

Research Article

Responsible Citizen Behavior Modeling in Urban Waste Management

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Abstract

Identifying factors affecting citizens' responsible behavior in the field of waste generation can provide insights for urban planners for policymaking and improving waste management practices. The aim of the present study is to identify the factors affecting citizens' responsible behavior in waste management. This study is exploratory in purpose and applied-developmental in nature. The study site in this research was the city of Arak in Markazi Province. In the qualitative section, related studies were reviewed using MAXQDA software, and the model's factors and items were identified and categorized. These factors were then evaluated through content validity and reliability testing using the Kappa coefficient. In the quantitative section, the designed model was validated using expert opinions and a Likert-scale questionnaire. Smart PLS software was used for data analysis. The study's findings identified seven components and twenty-three items, including economic and financial motivations, culture and media, social, legal, infrastructure, environmental and waste literacy, and individual and psychological characteristics, as influential factors in responsible waste management behavior. The Kappa coefficient, with a value of 0.95, confirmed the model's reliability. Additionally, the quantitative findings showed that the factor loadings obtained for all components were evaluated as acceptable or excellent. The highest Q² value belonged to the environmental literacy construct, indicating the model's predictive power for responsible waste management behavior through this construct. The obtained P values for all paths confirmed the model's hypotheses, and the structural fit of the model was also validated. Therefore, the critical necessity of developing environmental literacy and waste management to minimize waste—through green consumption, waste prevention, and recycling—is clearly emphasized.

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1. Introduction

In recent decades, the efficient management of urban waste has become one of the greatest challenges in densely

populated cities worldwide (Wilson et al., 2015). With the anticipated increase in urban population over the next two decades, policymakers and urban planners are under pressure to adopt effective and comprehensive measures to

prepare for the future (Opoku et al., 2024). In Iran, 80% of the total waste management expenditure is allocated to garbage collection, of which 60% is spent on worker wages. The importance of the issue lies in the fact that even small improvements in collection operations can significantly reduce overall costs (Ahmadi et al., 2022). The primary objective of waste management systems is to reduce solid waste disposal in landfills and maximize the reuse and recycling of resources (Crespo & Rivas, 2024). In this regard, waste producers, especially households, play a vital role in effective source-level waste management. Households act as key stakeholders in the stages of collection, transportation, and disposal of solid waste (Oberlin, 2011). Sustainable waste management at the household level remains a major challenge due to its heavy reliance on resident behavior (Jiang et al., 2021; Moh, 2017; Mukama et al., 2016). Motivation, attitude, and environmental concerns have all been identified as major drivers of people's waste separation practices in industrial countries (Choi et al., 2015). Moreover, increased public awareness of the negative impacts of waste on the natural environment can encourage recycling behavior. Values, religion, and social norms are all recognized as drivers of green purchasing (Garces et al., 2002). While both formal (laws and regulations) and informal actions can influence the effectiveness of waste management systems, without proper social participation, the success rate of these programs can be undermined. It can be said that various factors influence citizens' behavior in waste management. Pro-environmental behaviors (PEBs) are defined as actions that positively impact access to resources and energy, ecosystem structure and dynamics, and, in general, the biosphere (Stern, 2000). These behaviors encompass a wide range of actions aimed at reducing the negative effects of human activity on the environment. A 2012 study identified six types of pro-environmental behavior: environmental activism, avoidance, green consumerism, energy conservation, recycling, and green commuting (Cleveland et al., 2012). However, based on previous studies focusing on household waste reduction, it was found that only two of these behaviors—"green consumer" and "recycler"—are particularly active in this domain. Therefore, a new type of pro-environmental behavior called "waste prevention" is also considered in this study. The concept of waste prevention aligns with the European Commission's recommendations (EC, 2008), which emphasize limiting unnecessary consumption and choosing products that generate less waste as effective strategies for waste avoidance. These three behavioral categories encompass individuals whose goal is to minimize their environmental impact when purchasing goods and following the 3R principles (reduce, reuse,

recycle) (Esmaeilian et al., 2018). The three behavioral constructs are briefly described below:

Green consumer: Green consumers are individuals who engage in a wide range of eco-friendly behaviors due to environmental concerns (Battisti et al., 2020). These individuals are aware of sustainable development and take environmental preservation seriously (Cleveland et al., 2012). They are likely to be innovative users of available physical resources and seek new applications for their products (Pardini et al., 2020). Their primary motivation is strong moral beliefs and a desire to make a positive impact on the environment, which drives them to actively seek and choose environmentally friendly products and services (Lee et al., 2014). The potential benefits for the environment and society are their main motivations for engaging in this behavior. In other words, the green consumer not only looks for a product to meet their needs but also for one with minimal negative environmental impact. This concept stands in contrast to pure consumerism.

Recycler: Individuals in the recycler group actively engage in managing recyclable materials (Lee et al., 2014). This includes active participation in recycling programs, separating recyclable materials from general waste, and ensuring the responsible and environmentally friendly processing and reuse of these materials. Recycling is a critical loop in the circular economy and aims to return materials to the production cycle to reduce raw resource consumption and the volume of landfill waste.

