education, trade, and service activities across an international border context.

One of the activities contributing to coastal waste challenges is the waste transportation system. Limited infrastructure and inadequate transportation services constrain the capacity to transport collected waste to final disposal facilities. This condition also reduces waste collection effectiveness in coastal areas (Smith & Bernal, 2021). Several coastal regions in Indonesia have experienced significant

environmental degradation, demonstrated by the increasing presence of waste in marine waters (Harmesa & Cordova, 2021). Communities living along riverbanks frequently dispose of waste directly into rivers connected to marine ecosystems. The proximity of settlements to waterways facilitates such practices and gradually transforms them into environmentally harmful habits (Adeli & Goerlandt, 2026). Many coastal communities continue to perceive rivers, coastlines, and oceans as final disposal spaces with limited awareness of their long-term impacts on marine resources (Smith & Bernal, 2021).

Therefore, this study aims to examine community perspectives regarding the dynamics of coastal waste management in Indonesia's maritime border region, using Sebatik Island as a case study. Specifically, this research pursues three main objectives: (1) to map the socio-economic conditions of traditional fishing households in the Indonesia–Malaysia border region; (2) to identify community perceptions, needs, and readiness regarding coastal waste management; and (3) to analyze the suitability of community-based waste governance strategies based on local socio-economic conditions and community capacities. This study is expected to provide both theoretical and practical contributions to the development of coastal environmental governance that is more participatory, inclusive, and responsive to local community characteristics.

LITERATURE REVIEW

Coastal waste governance in border coastal regions represents a structurally complex policy challenge that cannot be adequately explained through technical or infrastructural analyses alone. The challenges encountered on Sebatik Island demonstrate a persistent gap between formal regulatory commitments and the capacities of communities and institutions to generate meaningful transformation. Scholarly debates in coastal governance increasingly acknowledge that such gaps reflect a misalignment between governance program designs and the socio-economic realities of the communities they are intended to serve (Freeman & Hwang, 2026; Joly et al., 2026; Mumford et al., 2026). To analyze this misalignment, this study adopts change management theory as its primary theoretical lens, operationalized through (Kotter, 2012) and (Lewin, 1951), while integrating the perspective of participatory governance theory. This multidimensional framework enables a critical examination of how structural conditions and community perceptions interact in shaping coastal waste governance outcomes within a transnational maritime border context (Ekendahl et al., 2026; Hu et al., 2025).

The fundamental premise of this study is derived from change management theory, which conceptualizes governance transformation not as a linear administrative process, but rather as a socially embedded phenomenon influenced by competing forces, institutional inertia, and context-dependent resistance (Kotter, 2012; Lewin, 1951). Lewin's Force Field Analysis provides a diagnostic framework for this research by arguing that every social system exists within a quasi-equilibrium state maintained by the balance between driving forces that encourage change and restraining forces that resist it. Applied to coastal waste governance on Sebatik Island, this framework reframes the central research problem, why high levels of community awareness do not translate into improved waste management practices, not as a question of individual irrationality, but as a problem of imbalance between competing forces.

In this context, driving forces include increasing community awareness regarding ecological risks associated with waste, growing regulatory pressure from global sustainability agendas, and explicit commitments from local governments. However, these forces are systematically constrained by restraining forces rooted in the structural vulnerability of fishing communities, including limited household income, low educational attainment, high dependency ratios, restricted access to capital, and insufficient technical capacity to implement sustainable waste management practices. This diagnostic framework provides the analytical foundation for the mixed-methods design of this study: quantitative survey data are employed to precisely measure structural parameters of socio-economic vulnerability, while qualitative analysis is used to interpret the meanings, perceptions, and institutional dynamics that sustain the imbalance of forces in practice.

Building upon Lewin's diagnostic framework, Kotter's Eight-Step Change Model introduces a process-oriented dimension explaining how governance transformation can be strategically organized and sustained over time. While Lewin identifies the factors that maintain a system in its current state, Kotter explains how such a system can be deliberately moved toward a new equilibrium. Within the context of coastal governance aligned with the Sustainable Development Goals (SDGs), Kotter's model emphasizes the importance of establishing a sense of urgency, building institutional coalitions, mobilizing community participation, and ensuring that early achievements are institutionalized to prevent regression (Kotter, 2012).

Critically, this model highlights an empirically relevant point for the Sebatik context: change initiatives designed without considering the initial conditions of target communities are unlikely to achieve the sustained support and behavioral transformation required for long-term governance improvement. This understanding positions socio-economic profiling not as a peripheral descriptive exercise, but as a theoretically necessary prerequisite for effective change design. It also explains why this study structures its analytical sequence by first understanding socio-economic baseline conditions, then examining governance processes, and finally formulating programmatic recommendations.

Participatory governance theory extends the change management framework by emphasizing that sustainable environmental governance requires active community agency rather than merely passive compliance with externally designed programs (De los Reyes-Marín et al., 2026). Participatory governance is operationalized through community-based waste management structures, inclusive decision-making processes, transparent resource allocation, and community-based monitoring mechanisms. Literature on participatory environmental management consistently demonstrates that governance programs failing to cultivate genuine participation tend to produce superficial behavioral compliance rather than internalized normative transformation (Abdolhosseinzadeh et al., 2026).

This issue becomes particularly consequential in contexts of socio-economic vulnerability, where communities may participate instrumentally, attending meetings and signing participation forms, while continuing existing waste disposal practices. For this study, participatory governance theory provides an analytical vocabulary for interpreting qualitative data collected through needs assessments, knowledge

transfer activities, and participatory observations. The theory directs analytical attention toward the quality and depth of participation rather than merely its presence, as well as toward the structural conditions that enable or constrain meaningful community agency in coastal waste governance.

Transboundary institutional theory complements this framework by addressing the transnational dimension of coastal waste governance that is particularly relevant to Sebatik Island, which is geographically divided between Indonesian and Malaysian sovereignty but shares interconnected coastal ecosystems, tidal flows, and waste accumulation patterns. Transboundary institutional theory argues that environmental problems whose physical dynamics exceed national boundaries cannot be effectively governed through unilateral national actions, regardless of the quality of domestic policies (Vaidya, 2026).

Effective transboundary governance requires institutional coordination mechanisms that harmonize regulatory standards, share monitoring responsibilities, and align enforcement capacities across jurisdictions. In the context of Sebatik Island, the absence of strong bilateral coordination between Indonesia and Malaysia represents a distinct structural constraint operating at the macro-institutional level, while its consequences are directly experienced through marine debris accumulation in shared coastal waters. This theoretical perspective provides an analytical lens for examining cross-border governance dynamics, not as a peripheral contextual observation, but as a structurally significant variable shaping the external boundaries of locally designed waste governance reforms (Wijaya et al., 2026).

