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Microplastic Threats: Urban–Rural Differences in Knowledge, Risk, and Psychosocial Factors among Households

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ABSTRACT

Introduction: Microplastic pollution has emerged as an increasingly urgent environmental problem, highlighting the need to better understand the psychological and social factors that encourage households to engage in pro-environmental behavior. Grounded in the Theory of Planned Behavior, this study examines how microplastic knowledge, risk perception, attitudes, subjective norms, and perceived behavioral control shape pro-environmental intentions among urban and rural housewives, extending TPB by integrating knowledge and risk perception.

Methods: A quantitative research design was applied by distributing structured questionnaires to 600 respondents, comprising 300 urban and 300 rural housewives in Bogor City and Bogor Regency. Data analysis involved independent t-tests to identify differences between the two groups, and Structural Equation Modeling (SEM) to examine the causal relationships among the studied variables.

Results: The results show significant urban–rural differences in microplastic knowledge, risk perception, subjective norms, and perceived behavioral control, while attitudes and pro-environmental behavioral intentions are relatively similar across contexts. In urban areas, knowledge significantly influences risk perception, whereas attitudes, subjective norms, and perceived behavioral control predict pro-environmental behavioral intention. In rural areas, risk perception and perceived behavioral control are the main predictors, with no direct effect of knowledge.

Conclusion: Overall, knowledge alone is insufficient to promote pro-environmental behavioral intention. Instead, behavioral intentions follow context-specific pathways, driven primarily by attitudinal and normative factors in urban areas and by risk awareness and perceived behavioral control in rural settings.

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INTRODUCTION

Indonesia is the world's second-largest contributor to marine plastic pollution after China, generating around 3.2 million tons of mismanaged plastic annually, of which 1.29 million tons enter the ocean, including an estimated 10 billion plastic bags each year (1,2). National data show that 33.3 million tons of waste are produced annually, with 13.3 million tons unmanaged; plastics account for nearly 20% of this, largely from household consumption managed by housewives (3).

Improperly managed waste leads to microplastic formation—particles <5 mm—which contaminate soil, water, air, and the food chain(4,5). Indonesians are estimated to ingest about 15 g of microplastics monthly, primarily from seafood and bottled water (6). Microplastics have been detected in human lungs, blood, placenta, kidneys, and reproductive organs (7–11). Despite these risks, public awareness and understanding remain low (12–15).

Knowledge plays a critical role in shaping risk perception, which subsequently influences pro-environmental behavior (16–18). Individuals with higher environmental knowledge tend to perceive greater risks and are more likely to adopt sustainable practices, highlighting the importance of cognitive factors in behavioral change. Given their central role in household decision-making, housewives represent key agents of microplastic reduction at the domestic level (19,20). Building on these insights, this study applies the Theory of Planned Behavior (TPB) (21) and extends it by incorporating knowledge and risk perception to examine pro-environmental intentions related to microplastic reduction in urban and rural contexts.

The uniqueness of this research lies in two aspects: first, analyzing the differences between urban and rural communities, where infrastructure, exposure, and behavioral norms differ significantly; and second, emphasizing the role of housewives as key agents of change in households to reduce microplastic exposure. This research is important because it provides theoretical contributions by expanding the TPB and offers practical implications for targeted education, behavioral interventions, and policy strategies tailored to different community contexts. Accordingly, the objectives of this research are to compare the factors of knowledge, risk perception, attitudes, subjective norms, and behavioral control between urban and rural communities; and to assess their influence on pro-environmental behavioral intentions toward microplastic reduction.

METHOD

This study employs a clear and systematic approach to ensure the reliability and validity of the findings. Below are the components of the methodology:

Research Methodology

This study applies a quantitative design to examine factors shaping pro-environmental behavioral intentions, including microplastic knowledge, risk perception, environmental attitudes, subjective norms, and perceived behavioral control. Data were collected from 600 survey respondents, evenly divided between rural and urban areas in Bogor Regency and Bogor City. The selected sites as Cicadas Village (Gunung Putri District) and Curug Mekar Subdistrict (Bogor Barat District), West Java were chosen due to their notable contribution to regional plastic waste (22,23). Representing distinct rural–urban contexts, these locations offer comparative insights into microplastic consumption patterns and community pro-environmental behaviors.