Waste preventer: Individuals in the waste preventer group actively take steps to reduce waste through lower consumption and selecting products that produce less waste. This behavior goes beyond merely being a green consumer, as it requires personal sacrifice or cost and has a direct impact on environmental protection. Tonglet et al. (2004) describe waste prevention as actions such as careful selection of new goods and emphasis on repair and reuse instead of replacement at the end of a product's life cycle. This concept fully aligns with the waste management hierarchy, which prioritizes waste reduction. This behavior is a key step toward fundamentally reducing waste and preventing its harmful environmental effects.

These three behavioral constructs green consumer, recycler, and waste preventer together provide a comprehensive approach to reducing the environmental impacts of consumption and waste. This theoretical framework demonstrates how individuals, through conscious choices and proactive actions, can play an effective role in environmental protection and sustainable development. The Theory of Planned Behavior (TPB) is a widely used and significant theoretical paradigm for understanding the implications and effects of various

psychological characteristics and factors on pro-environmental behavior.

This framework has frequently been used to examine individuals' intentions and actions toward environmentally friendly behaviors and emphasizes the importance of attitudinal components in predicting and explaining behavior (López-Mosquera & Sánchez, 2012). A search in the Scopus database revealed that by 2023, this theory had been cited around 300 times for explaining pro-environmental behaviors—more than twice as often as the second most popular theory, the Value-Belief-Norm hypothesis. TPB, which includes Attitude Toward the Behavior (ATTB), Subjective Norms (SUNO), and Perceived Behavioral Control (PEBC), provides a central paradigm for examining individuals' behavior concerning green products and services. It also enables the analysis of contextual variables such as ethics and external influences. As a result, TPB has become a foundational cornerstone in the field of pro-environmental behavior and has influenced countless studies and research projects (Kumar et al., 2017).

Research has shown that attitudes, perceived behavioral control and mental norms significantly influence citizens' goals to participate in green consumer behavior and prevent waste. The results of the studies showed that the fundamental psychological dimensions of the diversity observed in the behaviors of environmental waste reduction were highlighted among the inhabitants of an urban area in South America, especially in the developing world. (Crespo & Rivas, 2024). The result of one study showed that people's concerns about environmental threats (e.g., pollution) and their perceived health impacts generally do not influence their behavior regarding infectious waste management. However, when people perceive such threats to their health as more serious, they pay more attention to reducing and properly segregating infectious waste. Furthermore, concerns about environmental threats (only in relation to the environment) only lead to greater awareness about properly collecting infectious waste. Age and education level positively influence waste management behaviors; older and more educated people show better behaviors in this regard. Interestingly, income negatively affects the reduction of infectious waste generation. In other words, people with higher incomes pay less attention to reducing such waste (Janmaimool et al., 2024).

Phan et al. (2024) stated that plastic waste management is a complex system influenced by social, environmental, political, and community access to various resources. The results show that communities tend to support and participate in changes that improve this system. Among these, “embracing a zero-waste lifestyle” attracted the most attention, followed by “empowering social organizations”

and “using recycled or eco-friendly materials.” Additionally, individuals' preferences regarding how to improve waste management systems vary.

An academic study examined how citizens aligned with circular economy principles use internal and external knowledge networks to strengthen their 5R (repair, reduce, recycle, reuse, decompose) practices in emerging markets, particularly in Thailand. The results showed that practical experience and skill development in waste management are crucial. In other words, the more individual and collective experience people have with the 5Rs, the more likely they are to achieve their sustainability goals. The 5Rs can also be implemented at different scales and can serve as a model for other emerging markets that are trying to integrate circular economy principles into everyday life (Phonthanakitithaworn et al., 2024). Vieira & Mateus (2018), in their study titled “The Impact of Economic and Social Factors on Urban Solid Waste Generation in São Paulo, Brazil,” concluded that for improving waste management systems, social aspects are a crucial factor in planning, and inequality can influence consumption patterns and affect the types of waste generated (Vieira & Mateus, 2018). Wilson et al. (2015), by examining the factors influencing municipal waste separation behavior in Guangzhou, China, showed that environmental knowledge and moral commitments both positively impact environmental attitudes, which can lead to the desired pro-environmental behavior.

In addition to international studies, similar research has also been conducted in Iran in recent years. For example, Khoshnavaz et al. (2023) reported that factors influencing citizens' participation in waste management are affected by direct system components such as social capacity building, active participation of stakeholders or beneficiaries, social trust, social capital, civil society organizations, interaction and balance between participants, education on citizen rights and duties, and NGOs. Identified seven main categories—including policy gaps, lack of theoretical and practical knowledge, training deficiencies, weak implementation, consumerist views of nature, social devaluation, and rent-seeking alliances—as barriers to cultural development in Tehran's waste management (Zare et al., 2023). The findings of Ahmadi et al. (2022) showed that perceived behavioral control has the greatest contribution to explaining waste management behavior among Abadan residents. Soudagar et al. (2021) found that among the five districts of Zahedan, District 5 has the highest level of citizen participation. Their research results showed that women in Zahedan have adopted waste management practices to a greater extent than men. In addition, Heydari (2020) in a study on residents of District 19 of Tehran evaluated nine factors affecting participation in waste management and found that financial incentives

(mean 28.4) and individuals' perception of their abilities and skills (mean 94.3) were at a good level. However, individual willingness and tendency to participate were assessed at a moderate level.

