Archives of Environmental Protection
Vol. 51 no. 4 pp. 3–17

PL ISSN 2083-4772
DOI: 10.24425/aep.2025.157224



# Awareness, understanding and practices of household waste recycling: A comparative study of low-and high-income communities in the North of Pretoria, South Africa

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**Keywords:** Composting, household waste, South Africa, waste recycling, waste management

**Abstract:** This study assessed the awareness, understanding, and practices of household waste recycling in high-income and low-income communities in the North of Pretoria, South Africa. A structured questionnaire was administered through face-to-face interviews and a door-to-door survey. A purposive sampling involving 122 participants was carried out. Data were collected from September 2023 to April 2024 and analyzed using descriptive statistics and the Pearson chi-square test. The study area was divided into four sites (A, B, C, and D) based on income levels. At sites A, B, and C (low-income communities), 81.6%, 81.4%, and 75.0 % of participants, respectively, did not separate waste, whereas at Site D (high-income community), 61.5% of the participants did not separate their household waste before disposal. Participants from all the communities were aware of recycling in the following order: Site D (76.9%) >Site C (60.7%) >Site A (60.5%) >Site B (51.2%). However, actual recycling rates remained low, with only 30.7% of high-income and 15.8% to 20.1% of low-income participants partaking in recycling practices. Lack of time and inadequate infrastructure were identified as major obstacles to household waste recycling. Recycling was only carried out when there was a perceived financial benefit. Despite their knowledge of recycling, most participants did not recycle their household waste. Awareness campaigns and incentives ought to be introduced to encourage recycling and boost community participation. The establishment of local recycling centres could enhance engagement in recycling, resulting in employment opportunities.

## Introduction

The increasing quantity of solid waste is one of the major environmental problems faced worldwide (Ikechukwu, 2015). Municipal Solid Waste (MSW) production has surged globally due to economic and population growth, as have the lethal and harmful substances found within the waste stream (Schoeman and Rampedi, 2022). Waste is categorized into various types, including industrial solid waste, municipal solid waste, agricultural solid waste, plastic waste, electronic waste, mining waste and hazardous waste (Adeleye and Shakantu, 2022). If not properly managed, all these types of waste can lead to problems such as unpleasant odors, the release of toxic substances into the environment, and the pollution of soil, air, surface water, and underground water (Adeleye and Shakantu, 2022).

One of the major components of municipal solid waste is household waste (Pakpour *et al*. 2014). If household waste is not adequately managed during disposal, as is frequently the case in low- and middle-income countries, toxic components of the waste may become harmful when discarded in landfills or in the environment. This is due to greenhouse gases produced during the anaerobic decomposition, resulting in long term environmental pollution and negative human health impacts (Uddin *et al*. 2015). Improperly managed household solid waste can also introduce pathogens that spread rapidly, affecting both human beings and animals (Whang *et al*. 2016).

Although there are various methods of waste management, such as incineration, pyrolysis, gasification, and landfilling, recycling is one of the most acceptable approaches to effective waste management (Pakpour *et al*. 2014). Improper landfilling and open burning of waste can cause serious health problems to people living near landfill sites, including skin allergies, infectious diseases, cancers, respiratory disorders, and reproductive or birth complications (Kumari *et al*. 2019). Incineration of solid waste is environmentally harmful due to the release of greenhouse gases such as nitrogen oxide, sulphur oxides, and nitrous oxides (Shah *et al*. 2023). Gasification also contributes to environmental pollution through emissions of dioxins, furans, particulate matter, and the generation of solid

residues such as slag and ash, which contain heavy metals (Manesh *et al*. 2024). While pyrolysis has certain advantages over gasification and incineration, it has significant challenges such as the release of volatile organic compounds, polycyclic aromatic hydrocarbons, and particulate matter during incomplete pyrolysis (William, 2013).

Waste generation by households is immense and is anticipated to rise significantly. Therefore, the sustainable waste practice of recycling household waste is a key strategy for addressing environmental problems caused by solid waste (Volschenk et al. 2021). Recycling is considered the most widely applied practice for achieving a circular economy that aims to enhance material efficacy through the 3Rs: reduce, reuse, and recycle (Kirchherr *et al*. 2017). Recycling entails collecting and processing waste without transforming its vital nature and manufacturing new products from recycled waste (Oberoi, 2020). At the household level, materials such as metals, plastics, glass, textiles, organic substances, paper, and cardboard can be recycled (CSIR, 2016).

Recycling household waste has several benefits, such as job creation for citizens in countries worldwide (Cudjoe *et al*. 2021). It is estimated that one percent increase in a country's recycling rate may lead to a 0.4% growth in employment within the solid waste recycling sector (Liu *et al*. 2020). This could considerably contribute to poverty reduction, thus supporting the achievement of the United Nations Sustainable Development Goals 1, which is poverty eradication (Cudjoe *et al*. 2021). Furthermore, recycling can reduce global warming, aid in the conservation of raw materials, and save large amounts of energy, since recycled materials replace virgin resources in the production process (Cudjoe et al. 2021). In South Africa, recycling is a source of income for most informal recyclers. It is estimated that the total annual payments to the informal waste sector through buy-back centres increased from 625 million South African Rands in 2012 to 872 million in 2017 (Godfrey, 2021). If wastes such as plastic and paper are not recycled, they may be illegally dumped on agricultural land or in water bodies, resulting in pollution that harms both human and animal health (Cudjoe *et al*. 2021).

In South Africa, landfill space is already insufficient and rapidly diminishing, hence the need for improved waste management methods such as recycling (National Waste Strategy, 2020). However, current knowledge of the practice and importance of recycling seems to be low in the country, and where awareness exists, it is limited to more affluents communities (Schoeman and Rampedi, 2022). There is therefore a need to increase household awareness of the importance of recycling, especially as it reduces the amount of waste sent to landfills. Generally, people in South Africa display a negative attitude towards recycling, which is concerning because consumer participation is essential for successful household recycling (Bendak and Attili, 2017). Households must get involved in waste separation at the source, as this is a crucial strategy that improves both the quantity and quality of recyclable materials (Jalil *et al*. 2016). Separating household waste at the source enables the isolation of dry recyclable solid waste for resource recovery (Hettiarachchi *et al*. 2018), while wet organic waste such as food waste can be used for composting, thereby reducing the landfill load (Hettiarachchi *et al*. 2018). However, achieving desirable recycling levels is hindered by a lack of adequate knowledge and public awareness, thus leading to low participation (Hettiarachchi *et al*. 2018). Comprehending the factors that influence household recycling behavior is therefore vital for developing effective strategies to improve recycling practices (Schoeman and Rampedi, 2022).

