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BEHAVIORAL FACTORS AND INFRASTRUCTURE MODERATION IN HOUSEHOLD WASTE SORTING: URBAN-RURAL COMPARISON IN SLEMAN REGENCY

[a]Alifia Farah Pramudita, [b]Yori Herwangi
[a,b]Gadjah Mada University; Bulaksumur, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta, 55281; alifiafarahpramudita@mail.ugm.ac.id

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ABSTRACT

Waste management remains a critical environmental challenge, particularly in regions with significant urban-rural disparities. This study investigates household waste sorting behavior in Sleman Regency, Indonesia, by applying the Theory of Planned Behavior (TPB). The objectives are to examine the influence of attitude, subjective norms, and perceived behavioral control on the intention to sort waste, as well as to analyze the moderating effect of infrastructure on these relationships in urban and rural areas. A quantitative approach using Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed, with data collected from 796 households (399 urban, 397 rural). The findings reveal that attitude, subjective norms, and perceived behavioral control significantly influence sorting intentions, with subjective norms being more impactful in urban areas, while perceived behavioral control is more influential in rural areas. Infrastructure significantly moderates the relationship between perceived behavioral control and intention in rural areas but shows no significant moderating effect in urban areas. These results highlight the necessity of context-specific strategies in waste management. The study contributes to the TPB literature by incorporating the moderating role of infrastructure and offers practical insights for policymakers to design sustainable waste management interventions tailored to urban and rural contexts.

Keyword: *Household Waste Sorting, Infrastructure, Theory of Planned Behavior, Urban-Rural Disparities, Waste Management Strategies*

1. INTRODUCTION

Environmental issues, particularly waste management, have emerged as critical global challenges in the face of rapid industrialization and urbanization. These processes have significantly exacerbated environmental degradation and posed substantial public health risks (Arbolino et al. 2017; World Bank 2023). Projections indicate that global waste production will surge from 2.01 billion tons in 2016 to 3.4 billion tons annually by 2050, with Asia and Africa experiencing the fastest growth rates (World Bank 2023). While developed countries have implemented policies prioritizing environmental quality, many developing nations struggle to address these challenges due to resource constraints and institutional limitations (Arbolino et al. 2018). Among various strategies, household waste sorting has proven to be an effective approach, promoting sustainable recycling practices and waste management. However, its success largely depends on community participation, shaped by socio-cultural contexts and the availability of supporting infrastructure (Chen, Wang, and Hou 2020; Nie et al. 2018).

In Indonesia, waste management remains an urgent issue. The country generates approximately 35.17 million tons of waste annually, with 34.97%, or about 12.3 million tons, left unmanaged (Kementerian Lingkungan Hidup dan Kehutanan 2022). Households contribute the largest share, accounting for 23.3% of total waste, predominantly food waste (40.6%) and plastics (17.9%) (Kementerian Lingkungan Hidup dan Kehutanan 2022). Poorly managed household waste significantly contributes to environmental pollution, including water quality degradation and adverse public

health impacts (Hasibuan 2016). Various factors influence waste generation and management practices, such as population density, socioeconomic conditions, regional policies, and infrastructure availability (Dahlianah 2015; Sulistyorini 2005).

In Sleman Regency, Yogyakarta Special Region, these challenges are particularly pronounced. The region produces 707 tons of waste daily, much of which remains unmanaged, causing environmental and public health issues such as water pollution and air contamination (Hidayanti and Efendi 2021). This situation is further exacerbated by the closure of the Piyungan landfill in mid-2023 due to overcapacity. These developments underscore the urgency of adopting alternative solutions, such as Gerakan Pilah Sampah introduced through Surat Edaran No. 30 Tahun 2022, which encourages households to sort waste at its source to reduce landfill dependency. However, the success of this initiative relies on understanding and addressing barriers related to household sorting intentions and supporting infrastructure.

