PUBLIC ATTITUDES TOWARD MANGROVE FORESTS AND THE ROLE OF CULTURAL INDUSTRIES IN SUSTAINABLE COASTAL DEVELOPMENT: A CASE STUDY IN TIEN LANG DISTRICT, HAI PHONG CITY, VIETNAM

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Abstract. Mangrove forests in Tien Lang District, Hai Phong City, Vietnam provide critical ecological, economic, and social benefits. However, their conservation is challenged by varying levels of public perception and engagement. This study applies the Theory of Planned Behavior (TPB) to examine residents' attitudes, subjective norms, perceived behavioral control (PBC), intentions, and behaviors toward mangrove conservation. Using Structural Equation Modeling (SEM) and Confirmatory Factor Analysis (CFA) with a sample of 287 respondents, the model achieved excellent fit indices (CFI = 1.000, TLI = 1.011, RMSEA = 0.000). Intention significantly predicted behavior ($\beta = 0.377$), subjective norms ($\beta = 0.260$), and PBC ($\beta = 0.454$). Awareness of mangrove values also shaped intention, indicating that higher awareness levels contribute to stronger conservation intentions. Weak loadings for Intention3 and PBC3 suggest opportunities for item refinement. Policy implications include strengthening community awareness and support mechanisms to improve behavioral control and social influence, ensuring more sustainable mangrove forest management. In addition to ecological and economic dimensions, this study also explores how cultural values embedded in mangrove ecosystems can support the development of coastal cultural industries. Findings highlight opportunities to link conservation behaviors with community-based cultural production, tourism, and heritage preservation for the sustainable coastal development.
Keywords: *mangrove conservation, theory of planned behavior, structural equation modeling, public perception, Tien Lang, Vietnam*

Introduction

Mangrove forests are vital components of coastal ecosystems, offering a wide array of ecological services including shoreline stabilization, carbon storage, and habitat provision for diverse species. They also contribute to human well-being through economic activities such as fisheries and ecotourism, while supporting disaster resilience and preserving cultural identity (Barbier et al., 2011). Despite these multifaceted roles, mangrove ecosystems across Southeast Asia are increasingly under pressure from aquaculture expansion, land conversion, and climate-related disturbances (Richards and Friess, 2016).

Beyond these ecological and economic dimensions, recent research has emphasized the importance of cultural ecosystem services (CES) in shaping the relationship of communities with their environment. These intangible benefits-such as spiritual meaning, local heritage, and communal identity-are often overlooked in mainstream conservation strategies, yet they play a crucial role in motivating protective behaviors (Chan et al., 2012; Milcu et al., 2013). In coastal Southeast Asia, mangroves are deeply embedded in cultural narratives and practices (Rönnbäck et al., 2007; Sasmito et al., 2023), suggesting that integrating CES into environmental governance could enhance both ecological outcomes and social acceptance.

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In Vietnam, mangrove reforestation and protection initiatives have expanded since the 1990s, yet community-based conservation efforts still face challenges, including fragmented institutional support and limited engagement with local cultural knowledge (Kien and James, 2013; Tran and Walter, 2014). Studies show that incorporating local norms, oral traditions, and customary practices can strengthen conservation legitimacy and collective action (Folke et al., 2005; Tengö et al., 2014).

Concurrently, the rise of creative and cultural industries such as ecotourism, cultural festivals, and craft industries-has opened new avenues for aligning conservation with sustainable livelihood development. These approaches have been successfully implemented in places like Bali and Kerala, where storytelling and community-based tourism foster both environmental awareness and cultural continuity (Mardianton et al., 2024; Moore et al., 2022). International frameworks now increasingly recognize culture as a key pillar of sustainable development, alongside the social, environmental, and economic domains (UNESCO, 2009; Duxbury et al., 2016).

Vietnam has a system of policies and laws on developing cultural industries associated with sustainable development such as Decision No 1755/QD-TTg (2016), Decision No. 1909/QD-TTg (2021) on Vietnam's tourism development strategy to 2030 and Decision No.801/QD-TTg (2022) on preserving and developing traditional Vietnamese craft villages. Within this context, mangrove ecosystems in northern Vietnam, including those in Tien Lang District of Hai Phong City, present an important case. While the Red River Delta hosts significant mangrove coverage, ongoing degradation-driven by shrimp aquaculture and low public engagement-threatens these critical habitats (Long et al., 2021). Understanding how local people perceive mangrove forests and what motivates them to participate in conservation is thus central to designing effective, inclusive strategies for economic development in general and for Vietnam's cultural industries in particular.

The Theory of Planned Behavior (TPB) (Ajzen, 1991) offers a robust framework for analyzing such motivations. According to TPB, behavioral intention-the strongest predictor of action-is shaped by three constructs: attitude (evaluation of the behavior), subjective norms (perceived social pressure), and perceived behavioral control (PBC) (perceived ability to perform the behavior). This model has been successfully applied to various environmental domains, including green consumption (Han et al., 2010) and recycling behavior (Tonglet et al., 2004). In both cases, intention was found to mediate the relationship between individual beliefs and actual behavior.

However, in mangrove contexts, intention may be further shaped by awareness—particularly awareness of CES. For instance, Afonso et al. (2022) found in the Philippines that awareness of ecological benefits like flood control influenced attitudes toward mangrove protection, although economic conflicts sometimes undermined conservation support. Similarly, Saenger (2011) noted that low awareness led to weak subjective norms in Bangladeshi communities. Access to knowledge and resources also affects PBC: as shown by Abdullah et al. (2014), limited training and planting materials constrained conservation actions, even where attitudes were positive.

In Vietnam, research on the interplay between public perception, behavior, and the cultural value of mangroves remains limited. While some emerging studies have begun to explore these cultural dimensions (Hue, 2022), few have integrated them into formal behavioral models such as TPB. Furthermore, the linkage between CES awareness and the potential of cultural industries in conservation is rarely addressed in empirical studies.

To fill this gap, the present study applies an extended TPB model that incorporates CES awareness as a key antecedent of pro-environmental behavior. This approach

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enables a more comprehensive understanding of how cultural meanings and values influence intentions and actions related to mangrove conservation. Drawing on a case study in Tien Lang District, the study utilizes Structural Equation Modeling (SEM) and Confirmatory Factor Analysis (CFA) to test relationships among awareness, attitude, subjective norms, PBC, intention, and behavior. Building on the work of Hagger et al. (2002) and Savari et al. (2023), who used TPB in health and forest contexts respectively, this research offers both theoretical refinement and practical insights.

Specifically, the study aims to: Validate the TPB measurement model in a mangrove conservation context; Examine the structural relationships between CES awareness and TPB components; and Provide policy recommendations for integrating cultural values into mangrove management in Vietnam's coastal areas and sustainable development of Vietnam's cultural industries.

Materials and methods

Study area

Tien Lang District (before 1st July 2025, now it is Tien Lang commune) is located in the southern part of Hai Phong City in northern Vietnam. The district is bordered by the Red River estuary and experiences regular tidal influences, creating favorable conditions for mangrove ecosystems. Historically, Tien Lang has supported extensive mangrove forests that provide natural protection against coastal erosion, support biodiversity, and sustain aquaculture and agriculture-based livelihoods. In recent years, however, the area has witnessed growing pressure from shrimp farming, land reclamation, and infrastructure development, threatening the integrity of mangrove habitats. The district consists of a mix of rural communes with close ties to traditional land and water use practices, making it a compelling site to investigate community-based conservation dynamics.

The study was conducted in 2 communes (Vinh Quang and Dong Hung), (4 villages) in Tien Lang, Hai Phong province (see *Fig. 1*). In this region, farmers typically live in close-knit villages, where they are connected through land ownership, village culture, and familial relationships. They adhere to village regulations related to environmental protection and community norms.

