Evaluation of Public Perception and Knowledge of Plastic Recycling Technology in the Yogyakarta Special Region, Indonesia

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ABSTRACT

The accumulation of waste in Indonesia has been increasing year by year and remains poorly managed. This study evaluates public perception and knowledge of plastic recycling technology to support the implementation of a sustainable circular economy. This study employed a quantitative research approach, categorised as descriptive and verification research, using a survey-based confirmatory model to examine causal relationships among variables through hypothesis testing. Data were collected through random sampling surveys and analysed using the Structural Equation Model (SEM) and Partial Least Squares (PLS) techniques. A total of 63 respondents from the Yogyakarta region participated. The findings show that age, education, and primary occupation variables have loading factor values greater than 0.70. The structural model revealed that R-square was highest for the Public Understanding variable (0.133), followed by the Findings Implication variable (0.093). The significance test ($p < 0.05$) indicated a positive relationship between public understanding and the implications of the findings (0.305). In conclusion, the Public Understanding variable, which integrates both knowledge and perception, emerges as the most dominant factor among all variables. While this variable is influenced by several surrounding independent factors, the most substantial outcome is its role in driving behavioural change, as reflected in the involvement of all stakeholders in plastic recycling efforts, both manually (3R) and through the use of zero-to-waste technologies.

Keywords: Public understanding and level of knowledge, Plastic Recycling

INTRODUCTION

Plastic waste has become one of the most significant environmental challenges of the 21st century, particularly in urban areas. In the Yogyakarta Special Region (DIY), the rising consumption of packaged products, combined with suboptimal waste management practices focused on segregation and recycling, has exacerbated the accumulation of plastic waste in the environment. This issue mirrors global trends, in which rapid urbanisation and consumption patterns increase plastic waste generation [1,2]. Plastic recycling technologies have been developed globally to reduce pollution, conserve natural resources, and promote a circular economy. However, the success of these technologies largely depends on public acceptance and understanding, as the community plays a key role in waste collection and sorting.

Yogyakarta, a city in Indonesia renowned for its rich cultural heritage and rapid urban growth, is currently undergoing a transformation into a smart city [3,4]. This

initiative aims to address the challenges posed by an expanding urban population and the resulting surge in waste production. The shutdown of conventional landfills has intensified the need for innovative and sustainable waste management strategies[5]. With a Human Development Index (HDI) of 81.09 in 2023, marking an average annual rise of 0.47% from 2020 to 2023, Yogyakarta illustrates the intricate balance between urban development and sustainability [6].

According to data from the Ministry of Environment and Forestry (KLHK) in 2025, Indonesia generated approximately 33.621 million tons of waste annually, with 39.91% (13.417 million tons) unmanaged. Similar national studies indicate that solid waste management in Indonesia remains ineffective and inefficient, particularly due to low participation in recycling systems [7]. Cultural patterns in Indonesian society, where people tend to overlook waste accumulation rather than proactively seek solutions, further exacerbate this issue [8]. This means that around 92,112 tons of waste are produced daily by a population of 284 million, or approximately 0.32 kilograms of waste per person per day [9].

These indicators reveal that the management of solid waste, both organic and inorganic, remains ineffective and inefficient. This situation is further exacerbated by cultural patterns within Indonesian society, where people tend to overlook waste accumulation rather than actively seeking effective solutions to minimise waste generation. This tendency ultimately results in conventional waste management practices that fail to adopt innovative or sustainable approaches. Based on these studies, it can be concluded that public perception and knowledge of plastic recycling technology are key variables supporting the success of waste management programs, particularly at the local level, such as in the Yogyakarta Special Region (DIY).

MATERIAL AND METHOD

This research study employed a quantitative measurement approach. The population of this research from 221 individuals who are willing to be involved in this research with various educational and occupational backgrounds was sampled in the Yogyakarta Special Region which are spread across the city of Yogyakarta and four the districts of Sleman, Bantul, Kulon Progo, and Gunung Kidul, finally set amount 63 respondents were selected based on calculations using the Slovin Formula (with a margin of error value of 5%). The sampling technique used was simple random sampling, in which every member of the population has an equal chance of being

selected. The instrument used in this study was a questionnaire distributed to respondents via Google Forms. Data collection used a one-time survey technique and generated Likert-scale data. This study is categorised as descriptive and verification research, using a survey-based confirmatory model to examine causal relationships among variables through hypothesis testing. The research design applied the Second-Order Confirmatory Factor Analysis (CFA) model, which begins with theoretical foundation building. In this model, a latent variable consists of several indicators that cannot be measured directly and therefore require additional indicators to be measured accurately. This differs from the First-Order CFA, in which a latent factor has measurable indicators that can be directly assessed [20].

