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Intention and Willingness for Digital Participation in Marine Waste Management in Batam, Indonesia: Integrating the Theory of Planned Behavior and Adaptive Capacity

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ABSTRAK

Penelitian ini menganalisis faktor-faktor yang memengaruhi niat dan kesediaan untuk berpartisipasi secara digital dalam pengelolaan sampah laut di Batam, Indonesia, dengan mengintegrasikan Theory of Planned Behavior (TPB) dan kapasitas adaptif. Survei dilakukan terhadap 450 penduduk dewasa Batam yang aktif menggunakan platform digital, dan data dianalisis menggunakan Partial Least Squares Structural Equation Modeling (PLS-SEM). Hasil menunjukkan bahwa kapasitas adaptif berpengaruh positif dan signifikan terhadap niat (β = 0,790; p < 0,001) dan kesediaan berpartisipasi (β = 0,613; p < 0,001). Niat juga berpengaruh signifikan terhadap kesediaan berpartisipasi (β = 0,775; p < 0,001). Sebaliknya, sikap, norma subjektif, dan perceived behavioral control tidak menunjukkan pengaruh langsung yang signifikan terhadap niat maupun kesediaan berpartisipasi. Model menjelaskan 62,2% variasi niat dan 60,1% variasi kesediaan berpartisipasi. Temuan ini menunjukkan bahwa pada penduduk Batam yang aktif secara digital, kemampuan untuk menyesuaikan perilaku digital, belajar, berkolaborasi, dan memanfaatkan platform sosial lebih penting daripada sikap positif atau tekanan sosial saja dalam membentuk kesiapan berpartisipasi. Hasil penelitian ini dapat mendukung pengembangan literasi digital, pelaporan sampah laut berbasis masyarakat, kampanye daring, dan kolaborasi pemerintah–komunitas. Namun, temuan merepresentasikan niat dan kesediaan, bukan perilaku aktual atau dampak langsung terhadap pengurangan sampah laut.

Kata kunci: kapasitas adaptif, kesediaan berpartisipasi, niat, partisipasi digital, pengelolaan sampah laut, Theory of Planned Behavior

ABSTRACT

This study examines the factors influencing intention and willingness for digital participation in marine waste management in Batam, Indonesia, by integrating the Theory of Planned Behavior (TPB) with adaptive capacity. A survey was conducted among 450 digitally active adult residents of Batam, and the data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). Adaptive capacity had significant positive effects on intention (β = 0.790, p < 0.001) and willingness to participate (β = 0.613, p < 0.001). Intention also significantly predicted willingness to participate (β = 0.775, p < 0.001). In contrast, attitudes, subjective norms, and perceived behavioral control showed no significant direct effects on either intention or willingness to participate. The model explained 62.2% of the variance in intention and 60.1% of the variance in willingness to participate. These findings suggest that, among digitally active residents of Batam, the ability to adjust digital practices, learn, collaborate, and use social media platforms may be more important than favorable attitudes or social pressure alone in shaping readiness for participation. The findings can inform digital literacy initiatives, community-based marine debris reporting, online campaigns, and government–community collaboration. However, the study captures stated intention and willingness rather than actual participation or direct environmental outcomes.

Keywords: adaptive capacity, digital participation, intention, marine waste management, Theory of Planned Behavior, willingness to participate

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1. INTRODUCTION

Marine plastic pollution has emerged as a pervasive environmental challenge of the twenty-first century, exhibiting far-reaching consequences for marine ecosystems, coastal economies, tourism, fisheries, and community well-being (Adam, 2022;

Kurniawan et al., 2023; Ulhasanah et al., 2025a). Indonesia has consistently been recognized as a critical case in the global discourse on marine plastic leakage. Early global assessments, notably those reported by Jambeck et al. (2015), positioned Indonesia among nations with exceptionally high levels of mismanaged plastic waste entering the marine environment. However, such historical rankings should not be construed as a static global position, given the dynamic evolution of marine plastic estimates alongside advancements in waste-management systems, data availability, and methodological approaches. More recent investigations continue to affirm that Indonesia confronts substantial challenges related to marine debris, waste leakage, and coastal waste governance (Jambeck et al., 2015; Sianipar et al., 2022). These challenges are particularly pronounced in coastal and island urban centers, where inadequately managed waste from households, commercial enterprises, industry, transportation, and urban consumption can be rapidly transferred into the marine environment via drainage systems, rivers, shorelines, and maritime activities (Chubarenko et al., 2021; Gunasekara et al., 2025; Nurhati and Cordova, 2020).

Batam offers a particularly salient context for the examination of this issue. Situated in the Riau Islands Province within the Indonesia–Malaysia–Singapore Growth Triangle, Batam is characterized by accelerated urban and industrial development, intensive maritime activities, tourism, manufacturing, and a geographically dispersed coastal and island environment. These attributes establish multiple pathways through which terrestrial and maritime waste may ingress into coastal waters. Prior research has identified marine debris and plastic-waste pressures in Indonesian island and coastal environments, including areas associated with Batam and the Riau Islands (Nurhati and Cordova, 2020; Widiastutie et al., 2025). Local waste-management data further underscore the magnitude of the challenge. Batam generated approximately 432,868 tons of municipal solid waste in 2024, yet only 17.52% was reported as being managed through 3R (Reduce, Reuse, Recycle) practices, indicating considerable scope for improvement in waste reduction, reuse, and recycling (Sekretariat Satu Data Kota Batam, 2025).

Concurrently, Batam presents a significant digital context. As a highly urbanized city with robust economic linkages to Singapore and Malaysia, information and communication technologies (ICTs) have become progressively embedded in daily communication, business operations, public services, and community interaction. Official statistical publications from BPS Kota Batam specifically monitor indicators related to internet access reflecting the increasing salience of digital connectivity within the city (Badan Pusat Statistika Provinsi Kep. Riau, 2025). Earlier BPS-based evidence also indicated relatively extensive internet use among Batam residents, supporting the relevance of digital platforms as conduits for communication and community engagement. These environmental and digital characteristics render Batam suitable for investigating how digitally active residents perceive and respond to opportunities for participating in marine waste initiatives. Crucially, however, the present study does not presuppose that digital engagement automatically leads to measurable reductions in marine debris. Instead, it focuses on the behavioral antecedents of intention and willingness to participate through digital platforms.

Marine waste governance has historically relied upon regulatory instruments, physical waste-management infrastructure, collection systems, recycling, clean-up activities, and institutional enforcement (Wilson, 2023; Wu, 2022). These approaches remain indispensable, as marine debris cannot be mitigated through communication or awareness alone. Nevertheless, public participation can complement formal waste-management systems by facilitating information dissemination, citizen reporting, community mobilization, environmental education, and coordination of collective activities (D'Amico et al., 2021; Grace et al., 2023; Suhardono et al., 2025; Ulhasanah et al., 2025b). The proliferation of social media and mobile technologies has generated additional opportunities for such participation by enabling environmental information to circulate rapidly among individuals, communities, organizations, and governmental institutions (Zhang et al., 2024). Digital participation in this context can encompass diverse forms of engagement. Individuals may receive environmental information, share or repost campaign materials, engage in online discussions, create digital content, report environmental problems, or coordinate participation in offline activities. Digital platforms therefore possess the potential to bridge environmental awareness with collective action, although the mere presence of these platforms does not guarantee participation or environmental improvement (Hafferty et al., 2024; Kloppenburg et al., 2022; Sharma et al., 2022). In In marine waste management, online campaigns may enhance awareness of pollution sources and impacts, foster more responsible consumption and disposal practices, and facilitate community initiatives such as beach clean-ups and recycling activities (Jirasit, 2024; Suryawan et al., 2024). Digital engagement is consequently better understood as a potential supporting mechanism within environmental governance, rather than as a direct metric of marine waste-management effectiveness. This distinction is vital because willingness to participate, online engagement, actual behavioral participation, and measurable environmental outcomes represent distinct stages of the participation process.