As observed, the majority of studies and theories presented in the field of waste management emphasize the role of education and knowledge in shaping responsible environmental behaviors and proper waste management. Furthermore, some studies are limited to attitudinal variables and awareness assessment, while the high volume of waste produced in cities cannot be attributed solely to lack of awareness or environmental literacy. It appears that various other variables play a role in this issue.

This study specifically identifies and examines expected citizen behavior in waste management and contributes to the expansion of the relevant literature. It also aims to assess the impact of variables beyond gender, education, and awareness. The dependent variable in this study is responsible waste management behaviors of citizens, which in various studies have been introduced in three dimensions: reduction, reuse, and recycling of waste—namely, reducing waste at the source, reusing some consumables, and recycling valuable materials in waste, which are among the most effective methods for managing and controlling municipal solid waste in the waste management hierarchy.

Therefore, this study aims to better understand the factors that shape waste management behaviors in citizens, contributing to the development of targeted strategies and effective solutions for promoting sustainable behavior. By examining cultural and social influencing factors, this study seeks to provide tools that can optimize urban waste management systems.

2. Research Method

This research is applied and mixed-method in nature and was conducted in both qualitative and quantitative phases. In the qualitative phase, using literature review techniques and systematic examination of existing literature—especially through documentary studies and expert opinions—a meta-synthesis of the subject literature was carried out. In this regard, domestic and international databases were searched using keywords such as "citizenship education," "citizen participation," "waste management," "waste management education," "recycling education," "environmental education," "waste knowledge," and "waste management behavior." Article review continued until data saturation and no new data emerged. Experts interviewed in this study were individuals with multiple publications and research in the waste field (since 2012) and also had expertise in informal

education and experience in holding training courses.

Subsequently, the components influencing citizens' responsible behavior in waste management were classified through pattern analysis and a descriptive-analytical method using MAXQDA 2020 software. To further ensure the validity of items identified in the qualitative phase, validity and reliability assessments were conducted. To determine the Content Validity Ratio (CVR), experts in the field were asked to rate each identified item on a three-point scale: "Essential," "Useful but not essential," and "Not necessary." The content validity index was then calculated according to the Waltz and Bausell method.

The sampling method was snowball sampling, which continued until a theoretical consensus was reached. The criteria for selecting experts were having more than 20 years of experience in the field of waste management and also having numerous publications in the same field.

The closer the Content Validity Index (CVI) is to 0.99, the higher the content validity. Conversely, a lower CVI indicates weaker validity. To obtain the CVI, the expert panel was asked to evaluate each item for "relevance or specificity," "simplicity and clarity," and "transparency or explicitness." Experts rated relevance on a four-point Likert scale from 1 "Not relevant" to 4 "Highly relevant." Simplicity was rated from 1 "Not simple" to 4 "Highly simple," and clarity was similarly rated from 1 "Not clear" to 4 "Highly clear." Based on responses, the CVR was calculated according to Formula 1 (Hajizadeh & Asghari, 2011):

$$CvR = \frac{n_E - \left(\frac{N}{2}\right)}{\left(\frac{N}{2}\right)} \quad (1)$$

In this regard, n_E represents the number of experts who rated the item as "essential," and N is the total number of expert participants in the study. If the obtained value is greater than the value indicated in the table, the content validity of that item is accepted. Table 1 shows the acceptable threshold values for CVR based on the number of experts participating in the study, as recommended by Gilbert & Prion (2016) for estimating questionnaire validity.

The CVI value is calculated by dividing the number of agreement ratings (i.e., scores of 3 and 4) for each item by the total number of experts.

$$CVI = \frac{\text{The number of experts who rated the item as 3 or 4}}{\text{Total number of experts}}$$

To determine validity, the presence of experts with subject-specific expertise related to the designed indicators was required. Due to limitations such as the low number of experts in the fields of environmental science, environmental education, citizenship education, and waste management, as well as the interdisciplinary nature of the research, it was decided—based on the expert population that a minimum of 8 and a maximum of 16 individuals would participate in the study's validity assessment process.

This minimum number is twice the minimum recommended by Lawshe and can, with greater confidence, achieve the required consensus and a validity coefficient above 0.60 (Hassanzadeh Rangi et al., 2016). This number was also cited by Chadwick et al. (1984) as the minimum reliability coefficient for validity analysis. To address potential challenges such as non-returned questionnaires, the maximum number of experts for participation in this study was set at 16, which is twice the stated minimum.

A total of 20 experts with academic backgrounds in education, environment, waste management, citizenship education, and urban management were identified. They were contacted through various methods—by phone, in person, or via email. Out of these, 16 experts confirmed their willingness to participate in the study, and in the end, 8 completed questionnaires were received.

To assess the reliability of the identified factors, the Kappa coefficient was used. According to Gwet (2014), a Kappa value above 0.6 is considered acceptable, and a value above 0.8 is regarded as ideal for agreement between two raters. In this study, the Kappa coefficient was calculated as 0.95, indicating high reliability, which reflects excellent consistency of the model. The levels of Kappa coefficient reliability are presented in Table 2.

In the quantitative part of the current research, the dimensions and items formulated as a result of the qualitative inquiry were re-presented in a Likert-scale questionnaire to the sample of professionals in the field of research. The respondents were asked to report how much they agree to each component and item. In order to ascertain the suitability of the resulting data to undergo factor analysis, the KMO coefficient and Bartlett test were used. Bartlett evaluates whether the correlation matrix is equal to an identity one: In that case no structure would be detected (factor modeling). Factor analysis is appropriate in structural analysis in case the level of significance (sig) that had been calculated is less than 0.05. The obtained test statistic estimated in the Table is significant at the 0.000 level or 264.938.