Data Collection Procedure

Data were collected using a household-based approach, targeting housewives as respondents. A total of 600 participants were drawn through systematic random sampling across rural and urban areas, ensuring equal selection opportunities. Households were chosen at fixed intervals from sequential lists (e.g., starting with household 1 and selecting every third household). If an interview could not be completed, the next eligible household was approached. Respondents were required to be housewives—married or formerly married—with independent authority over household consumption decisions.

Data Collection Techniques

Data collection was conducted through direct interviews, where enumerators asked questions to respondents and the respondents provided their answers directly. Each interview session lasted approximately 20–30 minutes. The enumerators, who were final-year university students or recent graduates with backgrounds in social research, received prior training on research instruments, interview protocols, and the use of tools such as show cards. To ensure the validity of the data, they were also instructed to remain neutral throughout the interview process.

Ethical Clearance

This study obtained ethical approval from the Research Ethics Committee of IPB University with approval letter number: [1758/IT3.KEPMSM-IPB/SK/2025]. All respondents were provided with an explanation of the research objectives, interview procedures, and their rights to participate or withdraw without any consequences. Participation consent was obtained through an informed consent form administered before data collection began. The anonymity of respondents was strictly maintained, and all collected data were kept confidential to prevent any potential adverse effects on participants. The researcher ensured that all research activities adhered to the ethical principles of beneficence, respect for persons, and justice, thereby upholding ethical integrity and accountability throughout the research process.

Variables and Instruments

This study examined six primary variables adapted from previous research to ensure their alignment with the study's context. These variables included microplastic knowledge [10 indicators] (12,13,24), risk perception [8 indicators] ((17), attitudes toward microplastics [6 indicators] ((24), subjective norms [5 indicators] ((25), behavioral control [4 indicators], and pro-environmental behavioral intentions [6 indicators] (17). Microplastic knowledge was assessed using a true/false format, where respondents determined whether each statement regarding microplastics was correct or incorrect. In contrast, the remaining variables were measured using a five-point Likert scale ranging from "strongly disagree" [1] to "strongly agree" [5], allowing respondents to express varying degrees of agreement with statements related to each variable.

Instrument testing covered validity and reliability analyses for six latent constructs. Following item refinement, reliability was re-evaluated using SPSS based on pilot data from 30 respondents. The results indicated that all constructs achieved acceptable internal consistency, with Cronbach's Alpha values exceeding the recommended threshold of 0.6. Specifically, microplastic knowledge ($\alpha = 0.718$), risk perception ($\alpha = 0.925$), attitude toward microplastics ($\alpha = 0.819$), subjective norm ($\alpha = 0.679$), perceived behavioral control ($\alpha = 0.814$), and pro-environmental behavioral intention ($\alpha = 0.909$) were all deemed reliable, confirming the suitability of the measurement scales for subsequent structural analysis (See Table 1).

Table 1. Reliability test results of latent variables based on Cronbach's Alpha

Latent Variables	Cronbach's Alpha	Conclusion
Microplastic Knowledge	0.718	Reliable
Risk Perception	0.925	Reliable
Attitude Towards Microplastics	0.819	Reliable
Subjective Norm	0.679	Reliable
Perceived Behavioral Control	0.814	Reliable
Pro-environmental Behavioral Intention	0.909	Reliable

Data Analysis

Data analysis was carried out in several stages. First, descriptive statistics were generated in SPSS 25 to summarize respondents' demographic characteristics, including minimum, maximum, mean, and standard deviation values. Group differences based on demographic and other variables were then examined using t-tests in SPSS 25 to identify significant variations between the two groups. Finally, Structural Equation Modeling (SEM) with SmartPLS was employed to assess both direct and indirect relationships among the study variables.

RESULTS

Respondent Characteristics

The respondents were predominantly late adults aged 36–45 years (32.8%), followed by early elderly aged 46–55 years (27.8%). Nearly half (48.0%) fell into the low-income bracket (Rp600,000–Rp1,500,000), with a greater share in rural areas. Most had completed high school or vocational education, with wives (38.5%) generally less educated than husbands (56.3%). The majority of wives were housewives (76.7%), while husbands were mostly casual laborers (51.0%). Household size was typically large, with four dependents being most common (33.5%), showing similar patterns across rural and urban settings, though slightly higher in rural households.

