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Gorontalo city's strategy as a plastic waste-free coastal city 2030: Qualitative SWOT analysis and blue economy

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ABSTRACT

The phenomenon of the distribution of coastal plastic waste is dynamic—triggered by currents, winds, waves, and extreme events—so static policies fail to maintain the cleanliness of destinations. Gorontalo's main problems include drainage-estuary leaks, cross-OPD data standards that are not yet uniform, and the performance of WWTP that has not included microplastic fractions. This study aims to map the governance SWOT, estimate the economic benefits of the ecosystem for the competitiveness of blue tourism, and analyze economic-environmental vulnerabilities to formulate a roadmap for 2026–2030. Using qualitative research case studies, the data were collected through in-depth interviews, FGDs, destination-estuary observations, and document review (policies, visits, cleaning operations, WWTP). Framework/Thematic analysis is mapped to a SWOT matrix and downgraded to TOWS. Results: identified strengths (OPD–community commitments, basic facilities, GIS capacity), weaknesses (data, transport logistics, microplastics), opportunities (EPR, green procurement, mixed finance), and threats (storms/floods, re-beaching, greenwashing). The finding shows that data standardization, forecast-based rapid capture SOPs, and microplastic testing in WWTP raise hygiene scores, accelerate recovery, and increase length of stay. Discussion: findings confirm the linkage between water quality–logistics operations–destination reputation. GIS integration, performance-based service contracts, and "blue destination" labels lock in market compliance. This study is important because it integrates coastal science, water governance, and destination economics into an executable policy framework. Implication of the study to use measurable roadmap (indicators, targets, person in charge, public audit). Further studies are suggested on policy trials and strengthening of cross-season sensor datasets.

1. Introduction

The distribution of plastic waste in coastal areas does not follow a simple upstream-downstream current, but is influenced by the interaction of currents, winds, waves, and shoreline dynamics that make it temporarily "anchor" and then re-beaching. Recent modelling and observational evidence in the Balearic archipelago suggests that local currents drive redistribution between coastal zones and the export of materials out of the region; The incorporation of coastal cleanup data with high-resolution current simulations helps trace the origins of waste and intercoastal connectivity to optimize cleanup scheduling as well as the placement of trash capture infrastructure (Ramos-Alcántara et al., 2025). For the bay and tourist beaches in Gorontalo, understanding the pattern of transport–plastic re-landing needs to be tied to the design of barriers, garbage traps, and transport routes and frequencies that are adaptive to the wave/wind season. On the monitoring side, floating/shallowly submerged waste is often difficult to detect visually; sonar-based acoustic monitoring offers opportunities, but the extraction accuracy of small-sized, low-acoustic contrast plastic objects is still an obstacle, especially when deep learning models are tested on real-world conditions different from the trained data (Zhou & Mizuno, 2026). This physical-technical complexity confirms that the "Coastal Cities Free of Plastic Waste 2030" policy must be supported by an adaptive data and monitoring architecture, not just a seasonal static cleanup program (Ramos-Alcántara et al., 2025; Zhou & Mizuno, 2026).

Extreme weather phenomena accelerate the redistribution of plastic waste from land to sea and between coastal segments. Simulations of tropical cyclones show a significant acceleration of transport compared to calm conditions, as well as an increase in the chance of landing (beaching) due to land-based winds and storm surges; a fairly predictable accumulation pattern opens up space for the establishment of "target zones" for rapid post-event cleanup (Roome et al., 2026). Consequently, for Gorontalo, a post-disaster protocol is needed that includes "rapid capture" operations in bays, estuaries, and tourist pockets before plastic fragments into microplastics that are more difficult to recover. The integration of marine weather forecasts, tides, and access/logistics maps in extreme post-event hygiene SOPs can reduce cleanup costs, cut destination recovery times, and maintain the reputation of "blue tourism" (Ramos-Alcántara et al., 2025; Roome et al., 2026).

On the other hand, "invisible leakage" through wastewater networks makes microplastics a delicate process problem, especially when wastewater is enriched with anionic/cationic surfactants from household/industrial detergents. Recent experimental evidence shows that the performance of foam flotation—one of the technologies being looked at for microplastic recovery—drops sharply when the surface of the aging microplastics (photo-aged) is coated with surfactants; bubble–particle bonds weaken so that recovery efficiency decreases (Amani & Firouzi, 2026). This means that improving the performance of urban WWTP in cities/tourist destinations needs to include microplastic-surfactant specific process tests and upstream interventions through education on environmentally friendly detergents. In terms of policy, WWTP performance standards need to explicitly include microplastic fractions in addition to classical indicators (BOD/COD). This approach complements the oceanographic lens so that plastic-free targets are not canceled out by the "underground current" of waste (Amani & Firouzi, 2026; Ionescu et al., 2024).

The first problem is the limited detection and quantization of floating/floating debris in low visibility conditions and complex acoustic backgrounds. Cross-model evaluation shows that even advanced segmentation architectures struggle to surpass the medium detection quality of sonar imagery due to low acoustic contrast and target ambiguity, especially when the test domain is different from the trained domain (Zhou & Mizuno, 2026). Therefore, the monitoring architecture in Gorontalo should be hybrid: combining field observation (beach cleanup), acoustic sensors, imagery, and community participatory intelligence; Everything needs to be covered by data governance (standards, interoperability, protocols) so that the evidence flowing to policymakers can be reliable and audited. In line with that, the policy synthesis shows that the blue economy demands the integration of ecological–economic–social dimensions in a single framework, so environmental data must be able to "speak" to the destination economic indicators (Ionescu et al., 2024; Zhou & Mizuno, 2026).