A deeper understanding of the integration among these three theoretical frameworks requires an explicit articulation of the causal relationships connecting them. In this study, the socio-economic vulnerability of fishing communities is not treated as a static background variable, but rather as a structural factor actively shaping the balance of forces within Lewin's framework. The deeper the structural vulnerability of a community as measured through income, education, access to capital, and household dependency burden the greater the weight of restraining forces that must be overcome by any change initiative.

In other words, socio-economic conditions function as a causal mechanism directly determining community capacity to respond to and adopt governance transformations. This causal relationship can be expressed as: Socio-economic vulnerability → Dominant restraining forces → Limited change capacity. However, this mechanism is not deterministic. Participatory governance theory introduces a critical mediating variable: community agency and participation quality. Even under conditions of high structural vulnerability, communities with access to inclusive decision-making forums, adequate information, and functioning accountability mechanisms can transform collective awareness into organized collective action (Hochrainer-Stigler et al., 2024).

In the context of Sebatik Island, this implies that waste management programs positioning community participation as the primary entry point—rather than merely as a socialization component—have greater potential to shift the balance of forces than interventions relying solely on infrastructure development or regulatory enforcement. This causal mechanism subsequently forms the conceptual pathway underlying

this research: Socio-economic vulnerability → Dominance of restraining forces (Lewin) → Limited change capacity → Community agency and participation as mediating mechanisms (Ostrom; Pahl-Wostl) → Institutional coordination capacity → Coastal waste governance outcomes → Sustainable socio-economic transformation of fishing households. Each relationship within this pathway is empirically traceable: socio-economic conditions are measured through quantitative surveys; community agency and perceptions are interpreted through qualitative analysis; and transboundary institutional coordination is examined through document analysis and interviews with institutional actors.

Importantly, this pathway is not linear. Feedback mechanisms operate within the system: poor governance outcomes further deepen the economic vulnerability of fishing households through declining fisheries productivity and coastal ecosystem degradation, which subsequently reinforces restraining forces within the system. Recognizing these feedback dynamics distinguishes this study from linear policy analyses that treat socio-economic conditions merely as fixed independent variables.

Conventional approaches to coastal waste management, both in academic literature and policy practice, have predominantly focused on three intervention pillars: waste transportation and treatment infrastructure, disposal regulations and enforcement mechanisms, and recycling and waste-processing technologies. Although these three pillars remain important, such approaches contain a fundamental capacity mismatch when applied to structurally vulnerable coastal communities. They assume that communities possess the technical, economic, and institutional capacities required to effectively respond to these interventions.

This assumption is empirically questionable in the context of fishermen communities on Sebatik Island and theoretically contradicts the core premise of change management theory, which emphasizes alignment between intervention design and the initial conditions of target communities. Furthermore, infrastructure- and regulation-based approaches often reproduce policy implementation gaps: regulations are established, infrastructure is developed, yet waste disposal practices remain unchanged because the underlying causes structural vulnerability and the absence of meaningful participation remain unaddressed.

This study argues that sustainable governance transformation requires a paradigm shift from output-based approaches (infrastructure, regulations, and technology) toward capacity-based approaches that position community empowerment, social capital strengthening, and institutional coordination as primary governance investments rather than secondary components. This research does not conceptualize coastal waste merely as a technical waste management issue, but rather as a governance challenge involving four interconnected dimensions: institutional capacity, referring to the ability of local governments and communities to design, implement, and monitor waste management programs effectively; community empowerment, referring to the extent to which fishing communities possess genuine agency in determining waste management priorities and mechanisms; policy implementation gap, referring to the discrepancy between formal policies and actual practices on the ground; and

transboundary coordination, referring to the institutional capacity of Indonesia and Malaysia to collectively manage their shared coastal ecosystem.

By positioning coastal waste challenges at the intersection of these four dimensions, this study contributes to bridging two previously disconnected streams of literature: change management literature in public administration, which has traditionally focused on urban organizational contexts, and coastal environmental governance literature, which has largely emphasized ecological and technological dimensions while insufficiently considering community socio-economic conditions as causal variables.

The mixed-methods design adopted in this study is not merely a pragmatic methodological choice, but an epistemological consequence of the theoretical framework developed. Lewin's change management theory requires precise measurement of structural parameters representing restraining forces, operationalized through measurable socio-economic indicators such as income level, educational composition, and capital access. Without representative quantitative evidence, claims regarding the dominance of restraining forces would remain speculative.

Conversely, participatory governance theory and transboundary institutional theory require deeper understanding of meanings, perceptions, experiences, and relational dynamics that cannot be reduced to numerical indicators. Why do communities continue disposing waste into the sea despite recognizing its impacts? How do power relations between fishermen and village authorities shape participation quality in waste management programs? How do institutional actors across borders perceive and negotiate responsibility for shared coastal ecosystems?

These questions require qualitative approaches capable of capturing interpretive complexities underlying structural conditions. Therefore, mixed methods in this study function as an integrative strategy enabling triangulation between measurable objective conditions and lived subjective meanings, two dimensions necessary for developing a comprehensive and theoretically grounded understanding of coastal waste governance on Sebatik Island.

As a synthesis of the theoretical arguments developed, this study proposes an integrative conceptual model that moves beyond conventional sectoral approaches in coastal waste governance research. This model coherently integrates three analytical levels: micro-level (socio-economic vulnerability and community agency), meso-level (institutional capacity and program implementation), and macro-level (transboundary coordination and global regulatory pressures) into a unified framework explaining how these factors simultaneously interact in shaping governance outcomes.

This conceptual contribution extends beyond the Sebatik context by providing an analytical framework applicable to various coastal governance settings in maritime border regions, particularly in developing Southeast Asian countries facing similar combinations of coastal community vulnerability, limited institutional capacity, and cross-border coordination complexity. Thus, this study contributes not only to empirical understanding of waste governance on Sebatik Island, but also to the development of

environmental governance theory within comparative public administration that is sensitive to border contexts and the socio-economic realities of local communities.

RESEARCH METHODOLOGY

This study employed a mixed-methods approach with a participatory framework to obtain a comprehensive understanding of the socio-economic conditions, waste management practices, and needs of fishing households on Sebatik Island, located within the Indonesia–Malaysia border region. This approach positions fishing households as active partners throughout the data collection and analytical processes, consistent with the principles of Participatory Rural Appraisal (PRA), which emphasizes participatory mapping, community reflection, and validation of local knowledge prior to intervention design (Enayati et al., 2025; S et al., 2025).

The current research stage is exploratory and focused on baseline mapping; therefore, it does not yet include direct intervention implementation or action-based programs. The participatory approach enables researchers and fishing households to collaboratively: (1) identify actual problems and community needs, (2) map existing resources and practices, and (3) establish a knowledge foundation for future community empowerment program planning. Within the context of fishing households, this approach creates opportunities for the emergence of community-driven innovation, developed from local experiences, indigenous knowledge, and the actual needs of communities. The expected outcomes extend beyond improving waste management efficiency, but also include strengthening the long-term social and economic capacities of fishing communities.

