

Diagnosing Household Recycling Barriers and Service Preferences Through SULAM-Based Community Engagement

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ABSTRACT

Household recycling performance depends not only on environmental attitudes but also on the accessibility and convenience of local collection systems. This study provides a community-level diagnostic of household recycling practices, perceived barriers, programme awareness, and service preferences in local community conducted through Service Learning Malaysia-University for Society (SULAM) project. A cross-sectional questionnaire was distributed through neighbourhood, community, event-based, and digital channels, yielding 83 completed responses from participants aged 18 years and above. Responses were analysed using frequencies, percentages, descriptive cross-tabulations, and thematic grouping of open-ended feedback. Daily source separation was reported by 15.7% of respondents, while limited access to recycling facilities was the most frequently reported barrier (47.0%). Doorstep/curbside collection was the preferred material handover mechanism (67.5%), while cash payments (55.4%) and e-wallet transfers (39.8%) were the most frequently selected reward formats. Social media was the preferred information channel (65.1%). The findings indicate that access, convenience, programme visibility, and incentive configuration are relevant service attributes in the study setting. The study contributes a community-informed diagnostic pathway that translates reported user feedback into preliminary requirements for subsequent waste-management and engineering interventions. Given the convenience sampling and cross-sectional design, the findings should be interpreted as a localized diagnostic baseline rather than population-level or causal evidence.

Keywords: household recycling, source separation, municipal solid waste management, service accessibility, community engagement, SULAM

INTRODUCTION

Household recycling occurs at the interface between residents and the waste-management system, where storage capacity, sorting requirements, collection schedules, facility accessibility, and information influence the practical effort required to participate. Meta-analytic evidence identifies convenience, information, environmental concern, and social and moral norms as recurring determinants of household recycling behaviour (Miafodzyeva & Brandt, 2013). Malaysian studies similarly indicate that convenience and perceived benefits are associated with recycling participation (Teo, 2016), while evidence from Sabah suggests that convenience, perceived recycling costs, and social and moral norms can influence recycling behaviour even where environmental awareness is relatively high (Juliana et al., 2022).

Accordingly, low or inconsistent source separation should not be attributed solely to an awareness deficit. Households may support recycling while encountering practical constraints related to travel, storage, material preparation, collection schedules, or programme accessibility. Systematic evidence on household waste-separation interventions further suggests that contextual and behavioural measures are more effective when considered together rather than relying on information provision alone (Trushna et al., 2024). For municipal waste managers, understanding the difficulties reported by residents and the service attributes they prefer is therefore an important preliminary step before selecting or testing interventions.

Despite extensive research on recycling behaviour, fewer studies explicitly connect community-reported barriers with preliminary service and engineering requirements within a defined municipal context. Existing research has examined behavioural determinants, policy instruments, and collection arrangements, including household acceptance of curbside recycling in Malaysia (Zen & Siwar, 2015). However, a practical gap remains between diagnosing participation problems and specifying the collection, communication, access, and incentive attributes that should be evaluated locally. This study addresses that diagnostic gap by positioning community engagement as an evidence-generation stage in waste-system design.

SULAM provides the institutional context for this approach. Service-learning can connect academic activity with community needs and authentic problem contexts (Salam et al., 2019), while engineering service-learning is strengthened when community knowledge contributes substantively to problem definition and decision-making (Delaine et al., 2024). In the present study, undergraduate manufacturing engineering students supported questionnaire distribution and field engagement to document household recycling practices, perceived barriers, programme awareness, and preferred service arrangements. This study therefore examines the usefulness of community feedback for problem definition rather than claiming an educational effect that was not directly measured.

This study has two objectives: (1) to characterize reported household recycling practices, operational barriers, programme awareness, and service preferences in the study setting; and (2) to translate these findings into preliminary requirements for subsequent recycling-system intervention and validation.

Accordingly, this study addresses three research questions:

1. Which barriers are most frequently reported by participating respondents?
2. Which collection, communication, and incentive attributes are preferred?
3. How can reported community feedback be translated into testable requirements for local recycling-system design?

This study is therefore positioned as a diagnostic stage rather than an evaluation of intervention effectiveness.

METHODOLOGY

A quantitative, cross-sectional diagnostic design was adopted to examine household recycling practices, perceived operational barriers, awareness of existing recycling programmes, and preferences for recycling collection and incentive mechanisms. The study was conducted as part of a SULAM project involving undergraduate manufacturing engineering students. The research design was descriptive and diagnostic, with questionnaire responses used to establish a local baseline for problem identification and service-design considerations. No intervention, causal analysis, or longitudinal assessment was undertaken. Figure 1 shows the research framework comprised five sequential stages.