The second issue is the alignment of coastal destination infrastructure and spatial planning with the needs of "plastic-free" and local economic growth. GIS mapping of Gorontalo tourist facilities shows that most of the locations have been "good" in terms of basic infrastructure, but inequality between locations remains, requiring spatial data-based development priorities including synchronization of drop points/TPS-3R, transport routes, and road networks (Airawati et al., 2023). The experience of planning waste treatment facilities in other coastal areas shows how narrow the area is that it meets all technical, environmental and social criteria; The GIS-MCDA approach plus stakeholder participation is key (Adu et al., 2025). At the policy level, the study of the needs/challenges of the blue economy sector emphasizes the importance of aligning national-regional strategies with stakeholder perceptions so that implementation is not stalled and truly favors local actors (Adu et al., 2025; Airawati et al., 2023; Almeida et al., 2025).

The third problem is the risk of trade-offs and co-optation of "blue" narratives by less ecological interests. Macro-regional models show that the success of the green/blue transition relies heavily on inter-regional policy coordination, funding, and monitorable cross-sectoral indicators; the quality of the aquatic environment is the foundation of long-term productivity and growth (Ionescu et al., 2024).

At the destination scale, the blue economy will only sustain "blue tourism" when pollution control – including plastics – is linked to improving the well-being of coastal communities through strong local institutions (Airawati et al., 2023; Tambunan et al., 2025). Without strong accountability and participation mechanisms, plastic-free targets risk stopping at rhetoric (Airawati et al., 2023; Ionescu et al., 2024; Tambunan et al., 2025).

Ecologically, plastics/microplastics disrupt biodiversity and ecosystem function, including through eating/ingesting interactions, entanglement, as well as potential transfer to body tissues and trophic rise. In extreme events, the acceleration of transport and landing opportunities adds pressure to sensitive bays/estuaries, expanding the exposure area; without rapid post-storm intervention, stranded plastics tend to fragment into microplastics that are increasingly difficult to recover (Roome et al., 2026). In the medium term, the uncertainty of ecosystem service stocks (aesthetics, nursery habitats) reduces the quality of destination attractiveness and prolongs the ecological "window of disturbance" (Amani & Firouzi, 2026; Ramos-Alcántara et al., 2025; Roome et al., 2026).

Economically, destinations, beach cleanliness and visual quality influence the length of stay and spending of tourists—two important drivers of local multipliers. Evidence of coastal destinations in Indonesia shows a large tourism contribution, but is plagued by abrasion and waste; without an adaptive hygiene system and effective waste handling logistics, the competitive value of destinations is eroded (Airawati et al., 2023). Planning of coastal contextual waste treatment facilities (based on GIS-MCDA) can reduce logistics costs and emissions, while improving the reliability of sanitation services; on the upstream side, good water management correlates with the achievement of climate targets and environmental quality, which in turn underpins the "blue" destination brand (Adu et al., 2025; Airawati et al., 2023; Ionescu et al., 2024). Methodologically, a combination of beach cleanup, Lagrangian particle tracking, and wave-based modeling resulted in a more realistic understanding of the chances of landing and releasing plastic from the beach (Ramos-Alcántara et al., 2025). In the extreme weather domain, cross-cyclone simulations confirm the acceleration of transport and increased beaching opportunities which can be translated into directed rapid response SOPs to the accumulation "target zone" (Roome et al., 2026). On the monitoring side, benchmarks show the need for more representative data curation to improve the generalization of deep learning models on sonar imagery, especially on small/low-contrast targets (Zhou & Mizuno, 2026). Meanwhile, at the Indonesian destination level, blue economy indicators and SWOT analysis have been used to formulate sustainable tourism strategies in coastal areas; recommendations emphasize waste control, abrasion mitigation, and community capacity strengthening (Airawati et al., 2023).

A policy design perspective, the experience of locating residual facilities in coastal cities confirms the importance of GIS-MCDA that combines technical, environmental, and social criteria; only a small percentage of areas actually meet all criteria, so decisions need to be data-based and participatory (Adu et al., 2025). Macro perspective, economic-environmental modeling places water governance as a strategic instrument to achieve climate goals while maintaining economic productivity; this is in line with the principles of the blue economy at the city level (Ionescu et al., 2024). The integration of the common thread of methodology-monitoring-policy is capital to design a more robust 2026–2030 roadmap in Gorontalo (Adu et al., 2025; Ionescu et al., 2024; Ramos-Alcántara et al., 2025). There is no comprehensive framework for Gorontalo City that simultaneously: a). maps the SWOT of plastic waste management; b). integrates physical evidence on transport-re-landing and extreme weather impacts; c). incorporates the chemical/process dimensions of microplastics in the wastewater network; and d). translates it into an operational blue economy roadmap for "blue tourism". The literature provides a slice of solutions and resuspension models, cyclone dispersal simulations, acoustic AI benchmarks, and blue economy indicators but has not been stitched together into urban policy designs that are weather-adaptive, multi-source data-driven, and aligned with destination priorities and local institutional capacity (Ionescu et al., 2024; Roome et al., 2026; Zhou & Mizuno, 2026). At the destination level, GIS practices in Gorontalo are already available for tourist facilities, but they have not been closely linked to the source-waste absorption map and adaptive hygiene SOPs (Airawati et al., 2023). Closing this gap will reduce policy uncertainty and accelerate the economic benefits of destinations (Adu et al., 2025).

This study focuses on three problem formulations: a). What is the SWOT profile of plastic waste management in Gorontalo City and what are its implications for local economic growth based on the blue economy until 2030? b). How much benefit ecosystem economics—coastal ecotourism, fisheries, and ecosystem services—from reducing plastic leakage into the ocean for the competitiveness of "blue tourism"? c). To what extent does economic–environmental vulnerability to extreme events (storms/cyclones, coastal floods) accelerate the spread of plastic waste, and what post-disaster mitigation/logistics packages are most effective to minimize economic losses? The objectives of the study: a). identify SWOT and its economic implications; b). estimating the economic benefits of the ecosystem for reducing plastic leakage; and c). analyze economic-environmental vulnerabilities and design post-disaster mitigation/logistics measures with minimal losses. Expected implications include: evidence-based 2026–2030 roadmap, data-sensor requirements specification and standardization of monitoring protocols, post-disaster rapid capture SOPs, and pentahelix collaborative financing schemes for upstream–downstream infrastructure and interventions. At the technical level, GIS-based access facilities maps are combined with source-waste absorption maps and transport routes; At the institutional level, the results of the study prepared a cross-OPD policy matrix (DLH, Tourism Office, Bappeda, PDAM/WWTP) with performance indicators that can be audited by the public (Adu et al., 2025; Airawati et al., 2023; Ionescu et al., 2024).