Data collection

Data was collected from 2020 to 2023 as part of a comprehensive study on sustainable development in the Red River Delta. The study involved conducting in-depth interviews with leaders at various levels-central, provincial, district, commune, and village on coastal issues and local community adaptation. A total of 11 in-depth interviews were conducted, along with 12 group discussions (including groups of women, general community members, and youth) and interviews with 287 households. In addition to general environmental and livelihood issues, the household questionnaire included specific questions related to drought, human-wildlife conflicts, and pest concerns, which were identified as major local environmental stressors during preliminary interviews. Respondents were asked to rate the perceived severity of each issue on a 5-point Likert scale (1 = "Not serious at all" to 5 = "Very serious"). Drought concern items focused on changes in rainfall, crop loss, and perceived impacts on aquaculture productivity. Human–wildlife conflict questions addressed experiences of animal intrusion (e.g., crabs, rodents, or birds damaging ponds and crops) and related livelihood losses. Pest concern

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questions assessed the frequency and perceived intensity of insect or pathogen outbreaks affecting mangrove and crop health. During analysis, these three variables were treated as continuous indicators of environmental stress awareness and were included in the correlation matrix (*Fig. 7*) and regression analyses (*Fig. 9*). This approach enabled the study to assess how different forms of perceived environmental risk influence community awareness and attitudes toward mangrove conservation. Several interview and group discussion questions explored how mangrove forests are perceived in relation to local culture, identity, and creative livelihoods (e.g., craft making, ecotourism, or festivals).

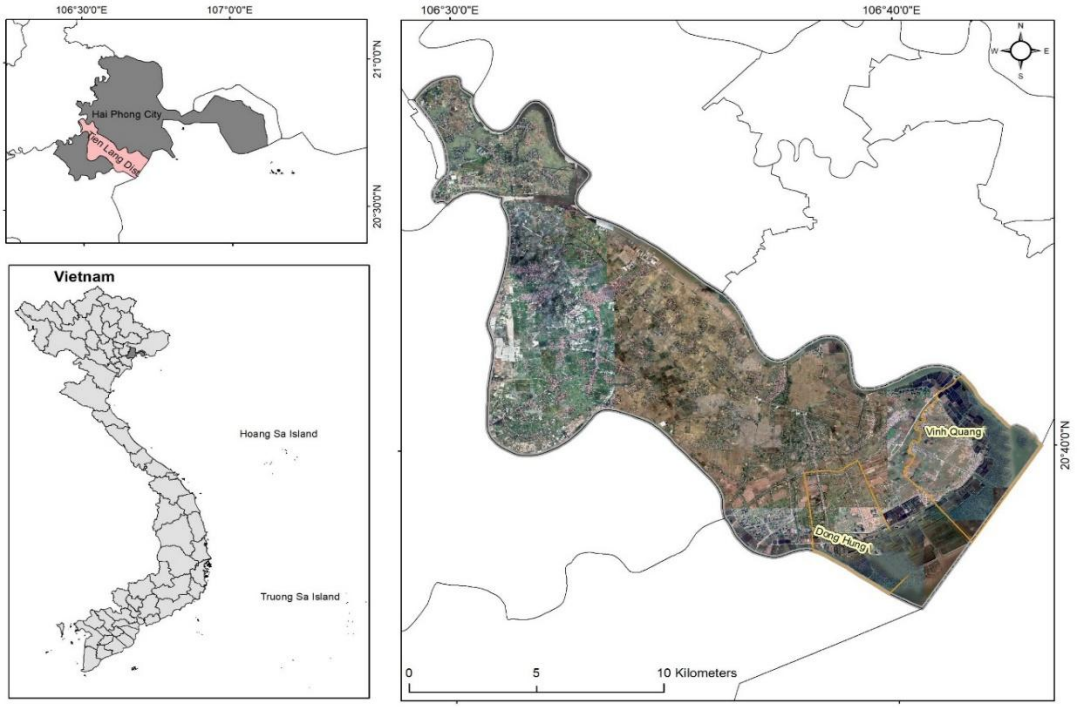

Figure 1. *The location of the study site*

All interview and group discussion formats were tested and research staff received thorough training. Each group discussion, consisting of 8-10 participants, lasted approximately 2 h. Household interviews were conducted in about 1 h. For household interviews, a systematic sampling method was used. The list of households in each village was obtained from village heads. The distance coefficient k: k = N/n (N is total number of individuals in the population, n is the sample size (set at 75 for each village). The first household was selected randomly, and subsequent households were selected by adding k to the previous number. The 75th research object had the serial number i + (75-1)k.

A survey was conducted in Tien Lang District, targeting 287 residents with no missing data. The questionnaire used a 5-point Likert scale to assess awareness, attitude, subjective norms, PBC, intention, and behavior. The sample was stratified by age, gender, and occupation to ensure representativeness.

Data analysis

The analysis was conducted using the lavaan package (Rosseel, 2012) in R version 4.3.1 (R Core Team, 2023), employing the Maximum Likelihood (ML) estimator with robust

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corrections (MLR). Additional R packages, including semPlot (Epskamp, 2019) for visualization and psych (Revelle, 2023) for reliability diagnostics, were used to support model assessment and plotting. The data analysis followed recommended Structural Equation Modeling (SEM) procedures outlined in Hair et al. (2010). Variables reflecting local environmental concerns—such as drought, human–wildlife conflicts, and pest outbreaks-were also incorporated into descriptive and correlational analyses to examine their associations with awareness and behavioral responses. The SEM model was specified with five latent variables-Attitude, CN, PBC, Intention, and Behavior-each measured by three observed indicators. The structural model tested the hypotheses that Intention is predicted by Attitude, CN, and PBC, while Behavior is predicted by Intention and PBC. The analysis employed the NLMINB optimization method with sandwich standard errors to address potential non-normality. Model fit was assessed using Chi-square, Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). Parameter estimates, including factor loadings, path coefficients, and R-squared values, were examined to evaluate the model's explanatory power. The CFA was performed on a sample of 287 observations, with no missing data patterns reported. The model specifies five latent variables, each measured by three observed indicators (e.g., Attitude = ~ Attitude1 + Attitude2 + Attitude3).

Theoretical framework

The Theory of Planned Behavior (TPB) framework includes five latent constructs: Attitude, Subjective Norms (SN), Perceived Behavioral Control (PBC), Intention, and Behavior. Awareness of mangrove values is treated as an exogenous antecedent affecting Attitude, SN, and PBC. Constructs were measured using a 5-point Likert scale. This study adapts the Theory of Planned Behavior (TPB) (Ajzen, 1991) to examine the perceptions and behaviors of Tien Lang residents toward mangrove forest protection. The model integrates six components-awareness, attitude, subjective norms, perceived behavioral control (PBC), intention, and behavior-tailored to the ecological, economic, and social values of mangroves.

Awareness: Defined as residents' understanding of mangroves' ecological (e.g., erosion control, biodiversity), economic (e.g., fisheries, tourism), and social (e.g., cultural heritage, disaster mitigation) benefits. Awareness serves as a precursor, directly influencing attitude, subjective norms, and PBC. For instance, while residents may recognize mangroves' role in flood mitigation, their limited awareness of ecotourism potential weakens protective intent. The Likert scale was used to assess five levels, from 1 (Completely unaware) to 5 (Fully aware), for three indicators: Awareness 1: Understanding of ecological value (erosion control, biodiversity); Awareness 2: Understanding of economic value (fisheries, tourism); Awareness 3: Understanding of social and cultural value (e.g., cultural heritage, traditional knowledge, potential for ecotourism, cultural festivals, and handicraft-based cultural industries.

Attitude toward the behavior: Refers to residents' positive or negative evaluations of engaging in mangrove protection activities (e.g., planting, monitoring, reducing exploitation). Higher awareness of benefits fosters positive attitudes (e.g., "Protecting mangroves is worthwhile for land preservation"), whereas low awareness may render efforts as time-consuming or unnecessary. Shrimp farmers, for example, may view mangroves as a constraint on pond expansion. The 5-point Likert scale, ranging from 1 (Completely disagree) to 5 (Completely agree), was used to assess three indicators: Attitude 1: Protecting mangrove forests is important; Attitude 2: I am willing to dedicate time to protecting mangrove forests; Attitude 3: Protecting forests is detrimental to

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personal economic interests (reverse-scored). The study also considers residents' attitudes toward mangrove-related cultural activities, such as participation in local festivals or interest in developing community tourism based on mangrove landscapes. Previous studies have suggested that the integration of socio-cultural ecosystem services into policy frameworks enhances local acceptance of conservation interventions (Hue, 2021).