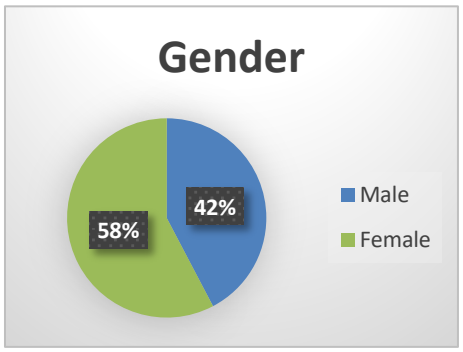
Data analysis was conducted using the Structural Equation Model (SEM) to examine linear relationships among variables. The Partial Least Square (PLS) method was specifically used to predict dependent variables involving multiple independent variables. The PLS approach includes two stages of evaluation: (1) the outer model, which assesses measurement validity and reliability, and (2) the inner model, which evaluates the structural relationships among constructs.

RESULTS AND DISCUSSION

Respondent Characteristics

A total of 63 respondents from the Yogyakarta Special Region participated in this study through an online questionnaire distributed using random sampling. By gender, 65.6% of respondents were female, and 34.4% were male. The largest age group was those aged below 29 years (51.7%), followed by those aged 29–44 years (41.7%).

In terms of education level, most respondents (53.8%) held a bachelor's degree (S1), followed by senior high school/vocational school graduates (29.2%) and postgraduate degrees (S2 and above) (16.9%). Regarding occupation, most respondents were students (49.2%), followed by civil servants (41.5%), entrepreneurs (7.7%), and private employees (1.5%). In terms of occupation, most respondents were students (49.2%), followed by civil servants (41.5%), entrepreneurs (7.7%), and private sector employees (1.5%).



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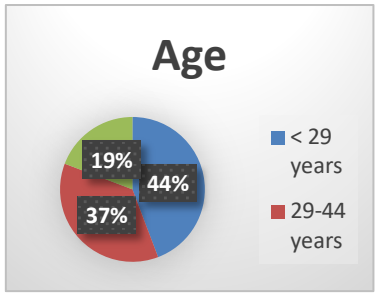

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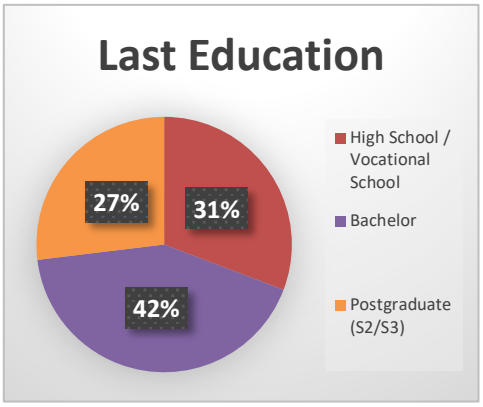

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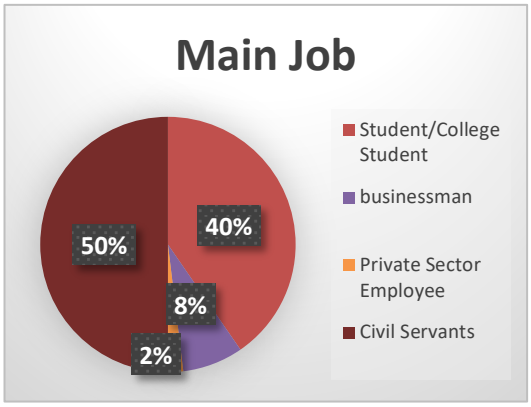

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Figure 1. Respondent Characteristics: (a) Gender, (b) Age, (c) Education Level, (d) Main Occupation

Based on the results of the convergent validity analysis, which assesses the degree of correlation among variables, the respondent characteristics, including Age (KR.2), Education Level (KR.3), and Main Occupation (KR.4), had factor loadings greater than 0.70. This indicates that these three indicators of respondent characteristics are highly correlated and significantly influence the dependent variable, namely public understanding, which encompasses both knowledge and perception of the community, particularly among respondents in the Yogyakarta Special Region, as determined through simple random sampling.