2. Method

This research uses a qualitative approach with a case study design in Gorontalo City to deeply understand the process, meaning, and relationships between actors in plastic waste management, as well as to develop a policy roadmap that is in line with the principles of the blue economy. The research paradigm is constructivist-interpretive, placing reality as the result of social construction captured through the narratives of stakeholders and triangulated between sources. The main analysis framework is Framework/Thematic Analysis with a SWOT matrix as *an a-priori* framework that is inducively enriched from field data, so that the final result not only maps strengths–weaknesses–opportunities–threats, but also reduces them into operational strategy packages for 2026–2030. To maintain rigor, reporting follows SRQR/COREQ standards and trustworthiness criteria (credibility, transferability, dependability, confirmability). This approach was chosen because it is appropriate to respond to the need for the integration of environmental–economic–social dimensions in blue economy policies at the urban level (Braun & Clarke, 2006; Lincoln & Guba, 1985; O'Brien, 2014).

2.1. Setting, Analysis Units, and Participants

The research setting includes: tourist coastlines, bays/estuaries as leakage hotspots, management facilities (TPS 3R/TPST/MRF), drainage networks to estuaries, and wastewater treatment plants (WWTP) related to destinations. The analysis unit includes (i) policies & institutions (Perda/Perwali, SOPs, performance plans), (ii) actors/actors (OPDs, tourism business actors, coastal communities/waste banks, WWTP/fleet operators, academics/NGOs), and (iii) physical space (destinations & waste logistics routes). Participants were selected using purposive sampling based on key roles and then expanded with snowballs. The target is 25-35 informants to saturation to reach a variety of perspectives: OPD 6–8 people, business actors 6–8 people, community 6–8 people, operators 4–6 people, academics/NGOs 3–5 people. Location and actor determination consider the need for water-waste–tourism policy integration within a blue economy framework that demands cross-sectoral indicators (Airawati et al., 2023; Ionescu et al., 2024; Tambunan et al., 2025).

2.2. Data Collection Strategy

2.2.1. Data for Problem Formulation 1 (SWOT Profile & Blue Economy Implications)

To map the SWOT profile of plastic waste governance and its implications on local economic growth based on the blue economy until 2030, this study collected data through three complementary flows: first, semi-structured in-depth interviews with relevant OPDs (DLH, Bappeda, Tourism), tourism business actors, coastal communities/waste banks, WWTP/TPS 3R/TPST operators, and academics/NGOs to explore policy flows, financing, infrastructure, plastic consumption behavior, and transport logistics as well as their relation to tourism indicators such as visits, length of stay, and shopping; second, review documents (Perda/SOP, program plans, visit data, cleanliness reports, WWTP performance, partnership MoU, and GIS maps of destinations/hotspots) to check policy consistency, implementation gaps, and blue economy indicators; third, contextual observations at destinations, estuaries, TPS 3R/TPST, transportation routes, and WWTP facilities to assess visual cleanliness, evidence of leakage, availability of sorting facilities, fleet accessibility, and signs/education. All findings were then analyzed with an inductively-enriched SWOT matrix from the field themes, and then linked to the destination's blue economic indicators (green jobs, circular added value, water quality, visits, length of stay, and spending) to identify the economic implications of each S–W–O–T factor. productivity and achievement of climate targets, as well as the practice of

Indonesia's coastal destinations that combine SWOT analysis with sustainable tourism indicators (Adu et al., 2025; Airawati et al., 2023; Ionescu et al., 2024).

2.2.2. Data for Problem Formulation 2 (Economic Benefits of Ecosystems & Competitiveness of Blue Tourism)

To assess the ecosystem economic benefits of reducing plastic leakage into the ocean and its impact on the competitiveness of *blue tourism*, this study combines three sources of corroborating evidence. First step, interviews with tourism business actors and coastal communities explored changes in visits, perceptions of cleanliness, destination ratings, and local business opportunities as beach cleanliness improves. Second step, the FGD was directed to be carried out in two clusters, FGD-1 (business actors) to confirm the transmission of benefits to destination metrics, and FGD-2 (community) to map the growth of circular economy opportunities and social co-benefits. Third step, documentation of visit/length of stay data, cleanliness complaints, and blue destination branding programs were used to triangulate narratives and reduce perception bias. All findings were analyzed with a Framework/Thematic that linked the theme of coastal environmental quality to destination competitiveness indicators, while GIS was used to map priority locations for interventions that have the most impact on tourism experiences and monetization of blue economy values. This design refers to coastal destination planning practices that emphasize waste control and institutional strengthening, while aligning strategies with stakeholder perceptions to maximize the economic benefits of thermonetization (Adu et al., 2025; Airawati et al., 2023; Almeida et al., 2025).

2.2.3. Data for Problem Formulation 3 (Economic–Environmental Vulnerability & Post-Disaster Mitigation/Logistics Packages)

To uncover the economic-environmental vulnerability to extreme events that accelerate the spread of plastic waste and formulate effective post-disaster mitigation/logistics packages, this study collected evidence through three integrated pathways. First, interviews were conducted with OPDs, fleet operators, and communities to record operational experiences during storms/cyclones and coastal floods, response travel times, access barriers, and priority determination of fast-catch areas. Second, post-incident observation (if it occurred within the study period) or reconstructive tracing based on disaster documents and hygiene records was carried out to map the "target zone" of rapid capture in bays, estuaries, and tourist pockets. Third, the study of marine weather forecast documents, tides, access/logistics maps, quick response SOPs, and proof of response performance was used to compile a realistic operation map. The analysis then integrates the field findings with scientific evidence that storms/cyclones accelerate transport and increase the chances of plastic beaching, so that a forecast-based rapid capture SOP and a clear logistics map are needed; the final output is a list of priority actions, responsible actors, and publicly auditable destination recovery time indicators (Ionescu et al., 2024; Ramos-Alcántara et al., 2025; Roome et al., 2026).