Despite the escalating role of digital technologies in public engagement, significant research gaps

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persist. Much of the literature on digital participation has concentrated on political activism, civic mobilization, disaster communication, or online collective action (Cao et al., 2021; Chekirova, 2022; Cheng et al., 2023; Hasfi et al., 2021). Comparatively less scholarly attention has been dedicated to digital mediation participation in environmental management, particularly within rapidly developing coastal cities in the Global South. Existing research on digital engagement also demonstrates that merely providing digital access is insufficient to ensure sustained participation; psychological motivation, perceived ability, learning capacity, and engagement processes remain crucial (Lippke et al., 2021; Lipschitz et al., 2023; Nahum-Shani et al., 2022).

The Theory of Planned Behavior (TPB) furnishes a valuable foundation for examining these differences. According to TPB, behavioral intention is primarily shaped by attitudes toward the behavior, subjective norms, and perceived behavioral control. Attitudes represent positive or negative evaluations of participation; subjective norms reflect perceived expectations or encouragement from salient social groups; and perceived behavioral control captures individuals' perceived ability and opportunity to perform the behavior (Alharbi et al., 2025; Guo et al., 2022; Khaliqi et al., 2023; Vijayan et al., 2023). This necessitates behavioral frameworks capable of elucidating why digitally connected individuals may nonetheless differ substantially in their intention and willingness to participate. (Alharbi et al., 2025; Guo et al., 2022; Khaliqi et al., 2023; Vijayan et al., 2023). In environmental behavior research, these constructs have been extensively employed to explain intention and willingness to adopt environmentally responsible practices.

However, digitally mediated environmental participation may entail additional capabilities not fully represented by the conventional TPB constructs. An individual may harbor a favorable attitude toward marine waste reduction, perceive strong encouragement from family or peers, and possess access to social media, yet still lack the capacity to identify appropriate campaigns, adapt online practices, learn from previous activities, collaborate digitally, or respond flexibly to new environmental information. This limitation is particularly pertinent in dynamic digital environments, where participation demands more than general approval of an environmental objective.

For this reason, the present study extends TPB by incorporating adaptive capacity. Adaptive capacity is defined herein as the ability of individuals to adjust their digital practices, learn from prior experiences, seek new information and participation opportunities, modify the type of content they share, and collaborate with others in response to evolving environmental needs. This concept has been widely applied in studies of resilience, environmental adaptation, and community responses to changing conditions (Rahman et al., 2025a; Sianipar et al., 2025; Sofiyah et al., 2026b; Suryawan et al., 2027; Ulhasanah et al., 2025b; Yang et al., 2024), Nevertheless, its application to digital environmental participation remains relatively constrained.

Integrating adaptive capacity with TPB therefore offers an opportunity to distinguish between having favorable perceptions toward participation and possessing the adaptive capability required to engage through digital platforms. This distinction is particularly important for the present study because adaptive capacity, intention, and willingness to participate are conceptually related but not identical. Adaptive capacity represents perceived capability for adjustment, learning, information seeking, and collaboration. Intention signifies a prospective motivational commitment to participate. Willingness to participate denotes stated readiness to undertake specific forms of digitally mediated engagement, such as sharing information, joining online discussions, or creating environmental content. None of these constructs should be interpreted as equivalent to directly observed environmental behavior or measured reductions in marine debris.

Accordingly, this study integrates the Theory of Planned Behavior and adaptive capacity to examine the factors associated with intention and willingness for digital participation in marine waste management among digitally active adult residents of Batam. The study does not evaluate the direct effectiveness of digital participation in reducing marine waste; rather, it investigates the psychological, social, perceived-control, and adaptive factors that shape residents' stated readiness to engage. By establishing this distinction, the study contributes to literature in three ways. First, it extends conventional TPB by incorporating adaptive capacity as an additional explanatory construct in digitally mediated environmental participation. Second, it disaggregates intention and willingness from actual participation and environmental outcomes, providing a more circumspect interpretation of digitally mediated engagement. Third, it provides context-specific evidence from a rapidly developing Indonesian coastal city where marine waste pressures coexist with expanding digital connectivity.

The Batam case is thus theoretically and practically relevant. From a theoretical perspective, it facilitates the examination of whether conventional TPB predictors remain dominant when participation occurs through digital platforms or whether adaptive capacity offers additional explanatory power. From a governance perspective, understanding these behavioral relationships may assist local government, coastal communities, waste-management actors, and digital-platform users in designing more appropriate mechanisms for environmental communication, marine-debris reporting, community campaigns, and online-to-offline participation. These implications should nevertheless be interpreted as potential applications of behavioral findings rather than as evidence that digital participation has already yielded

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measurable improvements in marine waste conditions. Figure 1 presents the conceptual framework linking attitudes, subjective norms, perceived behavioral control, and adaptive capacity with intention and willingness to participate in social media-based marine waste management in Batam. The framework positions TPB constructs and adaptive capacity as the principal explanatory factors, intention as a proximal psychological process, and willingness to participate as the stated participation outcome.

2. METHODOLOGY

2.1. Study Area

The study was conducted in Batam City, Riau Islands Province, Indonesia (Figure 2), an archipelagic and rapidly urbanizing coastal city located within the Indonesia–Malaysia–Singapore Growth Triangle. Batam has developed into a major center for manufacturing, shipping, logistics, tourism, and maritime services. Its strategic economic role has encouraged rapid population growth, urban expansion, and increased consumption, while also creating considerable pressure on coastal and marine environments. The city's geographical characteristics make marine waste management particularly important. Batam consists of a main urban island and numerous surrounding coastal and island communities, where waste generated from households, commercial activities, tourism, industry, and maritime transport can enter drainage systems, coastal waters, and nearshore environments. Previous studies have highlighted the persistence of marine debris and plastic-waste pressures in Indonesian coastal and island environments, including the Riau Islands region (Nurhati & Cordova, 2020; Widiastutie et al., 2025). These conditions make Batam an appropriate location for examining public engagement in marine waste management.

Batam is also relevant because environmental pressures coexist with increasing digital connectivity. Social media and mobile communication are widely integrated into daily communication, information exchange, community interaction, and public engagement. This digital context creates opportunities for residents to participate in marine waste-related activities through online campaigns, environmental information sharing, community discussions, and coordination of collective actions. Accordingly, Batam provides a suitable setting for examining how digitally active adult residents form intentions and willingness to participate in marine waste management through social media. The study does not assess the direct effectiveness of digital participation in reducing marine debris. Instead, Batam is used as a coastal urban case to investigate how behavioral factors and adaptive capacity are associated with stated intention and willingness for digitally mediated participation.

2.2. Sampling and Respondents

The target population for this study comprised adult residents of Batam City, aged 18 years or older, who actively engaged with digital platforms such as Facebook, Instagram, WhatsApp, or TikTok. These criteria were established to align with the study's specific focus on examining intentions and willingness to participate in marine waste-related activities via digital and social media channels. Consequently, the findings are representative of digitally active adult residents of Batam, rather than the broader Batam populace. This focus on digitally active Batam residents was integral to the original study design.

Respondents were recruited using a non-probability purposive/convenience sampling approach. The previous reference to "random sampling" has been removed due to the absence of a complete population sampling frame and the recruitment of respondents based on predefined eligibility criteria and accessibility. Data collection was facilitated through a hybrid approach, combining online and face-to-face surveys. The online survey was disseminated via digital communication and social media platforms, while face-to-face recruitment aimed to directly engage eligible respondents. This dual-mode approach was employed to enhance access to the target group, not to achieve probability-based representativeness. The previous manuscript similarly reported the use of both online and face-to-face data collection methods.