Table 1. Convergent Validity Values with Loading Factor > 0.70

VARIABLE CORRELATION	*OUTER LOADINGS*
IT.3 <- Findings Implication	1.000
KR.2 <- Respondent Characteristics	0.836
KR.3 <- Respondent Characteristics	0.802
KR.4 <- Respondent Characteristics	0.838

PM.1K <- Public Understanding	0.900
PM.2K <- Public Understanding	0.919

Based on the latent variable analysis used to assess the average variance extracted (AVE) values, two variables, Respondent Characteristics and Public Understanding, showed AVE values greater than 0.50, specifically 0.681 and 0.827, respectively. These AVE values indicate that the constructs explain more than half of the variance in their indicators. In other words, both the KR (Respondent Characteristics) and PM (Public Understanding) variables have average indicator values that explain approximately 60% to 80% of the total variance. Therefore, their convergent validity is considered acceptable.

Table 2. Average Variance Extracted (AVE) Values > 0.50

Variabel	*Cronbach' alpha*	*Composite reliability (rho_a)*	*Composite reliability (rho_c)*	*Average variance extracted (AVE)*
Respondent Characteristics	0.767	0.772	0.865	0.681
Public Understanding	0.791	0.796	0.905	0.827

Another measurement result concerns discriminant validity, with the criterion of cross-loading values greater than 0.70. This assessment ensures that the constructs being measured are not highly correlated with one another. The analysis revealed correlations among Respondent Characteristics and Findings Implications, Public Understanding and Findings Implications, and Public Understanding and Respondent Characteristics. Discriminant validity is essential to confirm that the constructs within the model do not overlap and that each measures a distinct phenomenon.

Table 3. Discriminant Validity

Variable	Findings Implication	Respondent Characteristics	Public Understanding
Findings Implication			
Respondent Characterist	0.242		
Public Understanding	0.342	0.464	

To verify the accuracy, consistency, and reliability of the measurement instrument, Composite Reliability (CR) was used as an evaluation criterion. Variables with CR values greater than 0.70 were considered acceptable. The analysis showed that two key variables Respondent Characteristics and Public Understanding had CR (rho_c) values of 0.865 and 0.905, respectively. This indicates that the indicators

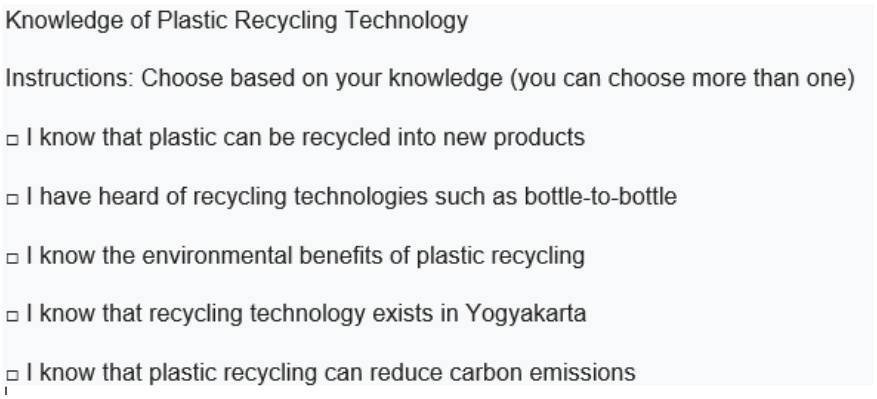
associated with these variables consistently measure the same construct, confirming their internal consistency reliability.

Table 4. Composite Reliability with CR > 0.70

	Cronbach's alpha	*Composite reliability (rho_a)*	*Composite reliability (rho_c)*	*Average variance extracted (AVE)*
Respondent Characteristics	0.767	0.772	0.865	0.681
Public Understand	0.791	0.796	0.905	0.827

Public Knowledge of Plastic Recycling Technology

Most respondents (93.7%) knew that plastic can be recycled into new products. However, only 30.2% of respondents had ever heard of bottle-to-bottle recycling technology. A total of 74.6% of respondents were aware of the environmental benefits of plastic recycling, and 68.3% knew that recycling plastic helps reduce carbon emissions. Nevertheless, only a small proportion (42.9%) were aware of recycling technology facilities in Yogyakarta. These findings indicate that public knowledge remains limited to general aspects and has not yet extended to the technical or detailed processes of plastic recycling. Although people in Yogyakarta recognise the environmental benefits of recycling, their understanding of local recycling technologies remains very limited. This is consistent with other research on the lack of local data, and literacy is a major obstacle to promoting the adoption of recycling technologies [21].