The analysis of data was carried on utilizing Smart PLS software. The model estimation algorithm implied the joint

implementation of two criteria, reliability and validity as the indicators of the goodness-of-fit of the measurement model. It was deemed to be reliable by assessing factor loadings, cronbach alpha and composite reliability indicators. Then, a set of indices was used to assess the structural model: root mean squared error of approximation (RMSEA), standardized root mean squared residual (SRMR), Tucker Lewis (TLI) and comparative fit index (CFI).

T-values for significance: A value greater than 1.96 is considered acceptable.

R² criterion: Values of 0.19, 0.33, and 0.67 are considered weak, moderate, and strong, respectively. Higher values indicate a better model fit (Agboola et al., 2020). Effect size (F²): According to Cohen, values of 0.02, 0.15, and 0.35 represent small, medium, and large effects, respectively. The effect size for each path in the model can be assessed using Cohen's F².

Stone-Geisser Q² criterion: Indicates the predictive relevance of the model for endogenous constructs. Values of 0.02, 0.15, and 0.35 represent weak, moderate, and strong predictive power, respectively. If the Q² value for an endogenous construct is zero or less, it indicates that the relationships between that construct and other constructs in the model are not well explained (Kock & Hadaya, 2018).

Hypothesis testing: According to the PLS data analysis algorithm, after assessing the measurement and structural model fit, each path's significance coefficient (Z or t-values) and standardized factor loadings are examined to test research hypotheses.

Table 1. Recommended CVR Acceptance Criteria (Gilbert & Prion, 2016)

Number of Experts	Minimum Acceptable CVR
5	0.99
6	0.99
7	0.99
8	0.75
9	0.78
10	0.62
11	0.59
12	0.56
13	0.54
14	0.51
15	0.49
20	0.42
25	0.37

Table 2. Levels of Kappa Reliability (Gwet, 2014)

Numerical Value	Level of Agreement	Kappa Results	Statistic
>0	Poor		
0-2%	Negligible		
0.21% – 0.40%	Fair	0.95	value
0.41% – 0.60%	Moderate		
0.61%-0.80%	Substantial		
0.81% - 1%	Excellent		

Regarding absolute coefficient values, values greater than 0.1 in various references are considered to indicate an effect along a path. If the significance coefficient is greater than 1.96, the path coefficient and the assumed relationship between model constructs are confirmed at the 95% confidence level.

3. Results

3.1. Findings from the qualitative phase of the study

After reviewing and analyzing expert opinions, the primary semantic units derived from interviews and the integration of coding led to the development of the components and items, which are presented in Table 2. As indicated, 7 components and 23 items influencing responsible citizen behavior regarding waste management were identified.

Additionally, the content validity ratio (CVR) was calculated for each item in the respective domains. Table 3 presents the CVR and CVI scores for each question, categorized by domain. Based on this, the scores obtained for all items were within or above the agreement threshold. Moreover, the content validity index (CVI) for all questions also fell within the acceptable agreement range. In this study, a sunburst chart model was used. The sunburst model is a visual representation that displays hierarchical data in a circular format and is commonly used to illustrate relationships and proportions.

The dependent variable in this research is responsible waste management behaviors of citizens, which have been categorized in various studies into three dimensions: reduction, reuse, and recycling of waste—that is, reducing waste at the source, reusing certain consumable materials, and recycling valuable materials present in the waste. These dimensions, based on the 3R model, are considered among the most effective methods for managing and controlling municipal solid waste within the waste management hierarchy.

The influential factors include economic factors and financial motivations, culture and media, social, legal, infrastructure, environmental and waste literacy, and individual and psychological characteristics. The related items under each component are illustrated in Figure 1.