Studies conducted over the years on household waste recycling in South Africa have focused mainly on the working conditions and health status of waste pickers at landfills (Mothiba *et al*. 2017), barriers to recycling (Strydom, 2018), household attitudes towards waste management and recycling (Smith, 2020), e- waste recycling (Ichikowitz and Hattingh, 2020), waste disposal practices in low-income settlements (Haywood *et al*. 2021), and challenges faced by the low-income community of Alexandra (Kubanza, 2024). However, none of these studies have adequately explored the unique dynamics between household income differences and the overall effect of reluctance towards recycling. There are differing perspectives on the relationship between household income and willingness to participate in recycling. For instance, Martin et al. (2006) suggested that financial stability, which enables greater freedom of choice, may foster positive behavior towards sustainability. This view was further supported by Sidique et al. (2010), who reported that high-income earners are more likely to participate in recycling, probably due to their income, higher level of education, accessibility to recycling facilities, and perceived benefits of recycling. On the contrary, other studies have also suggested that among low-income groups, the interest in recycling is often motivated less by environmental concern and more by the potential to generate income, as seen in the activities of waste pickers, waste sellers, or waste collectors within the recycling industry (Gutberlet, 2015). As a result, differences in recycling interest exist across socioeconomic groups, and factors such as recycling policies, infrastructure availability, and cultural norms may play a significant role in reshaping active participation in recycling programs across (Schoeman and Rampedi, 2022). Thus, there remains a gap in research and a need for continued inquiry into recycling interest, awareness, and understanding of recycling across low-income and high-income communities.

In both high- and low-income communities, the government provides a waste disposal service with weekly collection. However, different waste collection bins (labelled either for recycled or non-recycled materials) are not provided for waste separation. Some high-income communities often have access to private waste collection services that offer more comprehensive recycling options, including separate bins for different waste streams. This study therefore aimed to establish the practices, awareness, and understanding of household recycling in two economically distinct communities. Specifically, it examined households' willingness to engage in recycling, their knowledge on recycling, and the factors that influence their ability to separate waste into organic and inorganic components for composting and recycling respectively. Determining knowledge gaps in recycling practices in these economically different communities may be used as baseline data for developing targeted educational campaigns. Such initiatives would not only raise awareness of the importance of recycling but also provide opportunities for participation, enabling policymakers to implement

different recycling programs at the grassroots level in the country. Furthermore, the findings of this study may inform policymakers and municipal waste management authorities about community interests and existing gaps in recycling programs and community engagement strategies. This could result in the proposal of tailored interventions suited to different income groups to improve participation in household solid waste recycling.

## Materials and Methods

### *Study Areas*

The study was carried out in two economically different communities, comprising Sites A, B, and C (low-income communities) and Site D (a high-income community), all located in the northern part of Pretoria, in the Gauteng province of South Africa. Sites A. B, and C are situated in an apartheid-era township, which continues to face challenges such as underdevelopment, high unemployment, and limited access to private healthcare. In contrast, Site D is a well-established suburb with superior infrastructure, including well-maintained road networks and greater access to private services (Mashilo and Mahlangu, 2022).

The geographical coordinates of the low-income community are $25^{0}$37' 12' S $27^{0}$ 58' 48' E (VYMaps.com, 2016). This high-density township, located in the northern part of Pretoria, Gauteng, South Africa, is situated 32km from the Pretoria city centre (Kgari-Masondo, 2013), between Pretoria North and Pretoria West. Site D is a suburb in north Pretoria, Gauteng. It is located northwest of the Pretoria central business district and forms part of the Akasia area. Its geographical coordinates are $25^{0}$38' 47" S $28^{0}$ 6' 3" E (VYMaps.com, 2016). Both communities fall under the city of Tshwane Metropolitan Municipality in the Gauteng province. In South Africa, low-income communities typically consist of settlements that are characterized by a combination of informal housing, such as shacks and formal dwelling. These areas often face socio-economic problems, such as poverty and overcrowding, partly due to their smaller housing sizes compared to high-income communities (Weimann and Oni, 2019). In contrast, high-income communities are usually characterized by luxury housing and access to premium amenities such as private schools, gated estates, and other high-end services (Turok and Borel-Saladin, 2018). Furthermore, households in these communities commonly have substantially higher-than-average income levels and are employed in professional, high-paying sectors (Stats SA, 2020). The economic disparities between these communities are further shaped by inequalities in education quality because schools in low-income areas often lack adequate resources and infrastructure compared to those in high-income neighborhoods (Amnesty International, 2020).

### *Methodology*

The study employed a correlational research design, which is a non-experimental research method used to examine and determine the extent of the relationships between two or more non-manipulated variables (Creswell, 2012). This type of design enabled the researchers to effectively establish meaningful relationships between variables. A total of 122 individuals participated in the study, distributed as follows: Site A (38), Site B (43), Site C (28), and Site D (13). The purposive sampling method was chosen due to the nature of the study and the characteristics of the target population. This method also ensured the inclusion of participants who were willing to provide relevant information, thereby enhancing the representativeness of the sample in relation to the study population (Etikan et al. 2016).

Data collection took place between September 2023 and April 2024, with active fieldwork conducted over a total of 55 days. Data were collected only after permission was obtained from community councillors, as no access was granted prior to approval. The administration of questionnaires was not restricted to any specific season. A structured questionnaire, incorporating both closed and open-ended questions, was used for data collection. Ethical clearance was first obtained from the university, followed by consent from both the community councillors (local representatives) and participants. Participants were informed that their involvement was voluntary and that they could withdraw from the study at any time without any consequences. To ensure compliance with the Protection of Personal Information Act 4 of 2013 (POPI Act), the participants were assured that their personal information and their responses would remain confidential and would not be disclosed publicly.