Figure 1: Research framework in this study

Study Setting and Participants

The study was conducted within the administrative area of the Historic Melaka City Council (MBMB), Malaysia, where waste-management services are provided by SWM Environment Sdn. Bhd. The questionnaire was distributed during the “Anda Kitar, Kami Bayar” community event organized by MBMB on 16 May 2026,

from 08:00 to 14:00, as well as through neighbourhood visits, community hubs, and digital community channels. The questionnaire targeted individuals aged 18 years and above. A total of 83 completed responses were received and included in the analysis. Convenience sampling was employed because recruitment was conducted through accessible community and digital channels during the project period. Consequently, the findings describe feedback obtained from participating respondents and should not be interpreted as representative estimates of the wider household population in Melaka.

Respondent characteristics included age category (figure 2), housing type (Figure 3) and residential area (figure 4).

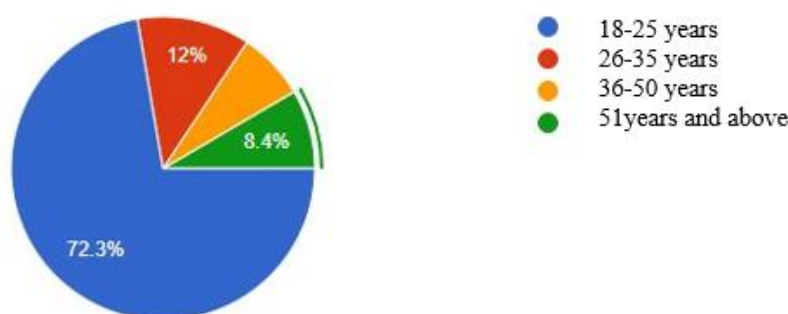


Figure 2: Age Distribution of Respondents



Figure 3: Distribution of Housing Types Among Respondents

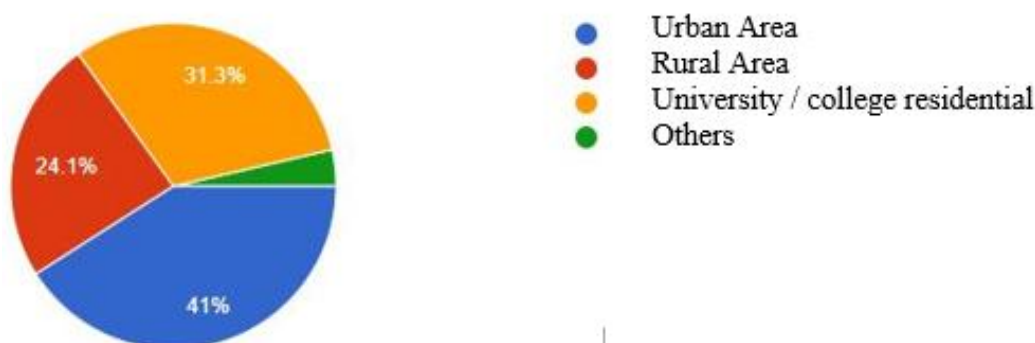


Figure 4: Geographic Location of Respondent Residences

Questionnaire Instrument

A structured questionnaire was developed to obtain information on household recycling practices, perceived operational barriers, programme awareness, and preferences for recycling services. The questions have also been discussed with MBMB's on their experience in organizing the recycling community event such as the "anda Kita, Kami Bayar" programme. The questionnaire comprised four sections. Section A recorded respondent characteristics, including age, housing type, and residential area. Section B examined household recycling practices, including the frequency of waste separation, recyclable material categories, cleaning practices, and willingness to purchase products made from recycled materials. Section C addressed perceived

barriers, acceptable travel distances to collection facilities, preferred collection frequency, and preferred material handover methods. Section D assessed awareness and participation in KITARecycle, an incentive-based recycling reward program introduced by SWM Environment Sdn. Bhd. and the MBMB “Anda Kitar, Kami Bayar” programme, preferred information channels, reward formats, and motivations for recycling. The questionnaire comprised categorical, multiple-response, and ordinal-response items. It was used primarily to obtain descriptive feedback from participating respondents; formal psychometric validation was not undertaken.

Questionnaire Distribution and Data Collection

The questionnaire was distributed as part of the SULAM field activity. Participating students were briefed on questionnaire administration, ethical conduct, and neutral engagement with respondents before field deployment. Paper questionnaires were distributed during neighbourhood visits and at community hubs, while a digital questionnaire was circulated through community and institutional social-media channels.