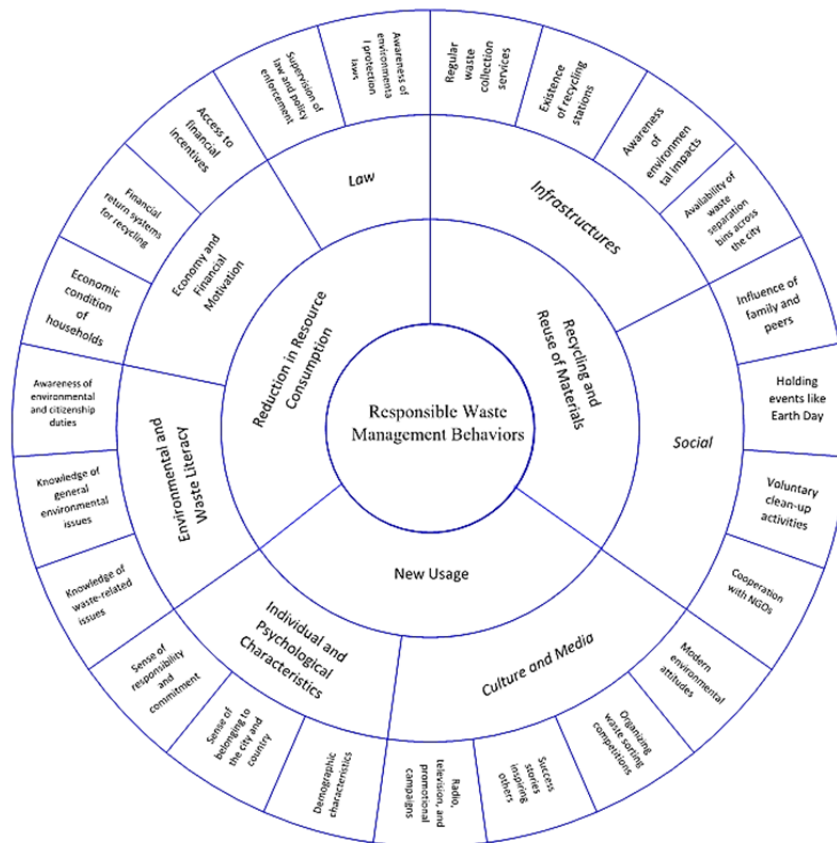


Figure 1. Qualitative Model of Responsible Waste Management Behaviors among Citizens (Source: Research Findings)

Table 3. Model Components and Items with Sources and Calculated Validity Values for Each Component

Component	Item	CVI	CVR	Source
Economy & Financial Motivation	Providing rewards and prizes to active citizens	1.00	0.99	Stern (2000)
	Financial return systems for recycling	0.87	0.75	Zhou, Jiang et al. (2021)
	Citizens' economic status	1.00	0.99	MordaeiKia (2022); Kheiri et al. (2014) Zorpas (2020); Jiang, Van Fan et al. (2021); Kala & Bolia (2020); Shen et al. (2019)
Culture & Media	Radio, television, and promotional campaigns	0.87	0.75	Sharma, Vanapalli et al. (2020); Chauhan, Jakhar et al. (2021)
	Success stories inspiring others	0.87	0.75	Viljoen, Schenck et al. (2021)
	Waste sorting contests and challenges	—	—	Garces et al (2002); Ramos et al. (2015)
	Modern environmental attitudes	1.00	0.99	Botha (2018); Arantes, Zou et al. (2020)
	Cooperation with NGOs	1.00	0.99	Battisti, Poeta et al. (2020); John, Cotterill et al. (2020)
Social	Voluntary clean-up activities	0.87	0.99	Rosalyn & Kurniawan (2019); Kala & Bolia (2020)
	Organizing public events like Earth Day	0.87	0.75	Shen, Si et al. (2019); Bui et al (2022)
Legal	Influence of friends, family, and neighbors on waste behavior	0.87	0.75	Shen, Si et al. (2019); Bui et al (2022)
	Awareness of environmental protection laws	1.00	0.99	Zorpas (2020); Guo, Xi et al. (2021)
	Supervision of law and policy enforcement	0.87	0.75	Agboola, Babatunde et al. (2020); Dary et al (2022)
Infrastructure	Availability of waste separation bins across the city	1.00	0.99	Rathore, Sarmah et al. (2020)
	Educational and awareness programs	0.87	0.75	Debrah, Vidal et al. (2021); Abubakar, Maniruzzaman et al. (2022)
	Existence of recycling stations	0.87	0.75	Yousefloo & Babazadeh (2020)
	Regular waste collection services	0.87	0.75	Pardini, Rodrigues et al. (2020); Sohag & Podder (2020)
	Awareness of environmental and citizenship duties	0.87	0.75	Bell (2022); Hadjichambis & Paraskeva-Hadjichambi (2020); Huttunen & Albrecht (2021); Smederevac-Lalic et al. (2020)
Environmental & Waste Literacy	Knowledge of general environmental issues	1.00	0.99	Ahmadi et al. (2022); Robelia & Murphy (2012); Zsóka et al. (2013); Abubakar et al. (2022)
	Knowledge of waste-related issues	1.00	0.99	Brotosusilo et al. (2020); Mwanza, Mbohwa et al. (2018); Rautela, Arya et al. (2021)
Individual & Psychological Traits	Sense of responsibility and commitment	1.00	0.99	Martin et al. (2019); Lee et al (2014); Soudagar et al. (2021)
	Sense of belonging to the city and country	1.00	0.99	Mordaeikia (2022); Zare et al (2023)
	Demographic characteristics	1.00	0.99	Esmaeilian, Wang et al. (2018); Knickmeyer (2020)
Responsible Waste Management Behavior	Waste reduction and green purchasing	0.87	0.75	Ahmadi et al. (2022); Crespo & Rivas (2024)
	Reuse	1.00	0.99	Ahmadi et al. (2022); Crespo & Rivas (2024)
	Recycling and source separation	1.00	0.99	Ahmadi et al. (2022); Crespo & Rivas (2024)

Table 4. KMO Statistic, Bartlett's Test, and Significance Level

Significance Level	Degrees of Freedom	Bartlett's Test Statistic	KMO Statistic
0.000	15	938.264	0.836

In this study, the Kappa coefficient was calculated as 0.95. Therefore, the model demonstrates reliable consistency, indicating excellent reliability

3.2. Findings from the quantitative phase of the study

The number of participants in the quantitative phase was 38. To assess the suitability of the collected data for performing factor analysis, the KMO coefficient and Bartlett's test were used. The results of these tests are presented in Table 4. According to the results in Table 4, the KMO coefficient is 0.836. The minimum acceptable value for the KMO sampling adequacy index is 0.60, meaning that if the KMO index is higher than 0.60, the sample size is considered adequate. The results of the present study indicate sampling adequacy. Given that the KMO index is above 0.70 and the Sig value of Bartlett's test is less than the 5% significance level, it can be concluded that the data are suitable for factor analysis.