Data were collected from the participants through face-to-face interviews conducted via a door-to-door survey, the questionnaire was divided into six sections: Section A: Demographics (gender, employment status, education level, and monthly household income), Section B: Materials considered to be recyclable, Section C: Waste management practices, Section D: Perceptions of participants about recycling, Section E: Composting, and Section F: Waste reduction. The structure of the questionnaire used in the survey was adapted and modified from previous studies conducted by Strydom (2018), and Kubanza, (2024). Questions on composting were included to assess participants' knowledge of composting and its relevance within the household, representing an improvement over the previously published research.

### *Statistical analysis*

The data were reviewed for consistency by comparing responses to related questions to identify any contradictions. Data analysis was conducted using SPSS version 28.0. Descriptive statistics such as frequencies and percentages were used to measure the variables and the Pearson chi-square test was used to examine the relationship between participants' knowledge of recycling and their recycling behavior.

## Results and Discussion

### *Demographics*

Table 1 shows the demographic characteristics of participants, including gender, education level, employment status, and monthly income. In the low-income communities (Sites A, B, and C), the majority of participants were female: 84.2%, 51.2%, and 71.4% of, respectively, while males accounted for 15.6%, 48.8%, and 28.6%, respectively. In contrast, at site D (high–income community), males constituted 69.2% of participants, with females representing 30.8%. In terms of education, most participants across all sites had attained a

**Table 1:** Demographics of participants in low-and high –income communities.

| Site | Gender of participants (%) | | Education level attained by participants (%) | | | | | Employment status of participants (%) | | | | Monthly income of participants R × $10^3$ (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male | Female | Primary School | High School | University Level | College Level | Never Went to School | Employed | Self employed | Unemp-loyed | Pensi-oner | < R2 | R2-R16 | R17-R24 | >R24 |
| **Site A** | 15.8 | 84.2 | 5.3 | 39.5 | 21.1 | 34.2 | 0.0 | 13.2 | 10.5 | 63.2 | 13.2 | 68.4 | 26.3 | 5.3 | 0.0 |
| **Site B** | 48.8 | 51.2 | 11.6 | 51.2 | 11.6 | 23.3 | 2.3 | 4.7 | 18.6 | 58.1 | 18.6 | 90.7 | 7.0 | 2.3 | 0.0 |
| **Site C** | 28.6 | 71.4 | 0.0 | 60.7 | 17.9 | 21.4 | 0.0 | 17.9 | 21.4 | 64.3 | 3.8 | 71.4 | 28.6 | 0.0 | 0.0 |
| **Site D** | 69.2 | 30.8 | 0.0 | 61.5 | 38.5 | 0.0 | 0.0 | 23.1 | 38.5 | 30.8 | 0.0 | 30.8 | 0.0 | 38.4 | 30.8 |

*R-Rands (South African currency)

**Table 2:** Materials considered to be recyclable by participants.

| Materials recycled | Low-income communities (%) | | | High-income community (%) |
|---|---|---|---|---|
| | Site A | Site B | Site C | Site D |
| **Organic waste** | 23.7 | 25.6 | 53.6 | 38.5 |
| **Surgical equipment** | 13.2 | 9.3 | 10.7 | 15.4 |
| **Metals** | 42.1 | 32.6 | 53.6 | 69.2 |
| **Electrical waste** | 13.1 | 18.6 | 21.4 | 53.8 |
| **Plastic** | 78.9 | 76.7 | 78.6 | 92.3 |
| **Textile** | 31.6 | 9.3 | 7.1 | 15.4 |
| **Glass** | 68.4 | 60.5 | 64.3 | 92.3 |
| **Paper** | 65.8 | 90.7 | 27.1 | 100.0 |
| **Cardboard** | 57.9 | 72.1 | 67.9 | 92.3 |
| **None of the above** | 26.0 | 0.0 | 3.6 | 0.0 |

high school qualification. Site D (high-income community) recorded the highest proportion of high school graduates (61.5%). At Sites A, B, and C, the percentage of participants who had high school qualifications was 39.5%, 51.2%, and 60.7%, respectively. Regarding university-level qualifications, Site D again had the highest percentage (38.5%), followed by Site A at 21.1%. Only Site B reported participants with no formal schooling (2.3%). Employment status varied markedly between communities. The highest unemployment rate was observed at Site C (64.3%), followed by Site A (63.2%) and Site B (58.1%). Site D reported the lowest unemployment rate (30.7%). Employment rates were highest at Site D (23.1%), followed by Site C (17.9%), Site A (13.2%), and Site B (4.7%) as seen in Table 1. Pensioners constituted 13.2% at Sites A, 18.6% at Site B, 3.8% at Site C, and none (0.0%) at Site D. With regards to monthly income, participants who earned less than R2000 were as follows: Site B (90.7%) > Site C (71.4%) >Site A (68.4%) > Site D (30.8%). At Sites A, B, and C, the percentages of participants who earned between R2000 - R16000 were 26.3%, 7.0% and 28.6%, respectively. At Sites A, B, and D, 5.3%, 2.3% and 38.4% of participants respectively earned between R17000- R24000) per month. Only participants at Site D (30.8%) earned more than R24000 per month, with no participants from the low-income communities falling within this income bracket.

### *Materials considered to be recyclable by participants*

Different types of materials found in household waste can be recycled. Table 2 shows materials that participants considered recyclable. Most households from Site C (53.6%) considered organic waste to be recyclable, since it can be converted into compost and biogas, while the lowest percentage (23.7%) waste at Site A. Only a small number of households regarded surgical equipment as recyclable - Site A (13.2%), Site B (9.3%), Site C (1.1%), and Site D (15.4%). With Regard to metals, 69.2% of households at Site D perceived metals as recyclable, compared to 42.1% of households at Site A, 32.6% at Site B, and 53.6% at Site C. A minority of households considered electrical waste recyclable at Site A (13.1%), Site B (18.6%), and Site C (21.4%), whereas over half of households at Site D (53.8%) considered it recyclable.

Site D had the highest percentage of households that considered plastic recyclable (92.3%), followed by Site A (78.9%), Site C (78.6%), and Site B (76.7%). With regards to textiles, only a low percentage of households considered them recyclable: 31.6% at Site A, 9.3% at Site B, 7.1% at Site C, and at 15.4% Site D. In terms of glass, most households across the communities considered it recyclable, with 92.3% at Site D, 68.4% at Site A, 60.5% at Site B, and 64.3% at Site C reporting so. For paper, 100% of households at Site D considered it recyclable, compared to 65.8% at Site A, 90.7% at Site B, and 27.1% at Site C. Regarding the recyclability of cardboard, most households in all communities considered it recyclable: 92.3% at Site D, 57.9% at Site A, 72.1% at Site B, and 67.9% at Site C. Statistical analysis revealed that there were no significant differences ($p>0.05$) in perceptions of recyclable materials between low-income and high-income communities.