The use of multiple distribution channels was intended to facilitate access to respondents with different communication preferences and availability. However, this approach may have introduced self-selection and mode effects. Because the number of individuals who received or were approached with the questionnaire was not systematically recorded, a response rate could not be calculated. The analysis therefore uses the 83 completed responses received as the study dataset.

Data Analysis

Completed questionnaire responses were coded and analysed using descriptive statistics. For each question, response frequencies and percentages were calculated based on the valid responses received for that item. For multiple-response questions, each selected option was counted separately; consequently, category percentages may exceed 100% when summed. Descriptive cross-tabulations were used, where relevant, to examine response distributions across selected respondent characteristics. These comparisons were interpreted as within-sample patterns and were not used to infer population-level relationships. Open-ended feedback was reviewed and grouped into recurring functional themes, including access, collection arrangements, information, and incentives. These themes were subsequently used to identify preliminary user requirements for recycling-service design. The qualitative responses were treated as supplementary exploratory evidence rather than as a formally validated qualitative dataset.

RESULTS

Household Recycling and Source-Separation Practices

Daily source separation was reported by 15.7% of respondents. The remaining respondents reported less frequent separation: 31.3% separated waste a few times per month, 26.5% a few times per week, and 21.7% rarely. These figures (shown in Figure 5) describe self-reported household practices within the respondent group and should not be interpreted as measured recycling rates.

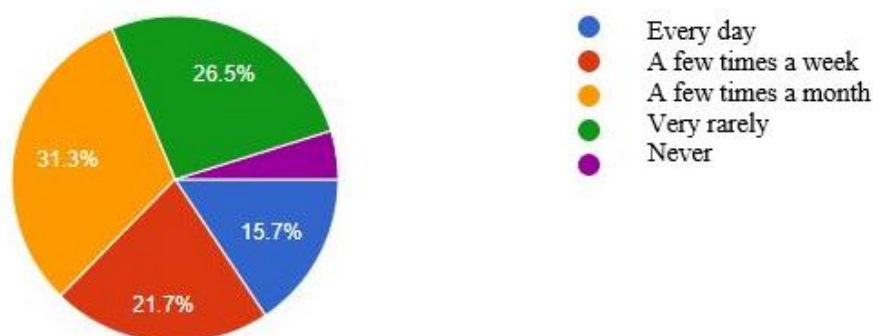


Figure 5: Frequency of At-Home Household Waste Separation

Plastic and paper/cardboard were the most frequently reported recyclable materials, selected by 81.9% and 54.2% of respondents, respectively. Aluminium/metal and glass were each selected by 43.4%. Because multiple selections were permitted, the percentages represent the proportion of respondents selecting each material category and therefore do not sum to 100% as shown in Figure 6.

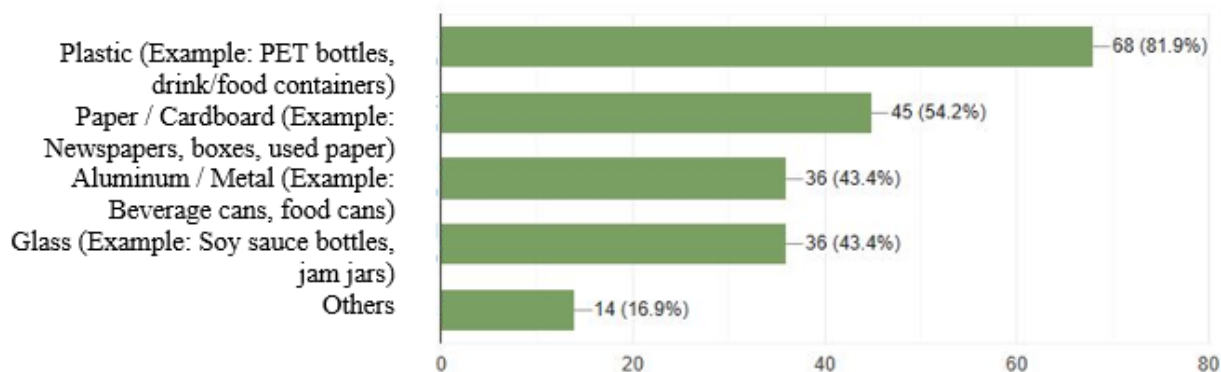


Figure 6: Primary Types of Recyclable Materials Separated by Respondents

Also, only 32.5% of respondents reported consistently washing or rinsing recyclable items before disposal. A further 49.4% did so conditionally, while 18.1% reported disposing of items without washing. These responses shown in Figure 7 identify household material preparation as a potential service-design consideration; however, physical contamination was not measured.