Eligibility for participation required respondents to: (1) be at least 18 years old; (2) reside in Batam City; (3) actively use at least one relevant digital or social media platform; and (4) voluntarily consent to complete the survey. Incomplete responses or those failing to meet the eligibility criteria were excluded from the final dataset. A total of 450 valid responses were collected between March and May 2025. This sample size was deemed adequate for the Partial Least Squares Structural Equation Modeling (PLS-SEM) analysis employed in the study, facilitating the estimation of relationships among attitudes, subjective norms, perceived behavioral control, adaptive capacity, intention, and willingness to participate.

The demographic composition of the sample exhibited a strong concentration among younger adults. Respondents aged 20–29 years constituted 59.1% (n = 266), followed by those aged 30–39 years at 28.4% (n = 128), 40–49 years at 9.3% (n = 42), and 50–59 years at 3.1% (n = 14). The sample was also predominantly unmarried, with 89.1% (n = 401) reporting single status and 10.9% (n = 49) reporting married status. Gender distribution was more balanced, comprising 58.4% male (n = 263) and 41.6% female (n = 187) respondents. These characteristics are pertinent to the interpretation of the study's findings. The observed concentration of younger, unmarried, and digitally active respondents may reflect the inherent biases associated with digital

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recruitment and social media engagement. Consequently, the results should not be generalized to the entire population of Batam, particularly older residents, individuals with limited digital access, or those who do not actively use social media. This limitation is now explicitly acknowledged within the manuscript. Prior to completing the questionnaire, all respondents received comprehensive information regarding the study's objectives, the voluntary nature of their participation, and the confidentiality of their responses. Information consent was obtained from all participants before their involvement in the study.

2.3. Questionnaire Design and Data Collection

The questionnaire was developed to measure psychological, social, and adaptive factors associated with intention and willingness for digital participation in marine waste management. The instrument was based on the Theory of Planned Behavior (TPB), which emphasizes attitudes, subjective norms, and perceived behavioral control as determinants of behavioral intention, while adaptive capacity was incorporated to capture respondents' ability to adjust, learn, seek information, and collaborate through digital platforms. The original instrument was structured around these constructs and used a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

To address possible conceptual overlap, the revised manuscript distinguishes the constructs more explicitly. Attitudes represent respondents' evaluations of engaging in social media-based marine waste activities. Subjective norms reflect perceived encouragement or expectations from family, friends, and the surrounding community. Perceived behavioral control refers to respondents' confidence and perceived ease of accessing and using social media for marine waste-related activities. Adaptive capacity refers to the ability to adjust digital habits, modify shared content, seek new campaigns or information, collaborate with others, and learn from previous online engagement.

Importantly, adaptive capacity is treated as an enabling capability rather than as actual participation. Although several adaptive-capacity items use action-oriented wording, such as seeking campaigns, collaborating, and learning from social media, these items were intended to represent flexibility, learning, and adjustment within digital environments rather than observed environmental behavior.

The study further distinguishes intention from willingness to participate. Intention represents a prospective motivational commitment to participate in social media campaigns related to marine waste reduction. It was measured using a single item: *"I intend to participate in social media campaigns about marine waste reduction in Batam."* Because intention was measured with a single indicator, internal consistency measures such as Cronbach's alpha and composite reliability are not applicable to this construct. This limitation is explicitly acknowledged in the revised manuscript.

In contrast, willingness to participate was measured using three items representing stated readiness to undertake specific forms of digital engagement: sharing or reposting information about beach clean-ups, participating in online discussions, webinars, or awareness campaigns, and creating or engaging with digital content such as videos, infographics, or hashtags. These indicators represent self-reported willingness rather than directly observed participation. The questionnaire also included socio-demographic information such as age, gender, marital status, education, and digital access. Before full implementation, the instrument was pre-tested with 30 respondents in Batam to assess clarity, wording, cultural appropriateness, and face validity. Feedback from the pre-test was used to simplify technical expressions and improve alignment with the local context of marine waste issues.

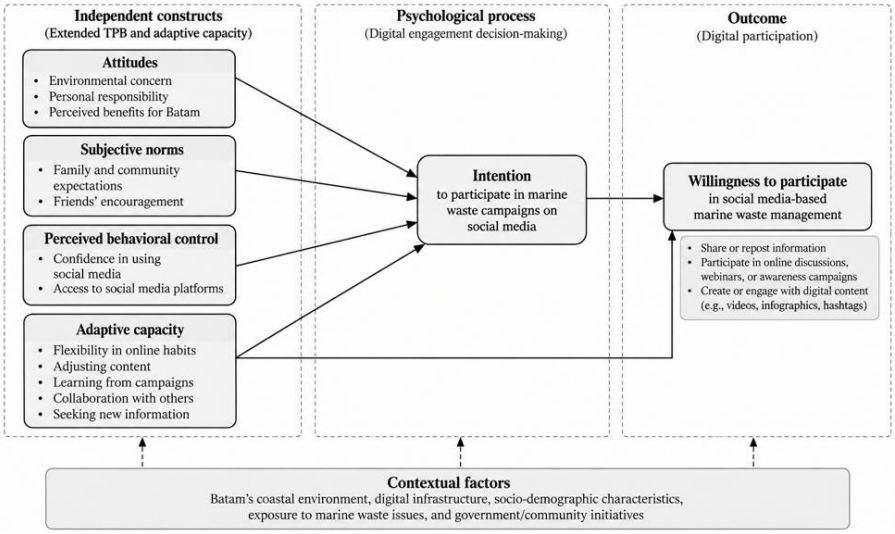


Figure 1. Conceptual Framework Integrating Theory of Planned Behavior (TPB) with Adaptive Capacity for Digital Participation in Marine Waste Management

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Data were subsequently collected through both online and face-to-face survey modes. Before participation, respondents were informed about the purpose of the study, anonymity and confidentiality of their responses, and the voluntary nature of participation. Informed consent was obtained before respondents completed the questionnaire. The questionnaire therefore captures perceptions, adaptive capability, intention, and stated willingness, rather than actual digital behavior or direct environmental outcomes. This distinction is important when interpreting the structural relationships examined in the subsequent PLS-SEM analysis.

2.4. Data Analysis

Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4.0. PLS-SEM was selected because the study examines multiple relationships among psychological, social, and adaptive constructs and focuses on explaining variation in intention and willingness to participate. The analysis followed two stages: assessment of the measurement model and evaluation of the structural model (Rahman et al., 2025a; Sianipar et al., 2025; Ulhasanah et al., 2025b; Yang et al., 2024). The measurement model was first evaluated to assess the reliability and validity of the constructs. For multi-item constructs, internal consistency reliability was examined using Cronbach's alpha, rho_A, and composite reliability (rho_C). Convergent validity was evaluated using indicator loadings and average variance extracted (AVE). Indicator loadings of approximately 0.60 or higher were considered acceptable, while AVE values above 0.50 indicated that a construct explained more than half of the variance in its indicators. Discriminant validity was also examined to ensure that theoretically related constructs, particularly adaptive capacity and willingness to participate, remained empirically distinguishable.

The intention construct was measured using a single indicator. Therefore, Cronbach's alpha and composite reliability were not interpreted for intention because internal consistency cannot be meaningfully evaluated for a single-item measure. The standardized loading of this indicator was 1.000, resulting in an AVE of 1.000. The use of a single-item intention measure is considered when interpreting the model and is acknowledged as a methodological limitation.

Following measurement-model assessment, the structural model was evaluated using standardized path coefficients (β), standard deviations (SD), t-statistics, p-values, and coefficients of determination (R^2). Statistical significance was evaluated at $p < 0.05$. R^2 values were used to assess the explanatory power of the model for endogenous constructs, including subjective norms, intention, and willingness to participate. Model-fit information, including the standardized root mean square residual (SRMR), squared Euclidean distance (d_ULS), geodesic distance (d_G), chi-square, and normed fit index (NFI), was also reported. Because the estimated-model SRMR exceeded the commonly applied conservative threshold, these fit statistics were interpreted cautiously rather than being used alone to claim overall model adequacy.