Study Location

This research was conducted in the Indonesia–Malaysia border region, specifically on Sebatik Island, which is administratively divided between Nunukan Regency, North Kalimantan Province (Indonesia), and several villages in Tawau, Sabah (Malaysia). The study focused on seven villages, including Tanjung Aru Village with Pantai Indah Hamlet and Mekar Hamlet (Indonesia), as well as Kg. Bergosong, Kg. Mentadak Baru, Kg. Sungai Melayu, Kg. Sungai Pukul, Kg. Sungai Tongkang, and Kg. Wallace Bay in Tawau, Sabah (Malaysia). This location like on Fig. 1.

Tanjung Aru Village, located in the southern part of Indonesian Sebatik Island, was selected due to its geographical proximity to Tawau, Sabah, Malaysia. This village represents one of the closest Indonesian border settlements to Tawau, separated only by a narrow strait, making it highly relevant for examining coastal waste governance challenges. The area has relatively accessible land and maritime connections, providing a strategic setting for investigating waste management issues in coastal border communities.

On the Malaysian side, the research was conducted in several villages within Tawau, including Kg. Bergosong, Kg. Mentadak Baru, Kg. Sungai Melayu, Kg. Sungai Pukul, Kg. Sungai Tongkang, and Kg. Wallace Bay. These villages were selected due to their accessibility through land and sea transportation.

However, access to Kg. Wallace Bay remains limited, with only one boat service available per day, requiring researchers to travel by land to Kg. Sungai Tongkang before continuing the journey by maritime transportation.

Source: Author, 2024

The selection and integration of these study locations were not intended to establish a cross-country comparison (comparative study), but rather to examine the interconnected socio-ecological and economic systems that have historically existed beyond contemporary administrative boundaries. Sebatik Island is conceptualized as a natural socio-ecological laboratory, where economic activities, kinship networks, and maritime cultures have developed in an interconnected manner despite political boundaries.

From the perspective of borderland livelihood systems, communities living in border areas such as Sebatik operate within hybrid livelihood systems that combine formal and informal economic activities across national boundaries and rely on transnational social networks to sustain household economic resilience. Therefore, this study is constructed based on a transnational livelihood system perspective, rather than differences in administrative jurisdiction.

Geographically, this region shares interconnected coastal ecosystem characteristics, including coastlines, fishing zones, and marine current patterns, meaning that ecological impacts generated on one side of the border directly influence the other side. Coastal waste management practices implemented locally in Indonesia, for instance, cannot be separated from marine currents and environmental policies in Malaysia, and vice versa.

Therefore, an analytical approach limited to a single administrative boundary would obscure the actual ecological and social interdependencies that operate across borders.

From a socio-economic perspective, fishing communities on both sides demonstrate intensive and continuous cross-border interactions. Communities in Indonesian and Malaysian Sebatik maintain mutual dependence through economic activities, seafood trade, and socio-cultural exchanges. The implementation of the border crossing pass policy (Ministry of Trade of the Republic of Indonesia, 2020) strengthens these interactions by facilitating cross-border mobility for economic and social purposes.

Fish catches from Indonesian Sebatik are largely marketed in Tawau, while many basic household necessities are supplied from Malaysia, creating a mutually connected and complementary economic relationship (Salim et al., 2020). Economic activities, seafood exchange, labor mobility, and cross-border kinship networks have also shaped the social identity of Sebatik communities. Many fishing households maintain family relationships and economic activities on both sides of the border, making national boundaries less significant in their everyday lives. Therefore, separating analysis based solely on administrative boundaries would create a scientific reduction of the complex reality of transnational livelihoods.

This integrative approach also contains important public policy implications. It enriches understanding of coastal waste governance while expanding theoretical perspectives on coastal community empowerment in Southeast Asian maritime border regions. Differences in waste management systems and coastal resource governance between Indonesia and Malaysia provide opportunities for cross-border policy learning, where strengths, weaknesses, and best practices from each governance system can be identified to formulate more effective environmental governance strategies. In this context, this research does not aim to compare policy effectiveness between countries, but rather to identify collaborative governance opportunities within the framework of Transboundary Environmental Governance (Shan et al., 2026), which emphasizes coordination, participation, and sustainability across jurisdictions.

Research Procedure

The research was conducted in a staged manner through a series of interrelated activities, as follows:

1. *Preparatory Phase*

The study began with the identification of problems faced by traditional fishing households in Sebatik Island, Nunukan Regency (Indonesia) and Tawau (Malaysia). The initial stage involved field observations and the establishment of discussion forums and knowledge exchange with researchers from both countries, Indonesia and Malaysia, in order to obtain a comprehensive academic perspective on socio-economic dynamics and environmental policy in the border region. The main focus was directed toward socio-economic conditions, levels of dependency on marine resources, and household waste management practices as well as fish catch waste handling practices that remain sub-optimally managed.

At this stage, a literature review was also conducted to strengthen the conceptual and methodological framework of the study. The literature was obtained from national and international peer-reviewed journals, local government policy reports, village planning documents (RPJMDes), as well as official statistical data from Statistics Indonesia (BPS) and the Sabah Fisheries Department. This stage served as the foundation for problem formulation, research direction, and the preparation of valid research instruments that are contextually appropriate for field conditions.

2. *Respondent Selection*

Respondent selection in this study combined purposive sampling and random sampling techniques to obtain representative and reliable data. Purposive sampling was employed to determine relevant criteria, namely traditional fishers directly engaged in fishing activities and residing in coastal areas in both Indonesia (Nunukan Regency) and Malaysia (Tawau District). Subsequently, random sampling was applied within this eligible population to ensure that each individual had an equal probability of being selected as a respondent.

The selection criteria were based on respondents' relevance and direct involvement in maritime activities and coastal waste management practices, enabling the study to capture an accurate representation of socio-economic conditions and coastal community perceptions of marine environmental issues.

In total, the study involved 159 respondents, consisting of 122 fishers from Tawau (Malaysia) and 37 fishers from Nunukan (Indonesia). This distribution was determined by considering the proportion of active fisher populations in each area and the accessibility of field locations. In addition, fishers who were actively at sea or had landed at fishing ports during the survey were also included to ensure that the collected data reflected real field conditions.