Analysis of Differences Between Urban and Rural Areas

The analysis revealed significant urban–rural differences across several variables. Knowledge of microplastics was significantly greater in urban areas (81.20 vs. 73.57; p = 0.000), as was risk perception (81.26 vs. 79.06; p = 0.010). No significant differences were found in attitudes (p = 0.802), pro-environmental intentions (p = 0.093), or intentions to replace microplastic products (p = 0.579). However, subjective norms were stronger in rural areas (57.65 vs. 47.82; p = 0.000), and behavioral control was also higher (75.12 vs. 71.56; p = 0.003) (see Table 2).

Table 2. Comparison test of research variables based on location

Variables	Location	Mean	Std. Deviation	Std. Error Mean	p-value
Microplastic Knowledge	Urban	81.20	16.31	0.94	0.000**
	Rural	73.57	17.11	0.99	
Risk Perception	Urban	81.26	11.21	0.65	0.010*
	Rural	79.06	9.44	0.55	
Attitude Toward Microplastics	Urban	74.75	13.51	0.78	0.802
	Rural	74.46	14.91	0.86	
Subjective Norm	Urban	47.82	17.98	1.04	0.000**
	Rural	57.65	15.83	0.91	
Perceived Behavioral Control	Urban	71.56	17.96	1.04	0.003**
	Rural	75.12	9.92	0.57	
Pro-Environmental Intention	Urban	74.01	16.65	0.96	0.093
	Rural	75.91	10.10	0.58	

Notes: * significant at p<0.01; ** significant at p<0.05

Structural Model Evaluation Analysis (Inner Model)

As shown in Table 3, in urban areas, risk perception exhibited a very low R^2 value of 0.053, indicating that only 5.3% of its variance was explained by the model. Attitude toward microplastics showed a moderate R^2 of 0.234, suggesting that approximately 23.4% of the variance in attitudes was explained. Pro-environmental behavioral intention demonstrated a relatively strong R^2 of 0.493, indicating that nearly half of the variance in behavioral intention was accounted for by the model.

In rural areas, risk perception had an extremely low R^2 of 0.005, reflecting minimal explanatory power. Attitude toward microplastics also showed a low R^2 of 0.081, while pro-environmental behavioral intention exhibited a very low R^2 of 0.061, suggesting that the model explains only a small proportion of variance in these constructs.

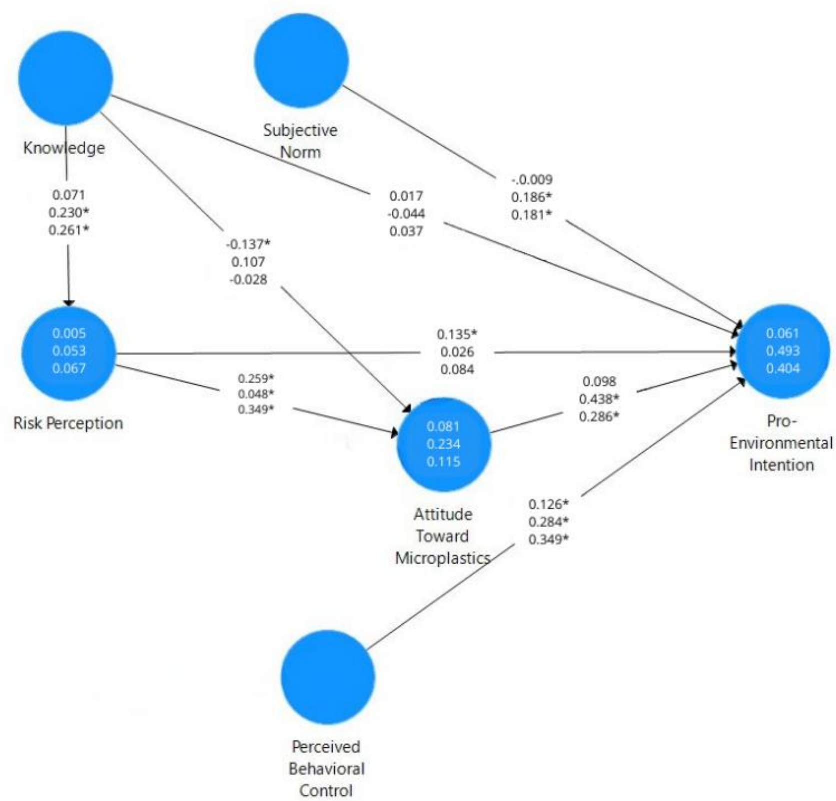
For the total sample, risk perception had an R^2 of 0.067, attitude toward microplastics 0.115, and pro-environmental behavioral intention 0.404. These results indicate that the model explains a moderate proportion of variance in pro-environmental behavioral intention, while its explanatory power for risk perception and attitude toward microplastics remains limited.