Ajzen's (1991), Theory of Planned Behavior (TPB) provides a robust framework for analyzing household waste sorting behavior. TPB posits that behavior is shaped by attitudes, subjective norms, and perceived behavioral control, which collectively influence behavioral intentions. Attitudes reflect an individual's evaluation of waste sorting, subjective norms capture social pressures to engage in the practice, and perceived behavioral control refers to the ease or difficulty of performing the behavior (Govindan, Zhuang, and Chen 2022; Wang, Chu, and Gu 2021; Zhang et al. 2019). Numerous studies have validated the application of TPB to pro-environmental behaviors, including waste sorting, across various contexts (Govindan et al. 2022; Liang, Song, Liu, et al. 2021).

Building on TPB, Nduneseokwu, Qu, and Appolloni (2017) introduced infrastructure as a moderating factor to understand its role in influencing behavioral intentions. Their findings indicated that adequate infrastructure enhances the positive effects of attitudes, subjective norms, and perceived behavioral control on intentions to participate in formal electronic waste collection. However, their research primarily focused on urban settings and specific waste streams, leaving rural contexts and general household waste sorting underexplored.

Recent studies emphasize the critical role of infrastructure in waste management, highlighting its potential to strengthen behavioral intentions (Govindan et al. 2022). Adequate infrastructure facilitates waste sorting by reducing logistical and physical barriers, thereby enhancing the relationship between individual attitudes, social pressures, and intentions to act. Nevertheless, most existing research centers on urban areas, with limited exploration of rural regions where infrastructure availability and social norms differ significantly(Guan et al. 2018; Long et al. 2016). Moreover, the COVID-19 pandemic underscored the importance of infrastructure in waste management, as it played a vital role in maintaining sorting practices during unprecedented behavioral shifts (Liang, Song, Wu, et al. 2021; Urban and Braun Kohlová 2022). However, post-pandemic conditions necessitate reevaluating these findings to ensure their continued relevance.

This study addresses these gaps by examining the relationships between attitudes (ATT), subjective norms (SN), and perceived behavioral control (PBC) in shaping household waste sorting intentions (INT) and behavior (BEH) cross urban and rural contexts. Furthermore, it investigates the moderating role of infrastructure (INF) in these relationships to determine its influence on strengthening behavioral intentions. By integrating behavioral and infrastructural insights, this research contributes to developing waste management strategies aligned with sustainable development goals. The findings aim to provide actionable recommendations for policymakers and urban planners to enhance waste management practices and improve environmental outcomes. The article proceeds with an analysis of findings, discussion of results, and concludes with key insights and implications for waste management policy. The theoretical framework of this article is illustrated in Figure 1.

2. DATA AND METHODS

2.1. Structural Equation Modelling (SEM)

Structural Equation Modelling (SEM) is one of the most effective methods for examining

causal relationships between latent variables and has been widely applied across various

