

Preliminary Analysis Of Governance, Social Norms, and Behavioral Determinants of Household Participation in Marine-Linked Waste Management in Gorontalo Province, Indonesia

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Abstract— This study investigates household willingness to adopt sustainable waste management practices in Gorontalo Province, Indonesia, a coastal region where unmanaged solid waste directly threatens marine natural capital such as mangroves, seagrass, and coral reef habitats. Using an extended Theory of Planned Behavior (TPB) framework, the research incorporated adaptive capacity as a governance-related antecedent to explain household pro-environmental behaviors. A cross-sectional survey of 63 respondents was conducted, and the data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The results demonstrate that attitudes had a modest effect on behavioral intentions (H4, $p = 0.038$), while subjective norms strongly predicted both perceived behavioral control (H2, $p < 0.001$) and intentions (H5, $p < 0.001$). Perceived behavioral control emerged as a decisive factor shaping intentions (H6, $p = 0.002$) and indirectly influencing behaviors ($p = 0.012$). Adaptive capacity significantly strengthened perceived behavioral control (H3, $p = 0.028$), confirming the importance of governance support in enabling household action. Finally, intentions strongly predicted actual behaviors (H7, $p < 0.001$), such as reducing single-use plastics and avoiding littering in coastal areas. These findings suggest that enhancing governance capacity, reinforcing social norms, and building household confidence are critical for aligning community waste practices with marine ecosystem protection.

Keywords— Gorontalo Province; Theory of Planned Behavior; adaptive capacity; waste management; marine natural capital; household participation

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I. INTRODUCTION

Marine natural capital is increasingly recognized as one of the most important assets for sustainable development [1], especially in archipelagic countries such as Indonesia. The ecological services provided by coastal and marine ecosystems extend beyond biodiversity protection, playing crucial roles in climate regulation, fisheries productivity, disaster mitigation, and coastal livelihood security [2–4]. In provinces such as Gorontalo, which lies on the northern arm of Sulawesi, these ecosystems are both ecologically significant and socio-economically indispensable. Yet the integrity of these natural systems is under mounting threat from household-generated solid waste [5], particularly plastic debris that enters waterways and eventually flows into coastal zones [6]. The mismanagement of waste in

Gorontalo has resulted in pollution of rivers, beaches, and reefs, undermining not only environmental sustainability but also food security and public health. The urgency to understand and improve household waste practices is therefore deeply tied to the protection of marine natural capital and the resilience of local communities [7,8].

Urbanization and population growth in Gorontalo have accelerated over the past two decades, leading to rising levels of consumption and increasing generation of household waste. According to the Indonesian Central Statistics Agency (BPS), Gorontalo's population has exceeded 1.1 million, with projections showing continued growth in coming years [9]. Urban neighborhoods in Gorontalo City generate significant amounts of waste daily, but collection and disposal services remain limited in coverage and efficiency. Coastal communities, which are often located in peri-urban or rural districts, face even greater challenges due to limited infrastructure and logistical difficulties [10–12]. In many of these areas, households resort to open dumping, burning, or direct disposal into rivers, which ultimately exacerbates marine litter problems [13,14]. These practices not only degrade the environment but also heighten risks of flooding and waterborne diseases. In this sense, waste governance in Gorontalo is inseparable from both ecological protection and human well-being. From a theoretical standpoint, the study of household waste practices has often been framed within the Theory of Planned Behavior (TPB), which posits that attitudes, subjective norms, and perceived behavioral

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control (PBC) are key predictors of behavioral intentions, which in turn drive actual behaviors [15–17]. Attitudes refer to the degree of positive or negative evaluation of a behavior, subjective norms capture the perceived social pressures to perform or not perform the behavior, and PBC reflects an individual's confidence in their capacity to act, given available resources and constraints. Over the past decades, TPB has been applied extensively to environmental behaviors such as recycling, energy conservation, and waste reduction, demonstrating its robustness as an explanatory model [18–22]. However, scholars have also noted that contextual factors such as governance quality, infrastructure provision, and institutional trust significantly shape the feasibility and effectiveness of pro-environmental behavior, particularly in developing countries.

In Gorontalo, where waste governance systems are uneven and fragmented, the integration of governance-related constructs into TPB is particularly important. This study introduces adaptive capacity as an antecedent variable that influences perceptions of control, intentions, and behaviors. Adaptive capacity encompasses the governance conditions that enable or constrain households in their waste management practices, including the availability of infrastructure, the flexibility of systems to respond to local challenges, the role of organizations and networks, the dissemination of knowledge, and the empowerment of communities [23–26]. In the Indonesian context, adaptive capacity has been discussed in relation to climate adaptation and disaster risk reduction [27–31], but its application to household waste governance remains limited. By embedding adaptive capacity within the TPB framework, this study advances a more comprehensive understanding of how institutional readiness and psychosocial factors intersect in shaping environmental-related behaviors [32].

The empirical gap that motivates this research is clear. While numerous studies have examined household waste practices in Indonesia, most focus on large metropolitan areas such as Jakarta [33–36], Surabaya [37–39] or Bali [7,40], where waste challenges are acute but governance structures are more established. Far less attention has been paid to smaller provinces such as Gorontalo, where institutional resources are more limited and coastal ecosystems play a central role in community life. Comparative studies have shown that willingness to participate in waste management varies significantly by context, influenced by both socio-demographic characteristics and governance conditions [41–44]. Yet in Gorontalo, the unique intersection of urban and coastal dynamics, combined with the province's reliance on marine resources, makes it imperative to explore household behaviors in relation to governance and natural capital. The novelty of this study lies in its combination of behavioral and governance perspectives through the extension of the TPB model. While traditional TPB research emphasizes psychological determinants [45–47], the addition of adaptive capacity acknowledges the institutional and infrastructural realities that shape behavior in practice. For example, a

household may have strong pro-environmental attitudes and perceive social pressure to reduce waste, but without adequate collection services or local enforcement [48,49], their perceived control is diminished, and behavioral intentions may not translate into action. By explicitly modeling adaptive capacity, this study highlights the ways in which governance support, such as the provision of waste banks, community clean-ups, or public education campaigns, can strengthen behavioral control and foster pro-environmental outcomes.