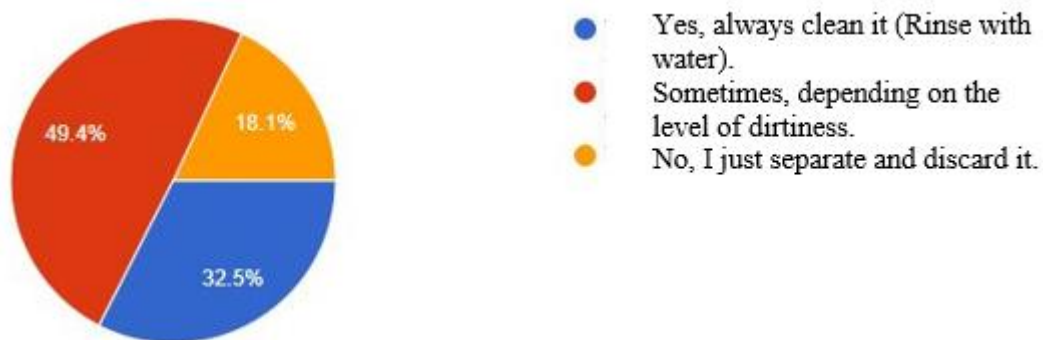


Figure 7: Pre-Separation Cleaning Practices for Recyclable Materials

A total of 79.5% of respondents (figure 8) reported willingness to purchase products made from recycled materials when price and quality were comparable with conventional alternatives. This finding represents stated purchase intention rather than observed purchasing behaviour or demonstrated market demand.

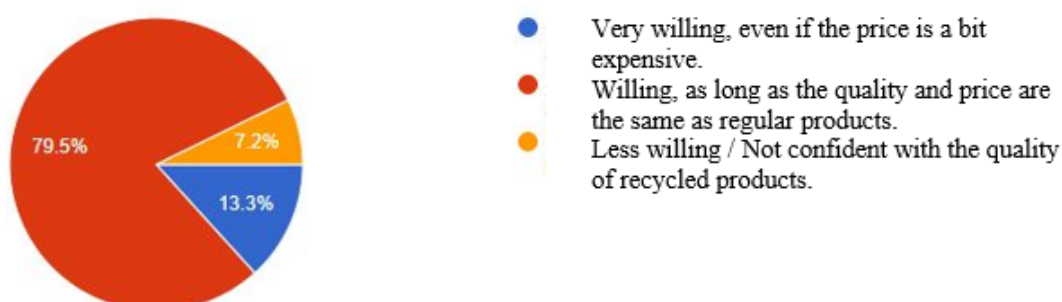


Figure 8: Willingness to Purchase Products Derived from Recycled Materials (Circular Manufacturing)

Operational and Logistical Barriers

Figure 9 shows that limited access to recycling facilities was the most frequently reported barrier, selected by 47.0% of respondents ($n = 39$). Logistical constraints were reported by 19.3%, followed by irregular collection schedules at 14.5%. Thus, access was the most prominent reported constraint within the respondent group. However, the cross-sectional design does not establish that improving access would necessarily increase recycling participation.

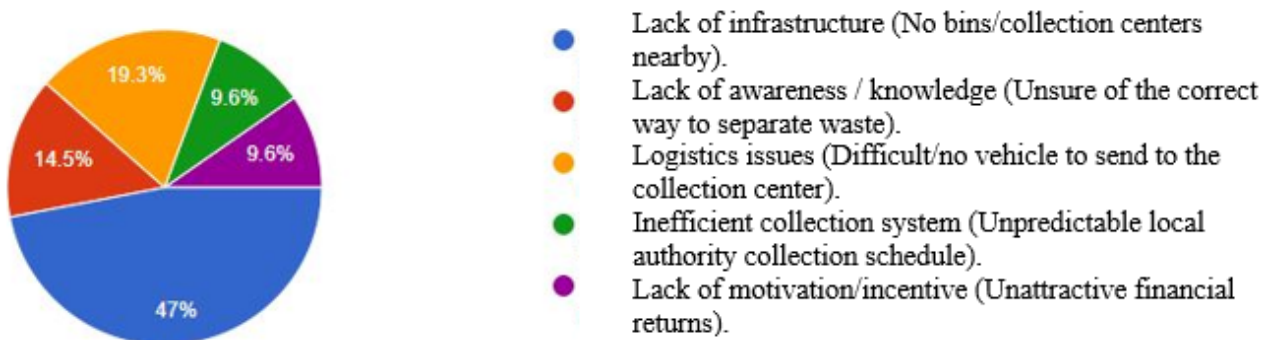


Figure 9: Primary Barriers to Consistent Household Recycling

For travel to drop-off facilities, 37.3% of respondents considered a distance of 1–3 km acceptable, while 27.7% accepted distances exceeding 5 km, as shown in Figure 10. This distribution indicates variation in stated travel tolerance and suggests that household preferences cannot be represented by a single distance threshold.