To address the proposed indirect relationships, mediation was assessed using specific indirect effects obtained through bootstrapping. An indirect effect was considered statistically supported when its bootstrap confidence interval did not include zero and the corresponding p-value was below 0.05. Mediation was therefore not inferred solely from the significance of individual direct paths. The type of mediation was interpreted by considering both the direct and indirect effects between the relevant constructs. Descriptive statistics, including means, skewness, and excess kurtosis, were additionally calculated for each questionnaire item to summarize respondents' response patterns. The structural findings were interpreted specifically as relationships among perceptions, adaptive capacity, intention, and stated willingness to participate. They were not interpreted as evidence of actual digital behavior or direct reductions in marine waste, because these outcomes were not directly measured in the study.

3. RESULTS

Table 1 presents the descriptive statistics of the items used to measure digital participation in marine waste management among respondents in Batam. The mean values indicate generally positive attitudes toward social media as a tool for supporting marine waste reduction, particularly in terms of recognizing its importance for protecting Batam's coastal environment (M = 4.45, SD = 0.66) and the encouragement received from friends (M = 4.28, SD = 0.91) and community expectations (M = 3.72, SD = 1.10). Confidence in using social media effectively (M = 3.59, SD = 1.13) and ease of access to platforms (M = 3.79, SD = 1.09) also scored above the midpoint, reflecting a readiness to engage in environmental discussions online.

Table 2 presents the reliability, convergent validity, and explanatory power of the constructs. For the multi-item constructs, Cronbach's alpha values ranged from 0.683 to 0.898, while composite reliability (rho_C) ranged from 0.819 to 0.924. All AVE values exceeded 0.50, indicating satisfactory convergent validity. Intention was measured using a single indicator and therefore was not assessed using internal consistency reliability coefficients. The structural model explained 57.6% of the variance in subjective norms ($R^2 = 0.576$), 62.2% in intention ($R^2 = 0.622$), and 60.1% in willingness to participate ($R^2 = 0.601$).

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Table 1. Descriptive Analysis of Items Measuring Digital Participation in Marine Waste Management

Name	Mean	Excess kurtosis	Skew ness
I believe participating in marine waste campaigns on social media is important for protecting Batam's coastal environment.	4.451	3.153	-1.409
I think sharing posts and content about reducing plastic waste on social media benefits tourism and community well-being in Batam.	3.556	-1.409	-0.286
I feel responsible for preventing marine waste pollution by actively engaging in social media discussions and campaigns.	4.173	0.924	-1.227
My friends encourage me to participate in marine waste campaigns on social media.	4.282	1.167	-1.361
My family and community expect me to engage with or share social media content about marine waste reduction.	3.716	-1.031	-0.557
I am confident that I can use social media effectively to support marine waste campaigns.	3.589	-1.314	-0.319
I can easily access social media platforms to participate in marine waste management discussions and activities.	3.791	-0.944	-0.591
I am willing to adapt my social media habits to promote marine waste awareness.	2.071	0.112	1.009
I can adjust the type of content I share on social media to support marine waste reduction.	2.329	-0.1	0.96
I actively look for new social media campaigns or groups related to marine waste management in Batam.	2.124	-0.016	0.947
I collaborate with others on social media to handle and respond to marine waste issues.	2.369	-0.152	0.862
I learn from social media campaigns and past online discussions to improve my contribution to marine waste management.	2.222	0.268	1.028
I intend to participate in social media campaigns about marine waste reduction in Batam.	2.213	-0.249	0.836
I am willing to share or repost information about beach clean-ups in Batam on social media.	2.369	-0.152	0.862
I am willing to participate in online discussions, webinars, or awareness campaigns about marine waste through social media.	2.222	0.268	1.028
I am willing to create or engage with digital content (e.g., videos, infographics, hashtags) to support marine waste reduction efforts.	2.311	-0.249	0.827

Note: *Responses were measured using a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.*

Table 2. Reliability and Validity of Constructs (Adaptive Capacity, Attitudes, Perceived Behavioral Control, Subjective Norms, Willingness to Participate)

Construct	Cronbach's alpha	Composite reliability (rho_A)	Composite reliability (rho_C)	AVE	R^2
Adaptive capacity	0.898	0.906	0.924	0.710	–
Attitudes	0.691	0.780	0.819	0.603	–
Perceived behavioral control	0.683	0.711	0.861	0.757	–
Subjective norms	0.794	0.814	0.906	0.828	0.576
Intention[a]	N/A	N/A	N/A	1.000	0.622
Willingness to participate	0.852	0.866	0.909	0.770	0.601

Note: *AVE = average variance extracted; rho_A = reliability coefficient rho_A; rho_C = composite reliability; R^2 = coefficient of determination. A dash (–) indicates an exogenous construct for which R^2 is not applicable.*

[a]*Intention was measured using a single indicator; therefore, Cronbach's alpha and composite reliability are not applicable. The standardized loading was 1.000, resulting in an AVE of 1.000.*

Table 3 presents the model fit indices for the saturated and estimated models. The saturated model showed an SRMR value of 0.071, while the estimated model had an SRMR of 0.108. The d_ULS values were 0.680 and 1.578, and the d_G values were 0.532 and 0.848 for the saturated and estimated models, respectively. The NFI values were 0.737 for the saturated model and 0.659 for the estimated model.

Table 3. Model Fit Indices for Saturated and Estimated Models

Parameters	Saturated model	Estimated model
SRMR	0.071	0.108
d_ULS	0.68	1.578
d_G	0.532	0.848
Chi-square	1346.993	1745.145
NFI	0.737	0.659

Note: *SRMR = standardized root mean square residual; d_ULS = squared Euclidean distance; d_G = geodesic distance; NFI = normed fit index.*

Figure 2 illustrates the SEM results for digital participation in marine waste management in Batam. The model integrates five latent constructs along with intention as a mediating factor. All observed items loaded strongly on their respective constructs, with factor loadings ranging from 0.691 to 0.928, demonstrating good measurement reliability. The path coefficients show the structural relationships among the constructs, with notable influences of adaptive capacity (β = 0.790) and intention (β = 1.000) on willingness to participate (R^2 = 0.601). Subjective norms and perceived behavioral control also contribute to intention (R^2 = 0.622), while attitudes exert a more modest effect. The model highlights that household engagement in digital marine waste initiatives is shaped not only by individual attitudes and social expectations but also by their perceived ability to act and adapt within digital platforms. By linking these factors, the SEM framework provides a comprehensive understanding of how psychological, social, and adaptive capacities interact to drive willingness to participate in digitally mediated environmental action.

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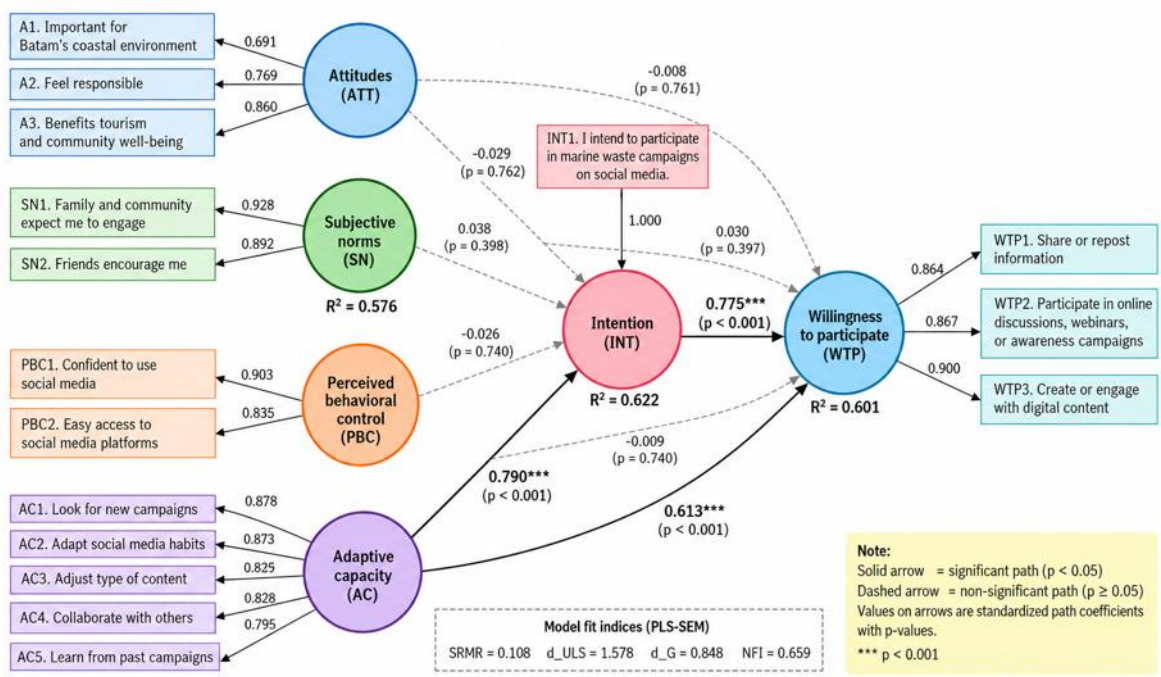