3.3. Measurement Model Fit

According to the model analysis algorithm, two criteria—reliability and validity—were used to evaluate the fit of the measurement models. To assess the reliability of the measurement models, the following indicators were calculated: factor loading coefficients, Cronbach's alpha,

and composite reliability, as described below:

The factor loadings are presented in Figure 2. In this model, all factor loadings are evaluated as either highly desirable or acceptable. In the current research model, the Cronbach's alpha values for all components were calculated to be above 0.70 (Table 5). Therefore, it can be concluded that all variables possess acceptable reliability, indicating a satisfactory internal consistency of the measurement model.

Furthermore, a composite reliability value below 0.60 indicates a lack of reliability. However, the findings in Table 5 show that the composite reliability values for all variables in the model are above 0.60, which confirms the adequate internal reliability of the model.

Additionally, the average variance extracted (AVE) for all constructs in the model was calculated to be above 0.50, thus confirming the discriminant validity of the model.

3.4. Structural Model Fit

R² and Q² Values

According to the values in Table 6, the coefficient of determination (R²) for the model is evaluated as noteworthy, confirming the adequacy of the structural model fit.

Furthermore, based on the values in Table 6, the Q² values obtained are above the 0.35 threshold, indicating that the model's predictive power is strong, and again confirming the proper fit of the structural model. The highest predictive power belongs to the construct of environmental and waste literacy. Table 6 shows the prioritization of the components (structures) under consideration.

Table 5. Cronbach's Alpha Results

No	Component	Cronbach's Alpha (α > 0.70)	Composite Reliability (CR > 0.70)	Average Variance Extracted (AVE \geq 0.50)
1	Economy & Financial Motivation	0.725	0.885	0.651
2	Culture & Media	0.751	0.812	0.602
3	Social	0.875	0.896	0.515
4	Legal	0.961	0.966	0.773
5	Infrastructure	0.721	0.865	0.593
6	Environmental & Waste Literacy	0.759	0.824	0.543
7	Individual & Psychological Characteristics	0.871	0.942	0.565
—	Responsible Waste Management Behavior	0.795	0.842	0.657

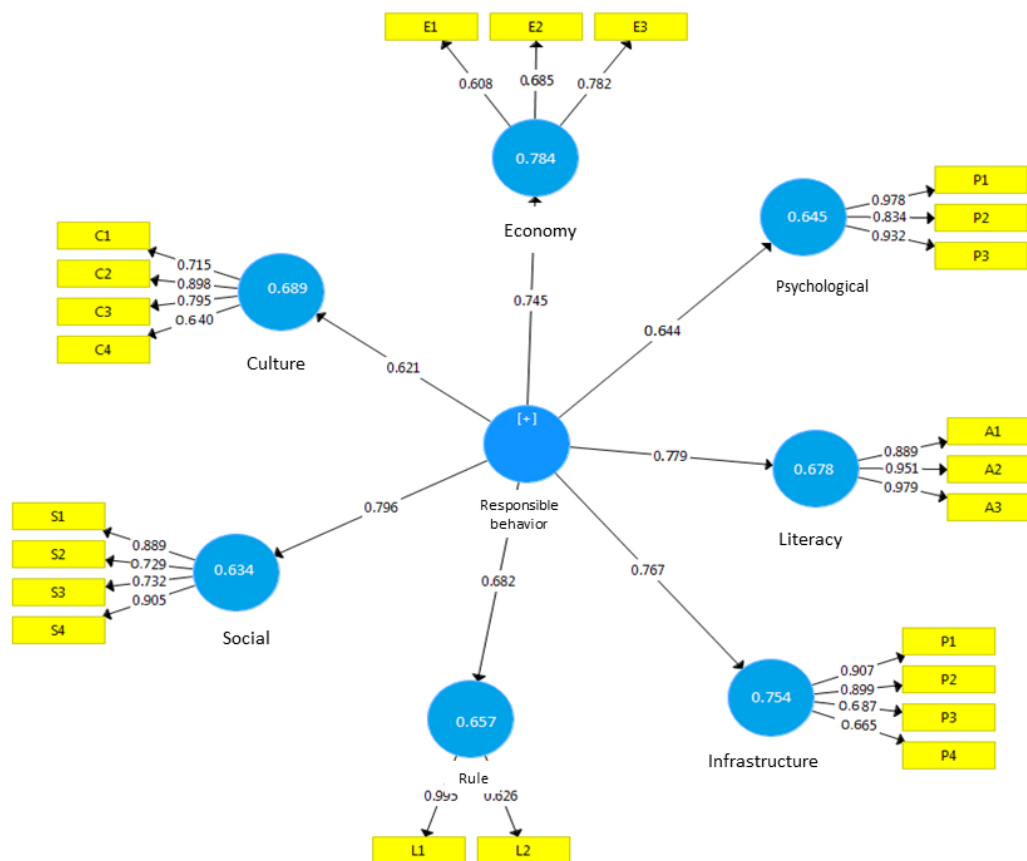


Figure 2. Factor Loadings in the Structural Equation Model

3.5. Structural Model Adequacy

Effect Size Criterion: F²

This criterion determines the strength of the relationship between the model’s constructs. According to Cohen, values of 0.02, 0.15, and 0.35 represent small, medium, and large effects, respectively. The effect size for each path in the model can be evaluated using Cohen’s F².