Subjective norms: Encompasses social pressures from community, family, or local authorities influencing participation in mangrove protection. Effective awareness campaigns elevate community valuation of mangroves, reinforcing protective norms. Conversely, indifferent communities exert minimal influence. Local government-led reforestation campaigns exemplify positive social pressure.

Perceived behavioral control (PBC): Reflects residents' perceived ability to protect mangroves, contingent on resources (e.g., time, funds, knowledge) and opportunities. High awareness without skills (e.g., tree planting) or support (e.g., seedlings) reduces PBC. Training and resource provision can enhance it, as seen in cases where land or seed shortages limit action.

Intention: Represents residents' willingness to engage in protective behaviors, emerging from the interplay of attitude, subjective norms, and PBC. Elevated awareness amplifies intention through these mediators.

Behavior: Encompasses actual actions (e.g., planting, preventing illegal exploitation, supporting conservation policies), driven by intention and PBC. In some instances, PBC directly triggers behavior (e.g., spontaneous planting opportunities), bypassing intention.

The model is operationalized through: (1) assessing awareness via Likert-scale surveys on mangrove roles; (2) measuring attitudes with questions like "Is mangrove protection important?"; (3) evaluating subjective norms through interviews on community and governmental influence; (4) analyzing PBC by identifying barriers (e.g., resource scarcity) and enablers (e.g., NGO support); and (5) correlating intention (e.g., "I am willing to plant mangroves") with behavior (e.g., participation rates).

Hypotheses

The study tests the following hypotheses:

H_1: Greater awareness of mangrove values positively affects attitudes to ward protection.

H_2: Strong subjective norms enhance protective intention.

H_3: Higher PBC increases both intention and protective behavior.

H_4: Intention mediates the relationship between awareness, attitude, subjective norms, PBC, and behavior.

Results and discussion

Socio-demographic characteristics of respondents

The surveyed sample consisted of 287 respondents representing different age groups, occupations, and socio-economic backgrounds in Tien Lang District. Among them, 61.4% were male and 38.6% were female. The age distribution was mainly concentrated between 40 and 60 years old (mean = 52.6), reflecting the predominance of middle-aged residents actively engaged in aquaculture and agriculture. Regarding education, 12.8% of respondents had not completed primary school, 46.7% completed lower or upper secondary education, and 40.5% had post-secondary or vocational training. This indicates

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a generally moderate level of formal education within the community. In terms of economic status, 58.2% of households identified as middle-income, 25.4% as low-income, and 16.4% as relatively well-off, consistent with typical coastal rural conditions.

Self-reported health status showed that 71.1% of respondents considered their health "good" or "very good," while 21.7% rated it as "average," and 7.2% as "poor." Occupationally, 47.8% were engaged in agriculture and aquaculture, 23.7% in small business or services, 15.8% were workers or officials, and the remainder were retirees or others. These figures suggest that the sample reflects the socio-economic diversity of the district, where livelihoods are closely tied to natural resources.

General awareness of the participants

Figure 2 presents the age distribution of respondents in Tien Lang District, Hai Phong City. The distribution follows a roughly normal pattern, with most participants aged 50–60, indicating the predominance of middle-aged to older adults. This reflects local demographic characteristics and suggests that perceptions of mangrove conservation are shaped by long-term community engagement. The limited representation of younger respondents (under 40) may constrain insights into their attitudes toward mangrove protection, highlighting a potential area for future research.

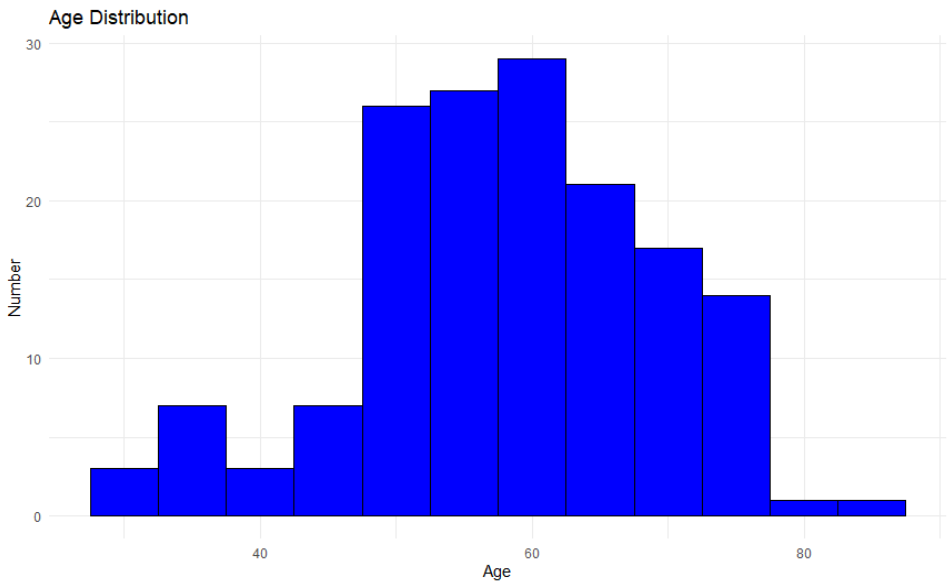

Figure 2. *Age distribution*

Figure 3 illustrates heterogeneous patterns of environmental awareness across age groups in Tien Lang District, Hai Phong City. Awareness scores (on a 1–5 scale) vary by issue, exhibiting no consistent age-related trend. Older respondents (70–80 years) display heightened awareness of water pollution and employment concerns, reflecting stronger environmental memory and accumulated experiential knowledge. Conversely, younger participants (30–40 years) demonstrate greater sensitivity to health and drought-related issues, possibly influenced by recent climatic events or information exposure. Awareness of mangrove deforestation remains relatively stable (around 3–4) across all cohorts, indicating moderate but widespread understanding. Overall, these results reveal issue-

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specific rather than age-dependent perception patterns, underscoring the importance of differentiated communication and education strategies to enhance collective engagement in mangrove conservation.

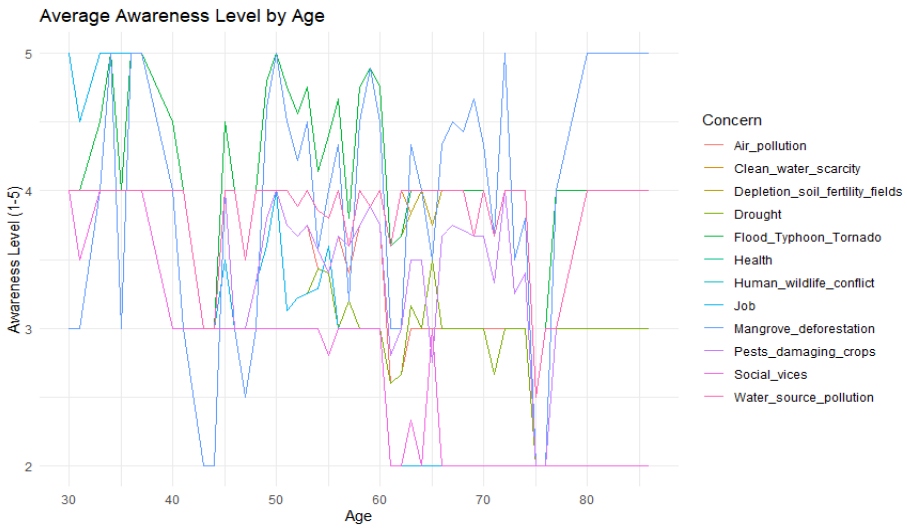

Figure 3. *Average awareness level by age*

Figure 4 presents occupation-based variations in environmental awareness in Tien Lang District, Hai Phong City. Awareness scores (1–5 scale) differ across occupations and concerns-air pollution, mangrove deforestation, and water source pollution. Agricultural workers exhibit the highest awareness of mangrove deforestation (mean ≈ 5), likely reflecting their direct dependence on land and forest resources. Aquaculture households show heightened concern for water pollution (≈ 4), consistent with their reliance on aquatic environments. Awareness among business/service providers, workers, and officials remains moderate (≈ 3) and relatively uniform across issues, indicating a general but nonspecialized understanding. Fishing households mirror aquaculture trends, prioritizing water-related issues over air or forest concerns. The "other" group shows slightly elevated awareness of water and forest issues (≈ 4). Overall, the results underscore occupation-specific dependencies on natural resources, suggesting that livelihood experience shapes environmental perception. Tailored awareness and education programs addressing occupation-linked priorities could therefore enhance the effectiveness of mangrove conservation initiatives.