The objective of this research is to conduct a preliminary explanatory analysis of household waste management behaviors in Gorontalo Province, using a sample of 63 respondents to test the extended TPB model. This sample size aligns with methodological guidance for preliminary PLS-SEM studies, where smaller samples can provide sufficient insight for instrument refinement and hypothesis screening. The study seeks to answer three interrelated questions: to what extent do attitudes, subjective norms, and perceived behavioral control explain household waste intentions and behaviors in Gorontalo; how does adaptive capacity influence these relationships; and what are the implications for governance and policy in safeguarding marine natural capital. The focus on preliminary analysis is particularly relevant given the limited availability of prior empirical data in Gorontalo, positioning this study as a foundation for larger and more representative future research. By situating household waste behaviors within both psychosocial and governance frameworks, this study provides insights that are directly relevant to Indonesia's broader sustainability goals. Indonesia has pledged to reduce marine plastic debris by 70 percent by 2025 [50], a target that cannot be achieved without robust local governance and active household participation [51]. Gorontalo, as a province where marine ecosystems underpin livelihoods and cultural identity, represents an important test case for integrating behavioral insights into waste governance strategies. The findings from this study are expected to inform both local government interventions and national policy frameworks, contributing to more effective, equitable, and participatory approaches to waste management.

II. METHOD

A. Study setting and hypothesis design

This study was conducted in Gorontalo Province, Indonesia, a region where the dynamics of urban and coastal development intersect with the sustainability of marine natural capital such as mangroves, seagrass beds, and coral reefs. Gorontalo's communities rely heavily on these ecosystems for fisheries, shoreline protection, and tourism livelihoods, yet they also face mounting pressures from unmanaged household solid waste. The leakage of plastic waste into rivers and coastal zones not only undermines marine biodiversity but also intensifies risks of flooding and waterborne diseases. Against this background, the study focuses on household-level participation in waste management and the behavioral drivers that determine whether residents contribute to reducing waste leakage into marine environments.

To examine these behavioral mechanisms, the study applies the Theory of Planned Behavior (TPB), which posits that human actions are shaped by attitudes, subjective norms, and perceived behavioral control, all of which influence behavioral intentions and ultimately actual behaviors [15]. This study extends TPB by incorporating adaptive capacity as a governance-related antecedent, reflecting the institutional, infrastructural, and organizational conditions that enable households to enact pro-environmental behaviors. Adaptive capacity is

defined here through dimensions such as the availability of waste bins, government-led awareness campaigns, enforcement of regulations, and community-level programs like waste banks, which collectively shape the context in which household choices are made. Based on TPB and governance literature, seven hypotheses (H1–H7) were formulated and integrated into a structural model tested using PLS-SEM (Figure 1).