3. Data Collection

Data collection was conducted through four main stages:

a) Socio-Economic Profile Survey of Fishing Households

This survey aimed to map the socio-economic conditions of fishing households, their level of dependency on marine resources, and existing waste management practices. Data were collected using structured questionnaires, in-depth interviews, and focus group discussions (FGDs).

b) Needs Assessment on Coastal Waste Management

The researcher identified community perceptions, needs, and problems related to waste management. The data were analyzed using a combination of qualitative (thematic analysis) and quantitative (descriptive statistics) approaches to develop a contextual understanding of community-specific needs.

c) Knowledge Transfer / Initial Socialization

This stage involved disseminating concepts of coastal waste management, introducing waste-to-value transformation through circular economy-based innovation, and enhancing participants' awareness and motivation. The purpose of this stage was to prepare participants as change agents and knowledge multipliers who could disseminate innovative practices to the wider community. This activity remained preliminary in nature and did not include full-scale implementation, serving instead as a foundation for subsequent participatory interventions.

d) Participatory Observation and Implementation Readiness Assessment

Following the socialization phase, participatory observation was conducted to assess the readiness of community groups to implement community-based waste management practices. The findings were used as a basis for designing further participatory and context-specific interventions.

4. Data Processing and Analysis

The collected data were analyzed using both qualitative and quantitative approaches. Qualitative data obtained from in-depth interviews and FGDs were first coded and then analyzed using thematic analysis to identify patterns, key issues, community needs, and potential stakeholder collaboration. This approach allowed the researcher to capture the depth of participants' experiences and perspectives.

Meanwhile, quantitative data obtained through questionnaires were analyzed using descriptive statistical methods. This analysis was used to describe respondents' characteristics, their perceptions of waste management, economic potential, and training needs. The quantitative findings served to strengthen empirical evidence and support the formulation of relevant and context-specific intervention strategies.

5. Program Suitability Assessment

Based on the results of needs analysis, qualitative and quantitative data, as well as participant feedback, the research team conducted an assessment of the suitability of the planned intervention program. This step was essential to ensure that the intervention design was truly aligned with the conditions, challenges, and potentials of fishing households in Sebatik Island.

This stage focused on formulating a framework relevant to community conditions, needs, and capacities, which subsequently served as a foundation for the implementation phase. The development of the empowerment model began with an in-depth analysis of socio-economic survey data, interviews, and FGDs, enabling a comprehensive understanding of fisher household profiles, existing waste management practices, available local resources, as well as potential constraints and challenges.

From this analysis, the team formulated core intervention objectives emphasizing: (1) strengthening the social and economic capacity of fishing communities; (2) enhancing awareness and practices of community-based waste management; and (3) preparing communities as local change agents capable of fostering innovation rooted in local knowledge and experience. The resulting needs-based mapping was then used to design a participatory, context-sensitive, and sustainable empowerment model. This model was intended to serve as a reference for future implementation of coastal community empowerment programs, ensuring that interventions are both structured and participatory while remaining responsive to real community needs.

Validity and Reliability

To ensure data validity and reliability, the study adopted the following strategies: Source Triangulation: According to (Tashakkori & Teddlie, 2021) data source triangulation involves comparing findings from interviews, questionnaires, and field observations. This process enhances data consistency and strengthens its credibility. Member Checking: As a measure to ensure data validity, interview findings were returned to selected respondents to confirm that the researcher's interpretations aligned with their perspectives and experiences. (Takona, 2024) emphasize that member checking is a key strategy for enhancing the credibility of qualitative research.

RESULTS AND FINDINGS

Socio-Economic Profile of Traditional Fishing Households in the Indonesia–Malaysia Border Region

The socio-economic conditions of coastal communities in Sebatik Island reflect the unique characteristics of a border region situated between two countries, Indonesia and Malaysia. Although the island is administratively divided, its communities are strongly interconnected in terms of shared history, kinship ties, and economic relations. The primary livelihood on both sides of the border is dominated by traditional capture fisheries, which are highly dependent on marine conditions and seasonal variability. In this context, traditional fishing households constitute the most vulnerable social group to economic fluctuations, ecological changes, and border governance policies.

Based on the survey findings, the majority of respondents, namely 94 individuals (59.1%), identified themselves as active fishers without alternative occupations. Meanwhile, 65 respondents (40.9%) reported having secondary occupations outside the fisheries sector. Among these secondary livelihoods, the largest proportion consists of casual laborers in palm oil mills (13.8%). Other secondary occupations include seaweed cultivation (6.3%), agricultural labor (6.9%), boat guiding services (7.5%), and small-scale entrepreneurial activities such as homestays (1.3%) and smallholder oil palm plantations (1.9%). Less frequently reported occupations include well construction, small-scale retail of basic goods, betel nut trading, carpentry, and boat operation services.

Although a considerable proportion of respondents engage in secondary occupations, these alternative livelihoods are predominantly subsistence-based and remain economically unproductive. Consequently, non-fisheries activities contribute only marginally to household income diversification. Furthermore, the absence of active cooperatives and limited access to stable microcredit facilities further constrains the economic capacity of households. As a result, many respondents reported relying on informal lenders or local intermediaries (tauke) to meet household financial needs.

The majority of respondents (53.5%) attained only primary education, while 33.3% completed secondary education (junior and senior high school). A small proportion, namely 6.9%, attained STPM/diploma-level education, while 6.3% had no formal education at all. Within the framework of empowerment theory (Yu & Hou, 2026) education functions as a critical capability factor determining individuals' access to economic opportunities and participation in development processes. Low educational attainment limits the adaptive capacity of Sebatik fishers in adopting technological innovations in fisheries and digitalization of fish marketing systems. Consequently, their skill development remains limited, reinforcing a dependency culture on highly volatile traditional fisheries.

Regarding asset ownership and occupational tools, 86 respondents (54.1%) reported using boats in their daily fishing activities, indicating a high dependency on marine transportation. Meanwhile, 73 respondents (45.9%) did not use boats due to limited access or engagement in non-fishing occupations.

In terms of ownership, the majority (93 respondents or 58.5%) owned their own boats, while a small proportion (2.5%) used rented or bank-financed boats, and another 2.5% shared boats within fishing groups. This pattern indicates a mixture of individual and collective ownership structures, reflecting dependence on key productive assets.

Fishers in the study area generally operate from 04:00 a.m. to 12:00 p.m. (Zainal et al., 2023; Sumarni & Syarif, 2021), depending on seasonal and weather conditions. Their income is unstable and relatively low. Field data show that the majority of respondents located in the Malaysian side of Sebatik, namely 114 individuals (71.7%), earn between RM1,500 and RM2,500 per month, equivalent to approximately IDR 5,100,000–8,500,000 (exchange rate: 1 RM = IDR 3,400). With the Malaysian minimum wage in 2025 set at RM1,700 per month (Ministry of Human Resources Malaysia, 2025), these fishers are generally above the minimum wage threshold; however, their income remains modest and only marginally sufficient to cover daily household expenditures, particularly fuel costs, food, and children's education.