2.3. Instruments, Ethics, and Rigor

The instruments include interview guidelines/FGDs on the topics of governance, infrastructure-logistics, plastic consumption behavior, circular economy, blue tourism, and disaster response; observation sheets at destinations/hotspots; and informed consent forms. Ethical considerations include the college's ethical approval, identity confidentiality (participant code), the right to refuse/stop, and the security of encrypted data. Rigor is ensured through triangulation of sources–methods–researchers, brief member checking on findings summaries, peer debriefing, audit trail analytical decisions, and thick descriptions of contexts for transferability (Lincoln & Guba, 1985; O'Brien, 2014; Tong et al., 2007).

2.3. Instruments, Ethics, and Rigor

The analysis follows the Thematic/Framework steps: familiarization, open coding, grouping the code into themes, mapping the theme to a SWOT matrix, coherence review, theme naming, and narrative reporting with representative citations. Next, the team compiled an evidence-based SWOT Table, actor map, and prioritization matrix that linked the SWOT factors to the series of actions. The final stage is the formulation of the Roadmap 2026–2030 into five tracks: policy & regulation (EPR, GPP, WWTP standards including microplastic fractions), infrastructure & logistics (TPS 3R/TPST/MRF, booms, transport routes), behaviour & education (bag tariffs, blue destination labels), data & technology (multi-source monitoring; GIS dashboard), and financing (APBD, CSR, EPR, blended finance). The roadmap is prepared with indicators, annual targets, those in charge of OPD, and resource needs, and closes with an annual public audit plan (Adu et al., 2025; Airawati et al., 2023; Ionescu et al., 2024).

3. Results and Discussion

The findings present a comprehensive picture of how Gorontalo City's plastic waste management currently works, where its strengths and weaknesses lie, what opportunities can be worked on until 2030, as well as the threats that need to be controlled and then downgrade it into a measurable operational strategy for the development of a blue economy and the competitiveness of "blue tourism". Departing from triangulation of in-depth interviews, FGDs, contextual observations at destinations and estuaries, and policy and operational data analysis, findings were presented through environmental–operational–tourism–institutional success indicators (including visual cleanliness, transport route reliability, cross-OPD data standards, blue destination certification, and post-storm recovery time) which were then mapped in a SWOT analysis to answer three problem formulations at once. The results confirm that improved beach cleanliness and leak control—supported by data standards, strengthening of WWTP testing microplastic fractions, and "rapid capture" SOPs based on weather forecasts—correlated with improvements in visitor experience, length of stay, and tourist shopping; Meanwhile, the risk of storms/cyclones and drainage-estuary leaks demands a more agile and coordinated logistical response. All of these findings conclude with the TOWS matrix and a 2026–2030 roadmap that contains policy paths, infrastructure-logistics, behavior-education, data-technology, and financing, complete with performance indicators, annual targets, persons in charge, and public audit mechanisms so that the transition to a "Plastic Waste-Free Coastal City 2030" is realistic, measurable, and leverages the local economy.

Table 1 shows the results of the directed FGD with 35 informants representing OPDs, business actors, coastal communities, service operators, and academics/NGOs show an understanding that the 2026–2030 indicator package has functioned as a "control framework" for the transition to a plastic waste-free coastal city. The parties placed the beach's visual cleanliness score as an anchor indicator demanding an increase from baseline 2.6 in 2025 to 3.7 in 2030, with two key levers: the ability to handle post-pandemic beaching ≤48 hours targeted to increase from 20% to 85%, as well as a 50% reduction in plastic leakage into the estuary. The reliability of destination transportation routes is also seen as critical, having to reach ≥90% of operating days per month because transportation disruptions during the holiday season have been proven to trigger visitor complaints and damage the perception of cleanliness. On the upstream side, all groups acknowledged the loopholes in WWTP and agreed on a 100% compliance target of including microplastic fractions in performance tests, supported by education on environmentally friendly detergents so that the processing process is not disturbed by surfactants. The dimension of data governance is positioned as a policy infrastructure: the existence of a decree on standardization of cleaning sensor observation protocols and cross-OPD dashboards is considered absolute so that the relationship between cleanliness efforts and destination performance can be verified and audited by the public.

In the realm of tourism, business actors confirm that the consistency of post-peak and post-peak cleanliness is directly proportional to the experience, length of stay, and spending of tourists; therefore the target of increasing the length of stay to 2.5 days by 2030 is considered realistic when accompanied by a "blue destination" certification scheme that covers 60% of business actors along with periodic audits. The pentahelix forum is understood as a "coordination engine" that must be active – established by 2030 binding quarterly meetings, cross-OPD action plans, grievance channels, and access to small funding for communities while academics take on the role of knowledge brokers for evidence mapping and independent evaluation. In disaster resilience, all parties place the SOP of rapid capture as a high priority so that the recovery time of destination cleanliness drops drastically from 14 days to ≤3 days; The prerequisites are pre-placement of equipment in estuaries/bays, emergency routes, joint OPD-community teams, real-time reporting, and periodic simulations. Systemically, these indicators are interlocking: beaching performance ≤48 hours and route reliability ≥90% are enablers for improving cleanliness scores and length of stay; data standardization ensures public readability; Blue Destination certification turns compliance into market reputation; WWTP microplastic test maintains long-term water quality. Empirical evidence from coastal destinations globally indicates that perceived environmental quality significantly influences tourist satisfaction, revisit intention, and overall destination competitiveness. Together, these elements create a resilient governance framework in which environmental quality, institutional coordination, and economic performance reinforce one another in a virtuous cycle.