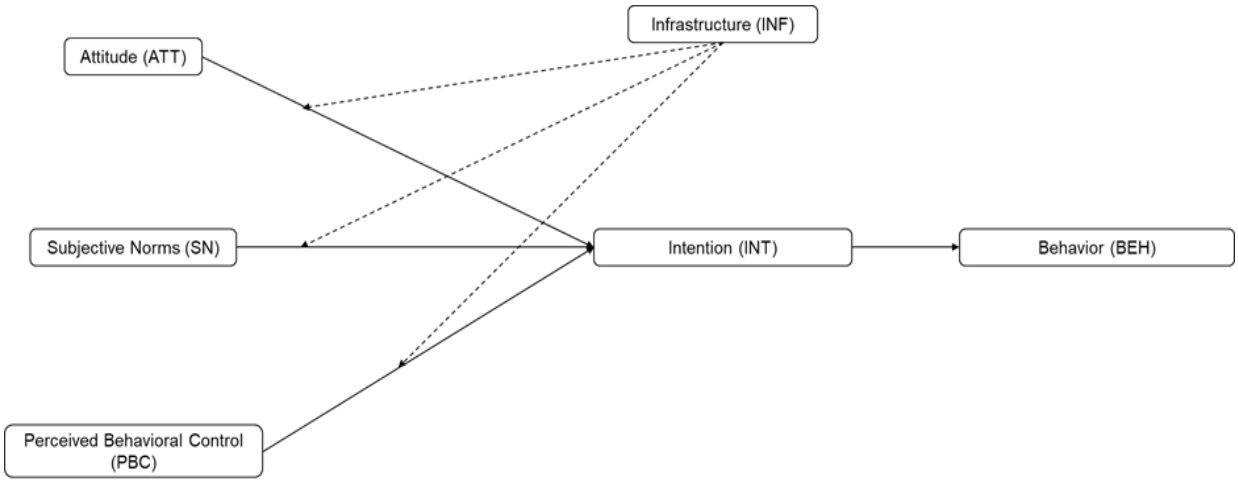

Figure 1. Theoretical Model

disciplines. This study employs the Partial Least Squares Structural Equation Modelling (SEM-PLS) method to analyze the relationships between attitudes, subjective norms, perceived behavioral control, intentions, behaviors, and infrastructure. These latent variables are represented by empirically measurable indicators, enabling the analysis of more complex relationships (Waluyo and W 2020; Widhiarso 2010).

SEM-PLS is used in this study due to its advantages in handling models with moderating effects, such as the influence of infrastructure on the relationships between attitudes, subjective norms, and perceived behavioral control with the intention to sort waste. Furthermore, this method is effective in analyzing data that is not normally distributed and with relatively small sample sizes, making it highly suitable for addressing the first and second objectives of this study (Hair, Ringle, and Sarstedt 2017). By providing a comprehensive framework to evaluate relationships between latent variables, SEM-PLS offers analytical flexibility that is particularly relevant for social research involving heterogeneous data.

2.2. Questionnaire Design

The questionnaire used in this study was designed to measure latent variables related to household waste sorting behavior, such as attitudes, subjective norms, perceived behavioral control, intentions, behaviors, and infrastructure. The survey instrument was divided into several main sections, including the collection of respondents' socio-demographic data and factors influencing their intention to sort waste. The latent variables were measured using a Likert scale ranging from 1 to 5, where 1 indicates "strongly disagree" and 5 indicates "strongly agree." This scale was adapted from previous research, such as Govindan et al. (2022), to ensure its suitability for the research objectives.

Each indicator in the survey was developed based on prior empirical findings to enhance its relevance and clarity for respondents. This approach allows for detailed measurement of latent variables, as recommended by Sugiyono (2011), who emphasizes the use of Likert scales to assess participants' attitudes, opinions, and perceptions of social phenomena. Additionally, the Likert scale facilitates the analysis of relationships between variables.

2.3. Study Area and Data Collection

Sleman Regency, located in the Special Region of Yogyakarta, was selected as the study area due to its inclusion of both urban and rural regions with distinct social, economic, and environmental characteristics (BPS Kabupaten Sleman 2022). This region consists of 17 sub-districts, encompassing 61 villages classified as urban and 25 villages classified as rural, as

stipulated in the Regional Spatial Plan (RTRW) of Sleman Regency 2021–2041. Urban areas in Sleman are characterized by higher population density, better infrastructure access, and land use predominantly for non-agricultural activities. Conversely, rural areas exhibit lower urbanization levels, with land use dominated by agricultural activities and more limited infrastructure access.

Data collection was conducted through a questionnaire survey from July 28, 2024, to August 29, 2024. Respondents were selected using convenience sampling to facilitate survey implementation, with the inclusion criteria of being residents of Sleman Regency and willing to participate (Creswell and Creswell 2018). The study involved 399 households from urban areas and 397 households from rural areas, resulting in a total of 796 participating households. Of these respondents, 256 were men (32%) and 540 were women (68%), highlighting the significant role of women in household waste management. All collected questionnaires were reviewed to ensure completeness and data consistency, and all were deemed valid for further analysis.