Based on the values in Table 7, the F² values for all constructs are large, with the strongest effect observed in the Participation construct.

3.6. T-Values and Path Coefficients

According to the PLS data analysis algorithm, after evaluating the fit of the measurement and structural models, the significance coefficients (Z-values or t-values) of each path and the standardized factor loadings related to the paths are examined to test the research hypotheses.

In terms of absolute coefficient values, in various references, coefficients greater than 0.1 are considered indicative of an effect along the path. If the t-value exceeds 1.96, the path coefficients and the assumption of a

relationship between the model’s constructs are confirmed at the 95% confidence level.

Based on the tested conceptual model, shown in the figure along with the values placed on the lines, the path coefficients and the relationships between latent variables are illustrated.

To assess the significance of each path coefficient, the t-value of each path must also be considered. According to Table 8, since the t-values for all paths are greater than 1.96, the predicted paths are statistically significant at the 95% confidence level, and the existence of relationships between the research constructs is confirmed.

4. Discussion

In recent years, the market for circular economy initiatives has been growing rapidly; however, Iran faces multiple challenges in this area. Despite low recycling rates and reliance on informal efforts for waste collection, the increasing volume of waste sent to landfills has made the need for comprehensive interventions and reforms in waste management more pressing than ever. In this regard, both public and private organizations have recognized the

urgency to take action. The goal of this study was to develop a structural model for analyzing responsible citizen behavior in relation to urban waste. Essentially, this research aims to provide practical insights for urban planners to improve waste management practices and formulate effective policies. To this end, both qualitative and quantitative methods were employed, including expert opinion. The study’s model attempts to fill the existing gaps in responsible behaviors related to waste management, including waste reduction, green consumer behavior, and recycling.

The authors believe that the factors identified in this research can help minimize the current waste generated by citizens. Through testing multiple hypotheses, the study explored the complex and multidimensional relationships that shape responsible waste management behavior. Ultimately, eight key components were introduced.

The results indicated that, based on academic sources, previous research, and expert interviews, seven components and twenty-three items affecting responsible citizen behavior in waste management were identified. These components include: economic issues and financial motivations, culture and media, social issues, law, infrastructure, environmental and waste literacy, and individual and psychological characteristics. These findings align with prior studies such as those by Shamsi et al. (2022), Zamani et al. (2022), Dary et al. (2022), Kumar et al. (2017), and Ayeleru et al. (2023). In terms of prioritization and importance, the highest weight (0.793) was assigned to “environmental literacy and awareness of waste”, which is consistent with both domestic and international studies. For example, Ahmadi et al. (2022), Heydari (2020), Saeedi Mehr et al. (2024), and Bui et al.

(2022) all emphasized the importance and role of environmental literacy in promoting civic behavior. This factor can be enhanced through both internal family teachings and external education (such as schools and universities), contributing to the development of environmental culture among individuals. Naturally, the component of “individual and psychological characteristics”, with a weight of 0.748, ranked as the second most influential factor, closely tied to the first. Environmental literacy and personal characteristics interact with one another—as Choi et al. (2015) noted, these two factors exert mutual influence.

In addition, the “law” component, also with a weight of 0.748, is another influential factor. Previous experiences show that in the absence of proper legislation, responsible behavior is less likely to emerge. This has also been emphasized in some domestic studies such as Dary et al. (2022) and Zare et al. (2023), although it differs in weight from some international studies like Jiang et al. (2021), where this factor was given relatively low significance.

The “economy and financial motivation” component, with a weight of 0.714, ranks fourth in importance. However, this factor somewhat contradicts the first two, as personal characteristics and environmental literacy may generate such strong internal motivation that economic considerations become secondary.

As Zamani et al. (2022) pointed out, the emergence of civic behavior is influenced primarily either by financial factors or by personality traits—it cannot be simultaneously driven by both. The “media and culture” component, with a weight of 0.608, ranks fifth. It is evident that social aspects and media feedback significantly shape individual character.

Table 6. Coefficients of Determination (R²) and Predictive Relevance (Q²) Values

No.	Construct	R ²	Q ²
1	Economy & Financial Motivation	0.833	0.714
2	Culture & Media	0.913	0.608
3	Social	0.688	0.605
4	Legal	0.667	0.748
5	Infrastructure	0.930	0.425
6	Environmental & Waste Literacy	0.956	0.793
7	Individual & Psychological Characteristics	0.897	0.748

Table 7. Effect Size (F²)

Construct	Economy & Financial Motivation	Culture & Media	Social	Legal	Infrastructure	Environmental & Waste Literacy	Individual & Psychological Characteristics
Model (F ² Effect Size)	0.326	0.456	0.620	0.332	0.420	0.881	0.374

Table 8. T-Statistics and Model Testing Results at the 95% Confidence Level

No.	Path	T-Statistic	P-Value
1	Responsible Waste Management Behavior → Economy & Financial Motivation	54.010	0.000
2	Responsible Waste Management Behavior → Culture & Media	70.274	0.000
3	Responsible Waste Management Behavior → Social	17.633	0.000
4	Responsible Waste Management Behavior → Legal	167.692	0.000
5	Responsible Waste Management Behavior → Infrastructure	16.967	0.000
6	Responsible Waste Management Behavior → Environmental & Waste Literacy	19.480	0.000
7	Responsible Waste Management Behavior → Individual & Psychological Characteristics	16.502	0.000