Meanwhile, among the 159 respondents, 23 individuals (14.47%) located on the Indonesian side of Sebatik reported incomes between IDR 1,600,000 and IDR 2,000,000, while 14 individuals (8.81%) earned between IDR 3,000,000 and IDR 5,000,000. When compared to the 2025 Nunukan Regency Minimum Wage (UMK) of IDR 3,479,000 (North Kalimantan Manpower Office, 2025), more than 60% of Indonesian-side fishers earn approximately 42–55% below the minimum wage threshold. This indicates that the majority of fishing households live below the minimum welfare standard and face difficulties in meeting basic needs such as nutrition, education, and healthcare.

Although nominal incomes of fishers on the Malaysian side appear higher than those on the Indonesian side, this disparity is largely influenced by exchange rate differences and variations in cost of living. When assessed in terms of real purchasing power and overall welfare, both groups demonstrate a similarly high level of livelihood vulnerability. Fishers in both border regions face comparable pressures, including dependence on seasonal catches, fluctuating fish prices, limited access to capital, and underdeveloped economic infrastructure.

In addition, limited access to formal financial institutions and social protection schemes further exacerbates their economic vulnerability. Most fishers lack savings or insurance coverage, meaning that adverse weather conditions or damaged fishing equipment immediately result in income loss without any financial safety net. Moreover, relatively large household sizes constitute another key determinant of welfare. Survey results indicate that households with six members (28.3%) and four members (22.6%) are the most common, while smaller households with 1–3 members account for only 6.3–7.5%.

From the perspective of household economy theory (Cheng et al., 2025) larger household size increases the dependency ratio, defined as the proportion of dependents relative to income-earning members. This condition exacerbates economic vulnerability, as most fishing households rely on a single primary income source from the household head engaged in traditional fishing activities. Within the framework of livelihood vulnerability theory (Pinuji & de Vries, 2026), Sebatik fishing communities experience a form

of double vulnerability: exposure to economic shocks due to income instability and exposure to ecological shocks resulting from declining fish stocks and marine pollution.

In conclusion, income disparities and low purchasing power among fishing households on both sides of the border indicate weak household economic capacity. Income levels below regional minimum wage thresholds demonstrate that these communities fall into the category of vulnerable poor, requiring policy interventions focused on local economic empowerment and livelihood diversification beyond the fisheries sector.

Perceptions of Fishing Households on Waste Management in Sebatik Island

Waste management in Sebatik Island is characterized by complex challenges involving social, economic, and infrastructural dimensions. The composition of waste generation on the island is dominated by plastic waste, particularly used bottles, which account for 52.38% of the total waste generated (Fig. 2). Local communities demonstrate adaptive and creative practices by reusing discarded plastic bottles as tools in seaweed cultivation activities. However, it is important to note that without adequate environmental education, these plastic bottles may degrade over time into microplastics, thereby contributing to marine pollution. The majority of waste generation originates from daily household consumption and cross-border trade activities.

Source: Author, 2024

The challenges of waste management in Sebatik Island are further exacerbated by infrastructural limitations, including the insufficient number of waste collection vehicles, inadequate disposal facilities, and low operational capacity. These constraints have resulted in suboptimal waste management effectiveness. Community perception data support this condition. Only approximately 33.5% of respondents reported having adequate knowledge and skills in coastal waste management. Respondents also indicated that no systematic governmental assistance or knowledge transfer initiatives have been provided regarding waste management practices. On the other hand, more than 75% of respondents expressed their readiness to participate in training programs, support waste management initiatives, and engage in the transformation of waste into innovative products. This finding indicates a clear gap between community motivation and existing institutional support mechanisms.

In terms of participation, respondents demonstrated awareness of the importance of coastal waste management. The majority of respondents (80.5%) considered coastal waste management to be highly important (Table 1). This indicates that most respondents recognize waste management as a crucial factor for environmental sustainability as well as their socio-economic well-being. However, only around 18.5% of respondents reported having seen innovative products derived from coastal waste in their surroundings, indicating the limited implementation of circular economy practices at the local level.

Table 1
Importance of Coastal Waste Management

Category	Frequency	Percent	Valid Percent	Cumulative Percent
Important	128	80.5%	80.5%	80.5%
Neutral	30	18.9%	18.9%	99.4%
Not Important	1	0.6%	0.6%	100.0%
Total	159	100%	100%	

Source: Processed by the researcher, 2023

From the community perception perspective, waste management performance in Sebatik Island is considered suboptimal, as the local government, particularly the Fisheries and Marine Affairs Office, has not yet implemented adequate empowerment programs or waste management training initiatives, despite relatively high levels of community readiness and willingness to participate.

Several factors contribute to the weak performance of waste management in Sebatik Island, including: (1) limited infrastructure; (2) suboptimal transport operations; (3) low revenue from waste service fees requiring operational subsidies; (4) insufficient operational funding; (5) weak government support for community-based waste management training; and (6) inadequate enforcement of regulations related to coastal waste violations.

To address these challenges, the government should not only expand waste service coverage and increase personnel and fleet capacity, but also strengthen the dissemination of information and training programs on value-added, innovation-based waste management. The majority of traditional fishers in Sebatik reported their willingness to participate in waste management training programs.

Existing regulations on waste management in Sebatik Island are relatively comprehensive, including Law No. 18/2008 on Waste Management, Presidential Regulation No. 97/2017 (National Policy and Strategy on Waste Management), and Regional Regulation No. 4/2019 on Waste Management. In addition, the establishment of the Waste Management Technical Implementation Unit (UPT) under Regent Regulation No. 33/2017 outlines the definitions, duties, principles, and functions of relevant agencies.

Furthermore, the government is encouraged to develop cross-border cooperation with Malaysia to address coastal waste issues more effectively at the transboundary level. Without adequate management, coastal areas in both border regions risk progressive environmental degradation over time, not only in the study site but also in other coastal regions across Indonesia (Wynne et al., 2018a).

DISCUSSION

The socio-economic profile documented in this study clearly positions fishing households in Sebatik within a structurally vulnerable livelihood system, confirming and extending findings from comparable

coastal contexts in the Global South. The dominance of dependence on the primary sector, with 59.1% of respondents reporting no alternative employment, reflects patterns identified by (Zwier, 2025), who argue that reliance on a single resource-based livelihood sector constitutes a critical dimension of fisheries vulnerability, intensifying sensitivity to both ecological and economic shocks. In Southeast Asia, coastal communities are highly dependent on marine resources and therefore particularly vulnerable to marine debris, while community-based initiatives have been shown to provide significant mitigation benefits (Soe et al., 2026).

The community's dependence on the primary sector means that natural resources are their sole means of meeting their basic needs. This indicates that the community follows a traditional way of life, is underdeveloped, and is not yet capable of socio-economic development. As the population grows, needs naturally increase, leading to greater extraction of resources and, consequently, the threat of overexploitation. If there is no change in the economic structure within the next one to two decades, there is a risk of ecological disaster in the marine environment. Conversely, should environmental degradation occur—particularly affecting the marine environment and its biodiversity the community will face socio-economic vulnerability and may even risk losing their livelihoods.