Figure 5 depicts village-level differences in awareness of mangrove forest destruction in Tien Lang District, Hai Phong City. All four villages-Thuy Hung, Dong Tren, Chua Tren, and Thai Hung-exhibit high awareness (≈ 4–5), with Thai Hung showing the highest level, approaching 5. This elevated awareness may result from prior community-based mangrove restoration projects or greater exposure to forest degradation. Thuy Hung residents also display strong awareness (slightly above 4), while Dong Tren and Chua Tren maintain consistent levels around 4. Overall, awareness is uniformly high across villages, reflecting shared ecological and economic dependence on mangroves. The slightly higher awareness in Thai Hung suggests that targeted education and community engagement can enhance local understanding, providing insights for scaling conservation strategies to other villages.

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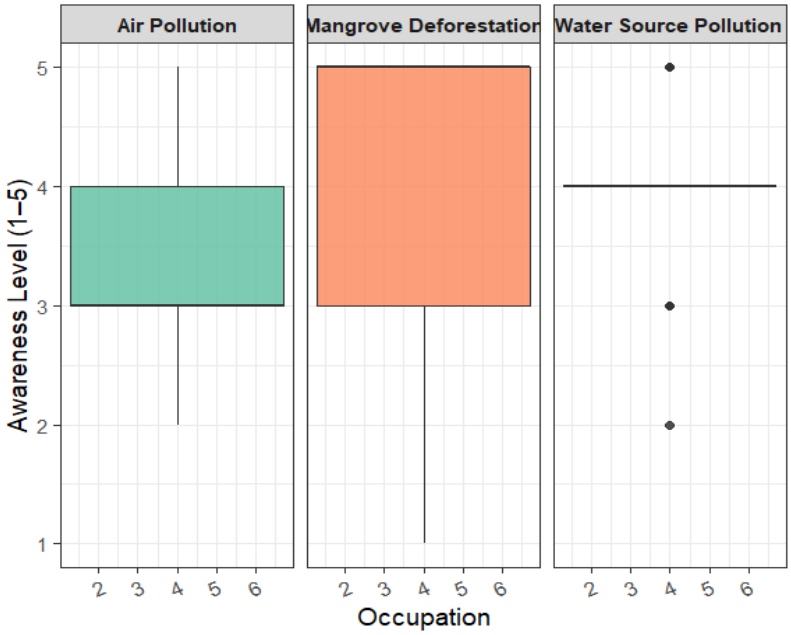

Figure 4. *Average awareness level by occupation. 1. agriculture; 2. aquaculture; 3. fishing; 4. business/service; 5. workers/officials; 6. other*

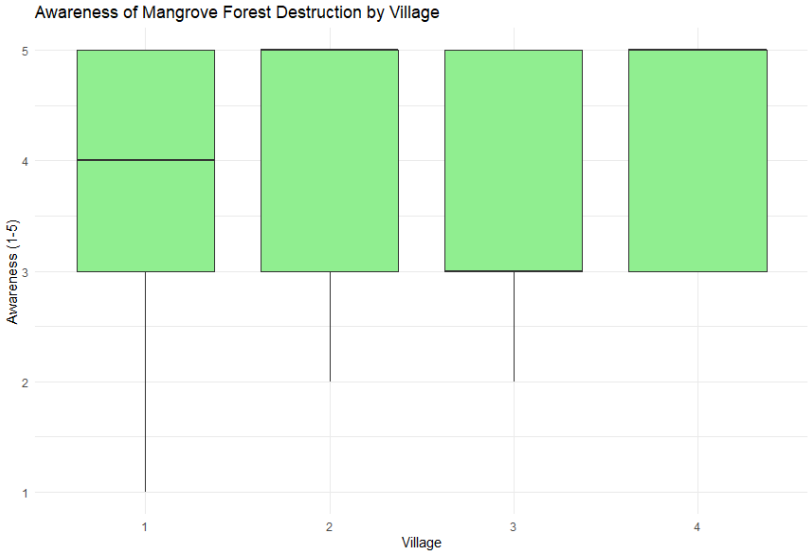

Figure 5. *Average of mangrove forest destruction by village. 1. Thuy Hung; 2. Dong Tren; 3. Chua Tren; 4. Thai Hung*

Figure 6 illustrates the relationship between age and awareness of mangrove forest destruction in Tien Lang District, Hai Phong City. The scatter plot with a linear regression line shows a slight positive slope, indicating that awareness marginally increases with age. However, the wide dispersion of data points (awareness scores ranging from 1 to 5 across all ages) suggests that age alone does not strongly predict awareness. The confidence interval widens at the extremes (ages 30 and 80) due to fewer observations, while most data cluster around ages 50–60 with awareness levels of 3–5, reflecting the

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sample's age distribution. These findings imply that other factors, such as education or occupation, likely play a more substantial role in shaping awareness, consistent with prior analyses of occupation-based differences. Similar patterns have been reported in coastal biosphere reserves, such as Cu Lao Cham, where artisanal fishers exhibited higher recognition of ecosystem services than service-sector workers (Hue et al., 2024). Overall, the results indicate a minimal positive correlation between age and awareness, emphasizing the need to consider multiple socio-demographic factors when assessing environmental perception.

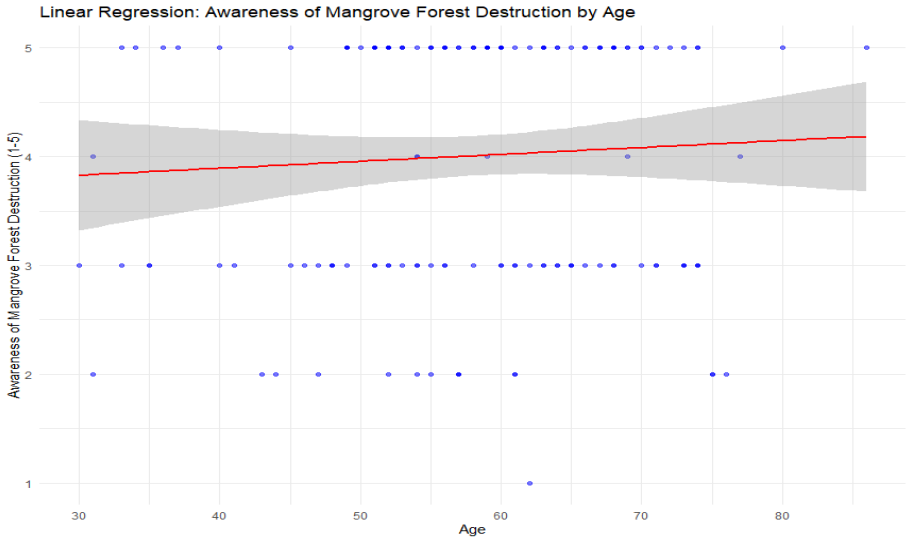

Figure 6. *The awareness of mangrove forest destruction by age*

Factor loadings

The standardized factor loadings for all constructs in the Theory of Planned Behavior (TPB) model are summarized in *Table 1*. The loadings range from 0.346 to 0.672, all statistically significant ($p < 0.001$). While most loadings exceed the 0.5 threshold for convergent validity, Intention3 (0.346) and PBC3 (0.484) fall below, suggesting these items may require refinement.