(a)

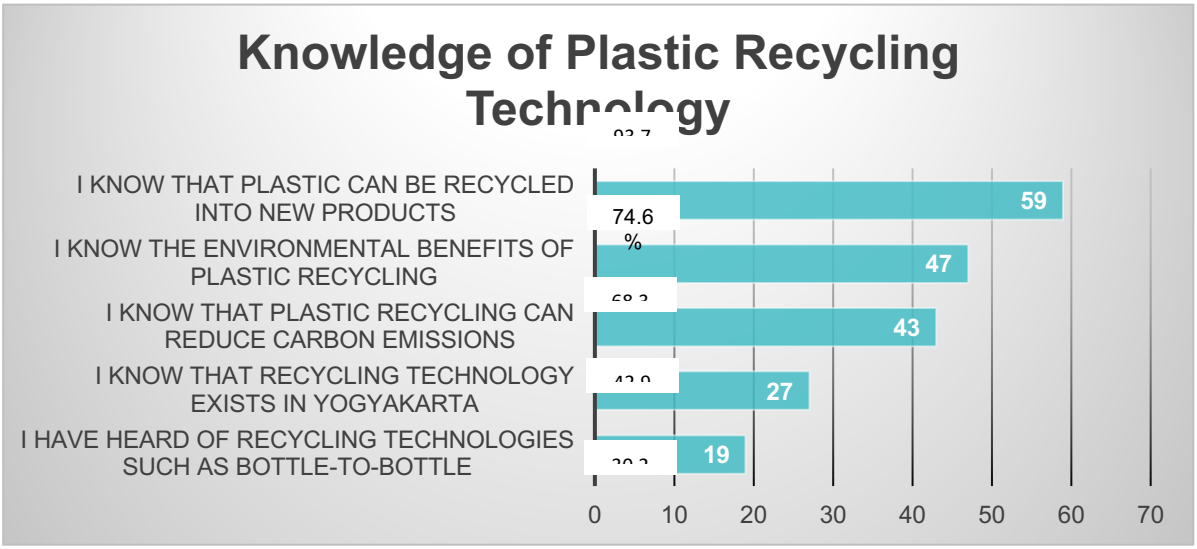


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Figure 2. Public Knowledge of Plastic Recycling Technology: (a) Survey Questions and Questionnaire Items, (b) Respondents' Answers

Based on the structural modelling (Inner Model) results, the R-Square values, which measure the degree of variation in the dependent variables explained by the independent variables, showed that the Public Understanding variable had the highest value ($R^2 = 0.133$) compared to the Findings Implication variable ($R^2 = 0.093$). This suggests that the level of public understanding of plastic recycling technology is relatively good. However, the implementation and utilisation of recycling technologies aimed at reducing plastic waste accumulation to support the "3R" program (Reduce, Reuse, Recycle) have not yet attracted sufficient public engagement. Consequently, the findings' implications, as a direct outcome of public understanding, do not exhibit a strong variation or significant direct impact.

Table 5. R-Square Values of Variables

	R-square	*R-square adjusted*
Findings Implication	0.093	0.078
Public Understanding	0.133	0.118

Public Perception of Plastic Recycling Technology

Most respondents (95.2%) stated that plastic recycling technology is effective in reducing the volume of plastic waste. However, only 47.6% of respondents believed that recycled products are safe for use. Regarding cost, only a small proportion (23.8%) considered that recycling technology remains too expensive to implement. This finding

indicates a gap between ideological support and perceived feasibility of recycling technology, as also identified by Gu et al. (2020)[18].