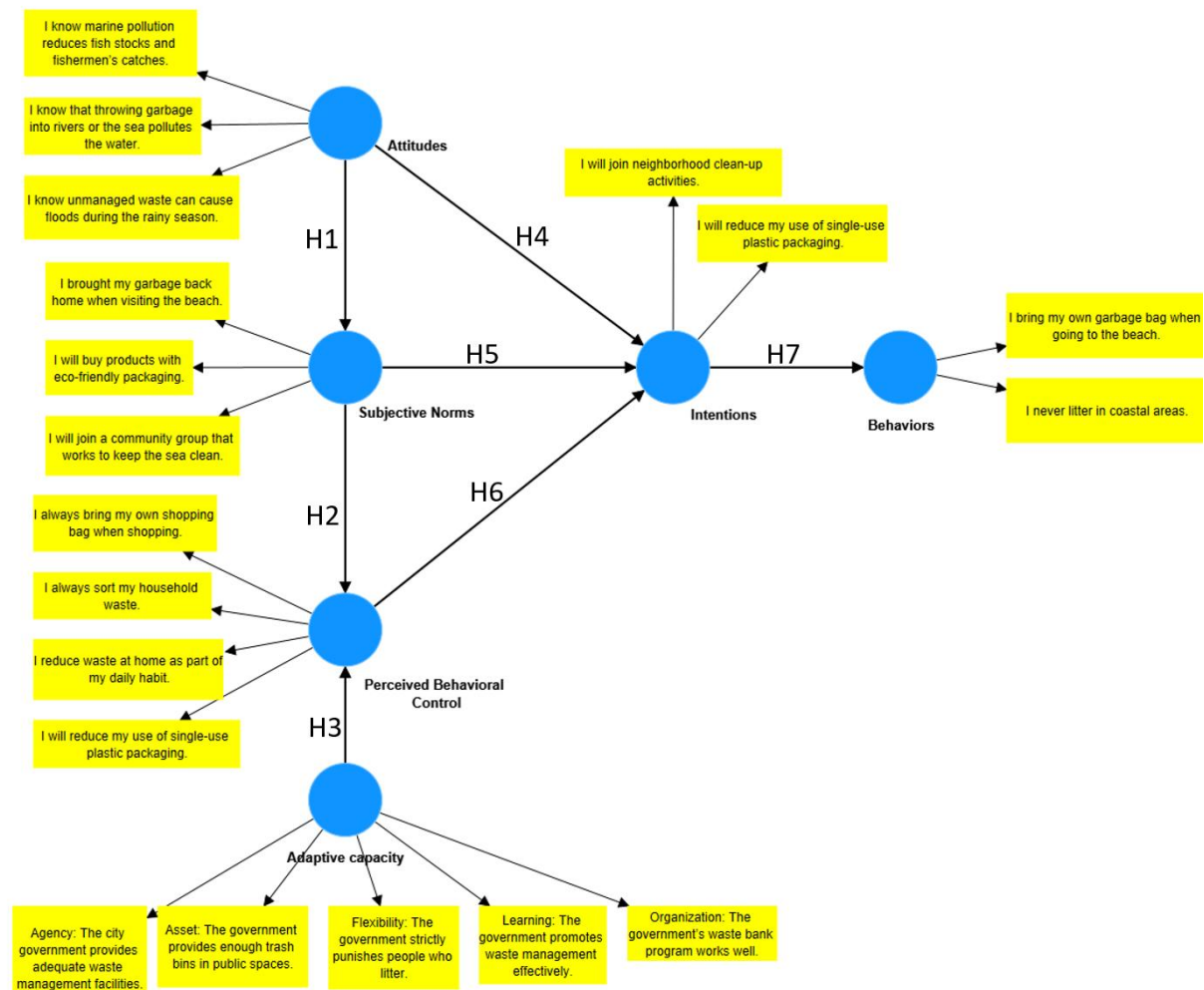


Figure 1. SEM framework for the Theory of Planned Behavior (TPB) and adaptive capacity in Gorontalo

H1. Attitudes → Subjective Norms. Attitudes reflect individual evaluations of waste practices, such as recognizing that marine pollution threatens fisheries or that unmanaged waste contributes to flooding. Positive attitudes are expected to strengthen alignment with community expectations, as individuals who value environmental responsibility are more likely to perceive and internalize social norms encouraging similar behavior. Thus, stronger pro-environmental attitudes are hypothesized to increase subjective norms.

H2. Subjective Norms → Perceived Behavioral Control (PBC). Subjective norms capture perceived social pressure to perform or avoid certain behaviors, such as joining a community clean-up group or reducing single-use plastics. When individuals perceive strong

social expectations, they are likely to feel greater personal responsibility and confidence in their ability to act, thereby enhancing perceived control over their behavior. Hence, stronger subjective norms are hypothesized to positively influence PBC.

H3. Adaptive Capacity → Perceived Behavioral Control. Adaptive capacity represents governance support structures that reduce barriers to waste management. For example, adequate trash bins in public spaces, government incentives, or effective promotion of waste programs reduce constraints and increase self-efficacy. Households embedded in supportive governance systems are therefore expected to report higher levels of PBC.

H4. Attitudes → Behavioral Intentions. According to TPB, favorable evaluations of pro-environmental practices lead directly to stronger intentions to engage in them. Residents who believe that reducing single-use plastics or bringing garbage home after beach visits is beneficial are more likely to intend to act accordingly. Thus, positive attitudes are hypothesized to enhance behavioral intentions.

H5. Subjective Norms → Behavioral Intentions. Social influence is a central predictor of behavioral intention. In Gorontalo's tight-knit communities, norms around communal clean-ups and eco-friendly shopping are powerful motivators. When residents perceive that neighbors and community groups endorse sustainable practices, they are more likely to form strong intentions to comply. Thus, subjective norms are hypothesized to significantly increase behavioral intentions.

H6. Perceived Behavioral Control → Behavioral Intentions. PBC reflects individuals' confidence in their ability to carry out waste-related practices, such as sorting household waste or reducing plastic packaging. Higher levels of perceived control, supported by accessible infrastructure and personal efficacy, are hypothesized to translate into stronger behavioral intentions.

H7. Behavioral Intentions → Behaviors. Intentions represent the immediate antecedent of action in TPB. Residents who intend to participate in neighborhood clean-ups or avoid littering in coastal areas are expected to follow through in their actual practices. Therefore, behavioral intentions are hypothesized to positively predict self-reported waste management behaviors.

B. Population, sample, and sampling

The population of interest in this study comprised adult household members aged 18 years and above, residing in both urban neighborhoods of Gorontalo City and coastal settlements in surrounding districts. Households were chosen as the unit of analysis because decisions related to daily waste management, sanitation practices, and participation in environmental initiatives are typically made at the household level. This dual focus on urban and coastal residents is particularly relevant in Gorontalo, where solid waste practices directly influence the integrity of marine natural capital such as mangroves, seagrass beds, and coral reefs, and where disparities in infrastructure between city centers and peri-coastal villages may shape behavioral responses.

Given the exploratory and preliminary nature of the research, the sample size was guided by methodological recommendations for pilot applications of structural equation modeling with partial least squares (PLS-SEM). Prior literature suggests that for model screening and instrument refinement, samples in the range of 30 to 50 respondents can provide sufficient information when constructs are measured with reliable multi-item indicators and the structural model is not highly complex. Building on this guidance, the study collected

63 valid and complete responses, which not only exceeded the minimum threshold but also satisfied the commonly used "10-times rule" in PLS-SEM. This rule requires that the sample size be greater than 10 times the maximum number of structural paths directed toward any single endogenous construct, thereby ensuring that the estimated path coefficients and measurement model parameters remain stable for preliminary evaluation. The sampling approach applied was stratified neighborhood intercept sampling, designed to capture heterogeneity across Gorontalo's urban and coastal settings. Strata were defined geographically to include both city-based households with greater exposure to municipal waste services and coastal households that often face limited access to sanitation facilities and are more directly affected by marine litter leakage. Within each stratum, eligible adult respondents were approached in public or community spaces and invited to participate in the survey. Only one adult per household was selected to avoid clustering bias, and eligibility was confirmed by verifying age and residency status.