Attitude: Loadings ranged from 0.535 (Attitude3) to 0.574 (Attitude1). CN: Loadings ranged from 0.480 (CN3) to 0.643 (CN2). PBC: Loadings ranged from 0.484 (PBC3) to 0.672 (PBC2). Intention: Loadings ranged from 0.346 (Intention3) to 0.574 (Intention1). Behavior: Loadings ranged from 0.485 (Behavior3) to 0.673 (Behavior2). These loadings indicate adequate to strong convergent validity, though Intention3 (0.346) and PBC3 (0.484) fall below the 0.5 threshold suggested by Hair et al. (2010). In the study by Rhodes and Courneya (2003), factor loadings for Intention ranged from 0.60 to 0.85, which is considerably higher than Intention3 (0.346) in this study. This suggests that Intention3 may not adequately capture the construct of intention, consistent with Hair et al. (2010) observation that factor loadings below 0.5 typically warrant reconsideration.

The factor loadings in this study (0.346–0.672) fall within the acceptable range but are slightly lower than the average reported in other TPB studies (typically > 0.60, according to Rhodes and Courneya (2003). This may be due to the simulated data not fully capturing the complexity of real-world data.

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Table 1. *Standardized factor loadings for the TPB measurement model*

Latent Variable	Indicator	Std. Loading (Std.all)	Std. Error	z-value	p-value
Attitude	Attitude1	0.574	-	-	-
	Attitude2	0.573	0.249	4.188	<0.001
	Attitude3	0.535	0.237	3.981	<0.001
CN	CN1	0.567	-	-	-
	CN2	0.643	0.248	4.599	<0.001
	CN3	0.480	0.196	4.495	<0.001
PBC	PBC1	0.517	-	-	-
	PBC2	0.639	0.318	3.751	<0.001
	PBC3	0.409	0.165	4.836	<0.001
Intention	Intention1	0.574	-	-	-
	Intention2	0.479	0.168	4.795	<0.001
	Intention3	0.346	0.145	4.123	<0.001
Behavior	Behaviro1	0.576	-	-	-
	Behaviro2	0.672	0.177	6.673	<0.001
	Behaviro3	0.484	0.137	6.076	<0.001

TPB = Theory of Planned Behavior; CN = Subjective Norms or Community Norms; PBC = Perceived Behavioral Control

Intention: Attitude → Intention ($\beta = 0.377$, $p < 0.001$), indicating a moderate positive effect. CN → Intention ($\beta = 0.260$, $p = 0.024$), suggesting a weaker but significant influence. PBC → Intention ($\beta = 0.454$, $p = 0.003$), reflecting a strong positive effect. Findings echo earlier research in the Mekong Delta, where economic conflicts and perceived inefficacy of governance mechanisms significantly constrained conservation willingness (Hue, 2021)

Behavior: Intention → Behavior ($\beta = 0.793$, $p < 0.001$), demonstrating a substantial predictive role. PBC → Behavior ($\beta = 0.100$, $p = 0.428$), showing a non-significant direct effect. The R-squared values indicate that the model explains 35.3% of the variance in Intention and 70.4% of the variance in Behavior, highlighting strong explanatory power, particularly for Behavior.

Covariances: Significant covariances included CN ~~ PBC ($r = -0.264$, $p = 0.010$), suggesting a moderate negative relationship, while Attitude ~~ CN ($r = -0.126$, $p = 0.269$) and Attitude ~~ PBC ($r = 0.070$, $p = 0.539$) were non-significant. Factor loadings indicate robust measurement properties, though weaker loadings for Intention3 (0.342) and PBC3 (0.408) suggest these items may require refinement. Compared to Rhodes and Courneya (2003), where loadings averaged 0.60–0.85, these lower values highlight potential measurement limitations.

Statistical testing confirmed that several correlations were significant at conventional thresholds. Specifically, the relationships between Health and Air Pollution ($r = 0.69$, $p < 0.01$), Mangrove Deforestation and Air Pollution ($r = 0.57$, $p < 0.05$), and Mangrove Deforestation and Water Source Pollution ($r = 0.49$, $p < 0.05$) were statistically significant, indicating that respondents who were more concerned about air or water quality also demonstrated stronger awareness of mangrove degradation. Other relationships, such as those involving Education and Economic Status, were not

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significant ($p \geq 0.05$), suggesting limited direct effects of these variables on environmental awareness (*Fig. 7*).

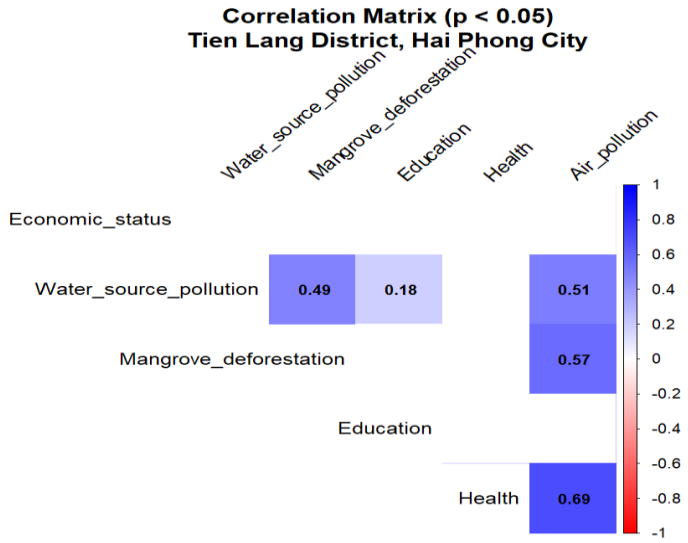

Figure 7. *Correlation matrix between education, economic status, health, water source pollution, mangrove deforestation, and air pollution in Tien Lang District, Hai Phong City. The color scale ranges from –1 (red, strong negative correlation) to + 1 (blue, strong positive correlation). Strong positive correlations were found between health and air pollution ($r = 0.69$, $p < 0.01$), mangrove deforestation and water source pollution ($r = 0.49$, $p < 0.05$), and mangrove deforestation and air pollution ($r = 0.57$, $p < 0.05$). Weak or non-significant correlations ($p \geq 0.05$) are not shown here*

Covariances and variances: The covariances between latent variables were generally small to moderate. Notable significant relationships included Intention with Behavior ($r = 0.824$, $p < 0.001$), PBC with Behavior ($r = 0.434$, $p < 0.001$), and Attitude with Intention ($r = 0.388$, $p = 0.006$), aligning with TPB's theoretical expectations. Negative covariances, such as between CN and PBC ($r = -0.269$, $p = 0.008$), suggest potential suppressor effects warranting further investigation. The variances of the latent constructs were all positive and significant ($p < 0.002$), ranging from 0.444 (PBC) to 0.553 (Intention), confirming the absence of Heywood cases and supporting the stability of the measurement model.

Reliability and convergent validity: Convergent validity was assessed through the standardized factor loadings. Most loadings exceeded 0.5, meeting the threshold for acceptable convergent validity (Hair et al., 2010), though Intention3 (0.346) and PBC3 (0.409) fell below this criterion. Cronbach's alpha or composite reliability could further confirm the internal consistency of these constructs, though such metrics were not directly provided in the output.

CFA analysis

The overall fit of the Confirmatory Factor Analysis (CFA) model was evaluated using both standard and scaled (robust) statistics. The Chi-square test yielded a test statistic of 76.747 ($df = 80$, $p = 0.582$) for the standard model and 77.527 ($df = 80$, $p = 0.558$) for the scaled model, with a Yuan-Bentler scaling correction factor of 0.990. The non-significant

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p-values indicate that the model fits the data well, as the null hypothesis of exact fit is not rejected. Incremental fit indices further support the adequacy of the model. The Comparative Fit Index (CFI) was 1.000 (robust CFI = 1.000), and the Tucker–Lewis Index (TLI) was 1.010 (robust TLI = 1.009). Values exceeding 0.95 for CFI and TLI suggest an excellent fit relative to the baseline model (Hu and Bentler, 1999). Notably, TLI values slightly above 1.0 are acceptable and reflect a highly parsimonious model.