The negative perception concerning the safety of recycled products highlights the need for public education and product standardisation. Recycled products must be guaranteed to be safe and compliant with quality standards to gain wider public trust and acceptance. Previous research has produced mixed findings regarding the effect of subjective norms on waste-sorting intentions, as this factor does not always exert a direct or significant influence[10,11]. In more individualistic cultures, personal attitudes tend to have a stronger impact than social pressure[12]. Conversely, studies suggest that in collectivist contexts such as Vietnam, individuals' intentions and behaviours are shaped by external expectations from family members and authority figures [13, 14]. Numerous studies have shown that public perception and environmental literacy strongly influence the effectiveness of waste management policies. When individuals understand the benefits and mechanisms of plastic recycling, they are more likely to participate actively in established recycling systems. Therefore, it is crucial to evaluate the extent of public understanding and perception of plastic recycling technologies, particularly at the local level, such as in the Yogyakarta Special Region (DIY). The purpose of this study is to assess community perception and knowledge regarding plastic recycling technology in Yogyakarta and to identify sociodemographic factors that influence these variables. The findings are expected to serve as a foundation for designing educational and community empowerment programs that support sustainable waste management systems.

A review of the relevant literature on factors shaping and influencing perception in society, as outlined by Robbins (2003), identifies three primary components: (1) the perceiver, (2) the target, and (3) the situation[15]. The interaction of these three elements determines how individuals or communities form perceptions toward specific conditions or objects in their environment. Meanwhile, knowledge, as defined by Notoatmodjo (2020), represents the result of understanding obtained by individuals or groups through interaction with environmental objects[16]. Several factors influence individuals or communities before adopting new behaviours derived from their acquired knowledge, which typically occur in the following sequential stages: (1) awareness of the surrounding stimuli, (2) interest in these stimuli, (3) evaluation by considering their relevance or benefits, (4) trial of new behaviours, and (5) adaptation through continuous practice aligned with one's attitude toward the stimuli.

Individual or group characteristics that precede the development of knowledge and perception in forming attitudes serve as the foundation for understanding and evaluating specific objects or issues. These characteristics can be influenced by both internal and external factors. Internal factors include gender, age, education level, and primary occupation. Collectively, these variables affect the degree of knowledge and perception that shape behavioural tendencies, whether positive or negative, toward specific activities or practices. However, these tendencies may change depending on external environmental conditions during the assessment period.

Perceptions of Plastic Recycling Technology

Instructions: Choose based on your knowledge (you can choose more than one option)

- ☐ Plastic recycling technology is effective in reducing the volume of plastic waste
- ☐ Products made from recycled plastic are safe to use
- ☐ The cost of managing plastic recycling technology is too high to implement
- ☐ Recycling technology should be widely implemented in society
- ☐ I am willing to sort plastic waste if recycling technology is available

(a)