### *Waste management by participants*

Not all participants reported recycling or segregating their household waste before disposal. Table 3 shows how participants managed household waste, including the percentages of those who were aware of recycling and the reasons for not separating waste before discarding it. Most of the households in both the low-income communities (Sites A, B, and C) and the high-income community (Site D) did not separate their household waste before disposal. The order of non-separation was as follows: Site A (81.6%) >Site B (81.4%)> Site C (75.0%) >Site D (61.5%).

At Site D, 76.9% of households admitted to knowing about recycling, compared to 60.5% at Site A, 51.2%) at Site B, and 60.7% at Site C. More households did not know about recycling in the low-income communities (39.5% at Site A, 48.8% at

**Table 3:** Waste management practices by participants and reasons for not separating household waste.

| Site | Separation of waste by households before discarding it (%) | | Participants who had knowledge about recycling (%) | | Participants who recycle their household waste (%) | | Participants who were willing to be introduced to recycling (%) | | Reasons given by participants for not separating their household waste (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | Yes | No | Yes | No | I do not have time | It is not important | I do not Care | Separating makes no difference | It is not my duty but that of the municipality | It is inconvenient and takes too much time. |
| **Site A** | 18.4 | 81.6 | 60.5 | 39.5 | 15.8 | 84.2 | 92.1 | 7.9 | 57.9 | 5.3 | 5.3 | 15.8 | 0.0 | 5.3 |
| **Site B** | 18.6 | 81.4 | 51.2 | 48.8 | 20.1 | 79.1 | 86.0 | 14.0 | 27.9 | 14.0 | 2.0 | 4.7 | 9.3 | 14.0 |
| **Site C** | 25.0 | 75.0 | 60.7 | 39.3 | 17.9 | 82.1 | 100 | 0.0 | 35.7 | 7.1 | 0.0 | 10.7 | 7.1 | 14.3 |
| **Site D** | 38.5 | 61.5 | 76.9 | 23.1 | 30.1 | 69.2 | 100 | 0.0 | 70.0 | 30.0 | 0.0 | 0.0 | 0.0 | 0.0 |

**Table 4:** Recycling participation across age groups

| Site | 18-35 years (%) | | 36-49 years (%) | | 50-64 years (%) | | >64years (%) | |
|---|---|---|---|---|---|---|---|---|
| | yes | No | Yes | No | Yes | No | Yes | No |
| **Site A** | 5.3 | 23.7 | 2.6 | 23.7 | 2.6 | 29.0 | 5.3 | 7.9 |
| **Site B** | 4.7 | 14 | 4.7 | 35.0 | 7.0 | 14.0 | 4.7 | 16.3 |
| **Site C** | 0.0 | 21.4 | 7.1 | 32.1 | 10.7 | 28.6 | 0.0 | 0.0 |
| **Site D** | 15.4 | 30.8 | 23.1 | 15.4 | 7.7 | 7.7 | 0.0 | 0.0 |

Site B, and 39.3% at Site C), compared to the high-income community (Site D), in which only 23.1% of households reported a lack of awareness of recycling. With regards to participants who recycled their waste, Site A had the lowest proportion of households actively recycling (15.8%), while Site D had the highest (30.7%). Site A also recorded the highest percentage of households not recycling (84.2%), followed by Site C (82.1%), Site B (79.1%), and Site D (69.2%).

When analyzing the relationship between knowledge of recycling and the actual recycling by participants, no statistical evidence was found, at the 5% level of significance, to indicate an association between the two variables. Therefore, statistically, there was no correlation between recycling knowledge and practice. Table 3 illustrates the percentages of participants who were willing to be introduced to recycling. Most of the participants in both low-income communities (Sites A, B, and C) and the high-income community (Site D) were willing to engage in recycling, except for a few households in the low-income areas - Site A (7.9%) and Site B (14%).

Several reasons were provided by participants for not separating their household waste, as shown in Table 3. The most frequently reported reason was a lack of time. At sites A, B, C, and D, 57.9%, 27.9%, 35.7%, and 70.0 % of participants, respectively, indicated that they did not have time for recycling. Some participants believed that recycling waste is unimportant, with 5.3% at Site A, 14% at Site B, 7.1% at Site C, and 30% at Site D expressing this view. Only a few participants did not care about recycling (5.3% at Site A and 2% at Site B). Others believed that separating waste at the source makes no difference - 15.8% at Site A, 4.7% at Site B, and 10.7% at Site C. A few participants felt that waste separation should be the sole responsibility of the municipality (9.3% at Site B and 7.1% at Site C). Additionally, some participants said they did not separate their household waste because they found it inconvenient or too time-consuming (5.3% at Site A, 14% at Site B, and 14.3% at Site C).

Recycling participation varied across age groups, as indicated in Table 4. Among participants aged 18- 35 years, recycling rates were highest at Site D (15.4%), followed by Site A (5.3%), Site B (4.7%), and Site C (0.0%). In the same age group, non-recyclers were most common at Site D (30.8%), Site A (23.7%), Site C (21.4%), and Site B (14.0%). For the 36-49 age group, recyclers were most prevalent at Site D (23.1%), followed by Site C (7.1%), Site B (4.7%), and Site A (2.6%). Non-recycling in this age group was highest at Site B (35.0%), then Site C (32.1%), Site A (23.7%), and Site D (15.4%). In the 50-64 age group, the order was Site C (10.7%) > Site D (7.7%) > Site B (7.0%)>Site A (2.6%) while that of non-recyclers was Site A (29.0%) > Site C (28.6%) >Site B (14.0%) >Site D (7.7%). Among participants aged over 64 years, no recycling participation was recorded at Sites C and D. Site A reported 5.3% of recyclers, and Site B reported 4.7%. For non-recyclers over 64 years, Site B had the highest proportion (16.3%), followed by Site A (7.9%). A Chi-square test revealed no **significant differences** in recycling participation across the sites.