C. Instrument development and measures

The questionnaire captured TPB and governance-related constructions using five-point Likert scales (1 = strongly disagree to 5 = strongly agree). Items were adapted to Gorontalo's waste and coastal context and organized into six latent constructs: Attitudes toward environmentally responsible waste practices; Subjective norms (perceived social expectations to act); Perceived behavioral control (self-efficacy and perceived constraints); Behavioral intentions (stated likelihood of engaging in target practices); Observed/ self-reported waste behaviors; and Adaptive capacity (household/community capability elements relevant to waste management and leakage prevention). Example items included knowledge that littering pollutes waterways, intention to reduce single-use plastics, willingness to join neighborhood clean-ups, sorting waste at home, and perceptions of local service provision and programs (e.g., bins, waste bank, promotion). The final item pool and construct map were compiled from the project's indicator set for attitudes, intentions, behaviors, PBC, subjective norms, and adaptive capacity, which guided coding and model specification. All constructs were modeled reflectively (Mode A in PLS), consistent with TPB, where the latent variable is conceived as the common cause of its indicators. Prior to fielding, the instrument underwent expert review for content validity and contextual fit, followed by language checks to ensure clarity and cultural appropriateness.

Data were collected in person by trained enumerators in September 2025. Interviews were conducted at respondents' homes or community venues at times convenient to households. Participation was voluntary; enumerators obtained informed consent after explaining the study's purpose, privacy protections, and the option to withdraw at any time without consequence. No directly identifying personal data were recorded. Completed forms were anonymized and stored in encrypted repositories accessible only to the research team. The protocol received approval from the host

institution's ethics committee and local administrative clearance.

D. Data Analysis

Prior to analysis, all survey responses were screened to ensure data quality and suitability for structural equation modeling. Cases were inspected for missing values, with thresholds of up to five percent per item allowable. Any such gaps would be addressed through expectation-maximization or item-mean substitution within the same construct to preserve consistency. Straight-lining and response-time irregularities were checked to identify inattentive responses, and univariate distributions were examined to assess skewness and kurtosis, recognizing that non-normality is typical in Likert-type data. Influential observations were further evaluated through leverage and Cook's distance. Because partial least squares structural equation modeling (PLS-SEM) is robust to distributional violations, no transformations were anticipated unless extreme departures were observed. To reduce the potential for common method bias, the questionnaire was designed with procedural safeguards, such as separating construct sections, varying scale anchors, and including reverse-coded items. Additional statistical checks were planned, including full collinearity variance inflation factors (target ≤ 3.3), Harman's single-factor test, and a marker variable approach if necessary.

Measurement models were specified for all constructs, each of which was reflective with at least three observed indicators where possible [32,52–56]. Outer loadings were targeted at or above 0.70, although items between 0.40 and 0.70 could be retained if they were theoretically essential and their exclusion did not improve average variance extracted (AVE) or composite reliability. Internal consistency was assessed through Cronbach's alpha, rho_A, and composite reliability, with values expected between 0.70 and 0.95. Convergent validity was established where AVE was greater than 0.50, while discriminant validity was tested through the Fornell–Larcker criterion, heterotrait–monotrait ratios (HTMT), and cross-loading checks. Multicollinearity was monitored using full collinearity VIF values, with a threshold of ≤ 3.3 to ensure both discriminant validity and absence of residual method bias. These criteria served as the decision framework for indicator retention and refinement before moving to the structural model.

The structural model was developed in alignment with the TPB. Paths were specified from attitudes to intentions, subjective norms to intentions, perceived behavioral control (PBC) to intentions, and intentions to behaviors, while a direct path from PBC to Behaviors was included to capture direct control effects. To account for governance-relevant influences, adaptive capacity was incorporated as an exogenous antecedent expected to shape PBC, Intentions, and potentially Behaviors, reflecting its role in strengthening agency, infrastructure, flexibility, and community knowledge. Correlations among exogenous constructs were permitted where

theoretically justified. Model performance was evaluated through R^2 and adjusted R^2 values [32,52–55]. Estimation was conducted using variance-based PLS-SEM with the path-weighting scheme. Bootstrapping with 5000 resamples was applied to generate standard errors, t-statistics, and bias-corrected confidence intervals, using two-tailed significance testing at $\alpha = 0.05$. Significance was judged from bootstrapped confidence intervals and associated p-values. Global model diagnostics included the standardized root mean square residual (SRMR, target < 0.08), along with d_ULS and d_G discrepancy measures, and the normed fit index (NFI) as an additional indicator [32,52–55]. Out-of-sample predictive validity was assessed using PLSpredict with 10-fold cross-validation, comparing prediction errors (RMSE and MAE) against linear benchmark models at the indicator level to evaluate practical predictivity.

All variables were coded so that higher scores reflected stronger pro-environmental attitudes, greater perceived social norms, stronger perceived control, stronger behavioral intentions, and higher adaptive capacity. Indicators covered knowledge and beliefs about marine and river pollution, household and plastic waste practices such as sorting, reducing single-use plastics, and participation in clean-ups, along with perceptions of government support, enforcement, and provision of waste facilities. This ensured alignment between the conceptual framework and the measurement model. With 63 valid cases, the study was designed as a preliminary exploration rather than a confirmatory test. PLS-SEM was appropriate given its robustness to small samples, ordinal indicators, and non-normal distributions, as well as its prediction orientation. While the modest sample limited the statistical power to detect very small effects and constrained the feasibility of extensive subgroup analysis, it was sufficient for identifying stable measurement properties and testing initial structural relationships.

III. RESULTS AND DISCUSSION

Table 1 presents the descriptive statistics of all questionnaire items used in the study, covering attitudes, subjective norms, perceived behavioral control, intentions, behaviors, and adaptive capacity. The table reports mean, median, scale range, standard deviation, excess kurtosis, and skewness for each item. Most items scored relatively high, particularly knowledge-related statements such as awareness that marine pollution reduces fish stocks (mean = 4.603) and understanding that throwing garbage into rivers pollutes the water (mean = 4.54). In contrast, items reflecting governance support, such as the adequacy of waste bank programs (mean = 2.746) and strict enforcement against littering (mean = 2.762), received lower scores. The skewness and kurtosis values were generally within acceptable ranges, confirming that the data distribution was appropriate for further PLS-SEM analysis.