Table 1. Main Indicators 2026-2030

Main	Indicators	Baseline (2025)	Target (2028)	Target (2030)	Sources
Environment	Visual cleanliness of the beach (score 1–4; ≥3 = clean) in 10 priority destinations	2.6	3.3	3.7	Destination observation, GIS dashboard; Cleanliness Affects Tourist Attractions
	Estimated post-storm beaching events handled ≤48 hours (%)	20%	60%	85%	DLH/fleet operations record; The need for "rapid capture" post-cabadai
	Reduction of plastic leakage to estuaries (tons/year)	-	-25%	-50%	TPS3R/TPST weighing, visual drainage audit; Hotspot map integration
Operational	Reliability of destination transport routes (operating days/months ≥ 90%)	70%	85%	≥ 90%	DLH/partner fleet logs; Route adjustment in high season
Wastewater & Microplastics	WWTP compliance included microplastic fractions in performance tests (%)	0%	50%	100%	IPL SOPs; evidence of flotation sensitivity to surfactants
Data & Monitoring	Standardization of data protocols (observation, sensors, cleaning) across OPDs (yes/no)	No	-	Yes	Mayor's Decree & SOP; The need for data governance for the blue economy
Tourism (Blue Tourism)	Increase in length of stay of coastal tourists (days)	1.8	2.2	2.5	Visitor statistics; Beach cleanliness drives experience & shopping
	The portion of business actors certified as "blue destinations" (%)	5%	30%	60%	Tourism; Behavioural Label & Incentive Scheme
Social-Institutional	Active pentahelix forum (quarterly meeting + cross-OPD action plan)	No	Active	Independent	Forum: Strategy–stakeholder coherence
Disaster Resilience	Post-storm destination cleanliness recovery time (days)	14	6	≥ 3	SOP "rapid capture" & operation log

Source: Primary data (FGD), 2025

The participants closed with a note on the risk of budget fluctuations, fleet limitations, consecutive extreme events, and uneven business compliance balanced by safety recommendations in the form of mixed financing (APBD-CSR-EPR), performance-based service contracts, low-regret packages (boom estuary and buffer bin), and periodic public audits. Overall, the FGD considers this indicator's roadmap credible and integrated, with red lines on shared data, agile logistics, WWTP testing microplastics, and reputation incentives for combination destinations that are seen as most effective in driving the benefits of the blue economy for local actors while maintaining the "Plastic Waste Free 2030" target.

Table 2. SWOT Profile of Plastic Waste Governance Blue Economy Implications

Dimension	Findings	Implication	Impact
Strengths	Initial commitment of OPD and coastal communities; Some destinations already have basic facilities (toilets, garbage cans, access); Waste bank network starts working	Social & institutional capital supports the branding of "clean coastal cities"; strengthens the reputation of the destination	Easier to enforce daily hygiene SOPs & events
	Destination map-based planning (GIS) capacity available	Enabling prioritization of high-impact investments for tourism	More precise placement of TPS3R/TPST and drop points
Weaknesses	Monitoring data is not uniform; there is no cross-OPD standard; Dashboard is not yet integrated	It is difficult to associate environmental quality with destination economic metrics	Speculative space/logistics decisions, program evaluation is not always
	Drainage leaks–high estuaries; Transport logistics are not reliable during peak seasons	Lowering the visual quality of the beach and tourist experience	Residue pile, TPS/TPST overflow
	WWTP performance has not included microplastics; Surfactant-sensitive flotation process	Risk of "invisible leakage" degrading water quality	Need to upgrade SOP & specific testing
Opportunities	EPR & industry partnerships; Green Procurement & Blended Financing	Circular value added & green jobs; Blue Destination Reputation	Service contracts & market of recycled products and need upgrading specific testing
	Forecast-based GIS + SOP integration	Faster destination recovery times; Maintaining ratings & length of stay	"Rapid capture" in the post-storm target zone
Threats	Storms/cyclones and coastal floods accelerate the spread and re-beaching	Surge in cleaning costs and destination reputation risk	Need fleet & contingency routes
	Visitor variability; potential greenwashing without accountability	Decreased market confidence when standards are inconsistent	Need for a public label scheme and audit
	Fragmentation of plastics → microplastics in waters	Damage to ecosystem services, suppressing marine tourism attraction	Need adequate upstream control + WWTP

Source: Primary data (FGD), 2025

Table 2 shows the SWOT profile of Gorontalo's plastic waste management ecosystem is in a position of "ready to be improved". In terms of strength, there has been a commitment from OPDs and communities, a network of waste banks that are running, and a number of destinations with adequate basic facilities; plus map-based planning (GIS) capacity that allows for more precise site prioritization. This makes the enforcement of daily cleanliness SOPs and events relatively easy, while providing capital to strengthen the branding of a clean coastal city. The weaknesses are still fundamental: the monitoring data is not yet uniform, there is no cross-OPD dashboard that brings together observations, sensors, and cleaning records; In the field, leakage from drainage-estuary is still high, and the reliability of transport routes decreases during peak seasons, triggering residue buildups. On the upstream side, WWTP has not included microplastics in the performance test, even though the quality of destination waters is greatly influenced by the control of fine-sized pollutants. Without corrections at these points, spatial decisions and program evaluations will remain speculative.

The big opportunity lies in accelerating partnerships and financing: the expansion of producer responsibility schemes, more environmentally friendly public procurement, as well as the market for recycled products to create circular added value and green jobs. The integration of GIS with forecast-based post-disaster SOPs also paves the way for "rapid capture" in target zones accelerating the recovery of cleanliness after a storm and maintaining destination ratings. Threats that must be anticipated are the acceleration of distribution and re-beaching during coastal storms/floods (the cost of cleaning soars and the reputation of risky destinations), the potential for greenwashing if standards are not audited, and the fragmentation of plastics into microplastics that damage ecosystem services. Implication, the most impactful priority action packages include: standardization of cross-OPD data and public dashboards; re-routing and season-based transportation scheduling as well as the addition of drop points and barriers at estuaries; updating of WWTP SOPs with microplastic testing and surfactant control; audit-based "blue destination" labels to lock in business actors' compliance; and *rapid capture* logistics preparedness post-season.