### *Perception of participants on recycling, recycling behavior, and motivating factors*

Table 5 illustrates participants' perceptions of recycling, their recycling behavior, and potential motivators. Most households across all sites believed that recycling provides environmental and social benefits: 100% at Site A, 90.7% at Site B, 89.3% at Site C, and 92.3% at Site D. Only a small minority did not share this belief - 10.7% at Site C, 9.3% at Site B, and 7.7% at Site D. Table 5 also indicates that many households believed that recycling could decrease landfill burden, with the highest agreement at Site D (100%), followed by Site A (97.3%), Site B (84.4%), and Site C (82.1%. The highest percentage of households that did not believe that recycling could decrease landfill burden was observed at Site C (17.9%), followed by Site B (4.7%).

Most households across all communities believed that recycling was a positive behavior, with 100% agreement at Site A and Site D, 88.4 % at Site B, and 96.4% at Site C. Only a small minority at Site C (3.6%) of households believed that recycling was not good behavior, while at Site B, 11.6% of households were unsure whether recycling was good behavior or not. In terms of actual practice, Site D had the highest percentage of households (50%) who said that they recycled household waste all the time. In contrast, Site A had the lowest proportion, with only 16.7% of households reporting consistent recycling.

At Sites B and C, 44.4% and 28.6% of participants, respectively, indicated that they recycle their household waste all the time. A Chi-square test revealed no significant differences between sites regarding the perception that recycling reduces landfill burden ($p>0.05$), nor in the frequency of actual recycling among those who reported partaking in the recycling of waste ($p>0.05$). However, significant differences were found between sites in the perception that recycling "is good behavior" ($p<0.05$), suggesting that moral and social norms associated with recycling may not be equally internalized across communities. Economic incentives emerged as the strongest motivator for recycling, with 47.4% of households

**Table 5:** Perception of participants on recycling, recycling behaviour and motivating factors

| Site | Perception of participants on whether recycling has environmental and social benefits (%) | | | Perception of participants on whether recycling could decrease landfill burden (%) | | | Perception of participants on whether recycling is good behaviour (%) | | | Frequency of recycling by those who do it (%) | | Factors that participants thought would be motivators for people to start recycling (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yes | No | I do not know | Yes | No | I do not know | Yes | No | I do not know | All the time | Sometime | Economic incentives | If my neighbours, friends and family do it | If a campaign on recycling and its benefits is done | Having recycling centres nearby | If the municipality provides bins for recycling |
| **Site A** | 100 | 0.0 | 0.0 | 97.3 | 2.6 | 0% | 100 | 0.0 | 0.0 | 16.7 | 83.3 | 47.4 | 15.8 | 21.1 | 21.1 | 10.5 |
| **Site B** | 90.7 | 9.3 | 0.0 | 84.4 | 7.0 | 4.7 | 88.4 | 0.0 | 11.6 | 44.4 | 55.6 | 72.1 | 4.7 | 16.3 | 30.2 | 14.0 |
| **Site C** | 89.3 | 10.7 | 0.0 | 82.1 | 17.9 | 0.0 | 96.4 | 3.6 | 0.0 | 28.6 | 71.4 | 67.9 | 32.1 | 25.0 | 25.0 | 25.0 |
| **Site D** | 92.3 | 7.7 | 0.0 | 100 | 0.0 | 0.0 | 100 | 0.0 | 0.0 | 50.0 | 50.0 | 38.5 | 15.4 | 15.4 | 23.1 | 15.4 |

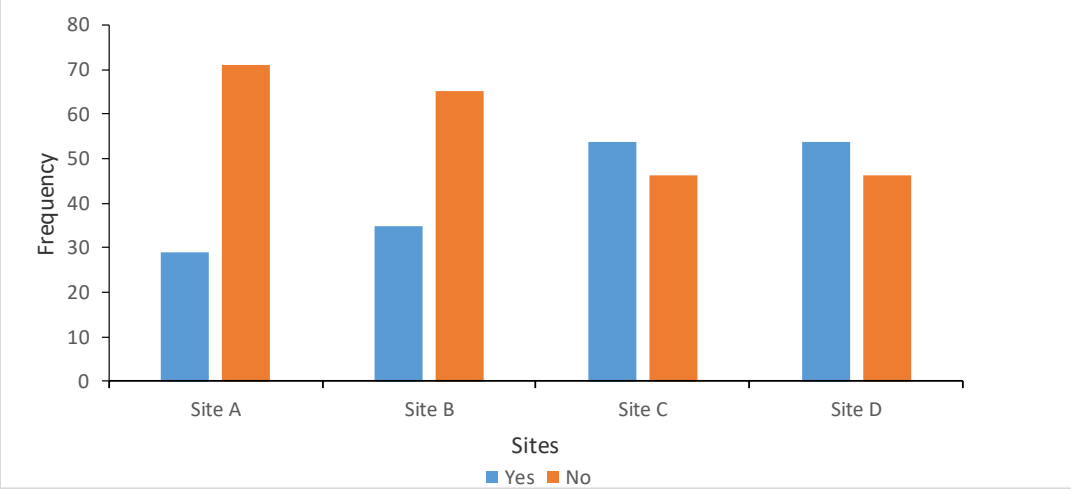


**Figure 1:** Number of participants with knowledge of the creation of compost.

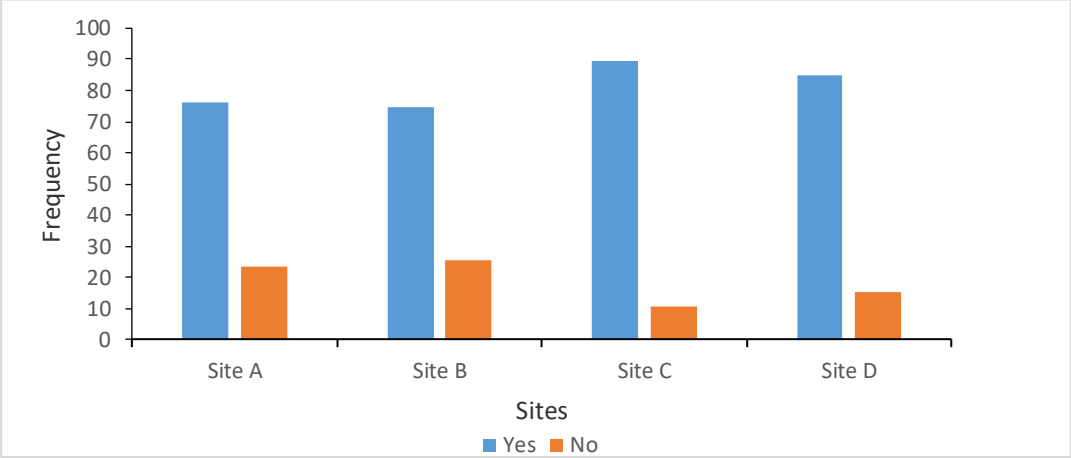


**Figure 2:** Participants who were willing to be taught how to compost.

at Site A, 72.1% at Site B, 67.9% at Site C, and 38.5% at Site D identifying it as their primary motivation. The second motivator was the availability of a nearby recycling centre, reported by 21.1% at Site A, 30.2% at Site B, 25% at Site C, and 23.1% at Site D.