Table 3. R-squared based on areas

Construct	Urban	Rural	Total
Risk Perception	0.053	0.005	0.067
Attitude Toward Microplastics	0.234	0.081	0.115
Pro-Environmental Behavioral Intention	0.493	0.061	0.404

Hypothesis Testing

Figure 1 illustrates the structural model across rural, urban, and total samples. The results reveal context-specific pathways, where perceived behavioral control consistently predicts pro-environmental behavioral intention across all samples. In urban areas, attitudes and subjective norms emerge as key drivers of intention, whereas in rural areas, risk perception and perceived behavioral control play a more prominent role. Microplastic knowledge primarily influences risk perception but does not directly affect behavioral intention.



Notes:
Arrow values: Path coefficients (Row order: Rural, Urban, Total)
Circle values: R^2 (Row order: Rural, Urban, Total)

Fig 1. Structural equation model results for rural, urban, and total samples

The hypothesis testing results presented in Table 4 show several significant relationships across rural, urban, and total samples. In rural areas, microplastic knowledge does not significantly influence risk perception ($\beta = 0.071$, $p = 0.204$) or pro-environmental behavioral intention ($\beta = 0.017$, $p = 0.771$), but it has a significant negative effect on attitudes toward microplastics ($\beta = -0.137$, $p = 0.011$). Risk perception significantly affects both attitudes toward microplastics ($\beta = 0.259$, $p < 0.001$) and pro-environmental behavioral intention ($\beta = 0.135$, $p = 0.026$). Perceived behavioral control also shows a significant positive effect on pro-environmental behavioral intention (β = 0.126, p = 0.036). However, attitudes toward microplastics (β = 0.098, p = 0.112) and subjective norms (β = −0.009, p = 0.867) do not significantly influence pro-environmental behavioral intention in rural areas.

In urban areas, microplastic knowledge has a significant positive effect on risk perception (β = 0.230, p < 0.001), but shows no significant influence on attitudes toward microplastics (β = 0.107, p = 0.058) or pro-environmental behavioral intention (β = −0.044, p = 0.329). Risk perception significantly affects attitudes toward microplastics (β = 0.448, p < 0.001), but does not directly influence pro-environmental behavioral intention (β = 0.026, p = 0.677). Attitudes toward microplastics demonstrate a strong positive effect on pro-environmental behavioral intention (β = 0.438, p < 0.001). In addition, subjective norms (β = 0.186, p < 0.001) and perceived behavioral control (β = 0.284, p < 0.001) also significantly influence pro-environmental behavioral intention in urban areas.

For the total sample, microplastic knowledge has a significant positive effect on risk perception (β = 0.261, p < 0.001), but does not significantly influence attitudes toward microplastics (β = −0.028, p = 0.549) or pro-environmental behavioral intention (β = 0.037, p = 0.285). Risk perception significantly affects attitudes toward microplastics (β = 0.349, p < 0.001), while its direct effect on pro-environmental behavioral intention is not statistically significant (β = 0.084, p = 0.063). Attitudes toward microplastics significantly influence pro-environmental behavioral intention (β = 0.286, p < 0.001). In addition, subjective norms (β = 0.181, p < 0.001) and perceived behavioral control (β = 0.349, p < 0.001) also show significant positive effects on pro-environmental behavioral intention.