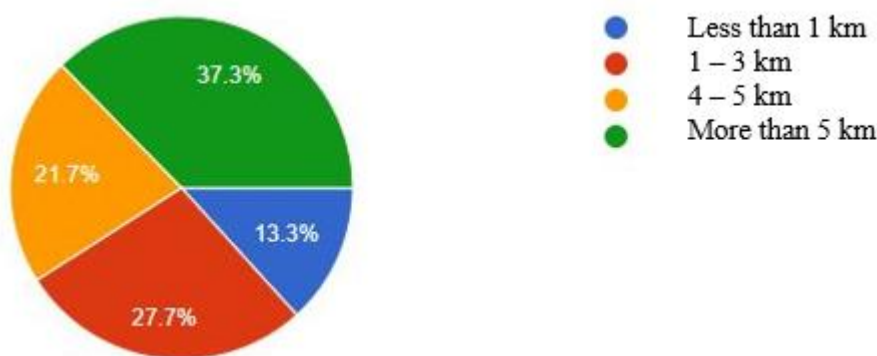


Figure 10: Maximum Acceptable Distance Travelled to Recycling Drop-Off Centres

Figure 11 shows that weekly collection was preferred by 44.6% of respondents, followed by bi-weekly collection at 36.1%. These values represent stated service preferences and do not indicate the collection frequency required to achieve a specific recovery rate or collection efficiency.

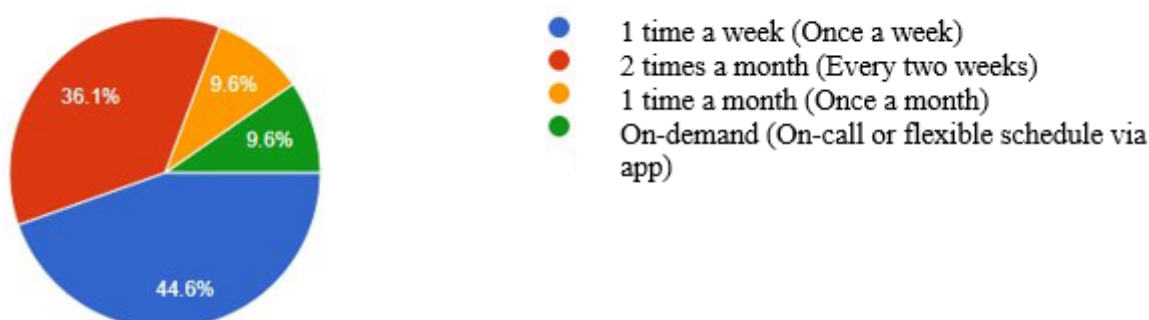


Figure 11: Preferred Collection Frequency for Recyclable Waste by Local Authorities / SWM Environment

Figure 12 shows that doorstep/ curb side collection was the preferred material handover mechanism, selected by 67.5% of respondents. Permanent drop-off facilities were selected by 22.9%, while temporary community counters were selected by 9.6%. This response pattern indicates a strong preference for a handover arrangement that reduces the need to travel to a fixed facility.



Figure 12: Preferred Recyclable Material Handover Methods

Program Awareness and Incentive Preferences

Active use of the KITARecycle application was reported by 15.7% of respondents; 49.4% were aware of the application but had not registered, while 34.9% reported no prior knowledge of it (Figure 1). This distribution distinguishes programme awareness from adoption, although the survey did not determine the reasons for non-registration.