### *Composting of organic waste by participants and their perception of composting*

Composting organic waste is another recognized form of recycling. Figure 1 illustrates the percentage of households that indicated their knowledge of composting. The highest levels of awareness were observed at Site D (53.8%) and Site C (53.6%). In contrast, Site A had the lowest proportion of households knowledgeable about compost creation (29%) and the highest percentage of households unaware of it (71%). At Site B, 65.1% of households reported not knowing about compost creation, compared to 46.4% at Site C and 46.2% at Site D.

The majority of participants expressed willingness to learn how to compost, as shown in Figure 2. Site C had the highest percentage of households open to composting education (89.3%), followed by Site D at 84.6%, Site A at 76.3%, and Site B (74.4%).

Most households reported that they do not compost organic waste produced in their homes (Figure 3). At site A, 21.1% of participants mentioned that they do compost their organic waste, while 78.9% do not. At Sites B and C, 11.6% and 32.1% of participants, respectively, indicated that they composted their organic waste, whereas 88.4% and 67.9%, respectively, did not. At Site D, 53.8% said they do not compost, while 46.2% said they do. The minority of households that compost their organic waste mainly manage food waste (fruit peels, vegetable scraps, and leftover food), garden waste, and paper.

When assessing whether there was a correlation between knowledge of how to create compost and the actual practice of composting organic waste, it was determined that, at the 5% level of significance, no significant correlation existed. The statistical test yielded a Chi square value of 1.920, with 3 degrees of df value and a p-value of 0.59. Regarding the benefits of composting, 100% of households at Site D believed that composting is beneficial. At Site A, 81.6% believed composting has benefits, while 18.4% did not. At Sites B and C, 79.1% and 78.6% of households, respectively, believed composting has benefits, whereas 20.6% and 21.4%, respectively, did not (Figure 4).