The urban and rural classification map of Sleman Regency, used as the reference for survey locations, is presented in Figure 2, while detailed sample characteristics are provided in Table 1. This study offers valuable insights into waste sorting behavior and the geographical context of the study area.

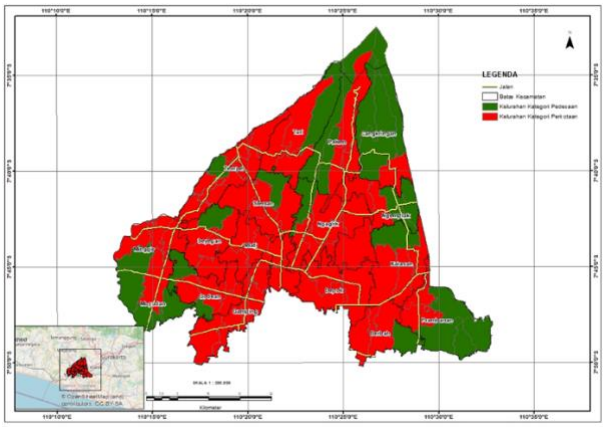

Figure 2. Urban and Rural Classification
Source: RTRW Kabupaten Sleman Tahun 2021–2041

3. RESULTS AND DISCUSSION

The SEM-PLS analysis was conducted to identify the relationships between attitudes, subjective norms, perceived behavioral control, intentions, behaviors, and the moderating effect of infrastructure on the intention to sort household waste in urban and rural areas of Sleman Regency. Data processing was performed using SmartPLS 3 software, which enables comprehensive testing of the structural model and the research hypotheses.

Table 1. Characteristics of Survey Sample

Demographic Characteristics		Amount	Frequency (%)
Gender	Male	256	32%
	Female	540	68%
Age	20 - 30	21	3%
	31 - 40	110	14%
	41 - 50	250	31%
	51 - 60	230	29%
	> 60	185	23%
Education	Elementary	40	5%
	Junior High	98	12%
	Senior High/Vocational	313	39%
	Undergraduate	329	41%
	Graduate/Postgraduate	15	2%
	Others	1	0%
Occupation	Civil Servant	39	5%
	Farmer/Livestock Farmer	119	15%
	Trader/Business Owner	82	10%
	Healthcare Worker/Educator	123	15%
	Construction Worker/Artisan	45	6%
	Retiree	99	12%
	Housewife	204	26%
	Others	85	11%
Monthly income	< 1000000	19	2%
	1000001 - 2000000	202	25%
	2000001 - 3000000	251	32%
	3000001 - 5000000	317	40%
	> 5000001	7	1%

Source: Primary Data, 2024

3.1. Measurement Model Analysis

SEM-PLS consists of two components: the measurement model and the structural model (Marcoulides and Saunders 2006). In this study, the measurement model was tested to ensure the reliability and validity of the data. Reliability was evaluated using Cronbach's Alpha (CA) and Composite Reliability (CR), which measure the internal consistency of the constructs. All constructs in this study demonstrated CA and CR values greater than 0.70, the recommended minimum threshold (Bagozzi and Yi 1988), indicating sufficient consistency.

The validity of the model was assessed through convergent and discriminant validity. Convergent validity was evaluated using Average Variance Extracted (AVE), which indicates the extent to which the indicators of a construct are theoretically related (Ru, Wang, and Yan 2018). All constructs in this study had AVE values greater than 0.50, meeting the minimum criteria for convergent validity (Chin and Newsted 1998). Table 2 presents the reliability and validity analysis results for both urban and rural areas.