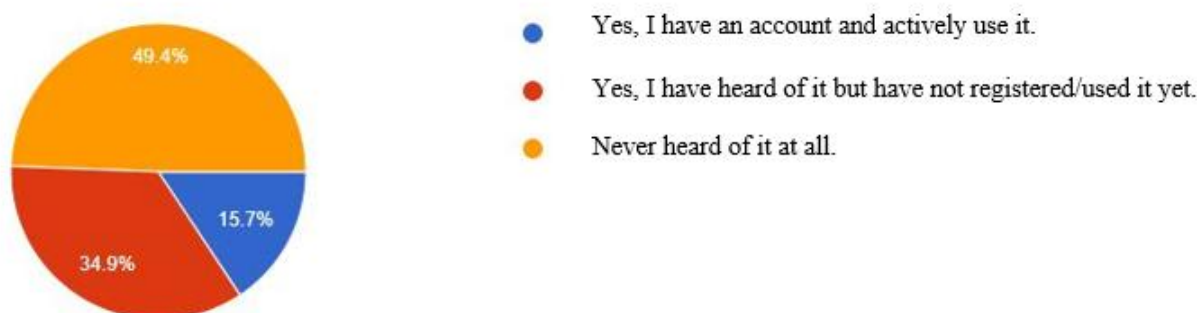


Figure 13: Level of Awareness and Adoption of the KITARecycle Mobile Application

Participation in MBMB's "Anda Kitar, Kami Bayar" programme was reported by 7.2% of respondents, while 51.8% indicated interest if access were expanded (Figure 14). The latter represents stated interest and should not be interpreted as predicted future participation.

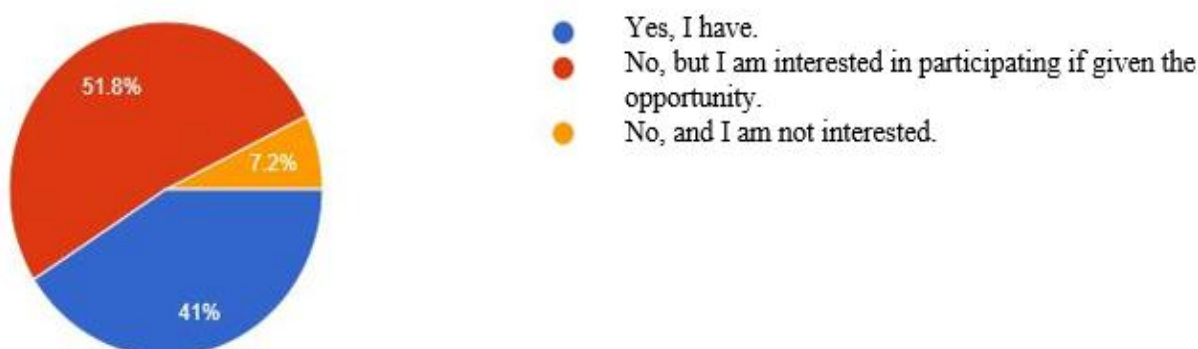


Figure 14: Community Participation and Interest in the MBMB "Anda Kitar, Kami Bayar" Program

Figure 15 shows that social media was the most frequently selected information channel, reported by 65.1% of respondents, followed by institutional announcements at 24.1%. This finding indicates a preference for digital communication within the respondent group but does not establish that social-media communication influences recycling behaviour.

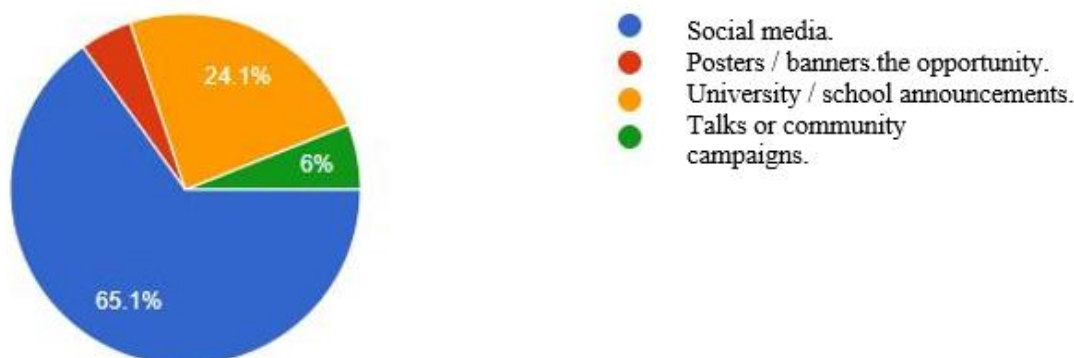


Figure 15: Primary Information Channels for Recycling Programs

Cash payments were preferred by 55.4% of respondents, followed by e-wallet transfers at 39.8%. Point redemption and tax rebates were selected by 1.2% and 3.6%, respectively. These results in figure 16 describe preferred reward formats rather than the effectiveness of specific incentives.