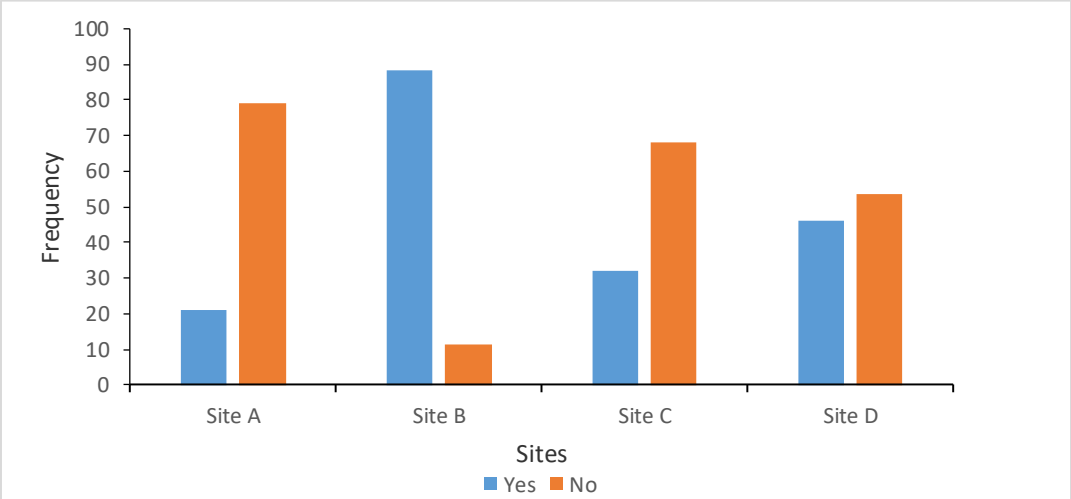


**Figure 3:** Participants who indicated that they compost their organic waste.

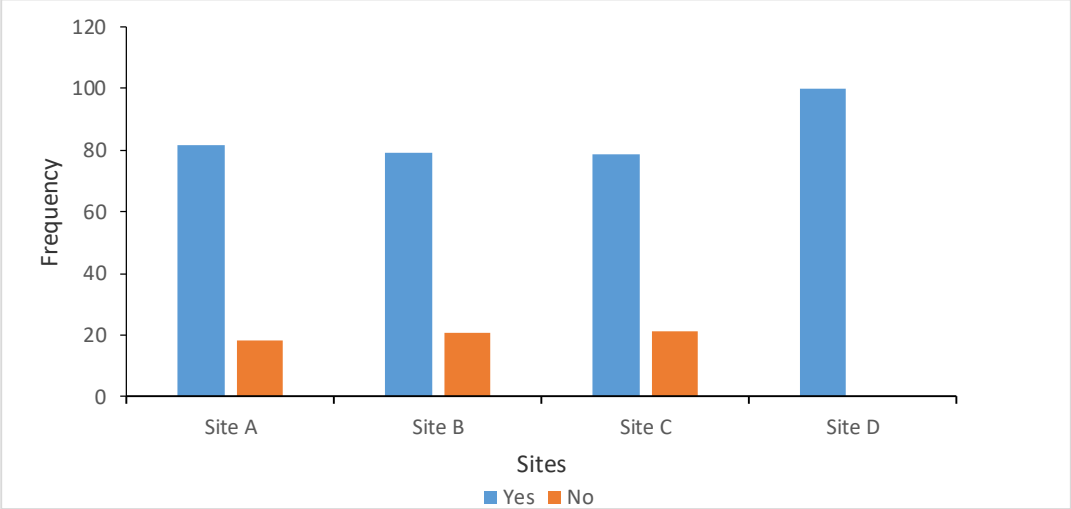


**Figure 4:** Opinions of participants on whether composting has any benefits.

### *Waste reduction by participants*

Regarding waste reduction, most households indicated that they make efforts to reduce waste production (Table 6). At Site D, 76.9% of participants reported attempting to reduce their household waste. In the low-income communities, Sites A, B, and C, 60.5%, 65.1%, and 64% of households, respectively, stated that they made efforts to reduce waste within their homes. Regarding methods used by participants to reduce waste within their households, participants reported actions recommended by the waste hierarchy: re-use, recycle, and recovery, with disposal as a last resort. Percentages of households practicing re-use method were as follows: Site A (31.6%), Site B (25.6%), Site C (53.6%), and Site D (30.8%). The use of recycling was reported by Site A (18.4%), Site B (32,6%), Site C (28.6%), and Site D (38.5%). Recovery methods were mentioned at Sites B (14%), C (17.9%), and D (15.4%). Households that reported reusing shopping bags rather than discarding them included Site A (31.6%), Site B (27.9%), Site C (21.4%), and Site D (23.1%). The majority of participants in all the communities were aware that waste reduction benefits the environment: Site A (84.2 %), Site B (93%), Site C (82.1%), and Site D (100%). A Chi-square test revealed no significant differences among the four sites in terms of waste reduction efforts, environmental beliefs, or commonly used methods ($P > 0.05$). However, statistically significant differences were observed in the use of "other" methods to reduce household waste.

## Discussion

In the low-income communities, female participants outnumbered males, most probably because men in these households were employed elsewhere or actively looking for work. At site D, however, male participants were more prevalent than female participants, probably because some men were self-employed and could arrange their work schedules more flexibly. Depending on the nature of their business, they may also have had the option to work from home. As previously noted, most participants living in low-income areas were not self-employed and were often in search of jobs. When work was available, it typically required them to be on-site rather than at home, due to their level of education or the nature of the jobs, which were predominantly unskilled. According to Statistics South Africa (2023), many

**Table 6:** Waste reduction efforts and methods used by participants to reduce waste in their households.

| Site | Effort to reduce waste (%) | | Belief that waste reduction benefits the environment (%) | | Methods used to reduce waste within the household (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | yes | no | yes | No | Re-use | recycling | Recover | Use own bags when shopping | Other |
| **Site A** | 60.5 | 39.5 | 84.2 | 15.8 | 31.6 | 18.4 | 0.0 | 31.6 | 5.7 |
| **Site B** | 65.1 | 34.9 | 93.0 | 7.0 | 25.6 | 32.6 | 14.0 | 27.9 | 0.0 |
| **Site C** | 64.0 | 36.0 | 82.1 | 17.9 | 53.6 | 28.6 | 17.9 | 21.4 | 0.0 |
| **Site D** | 76.9 | 23.1 | 100 | 0.0 | 30.8 | 38.5 | 15.4 | 23.1 | 23.1 |

occupations in South Africa are associated with low-income, unskilled work, such as manual labor, domestic work, informal trading, construction, and mining. These types of jobs generally cannot be performed from home but require physical presence at the workplace.

Limited awareness of organic waste, such as food scraps, fruit and vegetable peels, and garden wastes, as recyclable in some communities may be an indication of a lack of knowledge about organic waste management. However, at Site C, the proportion of participants who perceived organic waste as recyclable doubled compared to the Sites A and B in the low-income communities. This suggests that residents at site C may have had greater exposure to to information on organic waste recycling, possibly through non-governmental organizations (NGOs) or environmental community activists operating within the area.

The limited recognition of e-waste as recyclable among participants in low-income communities may be attributed to a general lack of consumer awareness and the absence of adequate collection mechanisms and infrastructure, as highlighted by Ichikowitz and Hattingh (2020). In contrast, most of the households across both community types recognized plastic as a recyclable material, as shown in Table 2. The widespread awareness of plastic recycling across several socio-economic groups can likely be attributed to its visibility through efforts of informal waste pickers and community-based recycling initiatives.

The low percentage of participants who recognized textiles as recyclable suggests limited exposure to textile recycling initiatives or insufficient infrastructure supporting textile reuse. According to Utebay et al. (2020), textile waste can cause environmental harm when improperly disposed of. Although textile recycling does exists in South Africa, infrastructure challenges continue to hinder its effectiveness (Romatex, 2022). It is not surprising that most participants considered paper and cardboard as recyclable. South Africa has a well-established paper recycling industry, supported by extensive awareness campaigns. In 2022, approximately 1.3 million tons of paper and paper packaging were diverted from landfill through recycling initiatives (Mpact Recycling, 2023).

Regarding waste segregation, most participants reported that they do not practice it. These findings are consistent with those of Ssemugabo et al. (2020), who found that 78.7% of participants did not segregate their household waste. Among low-income communities, the lack of waste separation may be associated with lower levels of formal education, as many participants had not attained a university qualification. Oyekale (2018) reported a substantial positive correlation between education level and recycling behavior. In high-income households, non-separation of waste may be attributed to reliable municipal services, which allow residents to dispose of all waste in a single bin with the expectation that it will be managed appropriately (Ssemugabo *et al*., 2020). Additionally, Volschenk *et al*. (2021) suggested that high-income households may not depend on income from recycling, as many individuals are employed or self-employed, and thus do not prioritize waste separation for financial gain.

Furthermore, waste separation is not commonly practiced because there is no official guidance or infrastructure to support it. The ability and willingness to separate waste largely depend on individuals, as this practice is not yet institutionalized in many parts of the country. Only certain household items, such as bottles and metallic objects, are typically sorted, as they can be sold or exchanged for goods. This may explain why waste separations was not widely practiced in either low- or high-income communities. In low-income areas, the separation of bottles and metals was largely motivated by the prospect of financial gain. These findings are in line with previous studies indicating that the absence of proper waste disposal facilities discourages participation in recycling, even when individuals understand its importance. As Zhuang et al. (2008) emphasize, willingness alone is insufficient and adequate tools and infrastructure are essential. Strydom (2018) also reported that convenience is a major determinant of positive recycling behavior; without accessible waste bins or dedicated collection system, individuals may develop negative attitudes toward recycling. In this study. most participants did not engage in household waste recycling, despite claiming to possess knowledge on recycling. These results are consistent with those reported by Gumbi et al. (2017), who carried out a study in the UMkhanyakude and Zululand district municipalities in the KwaZulu-Natal province of South Africa and found that only a minority of households there recycled their household waste.