Table 4. Hypothesis testing

Path	Original Sample (O)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Conclusion
Hypothesis Test Results for the Rural Area					
Knowledge → Risk Perception (H1)	0.071	0.056	1.271	0.204	Insignificant
Knowledge → Attitude Toward Microplastics (H2)	-0.137	0.054	2.554	0.011	Significant
Knowledge → Pro-Environmental Behavioral Intention (H3)	0.017	0.059	0.291	0.771	Insignificant
Risk Perception → Attitude Toward Microplastics (H4)	0.259	0.053	4.876	0.000	Significant
Risk Perception → Pro-Environmental Behavioral Intention (H5)	0.135	0.060	2.232	0.026	Significant
Attitude Toward Microplastics → Pro-Environmental Behavioral Intention (H6)	0.098	0.062	1.593	0.112	Insignificant
Subjective Norm → Pro-Environmental Behavioral Intention (H7)	-0.009	0.056	0.168	0.867	Insignificant
Perceived Behavioral Control→ Pro-Environmental Behavioral Intention (H8)	0.126	0.060	2.107	0.036	Significant
Hypothesis Test Results for the Urban Area					
Knowledge → Risk Perception (H1)	0.230	0.059	3.920	0.000	Significant
Knowledge → Attitude Toward Microplastics (H2)	0.107	0.056	1.903	0.058	Insignificant
Knowledge → Pro-Environmental Behavioral Intention (H3)	-0.044	0.045	0.978	0.329	Insignificant
Risk Perception → Attitude Toward Microplastics (H4)	0.448	0.054	8.314	0.000	Significant
Risk Perception → Pro-Environmental Behavioral Intention (H5)	0.026	0.063	0.417	0.677	Insignificant

Path	Original Sample (O)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Conclusion
Attitude Toward Microplastics → Pro-Environmental Behavioral Intention (H6)	0.438	0.056	7.876	0.000	Significant
Subjective Norm → Pro-Environmental Behavioral Intention (H7)	0.186	0.045	4.111	0.000	Significant
Perceived Behavioral Control→ Pro-Environmental Behavioral Intention (H8)	0.284	0.057	4.985	0.000	Significant
Hypothesis Test Results for the Total					
Knowledge → Risk Perception (H1)	0.261	0.038	6.877	0.000	Significant
Knowledge → Attitude Toward Microplastics (H2)	-0.028	0.047	0.600	0.549	Insignificant
Knowledge → Pro-Environmental Behavioral Intention (H3)	0.037	0.035	1.070	0.285	Insignificant
Risk Perception → Attitude Toward Microplastics (H4)	0.349	0.058	5.969	0.000	Significant
Risk Perception → Pro-Environmental Behavioral Intention (H5)	0.084	0.045	1.862	0.063	Insignificant
Attitude Toward Microplastics → Pro-Environmental Behavioral Intention (H6)	0.286	0.064	4.431	0.000	Significant
Subjective Norm → Pro-Environmental Behavioral Intention (H7)	0.181	0.043	4.157	0.000	Significant
Perceived Behavioral Control→ Pro-Environmental Behavioral Intention (H8)	0.349	0.046	7.612	0.000	Significant

The hypothesis testing results indicate notable differences between rural and urban areas. Microplastic knowledge does not significantly influence pro-environmental behavioral intention in either rural or urban areas. Risk perception significantly affects pro-environmental behavioral intention only in rural areas, while its effect is not significant in urban areas or in the total sample.

Attitude toward microplastics significantly influences pro-environmental behavioral intention in urban areas and in the total sample, but not in rural areas. Similarly, subjective norms significantly affect pro-environmental behavioral intention in urban areas and in the total sample, yet show no significant effect in rural areas. Perceived behavioral control consistently demonstrates a significant positive effect on pro-environmental behavioral intention across rural, urban, and total samples.

Overall, the findings suggest that urban pro-environmental behavioral intention is more strongly shaped by attitudinal and normative factors, whereas in rural areas, risk perception and behavioral control play a relatively more prominent role. However, these differences should be interpreted cautiously in the absence of formal multi-group analysis.

DISCUSSION

The Influence of Microplastic Knowledge on Risk Perception (H1)

The results show that microplastic knowledge significantly increases risk perception in urban areas and in the total sample, thereby partially supporting Hypothesis 1. However, this relationship is not significant in rural areas. These findings suggest that greater awareness of microplastics enhances perceived environmental and health risks primarily among urban respondents, aligning with prior evidence that knowledge heightens risk recognition (14,26).