TABLE 1.
DESCRIPTIVE STATISTICS OF QUESTIONNAIRE ITEMS ON HOUSEHOLD WASTE, SANITATION, AND MARINE DEBRIS BEHAVIOR IN GORONTALO.

No	Name	Mean	Median	Scale min	Scale max	Standard deviation	Excess kurtosis	Skewness
1	I know marine pollution reduces fish stocks and fishermen's catches.	4.603	5	3	5	0.631	0.767	-1.373
2	I know that throwing garbage into rivers or the sea pollutes the water.	4.54	5	3	5	0.686	0.147	-1.204
3	I know unmanaged waste can cause floods during the rainy season.	4.524	5	3	5	0.663	0.025	-1.093
4	I brought my garbage back home when visiting the beach.	3.397	4	1	5	1.475	-1.094	-0.568
5	I will buy products with eco-friendly packaging.	4.27	5	3	5	0.82	-1.321	-0.547
6	I will join a community group that works to keep the sea clean.	3.746	4	2	5	0.908	-1.167	0.143
7	I always bring my own shopping bag when shopping.	3.286	3	1	5	0.967	-0.248	-0.071
8	I always sort my household waste.	3.524	4	1	5	1.18	-0.41	-0.533
9	I reduce waste at home as part of my daily habit.	3.921	4	1	5	1.103	0.361	-0.931
10	I reduced my use of single-use plastic packaging.	4.063	4	1	5	0.924	0.299	-0.748
11	I will join neighborhood clean-up activities.	4.127	4	1	5	0.9	0.847	-0.928
12	I will reduce my use of single-use plastic packaging.	3.222	3	1	5	0.999	-0.077	0.023
13	I regularly join beach clean-up activities.	3.222	3	1	5	1.09	-0.42	-0.008
14	I never litter in coastal areas.	4.54	5	2	5	0.752	2.698	-1.743
16	The city government provides adequate waste management facilities.	2.984	3	1	5	1.091	-0.923	0.107
17	The government provides enough trash bins in public spaces.	3.317	4	1	5	1.066	-0.919	-0.272
18	The government strictly punishes people who litter.	2.762	3	1	5	1.388	-1.239	0.186
19	The government promotes waste management effectively.	3.127	3	1	5	1.12	-0.859	0.16
20	The government's waste bank program works well.	2.746	3	1	5	1.195	-1.137	-0.004

Table 2 summarizes the results of the reliability and validity assessment for the constructs included in the TPB-based model with adaptive capacity. The measures demonstrated acceptable to strong internal consistency, with Cronbach's alpha values ranging from 0.557 to 0.857 and composite reliability coefficients (ρ_c) all exceeding the 0.70 threshold for most constructs. Average variance extracted (AVE) values were above the recommended 0.50 cutoff, indicating convergent validity. Adaptive capacity ($\alpha = 0.857$; AVE = 0.639) and attitudes ($\alpha = 0.804$; AVE = 0.720) achieved the strongest reliability and validity. In contrast, subjective

norms ($\alpha = 0.557$; AVE = 0.533) and behaviors ($\alpha = 0.540$; AVE = 0.647) showed lower reliability, which is common in preliminary studies with smaller item sets. The explained variance (R^2) for endogenous constructs showed that intentions ($R^2 = 0.447$; adjusted $R^2 = 0.419$) and perceived behavioral control ($R^2 = 0.459$; adjusted $R^2 = 0.441$) had moderate predictive power, while behaviors ($R^2 = 0.173$; adjusted $R^2 = 0.159$) were more weakly explained.

TABLE 2.
RELIABILITY AND VALIDITY ASSESSMENT OF CONSTRUCTS RELATED TO WASTE AND MARINE BEHAVIOR.

Attribute	Reliability and validity					
	Cronbach's alpha	Composite reliability (ρ_a)	Composite reliability (ρ_c)	AVE	R^2	R^2 adjusted
Adaptive capacity	0.857	0.863	0.898	0.639	-	-
Attitudes	0.804	0.809	0.885	0.72	-	-
Behaviors	0.54	0.454	0.786	0.647	0.173	0.159
Intentions	0.672	0.672	0.859	0.753	0.447	0.419
Perceived behavioral control	0.739	0.769	0.838	0.569	0.459	0.441
Subjective norms	0.557	0.576	0.772	0.533	0	-0.016

Figure 2 presents the results of the structural equation modeling (SEM) used to test the hypotheses H1–H7 within the extended Theory of Planned Behavior framework. The model shows the causal relationships among attitudes, subjective norms, perceived behavioral control, intentions, and behaviors, while integrating adaptive capacity as a governance-relevant antecedent. Attitudes were hypothesized to influence intentions (H1), but the path coefficient indicates that this relationship is weaker compared to other drivers. Subjective norms were expected to shape intentions (H2), and the model confirms a meaningful positive effect, reflecting that social expectations and commitments play an important role in encouraging households to act more sustainably. Perceived behavioral control was hypothesized to affect both intentions (H3) and behaviors directly (H6). The results indicate that PBC strongly predicts intentions, suggesting that households with higher confidence in

their ability to manage waste are more likely to form pro-environmental commitments, while its direct effect on behavior remains modest. Adaptive capacity was included as an exogenous construct to test H4–H6, with the hypothesis that governance capacity enhances PBC (H4), intentions (H5), and possibly behaviors directly (H6). The results demonstrate that adaptive capacity significantly strengthens PBC, which in turn mediates its influence on behavioral outcomes. This confirms that governance support such as waste bins, enforcement, and waste banks plays a decisive role in enabling households to feel capable of adopting better waste practices. Intentions were hypothesized to drive actual behaviors (H7), and the model strongly supports this pathway, showing that intentions to reduce single-use plastics or join clean-up activities translate into tangible pro-environmental behaviors.