Figure 2. Structural Equation Modeling (SEM) Results for Digital Participation in Marine Waste Management in Batam

Table 4. Structural Relationship Testing Among Constructs in the SEM

Structural relationship	β (SD)	t-statistic	p-value	Result
Adaptive capacity → Intention	0.790 (0.018)	42.822	<0.001	Significant
Adaptive capacity → Willingness to participate	0.613 (0.027)	22.943	<0.001	Significant
Attitudes → Intention	−0.011 (0.036)	0.303	0.762	Not significant
Attitudes → Subjective norms	0.473 (0.041)	11.517	<0.001	Significant
Attitudes → Willingness to participate	−0.008 (0.028)	0.304	0.761	Not significant
Intention → Willingness to participate	0.775 (0.018)	43.082	<0.001	Significant
Perceived behavioral control → Intention	−0.012 (0.035)	0.332	0.740	Not significant
Perceived behavioral control → Subjective norms	0.371 (0.044)	8.405	<0.001	Significant
Perceived behavioral control → Willingness to participate	−0.009 (0.027)	0.332	0.740	Not significant
Subjective norms → Intention	0.038 (0.045)	0.845	0.398	Not significant
Subjective norms → Willingness to participate	0.030 (0.035)	0.848	0.397	Not significant

***Note**: β = standardized path coefficient; SD = standard deviation. Statistical significance was assessed at p < 0.05.*

Table 4 presents the structural path results. Adaptive capacity significantly predicted intention (β = 0.790, SD = 0.018, p < 0.001) and willingness to participate (β = 0.613, SD = 0.027, p < 0.001). Intention also significantly predicted willingness to participate (β = 0.775, SD = 0.018, p < 0.001). Attitudes significantly predicted subjective norms (β = 0.473, SD = 0.041, p < 0.001), while perceived behavioral control also significantly predicted subjective norms (β = 0.371, SD = 0.044, p < 0.001). The remaining direct relationships were not statistically significant.

The structural model indicates that adaptive capacity is the most robust predictor of both intention and willingness to participate in digitally mediated marine waste activities. Adaptive capacity demonstrated a strong positive effect on intention (β = 0.790, p < 0.001) and willingness to participate (β = 0.613, p < 0.001). These findings suggest that respondents with enhanced abilities to adjust digital practices, modify shared content, seek relevant information, learn from prior online experiences, and collaborate with others are more likely to express readiness for engagement in marine waste-related digital activities. This interpretation aligns with existing literature emphasizing the importance of adaptive skills, learning capacity, and digital competence in fostering community engagement and environmental governance (Dushkova and Ivlieva, 2024; Kangana et al., 2024; Kloppenburg et al., 2022). This finding also elucidates the role of adaptive capacity within the extended Theory of Planned Behavior (TPB) framework. Adaptive capacity should not be construed as actual digital participation itself. Rather, it represents an enabling capability that may facilitate the formation of intention and willingness. This distinction is particularly crucial given that the present study measures stated behavioral readiness rather than observed participation or quantifiable marine waste reduction. Therefore, the results indicate an association between adaptive capability and stronger intention and willingness among digitally active Batam residents, but they do not demonstrate that higher adaptive capacity has already yielded superior environmental performance.

Intention also exhibited a strong positive relationship with willingness to participate (β = 0.775,

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$p < 0.001$). This result is broadly consistent with the Theory of Planned Behavior, wherein intention serves as a proximal motivational antecedent of behavior (Ajzen, 1991; Concari et al., 2020; Zhao et al., 2022). In the present study, however, willingness to participate remains a stated behavioral outcome rather than observed behavior. Thus, the significant intention–willingness relationship indicates that stronger motivational commitment is associated with greater readiness to share information, participate in online discussions, and engage with digital environmental content. Any claim that intention mediates the relationship between adaptive capacity and willingness should be supported specifically by bootstrapped indirect-effect analysis, rather than solely by the significance of individual paths.

A particularly salient finding is that the conventional TPB predictors did not operate as anticipated. Attitudes evinced no significant direct effect on either intention ($\beta = -0.011$, $p = 0.762$) or willingness to participate ($\beta = -0.008$, $p = 0.761$). This deviates from the conventional TPB expectation that favorable attitudes contribute positively to behavioral intention. Nevertheless, attitudes were significantly associated with subjective norms ($\beta = 0.473$, $p < 0.001$). This suggests that favorable evaluations of marine waste engagement coexist with stronger perceptions of social expectations, although the present results do not demonstrate that this relationship subsequently produces participation. Earlier studies have similarly underscored that attitudes can interact with social expectations and social experience in shaping behavioral orientations (Roth and Salikutluk, 2012; Sofiyah et al., 2025; Wall, 1995). The absence of a significant direct attitude–intention relationship may be especially pertinent in a digital participation context. Respondents may generally acknowledge the importance of marine waste campaigns while still lacking sufficient motivation, experience, or adaptive capability to participate. In other words, positive environmental attitudes alone may not be sufficient to generate digital engagement. This attitude–action gap is significant because it suggests that communication strategies solely focused on raising awareness may have limited effects when residents are not simultaneously provided with clear, accessible, and meaningful opportunities for participation.

Perceived behavioral control also demonstrated no significant direct effect on intention or willingness to participate. However, perceived behavioral control was positively associated with subjective norms ($\beta = 0.371$, $p < 0.001$). This result indicates that confidence in social media use and perceived ease of digital access are related to the social context surrounding participation, but they do not independently predict stated readiness to participate in the present model. Therefore, this relationship should be interpreted cautiously and should not be described as an indirect effect on participation unless supported by specific indirect-effect analysis.

Subjective norms likewise did not significantly predict intention or willingness to participate, despite their observed relationships with attitudes and perceived behavioral control. This finding diverges from the standard TPB framework, in which social expectations are generally posited to contribute to behavioral intention. Previous studies have highlighted the importance of social and community influences in environmental behavior (Rahman et al., 2025b; Ulhasanah and Goto, 2018), but the present results suggest that social encouragement alone may not be sufficient to generate readiness for digitally mediated marine waste engagement. Collectively, these findings indicate that the conventional TPB constructs may exert a weaker direct role in this particular digital environmental context than anticipated. Rather than refuting TPB, the results suggest that the framework may benefit from additional constructs that capture the practical capacity to operate within digital environments. Adaptive capacity appears to provide this complementary explanation by representing respondents' ability to adjust, learn, seek opportunities, and collaborate online. This interpretation is consistent with the broader importance of adaptive capacity in environmental and community-based responses (Sianipar et al., 2025; Sofiyah et al., 2026a; Suryawan et al., 2027).