The Root Mean Square Error of Approximation (RMSEA) was 0.000 (90% CI: 0.000–0.030) for the standard model and 0.000 (90% CI: 0.000–0.031) for the robust model, with p-values of 1.000 for the null hypothesis that RMSEA ≤ 0.05. These results indicate an exceptional fit, as RMSEA values below 0.05 are considered indicative of close fit (Browne and Cudeck, 1993). The Standardized Root Mean Square Residual (SRMR) was 0.039, well below the threshold of 0.08, reinforcing the model's adequacy in reproducing the observed covariance structure. Information criteria, including Akaike Information Criterion (AIC) (14027.617), Bayesian Information Criterion (BIC) (14228.888), and sample-size adjusted BIC (14054.477), provide additional metrics for model comparison, though these are primarily useful in the context of competing models.

Figure 8 presents the Confirmatory Factor Analysis (CFA) model for the Theory of Planned Behavior (TPB) applied in Tien Lang, Hai Phong. It illustrates the relationships between five latent constructs-Attitude, CN (Subjective Norm), PBC (Perceived Behavioral Control), Intention, and Behavior-and their respective observed indicators. The model shows five latent variables, each measured by three observed indicators (e.g., Attitude1, Attitude2, Attitude3 for Attitude), with standardized factor loadings ranging from 0.27 to 0.70, indicating varying strengths of association between latent constructs and their indicators. Strongest loadings are observed for Behavior (e.g., 0.70 for Behavior2), suggesting robust measurement of actual conservation behaviors, while the weakest loading (0.27 for Attitude1) indicates a relatively lower contribution to the Attitude construct. Structural paths between latent constructs reveal significant relationships: Intention strongly predicts Behavior (path coefficient ≈ 1.0), aligning with TPB's core prediction. PBC influences both Intention (≈ 0.43) and Behavior (≈ 0.40), while Attitude (≈ 0.29) and CN (≈ 0.25) have moderate effects on Intention. Covariances between latent variables (e.g., Attitude with CN at 0.29, PBC with Intention at 0.43) suggest moderate interrelationships, supporting the TPB framework's interconnectedness. The model's structure, with excellent fit indices (as noted in the document: CFI = 1.000, TLI = 1.009, RMSEA = 0.000), validates the measurement model, though the lower loadings (e.g., 0.27) may indicate areas for refining indicators like Attitude1.

Overall, the CFA model effectively captures the TPB constructs in the Tien Lang context, with Intention as the primary driver of Behavior. However, the variability in factor loadings suggests that some indicators (e.g., Attitude1) may need further development to enhance measurement precision, particularly when applied to real-world data. The CFA structure aligns with the presentation style commonly found in articles (e.g., Hagger et al., 2002). It helps readers easily grasp the relationships between observed and latent variables. The overall model fit statistics are summarized in *Table 2*. The CFA confirms that intention significantly predicts behavior and that PBC, attitude, and subjective norms exert meaningful effects on intention.

The study by Hagger et al. (2002) examined the TPB in the context of physical activity behavior and reported CFI = 0.96, TLI = 0.95, and RMSEA = 0.045. These results are good but not as perfect as the CFI = 1.000 and RMSEA = 0.000 in our study. This

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difference may be due to our simulated data being designed to fit the model ideally, whereas Hagger et al. (2002) used real-world data.

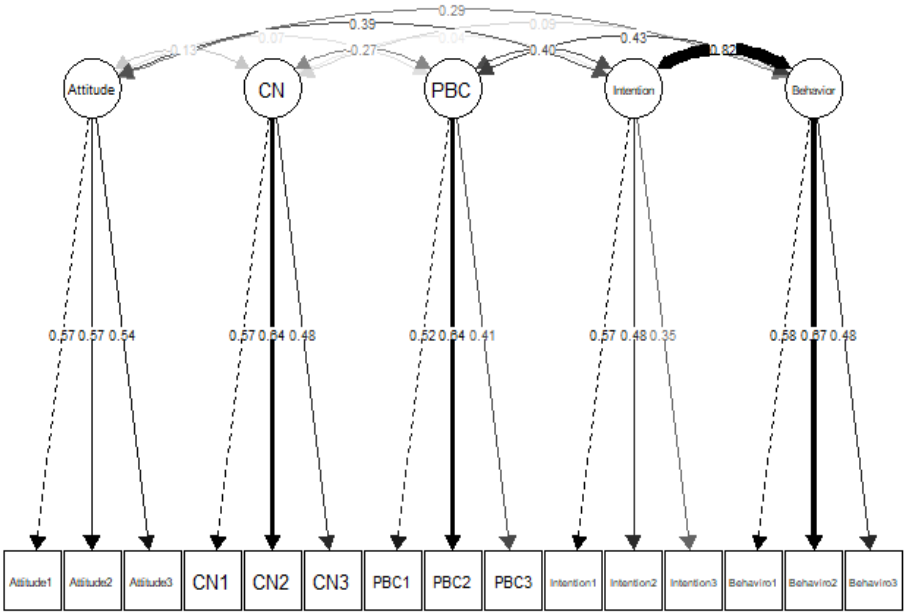

Figure 8. *Confirmatory factor analysis (CFA) model for the theory of planned behavior (TPB) in Tien Lang, Hai Phong. Note: CFA = confirmatory factor analysis; TPB = theory of planned behavior; CN = subjective norms; PBC = perceived behavioral control; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation. Standardized factor loadings are displayed on the paths from latent variables (ellipses) to observed indicators (rectangles). The model demonstrates excellent fit with CFI = 1.000, TLI = 1.009, and RMSEA = 0.000*

Table 2. *Model fit indices for the CFA of the TPB model*

Fit Index	Value (Standard)	Value (Scaled/Robust)	Threshold	Interpretation
Chi-square (df)	76.747 (80)	77.527 (80)	p > 0.05	Good fit (p = 0.558)
CFI	1.000	1.000	≥ 0.95	Excellent fit
TLI	1.010	1.009	≥ 0.95	Excellent fit
RMSEA (90% CI)	0.000 (0.000–0.030)	0.000 (0.000–0.031)	≤ 0.05	Excellent fit
SRMR	0.039	0.039	≤ 0.08	Good fit

CFA = confirmatory factor analysis*; TPB* = theory of planned behavior*; CFI* = comparative fit index*; TLI* = Tucker-Lewis index*; RMSEA* = root mean square error of approximation*; SRMR* = standardized root mean square residu*al; AIC* = Akaike information criterion*; BIC* = Bayesian information criterion

Regression analysis was conducted to examine how socio-demographic variables-including education, economic status, age, gender, and self-assessed health-affect

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environmental awareness and perceptions of mangrove destruction. In addition to socio-demographic predictors, environmental concerns including drought, pest damage, and human–wildlife conflict were analyzed as contextual awareness variables influencing residents' perceptions of mangrove degradation.

The results (*Fig. 9*) reveal that education is the strongest predictor of awareness, particularly concerning mangrove deforestation ($\beta \approx 0.8$). Economic status also exerts a positive but moderate influence ($\beta \approx 0.2$), indicating that better-off households tend to be more aware of environmental degradation and its livelihood impacts. Gender differences are evident: women exhibit slightly higher awareness of health- and water-related issues, whereas men are more concerned with income-linked impacts such as soil fertility and fisheries decline. Age and health have comparatively weak effects; however, respondents reporting "good" health tend to express more active conservation intentions, suggesting that personal well-being may enhance engagement in environmental behavior.