Table 2. Reliability and Validity Analysis Results

Construct	Area	Cronbach's Alpha	Composite Reliability	AVE
ATT	Urban	0.961	0.972	0.896
	Rural	0.954	0.966	0.878
SN	Urban	0.969	0.976	0.891
	Rural	0.972	0.978	0.900
PBC	Urban	0.929	0.950	0.825
	Rural	0.931	0.951	0.828
INT	Urban	0.983	0.989	0.968
	Rural	0.972	0.981	0.946
BEH	Urban	0.968	0.979	0.939
	Rural	0.961	0.974	0.927
INF	Urban	0.968	0.976	0.912
	Rural	0.950	0.964	0.869

Source: Primary Data, 2024

The results presented in Table 2 indicate that all constructs demonstrate adequate reliability and validity. The Cronbach's Alpha and Composite Reliability values for all constructs exceed 0.70, indicating excellent levels of internal consistency. Furthermore, the AVE values for all constructs are above 0.50, signifying strong convergent validity (Chin and Newsted 1998).

Discriminant validity in this study was evaluated using the Fornell-Larcker criterion, which confirms that all constructs meet the recommended criteria in both urban and rural areas (Fornell, C., & Larcker 1981). The square root of the AVE for each construct is greater than its correlations with other constructs, as shown on the diagonal of the correlation matrix. These results suggest that each construct is distinct from the others, establishing adequate discriminant validity in both urban and rural contexts.

3.2. Structural Model Analysis

The structural model analysis was conducted to evaluate the relationships between attitudes, subjective norms, and perceived behavioral control with the intention and behavior of household waste sorting, as well as to test the moderating effect of infrastructure on these relationships. The analysis was performed separately for urban and rural areas to understand the differences and similarities in the patterns.

3.2.1. Path Coefficients

The results in Table 3 indicate significant and positive relationships between attitudes, subjective norms, and perceived behavioral control with the intention to sort household waste, with intention playing a critical role in driving sorting behavior. The variation in relationships between urban and rural areas highlights the influence of local context on behavioral dynamics. Subjective norms are stronger in urban areas, while perceived behavioral control is more dominant in rural areas.

3.2.2. Moderation test

The moderation test results in Table 4 show that infrastructure does not have a significant moderating effect on the relationships between attitudes, subjective norms, and perceived behavioral control with the intention to sort waste in urban areas. However, in rural areas, infrastructure significantly strengthens the relationship between perceived behavioral

control and the intention to sort waste. These findings suggest that infrastructure plays a critical role in supporting individuals' capabilities to sort waste, particularly in areas with limited infrastructure access. The absence of a significant moderating effect in urban areas indicates that individual behavioral factors are more dominant than the role of infrastructure.

Table 3. Correlation Test Results

Path	Path Coefficient		P-Value	Correlation Significance
	Urban	Rural		
ATT → INT	0.350	0.348	0.000	Significant Positive
SN → INT	0.471	0.274	0.000	Significant Positive
PBC → INT	0.167	0.355	0.000	Significant Positive
INT → BEH	0.953	0.934	0.000	Significant Positive

Source: Primary Data, 2024

Table 4. Results of the Moderation Effect Test

Path	Area	Path Coefficient	T-Statistic	P-Value	Moderation Effect
ATT*INF → INT	Perkotaan	-0.086	1.623	0.105	Not Significant
	Perdesaan	-0.035	0.711	0.477	Not Significant
SN*INF → INT	Perkotaan	0.076	1.435	0.152	Not Significant
	Perdesaan	-0.04	0.901	0.368	Not Significant
PBC*INF → INT	Perkotaan	-0.026	0.632	0.527	Not Significant
	Perdesaan	0.117	2.441	0.015	Significant Positive

Source: Primary Data, 2024

3.3. Discussion

The findings of this study reaffirm the validity of the Theory of Planned Behavior (TPB) in understanding household waste sorting behavior in Sleman Regency. Positive attitudes toward waste sorting significantly influence intentions in both urban and rural areas, with path coefficients showing near equivalence (0.350 in urban areas and 0.348 in rural areas). This supports Ajzen's (1991) theory, which highlights attitudes as a universal predictor of intentions, and aligns with the findings of Govindan et al. (2022); Shi, Xu, and Duan (2022), which emphasize that positive perceptions of the benefits of waste sorting encourage public participation in waste management. The importance of attitudes highlights the need for educational campaigns to raise awareness about the positive environmental and health impacts of waste sorting.