The findings should nevertheless be interpreted within the characteristics of the study sample. Respondents were digitally active adult residents of Batam, and the sample was predominantly composed of younger and unmarried individuals. Therefore, the structural relationships identified here should not be generalized to all Batam residents, particularly those with limited digital access or lower levels of social media use. Moreover, the cross-sectional and self-reported design does not establish behavioral change over time or direct environmental outcomes.

4. POLICY IMPLICATIONS

The policy implications of this study are delineated in Figure 3, which translates the empirical findings from the structural model into a pragmatic framework designed to enhance digital participation in marine waste governance within Batam. This framework is structured around four interconnected components: key behavioral insights, strategic policy interventions, viable implementation pathways, and anticipated governance outcomes, all supported by a set of enabling conditions.

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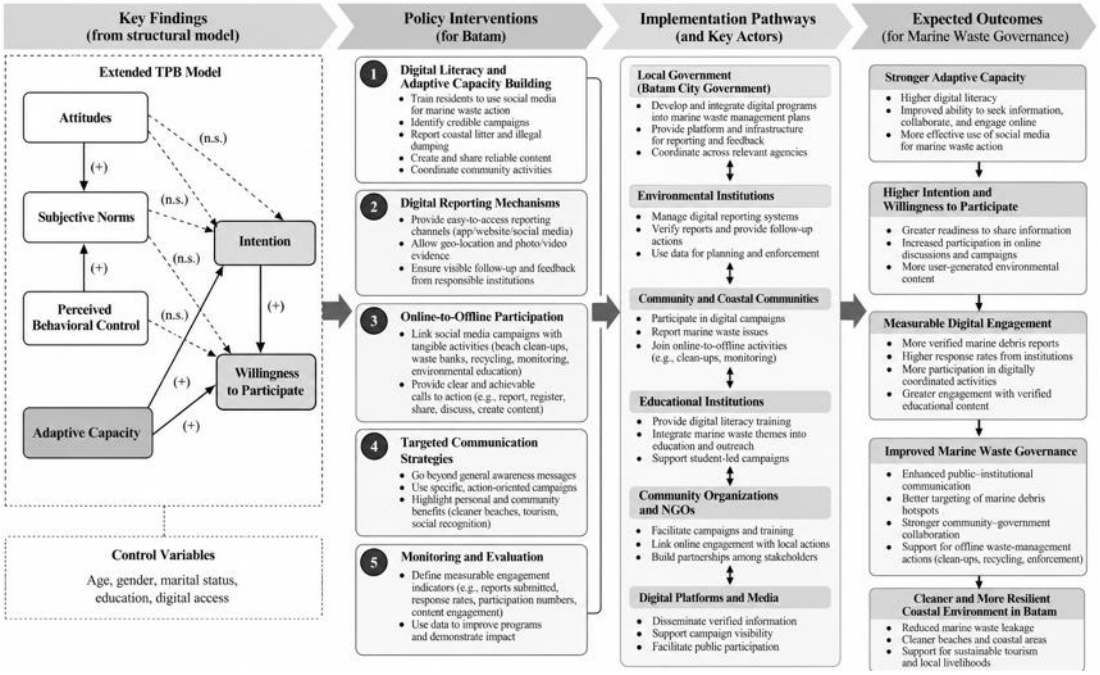


Figure 3. Policy Framework for Strengthening Digital Participation in Marine Waste Governance in Batam, Indonesia

The foremost policy imperative pertains to digital literacy and the cultivation of adaptive capacity. Adaptive capacity emerged as the most significant predictor of both intention and willingness to participate, underscoring the necessity for policy interventions to transcend generic environmental awareness campaigns. Consequently, programs should aim to fortify residents' practical proficiency in leveraging digital platforms for marine waste-related activities. This includes, but is not limited to, discerning credible campaigns, accessing reliable information, reporting coastal litter, generating or disseminating verified environmental content, learning from prior campaigns, and fostering collaborative efforts. Such capacity-building initiatives are instrumental in converting generalized environmental concern into more actionable forms of participation.

The second priority involves the development of accessible digital reporting mechanisms. The Batam City Government and pertinent environmental agencies are encouraged to establish user-friendly reporting channels via official websites, mobile applications, or established social media platforms. These systems would enable residents to submit reports concerning coastal litter, illicit dumping, or waste accumulation, ideally accompanied by geo-location data, photographic evidence, or other corroborating information. However, the efficacy of such mechanisms is contingent upon demonstrable institutional responsiveness. Therefore, reporting systems must be complemented by robust verification procedures, timely feedback mechanisms for residents, and transparent communication regarding the actions undertaken by responsible agencies.

Third, digital participation should be seamlessly integrated with online-to-offline participation pathways. Engagement on social media platforms are likely to yield more substantive outcomes when residents can transition from virtual interaction to tangible environmental activities. Digital campaigns should, therefore, be explicitly linked to initiatives such as beach clean-ups, waste-bank operations, recycling programs, coastal monitoring, and environmental education. Clear calls to action e.g., reporting a waste location, registering for a clean-up event, sharing verified information, joining an online discourse, or creating locally pertinent content—are anticipated to be more effective than broad awareness messages alone. This is particularly salient given that attitudes and subjective norms did not directly predict intention or willingness in the structural model.

A fourth policy direction centers on targeted communication strategies. Digital campaigns ought to be meticulously designed around specific actions and locally relevant benefits, rather than relying exclusively on generalized environmental messaging. Communication efforts could emphasize tangible advantages such as pristine coastal areas, enhanced tourism conditions, strengthened community participation, and heightened visibility of local environmental concerns. The objective is not merely to augment exposure to environmental information, but to furnish residents with clear and attainable opportunities for engagement.

The proposed framework also underscores the critical importance of monitoring and evaluation. Digital participation programs should incorporate measurable indicators, such as the volume of verified marine debris reports submitted, institutional response rates, participation in digitally coordinated

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clean-up activities, engagement with verified educational content, involvement in community campaigns, and follow-up actions executed by responsible organizations. These indicators are crucial for differentiating passive online visibility from more meaningful forms of citizen engagement. Effective implementation necessitates the involvement of multiple stakeholders. The Batam City Government can integrate digital participation mechanisms into its marine waste management planning and provide the requisite infrastructure for reporting and feedback. Environmental institutions and waste-management agencies are tasked with verifying reports, coordinating responses, and utilizing citizen-generated information for strategic planning and enforcement. Coastal communities and community organizations can serve as conduits, connecting digital reporting and campaigns with localized environmental action. Educational institutions can play a pivotal role in fostering digital literacy and spearheading student-led environmental campaigns, while digital platforms and media outlets can facilitate the dissemination of verified information and broaden campaign reach.

Several enabling conditions are prerequisite for the effective functioning of this framework. These include reliable digital infrastructure and internet access, clearly delineated institutional responsibilities, robust coordination among agencies and communities, continuous capacity development, and inclusive participation across diverse social and demographic strata. Given that the current sample was predominantly comprised of digitally active younger adults, future implementation strategies should also consider residents with lower digital access or limited experience with social media platforms. The anticipated outcomes of this framework warrant careful interpretation. In the short term, the proposed interventions are designed to bolster adaptive capacity, intention, willingness to participate, and measurable digital engagement. Over time, enhanced digital participation is expected to foster improved communication, expedited identification of marine debris issues, greater collaboration between communities and government, and more effective coordination of offline waste-management activities. However, the present study does not establish a direct causal link between higher digital willingness and a reduction in marine waste. Consequently, the framework represents a policy pathway linking behavioral evidence to potential governance improvements, rather than a demonstrated causal pathway to cleaner coastal conditions.