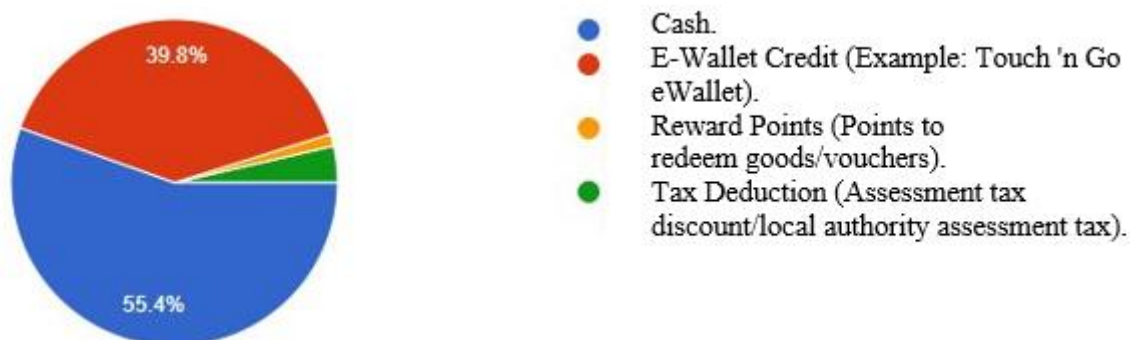


Figure 16: Preferred Incentive and Reward Formats for Sustained Recycling Engagement

Figure 17 shows that environmental sustainability was identified as the primary motivation by 43.4% of respondents. A further 25.3% selected a combination of environmental, economic, and social motivations, while 22.9% selected financial returns as their primary motivation. These responses indicate that motivations for recycling participation are heterogeneous.

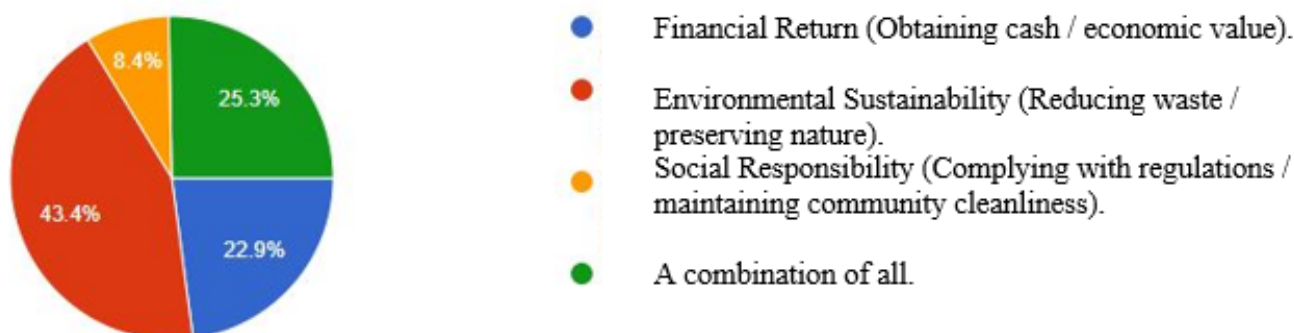


Figure 17: Primary Motivations for Participating in Household Recycling

DISCUSSION

From Environmental Support to Routine Recycling

The findings indicate a difference between stated willingness to support recycled-content products and reported routine source separation. Daily source separation was reported by 15.7% of respondents, whereas 79.5% expressed willingness to purchase recycled-content products when price and quality were comparable. These measures represent different behaviours and therefore should not be interpreted as a direct test of the attitude-behaviour relationship. Nevertheless, the observed pattern is consistent with evidence that positive environmental orientation does not necessarily translate into routine recycling when practical constraints remain (Juliana et al., 2022; Miafodzyeva & Brandt, 2013). The findings also support the importance of service convenience in the Malaysian context (Teo, 2016). Rather than treating low participation solely as an information problem, the results identify specific service attributes such as facility accessibility, collection frequency, handover mode, and programme on boarding are factors that can be considered in subsequent intervention design. This difference is important because information campaigns do not directly eliminate travel, storage, sorting, preparation, or scheduling burdens. Evidence from household waste-separation interventions supports the combination of informational measures with contextual and behavioural approaches (Trushna et al., 2024). The present study therefore provides formative evidence for intervention specification rather than evidence of intervention effectiveness. The principal contribution is the translation of reported community feedback into locally relevant service attributes. This diagnostic step complements existing behavioural research by identifying aspects of the service interface that can be tested before resources are committed to full-scale implementation.