Knowledge functions as a cognitive filter that enables individuals to interpret environmental cues, identify potential threats, and relate them to personal health concerns. In urban contexts, informed individuals may be better positioned to assess risks embedded in everyday practices such as food consumption and household waste management (27).

Values and beliefs further condition this relationship. Individuals who prioritize environmental sustainability tend to interpret information more cautiously and report greater concern (28). Effective risk appraisal therefore requires not only access to accurate information but also the capacity to process and integrate it within existing value frameworks (29). Taken together, these findings highlight the importance of strengthening public literacy on microplastics, particularly in urban areas. While knowledge alone may not be sufficient in rural contexts, embedding information within broader sustainability narratives may enhance risk awareness and support pro-environmental engagement.

The Influence of Microplastic Knowledge on Attitudes toward Microplastics (H2)

The results indicate that microplastic knowledge does not significantly influence attitudes toward microplastics in urban areas or in the total sample, leading to the rejection of H2 in these contexts. However, in rural areas, knowledge shows a significant negative association with attitudes, suggesting that greater awareness does not necessarily translate into more favorable attitudinal responses.

These findings imply that factual awareness alone may be insufficient to strengthen attitudes and, in some contexts, may even generate ambivalence. This pattern is consistent with prior studies showing that knowledge can coexist with weak concern or limited behavioral alignment (30,31). Within the TPB framework, knowledge appears to operate indirectly through risk perception rather than directly shaping attitudes, which are more strongly influenced by values, beliefs, and affective engagement (21,32).

Attitudes are also shaped by social and contextual factors, including prevailing norms and practical constraints such as the affordability of sustainable alternatives (33). Accordingly, information-based interventions should be complemented by normative influence and enhanced behavioral control to more effectively translate knowledge into positive attitudinal and behavioral outcomes.

The Influence of Microplastics on Pro-Environmental Behavioral Intentions (H3)

The results indicate that microplastic knowledge does not significantly influence pro-environmental behavioral intention in either urban or rural areas, nor in the total sample, leading to the rejection of H3. This finding is consistent with the TPB, which suggests that behavioral intentions are shaped primarily by attitudes, subjective norms, and perceived behavioral control rather than knowledge alone (21).

Knowledge appears to function mainly as a foundation for risk awareness; however, without alignment with personal values, social expectations, and enabling contextual conditions, it does not readily translate into behavioral intentions (34). This pattern reflects the commonly observed gap between awareness and action, where perceived social pressure and behavioral constraints play critical roles in decision-making (35).

Accordingly, while knowledge remains important for raising awareness, strengthening pro-environmental behavioral intentions requires integrated approaches that also address attitudinal, normative, and structural factors.

The Influence of Risk Perception on Attitudes toward Microplastics (H4)

Risk perception has a significant positive influence on attitudes toward microplastics in urban, rural, and total samples, leading to the acceptance of H4. Within the TPB framework, attitudes reflect individuals' evaluative judgments regarding potential risks and their consequences (21). The findings suggest that stronger perceptions of environmental and health risks are associated with more critical attitudes toward microplastics and greater concern for mitigation efforts (14,26).

Risk perception therefore plays a central cognitive role in shaping attitudinal responses. Individuals who perceive higher levels of risk are more likely to evaluate microplastic issues as serious and worthy of attention. This relationship is further shaped by personal values, prior experiences, and communication framing, which influence how risks are interpreted across different demographic groups (14,36). Variations in public understanding may also reflect knowledge gaps and differences in information processing (37).

These results highlight the importance of strengthening risk communication strategies. Enhancing public awareness of environmental and health risks may reinforce negative evaluations of microplastics and support the attitudinal pathway emphasized within the TPB framework.

The Influence of Risk Perception on Pro-Environmental Behavior Intentions (H5)

The results indicate that risk perception significantly influences pro-environmental behavioral intention only in rural areas, whereas its effects are not significant in urban areas or in the total sample, leading to partial support for H5. This suggests that heightened perceptions of environmental risk motivate behavioral intentions primarily among rural respondents.