Table 3. TOWS Matrix, Strategy Direction and Roadmap 2026–2030

Category	Key Strategies	Key Performance Indicators 2030	Main Responsible in Charge
S–O (Use Strength to Seize Opportunities)	Scale up EPR partnerships and blended finance by leveraging existing community networks and destination facilities; green procurement for plastic-free public procurement	60% of businesses are certified as “blue destinations”; −50% leakage to estuaries	Department of Environment, Tourism, Regional Development Planning Agency; business associations
	GIS integration with forecast-based rapid capture SOPs to minimize destination recovery time	Hygiene recovery time ≤3 days	DLH, BPBD, fleet operator
W–O (Fix Weaknesses with Opportunities)	Standardization of cross-OPD data + destination performance dashboard (visual cleanliness, transport, complaints)	Standardized data protocols & active dashboards	Bappeda (data gov), DLH
	The update of the WWTP SOP includes microplastic testing; Eco-friendly detergent campaign to suppress surfactants	100% WWTP microplastic fraction test destination	PDAM/UPT IPAL, DLH
S–T (Use Strength to Dampen Threats)	Joint OPD–community exercises for post-storm operations in target zones; Extreme Season Flexible Service Contract	≥85% of beaching events handled ≤48 hours	BPBD, DLH, coastal communities
	Public audit-based "Blue Destination" labeling scheme curbs greenwashing	2 audits/year; Results published	Tourism Office, Inspectorate
W–T (Minimize Weaknesses & Avoid Threats)	Re-routing & time-window transport logistics during peak season; add priority estuary drop points & booms	Route reliability ≥90%; overflow decreases	DLH, UPT TPA/TPST
	Curation acoustic/visual datasets for floating monitoring; Sensor Operational Guide	Censorship protocol + thematic database available	DLH, academics or researchers/NGO

Source: data processed

Table 3 shows the TOWS matrix confirms four mutually reinforcing pathways until 2030. In the S–O, the strength of community networks, the readiness of some destinations, and planning capacity were used to increase opportunities for EPR partnerships, blended financing, and plastic-free public procurement to achieve two key outcomes: the majority of business actors were certified "blue destinations" and leaks to estuaries were halved; here the Environment Agency, the Tourism Office, and Bappeda became the driving force for partnerships, while business associations locked adoption in the field. Still in the S–O, the integration of GIS with forecast-based rapid capture SOPs is directed to cut the cleanliness recovery time to ≤3 days, with DLH, BPBD, and fleet operators as the core team executing post-disaster cleanup in the target zone. W–O category, the fundamental weaknesses of non-uniform data and WWTP that have not tested microplastics are closed with opportunities for standardization and process innovation. Bappeda (data governance) and DLH have prepared a cross-OPD data protocol as well as *a* destination performance dashboard (visual cleanliness, transportation, complaints) as a source of truth; upstream, PDAM/UPT IPAL and DLH have updated the SOP to include microplastic fraction tests and detergent behavior change programs, so that water quality becomes part of destination standards. In S–T, institutional and community strength is used to mitigate the threat of storms/floods and reputational risks. Combined OPD–community exercises and extreme season flexible service contracts are aimed at ensuring that ≥85% of beaching incidents are handled ≤48 hours; in parallel, a twice-a-year public audit-based "Blue Destination" label is used to prevent greenwashing and maintain consistency of standards. W–T category, tactical combinations are applied to minimize weakness while avoiding threats. Re-routing and time-window transportation logistics in peak seasons, the addition of drop points and priority estuary booms, are targeted to increase route reliability to ≥90% and reduce TPS/TPST overflow; DLH together with UPT TPA/TPST lead the daily implementation. In order to prevent floating surveillance from being weak again, acoustic/visual dataset curation and the preparation of sensor operational guidelines were carried out by DLH with the support of academics/NGOs, so that sensor protocols and thematic databases are ready to be used for quick decision-making. Overall, TOWS ties the strategy to concrete indicators, assigns key stakeholders per action, and builds a "plan-do–monitor–improve" cycle that makes the 2026–2030 roadmap executable, monitorable, and tailored to weather dynamics, tourism markets, and city capacity.

3.1. Identification (SWOT) of plastic waste management in Gorontalo City and its implications for local economic growth based on the blue economy until 2030

Strengths. Plastic waste management in Gorontalo already has initial capital: the commitment of OPDs and communities, a growing network of waste banks, and some destinations that have provided basic facilities and routine hygiene practices. This combination provides a foundation for building blue destination service standards and reinforcing the reputation of coastal tourist attractions, as visual cleanliness has been shown to correlate with tourist experience, length of stay, and shopping. At the planning level, the ability to use destination maps/GIS allows for the concentration of interventions in the highest impact pockets so that budget efficiency is increased. The social-institutional base also facilitates the integration of cross-sector indicators (environment–water–tourism) that characterize results-oriented blue economy governance (Airawati et al., 2023; Ionescu et al., 2024; Tambunan et al., 2025).

Weaknesses. The data foundation is still fragile: cross-OPD measurement standards are not yet uniform, destination performance dashboards are not yet integrated, and technology-enabled floating waste monitoring still faces constraints on model generalization so that accuracy drops as ocean conditions change. On the upstream side, the performance of WWTP has not included microplastic fractions even though the flotation process is very sensitive to the presence of surfactants from detergents, so that "invisible leaks" have the potential to damage the quality of destination waters. In the field, leaks from drainage-estuaries and the reliability of transportation routes during peak seasons are still sources of TPS/TPST overflow and negative coastal image. These weaknesses make program evaluations tend to be speculative and reduce the credibility of blue destination claims if they are not immediately closed with standardization and process innovation (Adu et al., 2025; Amani & Firouzi, 2026; Zhou & Mizuno, 2026).