Site D had a high percentage of respondents who reported knowledge of recycling, likely because Site D is a high-income area where residents have greater access to information through platforms such as social media and newspapers. Their financial means may enable them to afford data or newspaper subscriptions. In contrast, the highest proportion of non-recyclers was found in low-income communities (Sites A, B, and C). This may be related to lower levels of education of the participants, which can affect their understanding of the importance of recycling. Additionally, some participants may perceive household recycling as offering limited financial rewards, thereby reducing motivation to participate. Such perceptions could be improved through targeted educational initiatives and the dissemination of accurate information on the benefits of recycling. Another factor contributing to low participation in recycling within low-income communities could be the stigma associated with recycling by people with less knowledge of the benefits of recycling. In South Africa, recycling is carried out by street recyclers, who are frequently marginalized or looked down upon. According to Bendak and Attili (2017), recycling may be stigmatized or viewed as an activity associated primarily with the poor.

It is understandable that most participants from both low– and high–income communities were more than willing to be introduced to recycling. Many respondents viewed recycling as a positive behavior that can reduce landfill burden and provide environmental and social benefits. Their perception likely contributed to their openness to learning more about recycling. Such willingness presents an opportunity to improve recycling levels within these communities. According to Mukherji *et al*. (2016), when communities are equipped with additional environmental knowledge and viable waste management practices, they are more likely to adopt pro-environmental behaviors.

Regarding the barriers to waste separation, most participants frequently cited a lack of time as the primary reason for not

separating household waste. Similar findings were obtained by Strydom (2018), who found that time constrains were the most significant factor preventing individuals form recycling. In Site D, most respondents were either employed or self-employed, which may explain why they lacked time to engage in household waste separation. In low-income communities, participants often spent more time seeking employment or performing informal work to meet basic needs, leaving little or no time for waste separation.

The study further revealed considerably lower recycling participation among respondents aged 65+ years compared to younger age groups, with no recyclers documented at Sites C and D. This trend may be attributed to age-related factors, such as reduced physical energy or health limitations, which can significantly constrain older adults' ability to engage in waste segregation activities. In contrast, the minimal participation observed at Sites A and B (4.7–5.3%) suggests that socioeconomic incentives, such as supplementary income from recyclables, or environmental advocacy may have motivated some elderly individuals to participate regardless of similar age barriers. Overall, the consistently low engagement across all sites highlights a gap in age-inclusive waste management strategies, including the absence of targeted outreach programs tailored to the needs and capabilities of older adults.

Respondents had different perceptions about recycling and the factors that could be motivators for recycling. Generally, most participants believed that recycling provides environmental and social benefits. These results are in correlation with those obtained by Schoeman and Rampedi (2022), who reported that the majority (65%) of participants agreed that recycling protects the environment. Although many respondents from low-income areas did not frequently engage in recycling, they still considered it to be good practice, which may be influenced by the time constraints they reported earlier. Economic incentives were identified as the primary motivator for most households in both low-income and high-income communities. Given the prevailing economic challenges, it is understandable that most respondents were particularly interested in financial rewards or other forms of incentives, such as tax breaks. Widdowson et al. (2014) emphasize that when designing incentive schemes, authorities must first identify the specific barriers to recycling within a community in order to develop effective programs. These barriers can vary considerably between communities, especially when comparing low-income and high-income areas.

*Most households across both income groups reported not composting organic waste, which may be largely attributed to a lack of knowledge about composting, as indicated by survey responses.* Despite this, most of the respondents from both low- and high-income communities expressed a willingness to learn to compost, recognizing the benefits of composting, such as providing essential nutrients for plants. Similalry, Matshika and Muzenda (2017) found that the limited practice of composting among households is often linked to a lack of education and awareness regarding its benefits, as well as cultural practices and preferences that discourage the organic waste separation and composting of organic waste.

Most households, regardless of income level, considered waste reduction to be important, as they believed that reducing waste generation would benefit the environment. However, some participants used methods beyond the recommended practices of re-use, recovery, and recycling. For instance, a few households reported burning waste – a practice that is not recommended since it contributes to environmental pollution by increasing greenhouse gases in the atmosphere, resulting in global warming.

## Conclusions and recommendations

The study evaluated the awareness, understanding, and practices of household waste recycling among low- and high-income communities in northern Pretoria, South Africa. Findings indicated that while awareness of recycling existed across communities, actual participation remained low. A considerable percentage of participants did not segregate their household waste prior to disposal, with time constraints and insufficient infrastructure cited as the main barriers. Households in high-income communities demonstrated higher awareness of recycling but did not actively participate, whereas low-income households showed limited awareness, primarily due to challenges in accessing recycling facilities. Despite these limitations, both communities exhibited a strong willingness to participate in recycling if economic incentives and easily accessible recycling facilities were provided. Similarly, participation in composting was low, largely owing to insufficient knowledge of its implementation and benefits.

Given that most households do not compost their organic waste or consistently segregate and recycle their household waste, several recommendations are proposed. The government and local municipalities should implement public awareness campaigns to educate communities on proper waste segregation and the benefits of recycling. Partnership with private companies could facilitate the establishment of community-based recycling centres closer to residential areas, reducing the inconvenience of transporting recyclable waste. Additionally, local municipalities should provide separate bins for recyclable waste in both low- and high-income communities to promote the separation of waste at the source. Economic or tax incentives could be introduced to encourage active participation, particularly among unemployed people, for whom recycling could serve as a source of income. Training sessions to educate households on composting organic waste and the benefits of composting should also be conducted by local municipalities.

The study further highlights the need for a comprehensive strategy to address disparities in recycling knowledge and practices between low-income and high-income groups in Pretoria. By improving knowledge, infrastructure, and community engagement, it is possible to foster equitable and efficient recycling practices across socio-economic boundaries. Future research should continue to explore innovative solutions and assessing the long-term impacts of such interventions.

## Acknowledgments

The authors would like to express their gratitude to all participants for their valuable contributions, and to the Friends of Toloane (NPC) for their assistance and support during the data collection process.

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