From the TPB perspective, this finding highlight risk perception as a context-dependent driver of behavioral intention (21). Previous studies have shown that increased awareness of environmental threats can encourage individuals to adopt sustainable practices, particularly when risks are perceived as immediate and personally relevant (38,39). Emotional responses to environmental concerns may further strengthen motivation to act (16,40).

These results imply that interventions aimed at strengthening pro-environmental intentions should emphasize risk communication particularly in rural settings, while in urban contexts greater attention may be needed to attitudinal, normative, and behavioral control factors.

The Influence of Attitudes toward Microplastics on Pro-Environmental Behavioral Intentions (H6)

Attitudes toward microplastics significantly influence pro-environmental behavioral intention in urban areas and in the total sample, but not in rural areas, resulting in partial support for H6. This finding aligns with the TPB premise that favorable evaluations of environmental issues strengthen behavioral intentions, particularly in contexts where individuals perceive greater agency and access to pro-environmental options (21).

Previous studies have emphasized attitudes as a key determinant of sustainable intentions and behaviors (41). Education contributes to shaping such attitudes, especially when it highlights the tangible consequences of plastic consumption for human and environmental health (42), although awareness alone may not be sufficient to produce sustained behavioral change without support from reinforcing factors (30). Public understanding of microplastics also varies widely, and high awareness does not always translate into accurate knowledge or concern (24).

These results suggest that while attitudes play an important role, especially in urban contexts, their influence is limited in rural settings, where behavioral intentions appear to depend more strongly on other TPB components such as perceived behavioral control. Accordingly, interventions should integrate attitudinal change with normative influence and structural support to more effectively promote pro-environmental action (43,44).

The Influence of Subjective Norms on Pro-Environmental Behavioral Intentions (H7)

Subjective norms, defined in the TPB as individuals' perceived social pressure to engage in or refrain from certain actions, significantly influence pro-environmental behavioral intention in urban areas and in the total sample, but not in rural areas, resulting in partial support for H7. This finding reinforces the TPB assumption that strong social expectations can shape behavioral intentions, particularly in contexts where social influence is more salient (21). Similar evidence has been observed among Chinese consumers, where subjective norms positively predicted intentions to use reusable shopping bags (45), although their effects may vary across settings (46).

Beyond their direct influence, subjective norms also interact with other TPB components by strengthening attitudes and perceived behavioral control, thereby reinforcing intention formation (33). Social context further conditions their impact, as community-level expectations can determine how strongly norms promote pro-environmental practices (47).

In practical terms, these results suggest that interventions should leverage peer influence and community engagement to normalize sustainable behaviors, especially in urban contexts where normative effects appear stronger.

The Influence of Behavioral Control on Pro-Environmental Behavior Intentions (H8)

Perceived behavioral control significantly influences pro-environmental behavioral intention in urban, rural, and total samples, leading to the acceptance of H8. This finding supports the TPB assertion that individuals are more likely to form intentions when they perceive sufficient ability and resources to act (21). It also indicates that environmental concern alone is insufficient; individuals must feel capable of translating intentions into action. Prior studies similarly report that self-efficacy strengthens pro-environmental behaviors (48) and that higher PBC encourages sustainable practices such as carrying reusable shopping bags (45).

PBC is shaped not only by individual beliefs but also by contextual conditions. Socioeconomic constraints can reduce perceived control and shift priorities toward short-term needs (16), while organizational and structural support can strengthen individuals' capacity to engage in sustainable actions (49).

Within the TPB framework, these results highlight PBC as a central driver linking environmental awareness with behavioral intention. Enhancing access to affordable eco-friendly options and supportive infrastructure may therefore be critical for translating pro-environmental intentions into concrete actions.

Theoretical Contribution

This study provides an exploratory extension of the TPB framework by incorporating environmental risk perception into the structural model and examining its role across urban and rural contexts. The findings reveal context-dependent pathways, with knowledge-related risk perception more salient in urban settings, while behavioral intentions in rural areas appear to rely more strongly on perceived behavioral control and risk awareness. Although the model's explanatory power remains modest, the results suggest that integrating risk perception into TPB applications may help capture contextual variation in pro-environmental decision-making.