The low level of formal education, more than 53% of respondents having only completed primary schooling, is consistent with empirical literature linking educational deficits to reduced adaptive capacity among small-scale fishing communities (Diedrich et al., 2026; Galveia & Macusi, 2026). A low level of education makes it difficult for fishermen to develop themselves. This situation is one of the factors hindering socio-economic development initiatives in their communities. Fishermen's knowledge is limited, making it difficult to achieve community-based economic diversification. To achieve this, government policy intervention is required, along with intensive and sustained support. The role of stakeholders is essential.

In force field analysis framework, this structural configuration translates directly into a dominant set of restraining forces: limited technical competence, high household dependency ratios, constrained access to formal credit, and income levels ranging 42–55% below the regional minimum wage on the Indonesian side (Ahmed et al., 2026). Poverty amongst fishermen is not merely due to low incomes, but also to limited assets, access to capital and technology, as well as weak institutions and markets. These variables do not operate in isolation but interact systemically, producing what is described as a condition of double vulnerability, whereby coastal households are simultaneously exposed to economic and ecological shocks with limited capacity to cope (Ma & Liu, 2026).

The decline in environmental quality in coastal areas and marine ecosystems is caused not only by the exploitation of marine resources, but also by waste. This study identified two gaps: one within the community and the other within the government sector. A key theoretical finding of this study is the pronounced mismatch between high levels of awareness and limited implementation of waste management practices a dissonance that lies at the heart of participatory governance theory and its critiques. This awareness practice gap has been consistently documented in coastal waste

management research. Studies in Philippine coastal communities show that socio-demographic factors, including education level, household size, and income, are significant predictors of waste management behavior, regardless of awareness levels (Pagaduan et al., 2025). The governance gap in Sebatik is thus not primarily legislative, but rather institutional and capacity-related, which has critical implications for policy design. Participatory governance theory consistently demonstrates that top-down interventions without genuine community agency tend to produce instrumental compliance rather than the normative internalization required for sustained behavioral change (Abdolhosseinzadeh et al., 2026; Cuartielles-Diaz et al., 2026). Sustainable environmental governance, collective action and environmental stewardship are required. Environmental governance takes the form of regulations, actively involved stakeholders with clearly defined roles, monitoring and evaluation, and feedback, followed by improvements.

Similarly, higher levels of engagement in environmental education and waste management programs are associated with greater adoption of sustainable practices, indicating that awareness alone does not lead to behavioral change without structured participatory frameworks. In line with institutional analysis of common-pool resources, awareness is a necessary but insufficient condition for behavioral transformation; what converts latent motivation into collective action is the presence of enabling institutional arrangements, clear rules, access to resources, and accountability mechanisms (Li et al., 2026). (Kotter, 2012) eight-step change model further reinforces this interpretation, suggesting that the gap between perceived urgency and actual behavioral transformation reflects an incomplete change process, particularly where coalition-building and capacity development have not been operationalized.

The institutional dimension of the governance deficit revealed in this study highlights a systemic failure that appears endemic in coastal governance systems in developing archipelagic states. Despite relatively comprehensive regulatory frameworks, from Law No. 18/2008 to Regional Regulation No. 4/2019, respondents consistently reported the absence of institutional support in the form of training, technical assistance, or community-based empowerment programs from relevant government agencies. Institutional weaknesses in coastal governance are evident in organisational and managerial shortcomings, leadership deficiencies, limited access to information and resources, low bargaining power, slow innovation and weak partnerships. This finding aligns with argue that coastal waste governance challenges are not primarily driven by a lack of national policy, but rather by the absence of locally embedded implementation mechanisms that connect policy commitments to behavioral change at the community level (Emmenegger, 2026).

Coastal governance requires a shared commitment; whether to preserve, improve environmental quality or enhance conditions, a comprehensive and integrated approach is essential. The roles of multiple stakeholders should be united, combined and harmonised, working in unison to foster innovation in marine ecosystems and ensure litter-free coastal environments. The 'reduce, reuse and recycle' approach is essential. The waste composition data, in which plastic bottles account for 52.38% of total waste, has significant implications for ecological risk assessment and the design of community-based circular economy interventions. Collective initiatives such as waste banks and organic fertiliser

management groups contribute to the circular economy. Communities are taking care of and taking responsibility for the marine ecosystem. This circular economy is essential, given the serious problems associated with plastic waste. The dominance of plastic waste in Sebatik is consistent with Indonesia's position as one of the largest contributors to global marine plastic pollution, while fragmented governance across sectors and spatial scales weakens implementation effectiveness at both national and sub-national levels (Freeman & Hwang, 2026).

Existing community practices that reuse plastic bottles as substrates for seaweed cultivation reflect embedded local ecological knowledge, but simultaneously reveal a critical long-term risk: without educational intervention, informal recycling may accelerate microplastic fragmentation rather than mitigate pollution. The use of plastic as a cultivation medium for seaweed can pose the risk of microplastics adhering to the surface of the seaweed, introducing contaminants, disrupting other micro-organisms, altering the quality of the seaweed yield, and potentially entering the food chain. The photodegradation of submerged plastic materials generates microplastic contamination that threatens the marine food chains on which these communities depend (Paschen et al., 2026; Sarver, 2026). Waste banks and the collection and sorting of plastic bottles for reintroduction into the economic cycle through reuse and recycling are vital. Furthermore, it is important to promote the 'Fishing for Plastic' movement among fishermen as a tangible collective action.

Importantly, this finding also reveals a latent circular economy asset: community familiarity with reuse practices provides a cognitive and behavioral entry point for formalized waste valorization programs. Global experience with circular economy transitions in island ecosystems suggests that successful transformation of waste into resources requires not only technical training but also an enabling culture of reuse supported by institutional infrastructure, market linkages, and financing mechanisms (Meng et al., 2020).

The transboundary dimension of Sebatik's governance challenge represents a structural constraint operating at a higher institutional level than community capacity deficits, yet producing direct ecological impacts at the local level. The shared coastal ecosystem characterized by tidal flows, overlapping fishing zones, and cross-boundary waste accumulation dynamics—cannot be effectively managed through unilateral national or sub-national interventions. This is what is known as the integralistic approach to empowering local communities in remote areas. The government should assist in establishing facilities for recycling waste into paving blocks, furniture and plant pots. This will foster the growth of circular entrepreneurs who can help make remote islands self-sufficient by supplying building materials, thereby contributing to economic diversification.