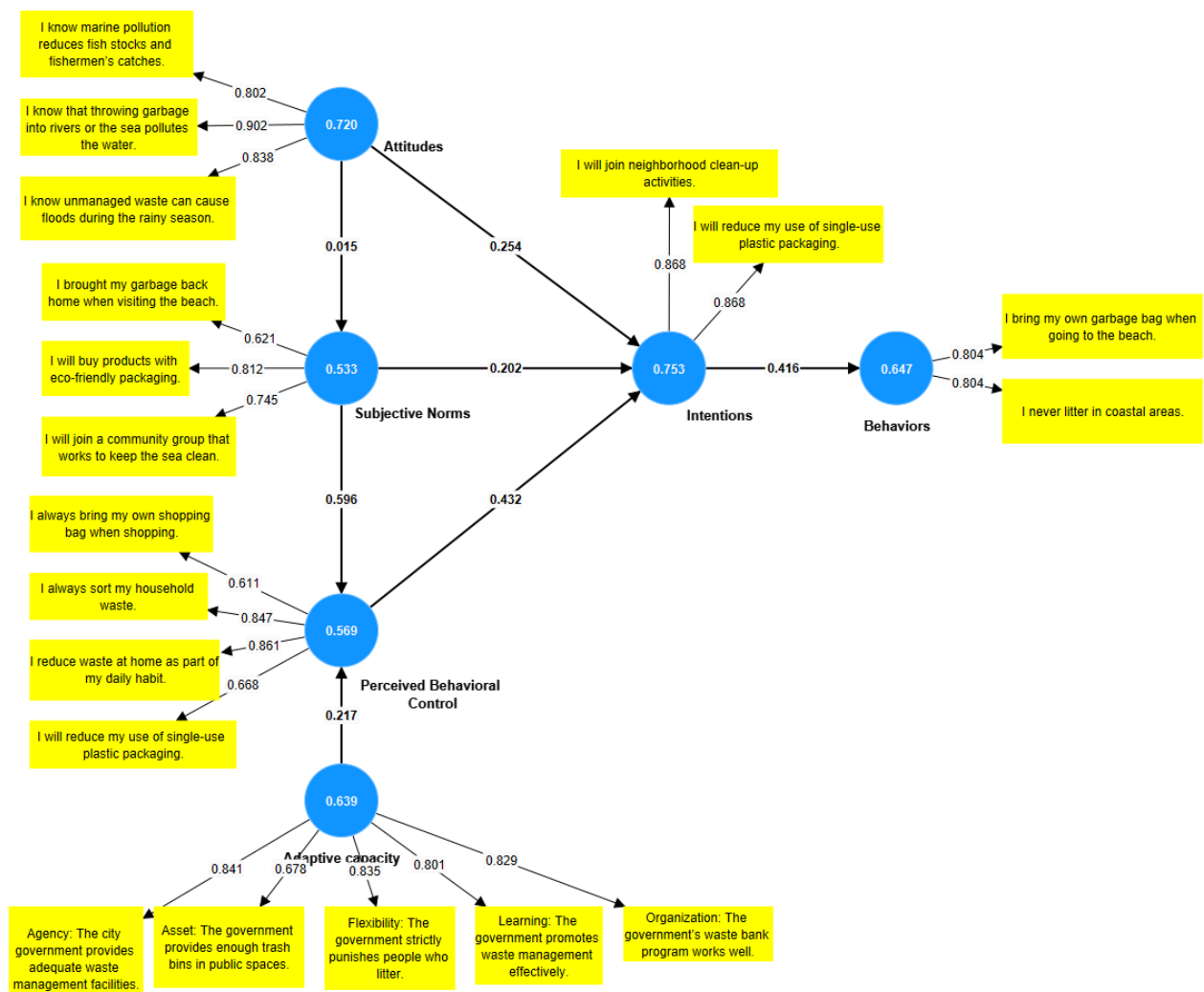


Figure 2. SEM results showing coefficient paths and AVE values.

Table 3 presents the Heterotrait–Monotrait Ratio (HTMT) assessment of discriminant validity for the constructs included in the extended Theory of Planned Behavior model. Discriminant validity ensures that each construction is empirically distinct from the others, which is a fundamental requirement in structural equation modeling. The HTMT values reported range

from 0.087 to 1.008. Most inter-construct correlations fall well below the conservative threshold of 0.85 and the liberal threshold of 0.90, indicating satisfactory discriminant validity across the majority of constructs. For instance, the HTMT ratio between adaptive capacity and attitudes is 0.349, while between adaptive capacity and behaviors it is 0.163, both comfortably within

acceptable bounds. Similarly, the relationship between subjective norms and attitudes registers a ratio of 0.256, further supporting construct distinctiveness. However, one pair perceived behavioral control and subjective norms records a value of 1.008, which slightly exceeds conventional thresholds. This suggests a potential overlap between these two constructs, possibly reflecting their conceptual proximity in the context of waste governance and community participation in Gorontalo. While this requires cautious interpretation, the overall HTMT profile confirms that the measurement model maintains adequate discriminant validity, thereby supporting its use for hypothesis testing in the SEM analysis.

TABLE 3.
HTMT (HETERO-TRAIT-MONOTRAIT RATIO) ASSESSMENT OF
DISCRIMINANT VALIDITY FOR HOUSEHOLD WASTE AND MARINE
CONSTRUCTS.