Empirically, this study contributes to microplastic behavior research by identifying key psychological drivers of pro-environmental intentions across population groups. The results indicate that attitudes, subjective norms, perceived behavioral control, and risk perception play differentiated roles depending on context, whereas knowledge alone shows limited direct influence. These findings highlight the importance of addressing perceptual, normative, and control-related dimensions alongside informational approaches and point to the need for further confirmatory research.

Managerial Implications

The findings highlight the importance of context-specific strategies to strengthen pro-environmental behavioral intentions. In rural areas, interventions should prioritize enhancing risk perception and perceived behavioral control by improving access to affordable eco-friendly alternatives and practical waste management facilities. Increasing awareness of the health and environmental impacts of microplastics may help strengthen motivation to adopt sustainable behaviors.

In urban areas, efforts should focus on reinforcing attitudes and social norms alongside perceived behavioral control. Community-based initiatives, peer influence, and visible pro-environmental practices can help normalize sustainable behavior, while supportive infrastructure can facilitate individual action.

Across both contexts, governmental involvement remains essential. Public policies should integrate regulatory measures, such as limiting single-use plastics, with supportive approaches including incentives for sustainable consumption and improvements in waste management systems. Education campaigns delivered through schools, community organizations, media, and NGOs can further embed pro-environmental norms and make sustainable practices more accessible.

Limitations

This study has several limitations. First, the research was confined to one urban and one rural area, which restricts the generalizability of the findings to regions with different social and cultural contexts. Second, the study examined behavioral intentions rather than actual behaviors, limiting its ability to capture whether intentions translate into real-world actions. Third, demographic characteristics were reported descriptively but not integrated as covariates in the structural model, which may introduce omitted variable bias. Finally, the cross-sectional design captures data at a single point in time, preventing analysis of how knowledge, attitudes, or intentions evolve over the longer term.

CONCLUSION

This study found significant urban–rural differences in microplastic knowledge, risk perception, subjective norms, and behavioral control, with urban respondents generally scoring higher, while attitudes toward microplastics and pro-environmental intentions showed no significant differences, indicating shared concern across contexts. The hypothesis test results show that knowledge significantly influences pro-environmental behavioral intention in the urban area, but not in the rural area. In both areas, risk perception, attitude toward microplastics, subjective norm, and behavioral control significantly affect pro-environmental behavioral intention, with a stronger impact in the urban area. Overall, risk perception and attitude are the dominant factors shaping pro-environmental behavior, especially in the urban area.

Building on the limitations of this study, several avenues for future research are recommended. First, the geographic scope should be broadened to include multiple urban and rural regions with varying socio-cultural contexts, enabling findings that are more representative and generalizable. Second, future studies should expand the range of explanatory variables. In addition to knowledge, attitudes, risk perception, subjective norms, and perceived behavioral control, factors such as socioeconomic status, education level, cultural values, environmental identity, social media exposure, government trust, and access to eco-friendly alternatives warrant investigation. Exploring these dimensions could provide a more comprehensive picture of the psychological, social, and structural determinants of pro-environmental behavior.

Methodologically, longitudinal designs are recommended to capture how knowledge, attitudes, and intentions evolve over time, as well as to assess whether intentions translate into consistent behavioral change. Finally, comparative studies across cultures or regions could reveal how contextual factors moderate the relationships specified in the TPB, offering insights into how interventions might be tailored to different populations.

AUTHOR CONTRIBUTION STATEMENT

Megawati Simanjuntak was responsible for conceptualization, study design, supervision, data analysis, and manuscript revision. Irni Rahmayani Johan and Ismayanti Pratiwi contributed to data analysis and manuscript preparation. Nurazizah Aprilia handled draft writing and overall manuscript preparation. Rohimatul Janah managed data collection, reference management, and administrative coordination. All authors reviewed and approved the final version of the manuscript.

CONFLICT OF INTEREST

The authors declare no financial or personal conflicts of interest that could have influenced the outcomes of this research.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

The authors utilized artificial intelligence solely for improving language clarity and correcting grammar. AI did not create any scientific content, analyze data, or interpret results. All conceptual work, research design, data gathering, analysis, and conclusions were carried out entirely by the authors, who take full responsibility for the intellectual content of this manuscript.

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