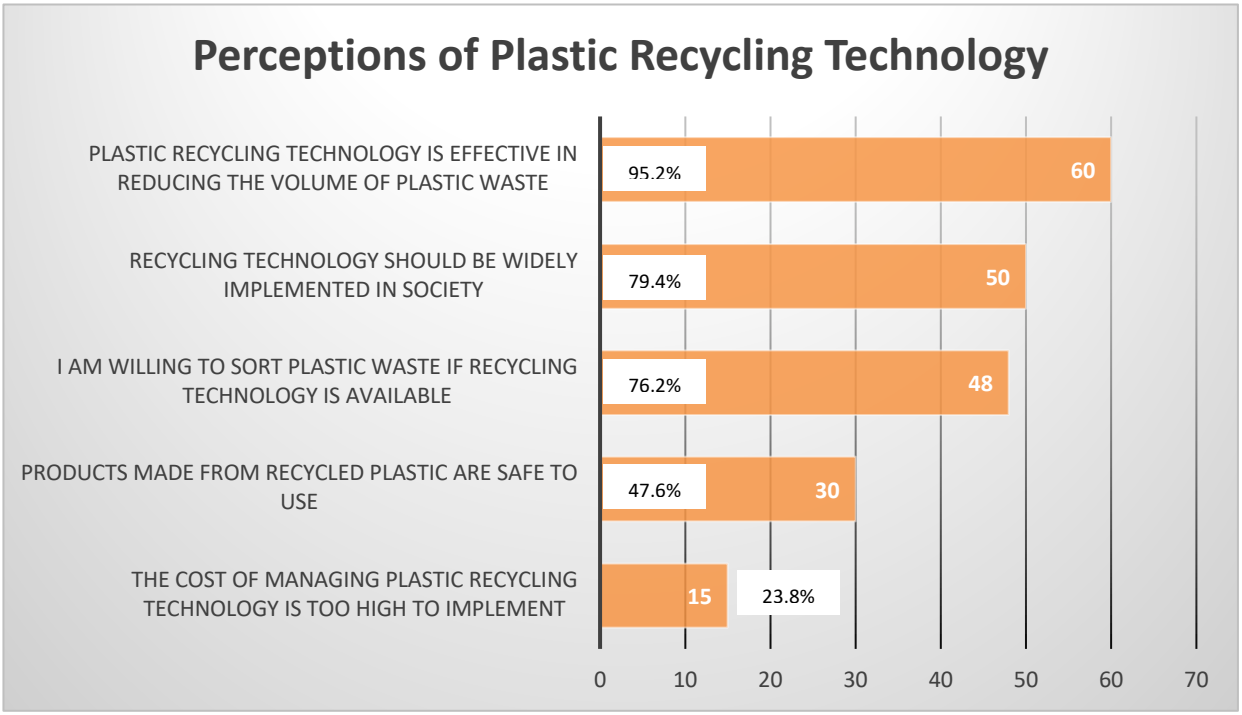

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Figure 3. Public Perception of Plastic Recycling Technology: (a) Survey Questions and Questionnaire Items, (b) Respondents' Answers

The significance test (hypothesis testing) with a p-value < 0.05 was conducted to determine the magnitude of the influence between the independent and dependent variables. The analysis revealed that the relationship between Respondent Characteristics and Public Understanding yielded a p-value < 0.05 and a negative effect (-0.364), indicating a non-significant, inverse relationship that does not meet the expected criteria. Conversely, the relationship between Public Understanding and Findings Implication also yielded a p-value < 0.05, but with a positive correlation coefficient (0.305). This suggests that the most relevant correlation in explaining the hypothesis lies in the variation between public understanding and the implications of findings, as reflected in positive attitudes, awareness, and willingness to engage in plastic recycling practices in accordance with existing regulations.

Table 6. Significance Test Results

Variable	*Original sample (C*	*Sample mean (M)*	*Standard deviation (STDEV)*	*T statistics (|O/STDEV|*	*P values*
Respondent Characteristics-> Public Understanding	-0.364	-0.383	0.085	4.264	0.000
Public Understanding-> Findings Implicati	0.305	0.296	0.068	4.508	0.000

Another measurement was conducted to assess the effect sizes of predictor variables on the model's structural level. The results showed that the relationship between Respondent Characteristics and Public Understanding had a moderate effect size (0.153), which was greater than the correlation between Public Understanding and Findings Implication (0.102). This indicates that the Public Understanding variable, which encompasses indicators of both knowledge and perception, is the most dominant factor among all variables. While this dependent variable can be influenced by surrounding independent factors, the most significant impact lies in the implications of behavioural change, measured by the involvement of all stakeholders in plastic recycling processes, whether through manual practices (3R: Reduce, Reuse, Recycle) or the adoption of innovative recycling technologies.

Table 7. Effect Size Measurement

	Findings Implication	Respondent Characteristics	Public Understandir
Findings Implication			
Respondent Characterist			0.153

Public Understanding	0.102

Finding Implications

In general, the results of this study indicate that although the majority of residents in Yogyakarta demonstrate awareness and positive attitudes toward recycling, a knowledge gap persists regarding advanced technologies and plastic recycling processes. This knowledge gap can hinder active participation in technology-based programs if not supported by adequate education and outreach.

A study by Liu et al. (2020) revealed that plastic food packaging contributes significantly to greenhouse gas emissions and ecotoxicity in China's food service sector [17]. The authors recommended regulations and the promotion of eco-friendly materials as part of broader strategies to mitigate plastic pollution. This underscores the importance of public awareness regarding the environmental impact of plastic use and the role of technology in addressing it. Gu et al. (2020) introduced the Multiple Life Cycle Assessment (MLCA) method to evaluate the environmental performance of polyethene terephthalate (PET) bottle recycling systems [18]. They emphasised that integrating policy interventions with technological improvements can significantly reduce environmental impacts. These findings highlight the importance of data-driven policy reformulation and public support for recycling technologies, including through educational initiatives. Meanwhile, Deshpande et al. (2020) emphasised that the success of waste management systems largely depends on stakeholder perceptions and involvement, including community participation [19]. In their assessment of fishing gear recycling systems, social dimensions such as public awareness and intersectoral partnerships were identified as crucial factors in developing sustainable waste management strategies.