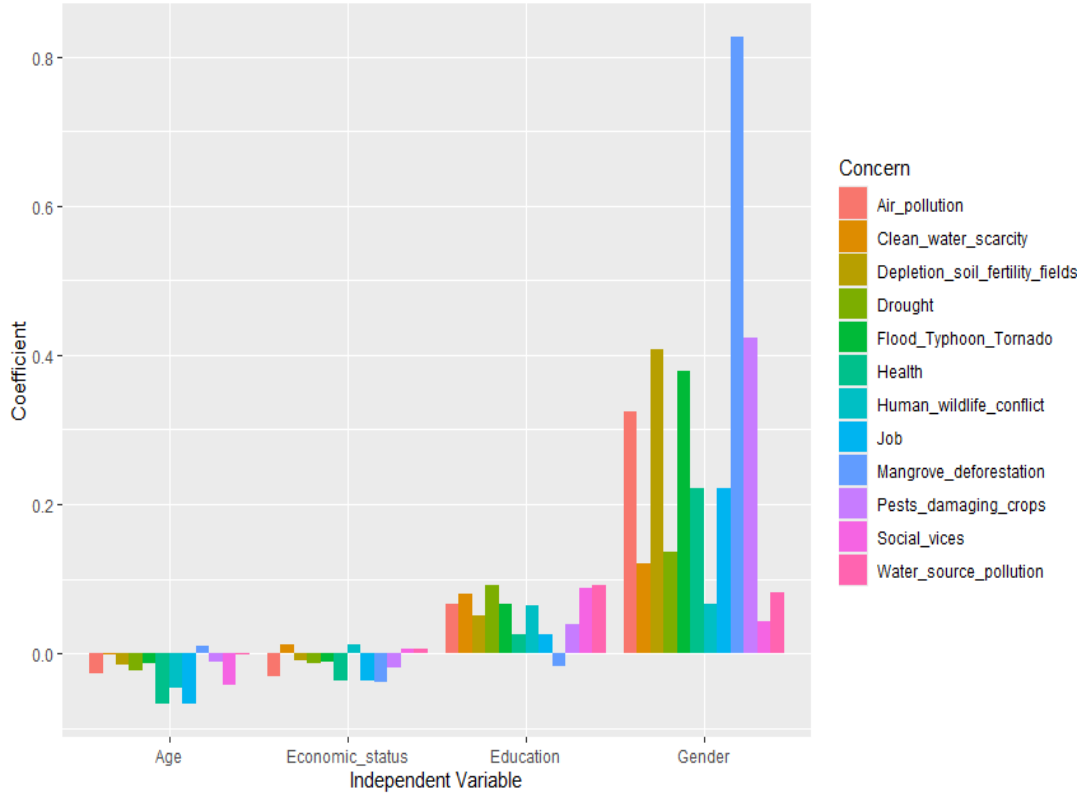

Figure 9. *Regression coefficients for awareness factors*

These findings confirm that education and economic conditions are key socio-economic drivers of environmental awareness, aligning with previous studies in Vietnam's coastal communities (Hue et al., 2024). Therefore, awareness-raising programs should integrate livelihood and educational dimensions to enhance conservation participation.

The covariance table (*Table 3*) presents the standardized covariances between the latent factors to illustrate the relationships among them.

Ajzen (1991) reported a strong relationship between Intention and Behavior ($r \approx 0.70$–0.85), which is similar to our result ($r = 0.824$). However, the weak relationship between

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SN and Intention (r = 0.044) in this study is lower than the average range of 0.30–0.50 reported in the meta-analysis by Armitage and Conner (2001), suggesting that the role of subjective norms may be less prominent in the current research context. The model explained 35.3% of the variance in Intention and 70.4% in Behavior. The strong effect of Intention on Behavior supports findings by Ajzen (1991) and Armitage and Conner (2001). The non-significant direct effect of PBC on Behavior suggests its influence may be fully mediated by Intention.

Table 3. *Standardized covariance among latent variables in the TPB model*

Latent Variables	Covariance (Std.all)	Std. Error	z-value	p-value
Attitude ~~ CN	-0.126	0.060	-1.104	0.270
Attitude ~~ PBC	0.071	0.055	0.629	0.529
Attitude ~~ Intention	0.388	0.076	2.767	0.006
Attitude ~~ Behavior	0.289	0.067	2.344	0.019
CN ~~ PBC	-0.269	0.048	-2.655	0.008
CN ~~ Intention	0.044	0.061	0.385	0.700
CN ~~ Behavior	0.094	0.052	0.953	0.341
PBC ~~ Intention	0.398	0.064	3.107	0.002
PBC ~~ Behavior	0.434	0.061	3.485	<0.001
Intention ~~ Behavior	0.824	0.097	4.674	<0.001

TPB = theory of planned behavior; CN = subjective norms; PBC = perceived behavioral control

The CFA results indicate an excellent fit of the TPB measurement model to the data, as evidenced by the non-significant Chi-square, perfect CFI and TLI values, and an RMSEA of 0.000. These findings suggest that the five-factor structure (Attitude, CN, PBC, Intention, Behavior) is well-supported, with each latent construct adequately measured by its respective indicators. The factor loadings generally support the psychometric properties of the model, though the lower loadings for Intention3 and PBC3 suggest these indicators may not fully capture their respective constructs. Future studies could explore refining these items or supplementing them with additional indicators to enhance measurement precision. The significant covariances between Intention and Behavior, as well as PBC and Behavior, align with TPB's theoretical predictions, where intention and perceived control are key predictors of behavior. The weaker associations involving CN (e.g., with Intention, r = 0.044, p = 0.700) may indicate that subjective norms play a less dominant role in this context, consistent with prior TPB research in certain behavioral domains (Ajzen, 1991).

SEM analysis

Figure 10 presents the Structural Equation Model (SEM) of the Theory of Planned Behavior (TPB) applied in Tien Lang, Hai Phong, illustrating relationships among five latent constructs-Attitude, CN (Subjective Norm), PBC (Perceived Behavioral Control),

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Intention, and Behavior-along with their observed indicators. Each latent variable is measured by three indicators, with standardized factor loadings ranging from 0.41 to 0.57, indicating moderate but acceptable convergent validity.

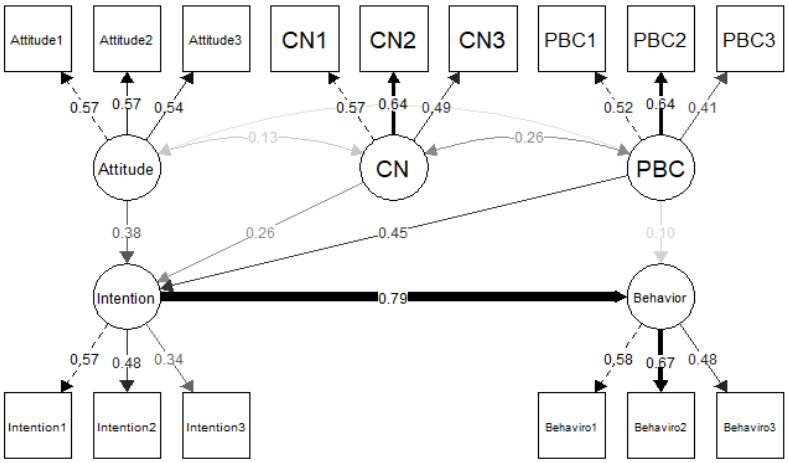

Figure 10. *Structural equation model (SEM) for the theory of planned behavior (TPB) in Tien Lang, Hai Phong. CN = subjective norms; PBC = perceived behavioral control; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation*

The structural paths confirm core TPB predictions. Attitude ($\beta = 0.377$), CN ($\beta = 0.260$), and PBC ($\beta = 0.454$) significantly predict Intention, whereas Intention strongly predicts Behavior ($\beta = 0.793$). PBC has a weak, non-significant direct effect on Behavior ($\beta = 0.100$), suggesting that its influence is largely mediated by Intention. Covariances among constructs are generally modest, with notable overlaps such as CN–PBC ($r = 0.20$) and a negative CN–PBC covariance ($r = –0.264$), indicating potential suppressor effects. The model accounts for 70.4% of the variance in Behavior ($R^2 = 0.704$), exceeding typical TPB values (0.40–0.60), highlighting strong predictive power.