Accessibility and Collection Configuration

Facility accessibility was the most frequently reported barrier (47.0%), while doorstep/curb side collection was the preferred handover mechanism (67.5%). The correspondence between a reported constraint and a preferred service attribute provides a clear design signal. It is also consistent with Malaysian evidence indicating demand for more convenient household recycling services (Zen & Siwar, 2015). However, a preference for curb side collection does not establish its operational or environmental superiority. Collection frequency, route density, vehicle utilization, labour requirements, contamination, and service costs would need to be assessed before implementation. The present finding should therefore be treated as a user-side requirement rather than a complete collection-system specification. Subsequent engineering studies could compare decentralized drop-off points, scheduled mobile collection, and household- or neighbourhood-based collection systems. Evaluation should integrate user acceptance with measurable system outcomes, including recovered mass, contamination, collection time, service cost per kilogram, and route efficiency. These findings support a socio-technical view of household recycling in which residents, storage and collection infrastructure, schedules, information, incentives, and downstream recovery processes interact. Improving one component without considering the others may simply shift the participation burden elsewhere within the system.

Programme Adoption and Incentive Design

The proportion of respondents using KITARecycle was substantially lower than the proportion who were aware of the application, while participation in the MBMB incentive programme was also limited. This distinction suggests that awareness does not necessarily translate into programme adoption. However, the survey does not establish whether non-adoption results from registration requirements, service coverage, perceived reward value, digital access, or other factors.

Cash and e-wallet rewards were the most frequently preferred formats, but stated preference does not demonstrate incentive effectiveness. Previous evidence indicates that financial incentives can have context-dependent effects on recycling behaviour (Li et al., 2021; Xu et al., 2023). Incentives should therefore be evaluated as components of the wider service configuration rather than assumed to be sufficient on their own.

A subsequent pilot could combine convenient collection, simplified programme onboarding, transparent rewa-

rd rules, and participation feedback. Such a package would reflect the preferences reported in this study while allowing the individual contribution of service access and incentives to be evaluated.

Social media was the preferred information channel for 65.1% of respondents. Municipal communication could therefore prioritize digital dissemination of collection schedules, accepted materials, registration procedures, and reward information. This finding represents a channel preference, however, rather than evidence that social-media exposure changes recycling behaviour.

Engineering Intervention Opportunities

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Community and Policy Intervention Opportunities

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Translating Community Findings into Engineering Requirements

The combination of facility accessibility as the leading reported barrier (47.0%) and curb side collection as the preferred handover mechanism (67.5%) provides a basis for defining preliminary design requirements. Potential requirements include convenient access, clear material identification, manageable handling, adequate

storage capacity, and compatibility with existing collection operations. These requirements represent design hypotheses derived from user feedback and require further validation.

Potential prototypes could include modular collection containers, standardized sorting cues, or scheduled neighbourhood collection arrangements. Their performance should be assessed using both engineering and waste-management indicators, including capacity, durability, handling effort, collection time, contamination, recovered material mass, cost per kilogram, and user acceptance. Digital identification technologies such as QR codes or RFID could also be considered for collection-event recording or reward administration where municipal systems and privacy requirements permit. These technologies were not evaluated in the present study and should therefore be treated solely as future design options. The finding that only 32.5% of respondents consistently washed or rinsed recyclable materials identifies a potential material-preparation issue. Because contamination was not physically measured, this finding cannot be used to quantify impacts on material quality. Future pilot studies could evaluate simple preparation prompts and measure changes in contamination alongside household effort.

CONCLUSION

This study provides a localized diagnostic of household recycling practices, perceived barriers, programme awareness, and service preferences within the MBMB context. Among the 83 completed responses, daily source separation was reported by 15.7% of respondents, limited access to recycling facilities was the leading reported barrier (47.0%), and doorstep/curb side collection was the preferred material handover mechanism (67.5%). Cash and e-wallet rewards were the most frequently preferred incentive formats, while programme adoption remained lower than programme awareness. Collectively, these findings identify accessibility, convenience, programme visibility, and service configuration as practical attributes for subsequent intervention testing.

CONTRIBUTION

The principal contribution of this study is a community-informed diagnostic pathway for recycling-system design through SULAM project.

LIMITATIONS

Interpretation of the findings is constrained by convenience sampling, the predominance of respondents aged 18–25 years (72.3%), self-reported measures, and the cross-sectional design. Because the recruitment denominator was not recorded, a response rate could not be calculated. The study also did not measure recovered material mass, contamination, collection costs, route efficiency, or post-intervention participation. In addition, the open-ended analysis was exploratory and did not include inter-coder reliability.

Future research should recruit larger and more demographically balanced samples, integrate municipal operational data, and evaluate candidate interventions using longitudinal or quasi-experimental designs. In particular, pilot studies comparing collection configurations and incentive arrangements could determine whether the preferences identified in this study translate into measurable changes in participation, recovered material, contamination, and service efficiency.

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