Discriminant validity				
Matrix	Adaptive capacity	Attitudes	Behaviors	Intentions
Adaptive capacity				
Attitudes	0.349			
Behaviors	0.163	0.517		
Intentions	0.087	0.465	0.753	
Perceived Behavioral Control	0.441	0.331	0.726	0.894
Subjective Norms	0.372	0.256	0.683	0.797

Table 4 presents the results of hypothesis testing for the structural equation model, covering both direct and indirect effects within the extended TPB framework. The model integrates adaptive capacity as a governance-related antecedent to better understand household waste management practices in Gorontalo. The direct effects demonstrate varying levels of statistical significance across the hypothesized pathways. The relationship between attitudes and subjective norms (H1) was found to be nonsignificant ($p = 0.899$), suggesting that positive attitudes toward waste reduction and marine protection do not automatically translate into perceptions of social expectations. By contrast, subjective norms had a highly significant positive influence on perceived behavioral control (H2, $p < 0.001$), highlighting the role of collective pressure and community engagement in strengthening individual perceptions of capability. Adaptive capacity also exhibited a significant effect on perceived behavioral control (H3, $p = 0.028$), underscoring the importance of governance structures, such as local government support and waste management facilities, in shaping household confidence to act. Attitudes were further shown to directly influence intentions (H4, $p = 0.038$), reinforcing the expectation that pro-environmental values contribute to stronger commitments toward sustainable waste practices. Subjective norms were even more decisive in predicting intentions (H5, $p < 0.001$), confirming that households are more likely to act when they perceive collective endorsement of waste management behaviors. Perceived behavioral control also emerged as a significant

determinant of intentions (H6, $p = 0.002$), reflecting the critical role of self-efficacy in shaping pro-environmental commitments. Finally, intentions were strongly linked to actual behaviors (H7, $p < 0.001$), demonstrating that stated commitments translate into tangible waste management practices, such as bringing garbage bags to the beach or avoiding littering in coastal areas. The indirect effects provide additional insights into the pathways that link governance, psychosocial constructs, and behavior. Adaptive capacity exerted indirect influences on behaviors ($p = 0.065$) and intentions ($p = 0.051$), both at marginal levels of significance, suggesting that governance factors operate partly through perceived behavioral control and intentions. Similarly, attitudes displayed a marginal indirect effect on behaviors ($p = 0.062$), mediated through intentions. Perceived behavioral control exerted a significant indirect effect on behaviors ($p = 0.012$), confirming its mediating role between governance factors and actual practices. Subjective norms also contributed significant indirect effects on behaviors ($p = 0.006$), reinforcing the idea that social expectations not only shape intentions but also indirectly drive behavior.

The results of this study provide strong empirical support for the TPB as a useful framework for understanding household waste management behaviors in Gorontalo's coastal and urban settings. The testing of H1–H7 highlights both the strengths and limitations of psychosocial determinants in predicting pro-environmental intentions and behaviors, while the integration of adaptive capacity underscores the importance of governance in shaping individual and collective action. These findings align with global evidence that waste management behaviors are not only determined by personal attitudes but also embedded in broader social, organizational, and policy contexts [57–59]. One of the first notable results is the nonsignificant relationship between attitudes and subjective norms (H1). Although respondents expressed strong awareness of marine pollution, flooding risks, and waste-related environmental damage, these attitudes did not translate into greater perceptions of social pressure or collective expectations. This gap reflects earlier findings that environmental awareness does not automatically lead to normative shifts or collective behavior unless supported by visible community practices and institutional reinforcement. In Gorontalo, while residents recognize the ecological consequences of unmanaged waste, there may still be limited integration of these attitudes into shared norms, especially in informal coastal communities where social sanctions against littering remain weak.

In contrast, the significant effect of subjective norms on perceived behavioral control (H2, $p < 0.001$) illustrates that when individuals perceive that their neighbors, family members, or community leaders support waste reduction, they feel more capable of engaging in those practices. This resonates with findings from Chenl. (2015), who showed that collective endorsement of recycling norms substantially strengthened individual self-efficacy [60]. In Gorontalo, this suggests that social mobilization campaigns,

neighborhood clean-ups, and public religious or cultural messaging could play an important role in building community confidence for sustainable waste practices. The role of adaptive capacity (H3) was also significant, supporting the argument that governance structures, institutional support, and public services influence household perceptions of control. When respondents felt that local governments provided adequate bins, enforced anti-littering laws, or supported waste banks, their sense of agency and perceived capacity to act increased. This confirms the idea that self-efficacy is shaped not only by

individual confidence but also by systemic conditions [61,62]. Governance-linked antecedents have been emphasized in Southeast Asian cities, where informal waste systems often undermine formal services, requiring stronger organizational performance and institutional trust [63–65]. For Gorontalo, where sanitation and waste services are unevenly distributed between urban and peri-coastal areas, this result highlights the need for investments in equitable infrastructure and transparent reporting systems.

TABLE 4.
HYPOTHESIS TESTING RESULTS ON HOUSEHOLD WILLINGNESS TO PARTICIPATE IN WASTE AND MARINE GOVERNANCE.

H	Attribute	Original sample	Sample mean	Standard deviation	T-statistics	p-value
Direct effect						
H1	Attitudes → Subjective norms	0.015	0.01	0.121	0.127	0.899
H2	Subjective Norms → Perceived behavioral control	0.596	0.592	0.083	7.206	< 0.001
H3	Adaptive capacity → Perceived behavioral control	0.217	0.215	0.098	2.202	0.028
H4	Attitudes → Intentions	0.261	0.252	0.126	2.079	0.038
H5	Subjective Norms → Intentions	0.459	0.466	0.09	5.087	< 0.001
H6	Perceived behavioral control → Intentions	0.432	0.414	0.142	3.035	0.002
H7	Intentions → Behaviors	0.416	0.42	0.1	4.146	< 0.001
Indirect effect						
	Adaptive capacity → Behaviors	0.039	0.035	0.021	1.846	0.065
	Adaptive capacity → Intentions	0.094	0.086	0.048	1.949	0.051
	Attitudes → Behaviors	0.109	0.105	0.058	1.866	0.062
	Attitudes → Perceived behavioral control	0.009	0.008	0.073	0.125	0.9
	Perceived behavioral control → Behaviors	0.18	0.173	0.072	2.506	0.012
	Subjective Norms → Behaviors	0.191	0.199	0.069	2.764	0.006