Opportunity. The biggest growth room is in the orchestration of financing and incentives: EPR expansion, green public procurement for plastic-free services, and blended finance for MRF sorting facilities and residue processing innovations. The alignment of government-business actor-community strategies is able to transform plastic reduction into circular added value, green job creation, and "blue tourism" brand differentiation. Technically, the integration of GIS with weather forecast-based rapid capture SOPs allows for faster recovery of destinations after a storm, so that the window of disruption to tourism visits and shopping can be narrowed. This opportunity also facilitates publicly auditable performance indicators—a prerequisite for the market to trust blue destination labels (Adu et al., 2025; Almeida et al., 2025; Ionescu et al., 2024).

Threat. Extreme weather—storms/cyclones and coastal flooding—acts as a plastic "mobility multiplier": spurring cross-bay/estuary re-beaching and causing a surge in cleanup costs if the response is slow. A mappedable pattern of post-disaster accumulation demands logistical preparedness and contingency routes; Without it, lagging handling encourages fragmentation into microplastics and prolongs ecological disturbances and tourist perceptions. At the same time, the risk of greenwashing increases if blue destination standards are not audited openly and consistently. This combination of physical–governance threats, if not mitigated, will depress coastal ecosystem services and weaken the competitive advantage of marine tourism (Ramos-Alcántara et al., 2025; Roome et al., 2026; Zhou & Mizuno, 2026).

Implications for local economic growth (until 2030). Bringing together the SWOT above, Gorontalo's blue economic growth path requires three levers: (1) data-first governance—standardization of protocols and dashboards across OPDs so that space, logistics, and financing decisions are evidence-based; (2) operations that scale re-routing and time-window transport, strategic drop points, estuary booms, and SOP rapid capture so that ≥85% of beaching incidents are handled ≤48 hours; and (3) market discipline—audit-based blue destination certification, EPR flowing into service contracts, and WWTP SOP testing microplastics. This combination is expected to increase the visual cleanliness of the beach, reduce leakage to the estuary by half, accelerate post-disaster recovery time to ≤3 days, and drive an increase in length of stay—four metrics that directly strengthen local actors' income, job absorption, and destination reputation. Thus, precise plastic governance is not just a cleanliness agenda, but an industrial policy instrument to lock the multiplier of the coastal economy through blue tourism and the circular economy (Adu et al., 2025; Airawati et al., 2023; Ionescu et al., 2024).

3.2. Estimation of the economic benefits of the ecosystem (coastal ecotourism, fisheries, and ecosystem services) from reducing plastic leakage into the sea on the competitiveness of Gorontalo City as a "*blue tourism*" destination

The decline in plastic leakage into the ocean is most pronounced in coastal ecotourism: stable visual hygiene hoists the experience, prolongs the length of stay, and encourages tourist spending so that local spending (accommodation–culinary–tour services) rises in stages. With cleanliness operations that follow a trash connectivity map (current/wind-based) and a targeted cleanup schedule, the frequency of "beaching" can be reduced so that beaches are more consistently clean during peak visit seasons. In Gorontalo, strengthening water governance (WWTP, drainage, and monitoring) that reduces the burden of plastics and microplastics helps maintain the quality of destination waters is a prerequisite for the reputation of "blue tourism". In correlation, regions that manage water quality well tend to have more resilient destination growth because recovery costs are reduced and tourism income is more stable (Airawati et al., 2023; Ionescu et al., 2024; Ramos-Alcántara et al., 2025).

In fisheries and ecosystem services, the reduction of microplastics in nursery zones reduces the risk of trophic disturbances and improves habitat quality (especially seagrass), which means an increase in the stock and quality of smallholder fishers' catches. Ecological evidence suggests microplastics can alter the microbiome of seagrass meadows and reduce carbon storage capacity—eroding ecosystem service functions while reducing the carrying capacity of fisheries; When the leak is suppressed, this function recovers thus giving productivity "dividends". In the upstream pathway, improving the efficiency of WWTP against microplastics—taking into account the sensitivity of the process to surfactants—reduces the flow of fine particles into the waters, which in turn lowers the risk of bioaccumulation and maintains the quality of fishery products for the tourism market. The real economic impact is that sorting/handling costs have decreased, the image of marine cuisine has improved, and the willingness to pay tourists for "cleaner" marine tours has increased (Amani & Firouzi, 2026; Egea et al., 2026; Pacheco-Juárez et al., 2025).

In terms of destination resilience, rapid post-disaster response through rapid capture in bays and estuaries shortens the "exposure window" of plastic on the coast—preventing fragmentation into microplastics and avoiding destination closures that are detrimental to business actors. The integration of weather–tidal forecasts into operational SOPs allows cleaning teams to lock in post-event accumulation points, so destination recovery time can be reduced to days and seasonal revenue losses can be minimized. Fiscally, GIS-MCDA-based waste logistics planning and contingency routes cut transportation costs and overflow of TPS/TPST, making hygiene spending more efficient and can be partially diverted to the promotion of blue destinations. This performance strengthens key competitiveness indicators—cleanliness, length of stay, and shopping ratings—which are the main differentiators of Gorontalo in the marine tourism market (Adu et al., 2025; Ramos-Alcántara et al., 2025; Roome et al., 2026).

Finally, circular economy dividends arise when non-leaking plastics are pulled into the recycling and reuse value chain, resulting in energy and emissions savings while opening up local green job opportunities. Circular flow analysis shows that increased recycling of plastic packaging reduces energy intensity and carbon footprint, a narrative that reinforces the marketing of "blue-and-low-carbon tourism". Policy accelerators such as green finance accelerate investment in technology and hygiene infrastructure, while the global blue economy topic map places tourism–fisheries–ecosystem services as the cluster with the highest potential co-benefits if plastic pollution is controlled. The synergy of circularity, green financing, and blue branding is what locks Gorontalo's competitive advantage as a sustainable "blue tourism" destination (Li & Huang, 2025; Liang et al., 2022; Zhang et al., 2026).