5. CONCLUSION

This study investigated the intention and willingness to participate digitally in marine waste management among digitally active adult residents of Batam. It achieved this by integrating the Theory of Planned Behavior (TPB) with the concept of adaptive capacity. The analysis revealed that adaptive capacity emerged as the most robust predictor for both intention and willingness to participate. Furthermore, intention itself significantly predicted willingness. Conversely, attitudes, subjective norms, and perceived behavioral control did not demonstrate significant direct effects on either intention or willingness. These findings suggest that practical adaptive skills—such as the ability to learn, adjust digital practices, seek information, and collaborate online—may exert a more substantial influence than positive attitudes or social encouragement alone. For Batam, these results advocate for policy interventions focused on enhancing digital literacy, facilitating accessible marine debris reporting mechanisms, implementing targeted awareness campaigns, and strengthening the nexus between online engagement and tangible offline environmental action. It is important to note, however, that the study's measures captured stated intention and willingness, rather than actual participation or direct reductions in marine waste.

The interpretation of these findings should acknowledge several inherent limitations. The sample was derived from non-probability recruitment and was predominantly composed of younger, unmarried, and digitally active respondents. Consequently, the generalizability of these results to the broader Batam population is restricted. Furthermore, the study employed a cross-sectional design and relied exclusively on self-reported data. An additional limitation pertains to the measurement of intention using a single-item indicator, and the conceptual proximity of some adaptive capacity indicators to actual participation-related activities.

Future research endeavors should endeavor to employ more representative sampling methodologies, utilize multi-item measures for intention, and adopt longitudinal research designs. Crucially, subsequent studies ought to incorporate actual behavioral indicators, such as verified digital reports, participation rates in clean-up initiatives, institutional responses, and quantifiable marine waste outcomes. Such an approach would enable a more comprehensive assessment of whether stated intention and willingness translate into genuine participation and demonstrable environmental improvement.

REFERENCES

Adam, I., 2022. Rational and Moral Antecedents of Tourists' Intention to Use Reusable Alternatives to Single-Use Plastics. J. Travel Res. 62, 949–968. https://doi.org/10.1177/00472875221105860

Ajzen, I., 1991. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50, 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Alharbi, K.M., Elshamly, A., Mahgoub, I.G., 2025. Do Regulatory Pressures and Stakeholder Expectations Drive CSR Adherence in the Chemical Industry? Sustainability.

© 2026, Program Studi Ilmu Lingkungan Sekolah Pascasarjana UNDIP

https://doi.org/10.3390/su17052128

Badan Pusat Statistika Provinsi Kep. Riau, 2025. Persentase Penduduk Berumur 5 Tahun ke Atas yang Mengakses Internet dalam 3 Bulan Terakhir (Persen), 2024 [WWW Document]. URL kepri.bps.go.id/id/statistics-table/2/NzE0IzI=/percentage-of-population-aged-5-years-and-over-who-accessed-the-internet-in-the-last-3-months.html

Cao, Xun, Zeng, Runxi, Evans, Richard, 2021. Digital activism and collective mourning by Chinese netizens during COVID-19. China Inf. 36, 159–179. https://doi.org/10.1177/0920203X211054172

Chekirova, A., 2022. Social Media and Cross-Border Political Participation: A Case Study of Kyrgyz Migrants' Online Activism. Soc. Sci. https://doi.org/10.3390/socsci11080370

Cheng, Edmund W, Lui, Elizabeth, Fu, King-wa, 2023. The power of digital activism for transnational advocacy: Leadership, engagement, and affordance. New Media Soc. 26, 6416–6439. https://doi.org/10.1177/14614448231155376

Chubarenko, B., Woelfel, J., Hofmann, J., Aldag, S., Beldowski, J., Burlakovs, J., Garrels, T., Gorbunova, J., Guizani, S., Kupczyk, A., Kotwicki, L., Domnin, D., Gajewska, M., Hogland, W., Kołecka, K., Nielsen, J., Schubert, H., 2021. Converting beach wrack into a resource as a challenge for the Baltic Sea (an overview). Ocean Coast. Manag. 200, 105413. https://doi.org/10.1016/j.ocecoaman.2020.105413

Concari, A., Kok, G., Martens, P., 2020. A Systematic Literature Review of Concepts and Factors Related to Pro-Environmental Consumer Behaviour in Relation to Waste Management Through an Interdisciplinary Approach. Sustainability. https://doi.org/10.3390/su12114452

D'Amico, G., Szopik-Depczyńska, K., Dembińska, I., Ioppolo, G., 2021. Smart and sustainable logistics of Port cities: A framework for comprehending enabling factors, domains and goals. Sustain. Cities Soc. 69, 102801. https://doi.org/10.1016/j.scs.2021.102801

Dushkova, D., Ivlieva, O., 2024. Empowering Communities to Act for a Change: A Review of the Community Empowerment Programs towards Sustainability and Resilience. Sustainability. https://doi.org/10.3390/su16198700

Grace, O., Iqbal, K., Rabbi, F., 2023. Creating Sustainable Urban Environments: The Vital Link between Development, Health, and Smart Cities. Int. J. Sustain. Infrastruct. Cities Soc. 8, 53–72.

Gunasekara, M.I., Mahawaththa, I., Madhubhashini, D., Amarasena, K., 2025. Pollution from Land-Based Sources, in: Coastal and Marine Pollution. pp. 27–44. https://doi.org/10.1002/9781394237029.ch2

Guo, X., Fan, Z., Zhu, H., Chen, X., Wang, M., Fu, H., 2022. Willingness to Pay for Healthy Housing During the COVID-19 Pandemic in China: Evidence From Eye-Tracking Experiment. Front. Public Heal. 10.

Hafferty, C., Reed, M.S., Brockett, B.F.T., Orford, S., Berry, R., Short, C., Davis, J., 2024. Engagement in the digital age: Understanding "what works" for participatory technologies in environmental decision-making. J. Environ. Manage. 365, 121365. https://doi.org/10.1016/j.jenvman.2024.121365

Hasfi, N., Fisher, M.R., Sahide, M.A.K., 2021. Overlooking the victims: Civic engagement on Twitter during Indonesia's 2019 fire and haze disaster. Int. J. Disaster Risk Reduct. 60, 102271. https://doi.org/10.1016/j.ijdrr.2021.102271

Jambeck, J., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R., Law, K.L., 2015. the Ocean : the Ocean : Mar. Pollut. 347, 768-.

Jirasit, A., 2024. The impact of social media campaigns on reducing plastic waste in Thailand's coastal areas. Stud. Soc. Sci. Humanit. 3, 44–49.

Kangana, N., Kankanamge, N., De Silva, C., Goonetilleke, A., Mahamood, R., Ranasinghe, D., 2024. Bridging Community Engagement and Technological Innovation for Creating Smart and Resilient Cities: A Systematic Literature Review. Smart Cities. https://doi.org/10.3390/smartcities7060147

Khaliqi, M. ri., Ramadhani, A., Pane, T.C., Sinaga, F.H., Darmansyah, D., Sari, I.R.M., 2023. Indonesian consumers' willingness to pay for organic coffee. IOP Conf. Ser. Earth Environ. Sci. 1230, 12019. https://doi.org/10.1088/1755-1315/1230/1/012019

Kloppenburg, S., Gupta, A., Kruk, S.R.L., Makris, S., Bergsvik, R., Korenhof, P., Solman, H., Toonen, H.M., 2022. Scrutinizing environmental governance in a digital age: New ways of seeing, participating, and intervening. One Earth 5, 232–241.

Kurniawan, T.A., Haider, A., Ahmad, H.M., Mohyuddin, A., Umer Aslam, H.M., Nadeem, S., Javed, M., Othman, M.H.D., Goh, H.H., Chew, K.W., 2023. Source, occurrence, distribution, fate, and implications of microplastic pollutants in freshwater on environment: A critical review and way forward. Chemosphere 325, 138367. https://doi.org/10.1016/j.chemosphere.2023.138367

Lippke, S., Dahmen, A., Gao, L., Guza, E., Nigg, C.R., 2021. To what extent is internet activity predictive of psychological well-being? Psychol. Res. Behav. Manag. 207–219.

Lipschitz, J.M., Pike, C.K., Hogan, T.P., Murphy, S.A., Burdick, K.E., 2023. The engagement problem: a review of engagement with digital mental health interventions and recommendations for a path forward. Curr. Treat. options psychiatry 10, 119–135.