However, subjective norms have a stronger influence in urban areas (0.471) compared to rural areas (0.274). This indicates that social norms, formed through interactions within communities, families, and media, are more organized in urban environments, making them a primary driver of sorting intentions. In contrast, social norms in rural areas tend to be more informal and unstructured, resulting in a weaker influence on intentions. This finding aligns with (Zhou et al. 2022), which suggests that social norms are more effective in environments with organized social networks. Therefore, community-based programs in rural areas could be optimized to strengthen the impact of social norms, for instance, by involving local leaders or integrating group activities into cultural traditions.

Perceived behavioral control (PBC) exhibits an opposite pattern. In rural areas, PBC has a stronger influence on intentions (0.355) than in urban areas (0.167). This supports Bandura's (1997) concept of self-efficacy, which posits that individuals' confidence in their abilities plays a key role in action-taking, especially in resource-constrained

environments. In Sleman Regency, rural residents rely heavily on their personal capacity to sort waste due to limited infrastructure access. Saleh et al. (2024) highlight that PBC is more significant in rural areas due to the limited availability of infrastructure. Therefore, enhancing individuals' confidence in sorting waste through training and technical assistance can be a vital strategy to encourage this behavior in rural areas.

The moderating effect of waste management infrastructure shows differences between urban and rural areas. In urban areas, infrastructure does not significantly moderate the relationship between attitudes, subjective norms, and PBC with intentions. However, in rural areas, infrastructure significantly strengthens the relationship between PBC and intentions (path coefficient 0.117, p = 0.015). These results differ from prior studies, such as Nduneseokwu et al. (2017), which highlight that infrastructure consistently strengthens the effects of attitudes and subjective norms. This variation may be attributed to the unique characteristics of Sleman Regency, where infrastructure in rural areas remains limited, and its impact is more focused on enhancing individuals' capabilities rather than supporting attitudes or social norms. This finding suggests that infrastructure in rural areas is more effective when directed toward improving perceived behavioral control.

The findings reveal that waste sorting behavior in Sleman Regency is shaped by a combination of individual, social, and infrastructural factors that vary between urban and rural contexts. Urban residents benefit from stronger social networks and greater access to infrastructure, making subjective norms a more prominent driver of intentions (Zhou et al. 2022). In contrast, rural residents face challenges in infrastructure availability, making perceived behavioral control the key factor in their intentions to sort waste. This divergence underscores the importance of context-sensitive strategies in waste management. The results also suggest that existing infrastructure in urban areas may have already reached a threshold where its incremental effect on behavior is minimal, while in rural areas, even small infrastructural improvements can significantly impact residents' confidence and willingness to sort waste.

From a practical standpoint, the findings emphasize the need for tailored waste management strategies. Urban areas should focus on leveraging social norms through media campaigns and community-based initiatives to sustain waste sorting behaviors. Rural areas, on the other hand, require a dual approach: enhancing infrastructure and providing education and training to empower residents. The study demonstrates that the success of waste management in Sleman Regency depends not only on technical interventions but also on integrating socio-cultural approaches that address the unique needs of urban and rural communities.

4. CONCLUSION

Based on this research, it can be concluded that the intention to sort household waste in Sleman Regency is significantly influenced by attitudes, subjective norms, and perceived behavioral control, with varying dynamics between urban and rural areas. Infrastructure plays a critical role as a moderator in rural areas, strengthening the relationship between perceived behavioral control and sorting intentions, while its effect is less pronounced in urban areas. These findings emphasize the importance of context-specific strategies in waste management planning, integrating behavioral and infrastructural approaches to address local needs. This approach is expected to contribute to sustainable waste management practices and community participation in environmental conservation efforts.

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