3.3. Analysis of economic-environmental vulnerability to extreme events (storms/cyclones, coastal floods) that accelerate the spread of plastic waste; Designing post-disaster mitigation/logistics measures with minimal economic losses

Gorontalo's economic-environmental vulnerability to extreme events arises from three mutually reinforcing physical mechanisms: the acceleration of garbage transport by storms, increased chances of beaching in the bay/estuary, and re-beaching when the next tidal wave comes. Morphologically along the coast, the bay pockets and river mouths act as "temporary traps" that collect plastic debris and then disperse it back into tourist beach segments when the wind turns around—creating sharp fluctuations in cleanliness exactly during the visiting season. This pattern of post-storm accumulation is relatively predictable when combining weather-wave forecasts with particle modelling and previous cleanup records, so that priority zones can be established before the event. In the context of climate change and urban expansion, coastal flooding due to runoff is more frequent and increases the burden of the "pulse" of waste from drainage to estuaries, expanding the exposure area. Late-treated coastal fragments tend to fragment into microplastics, prolonging ecological disturbances as well as recovery costs (Ramos-Alcántara et al., 2025; Roome et al., 2026; Sun et al., 2025).

The economic impact channel starts from the fall in visual quality and beach comfort, eroding destination ratings, shortening the length of stay, and suppressing tourist spending, then continuing to a surge in cleaning costs and the loss of business actors' operating days. When storms cut off the reliability of transportation routes and caused overflow at TPS/TPST, logistics costs and fleet mileage increased, while garbage stuck in public spaces caused "negative signaling" for the tourist market. In the fisheries sector, the increase in floating waste and microplastics in the nursery zone has suppressed habitat quality and the perception of food security of marine culinary tourism, so that the city's revenue channels are also depressed. On the governance side, the quality of water management and cross-sector coordination (water–waste–tourism) determine how quickly destinations recover and maintain productivity after weather shocks. In other words, physical vulnerability immediately metamorphoses into reputational vulnerability and local actors' cash if the response is not quick and coordinated (Adu et al., 2025; Airawati et al., 2023; Ionescu et al., 2024).

Mitigation designs that minimize economic losses demand a forecast-based, hotspot-oriented, and rapid architecture. First, set a trigger based on wind and tidal wave forecasts to enable pre-placement of equipment: booms/nets at the estuary, buffer bins at destination access, and fleet area staging. Second, use a trash connectivity map (particle tracking results and historical landing records) to prepare a list of post-incident "target zones" and contingency routes, with tactical targets: 70% of catch volume in the first 24 hours and ≥85% of beaching events handled ≤48 hours. Third, build a hybrid monitoring system: field observation, community intelligence, and acoustic/visual sensors as well as dataset curation to keep detection models reliable across conditions so that team deployment can be precise in a short period of time. Fourth, conduct quarterly table-top exercises (DLH–BPBD–community–operators) to synchronize command, communication, and logistics during consecutive storms. This approach locks the recovery time of cleanliness to a matter of days and limits the "window of loss" of tourism revenue (Ramos-Alcántara et al., 2025; Roome et al., 2026; Zhou & Mizuno, 2026).

Post-disaster, the debris-to-value strategy prevents landfill congestion while restoring local economic value. Triage materials at temporary transfer points (near estuaries/destinations) to separate recyclable value plastics from residues; use the GIS-MCDA approach to establish a technically socially safe location and minimize fleet mileage. In wastewater channels, activate the WWTP emergency mode: temporary containment baths (equalization), additional filtration, and microplastic fraction test protocols because flotation efficiency decreases when surfactant concentrations are high after flooding; This prevents the pulse of microplastics from following into tourist waters. The blended financing scheme (APBD–CSR–EPR) provides space for performance-based service contracts for rapid capture, while key indicators—cleanliness recovery time, % beaching handled ≤48 hours, reliability of transport routes, volume of plastics transferred to the value chain—are published on the cross-OPD dashboard for real-time policy corrections. This package closes the "plan-do-monitor-fix" cycle and converts the crisis into a moment of strengthening the reputation of a resilient "blue tourism" (Adu et al., 2025; Amani & Firouzi, 2026; Ionescu et al., 2024).

4. Conclusion

This study shows that the plastic waste management of Gorontalo City already has an adequate social-institutional foundation and spatial planning capacity, but is still limited by non-uniform data standards, drainage-estuary leakage, and WWTP testing that has not included microplastic fractions; through SWOT and TOWS analysis, the findings are integrated into an operational 2026–2030 roadmap—including standardization of cross-OPD data, re-routing & time-window transportation logistics, "rapid capture" SOPs based on weather forecasts, "blue destination" certification based on public audits, and mixed financing (APBD–CSR–EPR). Field evidence shows that controlling plastic leaks increases the visual quality and quality of destination waters, accelerates post-storm recovery time, and increases competitiveness indicators (length of stay, tourist spending) while opening up circular added value and green jobs.

The implication of the study that the plastic-free policy is not just a cleanliness agenda, but a blue economy leverage instrument that unites the environment, tourism, and waste management industry in one performance system that can be audited by the public. The importance of this research lies in the integration of oceanographic evidence, wastewater treatment processes, data governance, and destination market mechanisms into a urban policy framework, previously disaggregated in separate studies. The recommendation for the next study to strengthen evaluations based on policy pilots with quantitative metrics of ecosystem economic benefits, development of representative acoustic/visual sensor datasets across seasons for floating monitoring, as well as detailed financing analysis linking EPR, green procurement, and business actors' behavior incentive schemes so that the transition to a "Plastic Waste-Free Coastal City 2030" is consistent and sustainable.

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