Nahum-Shani, I., Shaw, S.D., Carpenter, S.M., Murphy, S.A., Yoon, C., 2022. Engagement in digital interventions. Am. Psychol. 77, 836.

Nurhati, I.S., Cordova, M.R., 2020. Marine Plastic Debris in Indonesia: Baseline Estimates (2010-2019) and Monitoring Strategy (2021-2025). Mar. Res. Indones. 45, 1–6. https://doi.org/10.14203/mri.v45i2.581

Rahman, A., Sofiyah, E.S., Sianipar, I.M.J., Edwisafira, A., Suhardono, S., Lee, C.-H., Nguyen, V.V., Suryawan, I.W.K., 2025a. Evaluating tourist importance-performance and support for development in Komodo National Park. Environ. Challenges 101229. https://doi.org/10.1016/j.envc.2025.101229

Rahman, A., Suhardono, S., Sofiyah, E.S., Sianipar, I.M.J., Lee, C.-H., Suryawan, I.W.K., 2025b. Impact of COVID-19 on visitor attitude and management strategies at Komodo National Park: Insights for enhancing park adaptive experience. Trees, For. People 20, 100825. https://doi.org/10.1016/j.tfp.2025.100825

Roth, T., Salikutluk, Z., 2012. Attitudes and expectations: do attitudes towards education mediate the

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relationship between social networks and parental expectations? Br. J. Sociol. Educ. 33, 701–722. https://doi.org/10.1080/01425692.2012.668835

Sekretariat Satu Data Kota Batam, 2025. Persentase Sampah Yang Dikelola Dengan Sistem 3R di Kota Batam [WWW Document]. URL https://satudata.batam.go.id/data/detail/persentasesampahyangdikeloladengansistem3r20250kotabatamahl3sd?utm_source=chatgpt.com

Sharma, S., Kar, A.K., Gupta, M.P., Dwivedi, Y.K., Janssen, M., 2022. Digital citizen empowerment: A systematic literature review of theories and development models. Inf. Technol. Dev. 28, 660–687. https://doi.org/10.1080/02681102.2022.2046533

Sianipar, I.M.J., Lee, C.-H., Wang, H.-J., Kim, D.-C., Suryawan, I.W.K., 2025. Adaptive strategies and community engagement for sustainable conservation and tourism in Komodo National Park, Indonesia. Int. J. Geoheritage Park. 13, 335–349. https://doi.org/10.1016/j.ijgeop.2024.09.004

Sianipar, I.M.J., Suryawan, I.W.K., Tarigan, S.R., 2022. The Challenges and Future of Marine Debris Policy in Indonesia and Taiwan Case Studies. J. Sustain. Infrastruct. 1, 56–62.

Sofiyah, E.S., Ridhosari, B., Suhardono, S., Lee, C.-H., Suryawan, I.W.K., 2026a. Assessing Importance-Performance Ecosystem Services in Adaptation to Community-Based Sanitation Programs in Metropolitan Areas. Environ. Qual. Manag. 35, e70286. https://doi.org/10.1002/tqem.70286

Sofiyah, E.S., Sianipar, I.M.J., Rahman, A., Caesarina, N.P., Suhardono, S., Suryawan, I.W.K., Lee, C.-H., 2025. Adaptive governance in the water-energy-food-ecosystem nexus for sustainable community sanitation. World Dev. Sustain. 100220. https://doi.org/10.1016/j.wds.2025.100220

Sofiyah, E.S., Suhardono, S., Ridhosari, B., Zahra, N.L., Suryawan, I.W.K., Lee, C.-H., 2026b. Community participation and governance pathways for antimicrobial resistance mitigation through urban wastewater surveillance and management policy. Clean. Water 8, 100318. https://doi.org/10.1016/j.clwat.2026.100318

Suhardono, S., Fitria, L., Prayogo, W., Lee, C.-H., Suryawan, I.W.K., 2025. Enhancing community engagement with digital twins: Technological adoption in marine debris management. J. Urban Manag. https://doi.org/10.1016/j.jum.2025.04.008

Suryawan, I.W.K., Suhardono, S., Lee, C.-H., 2024. Boosting beach clean-up participation through community resilience hypothetical scenarios. Mar. Pollut. Bull. 207.

Suryawan, I.W.K., Ulhasanah, N., Rahman, A., Sari, M.M., Suhardono, S., Sofiyah, E.S., Lee, C.-H., 2027. Climate resilience factors influencing coastal societies' willingness to participate in protecting marine natural capital. Mar. Policy 195, 107295. https://doi.org/10.1016/j.marpol.2026.107295

Ulhasanah, N., Goto, N., 2018. Assessment of citizens' environmental behavior toward municipal solid waste management for a better and appropriate system in Indonesia: a case study of Padang City. J. Mater. Cycles Waste Manag. 20, 1257–1272. https://doi.org/10.1007/s10163-017-0691-4

Ulhasanah, N., Sari, M.M., Sarwono, A., Johari, K., Suhardono, S., Sanda, D.V., Netriyunita, N., Lee, C.-H., Suryawan, I.W.K., 2025a. Exploratory factors in community-based adaptation strategies for managing marine microplastics. Reg. Stud. Mar. Sci. 82, 104015. https://doi.org/10.1016/j.rsma.2025.104015

Ulhasanah, N., Suhardono, S., Lee, C.-H., Faza, A.S., Zahir, A., Suryawan, I.W.K., 2025b. Modelling participation in waste bank initiatives at public transport hubs to advance circular economy development. Discov. Sustain. 6, 153. https://doi.org/10.1007/s43621-025-00940-4

Vijayan, R.V., Krishnan, M.M., Parayitam, S., Anantharaman Duraisami, S.P., Saravanaselvan, N.R., 2023. Exploring e-waste recycling behaviour intention among the households: Evidence from India. Clean. Mater. 7, 100174. https://doi.org/10.1016/j.clema.2023.100174

Wall, G., 1995. Barriers to Individual Environmental Action: The Influence of Attitudes and Social Experiences. Can. Rev. Sociol. Can. Sociol. 32, 465–489. https://doi.org/10.1111/j.1755-618X.1995.tb00182.x

Widiastutie, S., Maarif, D., Saraswati, D.P., Sianipar, I.M.J., Phan, T.T.T., Nguyen, V.V., 2025. Residents' adaptive marine plastic litter management in Galang Island, Indonesia: An importance-performance analysis. Mar. Policy 172, 106508. https://doi.org/10.1016/j.marpol.2024.106508

Wilson, D.C., 2023. Learning from the past to plan for the future: An historical review of the evolution of waste and resource management 1970–2020 and reflections on priorities 2020–2030 – The perspective of an involved witness. Waste Manag. Res. 41, 1754–1813. https://doi.org/10.1177/0734242X231178025

Wu, H.-H., 2022. A study on transnational regulatory governance for marine plastic debris: Trends, challenges, and prospect. Mar. Policy 136, 103988. https://doi.org/10.1016/j.marpol.2020.103988

Yang, B.C., Lee, C.H., Suryawan, I.W.K., 2024. Financial Support in E-waste Management within a Circular Economy with Structural Equation Modeling Analysis from Taiwan. Circ. Econ. Sustain. https://doi.org/10.1007/s43615-024-00459-2

Zhang, Z., Yu, J., Tian, J., 2024. Community Participation, Social Capital Cultivation and Sustainable Community Renewal: A Case Study from Xi'an's Southern Suburbs, China. J. Knowl. Econ. 15, 11007–11040. https://doi.org/10.1007/s13132-023-01536-x

Zhao, S., Duan, W., Zhao, D., Song, Q., 2022. Identifying the influence factors of residents' low-carbon behavior under the background of "Carbon Neutrality": An empirical study of Qingdao city, China. Energy Reports 8, 6876–6886. https://doi.org/10.1016/j.egyr.2022.05.023

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