To further illustrate the logical framework of the relationships among variables in the factor analysis structure that influence public perception and knowledge regarding the implementation of plastic recycling technology in Yogyakarta, the following conceptual framework is presented:

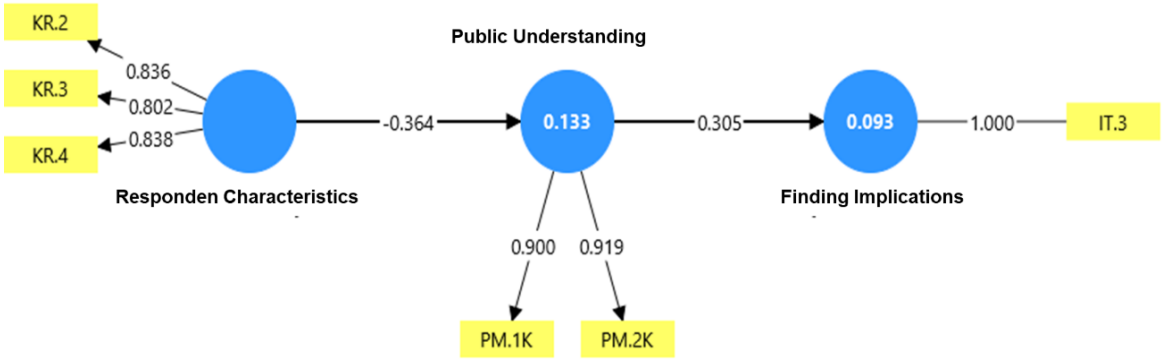

Figure 4. Logical Framework of the Relationship among Variables in the Analytical Structure

CONCLUSION

Based on the results of this study involving 63 respondents from the Yogyakarta Special Region, the age, education level, and primary occupation had loading factor values greater than 0.70, indicating a strong correlation among these indicators of respondent characteristics. These variables significantly influence the dependent variable, namely public understanding, which encompasses both knowledge and perception related to the management and utilisation of recycled products.

The structural model analysis showed that the R-Square value was higher for the Public Understanding variable (0.133) compared to the Findings Implication variable (0.093). This suggests that while public understanding of plastic recycling technology is relatively good, public participation in the implementation and technological utilisation to reduce waste accumulation under the “3R” (Reduce, Reuse, Recycle) program remains limited. Consequently, the Findings Implication variable, representing behavioural outcomes, does not exhibit a strong direct effect. Furthermore, the hypothesis testing results (p-value < 0.05) revealed a positive relationship (0.305) between Public Understanding and Findings Implication, indicating that positive attitudes, awareness, and willingness to participate in plastic recycling activities are significantly associated.

In conclusion, the Public Understanding variable, which integrates both knowledge and perception, emerges as the most dominant factor among all variables. While this variable is influenced by several surrounding independent factors, the most substantial outcome is its role in driving behavioural change, as reflected in the involvement of all stakeholders in plastic recycling efforts, both manually (3R) and through the use of zero-to-waste technologies.

Based on the results of this study, several key strategic recommendations for community empowerment can be provided for local governments. The following efforts are necessary:

1. Providing practical education and visualisation of the recycling process,
2. Collaborating with local governments, NGOs, and small businesses, and
3. Providing compensation in the form of participatory incentives through a digital app-based waste bank program.

AUTHORS' CONTRIBUTIONS

Redhita Rizky SP: Conceptualisation, Methodology, Writing - Original Draft
Dhinar Mustika Natalia: Validation, Writing - Review & Editing
Andika Dwi Saputra: Software, Formal analysis

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DATA AVAILABILITY STATEMENT

The research data used to contribute to this research are available from the corresponding author upon reasonable written request. Alternatively, you may share them with the journal or provide them as citations in your work.

DISCLOSURE STATEMENT

The views and opinions expressed in this article are solely those of the authors and do not necessarily reflect the official policies or positions of their affiliated institutions. The data presented are the result of the author's research, conducted on a sample basis, and have not been previously published in other publications or journals.

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