Attitudes had a modest but significant effect on intentions (H4, $p = 0.038$). This indicates that environmental values and awareness do contribute to behavioral commitments, even though their effect is weaker than social or governance influences. This is consistent with earlier meta-analyses that found attitudes often play a supporting rather than primary role in explaining waste-related behaviors [66,67]. Subjective norms, however, emerged as a much stronger determinant of intentions (H5, $p < 0.001$). This aligns with collectivist cultural contexts, such as Indonesia, where social approval and alignment with community expectations are powerful motivators [68]. Interventions that strengthen positive social norms around waste, such as public pledges, school campaigns, or faith-based programs, may therefore be more effective in shaping commitments than campaigns relying solely on awareness raising. Perceived behavioral control was also a robust predictor of intentions (H6, $p = 0.002$). Respondents who believed they had the ability, resources, and opportunities to manage waste were significantly more likely to commit to reducing single-use plastics or joining community clean-ups. This finding is particularly important in policy design, as it suggests that building supportive environments where households feel capable of acting is essential. International research has similarly demonstrated that

convenience, infrastructure, and institutional support are decisive in shaping waste behaviors, often more so than values alone [58,69–71].

Intentions strongly predicted behaviors (H7, $p < 0.001$), demonstrating that stated commitments translated into actual practices such as bringing garbage bags to the beach or avoiding littering in coastal areas. This confirms the predictive validity of TPB in the Gorontalo context and highlights the importance of strengthening intentions as an intermediate step toward behavior change. The indirect effects also provide meaningful insights. Adaptive capacity, attitudes, and subjective norms influenced behaviors indirectly through intentions and perceived control. This underscores the layered nature of waste governance, where institutional readiness and social expectations reinforce individual-level commitments and actions. The policy implications of these findings are significant for Gorontalo and similar coastal provinces in Indonesia. Strengthening adaptive capacity through investments in bins, drainage, and waste banks should be prioritized, as these measures directly enhance perceptions of control. Equally, fostering strong social norms through community-based and religious organizations can reinforce commitments to waste reduction. Programs must also address the current gap between environmental attitudes and normative influence, by making pro-environment

behaviors more visible, valued, and socially expected [72–75]. This may include campaigns highlighting the linkage between waste management, marine fisheries, and local livelihoods, reinforcing the direct benefits of sustainable practices.

From a governance perspective, these results also align with Indonesia's national commitment to reduce marine plastic debris by 70% by 2025 [51,76]. Achieving this target will require local governments like Gorontalo to not only improve infrastructure but also empower communities through agency, organizational support, and participatory decision-making. Embedding adaptive capacity within household-level behavior frameworks such as TPB provides a stronger bridge between individual psychology and institutional governance, which is critical for tackling marine plastic pollution. This study demonstrates that waste-related behaviors in Gorontalo are driven less by individual attitudes alone and more by the interplay of social norms, perceived behavioral control, and adaptive capacity. Policy interventions should therefore be designed to reinforce community norms, expand institutional support, and create enabling conditions for households to feel both capable and obligated to act. By aligning psychosocial determinants with governance investments, Gorontalo can safeguard its marine natural capital and contribute to Indonesia's broader sustainability agenda.

IV. CONCLUSION

This preliminary study in Gorontalo Province demonstrates that household waste management behaviors, particularly those linked to coastal and marine protection, are best explained by an integrated framework combining the Theory of Planned Behavior with governance-related antecedents of adaptive capacity. While environmental attitudes were positively related to intentions, their effect was modest compared to the much stronger influence of subjective norms and perceived behavioral control. Social expectations within communities played the most decisive role in shaping intentions, highlighting the significance of collective endorsement in a cultural context where community influence and group cohesion are central. Perceived behavioral control emerged as both a direct and indirect driver of waste-related intentions and behaviors, indicating that confidence in one's own ability to manage waste is essential for action. Adaptive capacity further strengthened these dynamics, as governance provisions such as adequate waste facilities, enforcement of anti-littering rules, and waste bank programs enhanced perceived behavioral control and indirectly fostered pro-environmental behaviors. Intentions were the strongest predictor of actual behaviors, confirming the TPB assumption that commitments serve as the bridge between psychological drivers and concrete action. The findings underline the importance of aligning psychosocial determinants with governance structures to foster sustainable household waste practices in Gorontalo. Building adaptive capacity, reinforcing positive social norms, and improving community perceptions of control are critical for safeguarding

marine natural capital and supporting Indonesia's broader waste reduction and sustainability targets.

A. Limitation and Future Studies

Although this study provides important early insights, its preliminary nature and modest sample size limit the generalizability of the results. Future research should expand to larger and more representative samples across Gorontalo Province, including rural and peri-coastal communities with different waste governance conditions. Longitudinal designs would allow for the testing of behavioral change over time, capturing how shifts in governance capacity and social norms alter household practices. Comparative studies across Indonesian coastal cities or within other Southeast Asian contexts would provide further evidence on the robustness of the extended TPB framework and help identify context-specific versus generalizable drivers of waste behavior. Moreover, future studies could integrate experimental or intervention-based designs, such as testing the effectiveness of social norm campaigns, governance reforms, or infrastructure improvements, to establish causal relationships. Additional attention should also be given to refining the measurement of adaptive capacity by incorporating digital governance tools, informal sector contributions, and cross-border marine waste dynamics. By addressing these gaps, future work can more precisely guide policies and community-based programs for reducing marine plastic pollution and strengthening sustainable waste governance in archipelagic and coastal settings.

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