This aligns with core arguments in transboundary institutional theory, which emphasize that ecosystems extending beyond political boundaries require coordinated institutional responses involving regulatory harmonization, shared monitoring responsibilities, and aligned enforcement capacities (Vaidya, 2026). In the context of Borneo, policy implementation capacity varies significantly across geopolitical units, and transnational coordination must address governance effectiveness, regulatory quality, sovereignty

constraints, and corruption control (Styhre & Brorström, 2026). The ASEAN 2019 Declaration on Marine Plastic Litter Cooperation represents a critical starting point for collective action, although it requires translation into operational policy instruments (Barquet & Coelho, 2026). The Sebatik case contributes empirical evidence demonstrating the direct consequences of institutional coordination failure at the community level: waste generated on one side of a shared coastal system circulates freely across borders, rendering localized interventions inherently suboptimal without bilateral institutional complementarity. There are alternative approaches that can be taken in cross-border governance to address the issues faced on Sebatik Island, namely a cross-border circular economy and joint marine waste management, to tackle these issues.

Overall, the empirical findings and theoretical analysis converge into a unified argument: the persistent failure of coastal waste governance in structurally vulnerable border communities is not attributable to a single factor, such as inadequate infrastructure, weak regulation, or low community awareness, but rather to a systemic misalignment between program design logic and socio-economic realities operating simultaneously across multiple analytical levels. At the micro level, structural vulnerability constrains behavioral change beyond what awareness alone can address; at the meso level, the absence of institutional support leaves a critical governance interface unstructured; and at the macro level, weak bilateral coordination allows waste accumulation across a shared ecosystem that exceeds the capacity of localized solutions. This multi-level diagnosis corresponds closely with (Kotter, 2012) framework, where the change process stalls at early stages, with urgency recognized but coalition-building, capacity investment, and institutional consolidation remaining underdeveloped.

Community empowerment has been shown to significantly enhance the sustainability of waste management initiatives by strengthening local human resources and increasing awareness of waste-related issues (Gunawan et al., 2026). Moreover, global experiences indicate that transforming fishing communities from contributors to marine pollution into stewards of ocean ecosystems requires training in best practices, incentives for environmentally friendly behavior, and the provision of infrastructure to reduce waste. Trained communities engaged in collecting, processing, and converting marine debris into value-added products contribute to zero-waste circular economies while simultaneously generating livelihood opportunities (Carugati et al., 2026).

In order to achieve this empowerment, economic diversification is required in addition to waste management. Economic diversification is essential to provide alternative livelihoods for the community, whilst also preserving the marine ecosystem. Economic value should be enhanced without putting pressure on the sea. Fishermen's incomes should be increased not by increasing catch volumes, but by improving the handling and quality of the catch, thereby ensuring it commands a high economic value. For example, by enhancing fishing skills so that fishermen are able to maintain the cleanliness of their vessels and supporting equipment, protect fish from physical damage, and sort fish according to species and size.

In addition, the government needs to support cold chain facilities, insulated holds, standardised fish ports and safe fish landing systems. Furthermore, to safeguard the marine ecosystem, several policies need to be implemented: a) Regulation of fishing and other marine resources b) Increasing fishermen's participation in the conservation of marine ecosystems through ongoing education c) Restoring key fish habitats through coral reef restoration, mangrove rehabilitation, seagrass bed protection, the control of coastal erosion, and the conservation of estuaries to support the life cycles of marine organisms d) Establishing marine and coastal conservation areas. The Sebatik case thus provides an empirically grounded and theoretically integrated analytical framework that can inform coastal waste governance design not only in the Indonesia–Malaysia border region, but also across structurally analogous coastal border communities throughout Southeast Asia. This study puts forward policy recommendations as set out in Table 2.

Table 2
Policy Recommendations

No	Objective	Problem Based on Analysis	Suggested Policy Alternatives	Policy Strategies
1	Increasing community participation in coastal waste management	Low community participation despite high awareness; limited technical capacity	Conduct regular training and mentoring for fishermen on waste management	- Collaboration between Waste Management UPT and fishing groups - Community-based mentoring programs - Education through schools and community outreach
2	Reducing plastic pollution in coastal and marine areas	Dominance of plastic waste, especially from households and cross-border trade; lack of waste segregation	Implementation of household waste segregation programs and provision of collection facilities	- Installation of segregated waste bins in villages and coastal areas - Placement of waste traps at river mouths - Strengthening regulations prohibiting marine dumping example fishing plastic, waste bank. - Circular entrepreneurship encompasses cross-border circular economies and collaborative management of marine waste through international cooperation. The aim is to promote economic diversification by supporting cold-chain facilities, insulated storage spaces (on-board fish storage), standardised fish ports, and safe fish landing systems.
3	Promoting waste utilization as an economic resource	Waste is not yet perceived as a valuable resource; limited knowledge and skills	Innovative waste management programs based on economic value, such as ecobricks and recycled products	- Training in ecobricks and creative recycling products - Government facilities and incentive support - Promotion of local and cross-border markets
4	Strengthening institutional capacity and government support	Limited waste management infrastructure; weak operational and fiscal support	Improvement of infrastructure and operational capacity for waste management	- Addition of waste transport vehicles and collection bins - Development of waste banks and landfill facilities - Operational subsidies and cross-sector coordination

No	Objective	Problem Based on Analysis	Suggested Policy Alternatives	Policy Strategies
5	Ensuring program sustainability	Waste management programs are sporadic and not sustainable	Integration of waste management programs with fisher poverty alleviation agendas	- Development of community-based management systems - Inclusion of coastal economic diversification programs - Regular monitoring and evaluation for policy adaptation
6	Strengthening transboundary waste management	Waste flow from Malaysia affects Sebatik; differences in policies and capacities between countries	Strengthening Indonesia–Malaysia transboundary cooperation on waste management	- Establishment of border coordination forum for waste management - Harmonization of standards and regulations - Joint coastal and river cleanup programs

Source: Author, 2024

CONCLUSION

This study demonstrates that the failure of coastal waste governance in maritime border regions is the result of a structural misalignment operating simultaneously across three analytical levels. At the micro level, the socio-economic vulnerability of fishing households in Sebatik, characterized by income levels below the regional minimum wage, low educational attainment, and high household dependency ratios, constitutes a dominant set of restraining forces that systematically outweigh existing motivations for behavioral change. At the meso level, the absence of sustained institutional facilitation creates a critical gap between formal regulatory commitments and the community's actual capacity to implement them. At the macro level, the lack of operational bilateral coordination mechanisms between Indonesia and Malaysia renders locally designed interventions inherently suboptimal in addressing a coastal ecosystem that is fundamentally transnational in nature.

One of the key findings of this study is the paradox of the gap between awareness and action, whereby a high level of public awareness regarding waste management does not lead to substantial behavioural change in the absence of institutional infrastructure capable of transforming latent motivation into collective action. This situation reinforces the core assumption of participatory governance theory that awareness is a necessary but insufficient condition for behavioural transformation; what ultimately determines the outcome is the quality of community initiatives and the existence of supportive institutional arrangements. We recommend circular entrepreneurship encompassing cross-border circular economies and collaborative marine litter management through international cooperation. The

aim is to promote economic diversification by supporting cold-chain facilities, insulated storage spaces (on-board fish storage), standardised fish ports, and safe fish landing systems.