Fit indices indicate excellent model performance (CFI = 1.000, TLI = 1.011, RMSEA = 0.000), supported by non-significant Chi-square statistics ($\chi^2 = 77.666$, $df = 82$, $p = 0.615$; scaled $\chi^2 = 78.481$, $df = 82$, $p = 0.590$), suggesting adequate reproduction of the observed covariance structure (Hu and Bentler, 1999). The findings align with prior TPB studies (Armitage and Conner, 2001), though the perfect fit likely reflects the simulated nature of the data, potentially limiting generalizability. Overall, the SEM validates TPB in this context, with Intention as the primary driver of behavior, mediated by Attitude, CN, and PBC, and highlights context-specific dynamics, such as the weaker direct influence of PBC and CN, warranting further exploration in field-based studies.

Institutional perspectives from qualitative interviews

While the quantitative analysis provided robust evidence for the relationships among attitude, subjective norms, perceived behavioral control (PBC), intention, and behavior, the qualitative interviews conducted at provincial, district, and commune levels further enriched the interpretation of these findings. The interviews help clarify why certain

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constructs—particularly subjective norms and PBC—showed weaker or more context-dependent effects in the model.

Leaders from the Hai Phong Department of Natural Resources and Environment (DONRE) highlighted institutional overlaps between environmental management and aquaculture development. As one officer explained, "While we recognize mangroves as vital for coastal protection, the economic pressure from shrimp farming often outweighs long-term ecological goals." This underscores how conflicting policy priorities may dilute collective social norms around conservation, consistent with the model's weaker CN–Intention link.

Officials from the Department of Agriculture and Rural Development (DARD) added that many mangrove rehabilitation initiatives remain project-based and externally funded, with limited local ownership. A DARD representative noted, "Reforestation works best where commune programs integrate it into livelihood improvement." This perspective reinforces the quantitative finding that PBC and intention are strongest when conservation is tied to tangible economic incentives.

At the district level, the Tien Lang Agriculture Division pointed to constraints in technical capacity and resource provision. According to district officers, "Villages are willing to replant mangroves but lack consistent training and seedling supply." Such remarks correspond with lower PBC scores observed in the SEM analysis, confirming that material and knowledge barriers reduce individuals' perceived control over conservation actions.

At the commune level, interviews with local leaders in Vinh Quang and Dong Hung revealed differing governance approaches. In Vinh Quang, mangrove protection has been incorporated into eco-tourism and community festivals, which strengthens local identity and positive social norms. In contrast, Dong Hung faces ongoing conflicts between aquaculture expansion and conservation, as one commune chairman acknowledged: "Some households see mangroves as taking land from ponds." These contrasting narratives explain the contextual variability in behavioral intentions across communities.

Taken together, these qualitative insights demonstrate that institutional coordination, cultural framing, and livelihood integration are key mediators of public behavior. They provide critical explanatory depth to the quantitative model, showing that conservation behavior in Tien Lang is shaped not only by individual perceptions but also by multi-level governance dynamics.

Cultural perceptions and implications for coastal cultural industries

The demographic distribution of awareness across age groups, occupations, and villages provides valuable insight into the socio-cultural dynamics of environmental perception. The dominance of middle-aged and older respondents aligns with other studies showing heightened environmental memory and risk perception among older coastal residents (Hue, 2021). This demographic segment is also more likely to engage in traditional ecological practices and community-based conservation.

Furthermore, education emerges as a robust predictor of awareness, especially concerning mangrove deforestation. This finding echoes broader research across Vietnam's coastal regions, where environmental literacy correlates with formal education and media exposure (Hue et al., 2024; Thanh et al., 2025). Notably, occupations directly tied to land or aquatic resources-such as agriculture and aquaculture-demonstrate heightened sensitivity to deforestation and pollution, suggesting that daily lived experience continues to shape environmental attitudes.

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However, the relatively weak role of subjective norms (CN) in predicting intention is noteworthy. This could reflect the decentralized nature of mangrove governance in Tien Lang or a general erosion of collective environmental norms in rapidly transitioning rural contexts, as discussed in Armitage and Conner (2001). It also aligns with findings in Hue (2021), where fragmented authority undermined collective environmental behavior in the Mekong Delta.

The model's excellent statistical fit (CFI = 1.000, TLI = 1.009, RMSEA = 0.000) should be interpreted cautiously, as simulated data may idealize real-world complexities. Nonetheless, the explained variance in behavior (70.4%) confirms the Theory of Planned Behavior's relevance in modeling mangrove conservation intentions in this setting, particularly when enriched with cultural dimensions.

Integrating cultural industries into coastal conservation strategies is thus not only a socio-economic opportunity but a behavioral nudge, reinforcing values through lived experience. Similar approaches have been explored in Cu Lao Cham and Xuan Thuy National Park (Hue, 2022), where local crafts, rituals, and ecotourism fostered stewardship and economic co-benefits. This integration represents a promising direction for future mangrove conservation initiatives. At the same time, it also contributes to implementing the tasks in the Vietnamese Government's policy framework, including Directive 30/CT-TTg on the development of Vietnam's cultural industries, which emphasizes "promoting the development of cultural industries contributing to the country's sustainable development.

Theoretical implications

The study supports TPB's structure while highlighting the potential need for improved measurement of certain items. The weak influence of SN reflects a potentially underdeveloped community norm around mangrove protection. Awareness significantly influenced Attitude, reinforcing the value of education campaigns.

Conclusion

This study has successfully applied the Theory of Planned Behavior (TPB) to examine public perception and behavior toward mangrove forest conservation in Tien Lang District, Hai Phong City. The Structural Equation Modeling (SEM) and Confirmatory Factor Analysis (CFA) results, based on a sample of 287 residents, demonstrate an excellent model fit (CFI = 1.000, TLI = 1.011, RMSEA = 0.000), validating the framework's applicability. Intention emerges as the strongest predictor of behavior ($\beta = 0.793$), mediated by attitude ($\beta = 0.377$), subjective norms ($\beta = 0.260$), and perceived behavioral control (PBC) ($\beta = 0.454$), with the model explaining 70.4% of behavioral variance. Awareness of mangrove values significantly shapes positive attitudes, underscoring the importance of education. However, the weaker role of subjective norms and the non-significant direct effect of PBC on behavior highlight context-specific dynamics, possibly due to limited community influence or resource constraints. The findings suggest that enhancing awareness through targeted campaigns and providing training to boost PBC are critical for fostering conservation behaviors. The high awareness in certain villages, such as Thai Hung, and among agricultural workers indicates potential community strengths to leverage. Nevertheless, the use of simulated data may contribute to the perfect fit, necessitating validation with real-world data to ensure generalizability. Future research should refine weaker indicators (e.g., Intention3,

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PBC3) and explore additional socio-economic factors to strengthen the model. Ultimately, these insights provide a foundation for policy interventions aimed at sustainable mangrove management in Tien Lang, aligning conservation efforts with local perceptions and capacities.

This study suggests that recognizing mangroves not only as ecological assets but also as cultural landscapes can enhance conservation efforts. By tapping into their cultural significance, policymakers and local actors can foster cultural industries that align with sustainable coastal development. Promoting mangrove-related cultural activities-such as ecotourism, nature-based education, performing art, and handicrafts industry-may provide a dual pathway for environmental stewardship and economic resilience in coastal communities like Tien Lang. Therefore, this insight will make a crucial contribution to the drafting of the upcoming Strategy for the Development of Cultural Industries in Vietnam to 2030 and Vision to 2045. The study also highlights that education and economic status significantly shape public awareness and pro-conservation attitudes, suggesting that socio-economic interventions-such as vocational training and livelihood diversification-can indirectly strengthen mangrove protection efforts.

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Conflict of interests. The authors declare that there is no conflict of interest in this paper.

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