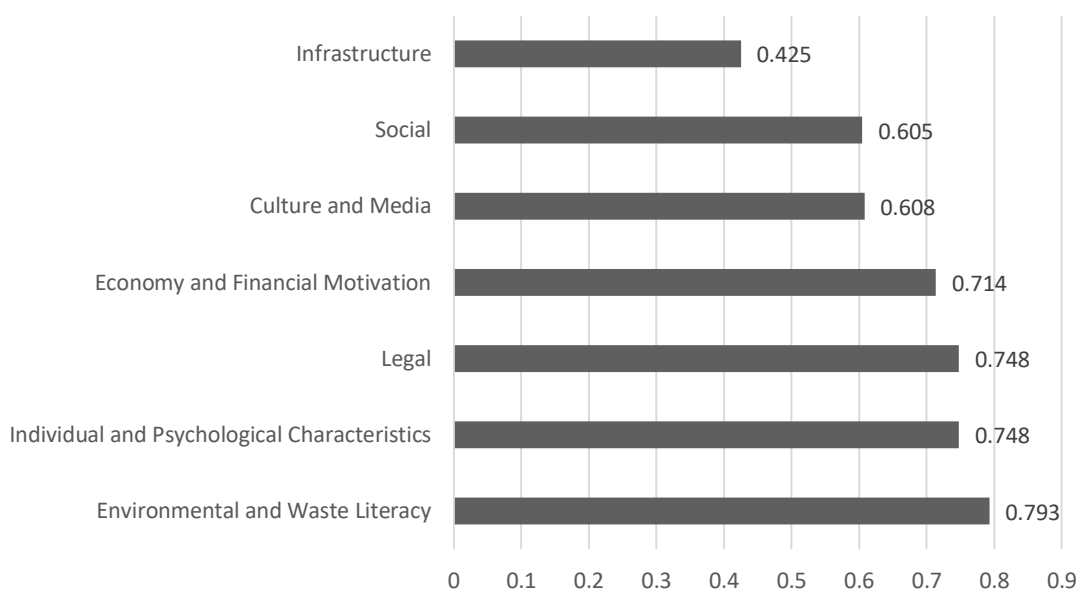


Figure 3. illustrates the prioritization of the examined components (constructs)

Social media, national broadcasting, and various audio-visual media outlets have the potential to influence civic behavior. These results are in full alignment with studies by [Kheiri & Azad Aramaki \(2014\)](#) and [Shamsi et al. \(2022\)](#). The social and infrastructure components are ranked next, though they carry relatively lower weights.

5. Conclusion

The findings of this research contribute key terms to the existing literature and offer new insights for future studies in this field. The importance of enhancing environmental and waste literacy—to encourage responsible and eco-friendly behaviors such as green consumerism, waste prevention, and recycling—was clearly demonstrated.

Effective waste management is only possible when the connection between citizens and waste collection and processing agents is strengthened. One of the best ways to build this connection is through education and cultural development. In summary, education is the key to the

success of all programs, ideas, and management initiatives in this area, provided that the educational content is effectively and appropriately delivered to the target audience.

Through this, it is hoped that by raising public awareness regarding waste management, effective steps can be taken to improve waste conditions and protect the environment.

This study successfully developed a structural model for analyzing responsible citizen behavior toward urban waste. The findings indicate that seven key components—economy and financial motivations, culture and media, social issues, law, infrastructure, environmental and waste literacy, and individual and psychological characteristics—influence responsible waste management behavior among citizens.

These results highlight the mutual interaction between environmental knowledge and personal characteristics in shaping sustainable behavior, while also emphasizing the vital role of supportive legal frameworks. Future research can focus on a more detailed investigation of the interactive

and complex relationships between the identified components—particularly the moderating or mediating roles of personal traits and environmental literacy in influencing other factors.

Moreover, empirical studies are needed to evaluate the effectiveness of proposed practical interventions, such as educational campaigns, financial incentives, or legislative changes, in altering citizen behavior.

Given the cultural diversity in Iran, examining how cultural and social components influence responsible civic behavior in various regions can aid in developing localized strategies.

Additionally, research on how emerging technologies (e.g., mobile applications, artificial intelligence, and blockchain) can facilitate and enhance citizen participation in waste management may also be of great significance.

The innovation of this research lies in the use of several techniques in the research method. On the other hand, the psychological aspects of waste management, especially citizenship behavior, have not been addressed so far.

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Authors Contribution

Mohammadali Nejat: Conceptualization.
 Mahdiah Rezaei: Formal analysis.
 Mohammadali Nejat: Funding acquisition.
 Mohammadali Nejat: Investigation.
 Saeed Motahari: Methodology.
 Azita Behbahani: Project administration.
 Mahdiah Rezaei: Resources.
 Mahdiah Rezaei: Software.
 Saeed Motahari & Azita Behbahani: Supervision.
 Mahdiah Rezaei: Validation.
 Mohammadali Nejat: Visualization.
 Mohammadali Nejat: Writing

Availability of data and materials

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Conflict of interests

The Authors declare that there is no conflict of interest.

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