The theoretical contribution of this research lies in its integration of Lewin's force field analysis, Kotter's change management model, and participatory governance theory into a multi-level conceptual framework that explains environmental governance dynamics in maritime border regions of developing countries. Practically, the study underscores that effective coastal waste management requires a paradigm shift from output-based approaches toward capacity-based approaches that prioritize community empowerment, strengthening of social capital, and cross-border institutional coordination as primary governance investments. The integration of waste management agendas with fisher household poverty alleviation programs is not merely an incremental recommendation, but a structural prerequisite for sustainable implementation that can be generalized to structurally analogous coastal border communities across Southeast Asia.

Limitations And Future Research Directions

This study has four main limitations, which simultaneously open a coherent agenda for future research. First, the asymmetrical sample distribution between the Indonesian side ($n = 37$) and the Malaysian side ($n = 122$) limits cross-jurisdictional comparability; therefore, bilateral comparative inferences should be interpreted with analytical caution. This limitation highlights the need for proportionally balanced comparative studies across Sebatik's coastal border communities, systematically controlling for population density and geographical accessibility as structural variables.

Second, the cross-sectional design of this study does not capture the temporal dynamics of behavioral change and institutional responses; consequently, the causal claims remain associative and diagnostic in nature. This limitation calls for longitudinal action research with a minimum time horizon of 24–36 months to empirically test the proposed community-based empowerment model, assess the effectiveness of knowledge transfer mechanisms, and validate the conditions necessary for a transition toward a coastal circular economy.

Third, the analysis of transboundary institutional dynamics in this study is primarily inferential rather than based on in-depth interviews with institutional actors. As such, claims regarding transboundary governance failure require further validation through comparative institutional studies that explicitly examine Indonesia–Malaysia coordination mechanisms and benchmark them against other maritime border regions in Southeast Asia, such as Indonesia–Papua New Guinea and Malaysia–Thailand, in order to test the generalizability of the proposed analytical model.

Fourth, as an exploratory mapping study, this research does not include empirical testing of intervention implementation; therefore, the resulting conceptual model remains at the level of theoretical proposition. This limitation opens space for interdisciplinary research on community-based coastal circular economy systems in developing country contexts, integrating public administration, development economics, and social innovation perspectives to produce models that are simultaneously economically viable, socially

equitable, and ecologically sustainable—an agenda relevant not only to Sebatik but also to thousands of island and coastal communities across the Indo-Pacific region.

Declarations

Ethical approval:

This research has been approved by the Universitas Sumatra Utara ethics committee, and all procedures have been carried out in accordance with the guidelines and regulations of Universitas Sumatra Utara. A formal ethical approval document has been issued by Universitas Sumatra Utara and is available upon request.

Clinical trial number

Clinical trial number 004: not applicable.

Consent to participate:

Informed consent was obtained from all participants.

Consent to publish:

Informed consent to publish was obtained from all participants/ individuals involved in the study.

Data availability:

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing Interests: No competing interest

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Authors Contributions

All authors contributed significantly to the development of the manuscript. D.A. was responsible for conceptualization, data collection, and drafting the original manuscript. M.S.S. contributed to the methodology, data analysis, and review and editing of the manuscript. E.J. provided supervision and managed the overall coordination of the project. J.A.B. handled resources, AE carried out an analysis and drafted a revised version of the manuscript and validation processes. ATS carried out an analysis and drafted a revised version of the manuscript and validation processes. M contributed by adding the introduction and literature review. M.D.E.T. carried out formal analysis and visualization to support the

research findings. All authors read and approved the final version of the manuscript prior to submission, ensuring the integrity and quality of the research.

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Figures



Figure 1

Study site locations. (a) Study site on the Indonesian border, located in Nunukan, North Kalimantan, Indonesia; (b) Study site on the Malaysian border, located in Tawau, Sabah, Malaysia.

Source: Author, 2024

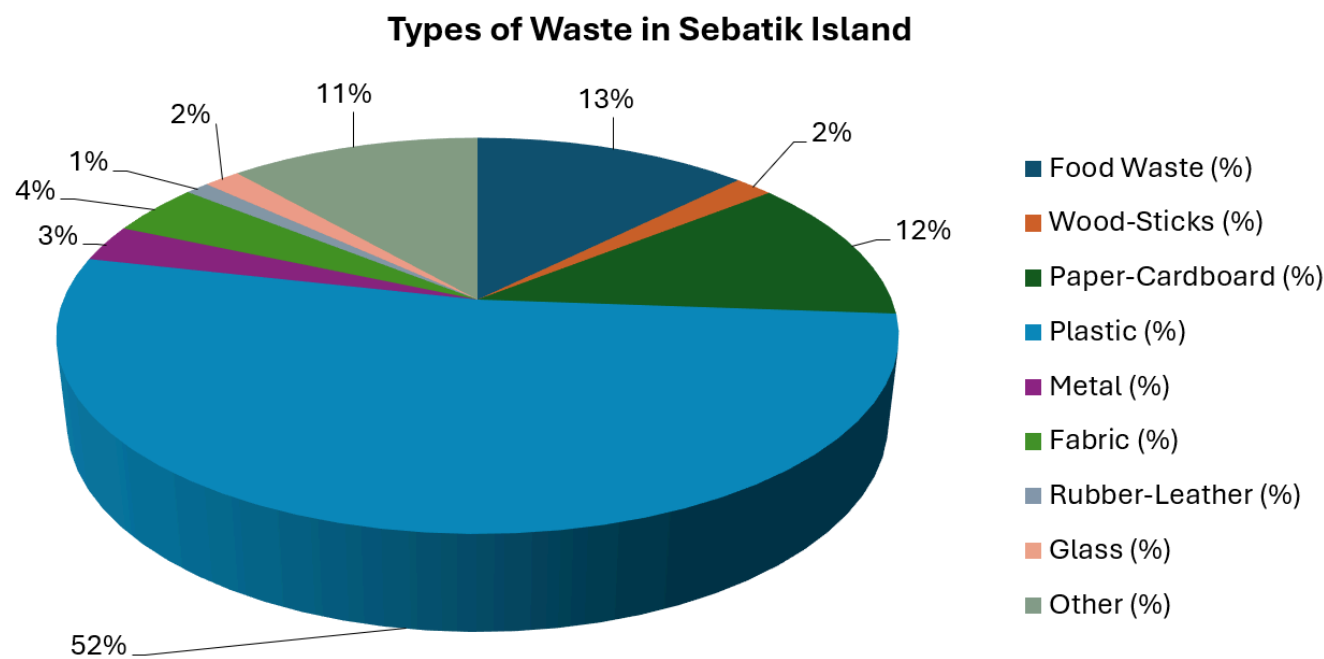


Figure 2

Types of Waste in the Study Area

Source: Author, 2024